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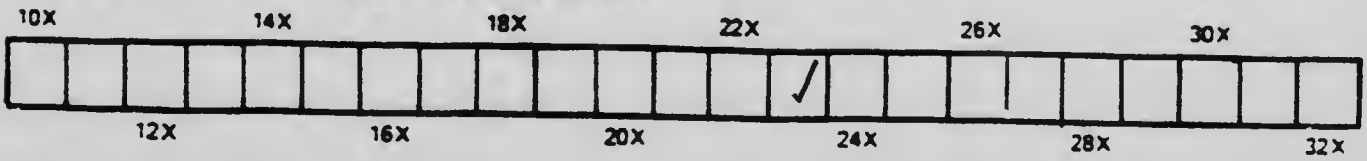

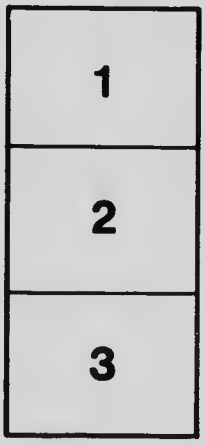

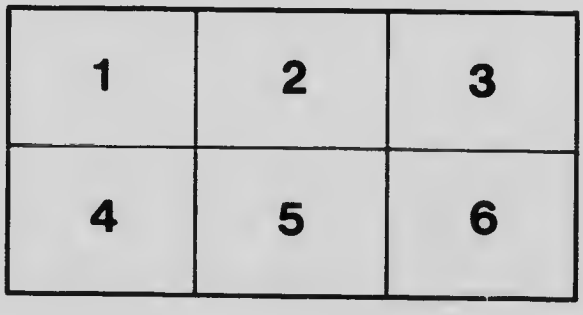

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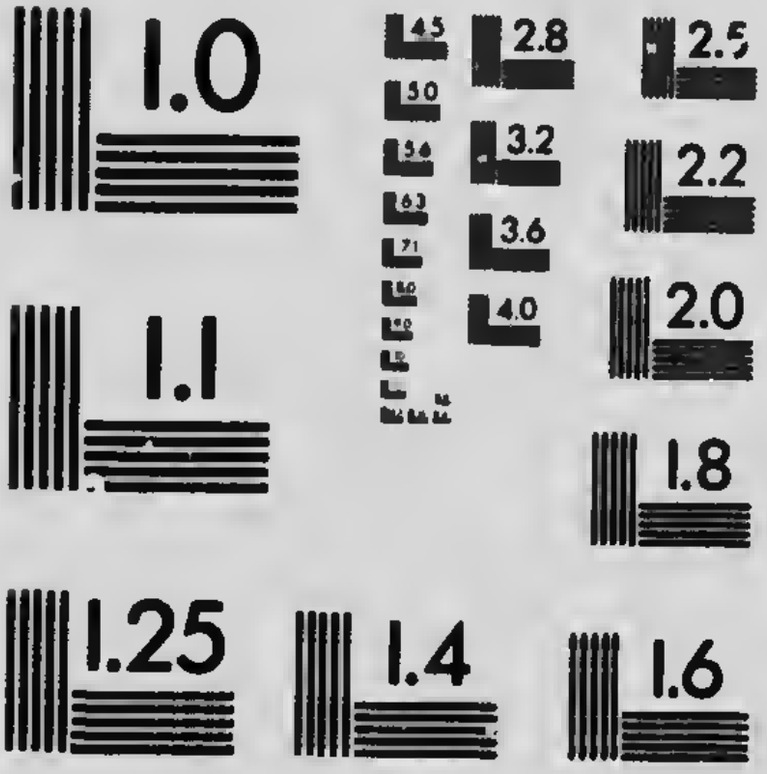

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FROM THE TRANSACTIONS OF THE ROYAL SOCIETY OF CANADA
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GEOLOGICAL AND BIOLOGICAL SCIENCES

NOTES ON CAMERIAN FAUNAS

By G. F. MATTHEW, LL.D.

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1902

III.—*Notes on Cambrian Faunas.*

By G. F. MATTHEW, LL.D.

Earlier "notes" were published in these Transactions in 1897-98 and '99.

(Read May 27, 1902.)

No. 5. OBOLOID SHELLS OF THE CAMBRIAN SYSTEM IN CANADA AND THEIR RELATIONSHIP.

Much has been done of late years to make known to us the type of Eichwald's genus Obolus, and especially through the monograph on this genus prepared by Michwitz. Through his writings we now know the main points of the internal anatomy of that genus as presented in the type species *O. Apollonis* and its variety *Quenstedti*, and can see how easily it might be misunderstood from the older representations of its form and internal features.

Depending, as the palæontologists have had to in the first case, on external features as the means of determining the genus, a number of species have been referred to Obolus, which, when better known, were found to exhibit important points of difference, these were chiefly in the moulding of the interior surface of the valves.

Of this moulding of the interior, the most distinctive markings are those which indicate the points of attachment of the muscles that move the valves, and the impressions of the main trunks of the circulatory system. Much variation was found in these two sets of markings, showing radical differences in the arrangement of the internal parts of the animal. Yet the more obvious characters of the external form, and the surface markings of the valves, are those which must necessarily first be used in assigning the species to its genus.

We propose in this brief note to point out some distinctions which have been made out from a knowledge of the internal characters of the shells of the Oboli of the Cambrian System in Canada; and indicate some possible relations to other genera of shells that have been assigned to the genus Obolus.

The species are referred to in succession, taking the oldest first, and continuing with those that are found in successively higher horizons in the Cambrian.

OBOLUS TORRENTIS (Plate 1, fig

This species, found in the shales enclosed in volcanic rocks of the base of the Cambrian, is referred to the genus only on the basis of general form. The internal moulding of the shell is not known, but the depressed band on the median line of dorsal valve indicates a relationship to the following species:

OBOLUS TRIPARILIS (Plate 1, fig. 2).

This species from the base of the Lower Etcheminian, is easily distinct from the type of the genus by the advanced position of the anterior adductors of the dorsal valve, and the close association with them of the "*j*" laterals. In *O. Apollonis* the first named muscles are wide apart and the "*j*" laterals are far in advance of them. There is also in the Etcheminian form a small scar between these laterals from which, with them, the species takes its name. Of this scar the cause is not known, but in size and appearance it resembles those made by the "*j*" laterals.

OBOLUS DISCUS (Plate 1, fig. 3).

This form by the arrangement of the central group of muscles and the sculpture shows it relation to the preceding. It is larger and more orbicular.

OBOLUS ÆQUIPUTEIS (Plate 1, fig. 4).

This Obolus also has the two pairs of scars of the central muscles of the dorsal valve, approximated, but the supposed "*j*" laterals are unusually large. It also has the small median scar that is found in the other two. The three form a series of closely related forms (EOOBOLUS).

OBOLUS LENS-PRIMUS.

This small Obolus is the initial form of a quite different series. The preceding three have the vascular trunks of the ventral valve wide apart as in *Obolus Apollonis*. In the series of which *O. lens-primus* is the oldest known form, the vascular trunks of this valve are approximated so as to resemble those of the Lingulepis. They may even be so close together as to enclose only a third of the area of the valve.

[1] The full description of this and the three following new species will be found in the author's report to the Director of the Geological Survey of Canada, on the Cambrian Rocks of Cape Breton.

The amount of chitinous matter in the valves of the species of this group is small, and the outer shell may have been calcareous. As preserved in the shales of the Cape Breton Cambrian, it is translucent and apparently silicious. These shells may be related to Obolella.

OBOLUS LENS (Plate 1, fig. 6).

This form is considerably larger than the preceding, and, like it, has regular concentric ridges on the surface. In this character they differ from the Oboli of the Lower Etcheminian, which have a surface ornamentation of waving irregular ridges.

OBOLUS BRETONENSIS (Plate 1, fig. 5).

The preceding species is found both above and below this one; the former is found in fine sandy shale, but the present species affected a mud in which clay was more plentiful. This species had more prominent and more widely set concentric ridges on the surface than the preceding.

These three forms belong to the section PALÆOBOLUS, characterized by approximated vascular trunks.

In the base of this division of the Etcheminian is a large Obolus, whose characters are not sufficiently known to enable us to use it in this comparison (*O? major*).

OBOLUS PULCHER (Plate 1, fig. 7).

In the base of the St. John group another Obolus appears, of a type quite different from either of the preceding. It is easily recognized by the peculiar ornamentation of cancellated ridges, resembling those of *Iphidea pannula*. The dorsal, by its incurved and flattened posterior slope, and its internal markings, shows a resemblance to the markings of Acrothele, and the beak of the ventral is more prominent than is usual in Obolus; but it is not pushed forward as in Acrothele, nor is the cardinal area visible from above.

One peculiar feature of this species is the larger size and fan-like form of the callus of the ventral valve; in this point it resembles some of the Orthids. The callus extends beyond the middle of the valve, and shows that in the ventral valve of this species, the central muscles were far forward. This is referred to the subgenus BOTSFORDIA.

Obolus pristinus (Plate 1, fig. 8).

Nearly cotemporaneous with the last is a somewhat larger species, which, if the markings are interpreted aright, has similarly advanced centrals in the ventral valve, but the anterior adductors of the dorsal are unusually far back. This is counterbalanced by the position of the "*j*" laterals which are only ¼ of the length of the valve from the front. The surface markings are fine and more like later than earlier species.

The Paradoxides beds, though containing a varied fauna and several genera of Brachiopoda, shows hardly a single example of Obolus; this is especially true of the Lower Paradoxides beds, where the bulk of the fauna is found.

Obolus Ella (Plate 1, fig. 9).

This form, formerly referred to Lingulella, is decidedly Oboloid in shape. It differs from the type in the backward position of the "*j*" laterals of the dorsal valve; also the anterior adductors of this valve are set further back than in *O. Apollonis*. Mr. Walcott's reference of it to Westonia would also indicate that the sculpturing of the surface of the valves differs from that of Eichwald's species.

Obolus refulgens (Plate 1, fig. 11).

This species is very near the geological horizon of *Obolus Apollonis*, but lived in a different habitat. The latter species abounded in sandstone beds, but the former in fine dark gray shales or mud-beds. Being very thin, the internal markings of the valves of *O. refulgens* are faint, and it is only lately that specimens have been found which show that it is not a typical Obolus. In Obolus proper (Euobolus) the scars of the anterior adductors of the dorsal valve are separated far from each other, but in this species they are closely approximated; they are closer together than those of Lingulella, and are parallelled only by those of *Monobolina*, Salter. *Lingulella Davisii*, which is nearly cotemporary with these two forms, is intermediate between them as regards the approximation of these two muscle scars.

From an examination of the internal features of the valves of the several species of Obolus, which the author has briefly outlined above, the reference of these species to that genus, taking *O. Apollonis*

as the type, is evidently open to question; the arrangement of the muscle scars and of the vascular trunks, relates them to other genera rather than to Obolus, as typified by the species above named. For this reason we have felt it necessary to propose sub-generic names to indicate these important differences.

The oldest group (Eoobolus) differs from the type in the advanced position of the whole group of the central muscles of the dorsal valve; not the "*j*" laterals alone.

The second group (Palæobolus differs in the approximation of the vascular trunks of the ventral valve, which enclose only a third of the area of the valve, whereas in *O. Apollonis* one-half of the surface is thus enclosed.

The third group (Botsfordia) differs in the close grouping of the central scars of the dorsal valve, and the posterior position of the lateral scars. Also in the very large callus of the ventral valve.

The fourth group represented by *Obolus pristinus* is different by the arrangement of the scars from any of the preceding, and also by its sculpture. It is, perhaps, on the line of development of *Obolus Ella* which Mr. Walcott on account of its surface, has referred to his subgenus Westonia; it, however, has no resemblance to Westonia in its surface-markings, and the "*j*" laterals of the dorsal are much farther forward.

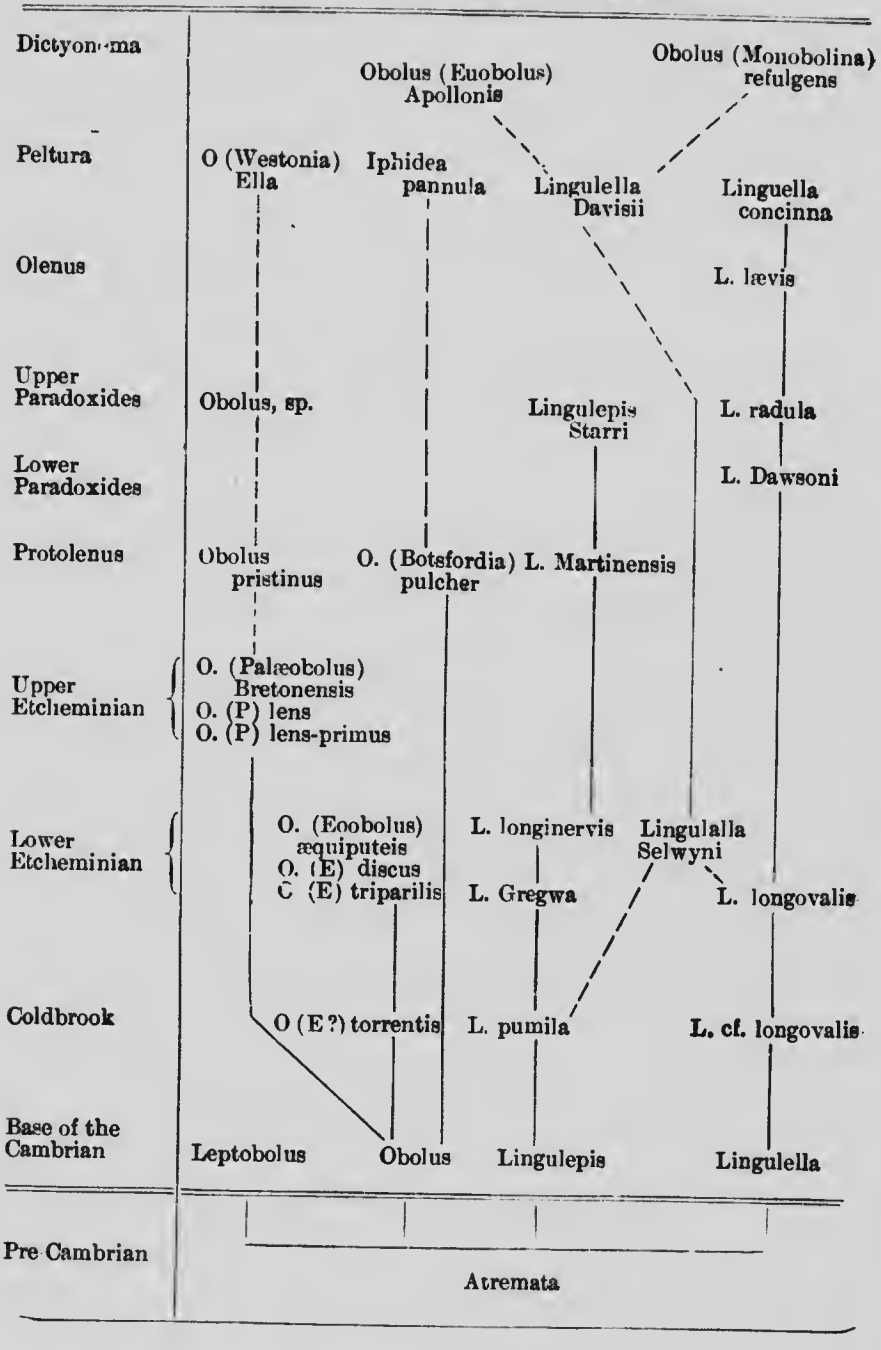
The fifth group (Monobolina) differs from the type in the close approximation of the anterior adductors of the dorsal valve.

There are also differences in the sculpture.— In the first group (Eoobolus) this consists of close, fine irregular waving concentric ridges. In the second (Palæobolus), of stronger and more regularly concentric ridges. In the third (Botsfordia), of cancellated ridges, forming a marked pattern. In the fourth, of fine concentric ridges, irregular in their elevation and prominence. In the fifth (Monobolina), in very fine and regular concentric ridges.

The following table is an attempt to show graphically the possible relations of the several species to each other, and to other genera, and subgenera of the Cambrian system.

The table shows the horizon in the Cambrian at which each of the species appeared in Eastern Canada, with some references to other species occurring outside that region.

CONJECTURAL LINES OF DESCENT OF THE CANADIAN OBOLI, WITH REFERENCES TO THE OLDEST KNOWN ATREMATA. THE ZONAL HORIZONS OF THE SEVERAL SPECIES ARE SHOWN IN THE MARGIN.



No. 6. Development in Size of the Inarticulate Brachiopods of the Basal Cambrian.

In comparing the Brachiopods of the Coldbrook Terrane (Base of the Cambrian) with resembling forms of the next terrane above, the writer observed that in all the genera the resembling forms were larger. This had been found to hold in the genus Acrotreta, which in the range of time from the beginning of the Cambrian to the Lower Ordovician increased considerably in the height of the ventral valve, and also in the bulk of the valves generally.

That this enlargement of the valves did not affect one genus only, but was notable in several, seems to indicate that there is a law of general application in the development of the Brachiopoda in this direction, such as is seen to have acted in the case of the Horse and of other Tertiary Mammalia.

Owing to the smallness of these early Brachiopods this peculiarity in the forms of the successive faunas is easily overlooked, but in reality the change of bulk is quite noticeable, and in some cases is nearly as great as that observed in the species counted in the descent of the Horse from Hyracotherium to the modern Horse.

The enlargement of the species of Acrotreta from the first that appeared in the base of the Cambrian to their culmination in Ordovician Time is described in some detail in a paper by the writer, contributed to the Bulletin of the Natural History Society of New Brunswick, last year.

Increase in Size of the Ventral valves of Acrotreta in the Cambrian and Lower Ordovician.

Terrane or Assise	Name	Length	Width	Proportion to height	Area
		mm	mm		
Coldbrook terrane.....	A. papillata-prima	2	2¼	2·	5·
Lower Etcheminian.....	A. papillata.....	2½	3	2·4	7·5
Upper Paradoxides	A. socialis, v. Seeb.....	3	3	1·5	9·
Dolgelly Group.....	A. bisecta.....	3	3¼	1·3	9·75
Llandello Group.....	A. subconica, Kutorga..	4	4	·85	16·
Increase of the latest beyond the first...	....	.....	.....	... .	3·2

In this table, the third column shows the proportion of the width to the height of the valve, from which it will be seen that the ventral valve became proportionally higher as time went on.

It is conceivable that if we could follow the series in the phylum of Acrotreta farther back in time, we would meet valves in which the umbo would be no higher than in Acrothele or Linnarssonia; or even until the umbo came down to the plane of the edges of the valve.

The fourth column represents the area of the opening of the valve, assuming it to be square, which, of course, it is not; but the extra third is left as an offset to the "third dimension," viz., the height, which is not shown in this and the following tables. This column is intended, therefore, to represent the *bulk* of the shell. In the case of Acrotreta it may be gathered from this table that the Ordovician Acrotretas had attained three times the bulk of the species that appeared at the beginning of Cambrian time. This then is the result of the observations already made on the genus Acrotreta.

Let me see how far this result is borne out by observations on other genera.

Several genera of Brachiopods are known to have appeared simultaneously in the base of the Cambrian in the Acadian provinces of Canada. These are:

Acrothyra.
Acrotreta.
Leptobolus.
Lingulepis.
Lingulella.
Obolus.

On comparing the species of these genera which appeared in the Coldbrook or lowest terrane, with the species in the next terrane which they most resemble, a decided, though not very great increase in bulk, is observable. This will be seen by the following table:

Coldbrook Terrane				Etchemin Terrane				
Species and Mutations	Length	Width	Area	Species	Length	Width	Area	Assise
	mm	mm			mm	mm		
Acrothyra signata-prima....	2	2½	4·50	A. signata.....	2	3	6·	E. 1 *b*
Acrotreta, papillata prima..	2	2½	5·00	A. papillata.....	2½	2½	6·25	E. 3 *d*
Leptobolus, torrentis.....	3	2	6·00	L. atavus.....	5	3½	17·50	E. 3 *e*
Lingulepis pumila	6	4½	27·	L. longinervis....	11	8	88·	E. 2 *b*
Linguella, c.f. longovalis....	7½	5	37·5	L. longovalis	9	6	54·	E. 1 *e*
Obolus torrentis.....	6	6	36·	O. triparilis.... ..	9	8	72·	E. 1 *b*

A circumstance affecting this comparison is that more abundant collections were made from the Etchemin terrane than from the Coldbrook, and as the size of the largest valves is recorded in the description of the species, this would give the Etchemin species an advantage as regards comparative size. But even after eliminating this possible occasion of a greater than the natural difference, there remains enough variation to prove an increase in size of the Brachiopods as time went on.

For the purpose of checking this result, an examination was made more in detail of the last four of the genera named above, as they are represented by species in the Etcheminian terrane, from which it will be seen that an increase in size is noticeable in all these genera, as they pass through the Etchemin terrane. The assise where each species occurs is given in the margin of the following table. The assises occur in the following order from below upward, the Coldbrook being the lower terrane.

Co: Fossiliferous Shale of the				Coldbrook Terrane
E. 1 *a*	Division 1	Lower Fauna	Etchemin Terrane	
E. 1 *b*				
E. 1 *c*				
E. 1 *d*				
E. 1 *e*				
E. 2 *a*	Division 2			
E. 2 *b*				
E. 2 *c*				
E. 3 *a*	Division 3	Upper Fauna		
E. 3 *b*				
E. 3 *c*				
E. 3 *d*				
E. 3 *e*				
E. 3 *f*				

The fauna of the two lower divisions of the Etcheminian is distinct by its species from that of the upper division, and to some extent also by the genera.

Leptobolus.

This is represented by two phyla in one of which the species are diminutive, tumid, long-oval, thin shelled brachiopods with the vascular trunks close to the margins. In the other phylum (*L. collicia, etc.*) the species are somewhat larger and the margins of the valves flatter. It is the first phylum which is considered here.

Valves of the smaller Leptoboli of the Etchemin Terrane, showing the increase in size from their first appearance onward.

Assise	Name	Length	Width	Proportion	Area
		mm	mm		
Co :	Leptobolus torrentis[1].....	3·	2·	1·5	6·
E. 1 *d*	L..... . tritavus	3·8	2·4	1·6	9·1
E. 2 *a* (*f*)	L..... insulæ	4·2	2·3	1 8	9·7
E. 3 *d*	L..... atavus.....	5·7	3·1	1·84	17.7
E. 3 *e*	L..... atavus.....	4·8	3·1	1·55	14.9
	Increase of the latest beyond the first..	.....	.....	.....	2·5

Lingulepis.

Under this generic name there are at least two phyla. One presenting small, thick shelled species, the other of larger species (*L. Gregwa, etc.*), that appeared in the principal mudbed of the Lower Etchemin fauna, and has not been met with higher up; for no Lingulepis is yet known in the Upper Etchemin Fauna. The phylum of small forms is here presented:

Valves of the smaller Lingulepides of the Etchemin Terrane, showing the increase in size from their first appearance onward.

Assise	Name.	Length	Width	Proportion	Area
		mm	mm		
Co .	Lingulepis pumila.....	6	4½	1·33	27·
E. 1 *d*	L..... Gregwa-robusta.....	10½	7½	1·64	78.75
E. 2 *b*	L..... longinervis.....	11	8	1·38	88·
	Increase of the latest beyond the first..	.....	.....	.....	3·3

[1] A full description of this and other new species of Cambrian fossils in these tables will be found in the writer's Report to the Director of the Geological Survey of Canada on the Cambrian Rocks of Cape Breton.

LINGULELLA.

The Lingulellas of these lower Cambrian Zones are none of them typical, that is they have not the "satchel shape" form characterizing the type of the genus, *L. Davisii*, of the Upper Cambrian. Those that are treated of here belong to a phylum of oval forms which are found at intervals throughout the Cambrian system. The Linguleipides just cited are perhaps nearer Lingulella-typical, than the species named below.

VALVES OF OVAL LINGULELLÆ OF THE ETCHEMIN TERRANE, SHOWING INCREASE IN SIZE FROM THEIR FIRST APPEARANCE ONWARD.

Assise	NAME	Length	Width	Proportion	Area
Co :	Lingulella cf. longovalis	7½	5	1·50	37·50
E. 1 *c*	L..... longovalis.....	8	5	1·60	40·
E. 1 *e*	L..... longovalis.....	9	6	1·50	54·
	Increase of the latest beyond the first.....	.....	.....	.....	1·5

The increase in area is only one-half above the first integer; but then the range in time was short, viz.: Coldbrook and one-half of the Lower Etchemin Fauna.

OBOLUS.

Here is a complex group in which several phyla are involved:

SIZE OF VALVES OF THE OBOLI AS THE SPECIES SUCCEED EACH OTHER IN THE ETCHEMIN TERRANE.

Assise	NAME	Length	Width	Proportion	Area
Co :	Obolus torrentis.	6	5	·83	30·
E. 1 *b*	O..... triparilis.....	9	8	·88	72·
E. 1 *e*	O..... discus.....	9½	9	·85	85·5
E. 2 (*af*)	O..... æquiputeis.....	12	11	·92	132·
E. 3 *b* & *e*	O..... iens.....	14	12	·86	168·
E. 3 *d*	O..... Bretonensis.....	15	17	1·13	255·
	Increase of the latest beyond the first.....	.....	.....	.....	8.5
				or	4.4

In this series there are at least two phyla. The interior of *O. torrentis* is unknown, but the next three are characterized by the equality and regular arrangement of the central scars of the dorsal valve (including the anterior laterals), and by the possession of a small scar in the middle of this group of muscles.. The first phylum may

be regarded as running through the Coldbrook and Lower Etchemin Faunas, and to have increased four fold in that time; or, if one should omit the Coldbrook species, they doubled in size.

The series of Oboli as a whole increased eight fold; but the two species of the Upper Etcheminian are of a different phylum, one especially, *O. Bretonensis*, was separate, if one may judge by the unusual course of the vascular trunks of the ventral valve, which, for an Obolus, are very close together. The two species of this faunæ (*O. lens* and *O. Bretonensis*) have a similar sculpture, and are likely to be from the same root form.

As a result of this enquiry one may present the following condensed statement:

Range in Time.	Name of the Genus or Phylum from which the Forms have Sprung	Number of integers of increase of bulk of the latest species beyond the first.
Entire Cambrian ..	Acrotreta, earliest species. A. papillata prima	3·2
Basal Cambrian ...	Leptobolus, " " L. torrentis.....	2·5
Includes Lower Etchemin.....	Lingulepis, " " L. pumila.....	3·3
Same, or for 4·3 rate		
Basal Cambrian..	Lingulella, " " L. cf. longovalis ..	4·3 or 1·5
Lower Etchemin inclusive.....	Obolus, " " O torrentis.....	4·4
Basal Cambrian as a whole.....	Obolus, as a genus, based on form.....	8·5

Acrothyra.

As a contrast to this result we present the variations traceable in the genus Acrothyra, from its earliest known appearance to the latest form, of which we have positive knowledge. This covers the whole of the Basal Cambrian time.

Size of ventral valves of Acrothyra from their first appearance to the top of the Basal Cambrian.

Assise	Name	Length	Width	Depth	Proportion	Area
		mm	mm	mm		
Co :	A. signata-prima.....	2½	2½	1¼	2·	6·25
E. 1 *b*	A. signata (type).....	3	2	1	2·	6·
E. 1 *c*	A..... sera.....	2½	2½	1½	1·7	6·25
E. 1 *d*	A..... tarda.....	2½	3	1½	2·	7·5
E. 2 *c*	A.. ..... orta.....	2	1⅞	1½	1·2	3·5
E. 3 *a*	A. proavia-prima.....	3	2	2	1·	6·
E. 3 *e*	A..... crassa.....	2½	2	1½	1·3	5·
E. 3 *e*	A. proavia (type).....	3	2	1½	1·3	6·
	Increase of the latest beyond the first....					·95

An increase in the elevation of the ventral valve (see fourth column) is quite as noticeable in this genus as in Acrotreta as it is found in the Basal Cambrian; but so far as bulk of the valve is concerned the two genera differ, for Acrothyra shows no increase, but on the contrary, if anything, a reduction in bulk. It would seem to have been a closed type, which had reached its culmination and was not capable of further development.

No. 7. Did the Upper Etcheminian Fauna invade Eastern Canada from the Southeast?

Some years ago, when president of Section IV. of this Society, the writer had the honour of asking the attention of the members of this section to certain conditions of the fauna and sediments of the early Palæozoic in the North Atlantic region, that seemed to indicate the manner of the migration of animal species at certain times from one side of the Atlantic to the other; the faunas in some cases being borne from Europe to America, and in others from the latter continent to Europe.

These conjectures in regard to the migration of species were based largely on the known spread of the genera from certain provinces where the faunas were in full force, to others where they were represented by a limited number of species.

For instance, the Paradoxides fauna, of which Anopolinus is a member, appeared to have its headquarters in Northern Europe, for there not only does it have the greatest variety of genera, but it also shows the most continuous chronological succession. Anopolinus, while it is found in Scandinavia and Britain and extends as far west as Newfoundland, has not been found in Canada. And the species of Paradoxides abundant in Europe and well represented as far as Maritime Canada, is reduced to one species (or two) in Massachusetts, and west of this is unknown.

A representative form of one species of this fauna, a *Liostracus* (the *Conocephalites tener* of Hartt), which we had thought to be peculiarly American, was sent to me this summer from the south of France, by Mons. Jean Miquel, it thus also proves to be European, but belongs in the southern facies of this fauna, represented in *Paradoxides rugulosus* and the associate species. The American fauna of Paradoxides thus drew its representatives from both the northern and southern provinces in Europe. It would be an instructive study to ascertain how and why the northern fauna of Paradoxides prevailed over the southern in Maritime Canada, and what held the Upper Fauna of

Paradoxides there, while the Olenus fauna was being developed in Europe.

In the article on the distribution of the Cambrian Faunas above referred to, the present writer ventured to suggest that the fauna of the Utica slate was a cold deep-water fauna, swept in upon America from the North Atlantic ocean. Since then R. Rudemann, the talented Assistant Palæontologist of the New York State survey, has found proof of the existence of such a current from the northeast prevailing over northeastern New York in Utica times. This he has demonstrated by observations on the attitude of colonies of graptolites entombed in the Utica shale in that region.

In the present author's article above cited, it was also inferred that the central part of North America was the headquarters of the Olenellus fauna, because it was there represented by a variety of species, whereas in Europe the fauna where it had been found consisted of only a few species, stragglers from the main swarm. The argument in reference to the Paradoxides fauna would imply a reversed current in the time of the Olenellus fauna, viz.: one flowing to the northeast, and carrying with it the migrating young of the Benthos. A possible confirmation of this view is found in the attitude of the entombed shells of the Etcheminian faunas in Cape Breton, especially the Upper fauna.

In the Upper Etcheminian fauna the orientation of its Brachiopods to the northeast is of a very marked character, indicating a current setting to the northeast along the Cambrian shore during the time of the entombment of the Upper Etcheminian fauna.

In the Lower Etcheminian the orientation is more capricious, some beds showing it distinctly and others not at all. But in the fossils of the Upper fauna it is very conspicuous in many of the layers. Sometimes as many as eighty per cent. of the valves are turned in the direction of the current. This would indicate a steady flow of water setting to the northeast during the time of the entombment of the Upper Etcheminian fauna.

It is in accordance with this that the fauna changed suddenly at the beginning of this time, a new set of species, and one new genus appearing among the Brachiopods. There was also a change in the kind of sediment deposited, as hard massive sandstones gave place to more flaggy beds and shales.

It does not seem likely that the phenomenon of orientation to the northeast was due to tidal action, for in the valley where this feature is most noticeable, the beds in which it was observed thicken to the southwest, indicating that the opening of the bay was in that

direction. Burials in tidal mud would occur in largest numbers at the recession of the tide, and the valves would have been oriented to the southwest, whereas these valves have just the opposite direction.

If then the burial of the shells was not by tidal mud but through sediment carried on a continuous marine current, this current undoubtedly set steadily to the northeast. The nature of the sediment which it carried and the species of fossils entombed by it, show that it was a shore current. Whether the currents of the open ocean set in the same direction, or not, there is no evidence to show. This may have had a reversed direction, just as the Gulf stream is complimentary to the Arctic current along the coast at the present day; but so far as the shore animals are concerned, these were subject to the conditions of transportation above inferred.

We as yet know nothing of the deep water animals of this time, which may have dwelt in a southwest current as did those of the Utica slate, and probably also those of the Paradoxides beds.

Full particulars of observations on the orientation of the Cape Breton Cambrian fossils are contained in the report on that region recently submitted by the writer to the Director of the Canadian Geological Survey.

No. 8. Cambrian Brachiopoda and Mollusca of Mt. Stephen, B.C., with the description of a new species of Metoptoma.

At the time that the trilobites of the Mt. Stephen fauna were reviewed by the author, the Brachipods were left, in hope that better material would come into his hands, than were found in the Walker collection. Since then, through the kindness of the late Director of the Geological Survey of Canada, opportunity was furnished to examine the collections that had been made for that survey by Messrs. McConnell and Ami. These gave some further material for study.

In this year, through the courtesy of the Director of the U. S. Geological Survey, I have seen the types of the species from Mt. Stephen described by him (except the Crania) and so am in a position to identify with some certainty the several Brachiopods collected by Mr. Walker and Dr. Ami.

Mr. Walcott, through the occurrence of several of the Mt. Stephen species in the Cambrian strata of central Nevada, correlates them with the fossils of a certain belt of shales that occurs in a section in that district.[1]

[1] Am. Jour. Sci., Vol. XXXVI. Sept., 1888.

He summarizes this section as follows :—

	Feet
1. Quartizite [at the top of which is the Olenellus fauna].....	350
2. Limestones and shales [at the top of which is the group of species corresponding to the Mt. Stephen Fauna].....	1,450
3. Massive limestones [in the upper part of which is the Dicellocephalus (Euloma-Niobe fauna, *fide* Brögger)].....	3,000
	4,800

By this section, the fauna corresponding to that of Mt. Stephen, is about 1,400 feet above the fauna of Olenellus in the same section.

At a later date than the publication of this section, Mr. Walcott described several of the Brachiopods of the Mt. Stephen Fauna, the characters of which, as described by him, are here given[1].

"Lingulella Macconnelli, n. sp."

"Shell subspatulate, height and breadth as 7 to 4½. Ventral valve subattenuate toward the apex; broadest midway, with the sides converging slightly toward the front,, and rather rapidly toward the apex; front broadly rounded. Dorsal valve short, height and breadth subequal; the broad front is squarely rounded.

The specimens are somewhat flattened in the shale, but the rather strong shell preserves a moderate convexity. Surface marked by concentric striæ of growth and radiating longitudinal lines."

In the examples in my hands the concentric and radiating striæ above referred to are obscured by a minute granulation; and the radiations are much finer than the concentric lines. An example of the ventral and one of the dorsal valves, both small, were found in the Walker collection.

"Crania (?) columbiana, n. sp."

Is described by Mr. Walcott as follows:—"Shell, small circular, or slightly longer than wide; apex, central or nearly so. Surface marked by fine costæ, that radiate from the apex to the margin. Traces of fine spines appear about the margin. Diameter, 2 mm."

The generic reference is made on account of the surface characters being more like those of shells referred to Crania than to those of other genera. *Crania Grayi*, Davidson ; *Crania Lælia*, Hall. (24th Rep. N.Y. State Cab. Nat. Hist., p. 220, pl. 7, fig. 16.)."

[1] Proc. U.S. Nat. Mus., June, 1889.

There is no example of this form in the Walker or Canad. Surv. Collections.

"ACROTRETA GEMMA, var. DEPRESSA, n. var."

"The specimens from Mt. Stephen are relatively much lower and broader in proportion to the height than the typical forms of *A. gemma*. On this account they are considered as a variety."

Mr. Walcott writes to me to say that the dorsal which he referred to *Linnarssonia sagittalis* Salt, he now thinks to be the dorsal valve of of the above species.

In the Walker collection is a dorsal valve which, by its sharp median septum and other features, appears to be the dorsal valve of this Acrotreta; the species appears to be sufficiently distinct from *A. gemma* and may be called *A. depressa*, Walcott.

"ORTHISINA ALBERTA, n. sp."

"Shell transversely suboval, front broadly rounded; the straight hinge-line is shorter than the full breadth of the valve; the area of the ventral valve high, bent backward from the hinge-line, divided by a large foramen that is covered by a convex deltidium. The area of the dorsal valve slopes back at about a right angle to the valve. The broad short foramen appears to have been covered by a low deltidium.

Surface marked by radiating costæ five in the distance of 3 mm. on the frontal margin.

This species recalls *Orthis Lindströmi, Linrs.* from the Paradoxides zone of Sweden."

Examples from the Walker collection are not well preserved and show no further characters.

There is another Orthid in the Walker collection, with ribs much wider apart, but not in good preservation.

"KUTORGINA PROSPECTENSIS, Walc.,?"[1]

"A fragment of a species of Kutorgina, closely related to *K. prospectensis*, occurs on slate in association with *Ptychoparia Cordillerœ*. It not improbably represents a new species."

No example of this was found in the collections that passed under

[1] Am. Jour. Sci., Vol. XXXVI., Sept., 1888, p. 166.

the writer's hands, all resembling specimens being referable to *Iphidea pannula*. (See below.)

The following species appear not to have been in Mr. Walcott's collection, received from the Dr. Rominger.

Iphidea pannula, White sp.

Fine examples of this species were f in the Mt. Stephen collections. They show well the characteristic ornamentation, which resembles that of *Obolus* (*Botsfordia*) *pulcher* in that the cancellated ornamentation is developed chiefly on the middle zone of the shell, the front part being concentrically striated only. Still, there are dorsals which show the cancellation over nearly the whole surface. The shell has the convex pseudo-deltidium characteristic of Iphidea. No examples showing the interior of the valves were obtained.

There are specimens of this shell in both the Walker and the Canadian Geological Survey collections.

Acrothele subsidua, White.

Mr. Walker's collection contains several examples of the valves of this species, usually much flattened. One or two show well the concentric ridging and the more minute, somewhat wavy ridglets between. One dorsal is 9 x 10 mm. in size. Owing to the crushing, the internal features are obscure in these valves.

Some good examples of this species were found in the collection received from Mr. Walker.

Obolus Ella, Hall & W.

Comparatively few examples of this species were found, and they do not show good interiors; still the discoid, circular form agrees better with Obolus than Lingulella; and the position of the central muscles, so far as they can be made out, corresponds to Obolus. Perhaps the low broad cardinal area of the ventral valve accords more decidedly with Obolus than the other peculiarities of the valves, which are modified to suit the discoid form of the valves.

The largest valve observed was a dorsal, somewhat abraded, 9 x 10½ mm. across. The species is somewhat "satchel"-shaped.

Mr. Walcott in an MS. note remarks that this species varies greatly in different localities and sediments. He refers it to his new subgenus *Westonia* on account of its surface which is not shown in the few specimens in my hands.

ACROTRETA of BAILEYI.[1]

A thin-shelled form which has suffered much from compression, is not rare in the Mt. Stephen shale. As in *A. Baileyi* the area of the ventral valve is quite short, and the median ridge of the interior of the dorsal has the broad lance-formed end of that of Linnarssonia.

Sculpture. This consists of very fine concentric striæ, somewhat obscured by a minute granulation.

Size. Length, 3½ mm.; width, 4 mm.; height (as compressed in the shale) less than 1 mm.

This species is very Linnarssonia-like but the beak is too sharp and too much elevated for that genus; also the smooth shining shell of Linnarssonia is wanting.

LEPTOBOLUS cf. GRANDIS.[2]

A number of examples of a small brachiopod were found, which by its size and form comes near the above species.[1] It is a thinner and flatter shell but the difference may be due to the occurrence in shale in place of sandstone. There is less difference in the comparative length of the two valves than in *L. grandis*, and the sculpture also is different. *Sculpture* consists of faintly marked fine, concentric striæ, with more distinct undulations of growth, the whole obscured by a minute granulation.

It is distinct from Hall's species of the Utica slate in the absence of minute concentric striæ, distinct, close and regular, also in its larger size.

METOPTOMA AMII, n. sp. (Plate 1, fig. 12).

Examples of this shell are usually much flattened and the natural form obscured. The apex was usually somewhat excentric and was acuminate. Outside of the acuminate apex the slopes of the shell were convex, and so continued to the margin.

Sculpture. Only very faintly marked radiating striæ are visible and a few concentric undulations of growth.

Size. Length of orifice 10 mm.; width, 8½ mm.; height (as compressed in the shale), 2 mm.

This species was not quite so large as *Metoptoma Barrandei*, Linrs., and differed in its smooth surface. It was much flatter and was smaller than the Metoptomæ of the Potsdam sandstone of Wisconsin.

[1] Trans. Roy. Soc. Can., Vol. III., p. 36, pl. v., figs. 13, 13 *a b c*.

[2] Trans. Roy. Soc. Can., Vol. XI., p. 91, pl. 16, figs. 7*a* to *c*.

DESCRIPTION OF THE PLATE.

Fig. 1. *Obolus torrentis.* Dorsal valve, Mag. $\frac{3}{1}$. Coldbrook terrane.

Fig. 2. *Obolus triparilis—a*, Ventral valve—*b*, Dorsal valve, interior—*c*, Section of same. All mag. $\frac{1}{1}$. Lower Etcheminian.

Fig. 3. *Obolus discus—a*, Ventral valve—*b*, Dorsal valve—*c*, Interior of same. All mag. $\frac{1}{1}$ —*d*, Cardinal area of dorsal, further enlarged. Lower Etcheminian.

Fig. 4. *Obolus æquiputeis—a*, Ventral valve—*b*, Interior of same—*c*, Dorsal valve—*d*, Interior of same. All mag. $\frac{8}{1}$ —*e*, Surface markings, enlarged $\frac{10}{1}$ Lower Etcheminian.

Fig. 5. *Obolus Bretonensis—a*, Ventral valve—*b*, Interior of same—*c*, Section of same—*d*, Dorsal valve—*e*, Interior of same. All mag. $\frac{2}{1}$. Upper Etcheminian.

Fig. 6. *Obolus lens—a*, Ventral valve—*b*, Interior of same—*c*, Section of same. All mag. $2\frac{1}{2}$ —*d*, Dorsal valve—*e*, Interior of same. Both mag. $\frac{2}{1}$ Upper Etcheminian.

Fig. 7. *Obolus pulcher—a*, Ventral valve, outline of interior—*b*, Dorsal valve, interior. Both mag. $\frac{4}{1}$. Protolenus Fauna.

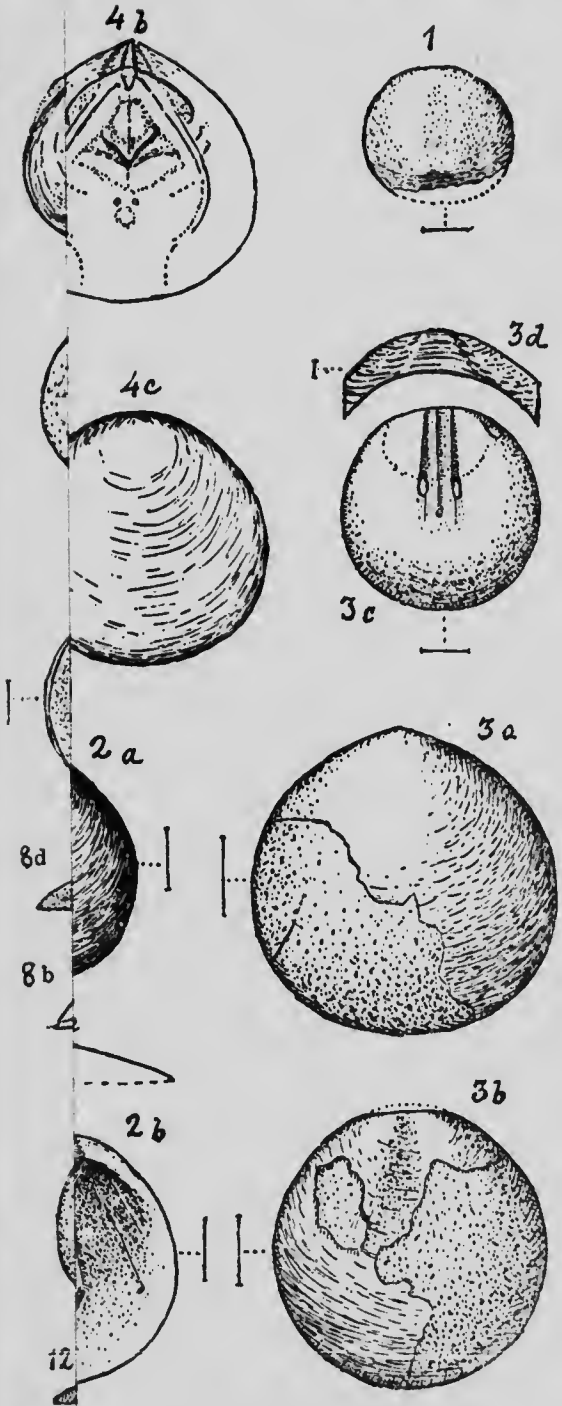
Fig. 8. *Obolus pristinus—a*, Ventral valve—*b*, Side of same—*c*, Mould of a ventral (?)—*d*, Back view of same. All mag. $\frac{2}{1}$ — *e*, Dorsal valve, young, mould of. Mag. $\frac{4}{1}$. Protolenus Fauna.

Fig. 9. *Obolus Ella—a*, Ventral, outline of interior—*b*, Dorsal valve, outline of interior. Both mag. $\frac{2}{1}$. Peltura Fauna.

Fig. 10. *Obolus Apollonis.* Eichwald, var. *Quenstedti.* After Michwitz. Diagrams of the ventral and dorsal valves, enlarged; showing positions of the muscle scars and vascular trunks (the branches of the latter are omitted). Dictyonema Fauna, or below.

Fig. 11. *Obolus refulgens—a*, Ventral valve, interior—*b*, Dorsal valve, mould of interior. Both mag. $\frac{1}{1}$. Dictyonema Fauna.

Fig. 12. *Metoptoma Amii*, n. sp.—*a*, Shell seen from above—*b*, Same from the side. Both mag. $\frac{2}{1}$. Peltura Fauna of Mt. Stephen, Field, B.C.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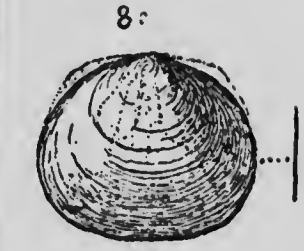
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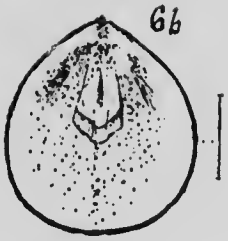
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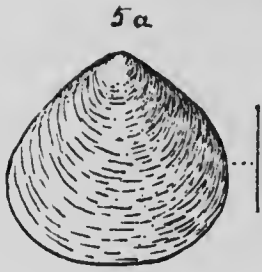
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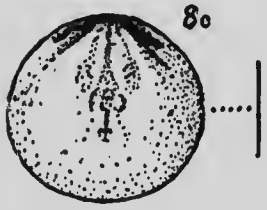
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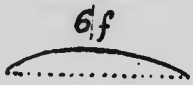
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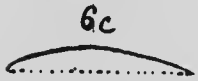
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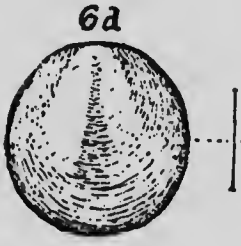
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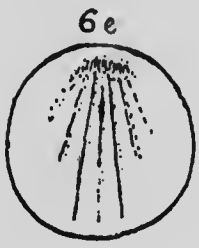
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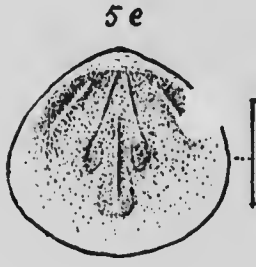
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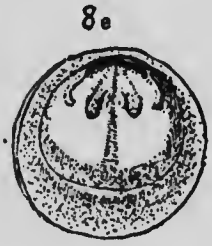
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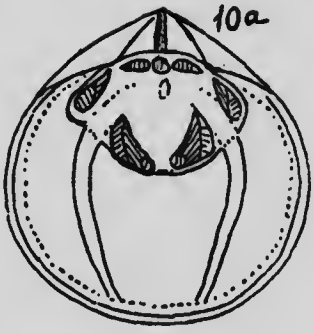
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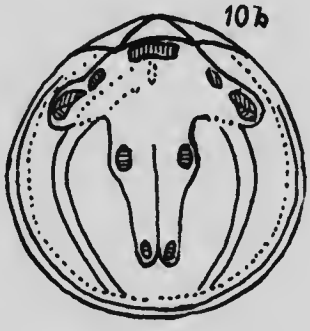
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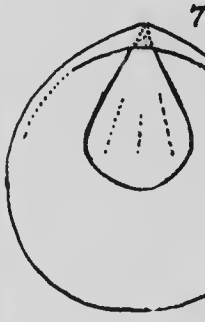
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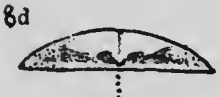
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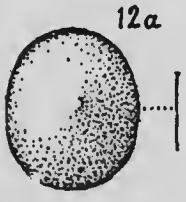
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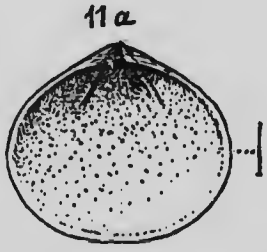
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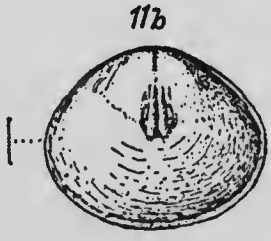
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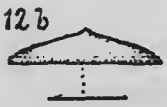
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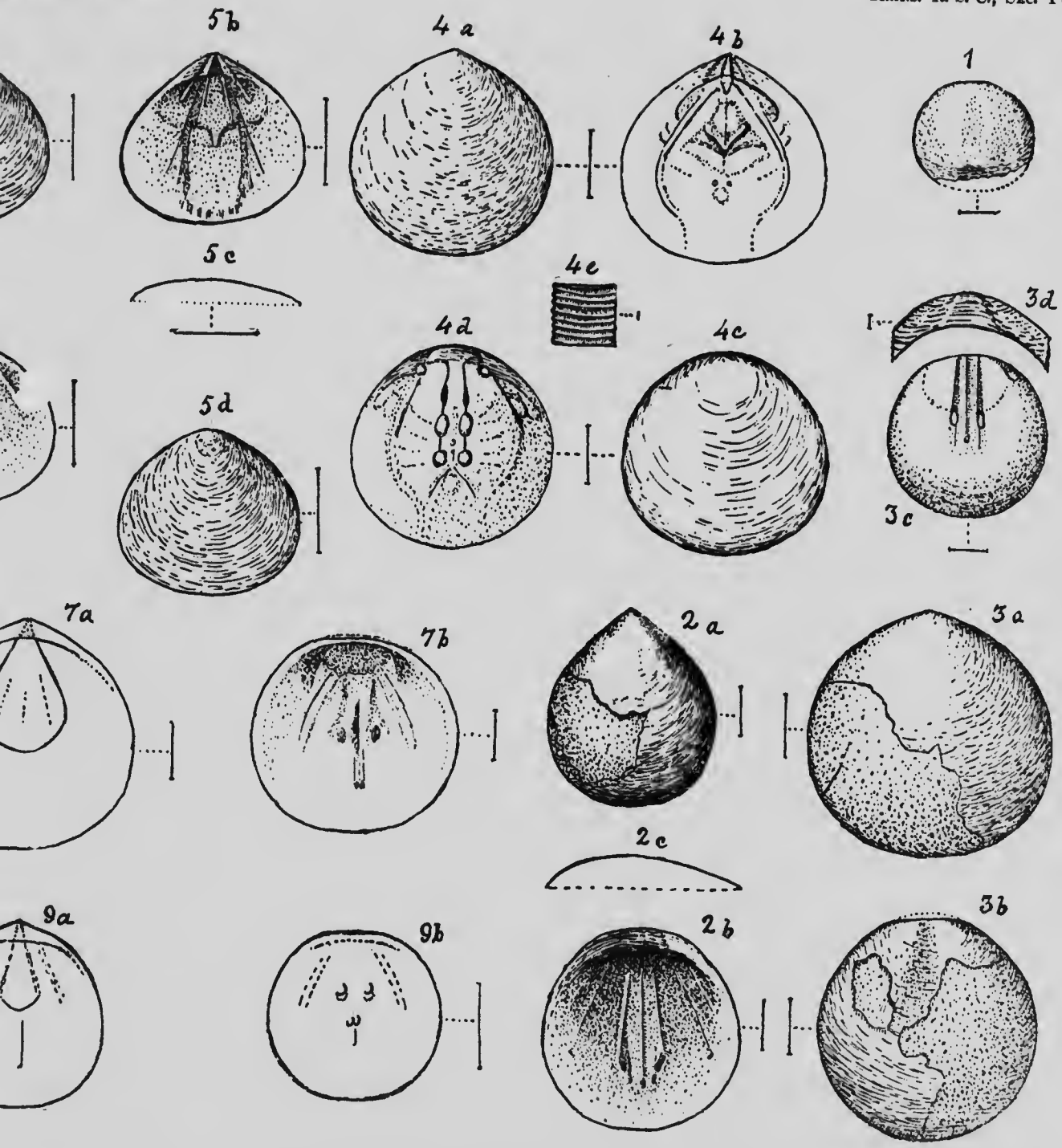
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