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ON

THE SILURIAN GASTROPODA AND PTEROPODA

OF

GOTLAND

BY

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WITH TWENTY ONE PLATES.

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INTRODUCTORY REMARKS.

If, in general, it is a hazardous undertaking to describe palæozoic fossils, which, as a rule, have only a few recent congeners, with which to be compared, it is the more so in regard to the fossil Gastropoda. Every zoologist is no doubt fully aware of the great difficulties, that surround his investigations, whenever he endeavours to make out the affinities and systematic place of fossil Gastropoda in general, and especially so of those of the palæozoic era. There is indeed not much in the often distorted shells to guide him. The microscopic structure — if there ever has been anything characteristic in it, which so seldom is the case even in the recent ones — is almost invariably destroyed or changed into a homogenous crystalline, calcareous spar, nor are there usually any traces left of the muscular impressions, which are peculiar to some few families. Moreover, what the naturalist in his study of the fossil shells has to grapple with, is the same as if he had to describe recent shells only from bleached and worn specimens cast ashore along the borders of the sea. There is indeed often evidence that several of the Silurian fossils of Gotland and consequently also the shells, had been rolled and tossed about in the sea before being embedded in the strata, which, according to all appearance, are nothing but beaches or deposits in shallow water. Moreover, when once fossilized they have of necessity shared in the vicissitudes, which afterwards befell the rock through metamorphic agencies, being changed as to structure, often deformed through pressure as to their exterior shape, worn and eroded, and consequently deprived of the fine ornamentation of the surface.

In almost every instance, the investigator has thus only the external shape of the shell, as it is, whereupon to found his conclusions, and we know how very little the empty shell informs us regarding the real nature of the animals, and how delusive, even amongst recent forms, the exterior shape can be. It may here suffice to cite an instance lately brought forward by J. Carrière.

In a paper on »Marginella glabella L. und die Pseudomarginellen»[1]) he relates his observations on two species of Gastropoda belonging, according to the structure of

[1]) »Zeitschrift für wissenschaftliche Zoologie Bd 37, 1882, p. 99.

the mollusca themselves not only to different genera, but even to different families. They had assumed, as it were, exactly the same sort of investment or shell as the true Marginella glabella, only differing in trifling and easily overlooked details, so as to

Sketch Map of Gotland showing the principal localities.

have been considered till now as of the same species as the last mentioned. What in reality are three different species, not even appertaining to the same genus, nor to the same family, had thus been regarded as one and the same species, until the anatomical structure of the animals revealed their fundamental dissimilarity.

In spite of the certainty of many unavoidable failings and shortcomings, which as pointed out above, follow from the nature and conditions of the material, I ventured to take up this study when it was found how unexpectedly rich and varied were the forms entombed in the Silurian strata of Gotland, and thanks to the munificence of the Royal Swedish Academy of Sciences it has now been brought to its conclusion. Though fragmentary in many respects this memoir may serve in some degree as a starting point for future labours in the same field.

Silurian strata of Gotland.

Before entering any further into the minor details of the composition of the Gastropodan Fauna, it may be proper to survey the physical conditions, in which the shells are found, as the strata, rocks and localities and also to inquire into their general faunistic characters. Through the classical researches of HISINGER the general features of the geological constitution of Gotland were very well known; but it was not until the visit of Sir RODERICK MURCHISON to the island in 1845 that the position of its strata was interpreted according to the researches, which were then carried on in other parts of Europe and especially in England by MURCHISON himself. After a stay of a few days, chiefly on the west coast of the island, he proclaimed the strata as Upper Silurian and arrived at the conclusion that they were to be subdivided into three groups, corresponding to the English Wenlock, Aymestry and Upper Ludlow, and that in fact the southernmost point with its substratum of sandstone was the youngest division, in direct opposition to HISINGER, who considered the sandstone as the oldest of the whole of the strata and underlying them all, though hidden from view north of Bursvik. The conclusions of MURCHISON were adopted by FRIEDRICH SCHMIDT, who followed up his researches and gave a more complete description. He also divided the island in three groups: Northwest Gotland or the Wisby Zone, Central Gotland and South Gotland, subdividing the second or Central Gotland in two beds, that of Pentamerus esthonus and Pent. conchidium, a division which cannot be upheld as Pent. conchidium occurs beneath P. esthonus as well as above it and moreover is restricted to very narrow limits within the large zone he has assigned to it. He assumed the strike of the strata to be N. E. and S. W. and their dip consequently from N. W. to S. E. His three groups form oblique belts across Gotland. He, as well as MURCHISON, had only palæontological evidence to adduce in favour of his opinion. MURCHISON'S, and consequently also SCHMIDT'S views have been contested, amongst others by FERD. ROEMER and HELMERSEN, and it is highly probable that their mode of viewing the stratification of Gotland is more consistent with the real state of the facts than that of the former geologists. As ROEMER and HELMERSEN have already demonstrated, there are neither stratigraphical nor palæontological evidences to support the views of MURCHISON and SCHMIDT. If, as the latter authors hold it, the shale along the west coast of Gotland belongs to at least two divisions, namely the beds around Wisby to the Wenlock shale and those south of Klintehamn to the Lower Ludlow, the superposition of these strata above each other must of necessity be seen somewhere. But as to the shale beds of Wisby they can be followed without interruption all along the coast from Hallshuk, in the north, to Gnisvärd, south of Wisby or for a length of nearly 6 Swedish or 36 English miles. At Gnisvärd, where the fossils are already, with regard to several species, identical with those found plentifully at Westergarn, the strata are obscured for about an English mile and a half by accumulations of sand and then again the same shale beds reappear horizontal as before and continue with a few breaks to the vicinity of Klinte. It is highly improbable that there should be any traces of superposition of the strata of Westergarn and Klinte above those of Wisby on the narrow belt covered by the drift. The shale beds of Westergarn which have so much in common with those of Wisby are combined with the shales of Eksta and Habblingbo through the shale beds of Stora Carlsö. As I have shown in a former paper [1]) the beds of Westergarn and Stora Carlsö are absolutely identical, having not only a great percentage of species in common, but these species are also of exactly the same varietal habitus. Further, there is no doubt that the shale of Stora Carlsö is in direct continuation with the shale of the nearest, opposite shore of Eksta and that this again is combined with the shale of Habblingbo. We have thus a continuation of shale beds along the coast for a length of nine and a half Swedish miles or 57 English ones. But these beds spread also, as can easily be seen in numerous sections, far inland under the limestone beds. The shale of Petesvik in Habblingbo can be traced from the shore upwards for a Swedish mile, to the saw mill of Alfva, having there reached a height of 80 feet. Quite the same sort of shale is again met with in Fardhem, where there are sections in several places and the shale retains nearly the same palæontological character as at Habblingbo. The same form of Rhizophyllum Gotlandicum has been found in both localities. But in Fardhem the shale begins to contain particles of mica and quartz in greater abundance than elsewhere and in fact partially to change into something intermediate between shale and sandstone, and this gradual transition can be followed, as it were, step by step along the road leading from Fardhem to Rone where the lowest stratum is found to have been completely changed into sandstone. This predominates along the shore towards the north for nearly three Engl. miles, now and then changing into patches of shaly limestone and at last passing into shale, as I remarked as long since as 1857 [2]). South of Rone, again, it is connected with the sandstone beds of the southernmost Gotland. The sandstone beds there and the shale beds of the north of Gotland thus belong to quite the same geological horizon and gradually pass into each other. But, as now the shales of Central Gotland lie under the hills of Klinte, Sandarfve and all other limestone beds there, the limestone hills of Hoburg must be considered as detached outliers of that central limestone plateau, with which they have in common many characteristic fossils, though separated from it by a wide region, where the uppermost beds have disappeared through denudation. A distance of nearly four Swedish miles intervenes between the northernmost hill of Hoburg and the nearest point northwards near Burs church, where the limestone is again found. Between the lowest stratum of shale and sandstone and the uppermost limestone, commonly called crinoidal limestone,

[1]) »Anteckningar om silurlagren på Carlsöarne» i Öfvers. Vet. Akad. Förhandl. 1882, nr 3, p. 5.
[2]) Öfversigt Vet. Akad. Förhandl. 1857, p. 33. »Till Gotlands Geologi».

strata of thinbedded limestone and shale are interposed, north of Grötlingbo and Rone, and they pass gradually upwards into the more uniform, hard crinoidal limestone. In the South of Gotland again, wherever the sandstone prevails, the intermediate stratum is oolite.

According to what has now been adduced, we have, from their petrographic character, three strata viz.

1. The oldest shale or sandstone stratum, in the following signed *a*.

2. The laminar limestone, intermingled with shale in the north, beds of oolite or pisolite in the south, signed *b*.

3. The highest limestone; covering all the other strata, signed *c*.

Along the east coast of Gotland this succession of the strata is somewhat obscured through frequent dips and contortions of the beds. In how far these three different strata can be well distinguished by their faunas, is at present, when so few groups have been monographically worked out, too early to decide and cannot be finally settled until the rich Silurian Fauna of that island will have been described through all its classes.

Regarding the chief characteristics of the different strata the following remarks may serve.

Stratum *a*. The thickness above the sea is extremely variable, owing to the many curvatures and domeshaped folds into which it has been thrown. Near Halls huk the shale is 50 feet thick, in Fardhem at Burge again it is found at 70 feet above the sea level and at Alfva saw mill even at 80 feet. But it is probable that its total thickness is still larger, as shale beds are met with in Follingbo at a height of more than 100 feet. The bottom of the harbour of Wisby at a depth of 20 feet, has been found to consist of shale, and consequently this rock attains there at least that amount of thickness below the level of the sea. Owing to the curvatures in this stratum it is, however, very questionable whether these 20 feet are to be added to the amount found in Follingbo. The sandstone south of Bursvik is not by far so thick, only 20 feet at the most. But the mass hidden in the sea is probably far thicker, as, owing to the southeastern inclination of the strata, only so little is visible. Fossils are found cast ashore on Norderstrand near Wisby, enclosed in a soft, red marly limestone. They are partially of the same species as in the gray shale but also of characteristic forms. There is a low depressed variety of Goniophyllum pyramidale, Phacops elliptifrons, a small Camerella, but also Arachnophyllum typus which never occurs in any higher stratum. This red marl is in all probability the basis of the oldest and lowest shale beds of Gotland and to be found *in situ* deeper in the sea, from where fragments are thrown up. Hitherto the oldest shale beds have only been found north of Wisby. Through the presence of Stricklandinia lirata, Euomphalus Gotlandicus, Pleurotomaria qualteriata var. and a species of Harpes, only found there, they announce their age as Upper Llandovery. Stricklandinia does not occur higher up in the shale beds. The beds above its zone, as well as the sandstone in the south, may be regarded as of Wenlock age. Sections of this stratum are also seen in several places on the east coast of Gotland as at Slite, Östergarn, though mixed up there with bands of hard crystalline limestone.

Fossils have been found in the shale and sandstone beds, which long had been regarded as distinguishing the Upper Ludlow rocks. Such are Phacops Downingiæ, Homalonotus etc. But this must not detain us any longer, as also in England, according to the last editions of Siluria, the Ludlow beds have very few species, which are not also found in older strata. Homalonotus and Chonetes striatella, once supposed to be so characteristic and exclusive, are now also found in the lowest Wenlock beds, both in England and Gotland. It cannot, however, be denied, that there are many circumscribed faunistic areas, as for instance in the shale along the west coast from Westergarn to Petesvik, including Stora Carlsö. Within this region there can be discerned at least four different facies in the distribution of the fossils, of which I have given detailed lists in the paper above cited[1]). Although there cannot be the slightest doubt that the shale beds of all these localities, as stated, lie on the same level and are coëval, the strange fact is obvious that the beds of Stora Carlsö have a fauna identical with the shale of Westergarn, which is a Swedish mile and a half distant. The fauna of Eksta at Djupvik is distinct with regard to its composition as well as its features in the common species, from both Westergarn and Petesvik in Habblingbo, but farther inland, at Fardhem, species from both Habblingbo and Eksta meet in the same bed. So again the fauna of Westergarn is distinct from that of Wisby, though both have species in common not met with anywhere else, as Leperditia Hisingeri, Lindströmia Dalmani, Oriostoma Roemeri and others. But, upon the whole, strange as such differences in nearly situated localities may seem, when they cannot be accounted for through changes due to time, they may, nevertheless, find their counterparts in other strata, as well as in the sea as it now is, where differences in depth or in the mineralogical nature of the bottom, cause contiguous regions of the littoral belt to differ in their faunas.

Stratum *b*. In northern and central Gotland a stratum of thin limestone flags interstratified with seams of coarse marly shale succeeds the stratum *a*. It attains a thickness of 70 feet, though at many points much less. Above the sandstone in the south of Gotland this rock is changed into coarse pisolite or oolite with a thickness at the highest of 20 feet. The change from limestone to oolite can be traced almost as gradually as that from shale to sandstone. The banded limestone reappears above the oolite in the section of Hoburg.

The stratum *c*, commonly called crinoidal limestone, covers almost the whole of the northern and central part of Gotland and, being denuded away over a large tract, between Burs and Sundre, it forms again the numerous hills around Hoburg. Its thickness amounts to at least 150 feet, measured from the steep cliffs of Lilla Carlsö, but owing to denudation it is seldom so considerable. The total amount of the Gotland strata then ought to be about 340 feet. Now the highest point determined lies 261 feet above the sea, according to STEINMETZ, near Rosendal in Follingbo, and there are thus nearly 80 feet unrepresented at that point.

As may well be imagined, this uppermost stratum is highly variable as to its structure and organic remains. In some parts it well deserves its name of crinoidal lime-

[1]) Silurlagren på Carlsöarne pag. 17.

stone in consequence of its richness in remains of Crinoidea, chiefly their stems and joints of stems. But in addition to this, there are also other beds of limestone, which from analogous reason have been denominated corallian limestone. This, however, is only partially true. With equal reason large portions of the limestone might be called Orthoceratite limestone or Bivalve limestone or Trimerella limestone or even Gastropodan limestone, being then nothing else than a breccia of these shells. It is indeed singular that the remains of one group of animals should predominate over all others in several beds. So for instance the fine grained limestone of Follingbo near Wisby consists largely of shells of Cephalopoda and the same is the case with the rich quarries of Samsugn, where Cephalopoda, somewhat mixed up with Gastropoda occur in enormous quantities. In other localities again shells of the Lamellibranchiates are the chief components of the rock. The largest of all Silurian bivalves in Gotland, Megalomus gotlandicus forms in thousands of specimens extensive banks, that stretch from the shores of Fårösund in the north across the island to the immediate vicinity of Wisby and also along the east coast at Östergarn and along the shores south of that parish. The oolitic strata near Bursvik contain almost only shells of Lamellibranchiates in great numbers of species and specimens and a similar deposit of the same richness of identical forms occurs further towards the north at Gothems hammar. At Bursvik and southwards to Hoburg there lies along the coast a bank, half a foot thick, of Pterinea retroflexa and besides several smaller.

Then there are localities where the chief mass consists of Brachiopoda, especially of the genera Pentamerus and Trimerella, the former within more circumscribed limits, the latter as a true rockbuilder across the island in a belt from north east to south west. The occurence of the Gastropoda is given below. At first I shall only enumerate the different localities, where they have been found, with some few remarks concerning the geology and palæontology of their strata.

Localities in the stratum a.

Wisby. Shale beds north of that town and along the shore to Halls huk and round that cliff a small distance south in the bay of Kapellshamn, where they disappear beneath the sea.

Gnisvärd, a place south of Wisby to which the shale continues, rich in Brachiopoda, partly common with Westergarn and partly with Wisby. A few Gastropoda common with Wisby.

Westergarn. Low shale beds, uncovered along the shore line, rich in fossils, finely preserved. Pleurotomaria labrosa and bicincta are often found here.

Stora Carlsö. The shale beds are well exposed along the east and west coast, chiefly rich in Corals and Brachiopoda.

Djupvik in Fröjel and Eksta. There is a long stretch of the coast comprised under this denomination from the northern shore of Skäret in Fröjel to the shore south of Djupvik, being of almost the same soft, blue shale filled with a large number of fossils of all orders. It is interrupted by the peculiar »calcareous shale» (kalkstensskiffer HISINGER) which, intermingled with sandy slates, occupies the shore around Skäret and contains a great number of curious tracks, besides fossils of a fauna distinct from that of the neighbouring shores.

Habblingbo. Along the flat shore of Petesvik a hard, blue shale, containing more limestone than those in north, is spread out, filled with Brachiopoda and also other shells. The highest point of this shale is further inland about one Swedish mile, 80 feet above the sea.

Fardhem. A section of micaceous shale is seen near a saw mill at Burge with fossils partly characteristic of Djupvik and partly of Habblingbo. Amongst the latter may be remarked the interesting Rhizophyllum Gotlandicum. In the same parish of Fardhem there is an extensive canal cut through a moorland, Wisne myr, lying open a fine section of the shale for nearly half a Swedish mile. The fossils it contains are very interesting, as species here meet with each other which were long considered as exclusively characteristic of widely remote localities and thus give additional support to the supposition that all shale beds are coherent and of the same age. Such are Phacops Downingiæ, also from the sandstone and oolite of S. Gotland and from the limestone bed b of Wisby, Tremanotus longitudinalis also from Wisby a, and the sandstone of Bursvik, Orthis canaliculata formerly from the eastern strata of Gotland, Burs etc., Strophom. funiculata, the same variety as in Habblingbo, not Eksta, Chonetes striatella, Pisocrinus ollula found in the shale of Petesvik, Pleurotomaria planorbis HIS. which is so abundant at Östergarn, the initial colony of Labechia or a kindred coral quite the same as that found on the same level at Slite.

Bursvik and Hoburg. The sandstone with thin seams of shale or clay, as described by HISINGER. The fossils are scarce, mostly of the same species as in the oolite above. The few Gastropoda found are well preserved with their shell.

Rone. Sandstone and shale along the shore.

Östergarn. Shale beds, on compact limestone, with Chonetes striatella and Atrypa didyma.

Slite. The lowest shale beds along the shore.

Hallshuk. The lowest beds there and for a while to the south along the west shores of Kapellshamn.

Stratum b.

Wisby. The limestone with interstratified shale in the neighbourhood of the town, well developed at Snäckgärdet, Skälsö, Wibble qvarn, Högklint and some localities along the coast northwards to Likkershamn, where also many fossils have been found.

Westergarn. On the fields farther inland, above the shale, scattered fragments of this stratum can be found.

Lansa on Fårö. Limestone and shale beds along the shore.

Slite. The median beds in the sections near the coast.

Boge. South of Slite in ditches along the road and in the cliffs near Klinte.

Ruthe. A canal leading from Stor myr is cut through strata of this group.

Gothemhammar. Beds of fine grained, nearly oolitic limestone with an abundance of shells of Lamellibranchiates, the same as found in the oolite of Bursvik. Fine specimens of the large Murchisoniæ have also been found here.

Dalhem. Along the brook near Nya Slitegårds a good section is laid open, rich especially in Brachiopods.

Kräklingbo. Marly limestone near the shore with the same fossils as at

Östergarn, where the limestone *b* is nodular, compact and gray.

Stora and Lilla Carlsö, where the strata are filled with corals in regular bands, each species apart from the others.

Lau. A declivity east of the church consists of beds of marl and limestone and is very rich in finely preserved fossils.

Grötlingbo, *Näs* and *Bursvik.* Beds of oolite and pisolite of variable thickness. Fossils much eroded and worn, the Lamellibranchiates extremely abundant and well preserved.

Hoburg. Above the sandstone oolite is resting, at first sandy, and afterwards more compact and not so rich in grains of oolite as further north. Limestone beds follow above this with seams of shale, containing Crotalocrinus, Labechia, Pentamerus galeatus, Orthis rustica, Strophomena euglypha, St. filosa, Orthis hybrida, Rhynch. deflexa, Meristella tumida. Two peculiar forms of Gastropoda have been found here.

Stratum c.

Lutterhorn on Fårö. Low cliffs of crystalline, grayish limestone with Oriostomata and Tryblidia.

Wialmsudd on the northwestern shore of Fårösund, hard crystalline limestone replete with Cephalopoda, Gastropoda and Trimerellæ. Near to it, farther inland, is a place Sändvik with the same fossils.

Slite. The uppermost limestone beds are rich in fine shells, especially in seams or vertical fissures filled with marl. Partly a breccia of small, comminuted shells.

Samsugn. In the extensive quarries of the limestone a great number of Cephalopoda, Gastropoda and Lamellibranchiata are found.

Hall. A canal near the farm of Westös has been cut through bluish, nodular limestone, rich in finely preserved fossils, especially Oriostomata.

Halls huk, *Bara*, *Ardre* and *Östergarn*, *Klinte*, *Wisby*, the top of *Carlsö*, are all localities nearly resembling each other lithologically, though their fossil contents differ.

Follingbo, Storwede. The limestone which is extensively quarried, varies very much within short distances, being in some places coarsely crystalline with many remains of crinoids, in others again of the finest texture resembling lithographic stone. The last mentioned variety consists mostly of fragments of Cephalopoda, with some few Gastropoda interspersed.

Wisby (Kyrkberget, Kålensqvarn). A gray, soft limestone, especially rich and replete with remains of Gastropoda.

Martebo a peculiar, yellowish soft limestone near Myre, rich in Oriostomata and their opercula.

Fardhem and Linde. Some isolated hills as Sandarfve and Linde kullar, partially consisting of crystalline, crinoidal limestone, partially a conglomerate of larger or smaller pieces of corals and Stromatoporæ and partly fine, earthy, red and gray limestone beds. The last are remarkably rich in shells of Cephalopoda and Gastropoda.

State of preservation.

The state of preservation of the Gastropoda as well as that of other fossils in these different rocks, is of course quite as variable as the nature of the rocks themselves and seems at first in several places quite unaccountable. So, for instance, the shells of the Gastropoda and Lamellibranchiata are in many shale beds, as a rule, dissolved and present only as nuclei, while corals, trilobites and brachiopoda are well preserved. Thus in one locality the shells are only represented as nuclei, as for instance at Petesvik in Habblingbo, and again in a neighbouring locality, Djupvik in Eksta, they are well preserved, with their shells. It may also be that many genera of Gastropoda, as in the shale of Wisby, only occur as casts or nuclei, such as Subulites, Loxonema, Murchisonia, Euomphalus, Bellerophon and Tremanotus, whilst in the same bed others as Oriostoma, Pleurotomaria and Platyceras have retained their shell. In all probability there is something in the condition of the chemical or mineralogical nature of the shell which thus causes it to be dissolved in one group and preserved in the other. In the upper limestone beds again by far the greatest number of the species are provided with their shell and all the delicate ornaments of its surface are visible.

But the difficulty is to get them out entire and perfectly intact from the rock. In such rich localities as Samsugn, Kyrkberget in Wisby many specimens can be collected as they have been detached through the disintegration of the rock, which is often crumbling to pieces on the surface. From the limestone of Sandarfve hill they can be removed by carefully using the hammer and chisel. By delicate operations with sharp needles they have been prepared out from almost all sorts of limestone and been cleaned in greater perfection than could be expected at first sight. In washing the fine, marly limestone mud, which is often found in fissures and has probably originated through the decomposition of the limestone, many small Gastropoda, such as the Murchisoniæ figured on plate XV have been obtained along with a number of other interesting fossils.

The few Gastropoda which have been found in the sandstone are remarkably well preserved, showing the fine sculpture of their surface.

In the majority of specimens the shell is entirely converted into calcareous spar, but in a few others there are remains of the microscopic structure left. So for instance in the genus Platyceras, in the common Platyceras cornutum, where at least three different stata can be discerned. The Patellid Tryblidium has also the intimate structure, to a certain extent, well preserved and also, on the inner side, the peculiar horseshoe-shaped ring of muscular scars beautifully and most distinctly visible. In this genus, as well as in Cyrtolites, Bellerophon and Oriostoma some specimens still show the pattern of the original colour bands. Traces of the nacreous lustre are also present on the inside of several species of the genera Oriostoma and Pleurotomaria. A number of specimens of the genus Oriostoma has been found with their large, calcareous operculum in situ, thus permitting to distinguish several, nearly allied species, the shells of which show very little difference. With regard to the position of the shells in the strata it may only be remarked that such elongated shells, as Murchisonia, Loxonema and Subulites lie horizontally or parallel with the plan of stratification. As for the rest they are heaped together without any order as the shells at the present day cast ashore.

The Murchisoniæ found in the shale beds of Wisby, and also many Bellerophons, had been almost entirely overgrown by colonies of the bryozoan Ceramopora and others, many times larger than the shells themselves and thus evidently preventing all possibility for the animal to move and consequently killing it. In a small lake south of Stockholm, Hammarbysjö, I found in the spring 1882 the common freshwater bryozoan Alcyonella fungosa PALLAS in great abundance and nearly every colony of it had chosen a specimen of Paludina vivipara L. for its basis and so completely covered it that the animal was unable to move, and large numbers of them were dead, the bryozoans continuing to thrive. Thus a powerful growth of a compound species has acted and still acts as a check to the increase of another species belonging to a different group and has probably also been an agent in its extinction on localities common to them both.

Distribution of the Species.

There is no doubt that the Gastropoda I am about to describe, numerous though they be, are only a fragment of all that once made up the fauna of these animals in the Silurian seas of Gotland. Several strata litterally teem with their broken shells and it is evident by several of these remains that they belonged to many other species than those mentioned further on, but too imperfect for description. As far as known at present the number of species and varieties amounts to 174 here described and figured. The numeric strength of their group in relation to that of other orders from the strata of Gotland may be seen from the following survey of the whole Lethæa.

List showing the number of species at present known from the Silurian Strata of Gotland.

Crustacea	Trilobitæ	53	
	Merostomata	2	
	Phyllopoda	4	
	Ostracoda	30	
	Cirrhipedia	1	90
Annelida	according to the researches of Dr J. G. HINDE with addition of the Tubicolar Annelides		50
		Carried forward	140

	Brought forward		140.
Mollusca			
	Cephalopoda about	100	
	Pteropoda	5	
	Gastropoda	174	
	Lamellibranchiata about	80	359
Molluscoida			
	Bryozoa about	50	
	Brachiopoda	150	200
Echinodermata			
	Asteroidea	2	
	Echinoidea	1	
	Crinoidea	180	183
Anthozoa about			100
Graptolitæ			5
Spongiæ			10
Dubious organisms (Algæ probably) and others			5
Tentaculitæ about			5
	Total 1,007 species and varieties.		

It is to be observed that the number of species in some groups has been rated somewhat low and that in all probability a detailed research will considerably increase it. As it now stands we see that the Gastropoda vie in numerical strength with such large groups as the Crinoidea and surpass all the others.

The minor details in the distribution, geographical and geological, of the Pteropoda and the Gastropoda may be learnt from the annexed lists[1]), in which first the chief localities or local regions are given in 27 columns, and then in the six last columns a summing up of their stratigraphical distribution. Under the headings of the localities, *a* signifies the lowest stratum, shale or sandstone, *b* the intermediate limestone or the oolite, *c* the uppermost limestone. When a species is recorded as found only in *a* and *c* this has been considered equivalent to its having been found in *b* also or in all strata.

As to the names of the localities, it should be borne in mind, that some of them are intended for a small district around a central point. Thus *Hall* chiefly means the strata *c* in the canal near Westös, but also the strata near the shore and at Halls huk. *Wialmsudd* includes the adjacent shores of Fårösund, as the strata of Sändvik, *Gothem* and *Bara* embrace chiefly the shore deposits at Gothemshammar and a number of quarries opened westwards in the direction of Bara, where a little hill, *Bara backe*, contains the same fossils. *Linde* and *Fardhem* comprises not only the limestone hills there, but also the marly and gritty shales.

The limestone beds of Samsugn in Othem, those of Wialmsudd and Wisby as well as others are very rich in shells of Gastropoda intermingled with those of Cephalopoda. But all these localities are by far surpassed by the limestone of Sandarfve kulle. This is one of the small hills, which in the central part of Gotland, a little

[1]) See page 16 and the following.

south east of Klinte have been formed through denudation and all prove, through the presence of such fossils as Pentamerus conchidium etc., that they are of the same age with each other and also coëval with Klinteberg. Sandarfve kulle, which is one of the smallest, attains a height of about 170 feet above the level of the sea. About 80 feet of its substratum consist of shale, similar to that of Petesvik in Habblingbo. The superimposed limestone, which forms the chief part of the hill, is in the lowest beds regularly stratified with a gray crystalline limestone, which passes upwards into a concretionar irregularly bedded limestone. This is partly bluish green, soft and earthy and partly in large patches red, giving the enclosed fossils with their colour a certain resemblance to the Lower Silurian fossils of the Orthoceratite limestone in the main land of Sweden. This rock contains in great abundance beautifully preserved shells of Gastropoda of numerous species and also rare Cephalopoda, such as Ascoceras, Ophidioceras, Cyrtoceras, numerous Orthoceratites, and also shells of the Lamellibranchiates, all not found elsewhere. The fauna has a peculiar dwarfed character, being composed chiefly of small shells, none attaining to what may be called the average size of those of the other localities. It forms, as it were, a narrowly circumscribed, local fauna, which has hitherto yielded no less than 39 species of Gastropoda, only from the the red and gray limestones. Of these as many as 27, or 69 percent of the whole amount, are peculiar to this stratum. This surpasses by far the conditions in all other localities. According to the list, »Wisby» is richer than any other with 77 species. But it must be remembered, first, that this denomination embraces a much larger space than the former region and includes such localities as Kyrkberget and Kålens qvarn, where the limestone is in fact a *lumachello*. Besides, there are many other localities for a considerable distance along the coast where the same palæontological characters prevail. Fourty one species are annotated as pertaining to the stratum *c* of Wisby, but of these only the small number of ten is peculiar. The shale beds at Djupvik in Eksta contain a Gastropodan fauna of 25 species and of these nine are peculiar. Of the other richer localities Samsugn has a total of 34 species against six peculiar, Slite 25 species in all against four peculiar, Follingbo 20 species in all against six peculiar, Klinte 23 species in all against two peculiar and Östergarn 21 species with only one species peculiar from the stratum *b*.

What must strike the attention after the first glance on the list of distribution is the great preponderance in number of species of the North Gotland localities over the localities south of Fardhem, such as Rone, Grötlingbo, Bursvik, Näs and Hoburg. This may chiefly be due to real poverty as no such rich deposits as those of North Gotland ever have been discovered there, but it is evident that the total amount of species found, especially at Hoburg, will be increased in future through continued and oftener repeated researches. Characteristic of these southern parts are the following six species, having their northern limit at Grötlingbo. They are: *Platyceras disciforme, Cyrtolites obliquus, Pleurotomaria dolium, Murchisonia moniliformis, Eunema muricatum* and *Craspedostoma spinulosum.* As a contrast to this minority, no less than 95 species, or more than half the number, have their limits within North Gotland as far as Westergarn in south on the west coast and Gothem on the east coast. A few continue as

Synoptical List of the distribution of the Silurian

	Fårö.		Hall	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Bara.	Guisvärd.
	Lutterhorn	Lansa.										
Pteropoda.												
Conularia Sow.												
1 cancellata Sandb	—	*b*	*a*	—	—	—	—	—	*b*	—	—	*a*
2 monile n.	—	—	—	—	—	—	—	—	*b*	—	—	—
3 lævis n.	—	*b*	—	—	—	—	—	—	*bc*	—	*c*	—
4 bilineata n.	—	*b*	—	—	—	—	—	—	—	—	—	—
5 aspersa n.	—	—	—	—	—	—	—	—	*bc*	—	—	—
		3	1						4		1	1
Gastropoda.												
Fam. I. **Chitonidæ** Guilding.												
Chelodes Davidson & King.												
1 Bergmani Dav. & King	—	—	—	—	—	—	—	—	—	—	—	—
2 Gotlandicus n.	—	—	—	—	—	—	—	—	*c*	—	—	—
Fam. II. **Patellidæ** d'Orb.												
Tryblidium Ldm.												
3 reticulatum Ldm.	*c*	*c*	*c*	*c*	—	—	*c*	—	—	—	—	—
4 unguis Ldm.	*c*	*c*	*c*	—	*c*	—	—	*c*	*bc*	*c*	—	—
5 radiatum n.	—	—	—	*c*	—	—	—	—	—	—	—	—
Fam. III. **Tecturidæ** Adams.												
Palæacmæa Hall.												
6 solarium n.	—	—	—	—	—	—	—	—	—	—	—	—
Fam. IV. **Calyptræidæ** Brod.												
Platyceras Conrad.												
7 cornutum His.	*c*	*bc*	*abc*	*c*	*abc*	*c*	*abc*	*abc*	*abc*	*c*	*bc*	*a*
8 var. loricatum n.	—	—	—	—	—	—	—	—	—	—	*b*	—
9 spiratum Sow p. p.	—	—	—	—	—	—	—	—	*a*	—	—	—
10 disciforme n.	—	—	—	—	—	—	—	—	—	—	—	—
11 enorme n.	—	—	—	—	—	—	*bc*	—	—	—	—	—
12 cyathinum n.	—	—	—	—	—	—	—	—	—	*c*	—	—
Fam. V. **Bellerophontidæ** M'Coy.												
Bellerophon. Montfort.												
13 sphæra n.	—	—	—	—	—	—	—	*c*	*ab*	—	—	—
14 fasciatus n.	—	—	—	—	—	—	—	—	*bc*	—	—	—
15 globulus n.	—	—	—	—	—	—	—	—	—	—	—	—
16 tænia n.	—	—	—	—	—	—	—	—	—	—	—	—
17 fastigiatus n.	—	—	—	—	—	—	—	—	—	—	—	—
18 tubulosus n.	—	—	—	—	—	—	—	—	*c*	—	—	—
Carried forward	3	3	3	3	2	1	3	3	7	3	2	1

Pteropoda and Gastropoda of Gotland.

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde and Fardhem.	Lau.	Habblingbo.	Grötlingbo.	Näs.	Bursvik.	Hoburg.	Stratigraphical distribution.					
															Only found in			Common to		
															a	b	c	all strata	ab	bc
......	......	......	......	......	......	*a*	......	......	......	......	......	......	......	......	......	......	......	......	*	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......	......
......	......	......	......	......	......	......	......	......	*b*	......	......	......	......	......	......	......	......	......	......	*
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*
						1			1							2			1	2
......	......	......	*c*	......	......	......	......	......	......	......	*b*	......	......	......	......	......	......	......	......	*
......	......	......	......	......	......	......	......	......	......	......	*b*	......	*a*	......	......	......	......	*	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......
......	......	......	......	......	......	......	......	*c*	......	......	......	......	......	......	......	......	*	......	......	......
a	*b*	*abc*	*abc*	*c*	*abc*	*a*	*abc*	*abc*	*b*	*a*	*b*	*b*	*ab*	*abc*	......	......	......	*	......	......
......	......	......	*c*	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*
......	......	......	*c*	......	......	......	*c*	*c*	......	......	......	......	......	......	......	......	......	*	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	*a*	*	......	......	......	......	......
......	*b*	......	*c*	......	......	*a*	......	......	*b*	......	......	*b*	*ab*	......	......	......	......	*	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......
......	......	......	......	......	......	......	......	......	......	*a*	......	......	......	......	......	......	......	*	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*
......	......	......	......	......	......	*a*	......	......	......	......	......	......	......	......	*	......	......	......	......	......
......	*b*	*b*	......	*c*	......	*c*	......	*c*	......	......	......	......	......	......	......	......	......	......	......	*
......	......	......	......	......	......	*a*	......	......	......	......	......	......	......	......	*	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	*	......	......	......
1	3	2	5	2	1	5	2	4	2	2	3	2	3	2	3	......	5	5	......	5

	Fårö. Lutterhorn.	Fårö. Lansa.	Hall.	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Bara.	Gnisvärd.
Brought forward	3	3	3	3	2	1	3	3	7	3	2	1
Bellerophon.												
19 squamosus n.	c	c		c					c			
20 Eiseni n.				c								
21 elegantulus n.									c			
22 latevittatus n.									a			
23 gemma n.									a			
24 pilula n.												
25 trilobatus Sow.									a			
Cyrtolites CONRAD.												
26 lamellifer n.					b				b			
27 pharetra n.												
28 arrosus n.								c				
29 obliquus n.												
30 euryomphalus n.												
31 discus n.									b			
32 orbiculus n.												
Tremanotus HALL.												
33 longitudinalis n.	c		ac	c			c	c	abc			
34 compressus n.												
Fam. VI. **Pleurotomaridæ** D'ORB. p. p.												
Pleurotomaria DE FRANCE.												
35 scutulata n.						c			c	c		
36 gradata n.												
37 Linnarssoni n.												
38 voluta n.												
39 claustrata n.					b	c			bc	c		
40 glandiformis n.												
41 biformis n.									a			
42 latefasciata n.									b			
43 Hindei n.						c						
44 Holmi n.									b			
45 Wisbyensis n.						c			c			
46 Lloydi Sow.		b	b						ac			
47 dolium n.												
48 laqueata n.									bc			
49 tubulosa n.												
50 robusta n.												
51 var. lævissima n.												
52 elliptica HIS.									a?			
53 bicincta HALL.		b				c	abc	c	b	c	b	
Carried forward	5	6	5	6	4	6	5	6	25	6	3	1

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde, Fardhem.	Lau.	Habblingbo.	Grötlingbo.	Näs.	Burgvik.	Hoburg.	Stratigraphical distribution. Only found in: a	b	c	Common to: all strata	ab	bc
1	3	2	5	2	1	5	2	4	2	2	3	2	3	2	3		5	5		5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	a	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	—	*	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a	—	—	ab	—	—	—	—	—	*	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	*	—	—	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	a	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	—	*	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	c	—	—	ab	—	a	b	a	—	—	ab	—	—	—	—	*	—	—
—	b	b	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
a	b	b	—	—	—	a	—	a	—	—	a	—	—	—	—	—	—	*	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	*	—	—	—	—	—
—	—	—	c	—	—	c	—	—	—	—	—	—	—	—	—	—	—	—	—	*
—	b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
—	—	—	—	—	—	a	—	—	—	a	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*?	—
a	—	ab	—	c	—	ab	—	—	—	—	—	—	—	—	—	—	—	*	—	—
3	6	7	7	3	1	16	2	11	3	5	4	2	9	2	13	5	16	9	3	7

	Fårö.		Hall.	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Barn.	Gnisvärd.
	Lutterhorn.	Lansa.										
Brought forward	5	6	5	6	4	6	5	6	25	6	3	1
Pleurotomaria.												
54 qualteriata SCHLOTH.									*a*			
55 valida n.												
56 Othemensis n.						*c*						
57 comata n.												
58 æquilatera WAHLENBERG	*c*		*c*	*c*		*c*	*c*		*a*	*c*	*c*	
59 labrosa HALL		*b*					*b*		*a*			
60 limata n.	*c*		*c*	*c*	*bc*		*c*		*abc*			*a*
61 replicata n.									*a?*			
62 alata WAHLENBERG	*c*	*c*	*c*		*a*	*c*	*ac*		*a*			
63 var. subcarinata n.		*b*										
64 var. opposita n.												
65 prætexta n.									*a*			
66 togata n.									*a*			
67 frenata n.									*a*			
68 undulans n.									*a*			*a*
69 Marklini n.												
70 cirrhosa n.												
71 planorbis HIS.												
72 helicina n.									*a*			
73 exquisita n.												
Murchisonia D'ARCH. & VERN.												
74 cingulata HIS			*c*								*b*	
75 cava n.								*c*	*c*		*bc*	
76 moniliformis n.												
77 obtusangula n.									*c*			
78 subplicata n.								*c*				
79 compressa n.												
80 attenuata HIS.							*ac*		*abc*	*c*	*b*	
81 crispa n.												
82 munda n.							*c*					
83 tortuosa n.										*c*		
84 imbricata n.							*c*		*c*			
85 cancellata n.												
86 cochleata n.												
87 deflexa n.												
Fam. VII. **Euomphalidæ** n.												
Euomphalus SOW.												
88 gotlandicus n.							*a*	*c*	*ac*			
89 triquetrus n.							*abc*	*c*				
Carried forward	8	9	9	8	6	9	14	10	41	9	7	3

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde, Fardhem,	Lau.	Habblingbo.	Grötlingbo.	Näs.	Burgsvik.	Hoburg.	Stratigraphical distribution. Only found in a	b	c	Common to all strata	ab	bc
3	6	7	7	3	1	16	2	11	3	5	4	2	9	2	13	5	16	9	3	7
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	c	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—
a	—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	—	—	—	*	—
a	—	—	c	—	c	—	a	—	—	—	—	—	—	—	—	—	—	*	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
a	—	—	c	—	—	—	a	—	—	—	—	b	—	—	—	—	—	*	—	—
a	—	—	—	—	—	a	—	—	—	—	—	b	b	—	—	—	—	—	*	—
—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
a	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	c	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	b	—	—	—	—	—	c	—	—	—	—	—	—	—	—	—	—	—	*
—	—	ab	—	—	—	—	—	a	—	—	—	—	—	—	—	—	—	—	*	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	—	—	—	*	—	—
—	—	—	—	—	—	a	—	—	—	—	—	—	—	—	—	—	—	*	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	*	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
—	b	b	—	b	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—	—
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—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
—	—	b	—	—	—	—	—	c	—	—	—	—	—	—	—	—	—	—	—	*
—	—	—	—	—	—	—	—	c	—	—	—	—	—	—	—	—	*	—	—	—
a	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*	—	—
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9	7	12	10	5	2	21	5	18	3	8	4	4	11	2	24	6	27	17	6	9

	Fårö. Lutterhorn.	Fårö. Lansa.	Hall.	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Barn.	Gnisvärd.
Brought forward	8	9	9	8	6	9	14	10	41	9	7	3
Euomphalus.												
90 tuba n.						c'						
91 præcursor n.									a			
92 Walmstedti n.												
Loxonema PHILLIPS.												
93 sinuosum SOWERBY									a			
94 attenuatum n.						c						
95 intumescens n.									c			
96 fasciatum n.												
97 strangulatum n.												
Fam. VIII. **Trochidæ** D'ORB. p. p.												
Trochus L.												
98 Gotlandicus n.	c	bc	c		b		c		bc			
99 fulminatus n.								bc	bc			
100 mollis n.						c						
101 Stuxbergi n.						c			c			
102 undulans n.						c	c					
103 profundus n.						c						
104 cavus n.												
105 Lundgreni n.	c					c						
106 Kolmodini n.										c		
107 Dalli n.									c			
108 Wisbyensis n.	c					c			c			
109 lamellosus n.			c			c						
110 incisus n.					c	c			c	c		
111 gyrans n.									c			
112 densestriatus n.												
113 astraliiformis n.												
Fam. IX. **Umbonidæ** n.												
Pycnomphalus n. gen.												
114 obesus n.		c		c								
115 acutus n.				c				c	c			
116 trochiformis n.									c			
Fam. X. **Turbinidæ** ALDER.												
Oriostoma MUNIER-CHALMAS.												
117 discors Sow.	c	c	c	c		c		c	c	c	c	
118 var. rugosum Sow.				c		c	c	c	ac	c	c	
119 contrarium n.	c		c	c		c			ac			
120 globosum SCHLOTH.	c	c	c	c				c	a		b	
121 var. sculptum Sow.	c	c	c	c		c	b	c	a			
Carried forward.	15	14	15	15	8	23	18	16	58	13	10	3

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde, Fardhem.	Lau.	Habblingbo.	Grötlingbo.	Näs.	Burgsvik.	Hoburg.	Stratigraphical distribution. Only found in a	b	c	Common to all strata	ab	bc
9	7	12	10	5	2	21	5	18	3	8	4	4	11	2	24	6	27	17	6	9
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-----	-----	-----	c	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	*	-----	-----	-----
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a	-----	b	-----	c	-----	a	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	*	-----	-----
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a	-----	-----	c	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	*	-----	-----
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a	c	c	-----	-----	c	-----	a	ac	-----	a	-----	-----	-----	-----	-----	-----	-----	*	-----	-----
-----	-----	-----	c	-----	c	a	a	-----	-----	-----	-----	-----	-----	b	-----	-----	-----	*	-----	-----
12	8	17	17	7	5	24	7	23	3	9	4	4	11	3	26	7	47	23	6	12

	Fårö.		Hall.	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Bara.	Guisvärd
	Lutterhorn.	Lansa.										
Brought forward	15	14	15	15	8	23	18	16	58	13	10	3
Oriostoma.												
122 coronatum n.											c	
123 acutum n.							c					
124 Wisbyense n.									bc			
125 angulifer n.												
126 Roemeri n.									ab			a
127 helicinum n.			c	c		c						
128 alatum n.									bc			
129 angulatum WAHLENB.	c	c		c		c	c		c	c	c	
130 lineatum n.												
131 nitidissimum n.												
132 dispar n.										c		
Cyclonema HALL.												
133 delicatulum n.					b				ab			
134 apicatum n.												
135 cancellatum n.												
136 distans n.												
137 striatum HIS.						c			a			
138 zonatum n.												
139 adstrictum n.												
140 carinatum SOW.						c	c			c		
141 nodulosum n.												
142 tenuissimum n.										c		
143 giganteum n.									a			
144 perversum n.												
145 (Trochonema) turritum n.						c		c	c			
Eunema SALTER.												
146 muricatum n.												
Craspedostoma n. gen.												
147 spinulosum n.												
148 elegantulum n.						c	c			c		
149 var. brevispira n.												
150 filistriatum n.						c						
151 involutum n.									c			
152 glabrum n.												
Fam. XI **Phoridæ** GRAY.												
Autodetus n. gen.												
153 calyptratus SCHRENK			ab		b		c		b			
Fam. XII **Litorinidæ** GRAY.												
Holopea HALL.												
154 nux n.						c						
155 transversa n.										c		
Carried forward	16	15	17	17	10	31	23	17	68	19	12	4

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde, Fardhem.	Lau.	Hablingbo.	Grötlingbo.	Näs.	Bursvik.	Hoburg.	Stratigraphical distribution.					
															Only found in			Common to		
															a	b	c	all strata	ab	bc
12	8	17	17	7	5	24	7	23	3	9	4	4	11	3	26	7	47	23	6	12
......	......	*b*	......	*c*	......	......	......	*c*	*b*	......	......	......	......	......	......	......	......	......	......	*
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......	......	*b*	......	......	......	*a*	......	*c*	*b*	......	*b*	......	*ab*	*ab*	......	......	......	*	......	......
......	......	......	......	......	......	......	......	*c*	......	......	......	......	......	......	......	......	*	......	......	......
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13	8	21	23	8	5	27	8	35	5	10	5	4	13	6	28	10	67	26	8	16

	Fårö.		Hall.	Wialmsudd.	Likkershamn.	Samsugn in Othem.	Slite.	Martebo.	Wisby.	Follingbo.	Gothem and Bara.	Gnisvärd.
	Lutterhorn.	Lansa.										
Brought forward	16	15	17	17	10	31	23	17	68	19	12	4
Holopea.												
156 perforata n.									*c*			
157 nitidissima n.									*c*	*c*		
158 applanata n.									*c*			
Fam. XIII **Scalaridæ** BRODERIP.												
Callonema HALL.												
159 obesum n.									*b*			
160 scalariforme n.									*b*			
Holopella M'COY.												
161 teres n.							*c*					
162 regularis n.									*a*			
163 minuta n.												
Fam. XIV **Pyramidellidæ** GRAY.												
Machrochilina BAYLE.												
164 cancellata n.												
165 bulimina n.												
166 fenestrata n.						*c*						
Fam. XV **Subulitidæ** n.												
Subulites CONRAD.												
167 ventricosus HALL		*b*							*a*			*a*
168 ventricosus var. curvus						*c*			*c*			
169 attenuatus n.		*b*		*c*				*c*	*a*			*a*
Euchrysalis LAUBE.												
170 lineolata n.												
Onychochilus n. gen.												
171 physa n.							*c*					
172 reticulatum n.												
173 cochleatum n.						*c*						
ADDENDUM.												
Murchisonia.												
174 paradoxa n.												
	16	17	17	18	10	34	25	18	77	20	12	6

Westergarn.	Kräklingbo.	Östergarn.	Klinte.	Ardre.	Lilla Carlsö.	Djupvik in Eksta.	Stora Carlsö.	Linde and Fardhem.	Lau.	Habblingbo.	Grötlingbo.	Näs.	Bursvik.	Hoburg.	Stratigraphical distribution. Only found in a	b	c	Common to all strata	ab	bc
13	8	21	23	8	5	27	8	35	5	10	5	4	13	6	28	10	67	26	8	16
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a	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	*	------
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a	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	*	------	------
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15	8	21	23	8	5	27	8	42	5	11	5	4	13	6	29	12	81	27	9	16

far as Klinteberg, but as they mostly are scarce there and frequent in the north they may be considered as North Gotland shells.

Only five species are common to the strata over the whole island and consequently the most characteristic species of all Gastropoda. These are *Platyceras cornutum*, *Tremanotus longitudinalis*, *Pleurotomaria alata*, *Oriostoma sculptum* and *Autodetus calyptratus*.

With the exception of the minor faunal districts which have been sketched above, such as Sandarfve and Djupvik, there are in other respects no obvious grounds for discerning larger, faunistic divisions, as was attempted in my paper on the Brachiopoda of Gotland [1]) some years ago. There are so many characteristic forms common, such as Autodetus, Craspedostoma and Tremanotus. Moreover, it is generally the case that distinctions based upon the occurrence of the species, are sooner or later effaced in the same degree as the material for study increases. It is then evident, that all such considerations have only a relative or transient value and properly speaking are only valid for the time they were made, as each year brings new forms and modifies older conclusions. New species are discovered and those formerly found are obtained from localities and strata where they were unknown.

As to the vertical distribution of the species as many as 29 have hitherto been found exclusively in the lowest or shale beds, signed *a* on the synoptical lists. It has not been possible, at present, to ascertain the succession of these species within the shale beds or if there really be zones of vertical distribution within the range of the more than hundred feet it comprises in thickness. In common with *b* it has besides nine species and with both *b* and *c* 27 species and contains thus in all 65 species. The next stratum *b* is nearly as rich, although having only twelve species of its own, and in common with *a* nine species, common with both *a* and *c* 27 species and with *c* alone sixteen species, thus in all 64 species. Richest of all is, however, the third stratum *c*, with so many as 81 species peculiar to it, which in addition to 16 common with *b* and 27 species common with both *a* and *b* make up the sum total of 124 species.

With regard to the occurrence of the 25 genera, of which the gastropodan fauna consists, in the different strata, there are some, as Tryblidium, Palæacmæa, Trochus, Pycnomphalus, Craspedostoma, Holopea, Euchrysalis, Macrochilina and Onychochilus, which are restricted exclusively to the highest strata. Some again, as Oriostoma, are most abundantly represented in the uppermost strata, though there are also species of it in the middle limestone and the shale.

It may be questioned whether not any evidence is found of mutations in such species, which occur in several strata, or in those, which have been found also in younger or older formations. Such changes, also indicated through the presence of nearly related species or varieties in older or younger formations, have most obviously occurred in the following species, which are now enumerated. The matter is more closely considered in the description of each species.

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[1]) Bidrag till kännedomen om Gotlands Brachiopoder. Öfvers. Vet.-Akad:s Förhandl. 1860, p. 337.

1. *Tryblidium reticulatum* LDM.
2. *Tryblidium unguis* LDM.
3. *Platyceras cornutum* HIS.
4. *Pleurotomaria limata* n. n.
5. *Pleurot. elliptica* HIS.
6. *Pleurot. bicincta* HALL.
7. *Pleurot. labrosa* HALL.
8. *Pleurot. qualteriata* SCHLOTH.
9. *Euomphalus Gotlandicus* n.
10. *Oriostoma rugosum* SOW.
11. *Subulites ventricosus* HALL.

In regard to the distribution of the Gotland Gastropoda beyond the limits of that island very little is at present known. As common with the nearest strata of **Ösel** and **Estland** the following species have been annotated: *Tryblidium unguis* LDM, *Platyceras cornutum* HIS. very common, *Pleurotomaria elliptica* HIS., *Pleurot. bicincta* HALL, *Oriostoma angulatum* WAHL., *Or. sculptum* SOW., *Or. discors* SOW. very common, *Pleurot. planorbis* HIS., *Autodetus calyptratus* SCHRENK, *Pleurot. qualteriata* var.

From the Upper Silurian strata of **Scania** at Bjersjölagård and Klinta I have seen *Platyceras cornutum* HIS. *Platyc. enorme* LINDSTR., *Autodetus calyptratus* SCHRENK and indeterminable nuclei of Murchisonia, Pleurotomaria and Bellerophon.

From **Norway,** I have only seen the few following species:

Conularia lævis n., *Pleurotomaria elliptica* HIS., *Oriost. globosum* SCHLOTH. In common with **England** the following species have been found viz. *Platyceras cornutum* HIS., *Platyc. spiratum* SOW., *Pleurotomaria limata* nom. nov. (= Euom. carinatus SOW.), *Pl. labrosa* HALL, *Pl. alata* HIS., *Pl. Lloydii* SOW., *Pl. bicincta* HALL, *Bellerophon trilobatus* SOW., *Loxonema sinuosum* SOW., *Oriostoma discors* SOW., *Or. rugosum* SOW., *Or. sculptum* SOW., *Cyclonema carinatum* SOW.

With the rich fauna of **Bohemia** not a single species can, for the present, be recorded as common. I have had access to a collection of 65 species of Bohemian Silurian Gastropoda, acquired by the State Museum of Sweden from the late M. SCHARY of Prag, and I cannot find in it a single species to identify. Euomphalus pulcher BARRANDE comes very near to *Oriost. Roemeri* and Euom. simplex BARR. near to *Oriost. sculptum* SOW., but they are probably different.

From the Silurian formation of **Podolia** and **Galizia** FRIEDR. SCHMIDT in »Einige Bemerkungen über die Podolisch-Galizische Silurformation» (1875) p. 17 enumerates six species of Gastropoda, but of these Euomph. (Pleurotomaria) alata is probably the only one which can be considered as identical.

VON ALTH gave in 1874 a list of Silurian Gastropoda in his work »Ueber die palæozoischen Gebilde Podoliens», page 31, amounting to 14 species, but as I have not seen a single specimen of them, I can not with any certainty identify them with those from Gotland.

Of **N. American** Silurian Gastropoda I have found as identical, *Platyceras cornutum* HIS., *Pleurotomaria labrosa* HALL, *Pleurot. bicincta* HALL, *Subulites ventricosus* HALL.

Pleurotomaria bicincta HALL, *Pleurot. elliptica* HIS., *Tryblidium unguis* LDM. occur in the highest strata of the Lower Silurian of Estland and *Pleurot. elliptica*, *Pleurot. qualteriata* are common with the Orthoceratite limestone of the Lower Silurian of

Sweden. Upwards, into the Devonian strata of France and N. America, only the following species is passing, viz. *Pleurot. labrosa* HALL, also found in the »Devonien inférieur» at Néhou and in North America in the Lower Helderberg rocks. *Platyceras cornutum* HIS. can in some of its varieties scarcely be distinguished from the Eifelian Pileopsis prisca to which it at all events stands in very close relation. *Bellerophon trilobatus* SOW. also seems to be a species which has continued in the Devonian time.

Zoological characters of the gastropodan fauna.

If we except Chelodes and the genera Subulites, Euchrysalis and perhaps Onychochilus, all the other belong to the large section, which on account of the circular peristome has been called that of the Holostomata. Chelodes as one of the Chitonidæ, belongs to the strange order Placophora. Subulites, Euchrysalis and possibly also Onychochilus again exhibit such characters in their aperture as to entitle us to place them with the great order Siphonostomata, hitherto regarded as of mesozoic origin and entirely unknown in the palæozoic formations. It cannot be denied that the evidence offered further down supports this conclusion and that it probably shall be corroborated by further observations. If then, as I suppose, Subulites is one of the Siphonostomata, these have originated much earlier than in the Gotlandic Silurian, as there are well preserved species of that genus in the Lower Silurian strata of Dalecarlia. Subulites nitens LDM (in Fragmenta Silurica p. 14) occurs already as early as in the Lower Gray Orthoceratite Limestone of Sjurberg, where besides this no other forms of the same order are known. A larger species, probably Subulites (Helicites) utricularis WAHLENBERG (Subul. elongatus PORTL. according to Fragm. Silur. p. 13), is found in the uppermost stratum of the Lower Silurian of Dalecarlia, the Leptæna limestone.

Of the fifteen families represented, as many as twelve are also recent. It must, however, be conceded that it is with great diffidence that several families, such as the Litorinidæ, the Pyramidellidæ, the Turbinidæ have been introduced in the lists. Of the 25 genera again, the majority or 23 are considered to be extinct and only two, Pleurotomaria and Trochus, still persisting. The former genus, rich as it was in the Silurian times, had not then reached its acme, which was attained in the Jurassic seas and now it has dwindled away to four species in the recent seas. Together with Murchisonia it gives to the fauna of the Gotland Gastropoda its chief character, their 54 species making nearly a third of the whole fauna. Like Pleurotomaria there are other genera, the systematic place of which cannot be contested. The beautifully preserved muscular scars on the inner side of Tryblidium certify their near connection with the recent Patellidæ. Chelodes with its numerous very characteristic plates belongs in all probability to the Chitonidæ. The numerous Oriostomata, forming such a prominent feature in the fauna, testify through their operculum and their nacreous interior strata to their relation with the Turbinidæ. It is also very likely that the strange Autodetus is an ancestral form representing the modern Phoridæ, the presence of which family has already been observed in the Devonian strata. But instead of attaching other objects to its shell as its presumed descendants, it fixed its own shell with the apex to other bodies. Of the occurrence of such an archaic from as Dentalium, nothing as yet has been ascertained. A few tubes from the shale beds of Wisby and Östergarn might possibly once have appertained to that group, but their imperfect condition precludes identification.

As genera especially characteristic of the Silurian beds of Gotland, may be mentioned: Craspedostoma, Onychochilus and probably also Pycnomphalus, though it is not certain whether the last does not occur in England and Oesel, but referred to the genus Platyschisma in a conception which is not that of the first author. Autodetus, which is spread over the whole island, occurs also on the neighbouring Oesel, though it is uncertain whether so common there as on Gotland and not recorded from any other Silurian region except Scania. As characteristic of the Upper Silurian formation in general may be annotated Chelodes, which has also been found in Bohemia, Tremanotus, Cyrtolites and Subulites also known from N. America and Canada, Subulites also from England, and Tryblidium found in Estland and Canada.

Concerning the many palæozoic genera, of which I have appended an Index in the end of this memoir, it depends much on individual opinions, as to what genus these old fossil shells are to be referred, but it is evident that it is highly futile to establish the genera only on a single and variable character. When comparing large numbers of specimens belonging to the same species and collected in the same locality the great variability in the form of the aperture, the columella, the height of the spire, the umbilicus, will be evident, and it is only necessary to remind of such forms as Platyceras cornutum to discover the wide range within which some species vary, chiefly those which have a large horizontal and vertical distribution. In almost the same degree Cyclonema delicatulum varies with high or low spire, slender or ventricose whorls, with open or closed umbilicus.

Among structural peculiarities ought to be observed that in the genus Euomphalus, as it has been long known, the shell, in the rule, near the apex or in the oldest whorls, is divided into one or several compartments or chambers by concave diaphragms, without, however, having any communication or sipho between them. The chambered apex has very often through the fossilisation become deciduous and the blunt end indicates the place, where the partition once traversed the shell. In Murchisonia, Loxonema and a presumed Trochus, Tr. gotlandicus, the apex is filled with a compact mass of calcareous matter quite as in the recent Magilus.

The peculiar and cellular structure of the external walls in Autodetus is a feature well deserving attention. In a few genera, as Platyceras, Pleurotomaria, Euomphalus, there is a tendency in several species to form scalarid varieties and in some species all specimens found have assumed that peculiarity in growth. In the large genus Pleurotomaria it is easy to follow the morphological changes which the characteristic slit band is subject to, from a concave groove to the large, thin lamina in the group Alatæ. In respect to the sculpture of the surface I have called the spiral lines, keels and ridges, which run from the apex to the aperture for longitudinal, as they follow the shell in its whole length, and, consequently, those intersecting them are to be denominated transverse. Some authors call all the later for lines of growth. But besides the real lines of growth or the old apertural lips, which are conspicuous by their lamellar edges, often uneven and at irregular distances from each other, there are fine and elevated, as it were, ornamental lines. These do not always run parallel to the lines of growth, but cross them obliquely in some species, as Pleurotomaria exquisita and Onychochilus cochleatum. These elevated lines of varying size are in several species replaced by sunk and narrow grooves. It would then be proper to distinguish between *lines of growth* and *ornamental lines*, which are formed independently of the former or coördinate to them.

Through the presence of certain genera the following conclusions may be drawn as to the character of the fauna, of which they formed an ingredient and consequently of the natural conditions of the sea in which the including strata were deposited.

1. *The fauna of the silurian beds of Gotland was a littoral fauna.* Such genera as Chelodes and Tryblidium make this conclusion valid. The Chitonidæ, to which Chelodes belongs, live now generally down to a depth of 25 fathoms, though some small ones have been found exceptionally at 100 fms. Tryblidium is a nember of the group of the Patellidæ. These are in a still higher degree shallow water shells, living near the shore on seaweeds and rocks, and the occurrence of the Tryblidia is suggestive of the former presence of algæ, on which they might have lived, though no traces of these are left. It has been said [1]) that the Upper Silurian shales of England through their fossils and the nature of the shale itself make it evident that they have been formed in a deep sea. Since the explorations of the later years the range of the deep sea region upwards cannot be considered higher than 400 fathoms. But already at a less considerable depth there reigns, as has been shown, an almost absolute stillness in the water and the motion of the surface cannot influence the bottom at a depth below 40 fms. Occasionally, at more exposed coast lines, as near New Foundland the bottom has been disturbed to a still greater depth, when violent tempests have raged, but this is of course exceptional and the traces of the disturbance must again, during the otherwise prevailing calm be effaced through new sediment.

In consequence of what has been advanced above, shells imbedded at greater depths could not show signs of having been subjected to any abrading motion of the waves. Now, the fossils enclosed in the shale beds of Gotland on the contrary attest in many instances by their abraded condition that they have been tossedabout by the waves and, consequently, have not been imbedded in a bottom of any considerable depth. The great movement in the sea, where they lived, is also evident through the shells sometimes having been broken and then mended. Thus there are specimens of Pleurotomaria labrosa from the shale of Westergarn, showing such a break in the body whorl, which had again been repaired during the lifetime of the animal. The superincumbent limestone strata are for the most part conglomerates of corals and other fossils, and, when fine grained, the limestone consists entirely of a sort of calcareous sand, the grains of which are comminuted shells and corals. It thus highly resembles the limestone, which is forming now a days out of similar material along the shores or on the beaches of the tropical regions for instance near the Westindian islands.

[1]) Fuchs, Welche Ablagerungen haben wir als Tiefseebildungen zu betrachten? in »Neues Jahrbuch für mineralogie etc.», II Beil. Bd. 1883, p. 565.

It must have been in some sheltered bights, where a calcareous mud found stillness enough to allow it to settle down, that such deposits as the fine grained limestone of Sandarfve, or Samsugn with their numerous and beautifully preserved shells originated.

In general the shells were middle sized, only a few, as Pleurotomaria valida, or Pl. cirrhosa attaining a greater size. Fragments of an undeterminable shell from the shale of Gnisvärd attain in the height of the body whorl alone 82 mm. and in breadth 98 mm., this being the largest fossil shell, known in Gotland. This size and the comparative rarity of tiny shells also militate against any assumption of great depth for these forms, as only small sized species have been dredged up from the abyssal depths.

2. *The fauna had a tropical character.* In consideration of the great numbers of Pleurotomariæ, Trochi, Turbinidæ and the large Pteropods the assumption of a tropical character of the fauna may seem justifiable.

Older descriptions of Gotland Gastropoda.

There has been no want of workers in this field, as we can learn by a review of the memoirs of the authors previous to this. The first time any mention has been made in print of the Silurian Gastropoda of Gotland was when MAGNUS VON BROMELL published the »Articulus secundus» of his »Lithographia Svecana» [1]). He there, pages 28—37, enumerates and summarily describes 21 different numbers of fossil Gotland Gastropoda. But as both the descriptions and the figures are very unsatisfactory — the originals being mostly mere nuclei — I have not been enabled with any degree of certainty to identify more than a few. Thus N:o 5, page 30, and N:o 6, p. 31, in all probability are specimens of Pleurotomaria alata. N:o 21, p. 36, is an Oriostoma and probably Oriostoma sculptum Sow. In N:os 26—27 we see nuclei of Murchisoniæ and N:o 27 may be M. attenuata.

LINNÆUS has left no descriptions of any fossil Gotland Gastropoda. In the relation of his travel on Gotland in 1741 he only mentions them in passing. On page 189 he says: »Petrificata plåckades af oss hela timarna på wästra Stranden (af Kapellshamn), ibland hwilka woro ganska många Conchitæ striatæ och Cochlitæ» . . . . i. e. »Petrifications were collected by us for several hours on the western shore, amongst which were a great number of Conchitæ striatæ and Cochlitæ» . . .

WILHELM HISINGER began his long, honourable and meritorious activity as the explorer of the geology and palæontology of Sweden so long back as in 1789 at the early age of 23 years with his first memoir and in 1798 [2]) he published »Minerographiske anmärkningar öfver Gottland». On page 286 he enumerates with other fossils only a single »*Turbo?* i pisolit kalksten». In 1808 »Samling till en mineralogisk Geografi öfver Sverige» was published and there he only recapitulates the remarks in the preceding paper. The number of Gastropoda accepted by HISINGER was raised to ten in his geological de-

[1]) In the »Acta Literaria et Scientiarum Sveciæ», Vol. III, Upsala 1738.

[2]) In the Transactions of the R. Swedish Ac. of Sciences.

scription of Gotland (Gottland, geognostiskt beskrifvet in Vet. Ak. Handl. 1826, p. 311). He enumerates 5 sp. of Helix (= Oriostoma) and 4 of Turbo, of which 8 had been some years ago described and denominated by WAHLENBERG in the memoir which further down shall be taken into due consideration. Himself he there only added Turbo sp. and Turritella meaning nuclei of Murchisoniæ. In the translation of his »Mineralogisk Geografi» in German by the renowned chemist FR. WÖHLER in 1826 the eight Helicites and Turbinites determined by WAHLENBERG are also enumerated on p. 228. In 1828 he published again in the fourth part of his »Anteckningar i Physik och Geognosi» the description of Gotland, which he gave in the Transactions for 1826, almost verbally with only a few additions. Thus there is the first figure, tab. VI f. 3, delineated as well as the others by Prof. P. F. WAHLBERG of Murchisonia compressa n. and of Pleurotomaria planorbis HIS. tab. VI f. 2, then named as Turbinites centrifugus. On tab. VI f. 6 there is under the name of Turbinites a variety of Platyceras cornutum. Helix obvallatus had been removed from the Gotland fossils and the number of species thus changed to nine. In 1829 »Esquisse d'un Tableau des Pétrifications de la Svède, distribuées en Ordre Systématique» appeared, containing 11 species, the same as before with addition of Delphinula funata Sow. (= Oristoma sculptum Sow. et others), D. subsulcata HIS. (= Or. globosum SCHLOTH.), Euomph. substriatus HIS. (Pleurot. planorbis HIS.), Euomph. costatus (a cephalopodous shell of the genus Trochoceras) and Turritella cingulata HIS. The names Delphinula and Euomphalus were then employed for the first time by HISINGER. In 1831 a new description of Gotland is given in the fifth part of »Anteckningar», and we there again find the same eleven species as enumerated before. But in fact there are only nine, as Euomphalus costatus is a Cephalopod and E. substriatus and centrifugus later by HISINGER himself were declared to be identical. New figures, good for the time, were given of several of them.

A new edition of »Esquisse d'un Tableau» was published in 1831 also with 11 species, the same as before.

HISINGERS greatest Palæontological work, »Lethæa Svecica», is commonly cited as published in 1837. But it seems that a part of it, from a quotation of BRONN in Vol. 3 of his »Handb. einer Geschichte der Natur, Nomenclator Bd I, p. XLI», where NILSSON is evidently an erratum for HISINGER, was already published in 1836 under the title »Icones petrifactorum Sueciæ, Fasc. I, tab. I—X., Animalia articulata et Mollusca Cephalopoda». In the Lethæa he describes 13 species, to which are to be added one more, from the »Supplementum Secundum» to the Lethæa 1840, thus making a total of 14 species, when Inachus costatus is excluded as a Cephalopod. These are as follows, viz.

Euomphalus cornu arietis = Oriostoma discors Sow.
Eu. alatus = Pleurotomaria alata.
Eu. æquilaterus = Pleurotomaria æquilatera.
Eu. catenulatus = Oriostoma rugosum Sow.
Eu. subsulcatus = Oriost. globosum SCHLOTH.
Eu. funatus = Oriost. sculptum Sow. & O. ROEMERI n.
Eu. supra angulatus = Oriost. angulatum WAHL.
Inachus angulatus identical with the preceding.
Inachus sulcatus = Pleurotomaria planorbis HIS.
Turbo striatus = Cyclonema striatum.

Turritella cingulata = Murchisonia cingulata p. p.
Turritella attenuata = Murchisonia attenuata.
Pileopsis cornuta }
Pil. sulcata } = Platyceras cornutum.

There are in reality thus thirteen species described by HISINGER in the Lethæa, when two out of the fourteen are identical with others and one, E. funatus, comprises two different species. Nor has this number been increased in the last publications of HISINGER, in the sixth part of »Anteckningar» and in »Förteckning öfver en Geognostisk och Petrificat-Samling från Sverige och Norige», printed in 1841. There is, however, the important corrections made that Turitella cingulata is considered to be a Pleurotomaria and that Murchisonia compressa is separated from it and referred to separately as »Stenkärnor af Turritellor», Leth. pl. 12, fig. 6 b.

In »Die Petrefaktenkunde» by SCHLOTHEIM (1820) there is only one of the the Gotland species described on page 162, Trochilites globosus, the type specimen of which I have had occasion to examine through the kindness of Professors BEYRICH and DAMES. It is the same that somewhat later was called Euom. funatus by SOWERBY.

GEORG WAHLENBERG describes in his »Petrificata Telluris Svecanæ», published in the »Acta Soc. Scient. Upsaliensis (1821), p. 68, *Turbinites cornu arietis*, which SOWERBY had already called Euomphalus discors and further

Turbinites alatus WAHL. is = Pleurotomaria alata.
Helicites catenulatus (p. 72) is = Oriostoma rugosum.
Hel. supra angulatus is identical with
Hel. angulatus = Oriostoma angulatum.
Hel. æquilaterus = Pleurot. æquilatera.
Hel. obvallatus »occurrit in Gotlandia rarius» = Pleurot. qualteriata p. p.?
Hel. obvallatus WAHLENBERG is different from Pl. qualteriata.

WAHLENBERG thus described in all six species, which were later adopted by HISINGER.

Professor N. P. ANGELIN, when a student of the University of Lund, distributed small collections of Gotland fossils under the title: »Museum palæontologicum svecicum» and a list of these is printed in the Danish »Naturhistorisk Tidskrift af KRÖYER», 2^d Vol. 1838. Amongst the 50 species there mentioned, we find *Euomphalus cornu arietis* (= Oriost. discors), but ANGELIN's specimens are Oriostoma Roemeri, *Euomphal. alatus* HIS = Pleurot. alata and *Littorina? striata* n. sp. In the existing copies of the »Museum» no specimens of the last species have been found and consequently the identity cannot be made out. In his works on the Palæontology of Sweden ANGELIN has not given any estimate of the numeric value of the Gastropoda. But he seems to have mentioned as his opinion to BARRANDE [1]) that the Scandinavian Upper Silurian beds were not so rich in these fossils as Bohemia, where BARRANDE then considered that he had 200 species, a number which is now manifold increased.

In his paper »On the Silurian Rocks of Sweden» [2]) Sir RODERICK MURCHISON also gave a sketch of the geology of Gotland. On page 29 he enumerates the following nine species of Gastropoda, viz.

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[1]) Parallèle entre les dépôts siluriens de Bohême et de Scandinavie, p. 59.
[2]) Quarterly Journal, Geol. Society of London 1847, p. 29.

Euomphalus discors, *rugosus*, *funatus*, *sculptus*, *carinatus*, *alatus* (Pleurot. alata), *Turritella obsoleta*, *Murchisonia corallii*, and *Turbo corallii*. The three last mentioned I have not been able to identify, as they have not been found in any one of the collections where MURCHISON and VERNEUIL in London and Paris have deposited the fossils they brought home from Gotland. As to Eu. carinatus Sow. I have through casts of the original specimens, received from Dr J. G. HINDE, ascertained that it is identical with the Gotland fossil described further down under the name of Pleurotomaria limata, as the name Pl. carinata was already before preoccupied.

G. VON HELMERSEN visited Gotland on a Geological tour in 1845, but it lasted till 1858 before he published a memoir on his observations, entitled »Geologische Bemerkungen auf einer Reise in Schweden und Norwegen». He enumerates in all 10 species: *Euomph. discors*, *rugosus*, *funatus*, *carinatus*, *alatus*, *catenulatus*, *Turbo striatus*, *Turritella cingulata*, *Murchisonia corallii* and *Natica inflata*. Of all these the last from Klinteberg is the only addition to those former known. He does not mention the author of that species, but it is likely that he thereby intended to designate a species described by F. AD. ROEMER in »Versteinerungen des Harzgebirges» tab. 7, fig. 8. Of all species found on Klinteberg there is none but Platyceras spiratum which comes near to ROEMERS species, though this is many times larger. I think then that HELMERSENS N. inflata must stand as a synonym to Pl. spiratum.

FRIEDRICH SCHMIDT made his researches on the palæontology and geology of Gotland in 1858 and published the results during the following year in a pamphlet, entitled »Beitrag zur Geologie der Insel Gotland» [1]). He enumerates 22 species of Pteropoda and Gastropoda. But his Euomph. cornu arietis must be removed, as he also mentions E. discors and his Patella sp. has since been found to be identical with Pholidops. Then there remain 20 species and they are:

Conularia Sowerbyi = Con. cancellata SANDB.
Theca anceps = Platyceras enorme.
Pileopsis cornuta } = Platyceras cornutum.
Natica parva }
Bellerophon dilatatus *.
Belleroph. aymestrensis *.
Pleurotomaria articulata = ? Murchisonia moniliformis n.
Murchisonia cingulata = M. compressa n.
Turritella obsoleta *.
Euomphalus catenulato aff. *
Euomph. sculptus = ? Oriostoma sculptum Sow.
Euomph. catenulatus = Or. rugosum Sow.
Euomph. funatus = Oriostoma globosum SCHLOTH.
Euomph. discors = Or. discors Sow.
Inachus sulcatus = Pleurotom. planorbis HIS.
Inach. angulatus = Oriost. angulatum.
Turbo striatus HIS. = Cyclonema striatum.
Trochus helicites = ? Pycnomphalus acutus.
Troch. coelatulus M'COY *.
Capulus calyptratus SCHRENK = Autodetus calyptratus.

BIGSBY gives in his Thesaurus Siluricus, 1868, in the lists of Gastropoda some Gotland species, which he copied from former authors. He has in all 30 species

[1]) Those marked * I have been unable to identify.

of Gastropoda from Gotland. But 23 remain, when seven are suppressed as partly duplicates [1]) and partly depending on misapprehension of the German terms of Helmersen [2]). These real species are in the main the same as given by Murchison, Helmersen and Schmidt and need not again be enumerated.

Finally in a small paper »Nomina fossilium siluricorum Gotlandiæ» published in 1867 I gave the names of 23 Gastropoda, but in reality there are only 19, as Eu. cornu arietis must be united with E. discors, E. supra angulatus with Inach. angulatus, Inachus costatus removed to the Cephalopoda and Acroculia sulcata united with A. cornuta. The remaining 19 are:

	Name in the present memoir.
Macrocheilus sp.	= Pleurotom. valida n.
Turbo striatus His.	= Cyclonema striatum His.
Trochus sp.	= Tr. gotlandicus n.
Euomph. alatus	= Pleur. alata Wahlenb.
Eu. discors	= Oriostoma discors Sow.
Eu. æquilaterus	= Pleur. æquilatera Wahl.
Eu. catenulatus	= Or. rugosum Sow.
Eu. subsulcatus	= Or. globosum Schloth.
Eu. funatus	= Or. Roemeri n.
Inachus angulatus	= Or. angulatum Wahl.
In. sulcatus	= Pleurot. planorbis His.
Pleurot. balteata	= Pleurot. labrosa Hall.
Holopella	= Loxonema sinuosum Sow.
Murchisonia cingulata	= M. compressa p. p.
Murchis. attenuata His.	The same.
Trochita calyptrata	= Autodetus calyptratus Schrenk.
Acroculia cornuta His.	= Platyceras cornutum His.
Bellerophon dilatatus	= Tremanotus longitudinalis n.
Subulites sp.	= S. ventricosus Hall.

To these must be added one more, viz. Theca sp., which was regarded as a Pteropod, but is identic with Platyceras enorme, and thus the number of species known in 1867 amounts to 20.

At the outset of this work only 20 or at the highest 23 species thus were known. The great increase is due chiefly to the material which had been accumulated during a long series of years in the Palæontological department of the Swedish State Museum of Natural History at Stockholm and the main part of information and most of the original types for the figures have been derived from that collection. But in preparing my work I have also been fortunate enough to have received contributions from many institutions and naturalists who have lent me specimens or whole collections for study and in other respects rendered me much valuable information. Prof. Walmstedt and Dr G. Holm have sent me all specimens I wanted from the Cabinet of the University of Upsala, Prof. Lilljeborg has given me free access to the Marklinian Collection in his charge; the late lamented Dr G. Linnarsson, his successor Dr A. Tullberg and Hr von Schmalensee have kindly lent me specimens from the Geological Survey of Sweden;

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2) Acroculia sulcata, Euomph. catenulatus, E. cornu arietis, Nat. inflata, Murchisonia articulata.

3) Bigsby did not see the meaning of Helmersen, when the latter in his lists has »Turbo (Steinkern)» etc. and Bigsby wrote »Turbo Steinkerni» and even »Euomph. Stinkerni».

Professor B. LUNDGREN has sent me specimens from the Museum of Lund and Lector STENBERG from the Museum of the town of Malmö, Prof. JOHNSTRUP in Copenhagen has sent me from the Mineralogical Museum of the University the whole collection of Silurian Gastropoda of Gotland formerly made by ANGELIN and others, Dr L. KOLMODIN, O. A. WESTÖÖ and M. KLINTBERG have lent me specimens from the Museum of the College of Wisby and also from private collections. From the Academician FRIEDR. SCHMIDT I received what he had collected in Estland and Oesel. Messrs JOHN GRAY in Hagley, JOHN E. LEE in Torquay, HENDERSON and JAMES SIMPSON, both in Edinburgh, presented to the State Museum specimens of English and Scottish Silurian Gastropoda. Good collections were also sent from Prof. A. H. WORTHEN in Springfield and Mr S. A. MILLER in Cincinnati together with information on American fossil Gastropoda. My thanks are also due for many good elucidations and specimens to Professors BEYRICH and DAMES in Berlin, P. T. CLEVE in Upsala, W. H. DALL in Washington, H. DOUVILLÉ in Paris, J. HALL in Albany, Dr J. G. HINDE in London, who kindly undertook to send me casts of some critical species, M. D. OEHLERT in Laval for a fine collection of Devonian fossils, Prof. FERD. ROEMER in Breslau, Prof. H. TRAUTSCHOLD in Moskwa, Lector S. L. TÖRNQUIST in Lund and Mr J. F. WHITEAVES in Ottawa, Canada. To all these friends I have to express the deep obligation under which I lie for their kindness to promote my work.

I have been most fortunate to have had the assistance of an excellent draughtsman, Hr G. LILJEVALL, in the execution of the plates. He has not only drawn on stone all the figures with the exception of the plates XV and XVIII, but also cleaned and prepared the original specimens before they were figured and he had his full share in our common interest for the work. His plates speak for themselves and are in no need of my praise.

PTEROPODA.

The fossil remains of the Upper Silurian Pteropoda of Gotland are by no means so common nor so characteristic of several beds, as are those of the Gastropoda. As I do not consider the Tentaculites as Pteropods in consequence of their close affinity to the fixed Cornulithes and similar, there is only one genus known.

Gen. **CONULARIA** Miller.

1818 Miller in Sowerby's Mineral Conchology III. p. 108.

Shell pyramidal, extremely thin, of several strata, each of these homogenous and transparent, brown or red; near the initial apex the shell is partitioned off by a transverse diaphragma. Apex often deciduous. Aperture narrow, partially closed by tonguelike prolongations from the corners. Side corners grooved or blunt. Along the middle of each face there runs from the aperture to the apex one or in some species two folds, which project only a little distance inwardly. In others they are totally wanting or represented by one or two longitudinal septa placed on the inner side. Surface ornamented by transverse ridges, smooth or tuberculated, forming an obtuse angle along the median line of the surface with its apex directed towards the aperture.

The systematic place of this genus and its allies has long been subject to some discussion and difference of opinion. Among the various opinions on the nature of Conularia may be annotated that it was ranged with the Cephalopoda by J. Sowerby, Bronn, F. A. Roemer, Blainville, G. B. Sowerby, Fleming, Hoeninghaus; this may partly have been occasioned by a false appearance of a siphuncle in the diaphragm, of which Hall still speaks as present in his Conularia trentonensis. D'Archiac and Verneuil seem to have been the first who considered Conularia as a Pteropod and they were in this view followed by D'Orbigny, Morris, De Koninck, Leonhard, G. Sandberger, Austin and almost all later naturalists.

Hæckel again, in his Morphologie vol. II, page cxiii, denies that the Conulariæ as well as the other palæozoic fossils hitherto presumed to be Pteropods belong to that group of Mollusca and he thinks that no true Pteropods are found in a fossil state anterior to the tertiary formations. In still stronger terms than HÆCKEL, NEUMAYR in his paper »Zur Kenntniss der Fauna des untersten Lias in den Nordalpen», Abhandlungen der K. K. Geologischen Reichsanstalt Bd VII Heft. 5 p. 18, also objects to the affinity of the Conulariæ with the Pteropods and he regards them rather as Gastropods nearly allied to the palæozoic Capulidæ [1]). But if we closer consider into this matter, there appear points of connexion between the Conulariæ as palæozoic presumed Pteropoda and the recent ones, which make it most likely that the questionable fossils really are Pteropods. First, as to the exterior shape, it seems very difficult to deny that the palæozoic Hyolithes and several of the recent, as for instance Cleodora australis RANG resemble each other in a high degree. There are also instances of a pyramidal shape in the threesided shell of Cleodora lanceolata RANG or Cleodora pyramidata and several others, Cleodora Deluciana forming an irregular sixsided pyramid thus making an approach to the foursided shell of Conularia. As to the peculiar transverse ornamentation of the last mentioned genus there are several instances of close resemblance to what obtains in Conularia lævis; as for instance in Cleodora balantium RANG (Balantium Childreni ADAMS p. p.) and others. Moreover, amongst the now living Pteropoda there is a sufficiently large amount of widely different forms, more so than in any other group of the mollusca, that it is almost unnecessary to talk about close correspondence in the exterior shape between species so widely apart in a chronological point of view as the Silurian or palæozoic and the recent ones.

If not the nature of the shell in Conularia did exclude all thought of their being Gastropoda allied to the thick-shelled Capulidæ, the presence of two peculiar longitudinal septa on the inner surfaces of the shell of some Conulariæ, as for instance C. bilineata and C. aspersa at once makes such a comparison impossible. Their presence, on the contrary, is a homology with the recent Pteropoda, amongst which several of the Cleodoræ and the Styliolæ are provided with quite similar septa. These septa do not occur in all Conulariæ, but are represented in many by one or more median, ingoing folds. When more specific forms shall have been found and there is more

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[1]) Lately also IHERING in his paper: »Die Aptychen als Beweismittel für die Dibranchiatennatur der Ammoniten» in N. Jahrbuch für Miner. und Geol. 1881, Bd 1 p. 87 insists that the Conulariæ are no Pteropods, but rather to be considered as Cephalopoda, analogous to Endoceras. Of course the thinness of the shell in most of the Conulariæ cannot in itself be held as a very valid argument for their relation to the Pteropods, but taken in connexion with the characteristic ornamentation of its exterior, with the remarkable longitudinal septa of the interior the aspect of the matter looks otherwise. The argument proferred that since the Palæozoic period no Pteropoda have been found before the Tertiary age is of no value. Since the year 1881, when IHERING published the statement given above, Conulariæ as well as Hyolithes have been detected in mesozoic formations and moreover the circumstance of a fossil form not having been found does not imply that it never did exist when the strata in question where formed. The same mode of reasoning might some time ago have been as well applied for instance to Chiton, of which then no specimens were known in the strata between the palæozoic and latest tertiary. The significance of the size in the palæozoic and the recent ones is not to be taxed as high as IHERING and his followers think. Nor can I find on what grounds IHERING enumerates HALL and SALTER amongst the supporters of his views. The former in his latest works at least places the Conulariæ amongst the Pteropoda, as well as SALTER in his posthumous Catalogue. DANA in the Manual of Geology makes the mistake to delineate the septum of Conularia with a siphonal opening. The presence of one or more diaphragms in this shell proves quite as little their nature of Cephalopoda as the occurrence of diaphragms in true Gastropoda or even other groups of animals (Serpulæ and others, Amplexus amongst Corals) prove anything for their being Cephalopoda.

ample material to work upon, these peculiarities in structure may serve to subdivide the Conulariæ in narrower circumscribed subgenera, as there are concomitant characters, for instance in the ornamentation.

As to the peculiar diaphragmas, which have been observed in so many Conulariæ near the apex, in some species one, in others several, there is nothing in this feature that is discordant with the interior structure of the Pteropods, in so many respects aberrant from the other Mollusca. In the genus Triptera QUOY & GAYMARD (Cuvieria RANG) [1]) there is a diaphragma or entire transverse septum near the apex, dividing the shell into one large chamber, where the animal is lodged, and one smaller, forming the empty tip and often deciduous, quite as it has been the case with Conularia, where the apex is gone below the septum. In consequence of what now has been stated, this genus Conularia may be left amongst the Pteropods, until some positive and decisive facts have been adduced, causing its removal into another systematic place.

There is, however, a species, C. fecunda, described by BARRANDE in his Syst. Silur. de Bohême, vol. III p. 38, which has an exceptionally thick and heavy shell, of many superimposed layers of shelly matter. Such a fossil may throw doubt on the Pteropodan nature of the whole genus. This species links another curious fossil, Tetradium FR. SCHMIDT, non DANA [2]), with the Conulariæ and makes it probable that it may stand in some affinity to them, though it not, as has been supposed, is likely to have been the operculum of some Conularia. It is quite as heavy and compact as C. fecunda and the anterior aperture has the side corners prolonged into hornlike spines. As to the interior tubular structure as shown by SCHMIDT in his fig. 8, and which according to him also is seen in Conularia, it may probably be derived from some parasitic fungus, as so often is the case and also may be seen further down in Tryblidium. In the specimens of Conularia, which I have examined, I have not hitherto found anything at all analogous.

In Sweden the Conulariæ make their first appearance in the Upper gray Orthoceratite limestone of the isle of Öland with a species, which is scarcely discernible from the later, which occur in the Chasmops limestone of Böda on Öland, in the younger Retiolites shale of Borenshult in Östergötland and, as it now seems likely, also in the Upper Silurian strata of Gotland under the name of C. cancellata SANDB.

Of this genus there are found in Gotland five species of which three are comparatively common, but of the two others only one specimen to each is known.

These species may be arranged in the following groups.

* Ornamental ribs thick with closely set tubercles.

1. C. cancellata SANDBERGER.
2. C. monile n.

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[1]) Description de deux genres nouveaux appartenant à la classe des Ptéropodes, Ann. Sc. Nat. Tome XII p. 324.

[2]) SCHMIDT Miscellanea Silurica II. in Mém. de l'Acad. Sc. de St. Petersbourg VII Ser. Tome XXI. N:o 11 p. 42.

** Ornamental ribs smooth.

3. C. lævis n.

*** Ornamental ribs extremely narrow and close with microscopically minute tubercbles. Two median septa along the faces.

4. C. ilineata n.
5. C. aspersa n.

1. **Conularia cancellata** Sandberger.

Pl. I fig. 1—3.

Conularia	*quadrisulcata.*	1824.	Dalman (not Sow.) Vet. Akad. Handl. 374, tab. IV f. 3.
»	»	1828.	Hisinger Anteckningar hft. 4; 72, 236.
»	»	1829.	Id. Tableau des pétrif., 8.
»	»	1831.	Id. » » Ed. 2, 6.
»	»	1837.	Id. Lethæa Suecica, 30, pl. X f. 5.
»	»	1839.	Sowerby in Murchison Silurian Syst. II, 626, pl. XII f. 22.
»	»	1840.	His. Anteckn. VII, 70.
C. Sowerbii.		1843.	Morris Catal. Brit. Foss. 168.
»		1845.	Verneuil in Murchis., Vern. & Keyserl. Russia vol. II, 348, pl. 24 fig. 5 a—b.
»		1854.	Morris Catal. Brit. Foss. 2d Ed. 232.
»		1855.	Salter Appendix to Sedgwicks British Palæozoic Fossils, VI.
»		1858.	Fr. Schmidt Untersuch. Silurform. Estlands, 209.
»		1859.	Salter Siluria 3'd Ed., 550, pl. 25 f. 10.
»		1860.	Eichwald Lethæa rossica vol. I, part II, 1052.
»		1867.	Etheridge in Siluria 4:th Ed., 534.
»		1867.	Lindström Nomina fossilium Gotlandiæ, 23.
»		1873.	Salter Catal. Cambridge Sil. Fossils, 67, 153, 171, 185.
C. cancellata		1847.	Sandberger Neues Jahrb. f. Min. & Geol., 20 (= C. quadrisulcata Sil. Syst.)
»		1848.	Bronn Nomenclator, 327.
»		1855.	Mac Coy in Sedgwick's Brit. Palæoz. Rocks, 287.
»		1867.	Etheridge in Siluria 4:th Ed., 534.
»		1869.	Heidenhain Graptolithführende Geschiebe der norddeutschen Ebene. Zeitschr. d. Deutsch. geol. Ges., 162.
C. curta.		1847.	Sandberger N. Jahrb., 14 (= C. quadrisulcata Dalman, His.)
»		1848.	Bronn Nomenclator, 327.
C. crenijugata.		1847.	Sandberger N. Jahrb., 19 (= C. Sowerbyi Vern. and Morris).
»		1848.	Bronn Nomenclator, 327.
C. proteica		1854.	Barrande Neues Jahrb. f. Min. & Geol., 2.
»		1865.	Id. Défense des Colon. III, 41.
»		1867.	Id. Syst. Sil. Boh. III, 48, pl. 5—6.

Shell conical, quadrilateral, but so much compressed from the sides, that it looks almost bilateral, two of the four faces being on the same side, divided through a deep furrow, which runs exactly along the median line of that side from the aperture to the apex. The two other dividing furrows are situated at the exterior edges of the shell. A transverse section near the apex is in well preserved specimens rhomboidal, further down towards the apex elliptical or resembling the number 8, being deeply indented along the median axis of the sides by the lateral grooves. The four sides are each, near the aperture, prolonged into a broad tonguelike lobe, through which the aperture is much narrowed, as these four lobes nearly meet and only have a narrow opening between them. The shell is exceedingly thin and consequently wrinkled and much crushed, but still retaining the delicate details of its fine ornamentation. It consists of two layers, the inner one being thinner and of a paler colour. The colour is pale yellow and in some instances brownish. The transverse ridges of crenulations which adorn the exterior surface are five on a length of 2 millimeters, and bent in an obtuse angle upwards, towards the median axis of the side, in some the inclination being so feeble, that the ridge nearly has the form of a straight line. The longitudinal axis is not always exactly in the midst of the side, being in some specimens situated a little nearer the outer edge and thus dividing the face in two unequal moieties. The furrows between these ridges are nearly twice as large as them. The ornamentation of the ridges and the furrows varies with the distance from the apex. Near this the ridges are smooth without any indentations, but they are higher up first beaded by blunt tubercles, which from the middle of the shell take the shape of more or less blunt spines, as is shown on a magnified scale in figures 1—3. Each spine continues downward into the furrows in a sort of handlelike prolongation, obliquely slanting towards the median axis of the side and between these handles there are oval, excavated pits. The spines of the adjacent ridges, as seen in figures 1—2, are arranged in alternating position; every second row having its spines above each other and placed opposite to the interstices of the two nearest, below and above. In a longitudinal section therefore, as figure 3, there are seen alternating long and short spiny projections, the long ones being real spines, the shorter again the next ridge, cut through in a spot between two of its spines. The spines are interiorly hollow towards their base and consequently, when the point is broken off, as often happens, an annular opening is formed. The septum, which is situated near the deciduous apex and closes the shell, when the apex is gone, is smooth and glossy, of the same pale yellow colour as the shell and covered by a few irregularly concentric lines.

Dimensions. Height 44 millim., breadth of a face near the aperture 16 millim.; fragment of another face 23 millim.

Occurrence. It has been found in the oldest shale beds (*a*) in Fårö at Kyrkviken, and other localities, in the lowest beds at Hallshuk, on the shore south of Gnisvärd, and at Djupvik in Eksta. It has also been collected in the overlying limestone of Lansa in Fårö, Snäckgärdet and Vattenfallet near Wisby. It is most common in Fårö, from where the State Museum possesses nearly 30 specimens.

This species has a wide distribution in time and space. I cannot distinguish the specimens occurring in the Upper gray Orthoceratite limestone of Öland, in the Chasmops limestone and in the Retiolites shale at Borenshult from the Upper Silurian species [1]). There are only small variations depending on the state of preservation and others of mere subordinary value. Nor can I find any specific distinction between the English and Bohemian specimens, which I have seen, and the Swedish ones. The beautiful plates of BARRANDE moreover are decisive. It is unaccountable how this species has been so often named as C. Sowerbyi DE FRANCE. In vain I have searched in

[1]) For an elucidation of the various groups of the Swedish Silurian formation, mentioned here and elsewhere in this memoir, see Appendix A.

the »Dictionnaire des Sc. Nat.» where it is stated that DE FRANCE has named it. I only find in vol. 32 p. 193, article »Mollusques», which is entirely written by BLAINVILLE, »Conul. Sowerbii DEFR. Dict. des Sc. nat., Fossiles», but on turning to that article nothing at all is found concerning Conularia. The accompanying figures are exact copies from the Mineral Conchology of SOWERBY of his C. quadrisulcata, which no doubt is a Carboniferous species. C. Sowerbyi is consequently a synonym of this species and not of the Silurian one. When thus neither the name C. quadrisulcata nor C. Sowerbyi can be employed, we are obliged to adopt the next in chronological order and then we have three described, all at the same time, by SANDBERGER. But these three species, cited above, are only synonyms. Of these I have chosen C. cancellata as being given to the species of the »Silurian System». C. curta has the priority but is very unappropriate and seems to be founded on a spurious specimen. As SALTER, App. Brit. Pal. Fossils p. VI, remarks, the Devonian C. Gerolsteiniensis D'ARCH. & VERN. is so nearly related to this, that it may be considered as a variety.

Amongst the American Conulariæ, described by HALL, C. trentonensis, Pal. N. York vol. 1 p. 222, possibly is the same as Con. cancellata. See also EICHWALD Leth. ross. 1 p. 1057 on Con. trentonensis.

2. **Conularia monile** n.

Pl. I, figs. 9—12.

Shell formed as a regular, foursided, narrow and elongated pyramid. The transverse section of the aperture is a regular quadrate having each of its corners inflected by a groove. The shell substance is comparatively thicker in this than in the other species and consists of an exterior, darkly coloured stratum, which is thicker than the interior thin and pale one. The ornamenting, transverse ridges, of which eight are contained within a length of 2 millim., are bent in an obtuse angle, larger than in any other Swedish species. Its apex is situated exactly on the median axis of the face. The interstitial furrows are quite as large as the ridges or a little narrower. The ridges near the apex of the shell are smooth or nearly so, higher up they are closely studded by narrow, elongated, laterally compressed or sharply edged lamellæ, ending in an accuminated point upwards and placed in oblique rows on the ridges, their lower apex turned against the median axis. The intervening furrows are quite smooth. On the nucleus, where the shell has been destroyed, there is an impression of a median ridge, nearly one millim. broad. It runs on the inside of the shell along the median axis of each face, thus corresponding to the line which may be thought combining all the apices of the angular ridges on the outside. It forms consequently a blunt, longitudinal ridge on the interior wall of the shell. Height 24 millim., diameter at the aperture 14 millim., diameter across the lower broken end 5 millim., diagonal line at the upper aperture 14 millim., diagonal at the lower end 6 millim. Found only once in the limestone strata *b* near Wisby.

3. Conularia lævis n.

Pl. I figs 13—16.

Shell regularly pyramidal, foursided, elongated and narrow. Transverse section of the aperture quadrate, the four faces being of the same size or nearly so. Owing to the deep furrow along the middle of each face the outline of the transverse section becomes nearly quadrilobate. The shell substance is thicker than in anyone of the other species. It is glossy, brownish yellow and an exterior thicker stratum covers the interior one, which is paler and thinner. It is transversally wrinkled by irregular folds, curved upwards in a gentle arch, sometimes large and sometimes narrow. In some specimens there are only faint traces of such wrinkles and the shell is almost smooth, even for long distances. The wrinkles are often not continuous across the deep, longitudinal furrow, which divides each face into two halves, but are in pairs, which do not always exactly correspond with each other, the opposite ones not being placed on the same level. Besides these wrinkles there is no other ornamentation excepting smaller and finer striæ parallel to the wrinkles. The longitudinal median furrow is, as already mentioned, uncommonly deep, but there are no vestiges of any septum, connected with it on the inside as in some other species. The grooves in the corners are entirely smooth and the transverse folds cease ere they reach them.

Height of the most complete specimen 27 millim., diameter at aperture 12 millim., diagonale 14 millim., diam. of the broken apex 4 millim. A fragmentary specimen from a detached block of the white limestone of the stratum *c* measures 35 millim. in length, 13 millim. in breadth.

It has been found in several specimens in Fårö, in the limestone of Bara hill, near Wisby in the middle limestone stratum, *b*, and in the passage bed with Pterygotus between the strata *b* and *c* and lastly in the limestone with Rhizophyllum near the church of Lau.

This beautiful species, so dissimilar to the other Gotland species is nearly related to the English Lower Silurian (Caradoc) C. lævigata SALTER Mem. Geol. Survey, III, 354, which, however, is rhomboidal in its section. The Bohemian C. pyramidata HOENINGHAUS (BARRANDE. Syst. Sil. Boh. vol. III, p. 50, pl. 2 fig. 1—6) is much larger, but of the same tapering, straight pyramidal form and has the wrinkles unequal. A much later species, the Con. missourensis SWALLOW from the Carboniferous formation, comes also very near to C. lævis.

4. Conularia bilineata n.

Pl. I figs 4—8.

Shell regularly foursided, pyramidal, but short in proportion to its broad basis. Two of the sides are larger than the others and the opposite sides are of the same size. The section of the aperture is rectangular with the corners rounded and a little bent in by the grooves. The substance of the shell is extremely thin, quite as much as in the following species, and seems to consist only of a single stratum, which has a chestnut brown colour. The outer surface is very finely striated by arched, almost microscopically minute, transverse lines. They form a gentle curve, highest at the median, longitudinal axis of the face and lowest at the corners, where they again are slightly bent upwards. They are so crowded as to be about 26 within a length of 2 millim. from the midst of the shell and upwards (fig. 7), but lower down, near the apex, they are more apart (fig. 6), that the interstitial furrows there are nearly thrice as large as the elevated lines. When these transverse lines are examined with high magnifying powers they are seen to be covered with closely set, elongated, oval tubercles (fig. 8), protracted into acuminated apices above and below. The interstitial furrows are quite smooth and glossy. What is most remarkable in this species is the presence of two longitudinal septa on the interior surface of each face. They are seen on the outside through the transparent shell, as two black longitudinal lines, which continue slightly diverging from each other, being one millim. distant near the apex and 3 millim. near the aperture, always on both sides of the median axis of the face. They project a little inward in the cavity of the shell, as seen in fig. 5 and they correspond evidently with the single ridge of which there is a faint trace in Conularia monile and are probably also homologous to the longitudinal septum of the recent Styliola. — Height 40 millim., breadth at aperture 32 millim., shorter diam. of same 28 millim., diagonal 35 millim., breadth at apex 5 millim. Hitherto only one specimen has been found in the shale beds at Lansa in Fårö.

5. **Conularia aspersa** n.

Pl. VII figs 1—3; pl. XIX fig. 1.

Shell tapering, conical, probably regularly pyramidal, but this cannot be ascertained as the extreme thinness of its substance has caused that it has been preserved only in compressed and wrinkled specimens and consequently the outlines of only one face is laid in view, when the soft, marly limestone in which it is enclosed, is split open. Although the thin shell is bent in many creases and wrinkles, its delicately ornamented surface is beautifully clear and distinct. Along the median axis of each face there run two straight, nearly parallel septa, visible on the outside as dark narrow lines. There are absolutely no ingoing folds on the exterior surface, where they are situated, what is so common in other species except the preceding one. They slightly deviate in their course upwards and are nearly two millimeters apart near the aperture. The transverse rows of the ornamental tubercles are more closely set than in the preceding, nearly related species. They number as many as 14 along a longitudinal line of one millim. Being so close, they with their tiny tubercles give the surface a chagreened appearance. The tubercles are nearly circular knobs with the interstices confusedly streaky. The colour is dark brown or chestnut.

Length 51 millim., breadth near aperture 25 millim.

Several specimens have been found in the Pterygotus beds between the middle and superior limestones at Vattenfallet near Wisby.

This and the preceding species form a division of their own with two septa on each face and the microscopically minute ornamentation. Among coëval species the Bohemian C. munita is somewhat resembling.

GASTROPODA.

Fam. I CHITONIDÆ Guilding.

Gen. **CHELODES** Davidson & King.

1867 *Chiton* Barrande Syst. Sil. de Bohême vol. III p. 175.
1874 *Chelodes* Davids. & K. Qu. Journ. Geol. Soc. p. 167.

Valves oblong, generally longer than broad; no laminæ of insertion nor sutural laminæ; apical area of the inside highly developed.

It was only with some hesitation that I placed these curious fossils, of which there are at least two species, amongst the Gastropoda as a genus of the Chitonidæ. Led astray by some superficial points of resemblance I at first mistook them for one of the aberrant group of the Brachiopoda, the Trimerellidæ, and accordingly sent the material I then could dispose of to Mr Davidson, when he jointly with Prof. King was working out a Monograph on that group. They described the only form which was then known as Chelodes Bergmani[1]), stating that it was none of the Trimerellidæ, but that it rather should be considered as belonging »to a section of the Coelenterates, represented by Calceola and Goniophyllum». The authors do not expressly say whether it should be regarded as the polyparium itself or as the operculum, but it seems most likely, that they have thought the last to be the case. There is, however, no coral in the Silurian formation of Gotland that possibly could have been provided with an operculum of so peculiar a shape. The form of the calyx at its aperture is generally circular or polyëdric, never assuming such an outline as Chelodes shows.

There is not the least doubt that these questionable fossils belong to the same genus as those which Barrande in the third volume of his grand work »Système Silurien de la Bohême p. 175, pl. 16 fig. 19—28 has figured and named Chiton Bohemicus. Besides this there are several other palæozoic fossils of almost the same shape, which have also been referred to the genus Chiton. Closely related to the Silurian ones are some detached plates, which Kirkby has described and figured with some hesitation

[1]) Qu. Journal Geol. Soc. 1874, p. 167.

as belonging to his Chiton? cordatus[1]). It may now be questioned whether all these similar fossils truly be remains of Chitons or not. What most strongly militated against their belonging to that family of Gastropoda was the circumstance that they are all entirely wanting the characteristic two apophyses or sutural laminæ which are situated in the anterior margin of the plate and believed to be present in all recent Chitons and in almost all the palæozoic ones described by DE KONINCK, RYCKHOLT, KIRKBY, BAILY, SALTER and SANDBERGER. In the Gotland specimens and, as far as one is able to judge from the figures and descriptions of BARRANDE and KIRKBY, also in the Bohemian and the supposed median plates of Chiton? cordatus there is not the least trace of there ever having been any apophyses. Nor does the elongate shape of the plates, generally longer than broad or often of the same height as breadth, agree with the transverse form of the plates so common amongst the recent and fossil Chitons. As KIRKBY remarks (Qu. Journ. Geol. Soc. vol. 15 p. 617) there is, however, one of the recent Chitons, Ch. hastatus Sow.[2]), in which the intermediate plates bear a close resemblance to the palæozoic ones. Moreover, in the recent genus Leptochiton CARPENTER, now confined to the arctic and temperate seas, there is an approach to the plates in the palæozoic Chitonidæ as they are without any laminæ of insertion, but mostly provided with sutural laminæ[3]).

On the inside of the plates of Chelodes there is also a feature, which is by far not so prominent in Chiton. At the pointed posterior end of the inside is a large triangular area, covered by transverse, parallel, curved lines of growth. In Chelodes Bergmani, for instance, it occupies a little more than half the length of the plate. A similar, I should be inclined to say a homologous, area is seen on quite the corresponding place in the more recent Chitons, although it there in most of the transverse plates is restricted to a narrow stripe. In others again it occupies nearly a third of the total length of the plate. It seems hardly to have received all the attention it deserves, even not by such an accurate monographist as MIDDENDORFF. It is evidently with this part of the interior surface that the plates posteriorly overlap each other and which consequently is not covered by the tissues of the animal. By the continued growth of the plate this area must be enlarged, when the soft tissues retire and a new line of growth is added to it. The mode of formation of the interior apical area of Chelodes has in all probability been the same, although it is enormously more developed than in most Chitons, perhaps only having its counterpart in Chit. hastatus.

Excepting the Chitons there are no other shell-covered animals with which Chelodes may be compared than the Lepadidæ. Amongst the numerous valves, which form the integument of the Lepadidæ there are only two or three regularly formed, whilst all the others are more or less oblique. There is indeed some similarity be-

[1]) »On the permian Chitonidæ». Qu. Journ. Geol. Soc. vol. 15 (1859) p. 616, pl. 16 figs. 25—26 and also in the Geological Magazine vol. 4, p. 341, pl. 16 figs 11a—11b, where KIRKBY and J. YOUNG describe the Chitons from the Carboniferous strata of Yorkshire and Western Scotland.

[2]) REEVE Conchologia Iconica, vol. IV, pl. 25 fig. 166 and plate showing details of sculpture, enlarged fig. 166.

[3]) DALL, H. W., the results of the recent investigations into the Natural Hist. of the Chitonidæ. Smithsonian Miscellaneous Collection, vol. XX, p. 193.

tween the valve which DARWIN calls rostrum[1]) and Chelodes. This is evident if we for instance compare the rostra of the genus Scalpellum DARWIN, Lepadidæ pl. VI, figs. 6a, 7a, 8a, and amongst the fossil ones Pollicipes Nilssoni DARWIN, Fossil Lepadidæ, Pl. III fig. 11 d, and it seems indeed very likely that some of them really have been mistaken for Chitons and figured by KIRKBY in the paper cited above. The general outline is almost the same and on the inside there is also an apical area, composed of concentric lines of growth. This area seems, however, not to have been formed in the same manner. In the Chitonidæ and consequently also in Chelodes its superior or youngest margin is always elevated above the upper or distal part of the interior face, as is also the whole area; in the Lepadidæ again the area is generally lower than the other surface. If Chelodes were a Cirrhipedian, it would be in the highest degree strange if only one valve, the regularly formed rostrum, had been preserved and not a single one of the others, which are at least six in number, but in some species much above hundred.

A quite different conjecture as to the nature of this fossil is given by IHERING in his paper on Aptychus[2]). He there, page 70, says »that it is at least to me highly probable that what BARRANDE has described as the plates of Chitons, in the reality are Aptychs of Silurian dibranchiate Cephalopoda». He continues, that if they are derived from Chitons, they can be interpretated only as the final plates and it is strange if only these were preserved of all eight plates. Against this is to be remarked first that the plates figured both by BARRANDE and by me are not all identical, but of different orders, secondly that in the recent Chiton hastatus the plates are quite as acuminate and elongated relatively as in the Silurian ones. Moreover, the conformation of the inside, which was unknown to IHERING, removes these fossils from Aptychus. As to the microscopical structure, on which IHERING justly lays so much stress, there is unfortunately no guidance to be had, as the chief mass of the very thick plates of Chelodes has been converted into clear, transparent calcareous spar.

What, for the rest, adduces me to range Chelodes, at least provisionally, with the Chitonidæ, notwithstanding all that has been said to prove its similarity with other groups, is the circumstance that the exterior ornamentation of the plates is in complete accordance with that of the Chitonidæ. Moreover, there is at least one ascertained instance, in which valves of the palæozoic Chitons, also wanting apophyses, have been found in their *original* position. In the specimen of Chiton Grayanus, drawn on plate I fig. 1 of DE KONINCK's »Deux espèces siluriennes de Chiton», there are five valves in juxtaposition.

But if we now are to conclude that Chelodes is one of the Chitonids, it shows so great differences from the others, that it cannot belong to the genus Chiton proper, where BARRANDE placed it, but must form a genus of its own. Of all the palæozoic subgenera, no less than 13 created within the last twenty years,there is one, Sagmaplaxus OEHLERT[3]), which so nearly coincides with Chelodes that both may be con-

[1]) DARWIN Monograph of Cirrhipedia. Lepadidæ. Ray Soc.

[2]) Die Aptychen als Beweismittel für die Dibranchiatennatur der Ammoniten. N. Jahrb. für Mineralogie etc. 1881, 1 Bd Heft 1, p. 44.

[3]) Documents pour servir à l'étude des Faunes dévoniennes dans l'ouest de France in Mém. Soc. Géol. de France 3:me Sér. tome II, p. 15, pl. II, fig. 3, 3 a, 3 b.

sidered as ranging very near to each other. The author says expressly »il n'existe pas d'apophyses d'insertion à la partie antérieure». Its area is also described as large as that in Chelodes. Sagmaplaxus occurs in the »Dévonien inférieur de la Sarthe» and can indeed be said to be a more developed descendant of Chelodes. It is by far larger and longer than the latter.

1. Chelodes Bergmani Davidson & King.

Pl. II figs 1—8.

Chelodes Bergmani 1874. Dav. & K. On the Trimerellidæ etc. Qu. Journ. Geol. Soc. vol. XXX, p. 167, pl. 18, fig. 14—14 a—d.

Plates of conical outline, anterior margin straight or slightly emarginated or even convex, lateral margins continuing nearly parallel a little below the middle, then suddenly converging to form the acute posterior apex. Surface somewhat weathered, shows faint traces of punctuate ornamentation on the transverse lines of growth. These are most conspicuous near the lateral margins and they are parallel with the anterior margin of the plate. In a transverse section the plate has the shape of a crescent, being evenly arched, without any sinuosity on the back. The inside of the plate is divided in two parts, of which the posterior, occupying exactly half the total length, consists of the slightly excavated apical area. The transverse, gently arched lines of growth resemble narrow, low ridges or callosities, they are very numerous and dense and the whole area is raised a little above the anterior part of the valve. This is longitudinally divided in two portions by a well marked sinus, towards which the sides gently slope. This anterior surface is smooth, showing only indistinct traces of muscular impressions towards the lateral margins, being near the sinus coarsely and longitudinally wrinkled. All around the lateral margins of the interior surface there runs an elevated narrow border, formed, as it were, by the bending over of the exterior shell stratum. The plate is at its thickest in the median part and thins off towards the apex.

Height 20 millim., breadth 13 millim.; thickness in the middle 5 millim., at the apex 1,5 millim.

Two specimens have been found in the uppermost limestone of Klinteberg and a single plate in the oolite quarry near Gannvik in Grötlingbo.

2. Chelodes Gotlandicus n.

Pl. II figs. 9—27.

Plates cordate, with anterior margin deeply emarginated, posterior apex acuminated, lateral lines, combining anterior margin and apex, gently curved. The plates are generally longer than broad, much varying, as may be seen by the dimensions given below, some even being transverse. They have consequently been placed in different positions of the series. They are much more elevated along the median line of the back, than in the former species and the sides are more sloping. In a transverse section (fig. 23) they form a nearly right angle. The surface is deeply grooved by transverse ridges, coinciding with the lines of growth and separated from each other through narrow interstices. They exactly follow the same direction as the outlines of the anterior margin, being bent backwards at the lateral margins, then forwards and on the middle of the back again backwards, thus forming a sigmoid line. They are most conspicuous near the margins. There is a central area formed by two lateral, longitudinal grooves, which run nearer to the lateral margin than to the central ridge and converge towards the posterior apex. These grooves are conspicuous in a few specimens, being effaced by corrosion in the others. The exterior surface is moreover ornamented by numerous, minute wartlets, which are closely set in regular, transverse rows (fig. 15). On the inside of the valves there is seen, first the posterior apical area, which is of highly varying width, in some occupying nearly half the length of the surface, in others only a fourth (fig. 25) just as in a recent Chiton, of which a figure is given on plate II, fig. 28. Owing to the state of conservation of the specimens, the lines of growth are more obscure than in the former species. The whole inside is longitudinally divided into two halves by a deep sinus; the sides being more scooped out at the apical area, the side parts of the anterior surface being more tumid. No traces of muscular impressions are visible.

Specimen A height 18 millim., breadth 14 millim., B h. 11 millim., br. 12 millim., C h. 18 millim., br. 11 millim. In a specimen of 14 millim. in length, the greatest thickness of the plate is 3 millim.

This species is more common than the preceding and has been found in several specimens at Grötlingbo in the oolite quarry near Gannviken, in the sandstone of Bursvik, in the oolite near Rone and also in several detached plates in the limestone above »Kålens qvarn» near Wisby.

Fam. II. PATELLIDÆ d'Orbigny.

Gen. **TRYBLIDIUM** Lindström.

Syn. 1836. *Metoptoma* Phillips p. p. Geol. of Yorkshire pt. 2 p. 223.

1880. *Tryblidium* Ldm apud Angelin & Lindström Fragmenta Silurica p. 15.

Shell patelliform, obovate, anteriorly acuminate, posteriorly enlarged, forming a very low cone. Apex anterior, nearly marginal, with only very little area beneath. Margin of the ovate aperture arched, so that the animal, when fixed, was not entirely hidden beneath its shell. Muscular scars in six, disconnected pairs, arranged in an oblong circle, open or nearly so towards the front part of the shell. Intimate structure of the shell somewhat resembling that of the recent Patella, being composed of thin strata of polygonous cells.

This new genus, which I at first described in Angelins and my work »Fragmenta Silurica» p. 15, had by some palæontologists long been considered as belonging to the brachiopoda, though they did not publish their opinion. When we, however, compare one of the species, Tr. unguis, with recent forms of the genus Patella, it is quite evident that it both on exterior and interior grounds should be numbered amongst the Gastropoda and especially in the family of the Patellidæ. In plate I, fig. 38 there is delineated a recent species of the subgenus Nacella ADAMS from Foua, which as to its exterior shape, sculpture and colouring as nearly as possible resembles Tr. unguis fig. 33. And again if we turn to the interior muscular scars and compare figures 30 and 37 on the same plate with Patella cochlear L. fig. 32, there is, if we except some differences in the details, the same disposition of the six or seven pairs of those impressions. The species of this Silurian genus Tryblidium, and especially, such a form as Tr. unguis may then be added to the so called persistent types of HUXLEY, which as the Lingulæ and Craniæ amongst the Brachiopoda and Calostylis amongst the Corals have continued till our time with small or insignificant modifications in their structure. It is intermediate between the recent genera Olana and Nacella.

In the Silurian species the scars are disconnected and deep, the more so in the oldest form, »*Patella*» *antiquissima*, from the Swedish Lower Silurian, being approached, though separated, in the Upper Silurian species. In the recent Patellæ, the scars are in most species nearly connected, though it, especially on their inner margin, is possible to discern how they have been independent. This is the more evident, when we turn to the animal itself, where muscular pairs of variable number in the same species, from six to nine, are distinctly detached and free at least partially and do not form a continuous ring as in the Scutellidæ. As in Tryblidium the foremost pair is also the largest with the recent Patellæ, but there is the great distinction that both these last muscles of the living Patellæ are united through a narrow stripe of muscular tissue, forming an arched curve, also visible as a scar on the shell, whereas in Tryblidium the narrow stripes which are emitted from the large, foremost scars do *not* unite, but leave an open space between them. Characteristic to the foremost pair in Tryblidium is also the large appendiculated scar on their inner margin, of a peculiar reticulation, described more in detail below in Trybl. unguis. The change in this respect from the older to the recent Patellæ has thus consisted in the concentration of the once detached and entirely independent muscular scars.

In the »Palæozoic Fossils of Canada» BILLINGS has described a species of Metoptoma, M. Hyrie, p. 87, fig. 79, which comes near to Tryblidium unguis as far as may be judged by the exterior appearance. It is evident that BILLINGS in the cited work has enclosed within that genus too many species which do not show the characters given by its author PHILLIPS in »Geology of Yorkshire» pt. 2, p. 223 and that consequently only some of them are true Metoptomæ. MEEK and WORTHEN[1]) make the adequate remark, that later authors have given to that genus a greater extension than PHILLIPS intended. The new genus which I have proposed, differs from Metoptoma in wanting the broad truncated area below the apex. The muscular scars also differentiate these two genera, as there in Metoptoma, for inst. M. pileus PHILLIPS, according to DE

[1]) Proc. Acad. Nat. Sc. Philadelphia, 1866, p. 266.

Koninck in Descript. Anim. foss. de Belgique Supplem., p. 685, pl. 58, fig. 1, exists a coherent muscular scar, horse shoe shaped, with the apex of the shell towards its hind side [1]), whereas in Tryblidium there are six pairs of detached scars, and the apex anterior.

From the uppermost beds of the Lower Silurian rocks of Esthonia, at Borkholm, I have seen specimens of two species belonging to this genus, true forerunners to the two Upper Silurian ones; of these one can scarcely be distinguished from Tr. unguis, the other again very closely resembles Tr. reticulatum. From Raiküll in Esthonia, in Friedrich Schmidts stratum G 3, at the base of his Upper Silurian there occurs also a third species, allied to Tr. unguis, but regularly, transversally imbricated by equidistant lines of growth, and of an almost elliptical outline.

Mr I. F. Whiteaves, of the Geol. Survey of Canada, has recently [2]) described a »Tryblidium Canadense» from the Guelph formation of Canada. In respect to its exterior shape it might well be united with the Tryblidia, though it is more elevated, but the figures of pl. V, f. 1 & 1a show a narrow, continuous ring of muscular impression, quite unlike what prevails in the other Tryblidia and, moreover, there are below the apex two oval depressions different from anything seen in the Tryblidia. Till these points are cleared up, the Canadian species can only with hesitation be placed in that genus. Whiteaves also thinks that Metoptoma Niobe, M. Nycteis, M. Eubule, M. Erato and M. Hyrie Billings are typical species of Tryblidium. This can, however, not be finally settled, before the muscular impressions shall have been discovered.

Metoptoma Erato Billings »Palæozoic Fossils of Canada» vol. 1 p. 39, is near to Tr. unguis, but probably identical with the Esthonian species, as it is derived from the Lower Silurian stratum called »Black River Limestone». Nearly allied to this genus is also the Lower Silurian »Patella antiquissima» described by Hisinger and formerly found at Borenshult in the Retiolites shale. In outward shape it reminds of Palæacmæa Hall, and it is also like several of the Metoptomæ, but the six pairs of most beautifully preserved muscular scars place it near Tryblidium.

As to the first appearance of this group within the palæozoic era Ihering says in his »Anatomie und Phylogenie der Mollusken», p. 82, »ist doch so viel sicher, dass die palæozoischen Patelloideen Tecturiden waren», and further: »in der Primordialfauna sind schon die Tecturiden und Lepetiden vertreten», and he seems to confound the Patellidæ with the Patelloideæ, as he numbers Patella vulgata amongst them, nor does he anywhere mention the occurrence of the Patellidæ. But through the occurrence of the Tryblidia and other kindred genera, already present in the Lower Silurian we find, that the Patellidæ were also represented by numerous, well developed shells and consequently that both families, the Tecturidæ and Patellidæ coexisted.

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[1]) Nicholson again in his Handbook of Palæontology II p. 34 says that in Metoptoma »the muscular scars consist of a number of disconnected cavities».

[2]) Geol. & Natural History Survey of Canada. Palæozoic Fossils, vol. III, pt 1, pp. 30—31, 1884.

1. Tryblidium reticulatum Lindstr.

Pl. I figs. 25—31, pl. III figs. 1—5.

Tr. reticulatum 1880. Lindst. in Angelin & Lindström Fragmenta Silurica p. 15, tab. X, fig. 7—16, tab. XIX, fig. 9—12.

Shell much depressed and generally more flat than the following. Apex obtuse, erect, with a narrow, area-like zone between itself and the margin of the shell. Outline of the shell, when seen from above obovate, anteriorly acuminate, enlarged towards the posterior margin. The surface is ornamented by a series of thick, transverse and concentric, elevated laminæ, which in the anterior, third part of the shell intercross with each other and thus form an elegant network, but in the other two thirds of the surface are parallel, wavy, thin at the edges, thickened towards their base, and evidently formed by the margins of the shell bending upwards. In the oldest part, corresponding to the shell of the young, the callous, transverse lines are very fine and crowded. Around the apex there is almost always an oblong space more or less exfoliated. The exterior stratum of the shell is there worn away, making the interior yellow stratum alone visible. Sometimes there is the false appearance as of a foramen, which has been filled up again, but this is evidently owing to imperfect corrosion.

The aperture is obovate, the margins very thick, forming a callous border. When seen from the side the line formed by the margin is an elongated curve or an arch, highest along the middle of the shell and sinking towards both ends. The foot of the animal, when resting on its basis, must then have been left uncovered along the sides. On the interior surface, which is very smooth and almost glossy, there is a dark coloured circle, formed by six pairs of muscular scars, of which the foremost are the largest and nearly connected by narrow appendages, like stripes, almost as in the recent Olana cochlear. See plate I figs. 30, 32. Each separate scar is more elevated towards its curved interior margin and at its exterior margin they are lobate or lacerated. The foremost pair is the largest, composed as it were, of several parts, of which the innermost is elongated, elliptical, the exterior one irregularly square; from its anterior margin there projects, from each pair, a narrow stripe; these stripes do not unite, but leave between them a short space. The central surface, enclosed by the muscular ring, is excavated in shallow, arched depressions all along the interior border of the scars, being situated in the interspaces between these. The scars themselves are separated through narrow projections from the enclosed surface. Sometimes there are large concentric callosities[1]) due to the irregular growth of the margin, which cross the central field.

There are specimens still retaining traces of the original colour of the shell in dark longitudinal stripes, distinctly conspicuous on the other dull surface (f. 29).

As to its intimate structure the shell consists of two distinct strata, of which the exterior one easily peels off and the interior, in specimens from certain localities, is the only one left on the nucleus of the shell. The exterior stratum is thick, attaining as much as 5 millimeters in some parts. It consists of very thin laminæ which seem

[1]) Fragm. Silur. pl. XIX fig. 9.

to be composed of prismatic cells. Near the apex this outer stratum is entirely prismatic. It is generally of a whitish hue, contrasting with the interior one, which is yellow. The later is very thin, consisting of minute lamellæ of an apparently prismatic structure. A singularity in structure is that figured on pl. III f. 4, a longitudinal section, showing the extremely thin lamellæ perforated, as it were, by narrow tubes. These cannot, as the following, be extraneous, later formed organisms, but must have originated at the same time as the laminæ of the shell, as it is clearly seen that these laminæ are bent exactly where the tubes are situated.

Almost the whole exterior stratum is closely perforated by what seems to me to be a different, parasitic organism. When seen with a pocket lens of sufficient power the surface is pitted by a number of irregularly placed, cream-coloured points (pl. III f. 5) which are somewhat elevated above the surface. In a thin, vertical section these white dots are seen to prolong downwards through the lamellæ of the shell as tubes which generally branch or anastomose so as to form three or four or even more branchlets (pl. III f. 1), all filled with the same uniform cream-coloured matter. In a transverse section they are also remarked to subdivide and to form openings of stellulate appearance (pl. III f. 2). Similar fossil and recent organisms have been found already long before. DUNCAN [1]) has described some small microscopic organisms, which penetrate the corals of the Devonian and Silurian times. KÖLLIKER [2]) has also more in full described a great number of such minute, parasitic forms from several invertebrate animals. Thus he mentions nine species of Gastropoda with perforated shells and he makes the same conclusion as WEDL before him, that this is due to fungous growth or to the mycelium of microscopic fungi. The white radiating tubuli in the shell-substance of Trybl. reticulatum make the impression of having been at first open and then to have been filled with limestone of another kind. In the nearly related species from Esthonia no such tubes are visible.

Length 40 millim., breadth 25 mill., height from margin of aperture 8 millim.

Found in the northern strata of Gotland, in Fårö at Lansa, Lutterhorn, in the limestone of Wialmsudd near Fårösund, Svarfvare huk, in the canal at Westöös in Hall and in the uppermost limestone beds of Slite. It belongs only to the higher limestone beds of Gotland, possibly beginning at the top of b. In the Lower Silurian of Esthonia at Borkholm, F. SCHMIDTS stage 3, a variety of this species has been found, only distinguished by its thinner shell and finer reticulation, the interspaces between the callosities of the surface being nearly of the same, small size over the whole shell.

2. **Tryblidium unguis** LINDST.

Pl. I figs. 33—37, pl. XIX fig. 2.

Tryblidium unguis 1880. LINDST. in ANGELIN & LM Fragmenta Silurica p. 16, pl. II, fig. 10—14, excl. fig. 15.

Shell of obovate outline, anteriorly acuminate, posteriorly expanded, with the greatest breadth somewhat behind the median, transverse axis of the shell. It is re-

[1]) On some unicellular Algæ parasitic within Silurian and Tertiary Corals. Qu. Journ. Geol. Soc. 1876, p. 205.

[2]) Ueber das ausgebreitete Vorkommen von pflanzlichen Parasiten in den Hartgebilden niederer Thiere. Zeitschrift f. wissensch. Zoologie 10r Bd 1860, p. 215.

gularly and moderately convex, being most elevated near the median transverse axis. The apex is close to the anterior margin and only very little prominent. The surface of the shell is covered with thread fine ornamental lines parallel to the regular concentric lines of growth, somewhat interrupted by deeper sulci. It is generally even excepting some wavy, irregular, shallow, longitudinal furrows. The aperture is oval with comparatively thin margins, somewhat reflexed outwards. When seen from the side it forms a moderately elevated arch, being highest near the median line of the shell. The central space of the interior surface is surrounded by an oval ring of six pairs of muscular scars, open anteriorly. The posterior ones are narrow and elongate, the middle ones are transversally broad and much enlarged towards the margin of the shell. The surface of these pairs is smooth or only partially scrobiculated. The uppermost pair is more complicated and consists, as in the kindred species, of a more shallow, elongated interior portion, and of a larger exterior one, from the inner corner of which there projects a narrow sinuous groove, directed obliquely upwards and leaving a small, smooth space between itself and the opposite similar one. The lower, interior part of this upper, muscular scar is pearshaped, wide below, with a narrow, stalklike neck upwards and its surface is finely reticulated by shallow pits and intervening ridges. Some dark, narrow streaks are directed from the enclosed central space of the shell towards the interstices between the muscular scars. The whole central part of the shell inside the scars and to their outer edges is of dark colour, while the outer border is lighter. Near the apex there is on the inside a little oval depression or pit, which quite resembles a scar, filled up, as if there had been a foramen. But I think it is in reality only the mark of the outlines of the initial shell, where now the apex is seen on the outside. The shell is very thin, scarcely exceeding 0,5 millim. in thickness and composed of thin, glossy lamellæ, which are not perforated by any parasite. The largest specimen has been found at Stor Wede in Follingbo and has attained a length of 67 millim., breadth of 51 and height of 15 mill.

This species has nearly the same geographical distribution as the former. It has been found in several specimens in Fårö at Lutterhorn, Lansa and Norsholm, in Svarfvare huk, the canal near Westöös in Hall, Westkinde, Häftingsklint, Lummelund, Stor Wede in Follingbo, the limestone cliffs near Wisby and Kyrkberget in Wisby. It has only been found in the strata *b* and *c* or the upper and lower limestone and never in the shale of *a*. This is rather unexpected as the same species or at least a nearly allied variety, as mentioned above, has been found in the Lower Silurian strata of Esthonia at Borkholm and also in the Upper Silurian at Koik, in the »Jördensche Schicht». These are only a little more elongate and not so enlarged as the specimens from Gotland. In the Lower Silurian of Canada there occurs a Metoptoma Hyrie, of which BILLINGS, Pal. Foss. Canada p. 87, has described a cast which also perhaps on closer examination may be found to be identical. Met. Erato of the same author, l. c. p. 39 and Report Progr. Geol. Survey of Canada 1863 p. 145, f. 95, can scarcely, as to outward shape, be distinguished from the Gotland species, only the distance from the beak to the margin is longer in the Canadian.

3. **Tryblidium? radiatum** n.

Pl. XVIII fig. 1, 2.

Shell oval, much elevatedly conical, the greatest height lying near the middle of the longitudinal axis. The apex anterior, truncated, curved as to lean forwards over the anterior margin of the aperture. The shell between the apex and the margin is consequently much concave. The apertural border is straight and horizontal. The surface is covered by fine, closely packed, radiating striæ and a few concentric lines of growth. The shell has been thick, as may be seen by a few fragments which are left along the borders. The general shape of this shell has led me to place it in this genus, with the other species of which it corresponds as to its outline. This is, however, more elevated like a Helcion.

Diameter from the apex to the hind edge 24 mill. The transverse diameter 20 millim. Height from the rim of the aperture 15 millim. Length of the aperture 23 mill.

Only a single specimen has been found in the crystalline limestone of Wialmsudd near Fårösund.

Fam. III. TECTURIDÆ Adams.

Gen. **PALÆACMÆA** Hall.

1873. 23d Rep. on the State Cab. of N. York p. 242.

Shell patelliform, aperture oblongate, exterior surface concentrically wrinkled, on the interior surface near the top a wreath of muscular impressions, nearly coherent.

It is only provisionally that the Gotland species, described below, can be placed within this genus. It is chiefly in consequence of its outward shape, which most resembles that of Palæacmæa. In Hall's specimens the muscular markings are unknown. The Patelloid shells which are now and then found in the older palæozoic strata belong probably to several different genera. The »Patella» antiquissima from the Lower Silurian of Sweden is nearly related to Tryblidium through its series of six pairs of detached muscular scars. The typical species of Metoptoma, which as De Koninck has shown have a coherent muscular band and consequently cannot, as Hall l. c. has hinted, be plates of a Chiton, agree with Lepetopsis in the conformation of this band. In the Red Orthoceratite limestone of Öland at Wickleby Hr von Schmalensee has found a specimen resembling a Metoptoma and another form probably belonging to the same generic group of which Whitfield has given figures in Geology of Wisconsin, vol. IV pl. 3 f. 15, 17, 18, but which scarcely can belong to Metoptoma as he assumes. The oldest Gastropod known in Sweden is Metoptoma Barrandei LINNARSSON from the Cambrian strata of Scania, in the lower portion of the zone of Paradoxides Tessini.

Palæacmæa? solarium n.

Pl. XIX fig. 3, 4.

Shell patelliform, regularly acuminate, apex nearly median or slightly anterior, the outline oblongate from above. Outside of the shell smooth, only concentrically wrinkled at regular distances by larger elevated ridges, the interstices between them being finely striated by parallel lines. Interiorly there is around the apex a narrow circle of detached muscular scars, visible on the nucleus as delineated in the figure. Height 3 millims., length 6 mm., breadth 4 mm.

Hitherto two specimens have been found in the red, conchiferous limestone of Sandarfve kulle.

Fam. IV. CALYPTRÆIDÆ BRODERIP.

Gen. PLATYCERAS CONRAD.

1809 *Helicites* MARTIN Petref. Derbyensia, pl. 40 fig. 43.
1810 *Capulus* MONTFORT Conch. System. II, 54; though not intended by him for fossil species, it was adopted for such by DE KONINCK Anim. Foss. de Belgique, 331.
1812 *Pileopsis* LAMARCK adopted by SOWERBY Min. Conchol. vol. VI pl. 607, 223.
1823 *Actita* FISCHER VON WALDHEIM Mém. Soc. Imp. Naturalistes de Moscou VI, 234.
1828 *Turbinites* HISINGER Anteckningar IV, 221.
1840 *Platyceras* CONRAD Ann. Rep. Geol. Surv. N. York, 205.
1841 *Acroculia* (rectius Acrocylia) PHILLIPS Pal. Foss. of Cornwall, 93.
1842 *Platyostoma* (rectius Platystoma) CONRAD Journ. Acad. Nat. Sc. Philad., 275.
1843 *Orthonychia* HALL Rept. 4th Distr. N. York Geol. Survey, 172.
1844 *Naticopsis* MAC COY p. p. Synops. Carb. Foss. Ireland, 33.
1859 *Strophostylus* HALL 12th Rept. State Cab. N. York, 20.
1859 *Igoceras* HALL Pal. N. York vol. III, 330.
1868 *Exogyroceras* MEEK & WORTHEN Geol. Survey Illinois, vol. III, 508.
1878 *Capreolus* R. ETHERIDGE SR. (lapsu!) Qu. Journ. Geol. Soc., vol 34, 603.

Shell globose or naticiform with small, depressed or only moderately prominent spire, last whorl enormously developed, globose or transversally protracted and elongated. Aperture circular or oval, outer lip reflected and enlarged into a thin laminar edge, which in well preserved specimens is persistent during the continued growth of the shell and gives the exterior surface a characteristic ornamentation of projecting, thin laminæ. The inner lip of the aperture much varying; sometimes with twisted (»Strophostylus»), sometimes thin and smooth columella (»Platyceras»). No operculum has ever been found.

In justification of the above list of synonymous genera the following statements of the opinions of various authors upon this matter may be adduced. The earliest description of any fossil belonging to this group is in MARTINS Petrificata Derbyensia plate 40 fig. 34, where he names a Carboniferous species as Helicites auricularis. Next him FISCHER VON WALDHEIM comes, who in 1823 in a list on the genera of Gastropoda gives Actita as identical with Capulus and Pileopsis. This is in a treatise called »Adversaria zoologica» Fasciculus III in the Mém. de la Soc. impér. des Nat. de Moscou vol. VI p. 234. That he therein also included the palæozoic species is evident, when he later in a paper of FAHRENKOHL in »Bull. de Moscou» 1844 p. 802 describes an Actita Münsteriana from the Carboniferous limestone of Moscow. If FISCHER really intended this genus for the palæozoic forms alone, his name ought to have the priority against the later, as Platyceras, but it is by his first publication evident that he gave his genus quite as wide limits as already had been given to Capulus and Pileopsis. Actita then must be considered only as a synonym. In 1828 HISINGER in his Anteckningar, pt. 4, p. 221 mentions a Turbinites, which he also figures, and this is the same which he later, 1837, in »Lethæa» named Pileopsis cornuta. In respect of the genus he follows the elder SOWERBY, who 1835 in his Mineral Conchology placed the English Carboniferous species in the genus Pileopsis. When CONRAD in 1840 had founded his genus Platyceras for the palæozoic fossils of this group and PHILLIPS in 1841 his genus Acroculia [1]) for the same, the subsequent American authors sided with their countryman, and the English ones with their, in spite of the former name having the priority and that with such a tenacity that it lasted until 1851 when S. P. WOODWARD in his Manual accepted Platyceras instead of Acroculia. Besides, the opinions of the authors were divided between accepting the older genera Capulus or Pileopsis. DE KONINCK is the first who insisted on adopting the genus Capulus of MONTFORT for the palæozoic species and especially those of the Carboniferous formation. Since MEEK and WORTHEN in 1866 [2]) announced that they had discovered horseshoe shaped muscular scars on casts of two species, Platyceras subplicatum and Pl. infundibulum, almost all authors were unanimous to range these fossils with Capulus. MEEK and WORTHEN, however, expressed as their opinion that these fossils »probably» are »distinct from the existing genus Capulus», but that they are more nearly allied to that group than is generally supposed to be the case. Moreover it may be questioned whether Plat. subplicatum and kindred really belong to the same genus at the Silurian ones. It has been found only in casts. As to the other species, of which only one specimen has been found, the last mentioned authors themselves seem to hesitate with placing it amongst the Platycerata. I have myself studied the interior surface of several specimens of Platyceras æquilaterum from the Burlington beds, without finding in them the least trace of any muscular scars. Nor have I been able to find any muscular impressions in the numerous specimens of the Silurian forms which I have examined. But this can, however, not be conclusive as to the deficiency of the muscular scars in the palæozoic species, because even in recent or tertiary Capuli the muscular impressions are very faint and in many specimens not discernible, owing to the glossy surface of the shell. It must then be very difficult and a thing of rare occurrence to detect them in specimens from palæozoic strata. Even if granted that these shells were provided with

[1]) Or Acrocylia as it ought to be written according to the derivation.

[2]) Proceedings Acad. Nat. Sc. Philadelphia 1866 p. 262.

muscular scars as in Capulus, the globular, low or high spired forms which almost insensibly merge into each other through numerous gradations unite them all at least the Silurian ones, in one genus, which although probably a near ally to Capulus, still must be considered as distinct. In accordance with HALL and the American authors I retain the genus Platyceras for the Silurian species. But I also think it proper to unite within its limits the genera Platystoma and Strophostylus. These, as may be seen by the following comparison, are indeed not much differentiated. According to the diagnosis given by HALL[1]) they are thus characterized:

Platyceras.	*Platystoma.*	*Strophostylus.*
»Shell depressed, subglobose, subovoid or obliquely subconical. Spire small, volutions few, sometimes *free* and sometimes contiguous *without columella*, aperture, more or less expanded, often campanulate and sometimes with the lip reflexed: peristome entire or sinuous».	»Shell subglobose; spire short; aperture very large suborbicular, dilated; labrum joining the body whorl at right angles to the axis of the shell» CONRAD; »having columella, columellar lip thickened.» HALL.	»Shell subglobose or ovoid-globose. Spire small, with a large ventricose body-whorl; outer lip thin, not reflected; *columella twisted or spirally grooved within*, not reflected; umbilicus none: aperture somewhat round-ovate or transversely broad oval.»

Consequently, the chief differences are that in Platyceras there is no columella and in Strophostylus a twisted columella and Platystoma is nearly related to Strophostylus. In the latest volume of »Palæontology of New-York», vol. V pt. II p. 129, HALL seems to hesitate about the distinction of the two first genera. »Platystoma, he writes, »is in some species scarcely separable from Platyceras by any persistent characters». BARROIS and other later authors agree with HALL in this point. But Strophostylus is also not tenable as the twisting in the columellar part of the reflexed lip is seen in specimens which else agree with Platyceras. Pl. II fig. 37—38. Even if Platystoma did not coincide entirely, as it seems to me, with Platyceras, this name could not be retained, as it has been preoccupied already several times before[2]). If we now turn our attention to the numerous figures given by HALL and to specimens from North America, we cannot fail to remark the extreme amount of variation, through which the forms are mixed up with each other. It is indeed very difficult to find any difference between the reflexed lip along the body whorl in Platyceras and Platystoma and the so called »twisted columella» in Strophostylus, which is in uninterrupted continuation with the outer lip and has no such separate callosity as in Natica for instance. Moreover, in many of the specimens figured on plate XI, vol. V pt. II of the Palæontology of N. Y. the »columella» is neither twisted nor grooved. In con-

[1]) Pal. of N.-York, vol. III pp. 299, 303, 309.

[2]) 1753 Platystoma KLEIN (= Helix, Ampularia, Natica & Nerita).
1803 Platystoma MEIGEN a dipterous insect.
1829 Platystoma AGASSIZ a fossil fish,
and moreover LAUBE in his work »Gastropoden der Hallstätter Schichten 1855, has also named a new genus of his Platystoma.

sequence of what now has been adduced I cannot but consider Strophostylus also as identical with Platyceras.

Besides, the highly variable and proteic forms of this genus have been ranged within many other genera of which some are enumerated here below.

Exogyroceras a subgenus proposed by MEEK and WORTHEN in 1868, Geol. Survey of Illinois vol. III p. 509 for shells with a sinistral spire and obscure columella.

Igoceras HALL. Established by HALL in 1859 in Pal. of New-York, vol. III p. 330. It differs from the straight Platycerata (Orthonychia) only in having the surface cancellated and it can consequently not be retained on so trifling a distinction.

Natica ADANSON. Both PICTET and D'ORBIGNY think that this genus occurs in the Silurian formation, but such species as Natica parva, Natica spirata or Wenlockensis (Sow. Sil. System pl. 5 & 12 and D'ORBIGNY Prodr. I p. 29) are true Platycerata. It is possible that also some of the Bohemian Naticæ, N. gregaria for instance, belong to this group.

Nerita L. is employed by SOWERBY in the Silurian System for the most common Platyceras.

Orthonychia HALL Rept. 4th distr. N.-York Geol. Survey p. 172 is a subgenus, created for the straight Platycerata, forming an elongate cone, with small spire and the ultime part very large. In the 12th Report N.-York State Cab. p. 18 HALL declares that a renewed examination has not shown any reliable characters, by which they may be separated from Platyceras. MEEK and WORTHEN, however, retain this name and it might perhaps be advisable to do so for all those species which are invariably straight or scalaroïd.

Then there may be some few species which belong to this group, but have been placed with the genera Holopea, Isonema, Naticopsis. Professor FERD. ROEMER placed one of the forms of Pl. cornutum in the genus Cyclonema.

D'ORBIGNY made use of Stomatia for one of the Lower Silurian Platycerata. Prodr. I p. 29. In how far the genus Poly(o)stomella of R. ETHERIDGE jr [1]) can be considered as related to Platyceras, I must leave undecided as I have not seen any specimens belonging to it. On the other hand it is likely that some fossils have been ranged with Platyceras, which in reality do not belong there, as for inst. some of SANDBERGER'S [2]).

The chief difficulties in the study of this genus are the dissimilar state of preservation of the exterior ornamentation of the shell and the almost incredible variations in its shape and growth. Some authors, as MORRIS in Qu. Journ. Geol. Soc. vol. 5 p. 332, write of a sinus in the outer lip of »Acroculia» nearly in the same sense as the remarkable one in the Pleurotomaridæ. But besides that every sign of it is often wanting in most specimens, there is by no means in those provided with it such a great regularity as in the Pleurotomaridæ, as there is only a wavy line, sometimes in the Orthonychidæ several, corresponding with the indentures in the apertural margin. If there is more than one sinus there are also quite as many wavy bands. These are,

[1]) Proc. Roy. Phys. Soc. Edinburgh. 1880 vol. 5 p. 163.
[2]) Versteiner. Nassaus. pl. XXVI fig. 18, Cap. psittacinus.

however, not bordered by elevated lines as in the Pleurotomaridæ, they resemble more what is seen in the recent Ianthinæ, which also sometimes exhibit such notches.

Probably much in consequence of this slight resemblance with the last mentioned group, some authors have given Platyceras (= Platystoma) its systematic place with the Ianthinæ. HALL in the fifth vol., IId part of Pal. of New-York, has signed the plates on the Platycerata as Ianthinidæ for Platystoma and Strophostylus, and Platyceridæ for Platyceras, but in the descriptive letterpress he is willing to unite all three genera into one genus. The thin and fragile shell of Ianthina is not corresponded by the thick and heavy one in Platyceras. Other authors, again, as STOLICZKA[1]) and WAAGEN[2]) see the affinity of the Platycerata with Velutina, to which several of them show some resemblance in the exterior shape of the shell. Platyceras may, however, as has been shown above, most fitly be ranked with the Capulidæ, with which they also share the peculiarity in habit of fixing themselves closely with the aperture to the surface of other marine animals, especially Crinoids.

In Sweden the oldest Platycerata found are from the beds of the Leptæna limestone of Dalecarlia, from where five different species have been described[3]). At least two of the Gotlandic species are also found in the Upper Silurian of Scania. The shells of this genus have been the most common of all Gastropoda in the palæozoic seas. While in the Silurian epoch Platyceras cornutum and others of spirally coiled forms were prevalent, in the Devonian of Harz and North America and still more so in the Carboniferous strata, especially the North American, the straight forms which constitute the subgenus Orthonychia are most abundant.

The Gotland species may be arranged as follows:

I. *Platyceras* proper, with spire coiled of three or four whorls and almost entirely or nearly contiguous with the body whorl.

1. Pl. cornutum HIS.
2. Pl. cornutum, var. loricatum n.
3. Pl. prototypum PHILLIPS.[4])
4. Pl. disciforme n.

II. *Orthonychia* spire diminutive or evanescent, shell straight, tubular.

5. Pl. enorme n.
6. Pl. cyathinum n.

1. Platyceras cornutum HISINGER.

Pl. II figs. 29—51, pl. III figs. 6—9, 19—26.

Turbinites.	1828.	HISINGER Anteckn. IV, 221, tab. VI f. 6.
Pileopsis cornuta.	1837.	HISINGER Lethæa Suecica, 41, pl. XII f. 11.
	1848.	BRONN Nomenclator, 973.
Pileopsis sulcata.	1837.	HISINGER Lethæa, 41, pl. XII f. 12.
	1848.	BRONN Nomenclator, 974.

[1]) Cretaceous Fossils of India p. 319.
[2]) Salt-Range Fossils p. 103.
[3]) ANGELIN & LINDSTRÖM. Fragm. Sil. p. 14.
[4]) By inadvertence this species was named *P. spiratum* SOW. in the list, page 16.

? *Natica glaucinoides.*	1839.	Sow. Sil. Syst., 603, pl. 3 f. 4.
	1843.	Morris Catal. Brit. Foss. 1st Ed. 154.
Natica parva.	1839.	Sow. Sil. Syst. 612, pl. 5 fig. 24.
	1843.	Morris Catal. 153.
	1848.	Bronn Nomencl. 786.
	1848.	Phillips Mem. Geol. Survey, II, 259.
	1854.	Morris Catal. 2d Ed. 263.
	1854.	Salter in Murchison Siluria 2d Ed., pl. XXV f. 1.
Pileopsis vetustis (? = vetustatis).	1839.	Sow. Sil. Syst. 616.
Nerita haliotis.	1839.	Sow. Sil. Syst. 625, pl. 12 f. 16.
	1843.	Morris Catal. 154.
	1848.	Bronn Nomencl. 805.
	1862.	Mac Coy Sil. Foss. Ireland, 13.
Capulus neritoides var. *sulcata.*	1848.	Bronn Nomencl. 217.
Natica subparva.	1850.	D'Orbigny Prodr. 29.
Capulus haliotis.	1850.	Id l. c. 31.
	1854.	Morris Catal. Ed. 2, 239.
	1855.	Mac Coy Pal. Foss. 290.
	1857.	Giebel Zeitschr. f. gesammte Naturwiss., 165.
Capulus euomphaloides.	1852.	Mac Coy A. N. H. ser. 2. vol. 10, 196.
	1854.	Morris Catal. 2d Ed. 239.
	1855.	Mac Coy Pal. Foss. 290, pl. 1 K, f. 39.
Platystoma niagarensis (= e).	1852.	Hall Pal. of N. York vol. II, 287, pl. 60 f. 1.
	1860.	F. Roemer Tennessee, 75, tab. V f. 15.
Acroculia haliotis.	1854. 1859.	Salter Siluria 2d Ed. 230 Id. Siluria 3d Ed. 548 } Pl. 24 f. 9.
	1871.	Baily Figures of charact. Brit. Fossils, part. III, 64, pl. XXI f. 12.
	1873.	Salter Cambridge Fossils, 89, 154.
	1874.	Alth Galizien, 31.
Capulus Brauni.	1857.	Giebel Zeitschr. gesammt. N. W. 167; according to him Hisinger's Pil. cornuta is the same as Münster's Cap. Brauni. Now, even if it could be proved that they were identical, this latter species was created some years later than Hisinger's and it would be contrary to all rules of equity and priority to abolish the older name.
Capulus sulcatus.	1857.	Giebel l. c. 166.
Acroculia cornuta. *Acroc. sulcata.*	1867. 1867.	} Lindström Nomina fossilium Gotl. 23.
Acroculia euomphaloides.	1873.	Salter Cambr. Foss. 171.
Naticopsis parva.	1873.	Id. l. c. 185.

Shell of highly variable shape, naticiform with prominent spire, neritoid with depressed spire or planorbiform with sunk spire. Generally transverse or broader than high, with the body whorl enormously developed. The ornamentation of the outside is characteristic. It is very difficult to find specimens, which exhibit it sufficiently clearly. They have mostly been subjected to the tear and wear on the shore before being imbedded or suffered from corrosion or also been changed after their fossilization. The ornamentation is of the same pattern in all, only changing in minor details. It changes with the age of the shell, different in the young and the adult or on the spire and the last whorls. It consists of two sets of lines, which intersect each other. There are delicate, wavy, longitudinal lines, interrupted by the often irregular lines of growth and other elevated lines. On the spire, pl. II figs. 30—31, the longitudinal lines are threadfine, elevated, with interstices many times surpassing their breadth and at regular distances they are interrupted by the transverse lines. On the body whorl near its middle line they have increased in size, with minute, microscopical lines between the large transverse ones. On the inferior side the longitudinal lines are large, broad, densely set, as it were, in groups of two or three with smooth interstices. They are wavy or interrupted in their continuity by the transverse lines. As is seen on pl. II f. 36, they form minute, steplike gradations or, as it were, terraces, each of the uppermost ones lying a little higher, than the succeeding inferior. The transverse lines form a sigmoid bend when they, more or less crowded, more or less prominent, continue from the suture to the umbilical side. The coarser ones which in most instances represent the outlines of former apertural lips are wavy or notched by two or three angular slits. On the spire they end towards the suture as a thin and sharp lamina, which bridges over the suture to the next whorl.

The spire is short in the most common variety, depressed and, as stated, even sunk in specimens which are planorbiform. The whorls vary in number from three and a half to four and a half. The last one is sometimes so much enlarged and widened, that it surpasses the spire with the lower rim of the aperture. The suture is tolerably deep.

There is a tendency in the body whorl to grow out free, without any connection with the older whorls, as is manifested in several specimens delineated on plate II. In fig. 48 it is just beginning to free itself, in figs. 50, 51 it is disconnected for a longer distance and tubular and in figs. 47 & 49 the whorls are nearly uncoiled. This is an approach to what is permanent in the younger Devonian and Carboniferous species and also in the Silurian Orthonychiæ. This peculiarity in the formation of the shell is what the German authors call »Skalaridenbildung», and may be found amongst several recent shells, where the last whorl as in Vermetus is free and tubular. Scalarid shells live together with normaly coiled of the same species, and races, varieties or even new species may take their origin from them if they prevail and persist. Thus resembling forms of analogous formation may arise or be repeated in genera which are not in the least related.

The aperture is oval, oblique or transverse, its margins thin or thickened, the columellar lip reflexed or in some specimens only in a small degree hiding the umbilical fissure. Sometimes it is so much developed that it completely covers the umbilicus, and thins out against the whorl, pl. II fig. 29. In some this lip, pl. II f. 37, 38, is thick and twisted and shows thus the characters of the genus Strophostylus. The exterior lip is regularly bent, sinuose or lobate. In pl. II fig. 32 and still more so in pl. III fig. 6 there are instances given of a highly sinuose aperture. In fig. 6 it is wrinkled and bent in several creases and folds. This is probably owing to the circumstance that they have been fixed to the shelly surface of some other marine animal and long time enough to have moulded the aperture according to the sculpture of this substratum. As is the case with the English and American specimens of this species and also with Platycerata from the Carboniferous formation of North America, these shells are sometimes found fixed on the perisome of Crinoids, as for inst. on Periechocrinus. When such sinuosities occur in the outer lip there is formed on the median line of the body whorl what in a distant manner reminds of the slit band of the Pleurotomariæ. It consists of the wavy lines of growth on the former site of a sinus. In others, as in the specimen which is the original type of Hisinger's Acroculia sulcata (pl. II fig. 52), there are at irregular intervals longitudinal, revolving grooves one or even as many as three and the surface with its lines of growth assumes a scaly or imbricate appearance. In one variety from the lowest shale beds of Wisby there is regularly a groove and an elevated ridge around the umbilicus.

In another form of the aperture there are large tonguelike lobes (pl. II fig. 41 & 42), giving not only the aperture, but also the shell an irregular shape.

On the inner side there are, as can best be seen through the casts (pl. II figs. 44 & 45), large transverse ridges or weals especially in the last volution and which are seldom seen on the outside. Although I have carefully searched for muscular scars on the inside of many well preserved specimens, I have never succeeded in finding such. On the inside of the body whorl a pocket lens reveals a peculiarly streaked surface of bifurcated and sinuous or branching lines with jagged borders in faint relievo on a dark surface. Pl. III fig. 23. A horizontal, thin section, made deeper below this surface presents the mottled appearance figured on plate III figs. 25—26. Vertical sections of the shell, magnified through the microscope are seen in plate III figs. 19—22. Of these fig. 22 shows three distinct strata, the outermost very thin, the median one composed of transparent prisms, the innermost, which is the thickest, is darkened through interspersed, small, black grains, which probably have been added during the process of fossilization. In other sections this stratum is composed, figs. 19—20, of angular lines of growth, resembling those which are seen in Pl. prototypum.

Dimensions of the specimen figured pl. II fig. 32—33. Height 21 mm., breadth 24 millim. Spec. figs. 39—40 height 30 millim., breadth 32 millim. Specim. figs. 34—35 height 15 millim., breadth 15 millim., height of spire 5 millim. Largest specimen, from Lindeklint, 42 mill. in height, 41 mm. in breadth.

This, the most common of all Silurian Gastropoda of Gotland, has been found almost everywhere, and in all strata between Hoburg and the northernmost point of Fårö. The largest specimens are as a rule found in the higher strata, as in the red limestone of Sandarfve kulle and Linde. The old truth that species which are widely spread and very rich in individuals, also are highly variable and as a rule even have a long duration in geological time, holds in the fullest sense good with this species. The first impression one gets when glancing at the bewildering dissimilarity of forms delineated as Platyceras cornutum on the plates II and III is that we have to deal with a great many different not only genera but also species, and the above list of synonyms shows indeed how the opinions of the authors run in many different directions. But by patiently comparing a large number of well preserved specimens from the same locality, the conviction forces itself upon the mind, however reluctant it may be, that they all belong to the same species. Variable as many of the Silurian Gastropoda are, this is the most variable of them all. It is difficult to decide whether this species is one of those plastic groups which truly may be called the main source of several different new specific forms or if it be one of those mocking species which easily assume the shape and features of others, often not at all related.

The most common of the Gotland forms is that which resembles SOWERBY's Nerita haliotis. It seldom attains so large a size as the English specimens, but it entirely agrees with it in shape and ornamentation. Another common form is similar to Capulus euomphaloides of MAC COY. There cannot be much doubt that when the various American species of Platyceras, Platystoma and Strophostylus have been sufficiently throughly examined, they may prove to contain many identical forms. Specimens sent to me from Mr S. A. MILLER in Cincinnati as Platystoma niagarense, do not in any sensible degree differ from certain varieties of Platyceras cornutum. This, however, in the European strata never attains such a great size as the American ones.

As to the geological duration of this species it seems to have continued also during the Devonian epoch, as it probably is identical with or nearly related to the Devonian Pileopsis prisca GOLDF. p. p.

2. **Platyceras cornutum**, var. **loricatum** n.

Pl. II, figs. 53—57.

Shell planorbiform, spire depressed or hidden within the volutions of the large and tumid body whorl. Surface imbricated by transverse, wavy laminæ which project in a thin edge, fig. 58, above the surface, and include thickset, threadfine longitudinal lines. The transverse lamellæ are more distantiated near the aperture than on the spire. The whorls are three or at the highest three and a half, rapidly decreasing in width towards the apex. The aperture is oval or lobate, forming grooves which continue on the body whorl. The sinuosities of the aperture are seen a long way up this whorl through the wavy lines of growth. The inner lip is straight, not reflexed. The spire is often so sunk as to be nearer the umbilical side of the shell than the apical. Height 8 millim., breadth 12 millim., in another specimen height 9 millim., breadth, 15 millim.

This variety which by transitional specimens is linked to the preceding, has been found near Nya Slitegårds in Dalhem, and in the limestone of Klinteberg.

3. **Platyceras prototypum** PHILLIPS.

Pl. III fig. 10—18.

Nerita spirata? var.	1839.	SOW. Sil. Syst., 625, pl. 12 f. 15.	
	1843.	MORRIS Catal. 154.	
	1848.	BRONN Nomenclat., 806.	
Nerita prototypa	1848.	PHILLIPS Mem. Geol. Surv. II, 358.	
	1854.	MORRIS Catal. 2d Ed., 264.	
Natica Wenlockensis	1850.	D'ORB. Prodr., 29.	
Acroculia prototypa	1854.	SALTER in Siluria 2d Ed., 230	pl. 24 f. 8.
	1859.	ID. ib. 3d Ed., 548	
	1871.	BAILY Figures of Charact. Brit. Fossils pt III 64, pl. XXI f. 11.	
	1873.	SALTER Catal. Cambridge Foss., 154.	
Strophostylus cyclostoma	1864.	HALL p. p. Transact. Albany Instit. vol. IV, 218.	
Cyclonema brevispira	1876.	FERD. ROEMER Leth. Geogn. Taf. 14 fig. 14.	

Shell naticiform, globose, with prominent acuminated spire. The ornamentation nearly of the same pattern as in Platyceras cornutum, only finer and denser. There are the same sort of graduated, wavy, longitudinal lines, and elevated, threadfine transverse lines. The grooves formed by these are deeper in the specimens from Sandarfve, than from Wisby. In the specimens from Klinteberg, figs. 10, 10a, the sculpture is only discernible on the apex. On the body whorl it is quite obliterated and covered by coarse transverse lines of growth. The whorls are five, tumid and globose, the body whorl being many times larger than the preceding ones. The suture is deep and narrow. The aperture is oval, longer than broad. The lips are continuous all round the aperture in the adult, pl. III figs. 10, 13; fig. 11 probably still young. The margins of the aperture are widely reflexed, so as to give it a trumpet-shaped form. As seen in figures 10a, 13 & 14, the aperture is thickened through the accumulation of the lamellar lips. Especially this is evident in specimens from the fine-grained limestone of Sandarfve kulle in which a great number of apertural lamellæ are preserved. Pl. III fig. 17. There are in this instance no less than seventeen such reflexed, apertural lamellæ left behind in their old place during the progressive growth of the shell. Seen through a microscope they show angular strata of calcareous spar.

Height 23 millim., breadth 26 millim.

This species has been found in many specimens in the shale of Wisby, but especially in the uppermost limestone beds of Sandarfve kulle, Klinteberg and Lilla Carlsö. There are specimens from Lansa in Fårö and from Follingbo, more largesized and with lower, blunt spire, which possibly may belong to this species, but the surface is too corroded to show any sculpture and the aperture is obscured.

Specimens sent from Mr S. A. Miller in Cincinnati as Strophostylus cyclostoma agree perfectly as to the ornamentation, but I cannot find the form of the aperture in them.

4. Platyceras disciforme n.

Pl. II figs. 73—78, pl. XIX fig. 5.

Shell discshaped or flat; whorls three and a half or four, the last free and without any connection with the others. The dorsal or exterior part of the whorls is thin and almost sharpedged, the opposite part being much higher. The spire of the three connected whorls is low and not visible above the other shell. The last whorl is enormously large, widening at the point where it becomes free, from 7 millim. to 28 millim. at the aperture. The aperture is of a shape between elliptic and triangular, narrow at its exterior lip, then widening and at highest near the median line, the interior lip so much reflexed as to touch the back of the spire. The surface is wrinkled by transverse undulating lines of growth which are bent forwards toward the aperture more at the dorsal side than at the opposite. There are moreover delicate, longitudinal, threadfine striæ somewhat wavy and interrupted where they are crossed by the transverse lines.

Height at the columellar side of the aperture 15 mill., breadth 39 millim. In all six specimens have been found in the sandstone of Hoburg, and a few also in the superjacent limestone of Nackshejd and Klef in Wamlingbo and Sundre.

5. **Platyceras enorme** n.

Pl. II figs 59—72.

Theca anceps 1859. Fr. Schmidt (nec Phillips) Geologie der Insel Gotland, Archiv Naturk. Estlands Bd II, 442.
Theca sp. 1867. Lindström Nomina, 23.

Shell straight, cylindrical, with a diminutive spire of one and a half whorls. Many specimens are curved as a crescent or a bow. The last whorl is considerably developed and large and the spire has dwindled to a mere appendage to it. In its general shape the shell thus resembles a diminutive Lituite. The surface is covered by transverse, sinuous striæ, the edges of which in the best preserved specimens project as thin reflexed lamellæ with smaller ones between them. Pl. II f. 72. These are intersected by fine, longitudinal lines, interrupted by the transverse ones as seen in fig. 71. The aperture, figs 66, 67, is oval or circular with thin lips, often sinuous or wavy. Length 17 millim., diameter at the aperture 8 millim. From the shale at Djupvik in Eksta, Rikvide in När, in the sandstone of Bursvik, in the oolitic beds of Hafdhem, Näs and Bursvik, and in the limestone beds at Hammar in Kräklingbo, Klinteberg and Länna near Slite, from which last locality the Mineral Cabinet of the University of Upsala has obtained specimens, collected by Professor P. T. Cleve.

This species and the following belong to that group of the Platycerata, which J. Hall has called Orthonychia and which is so prevalent both in the Devonian and the Carboniferous limestone strata.

6. **Platyceras cyathinum** n.

Pl. VII fig. 22.

Shell conical, nearly straight without spire of whorls, rapidly increasing in width, spirally twisted in two bends. Surface concentrically striated by fine transverse lines of growth and wrinkled in the same direction. Aperture circular with thin edges. Shell thick, consisting of several strata, glossy, opaque with only faint traces of prisms.

Length of the single specimen found 30 millim., breadth of aperture 20 millim., at the apex 2 millim.

Only one specimen has hitherto been found in the Crinoidal limestone of Follingbo.

This species is related to the Bohemian Capulus anguinus Barrande and kindred.

Fam. V. BELLEROPHONTIDÆ Mac Coy.

Shell globular or discoid, symmetrical or slightly deviating from the discoid plan, aperture widened with an angular slit in its dorsal or superior edge, forming by conti-

nued growth a slit band, which assumes the shape of an elevated keel or also a sunk, shallow groove; its inferior margin covering a part of the back of the preceding volution.

Table of the genera:

A) Slit band entire, continuous without any openings.

1. Shell globular, involute, apertural lips wide, trumpet shaped. Slit band broad, sunk.

Bellerophon MONTFORT.

2. Shell disciform, laterally compressed, aperture hastate, whorls in several species not involute, free and not contiguous. Slit band elevated, often forming a sharpedged keel.

Cyrtolites CONRAD [1])

B) Slit band always elevated, perforated by a series of oblong openings. Aperture many times wider than the volutions, ornamental lines spiral. Shell discoid, involute.

Tremanotus HALL.

As to the systematic place of this family every one conversant with the conchological literature is aware that there are few palæozoic genera on which the opinions of the authors have been more divided and differed more widely. For a succinct survey of these varying opinions it is enough to refer to the works of DE KONINCK [2]), MEEK [3]) and WAAGEN [4]), where a relation is given in full. Bellerophon has been placed amongst the Cephalopoda by its first discoverer HÜPSCH, by its denominator MONTFORT, by DE FRANCE, MAC COY, PHILLIPS, PORTLOCK and CHENU. It has been considered as one of the Heteropoda by SOWERBY, D'ORBIGNY, BRONN, DESHAYES, D'ARCHIAC and VERNEUIL [5]) PHILLIPI [6]), EICHWALD, OWEN [7]), SALTER, WOODWARD [8]) and ADAMS. It has been numbered amongst the Gastropoda by BLAINVILLE and VALENCIENNES (as related to Acera and Bulla), FLEMING (as Actæon), DE KONINCK and PICTET (to Emarginula »comme un lien perdu entre les Emarginules et les Pleurotomaires»), JAMES HALL, SANDBERGER, (joining them with Pleurotomaria through Porcellia), MEEK and WORTHEN. Among the most recent authors STOLICZKA [9]) hesitates between placing Bellerophon in the Heteropoda, Opisthobranchiata and Cephalopoda. IHERING [10]) denies the affinity of the Bellerophons to the recent Heteropoda and places them in a family of their own, quite

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[1]) A new generic type, intermediate between Bellerophon and Cyrtolites is probably formed by the species named B. norvegicus by BRÖGGER in his »Silurischen Etagen», p. 53.

[2]) Animaux fossiles de la Belgique p. 334.

[3]) On the affinities of the Bellerophontidæ in Proc. Chicago Ac. Sc. Vol. I, p. 9.

[4]) Palæontol. Indica. Ser. XIII p. 126.

[5]) Geol. Transactions vol. VI, p. 325.

[6]) Handbuch der Malacol. p. 285.

[7]) Palæontology p. 72.

[8]) Manual of Shells p. 201 to Atlantidæ, but in the Supplement edited by R. TATE in 1868 it is placed as a subfamily to the Pleurotomariæ amongst the Haliotidæ.

[9]) Palæontologia Indica. V. Gastrop. p. 393.

[10]) Nervensyst. der Mollusken p. 143.

as MAC COY already had done before him. But there is no reason to couple them with the Capulidæ as IHERING does, when he thinks that Carinaropsis is the connecting link. This genus is no doubt composed of incongruous elements, some being real Bellerophons, others Capulidæ or even Patellidæ. The remark of STOLICZKA that the Lepetidæ are near to Cyrtolites (»Some of the species of Anisomion exhibit a great relation to species of the palæozoic Cyrtolites, like C? expansus»), loses all its foundation, as it is evident that Cyrtolites expansus of HALL is no Cyrtolites, but a Platyceras.

MEEK (l. c.) lays, as it is quite right to do, much stress on the affinity of Tremanotus with Bellerophon and Bucania on the one side and with Haliotis and Pleurotomaria on the other. He concludes: »In other words it indicates for the family a position near the Fissurellidæ and Haliotidæ, and between these groups and the Pleurotomaridæ».

WAAGEN (l. c. p. 130) holds the opinion that a more or less close affinity of the Bellerophontidæ to the Pleurotomaridæ is highly probable. What makes the Bellerophons approach the Pleurotomariæ is a tendency observed amongst some to grow somewhat obliquely, thus nearing to the conical spiral. In accordance with DE KONINCK[1]) as this author formerly has stated, I do not think it advisable as WAAGEN has done, to place within this group such forms, which, although resembling the Bellerophons in the general form of the shell, do not show the least trace of apertural sinus nor of any slit band. DE KONINCK holds that such are young Goniatites and it is remarkable that in the Silurian formation, where no Goniatites are found, also such Bellerophon-like shells without any slit band are wanting. Such forms are comprehended in the new genera, which WAAGEN (l. c.) has proposed under the names Warthia, Mogulia and Stachella. The same is also the case with MEEK's Bucanella and MAC COY's Euphemus, though DE KONINCK and WAAGEN have again adopted the last genus. The slit band must indeed be considered as one of the most important, if not *the* most prominent character of the shell itself. Still it is very difficult absolutely to decide this as well as other cases of affinity amongst the palæozoic shells, as there may be other genera as for inst. Scissurella, with a distinct slit band on the shell, without any affinity between the animal itself and that of Pleurotomaria.

For my own part, I feel inclined to follow the precedence of MEEK and accept the Bellerophontidæ as most nearly related to Haliotis, a view in which DE KONINCK also in his last work participates. This view is strengthened by the similarities which are offered by Tremanotus with its perforated slit band and the sculpture of the surface which in so eminent a degree reminds of that of Haliotis. This position, however, cannot but remain hypothetical, as no more valid grounds taken from interior resemblances and homologies between the soft parts of the animals can be gained. Nor is there anything in the microscopic structure of the shell that either corroborates or contradicts such views. Not the least trace of any nacreons stratum has been found in the Gotlandic Bellerophontidæ.

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[1]) Mem. de la Soc. Roy. d. Sc. de Liége. 1878, p. 340. Fossiles paléozoïques de la Nouvelle-Galles du Sud.

Gen. BELLEROPHON Montfort.

Syn. 1781 *Nautilites* Hüpsch p. p. Naturgeschichte des Niederdeutschl. I, 23, pl. III f. 20—23.
1808 *Bellerophon* Montfort Conchyl. Systematique, I, 50, 51.
1812 *Ellipsolithes* Sowerby p. p. (non Montf.) Min. Conch. vol. 1, 81.
1825 *Bellerophus* Blainville (»mala emendatio» Hermansen) Man. de Conchyliologie, 4.
1847 *Bucania* Hall p. p. Pal. N. Y. vol. 1, 32.
1847 *Carinaropsis* Hall p. p. Pal. N. Y. vol. 1, 183.
1849 *Vasulites* Hermansen (non Montf.) Ind. Gen. Malac. Primordia II, 677. See below.
1861 *Phragmostoma* Hall 14 Rep. N. Y. State Cab., 94.
1882 *Waagenia* De Koninck Notice sur la famille des Bellerophontidæ, Ann. Soc. Géol. de Belgique IX, 14. This name being already given away by Neumayr it was changed by De Koninck into the following.
1883 *Waagenella* De Koninck Faune Carbonif. Belg. II pt. IV. Explic. des planches, pl. 38.

Shell globose, involute, with the whorls in the same plan or nearly so, concave on the umbilical side as well as on the apical one, so that no distinction can be made between them. Aperture circular or oval, suddenly much enlarged, lips thin, continuous, interior or columellar lip covering the back of the second convolution. The slit band is always distinct, originating from a deep notch in the middle of the exterior lip; it is in several species much varying, being elevated as a keel on the last convolution, sunk as a channel or a flat band lower down on the older whorls. It is covered with quite the same sort of semilunar, backwards curved wavelets as are seen in all Pleurotomariæ. The umbilicus is in the small specimens very large and open and is in the older ones covered and hidden beneath the reflexed margin of the aperture. In some, however, it continues uncovered or open. The exterior ornamentation of the shell consists of transverse striæ, which often are crossed by longitudinal ones. Moreover there is a peculiar feature, observed in Gotland specimens, consisting in a series of thin laminæ, which are nothing but the continuation of the lines of growth. They are gently curved outwards and are most crowded and perfect in the umbilical tube, where they have also been best protected against fracture. These laminæ may as in Tremanotus, each in its turn, have formed the successive apertures and then been partly absorbed, partly abraded and only preserved where they were protected.

In explanation of the synonyms given above the following remarks may serve. *Ellipsolithes* Sow. in Mineral Conchology, vol. I pp. 81, 83, 84 is not to be confounded with Montforts genus of the same name which only contains Polythalamia. That of Sowerby consists of one species of Nautilus, one of Goniatites, and one of Bellerophon (B. ovatus) according to his own emendation in Min. Conch. vol. 5 p. 107. But Morris, Cat. Brit. Foss. p. 302, regards them all as Cephalopods. *Bucania* Hall Pal. N. York vol. 1 p. 32 is chiefly distinguished thereby that the aperture is dorsally abruptly expanded and that the volutions are all visible in the umbilicus. In the fourth volume of Pal. N. York Hall seems to have abandoned his opinion on the distinction of this genus and includes it amongst the Bellerophons. The wide aperture is moreover common with most of the Bellerophons and as to the uncovered and large umbilicus Deshayes remarks in the Journal de Conchyliologie vol. I p. 205 »l'existence de l'ombilic est un caractère indifférent», and not of importance enough to be of value as generic distinction. Equally unimportant is the character added by De Koninck and Waagen that the shell is provided with longitudinal or spiral striæ, which cross the transverse ones. *Carinaropsis* Hall Pal. N. York vol. I p. 183 consists of Gastropoda belonging to different genera. Carin. carinata in all probability is a Bellerophon of the large, compressed species, while C. patelliformis and C. orbiculatus are evidently Patellid shells. *Phragmostoma* Hall 14 Rept. N. York St. Cab. p. 94 is also likely to be a broad, compressed Bellerophon. *Waagenia* De Koninck Ann. Soc. Géol. de Belgique 1882 p. 14, is distinguished only by callosities around the umbilical region. Hermannsen in his Index[1]) has *Vasulites* as a synonym of Bellerophon, but no such generic name is found in the book cited[2]) by him. Montfort in his Conchyliologie systématique[3]) himself cites B. vasulites from Hist. Naturelle des Mollusques, though only as a specific name.

Various efforts have been made by some authors to arrange the species of Bellerophon in different groups. De Koninck in his older work[4]) and Stache[5]) both propose two series, one characterized by an elevated dorsal keel, the other by a sunk slit band. But as it is evident, that generally in young specimens the slit band is sunk and in older specimens of the same species becomes an elevated keel and when moreover this change can be traced in the same specimen, this characteristic is not to be maintained. Nor is it possible to apply the differences, which lie in an open or closed umbilicus as this character is changing in one and the same specimen. It seems to be of more avail to group the different species, at least the Silurian ones, according to the pattern of the ornamentation. A good characteristic of several species is found in the size of the angle, in which the transverse striæ join the slit band, as well the manner in which they continue towards the sides. There is in very small specimens, of B. latevittatus especially, a peculiar feature in a strong transverse groove (étranglement) on the nucleus near the expanded apertural border. It reminds highly of what is seen in the small individuals of the Goniatites. But as similar grooves or necks are seen in other Gastropoda, as for inst. in Platyceras and Euomphalus, it needs not point to a Cephalopodan affinity of the Bellerophons as some authors have thought. This transverse sulcus is quite as deep in the middle of the shell as on the sides.

As to the geological history of this genus in Sweden, it may be remarked that the oldest specimens are already present in the Inferior Gray Orthoceratite limestone at Kongs Norrby, from where three different species have been found, and in the Superior Red Orthoceratite Limestone at Skarpåsen, both localities in Ostrogothia. Specimens have also been collected in almost all Lower Silurian regions of Sweden as Öland and Dalecarlia. I have not been able to identify with certainty a single species of the Gotland Bellerophons with those from other Silurian strata, excepting B. trilobatus. In the shale beds at Westergarn some few, badly preserved specimens have been found

[1]) Vol. II p. 677.
[2]) Denys-Montfort Hist. Nat. des Moll .... suite à l'Hist. N. de Buffon et Sonnini. Vol. IV p. 298.
[3]) Vol. I p. 51. Bellerophon vasulites.
[4]) Anim. foss. de Belgique p. 338.
[5]) Jahrbuch der Geol. Reichsanstalt 1877, № 3, p. 297.

of a species with considerably enlarged aperture and narrow whorls, representing the division of Bellerophons named Phragmostoma, which are of such frequent occurrence in the Upper Silurian shale beds of Scania. But they are too obscure for identification.

Conspectus of the Species:

I. Shell only with transverse striæ, radiating in pinnate arrangement from the slit band:
 1 B. sphæra n.
 2 B. fasciatus n.
 3 B. globulus n.
 4 B. tænia n.
 5 B. fastigiatus n.
 6 B. tubulosus n.

II. Shell with longitudinal striæ or furrows intersecting the transverse ones (= Bucania WAAGEN and DE KONINCK).
 7 B. squamosus n.
 8 B. Eiseni n.
 9 B. elegantulus n.
 10 B. latevittatus n.
 11 B. gemma n.
 12 B. pilula n.

III. Shell divided through two longitudinal grooves.
 13 B. trilobatus Sow.

1. **Bellerophon sphæra** n.

Pl. III figs. 35—38, pl. V figs. 1—16, pl. VII fig. 9.

Shell globular, extremely thin. Surface ornamented by closely set, transverse striæ, which abut upon the slit band in an acute angle of 45° and curve gently outward in a bow, the convexity of which is directed towards the aperture. There is some variation, as shown in the figures, with larger, smooth intervals between the striæ. Some faint longitudinal striæ crossing them are visible in several specimens. In well preserved shells and through sections in the umbilicus it is evident that many of the transverse striæ have continued as free, outwardly bent, thin laminæ. They have been especially crowded in the umbilicus, where they also are most completely preserved, imbedded in the soft shale. Several figures are given on plate V, showing details in natural size and magnified. Their length amounts to two millimeters and sometimes more. Where they have been well protected they stand out in relief as narrow hooks. These lamellæ have probably, each in its turn, been the apertural border of the widely expanded mouth.

The whorls are five and a half, much rounded, and, as seen in transverse sections, from two to three times as broad as high. The last whorl is much expanded near the aperture, with the slit band elevated as a blunt keel. The aperture is large, transversally obovate, the lips rather thick, the inner lip bent down as to hide the whorl on which it rests. The umbilicus is wide and open in the young specimens; in the older it becomes by degrees more and more narrow, and is at last so concealed by the large corners of the aperture and the interior lips, which have grown over it, that only a little space is left open.

As far as may be judged by the direction of the lines of growth there has been a deep and acuminate sinus in the outer lip. The slit band is comparatively narrow and sunk between two faintly elevated lines and covered by distantiated crescent shaped lines of growth. On the last whorl it changes into an elevated keel, on which every trace of the crescent shaped lines of growth is effaced. The height of this keel sometimes amounts to more than one millimeter above the surface of the whorl.

The thickness of the shell is much variable, generally thin, excepting along the interior corners of the aperture, where it covers the umbilicus and is several millimeters thick. The shell, in a thin section under the microscope, shows very thin, wavy lamellæ, through which clearer spaces or tubes vertically penetrate, pl. VII f. 9.

Colonies of a bryozoan, a Ceramopora, have often covered large specimens of this shell with their luxuriant growth and in all probability destroyed the shell, which has been dissolved, as only a cast of its surface is left on the calcareous basis of the Ceramopora.

Largest diameter 96 millim., breadth of aperture 65 millim., height of the same 55 millim., diameter of umbilicus 15 millim.

This shell has been found very common in the lowest shale near Wisby, in the superjacent limestone beds at Wisby and Martebo and also in the shale beds at Petesvik.

2. Bellerophon fasciatus n.

Pl. VI figs. 13—14.

Shell globular, the transverse striæ of the surface are in regular distances, with smooth, equal, band like interstices. They join the slit band in an angle of 66° and then stand out from the band nearly horizontally. The slit band is sunk and narrow. There are only three whorls visible, but probably they are at least four. The aperture is cordate, the exterior or superior margin with an acute angle and the interior one arched. Seen from the aperture the shell presents an obovate outline. The umbilicus is closed by a fold of the margin of the lowest apertural corner.

Of all the Gotland Bellerophons this is most nearly related to Bell. sphæra, but differs through its obovate outline and the transverse striæ. Height 25 millim., breadth 16 millim., height of aperture 10 millim., breadth 16 millim.

Only four specimens have been found in the middle limestone beds (b) and the lowest part of *c*, near Wisby and Kyrkberget in Wisby.

3. Bellerophon globulus n.

Pl. V figs. 25—34.

Shell of somewhat variable form, globular, ovate or elliptical in outline, surface of a dark, glossy hue, almost smooth, with extremely fine, densely packed transverse striæ, which join the slit band at an angle of 38°; they bend outwards towards the sides and again converge towards the umbilicus. The slit band forms an elevated keel with a flat top, on each side bordered by a fine line and wavy with the minute and delicate lines of growth. Whorls four and a half, regularly increasing in width, twice as large as high and consequently not so narrow as in Bell. sphæra. Shell thick and as common in this genus, at thickest around the umbilicus and at the inferior corners of the aperture. The last whorl, when seen from the side, is straight or only faintly curved, and its apertural and dorsal contours are nearly parallel, f. 26. In my specimens, which are not quite complete, the aperture is longer than the rest of the shell. The inferior corners of the aperture near the umbilicus, where the shell is at thickest, are rounded or cylindrical and completely hide the umbilicus, which in young specimens is open. Diamet. 20 millims., breadth at the fragmentary aperture 17 millims., height of the aperture 7 millim.

Occurs in the shale beds of Eksta at Djupvik and in Fröjel. It is nearly related to Bell. sphæra, but differs by having the umbilicus entirely covered by a fold of the reflexed border of the aperture. The shell is moreover thicker and the direction of the transverse striæ and their angle when joining the slit band quite different.

4. **Bellerophon tænia** n.

Pl. VI figs. 22—25, pl. VII figs. 4—5.

Shell discoid with six much compressed and thin whorls, transverse, nearly elliptical in their section, twice as broad as high, their dorsal side only a little convex, in many nearly flat, the lateral angles very thin and acute. All whorls are visible on the umbilical as well as on the apical side. The only specimen which shows some fragments of the expanded aperture makes it not clear whether there has been an open or closed umbilicus, but it seems likely that it has been more narrow than may be judged of by its wideness in the other samples. At the aperture, which seems to have been quite as large as in Bell. sphæra, the shell attains its greatest thickness and consists of several strata. On other parts, where fragments of it still are seen, it is very thin. The transverse striæ of the surface are nearly straight or only faintly curved in an angle of 68° near the slit band. This band is narrow and only a little elevated between two sharpedged lines. Height 60 millim., breadth of aperture 60 millim., breadth of the last whorl near the aperture 28 millim., height 19 millim. Occurs in the lower limestone beds at Östergarn and Ardre, and also on the shore of Hammar in Kräklingbo, and in the soft gray limestone of Lindeklint and Fröjel.

5. **Bellerophon fastigiatus** n.

Pl. VI, figs. 1—10.

Shell rather more discoid than globular, aperture transverse and triangular in outline, the base being only slightly arched. It is incomplete, the margins broken off and fragmentary. Whorls five, transverse, carinated on the dorsal side. Umbilicus open and large with steep borders. The transversal striæ of the surface crowded, joining the slit band in an acute angle of 32°, they are bent outwards and backwards to the umbilicus. In several specimens there is an indistinct carina on both sides of the slit band and parallel to it, placed at the point where the transverse striæ are bending backwards. The slit band is elevated, flat on its top, finely and transversally sculptured, somewhat concave along its median line and bordered on each side by two thinedged lines.

This species makes somehow an approach to the genus Cyrtolites by its acuminated dorsal side, its wide umbilicus and its laterally compressed whorls. Height 13 millim., breadth 10 millim., diameter of umbilicus 4 millim., height of aperture 5 millim.

Several specimens have been found in the shale at Djupvik in Eksta.

From the shale beds of Djupvik in Eksta some specimens of Bellerophon have been found along with the former, the affinities and exterior characters of which have been obscured through their bad conservation. But when sectioned they exhibit a peculiar deviation from the other Bellerophons in being evidently asymetric or having the whorls inclining nearer to the apical side, thus making an approach to a conical-spiral volution. In this respect they coincide with the new genus Stachella, which Waagen has instituted, and which chiefly is distinguished through its asymetric whorls. On plate VI the figures 11, 12 give an idea of these shells.

6. **Bellerophon tubulosus** n.

Pl. XIX fig. 6—11.

Shell globular or sphæroidal, with five whorls, thin, excepting around the umbilical region. Surface ornamented with narrow, transverse stripes which meet the slit band in an angle of 44°. They are elevated at their superior edge, the more so near the umbilicus, where they also are more numerous. Parallel with this edge they are finely striated. The slit band is narrow and the crescents of growth indistinct and distantiated. The aperture is semicircular and its superior lip is slightly angular. The lips are thin; their inferior side corners are prolonged in earlike lappets, curved like hooks inwards against the very narrow umbilical opening without closing it. During continued growth a tubular space is thus enclosed between the outside of the inferior borders of the aperture and the hooklike, lateral prolongations of the shell. Where they end they are, moreover, convoluted and directed backwards from the aperture. All around these peculiar umbilical tubes the shelly matter has been deposited to an amount, many times surpassing the thin shell on the dorsal side. In one specimen, fig. 6, there is a trace of a dark colour band around the covered umbilicus. H. 22 mill., breadth 16 mill.

A few specimens have been obtained from the superior limestone near Wisby at Kålens qvarn and inside that town on Kyrkberget. As to shape and ornamentation this species somewhat resembles B. fasciatus, though this is more angular on the superior edge of the dorsal side and has no tubes. As to these B. tubulosus comes near to B. elegantulus where the enclosed spaces are more narrow.

7. **Bellerophon squamosus** n.

Pl. V figs. 17—24.

Shell globular, somewhat compressed, the last whorl much enlarged towards the aperture. Whorls four, rapidly increasing in size, of elliptical section, the last one subcordate with dorsal keel. Outlines of aperture nearly circular, deeply indented in the midst of the exterior lip. Lateral and inferior borders smooth and gently curved. Umbilicus open and only partially concealed through the inferior corners of the aperture, which have grown down outside the same. The transverse lines of growth are imbricated and project as irregularly curved lamellæ, standing out much in relief with their edges. These edges are extremely thin, as may be gathered from a section drawn figs. 23—24, pl. V, and, moreover, much irregularly grown in many curvatures. At the base they regularly join the slit band in an angle of 58°. The interstices are finely striated by minute ornamental lines, parallel to the lines of growth and longitudinally grooved. The spaces between the equidistant grooves are gently arched. Where the grooves meet the transverse laminæ, they are a little indented and hence form a wavy line. The slit band is narrow, but distinct, situated between two elevated lines, somewhat sinuous and more prominent on the last whorl than elsewhere. Height 45 millim., breadth and height of aperture 38 millim.

Found in several specimens at Lutterhorn and Lansa in Fårö, Sändvik at Fårösund and on Kyrkberget in Wisby.

8. **Bellerophon Eiseni** n.

Pl. VI figs. 19—21.

Shell globular with enlarged aperture, as far as visible without laterally bent margins. Sculpture of the shell very characteristic, consisting of some eight to ten shallow, longitudinal grooves on both sides of the slit band and parallel with it, forming, as it were, a broad median zone, occupying nearly a third of the dorsal surface. On both sides of it there are no traces at all of any longitudinal sculpture. These lines are crossed by fine and closely set transverse lines, which occupy the whole surface and meet the slit band almost rectangularly, being only very slightly curved towards the aperture. The umbilicus seems to have been open. The slit band which is not well preserved has probably formed an elevated keel on the body whorl. Height 20 millim., breadth 36 millim., the umbilicus nearly 5 millim.

Only one fragmentary specimen was discovered by Dr G. Eisen in the hard crystalline limestone at Wialmsudd near Fårösund in the parish of Bunge.

9. **Bellerophon elegantulus** n.

Pl. VI figs. 15—18.

Shell thick, globular, umbilicus closed by a convoluted thick fold of the inferior apertural lip. A little above this fold, there is a transverse groove, partitioned off from the aperture of the shell through a new fold or process which joins the inner surface of the aperture. Exterior surface ornamented with regularly distantiated transverse lines of growth, which meet the slit band in a very acute angle of 29°, then spread in an arched curve towards the sides. The interstices are densely and longitudinaly wrinkled, as seen in the enlarged figures, giving the surface a finely cancellated appearance. Slit band narrow and moderately elevated with rare, crescent formed wavelets. Height 11 millims; width of aperture 12 millim., height of the same 7 millim.

One specimen has been obtained from the middle limestone bands near Wisby.

10. **Bellerophon latevittatus** n.

Pl. VI figs. 26—28, pl. VII figs. 6—8.

Shell globular, with expanded, transverse aperture. In the only specimen with the shell preserved the height of the aperture is contained nearly four times in its breadth. In casts of other specimens, which are almost entire, it is evident that the exterior lip has been thin and enlarged. Some two millimeters further inside it is provided with a thick transverse callosity or fold, which continues past the upper side of the umbilicus, along the exterior sides of the aperture, where it disappears. This callosity gives to the casts a strange appearance, in a certain way reminding of what is seen in the young Goniatites. But the same kind of callosity also occurs amongst other Gastropoda as for instance Platyceras cornutum. The interior or lower lip of the aperture seems to have been divided in two lobes, as in young specimens of the Carboniferous Bell. decussatus from Tournai. The umbilicus is open. The ornamentation of the surface consists of closely set, elevated, transverse lines, which meet the slit band nearly rectangularly. They are closely and longitudinally wrinkled. The slit band is relatively the largest, which any of the Gotlandic species is provided with, excepting B. gemma, being 1 millim. in breadth on a total diameter of the shell of 4 millim. It is elevated but flat. Height 7 millims., breadth at umbilicus 6 millim., at the aperture 10 mm., height of aperture 7 mm.

Four specimens have been found in the lowest shale beds near Wisby and also at Östergarn.

This species comes near to Bell. latefasciatus SANDBERGER, Verstein. des Rheinischen Schichtensystems, pl. 22 fig. 4.

11. **Bellerophon gemma** n.

Pl. XIX fig. 12—14.

Shell globular, last whorl rather rapidly expanding, in section broadly transverse or elliptical, inclining to crescent shape. The umbilicus is narrow and open. The ornamentation, which cannot be plainly seen without a strong lens, consists of a large slit band, covered by the same sort of densely crowded lines which decorate the sides and join the slit band in an angle of 63°. They are longitudinally streaked with elevated wrinkles, larger towards the opening and attenuated backwards. H. 5 mm., breadth at the aperture 6 mm. Only a single specimen has hitherto been found in the shales of Wisby. Another specimen in good preservation from the red limestone of Sandarfve kulle comes near to the preceding, but differs in the slit band not being elevated, only at the same level with the other surface, and also in the ornamental lines being more arched.

12. **Bellerophon pilula** n.

Pl. VI figs. 29—30.

Shell globular, aperture, as far as preserved, transverse, crescent shaped, more than four times as broad as high. Umbilicus open. Surface covered by a fine network of minute, elevated, longitudinal and transverse lines, which enclose regular, quadratic spaces. The slit band indistinct. Height 3 millim., breadth 2 millim.

Found in the oldest shale at Djupvik in Eksta.

13. **Bellerophon trilobatus** Sowerby p. p.

Pl. IV figs. 13—15.

Bellerophon trilobatus. 1839. Sowerby in Sil. Syst., 604. pl. 3 fig. 16.
1840. D'Orbigny H. Nat. Cephalop., 209, pl. 7 fig. 24—27. Pl. 8 figs. 13 is also cited, but in the copy of the work, to which I have had access there is no plate 8. Perhaps it has never been published.
1850. D'Orb. Prodr. I, 31.
1854. Morris Cat. Brit. Foss., 288.
1855. Mac Coy Brit. Pal. Foss., 311.
1856. Sandberger Verstein. des Rhein. Schichtensyst., 177, pl. 22 f., 1—3.
1867. Salter Siluria 3d Ed, 534, pl. 34 f. 9.
1873. Id. Catal. Cambr. Museum, 97, 192.

Shell involute, with three or four broadly and transversally flattened whorls, which are elliptical in section, and their height contained nearly three times in their breadth. The dorsal surface is divided in three different longitudinal fields through two deep grooves near the sides. The median field is at least of double the size of the lateral ones. As the specimens exist only in casts, there are no vestiges of the shell itself and it is even doubtful whether it really belongs to this genus as never any trace of the slit band has been found. Of the three varieties which SANDBERGER (l. c.) has described, his B. tumidus comes most near to the Gotlandic form. As to the shape it also agrees with the figure given by SOWERBY in Silurian System, although it is larger than his. The figure given by D'ORBIGNY is altogether different. Bucania trilobata CONRAD [1]) may also belong to this species. Largest diameter 18 millim., breadth of aperture 22 mm.; height of aperture 9 millim., diameter of umbilicus 3 mm.

It occurs in the shales of Petesvik in Habblingbo and of Wisby and in the oolite and sandstone of Bursvik.

Gen. **CYRTOLITES** CONRAD.

Synonyms. 1838. *Cyrtolites* CONRAD Ann. Rep. N. Y. Cab., 118.
1838. *Phragmolithes* CONRAD p. p. ibid., 119.
? 1839. *Ditaxopus* RAFINESQUE Bull. Soc. Géol. de France, vol. X, 378.
1845. *Microceras* HALL Sillim. Journ., vol. 48, 294.
1866. *Tropidiscus* MEEK Proceed. Chicago Acad. Sci., vol. 1, 9.
1880. *Tropidodiscus* WAAGEN (emendatio) Palæont. Indica XIII, 131.
1882. *Tropidocyclus* DE KONINCK Ann. Soc. Géol. de Belgique IX, 12.

Shell discoid, laterally compressed, involute or with free, not contiguous whorls, umbilicus open and double, aperture elongate and lanceolate. A dorsal keel originates from a sinus or slit in the superior border of the aperture and continues more or less elevated, the interior lip having its form moulded according to the whorl on which it rests.

In spite of all what has been stated [2]) to the contrary, there can be no doubt, nor mistake about the type species of this genus and what its first authors meant thereby. This type is C. ornatus, first named and shortly described by CONRAD in the Annual Report of the Geol. Survey of New York 1838 p. 118 and then again more in full described and figured by HALL in Palæontology of N. York vol. I p. 308 pl. 84 f. 1. There has been almost no dissension amongst the American authors as to this genus. It is of no avail that both CONRAD and HALL a few years later united with the first species other fossils, which are no Gastropoda at all, being in reality Cephalopoda, probably Cyrtocerata. [3]) The first described type must here, as always in similar cases, be the guiding one, around which to group related species and from which dissimilar ones are to be discarded. The other coëval genus, *Phragmolithes* of CONRAD, also coincides with Cyrtolites, as has been shown by HALL in Pal. of N. York vol. I. p. 188, and in which some lines of growth had been interpreted as septa. *Ditaxopus* of RAFINESQUE is a most obscure fossil, but may possibly be only a form of Cyrtolites. *Microceras* HALL is doubtingly described as septate, but MEEK has in Pal. of Ohio vol.

[1]) HALL Pal. N. York, vol. 2 p. 13, 93. — Planorbis trilobatus Geol. Rep. N. Y., 1838 p. 113.
[2]) DE KONINCK Faune Carbonif. II, IV, p. 293. — WAAGEN Palæont. Indica, Salt Range Foss. p. 132.
[3]) CONRAD Journal. Acad. N. Sc. Philadelphia vol. 8 p. 270 (C. trentonensis). HALL Pal. of N. Y. I, p. 188.

1 p. 147 shown that it in no essential characters differs from Cyrtolites. *Tropidiscus* MEEK, or *Tropidodiscus* as the name has been emendated by WAAGEN, is one of those forms in which the whorls are more numerous and involute than the others and the dorsal carina thin. As the name had already been preoccupied for a recent shell of the Planorbidæ, DE KONINCK has instead proposed *Tropidocyclus*, but this as well as the former ones must be regarded only as synonyms to Cyrtolites. Porcellia Verneuili D'ORB., DE KON. Faune Carbonifère, II, pt IV, 288, belongs probably also to the genus Cyrtolites.

There is some difference as to the involution and number of the whorls, and as to the size and sculpture of the dorsal carina. But the common compressed, discoid, shape and the form of the aperture, which as to its details is nearly alike in all, are sufficient grounds to unite them in the same genus.

The geological range of its species is limited in Sweden to the Upper Silurian formation of Gotland from where five species are known in the shale and sandstone beds, and three in the superjacent limestone, one species being common to both. Abroad Cyrtolites continued as far as now is known in both the Devonian and Carboniferous formations. In North America several species are found already in the Lower Silurian.

Conspectus of the species:

I. Whorls free or scarcely contiguous, few in number.
  1. C. lamellifer n.
  2. C. pharetra n.

II. Shell with contiguous whorls, numerous, disciform.
  3. C. arrosus n.
  4. C. obliquus n.
  5. C. euryomphalus n.
  6. C. discus n.
  7. C. orbiculus n.

1. **Cyrtolites lamellifer** n.

Pl. VI figs. 31—38.

Shell laterally compressed, along the median line of the sides somewhat tumid and thence elliptic in a transverse section. The surface is transversally ridged by a succession of regularly distantiated, outstanding lamellæ, wide apart at the dorsal side, converging towards the ventral side and most of them meeting. They stand out, slightly bent against the aperture of the shell (figs. 34, 37), looking like hooks when seen edgewise. They are about fifteen and represent the successive apertural borders. They are crossed by regular, elevated longitudinal striæ nearly of equal size, separated by interspaces of the same width. Rectangularly to them, minute threadfine ornamental lines are running. The dorsal keel or the slit band is moderately elevated and in direct continuation of a deep tongue shaped slit in the middle of the superior lip of the aperture. The slit band is even and consists of small arched lines (figs. 32, 38), with their curves directed backwards. A great many of them are direct continuations of the lateral, projecting lamellæ, which thus run without interruption all around the shell. The whorls are in the most perfect specimens two and a half, open, disjointed. In some, as that delineated in figure 34, there is only one and a half whorls, the shell resembling a Cyrtoceras. The aperture is elliptical, acuminated towards the dorsal and ventral sides. The middle of the inferior lip is elevated into a small, vaulted saddle. It does not, however, repose on the back of the preceding whorl as in the other species. On the ventral side of the shell quite opposite to the slit band, there is a shallow groove running down towards the apex. Diameter of the aperture 20 millim. in the fragment of a very large specimen. A complete specimen is 11 millim. at the aperture, the transverse diam. of the aperture is 6 millim., total length 18 millim.

This beautiful shell has been found in several specimens in the limestone beds (b) in the neighbourhood of Wisby and towards the north as far as Likkershamn.

2. Cyrtolites pharetra n.

Pl. VI figs. 39—51.

Shell discoid, compressed, tumid along the middle-line of the sides. The ornamentation consists in straight, equally distantiated sulci with blunt edges, but in an obtuse angle, directed forwards, near the back; they give to the surface an imbricated appearance and they converge towards the ventral side. They continue without interruption around the shell, forming at the dorsal carina a sinus backwards and downwards. The spaces between the sulci are smooth or slightly striated by fine, longitudinal lines. There are traces of longitudinal colour bands, alternately dark and light of unequal largeness, as represented in fig. 39. The whorls are two and a half, free and disjointed, rapidly increasing in width (fig. 45). The dorsal carina is low, almost vanishing near the aperture, gradually increasing in height backwards and also becoming more narrow. The aperture is ovate or in some approaching to circular, its interior lip reclines on the back of the nearest whorl and is, at the point of contact, bent in a small saddle. Corresponding to this a groove runs on the outside of the shell to the apex. The slit in the superior lip is shallow and broad. Length 15 millim., longest diam. of the aperture 9 millim., transverse diam. 6 millim.

Only found in the shale at Djupvik in Eksta from where several specimens are preserved in the State Museum at Stockholm.

3. Cyrtolites arrosus n.

Pl. VI figs. 52—53.

Shell discoid, tumid, involute, whorls three and a half, rapidly increasing in size. Surface with fine, transverse, regularly curved lamellar lines, with serrulated edges, as shown in fig. 53. The aperture is oval, the slit seems to have been deep and the saddle of the interior lip is large. The keel is blunt to judge by the cast of it. Height of the shell 33 millim., breadth 23 millim. Height of aperture 20 millim., breadth of same 15 millim.

Only one specimen has hitherto been found in the limestone of Martebo.

4. Cyrtolites obliquus n.

Pl. VI figs. 54—55.

Shell discoid, a little obliquely involute, terete; ornamental striæ most minute, closely set, with denticulated edges, dorsal carina blunt and narrow. Whorls three and a half. Diameter of the fragmentary shell 3 millims. From the sandstone of Bursvik.

5. Cyrtolites euryomphalus n.

Pl. VII figs. 10—15.

Shell discoid, involute, surface smooth, rather glossy, ornamented with regularly distantiated lines, elevated, giving the surface an imbricated appearance. Along the interior edge of the whorls there runs a narrow ridge, on which the transverse lines swell in a minute nodule. From this ridge the surface falls off abruptedly towards the centre of the shell. The whorls are four and a half, gradually increasing in width, contiguous. The aperture is broader than long, nearly pentagonal, with the dorsal carina forming a tonguelike processus from the superior edge. The slit band is much prominent, flat on its outer edge and covered with distantiated, crescent shaped lines of growth. Diameter 5 millim., breadth of aperture 3 millim.; height 2 millim.; diameter of space enclosed within the interior ridge 2 millim. From the shale at Djupvik in Eksta. Some twenty specimens known. A corroded specimen has also been obtained from the sandstone of Bursvik.

6. Cyrtolites discus n.

Pl. VII figs. 18—21.

Shell discoid or lenticular, slightly tumid, surface with linear, elevated, transverse striæ, curved gently backwards on the dorsal side, regularly distantiated and having between them much finer, minute lines. Whorls four, gradually increasing, the last one partially free. Aperture triangular, lower lip nearly straight, horizontal, lateral margins faintly curved, converging at the narrow dorsal slit. Slit band narrow, elevated, blunt, not much prominent, covered with small crescent shaped lines of growth.

Largest diameter 7 millim., breadth 3 millim.

The original specimen, which belongs to the Museum of the Geological Survey of Sweden, has been found in the sandstone of Bursvik. Later, another specimen has been found in the middle limestone beds near Wisby. This is more smooth without any smaller lines between the large transverse striæ.

It is distinguished from the following through its fewer and broader whorls, through its lower and blunt slit band and its triangular aperture.

7. **Cyrtolites orbiculus** n.

Pl. VII figs. 16—17.

Shell discoid, involute with all whorls contiguous. Surface with distantiated, threadfine, elevated, transverse lines, gently curved backwards, the interstices being smooth or indistinctly finely striated. The whorls are five and a half, at highest near their inner edge, which sinks vertically to the deep suture. Aperture broadly lanceolate. Slit band a thin, prominent keel more elevated than in any other Gotland species of this genus.

Largest diameter 13 millim; thickness 4 millim. at the aperture. Only one specimen has hitherto been found in the shale of Djupvik in Eksta.

Gen. **TREMANOTUS** Hall.

1864 *Tremanotus* Hall Extract of 18th Rept. St. Cab. N. York p. 43.
1868 *Gyrotrema* Barrande, according to Bigsby Thes. Silur. p. 167 and also to letters from M. Barrande himself.

Shell discoid, involute, whorls tumid, visible both from the umbilical and apical side, consequently with large, open, double umbilicus; aperture with greatly expanded and enlarged lips, the slit very shallow, continuing in a narrow keel, which is perforated by a number of oval apertures. These have subsequently been closed with shelly matter.

This genus was founded by James Hall, as is stated by Meek[1]), in an Extract from the 18th Report of Regents N. York. St. Cab. p. 43, which was issued in 1864, but this extract was never published along with the rest of the 18th Report[2]), being only in 1868 joined to the first edition of the 20th Report, with the date 1865 printed on the sheet wherein the said description is contained. It seems, however, not to be any valid grounds to follow Hall in placing it as a subgenus to Porcellia, a genus which belongs to a much later period and has a deep slit in the exterior lip and a slit band quite as in Pleurotomaria, but without apertures and, moreover, obliquely spiral. Tremanotus is indeed quite as much different from this genus as from all other Bellerophontidæ, excepting Tubina and possibly also Salpingostoma, in the presence of the apertures on the dorsal keel. It resembles, as to the expanded aperture, some of the species of Bucania, which genus, as it has been limited by its founder Hall in the Pal. of N. York vol. I, contains many heterogenous forms, of which several ones are extant only in obscure casts. Amongst other genera, *Tubina* Barrande[3]) is related

[1]) Meek Proc. Chicago Ac. Sc. 1865, vol. I. p. 10.
[2]) Issued in 1865.
[3]) Owen Palæontology 1860 p. 71 fig. 71, 8 and also named thus on labels in collections sent from Prag.

through the rows of apertures along the back and the sides, which, however, are prolonged into curved, spine like tubes. It seems also that Salpingostoma FERD. ROEMER, Leth. Geogn., Ed. 1876, Taf. 5 fig. 12, is related through its enlarged aperture and an elongated slit on the back of the last whorl. S. A. MILLER in his Supplement to the Catalogue of American Palæozoic Fossils p. 304, says that »Tremanotus is a synonym for Bucania. The supposed openings on the cast represent the spines upon the back of the anterior part of the last whorl of the shell». But this cannot be the case, as the smallest specimens already are provided with these apertures, which during the continued growth of the shell become hidden under the overlying whorls. There are no signs that the borders of the apertures have been formed through spines or tubes having been broken from them, they are even and smooth and resemble nothing more than those seen in the recent Haliotis. The peculiar ornamentation of longitudinal, coarse lines also augments the probability that both are nearly related to each other. This must, however, be left as an open question as there are no connecting links, the Tremanoti disappearing with the Silurian era and Haliotis at the earliest found in the Miocene strata.

This genus first appears in the Lower Silurian strata of Öland from the Chasmops limestone of which island, at Böda, the Swedish State Museum possesses fragments of a Tremanotus closely related to Tr. longitudinalis, if not identical.

In the strata of Gotland two species occur:

1. *Tr. longitudinalis* with whorls of circular section;
2. *Tr. compressus* with whorls of elliptical section.

1. Tremanotus longitudinalis n.

Pl. III f. 39, 40, pl. IV f. 1—7.

Syn.: *Bellerophon dilatatus* 1867. LINDSTRÖM (nec Sow.) Nomina fossil. Gotlandiæ p. 23. It may be that this species is identical with SOWERBY's B. dilatatus Sow. Sil. Syst. p. 627 pl. XII figs. 23, 24. According to M'COYS more elaborate description in Palæoz. Fossils p. 309 this species has spiral lines, but as in neither work any mention is made of apertures on the dorsal keel, I cannot refer my specimens to the English ones.

Shell thin, discoid, whorls four, visible on both sides, evenly rounded, cylindrical and of circular outline in transverse section. Aperture considerably enlarged, with anterior or outer lip turned up as seen in fig. 3 pl. IV, without any slit, only with a shallow indenture from which a small groove continues on the inside. Where fragments are left of the inner stratum of the shell, as at the inner lip of fig. 1 pl. IV it is smooth with only faint striæ and the lip is so much reflexed that it covers more than two thirds of the whorl on which it reclines. As this interior stratum often has been destroyed, there is on the aperture commonly only seen the impression of the outer side. The radiating striæ all arround the aperture, seen in the same figure 1, are impressions of the exterior surface which have been uncovered. The innermost opening in the middle of the apertural expansion is transverse or somewhat triangularly cordate, pointed towards the outer lip and broad on the opposite side. The outer side is ornamented by longitudinal, elevated bands, of unequal size, large and narrow, as it were, in pairs with larger interspaces. They are not quite parallel with the median axis and spreading toward the aperture in a sort of pinnate arrangement, new ones being intercalated from the dorsal keel. These bands are interrupted by transverse, sinuose, sunk lines, in older and worn specimens much reminding of the fringed sutural lines of the diaphragms of the Ammonites. As seen in figs. 4 and 6 pl. IV these interruptions are very evident along the transverse lines and it is indeed a new set of longitudinal bands which starts in the front of such transversals. These are, as may clearly be seen through fig. 39 pl. III, the edges of the old expanded apertures, which in perfect and intact specimens must have projected as imbricated lamellæ, the one beyond the other, as in some of the Cyrtolites.

Along the median line of the dorsal side an elevated, narrow keel is stretching, corresponding with the groove on the inside; at some distance from the superior margin of the outer lip there is a row of elongated, elliptical apertures with elevated borders. These apertures continue for a while open and become further down on the spire closed with shelly matter as in Haliotis.

Longitudinal axis of aperture 94 millim., transverse diam. of same 95 millim., diameter of last whorl near the aperture 31 millim. Distance from the edge of the outer lip to the opposite end of the whorl 115 millim.

This, one of the largest of our Silurian shells, has been found in many places on Gotland. In the oldest shale beds from Halls huk, along the shores north and south of Wisby, in the shale of Djupvik in Eksta, Petesvik in Habblingbo and further inland in the shales of Wisne myr in Fardhem, and also in the sandstone of Bursvik. The superjacent limestone and oolite beds also contain it. It has been found in these beds at the canal near Westöös in Hall, in Martebo, around Wisby, in a section near Stjernarfve in Eksta, in the limestone near Lau church and the oolite of Bursvik. From the uppermost limestone strata it has been obtained at Lutterhorn in Fårö, Martebo, Kålens qvarn near Wisby, the upper limestone of Slite, Wialmsudd at Fårösund and at Fröjelklint. It occurs almost always in casts, only a few specimens having been found with the shell, which is very thin.

Among nearly related species Treman. trigonostoma HALL and WHITFIELD Geol. Surv. Ohio, vol. II p. 146, pl. VIII f. 5 resembles Tr. longitudinalis in a high degree.

2. Tremanotus compressus n.

Pl. IV figs. 8—12.

Shell discoid, involute, whorls five, transverse with the lateral diameter largest. In a section the whorls are of an elliptical outline. In the nuclei, which have been found, nothing is left of the expanded aperture. There are faint traces of longitudinal lines. The apertures on the dorsal keel are smaller, more regular and closer set than in the preceding species, elliptical or ovate. Largest diameter 34 millim. Breadth of largest whorl at the aperture 32 millim. Height of the same 18 millim. Occurs in the limestone beds of Östergarn, but only as nuclei, also at Hammaren in Kräklingbo.

Amongst formerly known species, Bellerophon Aymestrensis Sow. Sil. syst. p. 616, pl. 6 fig. 12 seems to be nearest related to this species, but there are no apertures on its back, as far as the evidence goes.

Fam. VI. PLEUROTOMARIDÆ D'Orbigny.

Since Dall in the Bulletin of the Museum of Comparative Zoology, vol. IX, № 2 (1881) p. 77 and following, made known the results of his researches on the structure of the animals of two different species of Pleurotomaria, dredged up from the depths of the Mexican Gulf there are more valid grounds than before to attribute to the members of that large genus an independent position in a family of their own. Scissurella which had long been considered as the only living representative of the Pleurotomaridæ, must henceforth be separated from them and receive its place with the Trochidæ, while Pleurotomaria, according to Dall »stands nearest the Trochidæ, with features recalling the Haliotidæ». This same opinion had indeed also been pronounced by some other zoologists previous to Dall's researches on the animals themselves, as by Claus, though he includes Scissurella in this group.

It is, however, very difficult, on various grounds, to draw the exact limits in respect to several of the palæozoic forms and to tell with certainty, which are belonging to this family and which are not. It must be borne in mind that there are several shells, besides the Pleurotomariæ and belonging to quite different families, which are provided with a slit in the exterior lip and a slit band, as nearly as possible resembling that of Pleurotomaria. Scissurella, for inst., is provided with a similar band and also Emarginula, in both of which the organization of the animals is different from that of Pleurotomaria. In the Bellerophontidæ there also occurs a slit band, which in many of them, though not in all species, is formed upon the same plan as in Pleurotomaria.

The peculiarity in the structure of the body, which has caused the deep slit, may, no doubt, be shared by several other Gastropoda, else dissimilar, but in them originating only a shallow notch, as sometimes, not typical, in certain specimens of Platyceras or typical in all species of several genera, as in the next family, the Euomphalidæ or in the large genus Pleurotoma or in Siliquaria. In none of these, however, the peculiar slit band is marked by distinct crescent-formed lines of growth or lamellæ, sometimes attaining an enormous development and enclosed within two or even more distinct elevated lines or lamellæ.

The nacreous shell of the true Pleurotomariæ is still preserved in a great majority of the Silurian species which are described further on. There must rest some doubt concerning those, in which the nacre is not left behind, but which else in all details are like the Pleurotomaridæ and which, provisionally at least, may be included in this family.

According to the definition first given by De France all those palæozoic species, which have the characteristic, broad slit which by and by during continued growth is filled up and changed into the equally characteristic slit band, are numbered amongst them. This family is thus made to contain the following eight palæozoic genera, viz. Pleurotomaria, Murchisonia, Odontomaria, Brilonella, Porcellia, Catantostoma, Polytremaria and Trochotomaria. Of these only two, Pleurotomaria and Murchisonia, are represented through species in the Silurian formation of Gotland, but in such a large number that they make up nearly a third of the whole fauna of Gastropoda.

The limits between this family and the following, that of the Euomphalidæ, are somewhat obscured through such forms as Pleuronotus (Euomph.) Decewi, in which there is an approach to the formation of a complete slit band, in connection with a general form of the shell as in Euomphalus. It is although questionable whether one of the specimens[1]) figured by James Hall and in which the slit band is most prominent really belongs to the same species or to Euomphalus at all.

There are also some shells which have been placed in this family, though they sometimes exhibit a change of a regular and distinct slit band into the simple, notched, angulate rib, such as is characteristic of the Euomphali. Pleurotom. planorbis His. for instance thus forms in a certain degree a connecting link between both families. But in consequence of such structural variations some confusion has been unavoidable and some uncertainty ensued which genera are to belong to this or the following family. Moreover, genera, which do not at all show the characteristic features, have been placed amongst the Pleurotomaridæ, and, again, others, which of necessity must be numbered with them have been excluded. An attempt to clear up this somehow is made further down, when the respective genera are treated.

Gen. **PLEUROTOMARIA** De France.

1810? *Hercoles* Montfort p. p. Conchyl. System. II, 274.
1810 *Anatomus* Montf. p. p. ibid. 278.
1821 *Pleurotomaria* De France in Férussac Tableaux Systématiques, p. XXXIV.
1823 *Scissurella* D'Orbigny p. p. Mém. Soc. H. N. Par. vol. 1, 340.
1825 *Pleurotomarium* Blainville Malacologie, 429.
1837 *Inachus* His. p. p. Leth. Suec., 37.
1837 *Ptychomphalus* L. Agassiz Gross-Britanniens Mineral. Conch. 23, 222.
1842 *Scalites* Conrad p. p. in Emmon's Geol. Rept. 312.
1847 *Rhaphistoma* Hall Pal. N.-York I, 28.
1859 *Helicotoma* Salter Figures and Descript. of Canadian Organic Remains, Dec. I, 10.
1876 *Euomphalopterus* Ferd. Roemer Leth. Geogn. Ed. 4. 1:e Theil, Taf. 14 fig. 9.
1883 *Gosseletia* De Koninck Faune Carbonif. Belg. II, pt. 4, 28.
1883 *Agnesia* Id. Ibid. 99.
1883 *Luciella* Id. Ibid. 107.
1883 *Mourlonia* Id. Ibid. 245.

Shell of varying shape, trochiform, turbinated, discoid or globular, with a broad angular slit near the middle of the exterior lip, continued on the whorls by a band, which is bordered by one or two elevated lines on each side and towards which the trans-

[1]) Pal. of N.-York, vol. V, pt. II, pl. 29 fig. 7.

verse striæ of the upper and lower moiety of the whorls converge in direction backwards. In most well preserved specimens the shell is nacreous. In some species there is a tendency to fill up the apex of the shell with solid calcareous matter or even to partition off the apex by imperforated tabulæ or diaphragms.

Rich as this genus is in a great number of variously formed species, ranging in time from the basis of the Lower Silurians through all the Palæozoic formations with well nigh 500 species, it is conceivable, that many attempts have been made to divide and subdivide it in generic groups of a second order or even only in divisions of wider or more narrow circumscription. Before attempting to make any such divisions for the Gotlandic species, it may be convenient to take a review of older groupings or of genera which may be considered as synonymic.

As to the claims of DE FRANCE as the first author of Pleurotomaria, it cannot any longer, as DALL thinks, be doubted that DE FRANCE really must be regarded as the author and by almost unanimous consent also has been acknowledged as such. DALL again (Preliminary Rept. on the Mollusca, Bullet. Mus. Comp. Zool. Vol. IX n:o 2 p. 78) considers, that SOWERBY who was the first to publish its characters, is the real author and that his name has to replace that of DE FRANCE. But the case stands as follows. The name Pleurotomaria is printed for the first time in FÉRUSSAC's Tableaux Systématiques [1]), earlier than June 1821 and in December the same year it was characterized by SOWERBY in his Mineral Conchology vol. III p. 139, pl. 278. In 1823 FÉRUSSAC in a Note to the Memoir of D'ORBIGNY on Scissurella in the »Mémoires de la Soc. d'Hist. Nat. de Paris», vol. I p. 340, says on Pleurotomaria that »ce genre est connu depuis longtemps des Naturalistes de Paris et son nom est déjà imprimé dans plusieurs ouvrages». He does not name any body else but De FRANCE as the author. Moreover, JAMES SOWERBY himself before 1825, when the last pages of his »Genera of Recent and Fossil Shells» were published, in the descriptive letterpress to pl. 205, where Pleurotomaria is figured, expressly states that he considered DE FRANCE as the author, in saying »the Pleurotomaria of DE FRANCE», never mentioning himself as the author or making any claims as such and even not referring to his own previous description in the Mineral Conchology.

Prominent amongst the synonymic genera is Ptychomphalus L. AGASSIZ founded on a shell from the Mountain Limestone, Helicina compressa Sow. It should deviate from the others in the possession of a callosity on the umbilical centre. But DE KONINCK in his last work on the Carboniferous Fauna of Belgium includes in Ptychomphalus the majority of the Belgian Pleurotomariæ of that period, 59 species, and does not accept the genus Pleurotomaria at all, on the ground that the first species described by DE FRANCE have a wide umbilicus. Now the absence or presence of an umbilicus cannot, as DESHAYES [2]) long ago has remarked, have any influence on the

[1]) Tableaux Systématiques des Animaux Mollusques classés en familles naturelles, p. XXXIV. The second part of this work, »Tableau Systématique de la Famille des Limaces» bears on its title page the date »Juin 1821». The preceding pages i—xlvij, where Pleurotomaria is catalogued, are, consequently, still older.

[2]) Journal de Conchyliologie I p. 209.

creation of new genera, when it is known how this character varies in one and the same species and that, moreover, a single character seldom is so important as to distinguish a genus. Amongst the species of Ptychomphalus, established by De Koninck there are several without any callosity at all, and also others where a narrow umbilicus is seen. Of the other new genera, ranked by De Koninck with the Pleurotomaridæ, such genera as Baylea, Worthenia, Rhineoderma do not show the least trace of any slit band to judge from the figures, the descriptions and in some instances by such specimens of them as I have seen. The genus Agnesia again seems to have been founded only on the distinction of its being sinistral, but as it in other details agrees with Pleurotomaria and sinistral as well as dextral specimens occur within the same species of Pleurotomaria, as, for inst., Pl. decussata Sandberger (Versteiner. d. Rheinischen Schichtensystems p. 197, tab. 24 f. 2), there seems not to be valid grounds to create a new genus out of it. The same may be said in reference to Gosseletia [1]), Mourlonia and Luciella as none of them has such prominent or permanent characters as to entitle them to any generic distinction from Pleurotomaria.

Ferd. Roemer's Euomphalopterus, however aberrant, is nothing but an extreme form of Pleurotomaria, as will be shown further down. The extraordinary development of the slit band is shared by some species which have hitherto been placed within the incongruous genus Eccyliomphalus, as for inst. Ecc. alatus Ferd. Roemer. His Odontomaria, Leth. geogn. 4:th Ed. 1 Th. Taf. 29 fig. 10, of which he says that it »begreift gewissermassen abgerollte Pleurotomarien», is, as it, however, must be conceded, more straight than any other. As further instances of such Pleurotomaridæ may also be cited Pleurotomaria centrifuga F. Ad. Roemer, Verstein. des Harzgebirges p. 22, Taf. VII fig. 11[2]). But, as Ferd. Roemer himself long ago remarked [3]), the formation of scalarid shells can only have a subordinate value as a generic characteristic, as there are involute or evolute specimens belonging to the same species as we shall see in the description of Pleurotomaria qualteriata. The same peculiarity in the growth of the shell occurs also, as is already shown, in Platyceras and even in Euomphalus, without there being any grounds to ascribe to it specific, so much the less any generic value.

The genera Scalites, Rhaphistoma and Helicotoma are founded chiefly on American fossils and belong to the group of Pl. qualteriata, having the whorls on the apical side more or less flat and even; the slit band situated on the acute outstanding angle, which is formed where the apical and the umbilical sides meet. Most authors seem now to agree that all are identical and coincide with Pleurotomaria.

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[1]) This name has already been employed by Ch. Barrois in 1881 for a lamellibranchiate; Ann. Soc. Géol. du Nord, VIII, p. 176.

[2]) Pleurotomaria extensa Heidenhain Graptolithführende Diluv. p. 18, Taf. 1 f. 10 (= Bellerophon evolutus Haupt Taf. III f. 13) is perhaps only an Euomphalus.

[3]) Lethæa geognostica, Ed. 3, vol. I, p. 455. »Es kann jedoch jener Umstand wohl kaum zur Aufstellung einer eigenen Gattung genügen, da sehr verschiedene Gasteropoden-Gattungen (z. B. auch Helix) deren Umgänge regelmässig verbunden sind, ausnahmsweise zuweilen in Folge noch nicht näher erforschter Einwirkungen frei werden. In keinem Falle dürfen solche Arten von Euomphalus getrennt werden, bei welchen jene Trennung der Umgänge nicht stets, sondern nur vorherrschend sich findet.»

Besides the above enumerated genera, which have been exclusively, or almost so, instituted for the reception of species of Pleurotomaria, other genera, which have nothing in common with that genus, shelter a few true Pleurotomariæ, but have not been placed in the list of synonyms, as their authors did not intend them for Pleurotomariæ. So, for inst. Pleurotomaria elliptica His. has been by De Koninck included in the Trochoid genus Flemingia, established by him, but such instances are mentioned further down in the descriptions and synonyms of the species.

It must be conceded that the limits between this genus and Murchisonia are very difficult to draw, a wide field being given to arbitrary individual opinions through the vagueness attributed to the chief character of Murchisonia, viz. the length of its spire. It may, nevertheless be practically useful to distinguish such Pleurotomariæ, which have a long, slender spire of more than six, beadlike whorls (= Hormotoma Salter) as Murchisonia. In them the nacreous nature of the shell is not so evident as in Pleurotomaria proper. The nature of the Pleurotomarian shell as nacreous has been much contested, but it admits of no doubt through several Gotlandic specimens, which still retain the pearly coating interiorly.

The character of the slit in the Silurian species is rather deviating from what commonly is represented as its form in secondary and more recent formations. The lips are in these straight cut and the borders of the slit parallel, but in the Silurian ones the slit forms an acute angle and the borders are diverging. In some the slit is linear, as in Peurotom. æquilatera. As to the slit band, one of the most characteristic features in this genus, it deserves more than a passing attention. It is in almost all instances hemmed in by at least two, parallel, elevated lines, one to each side, always distinct. The band itself is of a varying breadth, linear as in Pleur. gradata, pl. VII, fig. 26, or large, relatively, as in Pleurotomaria exquisita, pl. XI fig. 3. The usual ornamentation consists in crescent-formed lines of growth, pl. IX, figs. 2, 4, 6, 15 etc., with the concavity towards the aperture. These crescents are sometimes crossed by longitudinal lines as in Pl. claustrata pl. VII f. 31, 34, Pl. glandiformis, Pl. biformis, pl. VII f. 42 or by a longitudinal ridge as in a whole group of Pleurotomaria with Pl. bicincta pl. VIII figs. 19, 21, 22, 23 as their type. In Pl. limata, pl. X figs. 14—16, the lamellæ of growth have a most extraordinary appearance being thin, prominent, bent forward, imbricated and in their midst divided through an ovate indenture. The bordering lines are either very low, of middling size or developed to an enormous length as lamellæ. There can be discerned certain gradations, by which the extreme development in Pl. alata is connected with the others. In Pl. claustrata, pl. VII f. 32, both the bordering lines project so much as to transform the slit band into a deep groove around the shell. In Pl. limata, pl. X fig. 8, 14, they stand forth and form a sharp keel around the shell. A magnified section of it is represented in pl. X fig. 14, being included in soft limestone, whereby the most delicate parts are preserved. The cusps inside are sections of the crescentic lamellæ of growth being cut obliquely. In pl. X fig. 17 a cloven, aliform slit band is figured. The moieties of two lamellæ are seen in their length from the broad, scooped out basis to the pointed apex. In pl. X figs. 27, 31, 37, details are given of the slit band of Pl. alata showing it, in fig. 27

(nat. size and magnified) sectioned transversally and the lamellæ of growth as in the former species, riblike with smooth interstices, directed obliquely outward, towards the aperture of the shell. In fig. 30 the slit band is sectioned along its whole breadth in a line from the whorl outwards, intersecting some ten lamellæ of growth obliquely. Section fig. 31 is taken parallel to the exterior border, showing the apices of eleven of the elongated crescentshaped lines of growth. The same large development also obtains in some other species which form the division »Alatæ» and of which several instances are given on plate XI. This extraordinary increase of the slit band might at the first look be regarded as a derived feature that attained such dimensions in the Upper Silurian times. But on finding shells as low down in the series as in the Lower Gray Orthoceratite limestone with a quite identical slit band one might as well ask whether there not has been a regress from the development of this band to what we find prevailing in a reduced shape during later geological periods. As we are not in possession of materials ample enough from still older strata, we are not able fairly to build any conclusion on this point. The aliform slit band is easily distinguished from other lamellar expansions, such as are found in some Trochi and others, by a section, through which the interior compartments become visible, whereas in the latter shells the interior is compact.

The character of the slit band varies in the selfsame specimen of some species, as for instance in Pl. elliptica and it changes its nature and shape during continued growth quite as is the case with the Bellerophons.

Another peculiarity amongst some of the Pleurotomariæ is that the apex has been either filled up with a solid mass of calcareous matter or has been subdivided in several small compartments through imperforated diaphragms or tabulæ. This peculiarity they share with Murchisonia, Loxonema and Euomphalus, amongst which it is common. At the same time this tendency is often accompanied by the formation of a scalarid shell.

Species of Pleurotomaria are already found in the Lower Red Orthoceratite limestone of Sweden, beginning with Pleurotomaria qualteriata. Pleurotomaria elliptica HISINGER also is found in the Upper Gray Orthoceratite Limestone of Sweden. But it was in the Upper Silurian seas, in the strata, which now make up the chief mass of Gotland that this genus attained a considerable development in no less than 39 species and varieties of changing aspect and ornamentation. These species may most conveniently be subdivided in groups, according to their agreement as to the chief characteristic, the slit band, along with which feature several peculiarities follow in the general form of the shell, its ornamentation, the position of the band on the whorls etc. I propose then to range the Gotlandic species in the following groups taking the form and ornamentation of the slit band as the principal ground of division.

I. **MULTICARINATÆ.** Slit band accompanied on each side by one or two lines, crescents crossed by several longitudinal lines.

1. Pl. scutulata n.
2. Pl. gradata n.

3. Pl. Linnarssoni n.
4. Pl. voluta n.
5. Pl. claustrata n.
6. Pl. glandiformis n.
7. Pl. biformis.
8. Pl. latezonata.
9. Pl. Hindei n.
10. Pl. Holmi n.
11. Pl. Wisbyensis.

II. **CRISPÆ.** Slit band with distantiated, sharpedged, regular crescents and smooth interstices. Shell ornamented by many keels.

12. Pl. Lloydii Sow.
13. Pl. dolium n.
14. Pl. laqueata n.
15. Pl. tubulosa n.

III. **FASTIGIATÆ.** Slit band forming a blunt, elevated ridge, crescents flat, oblique, densely packed; shell finely striated transversally.

16. Pl. robusta n.
17. Pl. lævissima n.
18. Pl. elliptica His.
19. Pl. bicincta Hall.
20. Pl. qualteriata Schloth.

IV. **SIMPLICES.** Slit band narrow, plain, with small, regular crescents, shell surface simply, transversally striated.

21. Pl. valida n.
22. Pl. Othemensis n.
23. Pl. comata n.
24. Pl. æquilatera Wahlenberg.

V. **INCISÆ.** Slit band with large, lamellar crescents which are divided in their middle. Shell richly ornamented.

25. Pl. labrosa Hall.
26. Pl. limata nom. nov.

VI. **ALATÆ.** Slit band forming a large, thinedged keel all around the shell, both the bordering lines of the slit band being widened and having developed into thin lamellæ, which have coalesced with their edges enclosing the crescents of growth.

27. Pl. replicata n.
28. Pl. alata Wahlenberg.
29. Pl. alata, var. subcarinata n.
30. Pl. alata, var. opposita n.

31. Pl. prætexta n.
32. Pl. togata n.
33. Pl. frenata n.
34. Pl. undulans n.
35. Pl. Marklini n.
36. Pl. cirrhosa n.

VII. **PLANORBIFORMES.** Shell discoid, slit band situated on the apical side near the suture, narrow, much variable to its sculpture. Schizostoma BRONN p. p.
37. Pl. planorbis HIS.
38. Pl. helicina n.

VIII. **NATICOIDEÆ.** Shell globose, slit band larger than in any other division, at a level with the other surface, ornamentation of the shell of microscopic, oblique lines, also crossing the slit band. Only one species known.
39. Pl. exquisita n.

Divisio I. MULTICARINATÆ.

1. Pleurotomaria scutulata n.

Pl. VII, figs. 23—25, 28, 29, 30.

Shell conical, turbinated, whorls eight and a half, globose or rounded, separated from each other through a deep suture, spire acuminate. Slit band situated exactly on the middle line of the free body whorl and close to the suture on the superior, visible part of the other whorls. It is narrow, somewhat concave and with dense, regularly curved crescents and one or two faint longitudinal lines crossing them. The enclosing lines are sharpedged. The slit band is on both sides environed by a belt of different ornamentation than the other surface and this belt is enclosed by one prominent line on each side. Within this area there are fine longitudinal and transverse lines crossing and above the uppermost line there is also a broad space equally ornamented. This median belt with its central slit band projects as a ridge all around the shell (fig. 25). On each side of the belt there is a longitudinal slight concavity. The ornamentation of the other surface consists of fine cross lines of equal size, forming nodules where they meet and enclosing small squares and rhombs. The aperture is large and nearly ovate. The columellar lip is reflexed and bent a little round the umbilicus, which is large and funnelshaped.

Height 20 millim., breadth 17 millim. Aperture 11 millim. in height, breadth 9 millim. Apical angle 80°.

This elegant shell occurs in the limestone of Samsugn in Othem, at Stor Wede in Follingbo and at Kyrkberget in Wisby. There is some variability in its shape, with more slender spire (angle 55°) from Follingbo or quite the reverse, 85°, depressed, as those from Samsugn.

2. **Pleurotomaria gradata** n.

Pl. VII figs. 26—27.

Shell conical, trochiform, spire blunt, broad, whorls eight with regularly straight, sloping sides of faint convexity, abruptedly bent along the superior suture through the vertical and almost even zone around the slit band. This band is central on the body whorl and remarkable as being one of the narrowest amongst all the Silurian Pleurotomariæ and perhaps amongst all known. It is reduced to a narrow fissure, a mere fraction of a millimetre and thin as a knife edge. It continues open a long way round the body whorl and the next, and then at last is filled up. But owing to its narrowness it is impossible to discern any crescents on it. Like the related, preceding one, the slit band is enclosed within a separate zone, differently ornamented from the other surface and bordered by a narrow line on each side. In this median field there are only transverse lines crossed by a few, obscure, longitudinal ones. On some distance a blunt ridge is running on each side. The ornamentation of the whorls consists of somewhat distantiated, transverse lines, connected by more narrow spiral ones and parallel to the slit band; in the interstices microscopically minute transverse lines are seen. The belt around the slit band does not form any prominent ridge as in the former species, but rather a somewhat concave or straight facet on the whorl. The suture is shallow. The aperture is rather more broad than high, its columellar lip is strongly reflexed around the open umbilicus.

Height 22 millim., breadth 20 millim. Apical angle 69°. Another specimen has 24 millim. in height and 23 mill. in breadth. Found in numerous specimens in the limestone of Sandarfve kulle and also in the gray limestone of Linde kulle.

Oehlert has described a Pl. Virensis from the Lower Devonian of France, and this comes near to our species through its ornamentation and the slit band, though its spire is lower.

3. **Pleurotomaria Linnarssoni** n.

Pl. XX fig. 21—24.

Shell small, discoid, spire moderately prominent, whorls six, increasing in size slowly and proportionately. They are adorned with a delicate network, on the apical side consisting of intercrossing striæ of which the transverse ones are directed backwards in an acute angle against the slit band. At the intercrossing of these lines small nodules are formed giving the surface a prickly appearance, with small pits in the interstices. The slit band is placed below a narrow keel which divides the shell exactly in two halves. It is exceedingly narrow and accompanied on both sides by longitudinal lines, which are more prominent than the others. On the umbilical side the whorls are more ventricose than on the opposite and also similarly ornamented. The aperture is circular and the umbilicus is large and open. H. 4 mill., br. 8 mill.

A dozen specimens have been found in the red limestone of Sandarfve kulle and a few also in Linde klint. Through its ornamentation and its slit band it is nearest allied to Pl. gradata from the same localities.

4. **Pleurotomaria voluta** n.

Pl. XIX fig. 25—29.

Shell discoid, tumid, with slightly prominent spire. Whorls eight, of regular increase. The shell is on both the apical and umbilical side decorated with sharp, sigmoid transverse lines curved towards the aperture near the suture and backwards near the slit band. They are crossed by finer, longitudinal lines, forming minute tubercles where they meet. The section of the whorls is nearly ovate, high, arched above, flattened below. The belt of the slit band is situated much beneath the middle line of the body whorl and divides the flattened surface of the shell from the more tumid. It is relatively large and is crossed by some longitudinal lines. The slit band itself cannot be discerned through the bad preservation of exactly this part.

Through its general form and as far as can be judged in the conformation of the zone of the slit band this species comes near to the preceding, from which it, however, is sufficiently, distinct by its greater tumidity, its ornamentation and wider umbilicus. Height 4 mill., br. 11 mill., diameter of umbilicus 6 mill.

Two specimens have been found in the red and gray limestone beds of Sandarfve kulle.

5. **Pleurotomaria claustrata** n.

Pl. VII f. 31—36.

Shell conical, trochoid, whorls seven or eight, gently convex, forming an acute angle at the oblique slit band, which is placed somewhat above the median line of the whorls. Its surface is almost flat, sloping inward, towards the columellar axis of the shell, larger than in any other species of its group, bordered by two outstanding lamellar edges, as seen in sections, fig. 32 and 36. The crescents are large, distantiated and intersected by at least ten longitudinal lines. On the surface of the shell there are fine, transverse, backwards directed striæ, with interstices nearly five times as large as them, and partitioned off by small striæ, distantiated, parallel with the slit band, causing a likeness with a ladder, as they are enclosed within their interstices and not connected with each other in continuous longitudinal lines. If seen with a lens they, at least in some parts of the shell, continue uninterrupted over the transverse lines, fig. 35. The aperture is transverse, the columellar lip reflexed around the narrow, but open and funnel shaped umbilicus.

Height 15 millim., br. 18 millim. Apical angle 85°. Specimens have been found at Likkershamn, Samsugn, Follingbo, Kyrkberget in Wisby and Snäckgärdet near that town.

6. **Pleurotomaria glandiformis** n.

Pl. VII fig. 37—38.

Shell elongatedly conical, turbinated, with seven convex whorls. The slit band is placed a little above the middle line of the body whorl, relatively more narrow than in the preceding species or nearly half that size. In the other whorls it is situated a little below the superior suture. The bordering lines are not so prominent as in the preceding. The crescents are nearly alike, distantiated, regular, crossed by two or three longitudinal lines. The surface on both sides of the band has a regular, cancellated ornamentation by equal sized lines, which at their crossing point form a little, elevated nodule. Suture deep. Aperture elongate, higher than broad, umbilicus narrow, but open.

Height 19 mill., breadth 15 mill. Aperture in height 8 mill., br. 7 millim. Apical angle 56°.

It has been found in many specimens in the red limestone of Sandarfve kulle, a few in the gray limestone and also in the neighbouring Linde klint.

This species is very nearly related to the preceding one, having the slit band formed on almost the same type, but it differs through the ornamentation of the surface where small nodules are formed at the crossing point, as well as in the shape of the shell and the whorls, which are angular in the former and evenly rounded in this species.

7. **Pleurotomaria biformis** n.

Pl. VII fig. 39—42.

Shell broadly conical, turbinated, with seven tumid whorls, four times as broad as high and having the slit band a little below the middle line of the body whorl and midway between the upper suture and the median, transverse line of the other whorls. It is much concave, forming a shallow groove around the shell, with sharp, elevated borders on both sides. The crescents are fine, narrow, densely packed, more curved than in the others and crossed by numerous, equally fine, longitudinal streaks. As seen by the fig. 42 the ornamentation is widely dissimilar above and beneath the slit band, being imbricate and crossbarred above, and with two different sets of striæ below: one consisting of coarse, irregular and distantiated transverse wrinkles, in their direction corresponding with those above the band, though meeting the slit band in a more acute angle, the other crossing these obliquely, nearly parallel with the slit band. They are microscopically minute and remind of those which cover the whole shell of Pleurot. exquisita. There is besides on the whorls an obtuse ridge beneath the slit band, parallel with it and close above the suture the whorl ends in a somewhat nodular ridge or string. The aperture is nearly circular. The umbilicus is narrow and open, on its distal side enclosed by a low ridge, which emanates from the back of the columellar lip, on its proximal side it is hemmed in by the basis of this lip, which is enlargened as a broad lamella and nearly hides the umbilicus, when seen from above.

Height 23 millim., br. 20 millim. The aperture has in height 13 millim., in breadth 10 mill. Apical angle 69°. A specimen from Wisby is 29 millim. high and at largest 25 mill. Apical angle 71°.

This species has been found in six specimens in the shale at Djupvik in Eksta and in fifteen specimens in the same shale bed near Wisby; from the later locality nuclei mostly have been collected. A single specimen from the middle limestone stratum near Wisby belongs probably also to this species, as well as two badly preserved specimens from Kålens Qvarn, north of Wisby.

8. **Pleurotomaria latezonata** n. [1])

Pl. X fig. 1.

Shell conical, turbinated, with five tumid whorls and fragments of the sixth or the body whorl. Slit band situated on the middle of the free whorl or near the superior suture in the lower ones. In its ornamentation it resembles much that of the preceding species, but it is not so much concave or scooped out, the crescents are not so much curved, rather thicker or coarser. The ornamentation below this band consists in crossbarred striæ, with a few larger, longitudinal ribs. The suture is deep. The shape of the aperture and the umbilicus cannot be ascertained as the shell is broken in those parts.

Height 7 millim., breadth 6 millim. Apical angle 77°. Only one specimen has been found in the middle limestone of Wisby (b).

It comes near to the preceding species through its slit band, but the shape and ornamentation of the whorls differ, being in this species thrice as broad as high and in the former nearly four times as broad as high.

9. **Pleurotomaria Hindei** n.

Pl. XIX f. 15—16.

Shell turbinated with seven tumid, transverse whorls, of which the body whorl is more than double the size of the others and nearly double as broad as high. The slit band, which is situated a little below the median line of the body whorl and near the upper suture in the other whorls, is broad, with thick, projecting margins and covered with regularly curved crescents of growth. There are some faint traces of longitudinal lines crossing them. The surface below the slit band is evenly rounded, nearly flattened out. There are minute, longitudinal, as well as transverse striæ of equal size forming regular squares and at their meeting point there seems to have been a small gibbosity, causing a prickly surface. The umbilical surface is corroded, but, as discernible on some patches, has had the same sculpture. The aperture is nearly circular, the outer lip thin, the inner one reflexed as to form a little tube along the narrow umbilicus and broadly enlarged at its basis. H. 15 mill., br. 13 mill.

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[1]) I was not aware that a Pleurot. latifasciata MAC COY already existed, when I had named this species Pl. latefasciata on page 18.

A single specimen found in the limestone at Samsugn in Othem. The form of the slit band and the sculpture of the surface unite it with the »Multicarinatæ» and especially with Pl. scutulata from which it is distinguished through the different slit band.

10. Pleurotomaria Holmi n.

Pl. XIX fig. 18—20.

Shell conical, turbinated with seven ventricose whorls, body whorl of the same size as the others taken together, all nearly thrice as broad as high. The slit band is situated a little below the median line of the body whorl and exactly on the median line of the other whorls. It is large, projecting, with convex surface. As far as can be made out on the much corroded band, the crescents are regular and distantiated. The ornamentation on both sides consists in thin, exert, transverse and longitudinal lines, closely set, forming a dense network with indistinct nodules at the crossing point. The transverse lines have a sigmoid direction and are regularly curved backwards close to the slit band. Below the slit band there is a sharpedged ridge near the suture and above that band a slight bulging out of the surface as a callosity is seen in some specimens. The aperture is circular, and the umbilicus is narrow. H. 15 mill., br. 12 mill.

A few specimens have been found in the middle limestone near Wisby. From the limestone at Slite a small shell (Pl. XIX f. 17) has been obtained nearly resembling the former as to its shape and the prominent slit band. This is, however, placed exactly on the median line of the body whorl and the ornamentation seems to consist only of transverse striæ. H. 5 mill., br. 5 mill.

11. Pleurotomaria Wisbyensis n.

Pl. XVIII fig. 50—51.

Shell rather depressedly conical, turbinated, with six ventricose whorls separated by a shallow suture, the apex obtuse and spire short of five whorls, together smaller than the body whorl. The slit band is placed somewhat above the middle line of the body whorl and is hidden from view in the smaller whorls. It is prominent and convex as to its surface. The ornamentation below the slit band is of the common reticulate crossbar pattern, the longitudinal lines being stronger than the transverse ones. The same sort of sculpture seems to have occupied the umbilical surface, but is mostly effaced. The aperture is circular with thin lips. The umbilicus is deep and wide, and defined through a sharp, abrupt edge. H. 10 mill. br. 10 mm. Largest specimen from Samsugn has h. 15 mm., br. 13 mm.

Four specimens have been found in the superior limestone on Kyrkberget in Wisby and one in the quarries of Samsugn in Othem. It is only in consequence of it is reticulate sculpture this shell has been placed with the Multicarinatæ, and its position must be afffirmed through the find of more complete specimens.

Divisio II. CRISPÆ.

12. Pleurotomaria Lloydii Sowerby.

Pl. VII fig. 43—49, pl. VIII fig. 1.

Pleurotomaria Lloydii	1839	Sow. in Sil. Syst. II, 619, pl. 8 f. 14.
	1843	Morris Catal. Brit. Foss. 1 Ed., 158.
Murchisonia Lloydii	1841	Archiac & Verneuil Bull. Soc. Geol., 160.
	1848	Bronn Nomenclator, 748.
	1850	D'Orbigny Prodrome I, 31.
	1854	Morris Catal., 259.
	1855	Mac Coy Palæozoic Fossils, 293.
	1867	Salter Siluria, 532.

Shell turbinated, whorls six or seven, ventricose. The slit band is situated exactly on the middle line of the body whorl and a little below the upper suture of the other whorls. It is broad, elevated, with an even surface and, as far as can be made out from the not quite complete specimens, covered with distantiated crescents and smooth interspaces. Above the slit band there are some twelve longitudinal ridges of equal size and parallel to them smaller, threadfine lines, both crossed by fine, distantiated transverse lines. Beneath the slit band the longitudinal ridges are not so numerous, four at the highest and much unequal. Near the suture the transverse lines are thicker than higher up. The apex of the shell has been filled up with solid, calcareous matter and the lowest whorl of the nucleus ends consequently in a blunt point. The aperture is large and obliquely ovate (Pl. VII f. 43). The umbilicus is narrow and open.

Widely spread as this shell is, it seems to be much variable and there are many Gotland specimens, which only hesitatingly and provisionally can be refered to Pl. Lloydii, as the English species according to the figure given by Sowerby is more elongated and the whorls by far not so ventricose as in the former. Mac Coy l. c. also says that he has not seen specimens of the same length as in Sowerby's figure. His descriptions nearly agree with the Swedish specimens.

The variety from the shale beds near Wisby (Pl. VII figs 46—49) has still more ventricose whorls and the parts around the slit band not so much angularly prominent as in those from the other localities and it may rank as a well distinct variety.

Next, there is a depressed, short form, chiefly found as nuclei with indistinct impressions of sculpture and with the body whorl nearly elliptical in a longitudinal section. A few specimens of this, concerning which it for the present cannot be decided, whether it is a variety or an independent species, has been found at Westergarn, in Östergarn at Gannviken and Grogarn, and in Ardre. Its dimensions are: height 32 millim., breadth 31 mm. apical angle 87 °.

The typical specimens of Pl. Lloydii attain a height of 49 millim., breadth of 34 mill., apical angle 56 °.

It has chiefly been found in the shale beds at Wisby, Follingbo, Westergarn, Djupvik in Eksta, Habblingbo, Alfva saw mill, Qvinnegårda in Hafdhem, the canal from

Wisne myr in Fardhem, Östergarn, Stor Myr in Rute, but also in the limestone beds of Fårö, Medebys in Hall, Wisby Kyrkberg, Djupvik in Kräklingbo. It very seldom is found but in nuclei. In some instances the interior nacreous coating is retained as in specimens from Östergarn.

Pl. percarinata HALL Pal. N. Y. Vol. I p. 177 pl. 38 fig. 4 resembles somewhat this species.

13. **Pleurotomaria dolium** n.

Pl. IX fig. 1—3.

Shell turbinated, rotundate, with the body whorl much in excess of the other three whorls. Slit band situated a little below the middle line of the body whorl, large, scooped out as to form a regular groove around the shell with somewhat outstanding borders. The crescents are regular, wide apart, with prominent lamellar edge and smooth interstices. The ornamentation above the band consists in two or three obtuse longitudinal ridges, a little nodular where they are crossed by the fine transverse lines, which are obliquely lamellar near the slit band. Beneath this band there is only a single sharpedged ridge, halfway between the band and the suture, and oblique, closely set, narrow, transverse lines. Suture very shallow. The aperture is nearly circular, no umbilicus can be discerned.

Height 6 millim., breadth 5 millim., body whorl nearly 4 millim. in length. Apical angle 77 °.

Only one specimen has been found in the sandstone of Bursvik. It comes near to the smaller specimens of Pl. Lloydii (Pl. VII fig. 43, 44) but is easily distinguished through its broad slit band, its want of umbilicus and the form of the whorls.

14. **Pleurotomaria laqueata** n.

Pl. IX fig. 4—6.

Shell turbinated, whorls five, ventricose. The slit band more than a millimeter in breadth, convex, is situated a little beneath the median line of the whorls, ornamented with laminated or, as it were, imbricated crescents. It is bordered by two sharp edged lines, one on each side, and with jagged outside. On each side of this band there is a varying number of parallel, elevated, longitudinal ridges. In one specimen there is only one beneath the band and one above. In another specimen there are three ridges above the slit band and one below. All these ridges are crossed by transverse, lamellar striæ with thin, elevated edges and directed obliquely against the slit band, which they do not cross. Suture shallow. The aperture is oval with the columellar lip thick, reflexed, without any umbilicus.

There is some variation as to the distance and number of the transverse striæ, which lie imbricated with lamellar edges and through their varying position giving the surface a more or less fine striation.

Height 25 millim., width of body whorl 17 millim. Height of aperture 12 millim. Width of body whorl in a fragmentary specimen 23 millim.

A few specimens have been found in the uppermost limestone of Klinteberg, Fröjel and Wisby (b. c.).

15. Pleurotomaria tubulosa n.

Pl. IX fig. 7—10.

Shell turbinated, with ventricose whorls, of which only the body whorl and part of the next are left, in the only specimen, which has been found. The slit band is placed somewhat beneath the median line of the body whorl, relatively narrow, prominent and much convex, the crescents much more distantiated than in any one of the other Silurian Pleurotomariæ and continue backwards as a narrow tube, which is overlapped by the next crescent, the whole thus forming a tube in tube system. The band is bordered by low lines and these and the direction of the striæ against it distinguish it from the nearly alike keels above and below. There are three narrow and prominent keels above the slit band and one beneath the same. When crossing them the transverse, ornamental lines are lifted upwards and obliquely backwards, more strongly in some of them, than in others. These stronger transverse lines of growth are in a peculiar manner accompanied by smaller ones in the interspaces between the keels, diverging in an acute angle from their side or in gentle curves forming with them an ovale, as is shown in the details of figures 9 and 10. These lamellate, transverse lines continue also across the suture, which is shallow, and they are thus connected with the lamellæ of the adjoining whorl. The surface between these large ridges is finely, transversally striated. On the umbilical surface the coarser striæ interlace and form a sort of network, with large meshes. There is no open umbilicus, and the aperture seems to have been obovate. Height 26 millim. breadth 25 mill.

Only one specimen from Hammarudd in Kräklingbo.

Divisio III. FASTIGIATÆ.

16. Pleurotomaria robusta n.

Pl. VIII, fig. 2—7.

Shell globular, consisting of six highly ventricose whorls, gradually ascending in an angle approaching more or less to a right angle, 82—90°. Surface nearly smooth or with very fine, transverse striæ grouped in larger bands. Slit band nearly on the middle line of the body whorl and near the upper suture in the other whorls. It is enclosed within two fine, neatly defined lines. A little below its median line it has an obtuse ridge, thus nearer to the inferior border, and the band consequently standing out from the surface in an angle, the sides of which are a little concave. The crescents are thickly set, oblique, with their largest bend coinciding with the median ridge. Above the slit band some faint longitudinal striæ are seen, intersected by distantiated, transverse ones. Beneath the band there runs an angular keel. The surface is for the rest almost glossy and shining. The suture is deep. The aperture is large, transverse, the columellar lip is thick, strongly reflexed and nearly hiding the opening of the umbilicus, which continues in an oblique direction inwards.

The specimens are generally much worn or obscured by corrosion and by foreign bodies, which have grown on the surface and it is consequently difficult to get a clear idea of its appearance. On the nucleus the impression of the slit band forms an angular, projecting keel. Height 55 millim., breadth at the base 55 millim., aperture 30 mill.

Several specimens have been obtained from the shale beds of Djupvik in Eksta, and Petesvik in Habblingbo.

17. **Pleurotomaria robusta** var. **lævissima** n.

Pl. VIII fig. 8—9.

Shell globular, with six whorls, slit band placed exactly on the middle of the whorl, ornamented with the most delicate crescents and moreover with a narrow ridge more median than in the former. The band is for the rest, not so much angularly elevated, rather square cut, as seen in the section. The surface on both sides of the band is smooth and glossy, with only few obscure spiral bands and with scarcely perceptible, transverse sinuous striæ. The suture is shallow. The aperture is circular, the interior lip thin, reflexed around the umbilicus which is narrow and open. Height 17 millim., breadth 19 millim., height of aperture 11 millim.

Found in the shale of Djupvik in Eksta.

18. **Pleurotomaria elliptica** His.

Pl. VIII fig. 10—14.

Trochus ellipticus	1829.	Hisinger Tabl. ed. 1, 11.
	1831.	Id. Anteckn. V, ii, tab. 2 fig. 2, 2, 2,
	1831.	Id. Tabl. ed. 2, 9.
	1837.	Id. Leth. 35, tab. 11 fig. 1 a—b.
	1841.	Id. Förteckning öfver en geognostisk och petrifikatsamling från Sverige och Norrige, 61.
	1843.	Portlock Geol. Rep. Londonderry, 414, pl. 31 f. 1, very doubtful.
	1848.	Bronn Nomenclator, 1300.
Turbo antiquissimus	1840.	Eichwald Sil. Schichtensyst. Estlands, 119.
	1842.	Id. Urwelt Russlands, 2, 53, tab. 2 f. 7.
Turbo ellipticus	1846.	Id. Bullet. Moscou, XIX, 104.
Pleurotomaria elliptica	1858.	Friedr. Schmidt Silurform. Esthlands, 203.
	1867.	Törnquist Lagerföljden i Dalarnes Undersiluriska bildningar, 19.
	1876.	Ferd. Roemer Leth. geogn. 4 Ed. Atlas, 1 Thl. pl. 5, f. 3.
	1880.	Angelin & Lindström Fragmenta silurica, 13, tab. XV, fig. 8.
Pleurotomaria antiquissima	1860.	Eichwald Leth. Rossica I, ii, 1168, pl. 42 f. 17 a b.
Pleurotomaria subconica	1865.	Kjerulf (nec Hall) Veiviser 7, fig. 15.
Flemingia elliptica	1882.	De Koninck Faune II, pt. 3, 94.

Shell largely conical, trochiform, with ten gently convex whorls, angular at the shallow suture where the slit band is placed in the older whorls, being median in the free body whorl. It is comparatively large, with a longitudinal ridge above the middle line, not far from the superior border. This, however, as may be gathered from the figures 10, 12, 14, varies, the ridge being nearest the central line in specimen fig. 14, which is from the Lower Silurian of Öland at Lerkaka, and more prominent than in any one of the others. In specimen figure 10, the ridge of the slit band is placed nearer to the superior border than in the others and is only very little prominent. The crescents are consequently more or less oblique, as their greatest curve coincides with this ridge. They are densely set, fine, thicker at the ridge and thinning out towards the borders. The surface on both sides of the ridge is a little scooped out, as seen in the profiles delineated. This median ridge does not, however, continue all the way round, but ceases in the vicinity of the aperture, as seen in fig. 10, upper detail, where the large slit band is only obscurely hemmed in by bordering lines and covered with regularly curved crescents. The slit is angular, tongue shaped with evenly curved sides. On the nucleus the slit band has made an impression as a shallow groove. The thin shell which seldom is preserved entire, is covered by fine striæ, which meet the slit band as usual in a highly acute angle. At their basis, near the suture they are more apart and form band like plaits. The aperture is transverse, with the exterior lip thin and sharp and the interior lip regularly reflexed, but not so much as to hide the narrow and open umbilicus. Length 30 millim., breadth at the basis 26 mill., apical angle 71 °.

Only two specimens have been found in Gotland; one, fig. 10, in a detached block from the Norderstrand near Wisby, the other, fig. 12, from Östergarn. As to the derivation of the former, it is questionable whether it really has been included in a Gotland rock and rather not has been found in an erratic block, of which some, spread over Gotland, contain Lower Silurian fossils. The specimen from Östergarn seems indeed, to judge from the rock, to have been found in the Upper Silurian strata of that locality.

There cannot be any doubt that this species is the same as that so named by Hisinger. The original specimens of this author are contained in his own collection, now in the Palæontological Department of the Swedish State Museum and consist of two badly preserved nuclei from Dalecarlia, without any traces left of the shell. One of them, a little compressed from the sides, is the original specimen to his figures in »Anteckningar» pt. 5, two af which have been copied in the »Lethæa Suecica». Later, several complete specimens have been found in strata of Öland, contemporaneous with the former. As can be seen on the plate VIII to this work, fig. 14, the Öland specimen has only trifling deviations in the character of the slit band, such as only can be expected in a species of so wide a geological range. There exists then, as I suppose, no necessity to subdivide this species into new ones, as some later authors seem inclined to do by always citing »Pleur. elliptica His. sp.» There may at the utmost be mutations. The oldest known mutation is from the Upper Gray Orthoceratite limestone of Dalecarlia and Öland. It has almost the same general form as the Gotlandic one, the ornamentation is quite the same, the slit band is different by the longitudinal ridge, though still above the median line of the band, being placed nearer to it than in any other of the later mutations, where it is placed higher. In the specimen from Wisby (fig. 10) the ridge is placed at the highest and in the next from Östergarn it is midway between the position in the two former. There are, of course, in this, as in almost all other species of shells individual variations as to the greater or smaller convexity of the whorls, the size of the apical angle, of very little importance as to the specific distinction. Thus I think that Pl. subconica KJERULF may without hesitation be placed in this species. It is not at all identical with Pl. subconica HALL, as this author expressly states, that it is »cancellated», whereas the Norwegian shell only is transversally striated. Murchisonia Hercyniæ BILLINGS, Palæoz. Foss. Canada p. 158 f. 141, comes also near to Pl. elliptica, but is more elongated, with more acute apical angle, and may possibly be only a variety of this. Pl. elliptica GOLDFUSS Petrif. Germ. p. 50, pl. 178 fig. 4, is not at all related to our species. It is a sinistral and longitudinally carinated, Devonian species, only found as nucleus. DE KONINCK led by the general, exterior shape thinks, in his Faune Carbonif. de Belgique II pt. 3, p. 94 that »Trochus ellipticus HISINGER» ought »probablement» to be placed in his genus Flemingia, but this cannot be so, since the slit band has been demonstrated in this species.

In some specimens, as that from Wisby and that figured by FERD. ROEMER from the Lower Silurian, there is the peculiarity, that the impression of the slit band on the nucleus is a shallow groove, while it in all other specimens is a distinct keel or at least not so much grooved. The geological range of this species in Sweden is then, according to the statements, given above, from the Upper Gray Orthoceratite limestone included, through the Chasmops limestone into the Upper Silurian shale beds of Gotland.

19. **Pleurotomaria bicincta** HALL.

Pl. VIII fig. 15—25.

? Pleurotomaria angulata	1838	SOW. in Sil. Syst., 641 pl. 21 f. 20 (not identical with Pl. angulata MAC COY Sil. Foss. Ireland, 16, pl. I f. 17).
Murchisonia bicincta [1])	1847	HALL Pal. N. York vol. I, 177 pl. 38 fig. 5 a—h.
	1850	SALTER Geol. Survey of Canada, Organic Rem., Dec. I, 19, pl. IV f. 5—6.
Turbo sp. »probably new»	1851	SALTER Qu. Journ. Geol. Soc. vol. VIII, 178, pl. IX f. 15.
Pleurotomaria sp.	1858	FR. SCHMIDT Estland, 202.
? Pleurotomaria latifasciata	1862	MAC COY Synops. Silur. Foss. of Ireland, 15, tab. I f. 16.
Trochonema (Eunema) *fatua*	1868	HALL 20:th Rep. N. York State Cab., 345, pl. 15 f. 7—8. Revised. Ed. 394, tab. 15, fig. 7—8.
Trochonema rectilatera	1872	HALL & WHITFIELD 24:th Rep. N. York State Cab., 193, figured in the 27:th Rept. pl. 13 f. 4—5.

Shell conical, turbinated with five or six whorls. Each whorl is moderately convex and shows, when free, three different faces, the inferior one, sloping against the

[1]) Murchisonia bicincta? MEEK & WORTHEN Geol. Illinois vol. III, 317 pl. 3 f. 4 is too obscure to be with any certainty regarded as this species.

central axis, is near the suture swelling in a narrow obtuse ridge, the median face is parallel to the axis of the shell, and the superior one is moderately convex sloping outwards. The median face is confined within the characteristic two longitudinal ridges, which are more or less prominent in the different specimens. Of these ridges the largest or second one from above is the slit band, as may be learned through a closer inspection and by the direction of the ornamental striæ of the surface on each side of it. As seen in the figures, especially in fig. 23, it is distinctly separated from the other surface by bordering lines. It is formed on the same plan as in the preceding species, of oblique, dense crescents, the obliquity of which is influenced by the position of the longitudinal ridge. This ridge varies as to its position more than in any other species of this division, being placed in the middle of the band (fig. 19, 21) or near the superior border (fig. 22) or quite on the contrary near the inferior border (fig. 23). Its variations as to the size may also be perceived from inspection of such extremes as figs. 19 and 22.

The surface is densely covered by transverse, fine, elevated striæ, which are directed backwards from the suture in an elegant curve. Above the slit band they continue nearly vertically and again above the uppermost ridge curve backwards. There is some variation as to their fineness and proximity, of which figures are given. From Gothemshammar there is a peculiar variety (figs. 24—25) agreeing in all particulars with the described specimen, but being provided with a ridge beneath the slit band, midway between this and the suture. The aperture is elongated, nearly twice as long as broad, the exterior lip angular, thin and sharp, the inner lip reflexed in a large, smooth fold, which is often scooped out longitudinally and entirely covers the umbilicus.

The nucleus is strangely globose in the older whorls, only angular in the body whorl, and a thin covering of a nacreous stratum is left behind on it.

Dimensions. Largest specimen 65 millim. in height, 35 mill. in breadth, apical angle 62 °.

	Height.	Breadth.	Apical angle.
Specim. fig. 15	45 mm.	33 mm.	78 °.
— 18	45 »	39 »	87 °.
— 24	10 »	6 »	62 °.

By this and many other instances may be found how little reliance can be put on the size of the apical angle as a specific character. This beautiful and characteristic shell has been found in several specimens in many localities of Gotland, in Fårö at Lansa, at Slite in the shale beds and the superimposed limestone, Gothemshammar, Östergarn, Ardre, Samsugn in Othem, Martebo, in the limestone of Wisby, at Stor Wede in Follingbo, Krokstäde in Tofta, Westergarn, Djupvik in Eksta and in a section between Stjernarfve and Lefvede, on the shore of Kylley, in the canal near Atlingbo church.

This species has a geological range from the Lower Silurian strata of Borkholm in Esthonia, through the Upper Silurian into the Upper Helderberg strata of the Devonian group. Turbo bicingulata F. A. ROEMER Palæontogr. vol. 3 pl. V fig. 20 from the Devonian of the Harz mountains is probably also identical. Its geographical distribution is equally wide, as it besides Sweden occurs in N. America, Scotland, Ireland and Russia. It is consequently one of the most characteristic Gastropods of the Silurian formation. That there should be a great amount of variation in a form of such wide a horizontal and vertical distribution is nothing more than could be expected. As the figures show, there are elongated and short forms. The variety from Esthonia, fig. 17, is the shortest and more coarsely striated, the body whorl nearly double the size as the others. Its height is 28 millim., its breadth 30 mm. The specimens from the limestone of Slite, figs. 18, 19, are also short and broad reminding of the Devonian form which HALL and WHITFIELD have called Trochonema rectilatera.

20. Pleurotomaria qualteriata SCHLOTHEIM.

Pl. XIII fig. 15—16.

Helicites qualteriatus	1820.	SCHLOTH. Petref. Kunde, 103.
	1822.	ID. Nachträge, 61, tab. XI f. 3 a—c.
Solarium? petropolitanum	1830.	PANDER Beiträge zur Geogn. Russlands, 150, tab. I f. 3 a—3 b, tab. 28 f. 14.
Euomphalus qualteriatus	1834.	GOLDFUSS in KLÖDEN, Versteiner. Mark Brandenburgs, 155.
	1835.	BRONN Leth. Geogn. 1:e Aufl. Bd I, 94, Taf. II f. 1 a, b.
	1840.	EICHWALD Schichtensyst. Estlands, 115.
	1844.	GOLDFUSS Petrefacta Germaniæ III, 81, tab. 189 f. 3.
	1845.	VERNEUIL Russia, vol. 2, 333, tab. 23 f. 1 a—b, 2 a—b.
	1848.	SALTER Memoirs Geol. Survey II, I, 356, pl. XIV f. 7.
	1858.	FRIEDR. SCHMIDT Geol. Estlands, 206.
	1865.	KJERULF Veiviser, 7
	1867.	TÖRNQUIST Lagerföljden i Dalarne, 19.
	1869.	KARSTEN Versteinerungen ... in Schleswig und Holstein. 43, tab. 14 fig. 9 a—b.
	1880.	ANGELIN & LINDSTRÖM p. p. Fragmenta Silurica, 12, tab. XV f. 10, 11 (excl. fig. 12—14).
Pleurotomaria lenticularis	1843.	CONRAD in EMMONS Geol. N. York pt. II, 392—393 f. 101,2 & 102. Pl. lenticularis HALL Pal. N. Y. vol. I, 172 is quite different.
Euomphalus gualteriatus	1848.	BRONN Nomencl., 480.
	1854.	FERD. ROEMER Leth. geognostica ed. 3, I, I, 459, tab. 2, f. 1 a—b.
	1860.	EICHWALD p. p. Lethæa rossica I, II, 114.
Straparollus qualterianus	1850.	D'ORBIGNY Prodr. I, 6.
Straparollus pseudoqualteriatus	1850.	ID. Ibid. I, 30.
Rhaphistoma qualteriatum	1859.	SALTER Canad. Organic Remains, Dec. I, 13.
?Ophileta Ottawensis	1860.	BILLINGS Canadian Naturalist, 166, fig. 9—10.

Shell discoid with short, flat spire of five and a half whorls. The apical side is gently convex or nearly flat and the sutures are very shallow. The whorls are on the umbilical side more convex, increasing in height and convexity near the umbilicus, which is large and open.

The angle formed by the slit band is interposed between the umbilical and apical sides and is highly acute, of 30°. Its limits are designated through the converging threadfine ornamental lines of the surface which for the rest is smooth. The slit band is at largest on the apical side and there separated from the other surface through no distinct bordering lines. The crescents are fine and indistinct.

As may be perceived from the dimensions given below, the Gotland mutation of this species is more discoid than the older, which are relatively higher in their last whorl.

The Gotland specimens are only nuclei and consequently the details of the surface have been taken from Lower Silurian specimens of nearly the same form.

In the oldest shale beds near Wisby six specimens or nuclei have been found in situ and thus there is certainty that they have not been transported. As may be seen through the dimensions given, they are more flat than those from the Lower Silurian strata. Largest diameter 43 millim., height 15 millim. Breadth of the largest whorl 16 millim., height of the same 11 mill., while in one of the Lower Silurian ones the largest whorl near the aperture is 18 millim. in breadth and in height 13 mill. A specimen from Borkholm in Esthonia has the aperture of 18 mill. in height and 20 mill. in breadth. Specimens which nearest resemble this are first met with in the uppermost strata of the Lower Red Orthoceratite limestone from Källa in Öland. It then occurs in numerous specimens in the Lower and Upper Gray Orthoceratite limestone of Dalecarlia and Öland and also of other provinces, and returns again in the uppermost limestone strata of the Lower Silurian. Coëval with this species there lived at least one nearly allied species and two others which have been rather confounded with them. The characters of all four are shortly given below, in order in some way to clear up the distinctive features of these very common fossils.

1. *Pleurot. qualteriata* Schloth. 1820, with flat, horizontal or faintly convex apex, slit band largest on the apical side, only discernible through the direction of the sculptural lines.

As to the quaint name of this species it seems that Schlotheim, when he compares it with Helix gualteriana, had intended to name it gualteriana or gualteriata, but that through some error the g had been changed into a q. He, nevertheless, retained the later, without giving any clue to its derivation.

2. *Pleurot. obvallata* Wahlenberg 1818 (Petref. Svec. p. 73 tab. IV fig. 1—2) with prominent apex of steplike whorls, slit band (pl. XIII fig. 18) large on the apical side, narrow on the umbilical side, in its centre with densely packed crescents, nearly resembling those of Pleur. bicincta. This species is more common than the former and it has, in the same way, filled up the apex with solid calcareous matter. It is found in the Lower and Upper Gray Orthoceratite Limestone of Öland and Dalecarlia. Then there are two other species which belong to a quite different type, as they have the slit band built upon the same plan as prevails in the Division of the Alatæ.

1. *Pleurot. marginata* Eichwald. This forms the transition to the next extreme species. It is large, with six ventricose, contiguous whorls, on the apical side sunken in a wide, open funnel, their inner face abruptedly sloping inwards. The slit band on the inferior edge of the whorls is thin, lamellar, and winglike. The surface is finely, transversally striated, on the umbilical side there are broad plaits. It occurs in the Lower and Upper Gray Orthoceratite limestone of Öland. A variety, with the youngest whorls uncoiled, belongs also to this species and occurs in the youngest limestone beds of Öland. There are several diaphragms in the apex of this shell. This species is related to the Canadian Ophileta as it has been described by Salter in »Canad. Organ. Remains». Dec. 1 p. 16, through the slit band is more developed in Pl. marginata.

4. *Pleurot. sp.* (=? Eccyliomphalus alatus ROEMER, ? Helicites centrifugus WAHLENBERG, see also Pl. XV, fig. 12—14 in »Fragmenta Silurica). This is a smaller species than the former, more uncoiled and tending to complete scalarid formation. The inside of the whorls is not so steep as in Pl. marginata and the funnel formed on the apical side not so regular as in that. The sculpture is more distinct of coarse transverse lines and the slit band is more prominently alate or laminar than in them. This occurs in the Lower Gray Orthoceratite limestone, in the Upper Red and Upper Gray Orthoceratite limestone and also in the Chasmops limestone of Öland.

It is of such forms as this, that the genus Eccyliomphalus has been built up, commingled with others, as evolute Euomphali. To elucidate their distribution in time the following table may serve.

	Lower Red Orthoc. Limestone.	Lower Gray Orthoc. Limestone.	Upper Red Orthoc. Limestone.	Upper Gray Orthoc. Limestone.	Chasmops Limestone.	Youngest Limestone of Öland.	Leptæna Limestone of Dalecarlia.	Shale of Gotland.
1 Pl. qualteriata SCHL.	*	*		*		?		*
2 Pl. obvallata WAHL.		*		*				
3 Pl. marginata EICHW.		*		*		*		
4 Pl. sp.[1]		*	*	*	*	*		

Divisio IV. SIMPLICES.

21. Pleurotomaria valida n.

Pl. IX fig. 11—13.

Shell elongate, turbinated, with seven or seven and a half whorls, which are ventricose, the superior ones forming an obtuse angle midway between the median line of the whorl and the suture where the slit band is situated.

The whorl is almost flat beneath the slit band sloping suddenly inwards towards the suture. There are only some slight traces left of the sculpture of this uncommonly thick shell, and it consists in transverse striæ. The slit band is very large, nearly 4 mill. across, the height of the whorl being 27 mill. The aperture is oblong and the columellar lip thick and reflexed, so as to hide the umbilicus of which there is no trace, as the columella is solid. The shell seems to have been much exposed and weathered before it was enclosed in the limestone.

It has been found in a hard, crystalline limestone near Lillugn in a wood between the parishes of Ardre and Alskog. Pl. inflata MAC COY, Sil. Foss. of Ireland p. 15 pl. 1 f. 15, somewhat resembles this shell in form.

[1]) Pl. replicata, nearly related to this, is found in the Gotland shale.

This is the largest of the Gotlandic Pleurotomariæ, attaining a length of 1,03 decimeter and a width of 60 millim. The thickness of the shell near the umbilicus is 5 millim. and in the body whorl of the largest specimen 6 m. m.

22. Pleurotomaria Othemensis n.

Pl. IX fig. 14—16.

Shell elongate, turriculate, with seven ventricose whorls, which form an obtuse angle along their median line, where the slit band is situated. This band is relatively large, with convex surface, covered with regular, distantiated crescents. It is hemmed in by two much projecting lamellæ which grow out in converging direction. The ornamentation is only transverse, of lamellæ, with a peculiar wavy or broadly indented edge. The aperture is ovate, the outer lip thin, with the broad slit in the middle, the inner lip a little more thickened, reflexed around the narrow umbilicus. H. 34 mill., br. 25 mill. Apical angle 63°. It has been found in several specimens in the richly fossiliferous limestone of Samsugn in Othem. It might at first have been taken for a variety of the former. But its more narrow slit band, placed on the median line of the whorls, which are more angular than in Pl. valida, and its peculiar ornamentation sufficiently distinguish it as an independent species.

23. Pleurotomaria comata n.

Pl. IX fig. 18—19.

Shell regularly turbinated with seven ventricose whorls. Slit band placed on the median line of the body whorl, high up near the suture on the lower whorls, concave, with the bordering lines only slightly projecting, crescents microscopically minute, crowded. The ornamentation of the surface consists in densely packed, nearly straight, threadfine lines. Aperture ovate, umbilicus open, narrow. Length 9 millim., breadth 7 millim. Apical angle 64°.

Occurs in the shale of Djupvik, from where the State Museum at Stockholm has obtained several specimens.

It is nearly related to the preceding, but differs through more globose whorls, the higher position of the slit band and the sculpture of that band, as well as that of the surface.

24. Pleurotomaria æquilatera Wahlenberg.

Pl. IX fig. 20—29.

Helicites æquilaterus 1818. Wahlenberg Petrif. Svec., 73[1]).
1828. Hising. Anteckn. IV, 237.

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[1]) The date of most of the species published by Wahlenberg must be changed to 1818 instead of 1821, as so often has been used. His memoir »Petrificata Telluris Svecana» in the eighth volume of the »Acta

Delphinula æquilatera	1829.	HISINGER Tableau Ed. 1, 10,
	1831.	ID. Tableau Ed. 2, 8.
	1831.	ID. Anteckn. 5, 113.
Euomphalus æquilaterus	1837.	ID. Lethæa, 36, tab. XI f. 8.
	1841.	ID. Förteckning, 55.
Pleurotomaria æquilatera	1848.	BRONN Nomenclator, 1012.
Straparollus æquilaterus	1850.	D'ORBIGNY Prodr. I, 29.

Shell globular or disciform, with short spire of seven whorls, resembling those of an Helix. The slit band is only a little below the middle of the body whorl, and close to the suture, near the upper border of the other whorls. It is narrow and open for a long way from the aperture on the body whorl. Its surface is even and the bordering lines are lamellar, projecting. No definite sculpture is discernible owing to its considerable narrowness. The surface of the shell is sculptured with fine, recurved transversal lines. The whorls are somewhat flattened below the slit band, rounded on the umbilical surface. The aperture is transversally oval, the umbilicus wide, and all whorls visible. Diameter 45 millim., height 20 millim.

Occurs in the shale beds (a) at Wisby, in the limestone of Samsugn in Othem, Stor Wede at Follingbo, Westöös in Hall, Kyrkberget of Wisby, Kålens Qvarn near Wisby, the hill of Bara, Wialmsudd at Fårösund and also Fårö, Lutterhorn and Stor Myr in Rute. The Mineralogical Cabinet of the University of Upsala has a specimen collected by Professor P. T. CLEVE in the limestone of Slite.

There exists a great variability in this shell, especially as to the width of the umbilicus and the height of the spire as remarkable through the figures of the typical specimen of WAHLENBERG, which has been kindly lent from the Mineralogical Cabinet of Upsala, with its low spire and flattened whorls to these globose shells delineated in the figs. 26 and 27. Through the former, fig. 20—22, there can be no doubt of what WAHLENBERG really meant by his species. But there is no reason with him and HISINGER to suppose that it also has been found in the Lower Silurian. I have not seen a single specimen from that formation appertaining to this species. In HISINGER's own collection there are specimens from Holmestrand in Norway, badly preserved, and by him called Euomph. æquilaterus. One specimen, the best, may possibly belong to this species. In the same collection there are also specimens from Gotland called Euomph. æquilaterus. They are five, much worn specimens of Oriostoma discors from Kapellshamn and one specimen of Pleurotomaria undulans. EICHWALD, Leth. Rossica I, II, 1170, adopts also this species, but the identification is questionable, as well as that of KJERULF in Veiviser p. 24.

Societatis Regiæ Scientiarum» was indeed printed already in 1818, as WAHLENBERG himself says in the beginning of the »Additamenta» to that memoir, page 293 of the same volume. The statement there given is: »Postquam anno 1818 impressa fuerat Commentatio de Petrificatis Svecanis» etc. The memoir had also been early enough distributed by its author to some geologists, as can be perceived by what BRONGNIART says in his »Crustacés fossiles» (1822) p. 2, viz.» . . M. WAHLENBERG, dont le travail . . . n'est venu à ma connaissance qu'en 1819». But on the title page of volume VIII, containing the collected memoirs and papers, the year 1821 is printed, as it was not issued complete before that year.

Divisio V. INCISÆ.

25. Pleurotomaria labrosa J. Hall.

Pl. IX figs. 30—38.

Pleurot. labrosa	1859.	J. Hall Pal. N. York vol. III, 339, pl. 66 f. 1—5, pl. 67 f. 6.
Pleurot. balteata	1867.	Lindström (not Phillips) Nomina foss. Gotl., 23.
Pleurot. labrosa var. *occidens*	1868.	J. Hall 20:th Rep. N. York St. Cab. 1:st Ed. 343.
Pleurot. occidens	1868.	Hall 20:th Rep. 1:st Ed. 364, pl. 15 (6) fig. 11—12.
	1868.	Id. 20:th Rep. Revised Ed., 392, pl. XV f. 11—12, pl. XXV f. 9—10.
	1875.	Hall & Whitfield Geol. Survey of Ohio, vol. II, 142, pl. 8 f. 2.
	1877.	Oehlert Bull. Soc. Geol., 585, pl. IX f. 6, 6 a.
	1877.	Miller American Fossils, 160.

Shell turbinated, with a short spire and the body whorl enlarged many times the size of the other whorls. Whorls five, almost flat or horizontal beneath the large and prominent slit band, above it convex and ventricose. This band is situated beneath the median line of the whorls, it is oblique with the surface directed downwards; the thin and sharp edges (fig. 35) transform it into a deep groove, somewhat wavy in its course (fig. 33). The crescents (fig. 34) are thin, deeply incised lamellæ, concentrically striated, obliquely hiding behind each other. The inferior, flat side of the whorls is transversally striated by crowded lines of growth, which are crossed by a several elevated, longitudinal striæ in some specimens, while they are completely wanting in others. The superior moiety of the whorls is ornamented by a number of spiral ribs, which together with the longitudinal lines form a regular, cancellated trellis work. There are also finer transverse striæ. The slit in the aperture continues open for a long distance. The aperture is rather rhomboidal and angular in the four corners, below, above and at the sides, in the lowest corner acuminate. The exterior lip is thin and sharp, the interior or columellar border thick, smooth and callous, folded back tightly against the body whorl, so that no umbilicus is visible. Height 48 millim., breadth 45 mill., longitudinal diameter of the aperture 35 mill., transverse diam. 30 mill.

It occurs in the soft shale at Wisby, at Westergarn, where the most numerous specimens have been found, Stora Carlsö, Ejmunds, in the canal between Atlingbo church and Hogrän, Klints in Boge and Lansa in Fårö. It does not occur in the limestone beds above the shale.

This species is interesting in consequence of its being one of the few which continue in the Devonian formation. It was first described by Hall from that formation and Oehlert later also found it in the oldest Devonian strata of the north of France. Its geographical range is also great, as it has been found in England, besides in N. America and France. In England it has been found in the Wenlock Strata at Walsall according to a specimen in the Museum of Practical Geology in London, of which Dr G. J. HINDE kindly has sent me a cast to compare. It has often been confounded with Pleurot. balteata PHILLIPS which is a quite different species, as I have learnt also through a cast kindly sent from Dr HINDE.

26. **Pleurotomaria limata** nom. nov.

Pl. X fig. 2—17.

Euomphalus carinatus 1839. SOWERBY in Sil. Syst.. 616, pl. 6 f. 10.
1843. MORRIS Catal. Brit. Fossils Ed. 1, 144.
1847. MURCHISON Silurian Rocks of Sweden, Qu. Journ. Geol. Soc. Lond., 29, 49.
1854. MORRIS Catal. 2:d Ed., 247.
1867. SALTER Siluria 3:d Ed., 531, pl. 24 f. 11.
1873. ID. Catal. Cambridge Foss., 157.
Straparollus carinatus 1850. D'ORB. Prodr. I, 29.

Shell globular with short spire or turbinated with elongated spire and ventricose whorls. The former variety, figs 2—6, is from the southern localities of Gotland, mentioned below, the later, figs. 7, 8, 10, from the northern ones. The slit band is placed a little above the middle line or exactly on it in the body whorl, near the upper suture on the other whorls. As to its course it follows not always the same line, but deviates from it obliquely as seen in figure 7. It is much prominent, more so than in any one of the preceding and nearly as much as in the following. Details of it are given in figs. 14—17. The crescents are of a most peculiar shape, figs. 15—16, being lamellæ divided into two lobes through a large, oval slit widening backwards. The two lobes are of unequal size, the lower one usually larger. The deep groove in the midst between them is longitudinally as well as concentrically striated. These lamellæ have grown longer in the same proportion as both the bordering edges have changed and, as seen in the longitudinal section fig. 17, become elongated as thin lamellæ, directed obliquely towards the aperture and thinning out near the outer margin. The slit band thus attains to a large size and in some as much as five millim. in a transverse line. See fig. 12. In fig. 14 there is an enlarged transverse section, in which two pairs of the lobes have been cut through.

The depressed variety has five whorls, sloping in an acute angle to the slit band. The aperture is transversally ovate, broader than high. The surface is richly sculptured by a great number of spiral lines, varying from three to ten or more, crossed by lines parallel with the lines of growth. Beneath the slit band the spiral lines are more numerous and close, forming with the transverse lines a fine trellis work of minute meshes and points, nearly alike the surface of a fine polishing file, fig. 3, 13. The umbilicus is either open as to show all whorls, fig. 6, or partially concealed through the acute angle formed by the interior lip of the aperture, f. 3.

The elongated variety, figs. 7—12, from the northern localities of Gotland is turbinate with longer spire and ventricose whorls. There is usually only one spiral ridge above the slit band, seldom two, but much prominent. Beneath the slit band there is a varying number from a single longitudinal line to quite as many as in the former variety. The shell consists of two strata of which the interior one is smooth and glossy. The aperture is obliquely ovate, higher than broad and the umbilicus narrow. In some, fig. 7, 8, the suture is very deep. The slit band is also placed lower, than in the former, where it is close to the suture on the smaller whorls. Dimensions of the lower form: height 32 milim., width 55 mill., height of aperture 15 millim. The elongated variety has in height 32 millim., breadth 35 mill., aperture 21 mm.

The shorter variety is found at Klinteberg and Lilla Carlsö in the limestone beds, in the shale beds at Wisby, Gnisvärd, Westergarn and Stora Carlsö. The elongated form is found in the limestone beds of Wisby, Likkershamn, in the canal near Westöös in Hall, Samsugn in Othem, Lännaberget near Slite, Wialmsudd in Bunge, Lutterhorn in Fårö, Kålens Qvarn, Kristklint in the bay of Kapellshamn.

Pleurotomaria crenulata Mac Coy, Palæoz. Fossils p. 291, pl. I K. f. 45, may also be referable to this species, but I cannot be sure of it through the description and figure alone. There cannot be any doubt left that this species really is the E. carinatus of Sow. since Murchison says he also found it in Gotland and, above all, since I have had occasion to see a cast of the original specimen of Sowerby in the Mus. of the Geol. Soc. of London from the Aymestry Limestone at Aymestry.

Murchison says in the »Postscript» to the paper on the Silurian Rocks of Sweden: »Mr Sowerby is responsible for the E. carinatus, which is distinct from Inachus sulcatus Hisinger.» This statement, even if the figure in the Silurian System did not show the identity, must suffice to dispel the identification of this shell with Inachus costatus or centrifugus as Morris l. c. and Bronn Nomenclator p. 478, have it.

I have been obliged to give this species a new name, as there already before exists a Pleurotomaria carinata Sow. 1834, Mineral Conch. p. 247.

Divisio VI. ALATÆ

(Euomphalopterus F. Roemer.)

27. **Pleurotomaria replicata** n.

Pl. XIII fig. 39—44.

Shell evolute, with lowly sunk spire, whorls three and a half, wide apart. Slit band situated on the lower and exterior edge of the trigonal whorls, consequently directed downwards towards the apical side, as usual with so many Pleurotomariæ having this band winglike or expanded. Like that in Pl. alata it is enormously widened, figs 42—43, into an aliform lamina, nearly as long across as the widest diameter of the whorl. The crescents closely set, elongated as lamellæ, directed outwards towards the aperture. In a section across the band, fig. 43, more than twelve crescents may be seen cut across. A section along the exterior edge of the aliform band reveals, fig. 44, the extreme, thin outlines of the much distantiated crescents. A section of the whorls, fig. 39, gives the figure of a nearly isoscele triangle, the short basal line of which is the sloping, interior umbilical side and the both equal sides are the exterior and the apical sides. There is thus a narrow ridge running along the middle of the umbilical side, being in older whorls as thin as a knife edge. The ornamentation consists of transversal, regularly distantiated, narrow lines, somewhat wavy and enclosing between them numerous, minute lines, parallel with them. When reaching the wing of the slit band they are bent in a gentle curve backwards. On the umbilical side the sculpture is more coarse and consists of imbricated lamellæ.

Length of whorl and slit band near the aperture 21 millim. Length of slit band alone 10 millim. Breadth of whorl near the aperture 10 millim.

Only one specimen has hitherto been found in a detached stone on the shale beds near Wisby, which probably, as far as can be judged by the rock, belongs to the Upper Silurian of Gotland and the oldest shale.

This species is related to Eccyliomphalus alatus FERD. ROEMER Leth. Geogn. 1876, tab. 5 fig. 5, in which, however, *the apical spire is elevated into an apex on the umbilical side*, the slit band is shorter and the section of the whorls is rather more oval than triangular. E. alatus or a nearly related species also occurs in the Upper Red Orthoceratite limestone of Öland, while another, which comes near to Pleurotomaria replicata, has been found in the Upper Gray limestone of Dalecarlia. These fossils have been numbered with Eccyliomphalus, but I shall further down attempt to show that this genus cannot be retained, as it contains either evolute Pleurotomariæ as this species and kindred, or evolute Euomphali, the peculiarity of the uncoiled whorls being in no way any characteristic sufficient enough for generic distinction, when taken alone. This Pl. replicata is a direct development from such forms as those described with Pl. qualteriata and connects them with the group Alatæ, being probably in genetic connection with the fourth of these Qualteriatæ.

28. **Pleurotomaria alata** WAHLENBERG.

Pl. X, fig. 18—32.

Cornu Ammonis lævis vestigium. 1730 BROMELL, Lithogr. Svec. in Act. liter. Scient. Svec. p. 31.

Turbinites alatus	1818.	WAHLENBERG Petref. Svec., 69. tab. III f. 6—8.
	1828.	HISINGER Anteckn. IV, 221, 237.
Turbo alatus	1824.	KÖNIG Icones fossilium sectiles, pl. IX fig. 107.
Delphinula alata	1829.	HISINGER Tableau ed. 1, 10.
	1831.	ID. Anteckn. V, 113.
	1831.	ID. Tabl. ed. 2, 8.
Euomphalus alatus	1829.	BRONGNIART Tableau des terrains, 428.
	1837.	HISINGER Lethæa, 36, tab. XI f. 7 a—b.
	1839.	ANGELIN Museum Palæontologicum Scandinav. N:o 30.
	1839.	SOWERBY Sil. Syst., 631, pl. 13 f. 28.
	1841.	HISINGER Förteckn., 55.
	1843.	MORRIS Brit. Fossils, Ed. 1, 144.
	1847.	MURCHISON Quart. Journ. Geol. Soc., 29.
	1848.	BRONN Nomenclator, 478.
	1848.	PHILLIPS Mem. Geol. Survey II, I, 356.

Euomphalus alatus	1854.	MORRIS Brit. Fossils Ed. 2, 247.
	1855.	PICTET Traité de Pal. III, 155, pl. LXII f. 12.
	1862.	MAC COY Synopsis Sil. Foss. Ireland, 13.
	1867.	SALTER Siluria 3 Ed., 531, pl. 25 f. 4.
	1867.	LINDSTRÖM Nomina foss. Gotl., 23.
	1867.	QUENSTEDT Handbuch der Petrefaktenkunde, 506, tab. 45 f. 64.
	1868.	BIGSBY Thesaurus Siluricus, 153.
	? 1871.	BAILY Figures of Characteristic British Fossils pt. III, pl. 21 f. 7 (scarcely).
	1873.	SALTER Cat. Cambr. Mus., 157.
	1882.	QUENSTEDT Petrefaktenkunde Deutschlands 1:e Abth. 7:e Bd., 327, tab. 197 f. 41.
Schizostoma alatum	1842.	D'ARCHIAC & VERN. Trans. Geol. Soc. Lond. 2:d Ser. vol. VI, 365.
Straparollus alatus	1850.	D'ORBIGNY Prodr. I, 29.
Pleurotomaria alata	1858.	FR. SCHMIDT Esthland, 201.
Euomphalopterus alatus	1876.	FERD. ROEMER Leth. Geogn. tab. 14 f. 9 a—9 b.

Shell turbinate, spire broad and short, consisting of six or seven tubular whorls, circular in section, fig. 29. The slit band is placed above the median line of the whorl, nearly on a level with the upper edge of the aperture. This large, lamellar slit band, which is built on an exactly homologous plan with that of Pleur. replicata and Pl. limata, occupies a belt around the shell, which on the last whorl attains a length across of 12 millm. in the largest specimens, the whole diameter being 50 mm. It is directed at first obliquely upwards, fig. 29, 30, and turns at the exterior edge abruptedly downwards in a curve, which sometimes has the appearance of a hook, f. 30, 32. Along its outermost margins this lamina is in some specimens folded in undulations f. 24. If this large slit band be split in two halves along its median line, it is found on each side to consists of two thin strata (f. 27) the exterior one transversally striated on its surface and the interior one quite smooth and transparent. Within these are enclosed the crescentic laminæ and through their development the space between the bordering laminæ seems to be divided into a number of narrow compartments (fig. 27, the enlarged portion). They are wider apart near their exterior ends and converging towards the whorls. When the slit band is sectioned transversally across these crescents the appearance shown in fig. 30 is produced. The curved outlines of ten obliquely sectioned, crescentic lamellæ are seen in the dark shale between the bordering edges of the slit band. These enclosing lamellæ are in direct continuation with the exterior darker stratum of the shell, composed of minute, angular laminæ. Within this exterior stratum another of clear crystalline calcite lies, often retaining a nacreous lustre. There are absolutely no communications, nor perforations or tubes between the interior cavity of the whorls and the spaces separating the crescentic lamellæ of the slitband as FERD. ROEMER has supposed. The interior cavity is closed as in other Pleurotomariæ. Along the exterior edge of the slit band, fig. 31, the ends of the crescents are discerned, especially when a little cut; the thin edges of the band are usually broken on the older whorls, f. 22.

The umbilical side of the shell is nearly cup shaped, being hemmed in around the edges by the high, turned up slit band and sunk towards the umbilicus, around which there is an elevation.

The surface is only transversally striated, the striæ running straight down to the slit band and, chiefly on the umbilical side, directed *towards* the aperture and at the very edge of the laminal slit band turning back *from* the aperture, quite as is the case in all Pleurotomariæ with transverse striæ on the surface. The smallness of the apertural slit in this and similar species causes this dissimilarity from the other Pleurotomariæ. Around the umbilicus a small ridge is running, a little knotty where the transverse lines cross it. On the spire the transverse lines are more distantiated, elevated, and formed by the lines of growth. The aperture is circular, the lips sharp and thin, not reflexed, the exterior one extending into a triangular appendix, a narrow groove, representing the sinus or the slit, which here is reduced to a minimum. The umbilical side of the aperture is deeply insinuated, almost as much as in some of the Devonian shells which D'Archiac and Verneuil have placed in the genus Schizostoma, Sch. radiata for instance, but which probably are different from Bronn's Schizostoma. The umbilicus is very wide and open and all whorls are seen to the bottom of the umbilical funnel. On the umbilical side of the slit band there are in some specimens discerned two or three darker spiral bands, a little deepened in the shell, somewhat reminding of rests of colour bands.

Largest specimen 26 millim. in height, 51 millim. in breadth. Another specimen attains 18 millim. in height, 35 millim. in breadth, the umbilicus has 9 millim. in diameter and the slit band is 7 mill. wide across.

This characteristic species has been found in numerous specimens in almost all strata of Gotland, in the shale beds of Wisby, Westergarn and Slite, in the limestone of Lutterhorn and Lansa of Fårö, of Slite, Samsugn in Othem, Klinteberg, Westöös in Hall, Kylley, Kålens Qvarn, Stora Carlsö, the canal of Atlingbo.

This species has by Ferd. Roemer been made the type of a new genus Euomphalopterus, which is characterized by tubular perforations through the lamellar edge, which surrounds the shell, and also penetrate through the walls of the shell into the interior of the whorls. But, as stated above, there do not exist any such perforations in the walls of this shell and the tubes are, as shown above, nothing but the spaces between the lamellar crescents of the slit band. Nor has ever any operculum been found to this species [1]) or to other Pleurotomariæ. There is consequently, not any reason to place this in a new genus, at the highest this and the following ones may form a subgenus to Pleurotomaria.

29. **Pleurotomaria alata** var. **subcarinata.**

Pl. X fig. 33—37.

This small variety differs chiefly in having an obtuse ridge beneath the slit band, and where it runs, the whorls are angular, while in Pl. alata, figs. 18, 19, the whorls are rounded on the corresponding surface. There is a revolving ridge around the umbilicus in this, as well as in the principal form, though not in all specimens. There is no reason to consider this as more than a variety of the former, as there are some

[1]) See Zittel Handbuch der Palæontologie Bd. 1, 2 Abth. p. 206, where he describes an operculum of Euomphalopterus, but which in reality belongs to some Oriostoma.

few specimens of Pl. alata, fig. 28, which also show a very faint rib nearly on the same place as in the variety. Height 8 millim.; breadth 16 mill.

From Djupvik in Eksta, Lingsarfve in Näs, Fårö, Westergarn and in the oolitic limestone of Bursvik.

30. **Pleurotomaria alata** var. **opposita** n.

Pl. X. fig. 38—40.

Shell trochiform, broader than high, spire of five or six whorls, more ventricose than in the preceding varieties of the species. Slit band situated a little above the median line of the whorls. Beneath the band, near the suture, a narrow keel is seen and there is none around the umbilicus. This variety is best distinguished by the direction of the transverse striæ, which, as seen in fig. 39, are more prominent and elevated than in the others and are obliquely turned *against* the aperture, quite opposite to what obtains in most of the other Pleurotomariæ. The ends of the larger striæ radiate in an expanded brush of minute striæ, fig. 40. In the preceding forms the striæ meet the slit band either rectangularly or directed backwards. Height 7 mill., breadth 13 mill.

From the shale at Petesvik in Habblingbo.

31. **Pleurotomaria prætexta** n.

Pl. XI fig. 1—7.

Shell trochiform, moderately elongated, with six whorls, which are convex and evenly rounded below, the umbilical side almost flat. The keel formed by the slit band is broad, near its junction with the whorls on both sides ornamented with a strongly prominent, spiral ridge, on which the transverse striæ form nodules. The band is placed a little above the median line of the body whorl and on the other whorls high up, close to the suture. As seen in fig. 5 its interior crescentic lamellæ are very closely packed, elongated and reach obliquely forwards to the margin of the keel. This margin, fig. 6, is sometimes folded in a number of small wavelets, nearly as in Pl. undulans though more regularly. The transverse striæ of the surface are approached, although at regular distances, and have some smaller, parallel ones in the interstices. The aperture is circular and a little angular in its interior corner and the umbilicus open and narrow. Height 13 mill., breadth 16 mill, aperture 6 millim., umbilicus 3 millim.

Occurs in the lowest shale beds near Wisby.

This species is nearly related to Pl. alata, from which it is readily distinguished by the elevated ridges near the edge of the slit band.

32. **Pleurotomaria togata** n.

Pl. XI fig. 8—13.

Shell trochiform of seven angular whorls, slit band thick and short, fig. 13, placed above the median line of the body whorl and close below the suture in the other whorls. It shows in the margin, fig. 12, the ends of the enclosed crescents, which are formed upon the same plan as in the other »Alatæ». In a transversal section, fig. 13, the uncommonly thick shell substance of the bordering lines encloses a most narrow slit band. Beneath the slit band an angular ridge is seen and below that the wall slopes abruptedly inwards to the suture. The surface is transversally divided into large sinuous folds, the interstices being streaked with minute, parallel lines, fig. 12. The umbilical side, fig. 10, is comparatively smooth and glossy, the transverse lines being most conspicuous near the margin, where, a little inwards, a blunt rib runs parallel with it, corresponding to a similar one on the lower side, though not so distinct. Another ridge, more distinct, encircles the umbilicus, which is open, but narrow. The aperture is circular as well as the section of the whorls, the lips are thin and sharp-edged without being reflexed.

Dimensions of the specimen figured: height 12 millim., breadth 20 mill., aperture 7 mill.

Several species are found in the shale beds of Wisby and Petesvik in Habblingbo.

33. **Pleurotomaria frenata** n.

Pl. XI fig. 14.

Shell turbinate of five ventricose whorls. Slit band situated only a little above the median line of the whorls, its keel is short, of triangular section, with broad base of plaited folds, fig. 14, with angular ends. The crescents of the band are as wide apart at their ends as in the other species. The surface on both sides is covered by fine, minute striæ, wavy and interlacing, forming a reticulate surface like that of the next species. The striæ are directed towards the aperture and turn backwards only on the slit band. The aperture is regularly circular with thin, sharp lips, the umbilicus is open.

Dimensions. Height 19 millim., breadth 26 mill., aperture 11 millim. Five specimens have been found in the shale beds near Wisby.

This species is intermediate between Pleurot. prætexta and Pleur. undulans, uniting a slit band like that of the former with an ornamentation resembling that of the latter.

34. **Pleurotomaria undulans** n.

Pl. XI. fig. 15—23.

Euomph. æquilaterus 1867. LINDSTR. Nomina, 23.

Shell helicoid, thin and fragile, and consequently usually crushed and distorted, spire short, whorls six, ventricose. Slit band situated nearly on the middle line of the body whorl, on the other whorls close to the upper suture, which it covers, very narrow and often enlargened into a thin lamina, which is bent and folded into a succession of irregular waves, as delineated in the figures. Its interior structure coincides entirely with that of the others in this group. Fig. 23 represents it sectioned across with some ten crescentic lamellæ obliquely cut, and fig. 22 is a section rectangular to the former. In fig. 21 a magnified portion of a cloven band is delineated, where in the interior the elongated, crescentic lamellæ are directed obliquely, diverging outwards. The whorls are beneath the slit band rounded and covered by fine, threadlike, elevated striæ, equally distantiated. Above the slit band the transverse striæ are still finer and more numerous and a little sinuous. The striæ are directed towards the aperture till they reach the slit band lamina, on which they turn backwards. The aperture is transversally ovate, almost twice as broad as high and the lips thin and sharp. The umbilicus is open and measures nearly a third part of the diameter. Some specimens still retain the nacreous lustre very vividly on the nucleus. A nucleus, fig. 20, shows traces of a ridge around the umbilicus, which, however, has not been observed on the outside of the more complete specimens. But this, as well as similar impressions on the inferior surface of the whorls may be due to the crushing of the specimen. Height 20 millim., breadth 28 mill., breadth of the umbilicus 9 mill. in a shell having 25 millim. in a transverse line.

Found in the shale and limestone in the vicinity of Wisby, and also in south along the coast in the shale at Gnisvärd and Westergarn and in north as far as the shale of Halls huk.

35. Pleurotomaria Marklini n.

Pl. XI, f. 24—26.

Shell trochiform, nearly flat on the umbilical side. Whorls six with even sides. Slit band placed a little above the median line of the whorls, thin and folded in irregular wavy curves. The sculpture consists in transverse, oblique lines, which on the umbilical side are coarse, callous ridges. Aperture obliquely ovate, umbilicus open, but narrow. Height 14 mill., br. 18 millim, aperture in height 6 mill., breadth 7 mill.

Three specimens have been found in the limestone of Klinteberg and the figured one is from the Marklinian Collection in Upsala.

36. Pleurotomaria cirrhosa n.

Pl. XI f. 27—29. pl. XII fig. 1—3.

Shell large, trochiform, nearly flat on the umbilical side, whorls seven, moderately convex. Slit band situated a little above the median line of the whorls, forming an extremely thin lamina with narrow edge. It is folded regularly and transversally by grooves parallel with the transverse striæ and in the older whorls its broken margins have coälesced with the surface of the next younger whorl. The ornamentation on both sides of the band consists of gently curved striæ, turning backwards from the aperture and meeting in an acute angle at the slit band. The interstices between the striæ are crossed by short, irregular, unconnected lines between which the surface is deepened, and thence having a pitted aspect. The aperture is obliquely elliptical, broader than high. The lips seem to have been thin, not reflexed. The umbilicus is open and wide and all whorls are visible inside.

Height 55 mill., breadth 1,1 decim. Body whorl near the aperture 52 mill. across.

About eight specimens of this large shell have been found in the lower limestone strata of Östergarn and a smaller in the uppermost limestone of Linde klint.

As the specimens found are mostly nuclei and only few traces or shreds of the shell are left, there may be some doubt if this species belongs to Pleurotomaria. But the direction of the transverse striæ seem to warrant such a supposition, even if there is no certain evidence in the section of the very thin slit band lamella, pl. XI fig. 28.

Divisio VII. PLANORBIFORMES.

37. Pleurotomaria planorbis Hisinger.

Pl. XIX fig. 30—39.

Turbinites centrifugus	1828.	Hisinger (not Wahlenberg). Anteckn. IV, 221, 237, tab. VI f. 2.
Helicites? centrifugus	1828.	Id. Ibid. in the explan. of the figures.
Euomphalus centrifugus	1829.	Id. Tableau, ed. 1, 10.
	1831.	Id. Anteckn. V, 114, tab. 1 fig. d.
	1831.	Id. Tableau, 9.
	1848.	Bronn. Nomenlator, 478.
	1854.	Morris. Catal. Brit. Foss. Sec. Ed., 247.
	1855.	Mac Coy. Palæozoic Fossils, 297.
	1867.	Salter, Siluria, 231, 531.
	1873.	Id. Catal. Cambr. Foss., 156, 172.
	1876.	Ferd. Roemer, Lethæa Geogn. Taf. 14 f. 13.
Euomphalus substriatus	1829.	Hisinger Tableau ed. 1, 11.
	1831.	Id. Anteckn. V., 114. Tab. 1 fig. e.
	1831.	Id. Tableau ed. 2, 9.
Centrifugus planorbis	1835.	Hisinger, according to Bronn Leth. geogn. Ed. 1, Bd. 1, 97.
	1848.	Bronn Nomenclator, 256.
Inachus sulcatus	1837.	His. Lethæa Suec., 38, tab. XII f. 1 a—c.
	1841.	Id. Förteckn., 55.
	1867.	Lindstr. Nomina, 29.
	1882.	Quenstedt Petrefaktenkunde Deutschlands 1e Abtheil. 7r Bd., 395, tab. 200 fig. 81.
Straparollus sulcatus	1850.	D'Orbigny Prodr., 30.

Shell disciform, with five whorls, rapidly increasing in size in the following ratio.

Body whorl	22	mill.,	in breadth.
2	11	»	»
3	5	»	»
4	3	»	»
5	2	»	»

The slit is at first large and broad and forms, where it ends, a narrow, acute angle. It, as well as its continuation, the slit band, is situated on the apical side of the shell, close to the suture as in the following species. It is comparatively narrow, elevated above the surface as a thin string and included only by the straight edges of the shell, though in a few instances there are obscure traces of bordering lines.

The crescents vary as to their shape, as may be seen by the figures, being commonly dense, regular and distantiated or thick and oblique with the greatest bend near the outer lip. But then there are specimens showing, at least for some distance, an angularity in the transverse striæ instead of the slit band, a conformation quite resembling that which prevails amongst the Euomphalidæ and of which also traces are seen in some of the Murchisoniæ.

The whorls are nearly tubular or quite as much rounded on the umbilical as on the apical side although they in some instances seem to be somewhat more flattened on the umbilical side. On the apical side there are on the body whorl about fourteen narrow, longitudinal keels, alternately larger and smaller. The uppermost one, which separates both faces, is the largest of all, blunt and horizontally outstanding. These keels are crossed by regular, elevated, threadlike striæ, between which are others still more minute and fine. These meet the slit band on both sides as usual in an acute angle directed backwards. On the umbilical side there are dense, fine, transversal striæ, bent in a great curve backwards, and then, near the keel, forwards. In some specimens there are as many as seven low, only slightly, elevated, longitudinal keels, which are more distinct in the young specimens than in the older ones. In these usually no keels at all are visible.

The three oldest whorls are filled with an organic deposit of a solid, calcareous mass, ending in a concave surface, without any sign of diaphragms. In most specimens this apex is often deciduous. The interior whorls are tightly enclosed by the exterior ones, the longitudinal keels of all being interlocked with each other in the interstitial grooves. The whorls have never been found disjointed, though this seems to have been the impression of Hisinger, probably owing its origin to the observation of the nucleus alone, when the uncommonly thick shell had been removed.

The aperture is circular, approaching to transversally elliptic, its outer lip being more prominent and protruding, sloping inwards in a gentle sigmoid insinuation.

Greatest diameter 66 millim. Height of body whorl 22 millim.

This shell has been found chiefly in the lowest, marly shale beds of Gotland, in numerous specimens, well preserved, at Grogarn and other places of Östergarn, in the limestone beds of Ardre, and also in the shale of Fardhem, Wisne myr, on which the limestone beds of Sandarfve and Linde repose. From the limestone strata of Östergarn a single specimen has been obtained.

Hisinger and Bronn considered this very characteristic shell so much distinct from the so called Euomphali, with which it commonly had been placed, as to create for its reception new genera. It seems that the former in a letter to Bronn in 1835 proposed to name it Centrifugus[1]) led by a mistaken notion that this fossil was identical with the Turbinites centrifugus of Wahlenberg[2]), which cannot be the case, as that shell rather, as far as can be judged, is either a Pleurotomaria of the evolute form or an evolute Euomphalus, of which both genera there have been specimens found in the Orthoceratite Limestone of Dalecarlia, the only stratum from which Wahlenberg cites

[1]) Nomenclator p. 256.
[2]) Petrificata Telluris Svecanæ p. 71.

his Centrifugus. He does not anywhere mention it as found in Gotland. I cannot, however, find that HISINGER himself ever in his published writings made any use of the generic name Centrifugus. It occurs only with BRONN for the first time in Lethæa geognostica ed. 1, Bd I p. 97, which part of the volume was published already in 1835 as may be concluded by referring to the half yearly Catalogue of the German booksellers for that year. This genus included Centrif. costatus His., the type specimen of which is kept in the Cabinet of the School at Wisby and certainly is the shell of a Cephalopodan, probably a Trochoceras. The second species which BRONN names, C. planorbis, is identical with the sulcatus of HISINGER as can be seen by BRONNS Nomenclator p. 256[1]). But already in 1837 in the Lethæa Suecica HISINGER gave it the name Inachus. As this name in 1798 had been bestowed on a crustacean by FABRICIUS, it could not be retained even if the fossil did form an independent genus. The presence of the characteristic slit band, which has not been before observed[2]), at once settles the question of its systematic place. It must, however, be conceded, as has been pointed out above in the description, that there are some features in the position and structure of the band, which remind of Euomphalus. It seems that DE KONINCK, Faune Carbonif. de Belgique II, partie III p. 107, intended to give this species the generic name Polytropis instead of Inachus, but as he is citing Euomph. dicors as the typical species, the name Polytropis must be identified with Oriostoma, of which see below.

In 1831 HISINGER gave the figure of his Euomph. substriatus, Anteckningar V, tab. I fig. e, which as far as can be seen, without access to the unknown type specimen, is a species of Trochoceras found at Fårö. He, however, in the Lethæa unites this form with In. sulcatus, giving it as the umbilical side. Now a glance on the cited tab. I fig. *d & e*, is convincing that both *d* and *e* are apical sides of different shells and he must himself have been aware thereof, as the latter figure in the Lethæa is drawn in a reversed position, so as to match the apical side.

Euomphalus carinatus, SOWERBY, identical with the Pleurotomaria described above as P. limata, has also by some English authors been confounded with Pl. planorbis, but it is certainly distinct from it as MURCHISON[3]) also conceded and as has been more particularly stated above.

38. **Pleurotomaria helicina** n.

Pl. XI figs. 34—37.

Shell discoid, with short, nearly flat spire of five whorls. The slit band is large, placed beneath the median line of the body whorl, hidden from view on the other whorls through the covering, lower edge of the next whorls. The crescents are obscure, distantiated. The surface is smooth and glossy with some few, indistinct transverse grooves and lines of growth, which are curved backwards. The aperture is nearly

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1) »HISINGER 1835 in litteris» he says l. c.

2) In QUENSTEDT's Petrefaktenkunde Deutschlands 1:e Abth. 7:r Bd. pl. 200 f. 81 a good delineation shows the slit band, but this has not been remarked by him in the letterpress.

3) Qu. Journ. Geol. Soc. 1847 in the Postscript p. 1 to »Silurian Rocks of Sweden».

circular with thin lips. The peristome is interrupted. The umbilicus is open and wide, showing all the interior whorls. It is accompanied by a spiral groove near the interior border of the whorls.

Height 5 millim., breadth 16 mill.

Occurs plentifully in the shale beds of Djupvik in Eksta and has also been found in a few specimens in the shale of Wisby.

As to its depressed spire and the position of the slit band this species resembles very much some Devonian Schizostomata figured by GOLDFUSS in his Petref. Germaniæ, plate 188 figs 4—6.

Divisio VIII. NATICOIDEÆ.

39. Pleurotomaria exquisita n.

Pl. XI, figs. 30—33.

Shell ovato-globose, naticoid, glossy, with five ventricose whorls, of which the body whorl many times surpasses the others in size. The slit band is situated above the median line of the body whorl and is in the others completely hidden under the covering lower edge of the superjacent whorl. It is comparatively large, on a level with the other surface and enclosed by a fine, distinct line on each side and crossed by irregularly distantiated, linear crescents, which are a little oblique, fig. 32. Some three or four shallow grooves run rectangularly to these along the median line of the band. The transverse lines of growth are bent in curves directed from the aperture backwards, those above the slit band being more curved than the others. In the opposite direction, obliquely crossing them, almost microscopically minute striæ are seen, on both sides of the slit band, as well as on this band. Those above the slit band do not cross its superior bordering line, but follow it in a highly acute angle, densely packed. They are sinuous and bifurcated. Those on the slit band are in direct continuation with those below, which are sinuous without bifurcation, more distantiated and more oblique. The suture is so shallow, that the whorls on both sides of it form nearly an even line. The aperture is obliquely elongated, longer than broad, the lips are thin, the inner one reflexed around the umbilicus, which is of moderate size.

Dimensions: height 9 millim., breadth nearly 10 mm.

This beautiful little shell, one of the most remarkable through its peculiar ornamentation, has been found in numerous specimens in the shale beds of Djupvik in Eksta. There is probably also a specimen from the shale of Wisby.

Gen. MURCHISONIA D'ARCHIAC & VERNEUIL.

1841. *Murchisonia* D'ARCHIAC & VERN. Bull. Soc. Geol. XII p. 154.
1859. *Hormotoma* SALTER Canad. Organ. Remains Dec. I p. 18.

Shell elongated turriculate, whorls numerous, slowly increasing in size, oldest whorls filled with organic deposit of calcareous matter. Slit band and ornamentation as in Pleurotomaria. Nacreous lustre not observed.

It is very difficult to find any characteristics wherewith to distinguish those forms called Murchisonia in a ready manner from Pleurotomaria. According to the authors of this genus the aperture should be »terminée à sa base par un canal très court ou tronqué». But in several Pleurotomariæ the superior corner of the aperture may also be seen to be protracted in an angle. SALTER in Canad. Org. Remains, vol. I p. 18 divides this genus in Murchisonia proper with acutely carinated whorls and Hormotoma with beaded, rounded whorls and rounded aperture. But while then in the former genus many Pleurotomariæ with broad spire have been included, it is more practical with BRONN to include all banded shells with elongated and slender spire of many whorls whether carinated and ornamented or plain, in Murchisonia and consider it as a subgenus merely to Pleurotomaria.

This genus occurs as early as in the Bala limestone of the Cambrian formation, according to SALTER, Catal. Cambr. Foss. p. 68, and continued through all Palæozoic formations, while in the Mesozoic ones no such elongated Pleurotomariæ are known with any degree of certainty. With us in Sweden they are scarce in the Lower Silurian, a large species, related to the Esthonian M. insignis EICHW., having been found in a few specimens at Gräsgård and Segersta in Öland in the uppermost limestone beds. In the Upper Silurian, again, of Gotland they are numerous and especially there are nuclei of such elongately whorled forms, which also may be Loxonemata, filling the strata in several places. Of some species the shell has always been destroyed and they are known only by the impression of it in the rock. This is very strange as the shell of the nearly related Pleurotomariæ is often well preserved in the same strata. The slit band is built upon the same plan as in Pleurotomaria. In Murchis. deflexa there is a peculiar deviation, as described in detail further down, when the superior margin attains so large a development that it, in its downward growth, hides the band. In M. attenuata the slit band is changed, on the body whorl, into a ridge, on which the apex of the angular transverse lines rests, quite as in the Euomphalidæ.

As there, at least in the first division of this genus, is a certain similar uniformity prevailing in the ornamentation of the shell, the position of the slit band, the shape and the size of the whorls, these will be the chief characteristics for distinguishing the various species. The genus may be fitly divided in two groups.

Divisio I. **SIMPLICES.**

Ornamentation uniform of backwards directed striæ meeting the generally large slit band in an acute angle; position of the band and shape and size of the whorls giving the characteristics.

1. M. cingulata HIS.
2. M. cava n.
3. M. moniliformis n.
4. M. obtusangula n.
5. M. subplicata n.
6. M. compressa n.

7. M. attenuata His.
8. M. paradoxa n.

Divisio II. **ORNATÆ.**

Shell more or less richly ornated, slit band enclosed by one or more variously sculptured bordering lines. Almost all very small species.

9. M. crispa n.
10. M. munda n.
11. M. tortuosa n.
12. M. imbricata n.
13. M. cancellata n.
14. M. cochleata n.
15. M. deflexa n.

Divisio I. SIMPLICES.

1. Murchisonia cingulata His.

Pl. XII fig. 9—10.

?Turbinites lævis major etc. 1738 Bromell Lithogr. Svec. in Acta Lit. Sveciæ vol. III p. 37.

Turritella cingulata	1829.	Hisinger p. p. Tableau ed. 1, 11.
	1831.	Id. p. p. Anteckn. V, 115, tab. II f. 1.
	1831.	Id. p. p. Tableau ed. 2, 9.
	1837.	Id. p. p. Lethæa, 39, tab. XII, f. 6 a.
	1841.	Id. Förteckning, 56[1]).
Murchisonia cingulata	1841.	D'Archiac & Verneuil Bull. Soc. Géol. de France vol. XII, 159.
	1867.	Lindström Nomina, 23.
Terebra ? sinuosa	1848.	Salter Mem. Geol. Survey II pt. 1, 357, pl. 14 f. 2.

Again, the following synonyms do not belong to this species.

Murchisonia cingulata	M'Coy Palæozoic Fossils, 293.
	Salter Cambr. Catal., 172.
	M'Coy Sil. Foss. Ireland, 6.
	Kjerulf Veiviser, 29.
	Murch. Vern. & Keys. Russia, vol. II, 339.
	Krause Zeitschr. d. deutsch. Geol. Ges. 1877, 22.
	Kiesow Ueber silurische und devonische Geschiebe Westpreussens 1884, 58.
Pleurotomaria cingulata	Buch Beitr. zur Gebirgskunde von Russland, 116.
	Eichwald Leth. rossica I, 2, 1166, pl. 43 f. 2.

Shell elongate, turreted, rather slowly increasing, whorls seven, almost conical, slightly ventricose and with shallow suture. Slit band 3 millims. wide, situated above the middle of the body whorl and on the other whorls near the upper suture, at a level with the surface of the shell, the crescents small and narrow, very dense. The ornamental lines are transversal, uniform, dense, turned in a highly acute angle towards the slit band. The aperture is ovate, higher than broad. The umbilicus is very narrow and nearly hidden by a reflexion of the columellar lip.

[1]) In a foot-note to this Hisinger added: (Pleurotomaria?)

Height 63 mill., width of body whorl 28 mill., width of smallest whorl 7 mill. Height of aperture 19 mill., width of the same 15 mill. Apical angle 36 °.

The original specimen of HISINGER, now figured anew, pl. XII f. 9, has been found by him in a detached stone near the church of Gothem. The rock is a variety of oolite, peculiar to a quarry at the base of Bara backe and consequently there cannot be any doubt of its being derived from that place. Quite similar specimens have been found in the gritty limestone near Gothems hammar. Those from neighbouring quarries in Hörsne are also nearly allied, though there is some little difference as to the relative size of the whorls.

Fragments of a fine specimen have been obtained from the canal near Westöös in Hall. Nuclei which in all probability belong to this species to judge from their shape, have been found in the hard shale of Petesvik in Habblingbo. They are larger than those from Gothem measuring as much as 35 mill. in width of the body whorl. The Museum of Copenhagen has specimens from Näs.

2. **Murchisonia cava** n.

Pl. XII fig. 4.

Shell cylindrical, turreted, whorls, only six left in the fragmentary specimens, ventricose, rather angular near the slit band. This is narrow, situated exactly on the middle of the body whorl and near the upper suture in the other whorls, more deeply excavated than in any other species of its group, the crescents oblique, distantiated. Aperture ovate. Dimensions of specimen from Djupvik in Eksta: h. 51 mm., br. 28 mm. Specimens have been obtained from Martebo, Djupvik in Eksta, Hörsne and the limestone near Wisby.

3. **Murchisonia moniliformis** n.

Pl. XII fig. 5—6.

Shell tapering, turreted, narrow in proportion to its length. Whorls eleven, globose, with deep suture, rapidly increasing in size. Slit band nearly in the middle of the whorls or a little above it, slightly concave. Aperture ovate, with lips much reflexed both near the columella and in the superior border. Umbilicus hidden through the reflexion of the columellar lip.

Length 36 millim., breadth 11 mill., apical angle 22 °.

From the sandstone and the oolite of Bursvik, where it is common.

4. **Murchisonia obtusangula** n.

Pl. XII fig. 7, 11, 12.

Shell turreted, moderately tapering, with twelve ventricose whorls widened on the middle in an obtuse angle, where the elevated slit band is situated. The aperture ovate. The umbilicus is hidden through a fold of the columellar lip. Ornamentation in this and the two preceding species almost the same as in M. cingulata.

Height 30 mill., br. 10 mill. Apical angle 29 °.

The typical specimens are derived from the limestone beds of Kyrkberget (Rackarbacken) in Wisby. Others are from Lummelund, Samsugn in Othem, Lutterhorn in Fårö, and some specimens from Wialmsudd may perhaps also belong here. Those from Samsugn, fig. 11—12, are much altered through corrosion and in some there is a false appearance as if the slit band were lineated longitudinally, but this may on closer inspection and comparison be traced to changes after the fossilization. These specimens, however, are somewhat less angular than those from the other localities.

5. **Murchisonia subplicata** n.

Pl. XII fig. 8.

Shell short and thick in comparison with its congeners. Whorls nine, slowly increasing, widened on the middle into an obtuse ridge where the shallow slit band is placed. The inferior border of the whorls is folded into a callous ridge, which overlies and partially covers the deep and narrow suture. The aperture is ovate, the inner lip reflexed and the umbilicus a narrow fissure.

Height 27 millim., breadth 21 mill., apical angle 35 °.

In all, six specimens have been obtained from Lummelund in the superior limestone.

6. **Murchisonia compressa** n.

Pl. XII fig. 15—19.

»*Turritella ? (Turbo L.)*»	1828.	HISINGER Anteckningar IV, 221, tab. VI f. 3.
Turritella cingulata	1831.	ID. p. p. Anteckn. V, 115, tab. II f. 1 (nucleus).
	1837.	ID. p. p. Lethæa Suec., 39, tab. XII fig. 6 b.
»Stenkärnor af Turriteller»	1841.	ID. Förteckning, 56.

Shell elongately turriculate, with slowly tapering whorls, only moderately ventricose, numerous — as many as 18 have been numbered in one specimen. The ratio of the increase in the whorls is in this species much slower than in any other, the breadth augmenting much faster than the height, as is made evident through the following comparative table of the dimensions of the whorls in five species.

	M. cingulata.		M. cava.		M. compressa.		M. attenuata. Two specimens. Spec. A.		Spec. B.		M. obtusangula.	
	Height of whorls.	Breadth.	H.	Br.	H.	Br.	H.	Br.	H.	Br.	H.	Br.
Body whorl	17 mm.	31 mm.	12 mm.	22 mm.	9 mm.	20 mm.	17 mm.	20 mm.	18 mm.	22 mm.	7 mm.	11 mm.
2	12 »	25 »	10 »	19 »	8 »	18 »	12 »	15 »	17 »	18 »	6 »	9 »
3	10 »	18 »	8 »	15 »	7 »	17 »	10 »	12 »	12 »	14 »	4 »	8 »
4	7 »	14 »	—	—	7 »	15 »	6 »	10 »	9 »	11 »	3 »	6 »
5	—	—	—	—	6 »	13 »	5 »	—	6 »	—	3 »	5 »
6	—	—	—	—	5 »	12 »	—	—	—	—	2 »	4 »
7	—	—	—	—	5 »	10 »	—	—	—	—	2 »	3 »
8	—	—	—	—	4 »	9 »	—	—	—	—	1 »	2 »
9	—	—	—	—	4 »	8 »	—	—	—	—	—	—
10	—	—	—	—	3 »	7 »	—	—	—	—	—	—
11	—	—	—	—	3 »	6 »	—	—	—	—	—	—
12	—	—	—	—	3 »	6 »	—	—	—	—	—	—

The apex of the spire is in all specimens, which have been investigated, filled up with solid calcareous spar of a brownish colour, without any trace of transverse diaphragmata. The nuclei have a glossy surface and look as if the interior walls of the shell had been porcellanous. The slit band is prominent a little above the middle of the whorls, it is narrow and slightly concave along its median line. The aperture is rather obovate approaching to the circular. The umbilicus seems to have been large and open as shown by longitudinal sections when there is no compact columella (fig. 18), but an open tubular axis interiorly.

Very frequent in the inferior limestone of Östergarn at Grogarn and Katthammarsvik, but almost only as nuclei, on which traces of the sculpture of the shell are visible. It has also been found in the neighbouring strata of Kräklingbo and Ardre, and it is probable that some nuclei from the limestone of Wisby belong to this species.

Height 80 millim., breadth 21 mill., apical angle 22 °.

This common species has usually been confounded with Murch. cingulata, as HISINGER himself did, till he in his »Förteckning öfver Svenska petrificater», edited 1841, p. 56, separates it from M. cingulata, without giving it any new name.

7. **Murchisonia attenuata** HISINGER.

Pl. XII fig. 20—24.

Turbinis marini nucleus lapideus lævis etc. BROMELL Act. Lit. Suec. 1738 vol. III p. 37.

Turritella attenuata	1840.	HIS. Leth. Suec. Supplem. Secundum, 4. tab. 37 f. 7.
	1841.	ID. Förteckning, 56.
	1848.	BRONN Nomenclator, 1331.
Murchisonia attenuata	1867.	LINDSTRÖM Nomina foss. Gotl., 23 (nec. Murchisonia attenuata HALL 1856, Trans. Albany Instit. vol. IV, 27).

Shell elongate, whorls seven in the most complete specimens, though there have certainly been many more. The whorls are ventricose, nearly as long as broad, somewhat angular where the slit band is projecting. This band is narrow, placed a little below the median line of the body whorl and quite on the middle line of the other whorls. It has an even surface, fig. 24 section, the crescents are regular, fig. 23. But near the aperture in large specimens the transverse ornamental striæ above and beneath are confluent with the band without any separating or bordering lines and it continues only as an elevated ridge, sometimes not clearly distinct from the surface. In this feature it shows relations to such genera as Euomphalus and Loxonema (for inst. pl. XV fig. 9) and also to Pleurot. planorbis HIS. The shallow suture crosses the longitudinal axis in a line more oblique than in the other species. There is no umbilicus and the aperture is oblong, the uppermost corner acuminated, its columellar lip thin, reflexed. Height 51 millim., width of body whorl 18 millim.

The original specimen of HISINGER is from Östergarn from where lately more specimens have been obtained, and quite similar ones are very common in the lowest shale near Wisby. It has also been found in the limestone of Gothemshammar, in the shale beds and limestone of Slite, on Furillen, in Follingbo and in the limestone at Kålens Qvarn.

8. **Murchisonia paradoxa** n.

Pl. XXI fig. 1—3.

Shell cylindrical, turreted, slowly increasing in width, whorls seven in the best preserved of two fragmentary specimens. The slit band is situated a little above the median line of the whorls, it is elevated, with a flat surface, crescents regular, dense, placed obliquely on the band which is crossing the axis of the shell in a highly acute angle. The whorls which are of equal breadth and height, are of an only slightly convex outline, though a little more bulging out in one of the specimens. They are adorned with minute transverse lines of the same pattern as in M. attenuata and M. cingulata. The uppermost margin of the whorls is at first constricted by a shallow groove, then widened in a stringlike rib, which covers the basis of the overlying whorls. The state of preservation of the specimens prohibits to ascertain the shape of the aperture and the umbilicus. Height of most complete specimen 36 mm., br. 10 mm.

Rate of growth of the whorls:

	H.	Br.
1	10 mm.	10 mm.
2	8 »	9 »
3	7 »	8 »
4	5 »	7 »
5	5 »	6 »
6	4 »	5 »

Two specimens have been obtained from the gray limestone of Lindeklint.

Divisio II. ORNATÆ.

9. **Murchisonia crispa** n.

Pl. XII fig. 13—14.

Shell turriculate, obese, thick, with six ventricose whorls which at their lowest edge near the suture are constricted, forming a narrow vertical belt. The slit band is placed much beneath the middle line of the whorls, a little above the suture. It is not distinctly separated from the other surface through bordering lines and the crescents are in direct continuation with the transversal lines. These are distantiated, lamellar, imbricated. The slit is well preserved, short and tongue shaped. No umbilicus is visible and the aperture is ovate. Height 21 millim., breadth 12 millim. Apical angle 38 °.

It has been found in the coralliferous limestone of Lindeklint and Sandarfve kulle, one specimen from each locality.

10. **Murchisonia munda** n.

Pl. XIII fig. 6.

Shell turriculate, terete, with eight short, ventricose whorls, twice as broad as high. The narrow, ropelike slit band forms a prominent angle a little below the median line of the body whorl and a little above the same line in the other whorls. It is hemmed in by two distinct lines and its surface is prominent and convex, the crescents are distantiated, smooth, lamellar and imbricated, quite as in that group of the Pleurotomariæ, which has been called Crispæ. In this feature the four first species of the Murchisoniæ ornatæ are similar. Above the band, and parallel with it, a small ridge runs on the body whorl. The surface is transversally striated by gently undulating, lamellar, densely placed lines, imbricated as it were. For the rest the shell is quite smooth without any longitudinal or transverse striæ. The aperture is nearly obliquely elliptic and the columellar lip thin and reflexed, hiding the umbilicus.

Height nearly 6 millim., breadth 3 millim.

A few specimens found in the marly strata of the upper limestone of Slite.

It comes near to the preceding species as to the ornamentation, though this is much finer in M. munda.

11. **Murchisonia tortuosa** n.

Pl. XIII fig. 4, 5, 13, 14.

Shell turriculate, of nine ventricose whorls, nearly twice as broad as high, angulated a little below the middle of the whorls, where the chordlike slit band is placed. This band is narrow, convex and outstanding, composed of nearly tubular and lamellar crescents, which cover each other successively, in an imbricating way. The lowest part of the whorls is abruptly bent in towards the suture in a face, whereby the suture is uncommonly deep. There is a low ridge between the slit band and the umbilicus parallel with the former. In one specimen, fig. 13 there are also two or three low ridges on both sides of the slit band. The ornamentation consists for the rest in transverse, sinuous, lamellar striæ. On the umbilical part there is also much variation, in some a succession of concentric ridges, cut by striæ, which are sinuous, as in fig. 14, or in others, as in fig. 5, only transverse striæ and concentric ones near the edges. H. 11 mm., br. 6 mill.

The aperture is ovate, the inner lip reflexed and hiding the umbilicus.

Only two specimens have been found, one from the crinoidal limestone of Stor Wede in Follingbo and the other variety from a limestone ridge near the church of Burs.

12. **Murchisonia imbricata** n.

Pl. XIII fig. 7—12.

Shell turriculate, elongate and slender, fig. 7, or short and terete, fig. 8; whorls nine, broader than high. The slit band is prominent as a sharp edge, nearly on the middle of all whorls or a little above. It is narrow, the crescents are long, protracted and tube shaped, slender at their origin beneath the next preceding and slowly widening till they form an erect, somewhat reflexed edge, fig. 11, 12. This form of the crescents very much reminds of that in Pleurotomaria tubulosa, pl. IX f. 8, though the crescents are more narrow and elongate in Murchisonia imbricata. The same sort of slit band also distinguishes this species from the two nearly related, preceding ones. In the two varieties, fig. 7, 8, the ornamentation of the surface is thus far dissimilar, that it is finer in the elongated form, than in the other. There are in both transverse, oblique striæ, somewhat elevated and lamellar at their edges and thence causing an imbricated appearance. They are crossed by a low and narrow ridge above the slit band on the body whorl and by a more prominent, sharp ridge on all whorls near the suture, which is very deep. On the umbilical side the striæ are finer and closer. The aperture is nearly circular and its columellar lip reflexed, though not so much as to hide the narrow umbilicus. H. 5 millim. br. 2 mill.

This little, beautiful shell occurs plentifully in the marly seams of the upper limestone of Lotsbacken in Slite and a few specimens have also been found in the limestone near Kålens Qvarn and both in the red and gray limestone of Sandarfve kulle.

13. **Murchisonia cancellata** n.

Pl. XIII fig. 1.

Shell turriculate, with eight transverse whorls of greater breadth than height, angulated on the middle, where the slit band is situated. This band is enclosed within two longitudinal, sharply projecting lines on each side and these again have between them a narrow concave belt, streaked with short, oblique lines. The slit band proper is thus very narrow, concave, the crescents of so small a size as not to be distinguishable. The other shell surface is cancellated by transverse and longitudinal threads of equal size, though somewhat unequally distantiated. The aperture is nearly ovate, the umbilicus is larger than in the others. Height of the most complete specimen 8 mill., br. 4 mill.

Some specimens have been found in the red limestone of Sandarfve kulle. From this locality there is also a variety with more ventricose whorls, which seems to have been larger.

14. **Murchisonia cochleata** n.

Pl. XIII fig. 2—3.

Shell turriculate, slender and tapering with twelve or thirteen whorls, much angulated and prominent along the median line. The sides of the whorls on both sides of the slit band are rather much more concave than in any of the preceding species, and constricted into a vertical ring near the lower suture. The slit band is prominently convex, hemmed in only by the uneven edges of the surface, and covered by very unequal, regularly curved crescents of which some prominent are mingled with fainter. The ornamentation on both sides consists of transverse, much curved, elevated sulci, remote, the interstices striped with minute striæ. On some distance from the slit band three or four elevated ridges are crossing them; the largest is placed at highest above the band, encircling the umbilical surface. On this same surface there are several others, low, concentric ridges, which are crossed by finer and more closer striæ. The aperture is nearly circular and the columellar lip largely reflexed, widened in a broad lamina near its superior corner and hiding the opening of the umbilicus. The suture is distinct and slightly impressed. H. 18 millim. br. 8 millim.

This species has been found in some 30 specimens in the red limestone of Sandarfve kulle and also a few from the limestone of Katthammarsvik in Östergarn.

15. **Murchisonia deflexa** n.

Pl. XX fig. 1—6.

Shell turriculate, with nine transverse, tumid whorls, carinated through many sharp, longitudinal keels. The whorls rapidly increase in size in the following regular proportion:

	H.	Br.
1 or body whorl,	4 mill.	8 mill.
2	3 »	6 »
3	2 »	4 »
4	1,5 »	3 »

the breadth thus increasing exactly in the double ratio of the height. A longitudinal section of the whorls gives an oval, nearly pyriform outline, broadest above and narrow below. The slit band, the greatest peculiarity of this species, is situated a little above the median line of the whorls. It is a narrow and excavated groove, covered with oblique crescents. Its superior, bordering line has grown out in a vaulted lamella, which is bent down over the band so much that it completely hides it and its surface only can be seen where this lamella is broken. This superior lamella is thin and sharp edged, like a claw in the section, the inferior bordering line again is short, blunt and horizontal. As seen in the section, fig. 6, the slit continues open along half the body whorl. The surface on both sides of the slit band is delicately and finely cancellated by lines of which the transversal ones above the slit band curve backwards only on the very edge of the covering lamella. Those below the band form a large curve, directed forwards with its greatest convexity and with its upper end at the slit band bent backwards. The transverse lines are nearly thrice as large as the longitudinal ones and, where they meet, a thick, blunt nodule is formed. Above the slit band there are two longitudinal keels and one smaller around the umbilicus. Close below the slit band a sharp longitudinal keel is running and the lowest edge of the whorl is widened into a narrow ridge, which covers the much impressed suture. A great peculiarity, which has not been observed in any other species of the Murchisoniæ, nor in any other gastropodan shell of the Silurian formation, consists in two interior, longitudinal keels, of which one narrow and thin, follows the inner wall of the outer side of the shell from the lower corner of the outer apertural lip, where it is placed a little below the lowest keel. It continues on the same level through the whole shell, as may be seen in the longitudinal section, given in fig. 6. On the nucleus this ridge has of course occasioned an impression as a narrow groove, fig 4. The other keel runs higher up near the top of the whorls on their umbilical side and corresponds with the narrow ridge, which is visible around the umbilicus. These may in some way be regarded as formations homologous with the continuous ridges which interiorly cover the walls of the Nerinææ.

The aperture is large, obovate, its outer lip is thin, the inner is lamellar, reflexed and at broadest in its superior corner. The umbilicus is narrow, where it opens, and continues downwards as a hollow axis.

The shell has in many specimens, especially on the interior side, an intense ochraceous yellow colour, but whether this is due to later mineral agencies or to its retaining anything of the original colouring is uncertain. H. 12 mill., br. 8 mill. Height of aperture 4 mill., br. 4 mill.

In all, nine specimens have been found of this curious shell in the gray limestone of Linde klint, on its northernmost side, and also a few specimens on Sandarfve kulle in the gray and red limestone.

Fam. VII. EUOMPHALIDÆ De Koninck.

Shell discoid or turriculate, on the apical side or on the middle of the body whorl provided with a shallow notch in the outer lip, in continuation of which there runs on the surface of the whorls a slender, elevated ridge, on which the transverse striæ are forming a small angle, directed backwards without any resemblance with a true slit band. The apex of the shell is commonly filled with solid calcareous matter of an organic deposit or even divided in various compartments through transverse, imperforated diaphragmata.

In adopting the name given by De Koninck[1]) to this family it is in a much more restricted sense than he intended and such genera as Straparolus, Straparollina, Maclurea and Rhaphistoma are according to the definition given above not to be included. The shells of this family, of which only the genera Euomphalus, *sensu strictiori*, and Loxonema

[1]) Faune du Calcaire Carbonif. de la Belgique, II, III p. 107.

are Silurian, have a slit in the lower edge of the exterior lip, much more shallow than that of the Pleurotomaridæ and nearly alike that in Pleurotoma and also in Turritella[1]). During the growth this slit is never changed into a real slit band as in the Pleurotomaridæ, at the highest there is a narrow ridge, where the lines of growth are curved backwards. When we see how mollusca, in other respects dissimilar, are provided with this slit in their shell, it is indeed very questionable whether the Loxonemata only on that ground are so nearly related to the genus Euomphalus as to be included in the same family as here proposed. There may, however, be added the similarity in the consolidated apex, and they may thus, at least provisionally, be regarded as related and Loxonema in a certain way to hold the same position to Euomphalus as Murchisonia holds to Pleurotomaria.

Gen. **EUOMPHALUS** SOWERBY p. p.

1814 *Euomphalus* SOW. p. p. Mineral Conch. I, 97.
1833 *Bifrontia* DESHAYES p. p. Descr. Coqu. foss. des environs de Paris, 221.
1835 *Schizostoma* BRONN Lethæa Geogn. Ed. 1, 95.
1843 *Eccyliomphalus* PORTLOCK p. p. Report Geol. of Londonderry, 411.

Shell discoid with contiguous or disjointed whorls; on the apical side of the aperture a shallow and obtuse slit or sinus is situated, the traces of which are seen on the whorls as a more or less elevated ridge, towards which the lines of growth are turning their apical angle. The apex of the shell is filled with a solid calcareous deposition of organic origin and is often subdivided through transverse diaphragms.

After the detailed expositions of the affinities of this genus as given by DE KONINCK in his latest grand work and by STOLICZKA[2]), WAAGEN[3]) and ETHERIDGE JR[4]) only a few remarks need be added, chiefly to show the standing point in this question of J. SOWERBY and DESHAYES, the conchologists who have most essentially influenced the opinion of others.

When JAMES SOWERBY in February 1814 published his new genus Euomphalus in № IX of the Mineral Conchology p. 97, he founded it on such species as Euomph. pentangulatus, catillus and nodosus, all provided with the small notch in the corner of the aperture on the apical side and a ridge in connection with it on the surface of the whorls. But already in April the same year he joined with them in that very genus others as E. discors, rugosus etc., which do not share in the peculiarity of conformation, distinctive of the former. Consequently, when we are to fix the characters of Euomphalus it must be in the original conception of its author. Next, the opinions of DESHAYES are of great importance, as most of the subsequent authors seem to have followed him. In 1830[5]) he did not accept Euomphalus as an independent genus, but

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[1]) BOOGE WATSON Mollusca of the Challenger Exp. in Journ. Linn. Soc., Zoology, vol. 15, p. 220.
[2]) Palæontologia Indica V, p. 247.
[3]) Pal. Ind. XIII p. 86.
[4]) Ann. mag. N. H. 5th Ser. vol. 5, p. 480.
[5]) Encycl. Method., Hist. Nat. d. Vers, vol. II p. 162.

creates a section of it in Solarium, comprising all the three, first original species of SOWERBY. The later species, viz. E. discors, rugosus and funatus he says belong to Turbo, and others again to Delphinula. He then quite rightly distinguished the true Euomphali from the others and in all probability assigned to the E. discors etc. their true place.

In the same work he in 1832[1]) identifies Straparolus of MONTFORT with Euomphalus or Solarium. As the confusion in this respect has originated with him and as most of the later authors have participated his views, it may be as well, here at once to try to clear up this matter. MONTFORT established, as is well known, his genus Straparolus[2]) in 1810, taking Str. Dionysii as the typical species. On comparing specimens of this shell with specimens of E. pentangulatus or E. catillus it must, however, be evident that they cannot possibly be regarded as of the same genus. In Straparolus the shell has rounded, tubular whorls without the least trace of ridges, only with some faint, longitudinal stripes and the transverse striæ are not angular, as in Euomphalus, in Euomphalus again the whorls are angular and provided with the distinctive ridge on the apical side. It is, moreover, highly questionable whether Straparolus is identical with those Silurian shells which formerly were confounded with Euomphalus, as E. discors etc. These have in the present memoir, in consequence of the nacreous structure of the shell and the characteristic opercula been placed amongst the Turbinidæ and in the genus Oriostoma. No opercula have ever been found belonging either to Euomphalus sensu strict. or to Straparolus nor are they nacreous. If it steadily is kept in view that Straparolus not at all is identical with Euomphalus s. str. and scarcely with Oriostoma, a great deal of difficulties will be overcome.

A change is made in 1833[3]) by DESHAYES thus far that he creates a new genus Bifrontia and in this he ranges E. catillus, while the other two species are left with Solarium as before. It cannot be denied, that there is a certain resemblance between such shells as the Gotlandic E. tuba and DESHAYES' Bifrontia ammonoides and B. Deshayesii[4]) and likewise amongst recent shells, Omalaxis (Bifrontia) supranitida WOOD has a shape that reminds of that of the palæozoic.

In his last great work[5]) he maintains Euomphalus as a genus distinct from Solarium, though belonging to the same family. He is further (l. c. p. 678) willing to accept BRONN'S Schizostoma for E. catillus. As to the last mentioned genus, established with E. catillus as type, it was rejected by FERD. ROEMER[6]), who regards the indented curvature of the aperture too insignificant as a generic character. It may, however, be questioned whether this genus ought not to be retained for such Devonian species

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[1]) Vol. III p. 986.
[2]) Conchyliologie System. II, 174.
[3]) Description des Coquilles foss. des Environs de Paris II p. 221. This work is dated 1824 on the title page, but it was published in small parts and it lasted till 1839 before it was completed. According to HERMANNSEN Indic. Generum, Bifrontia was published in 1833.
[4]) Anim. sans vertèbres dans le Bassin de Paris, II pl. 26 f. 22—28.
[5]) Anim. sans vertèbr. dans le basin de Paris. Vol. II, 660.
[6]) Leth. Geogn. 3:e Aufl. 1 Bd, 456.

as Schizostoma Pusozii and Sch. radiatum, which are of a type entirely different from E. catillus.

To sum up the chief results now gained, I believe:

1:o) that Euomphalus is to be maintained in the sense which Sowerby at first gave it.

2:o) that Straparolus, as well as Oriostoma must be removed from Euomphalus as not identical with it and belonging to different families, Oriostoma being one of the Turbinidæ.

3:o) that of the Silurian shells Euomphalus along with Loxonema must be regarded as members of the family of the Euomphalidæ De Kon. p. p. and

4:o) that this is to have its systematic place next to the Pleurotomaridæ, as there are forms linking both together.

Eccyliomphalus, the only remaining synonymic genus, the identity of which with Phanerotinus is doubtful, comprised, when first established, two species and the author, Portlock, lays stress on »its great resemblance to an unrolled Euomphalus». And, in fact, these species come near to such as our E. Gotlandicus and E. triquetrus. But by and by quite different shells were introduced into it. Eccyl. alatus Ferd. Roemer, concerning which species see above at page 110, is an instance of the adventitious forms. This genus has thus come to contain species of evolute Euomphali and likewise evolute Pleurotomariæ. It must, consequently, be broken up, and its species be distributed in these genera. Both the typical species are Euomphali.

The genus Euomphalus has a wide geological range. In Sweden the oldest specimens have been found as deep down in the Lower Silurian as in the Lower Gray Orthoceratite limestone of Dalecarlia, from where the specimen, delineated on pl. XIII fig. 36—38 has been derived. It is evolute, with three widely separated whorls of circular section, the aperture angulated in its lowest corner, where the large and distinct slit, fig. 36, is situated. The ridge in continuation of this runs very sharp along the whole apical side of the whorls. The ornamentation consists of imbricated, transverse striæ, curved back in an acute angle, where they cross the apical ridge. The oldest whorls on the visible part of the apex is divided in chambers through at least four transverse diaphragmata. I have named this interesting species *Euomphalus Angelini* in remembrance of the indefatigable and gifted man, Professor N. P. Angelin who devoted his life to the investigation and elucidation of the palæontology of Scandinavia.

Next in order of time we find a Euomph. obtusangulus[1]) which resembles the Upper Silurian E. Walmstedti and E. præcursor, in the Leptæna limestone of Dalecarlia. In the Upper Silurian of Gotland there are five species, besides fragments indicating others. It is well known that there have been several species found both in the Devonian and Carboniferous formations expecially in the later, where the genus seems to have attained its culmen. Whether the Euomphali had continued during the Mesozoic times is uncertain. They have, it is true, been recorded as occurring in the Triassic Rocks of Austria[2]). But the form of these presumed Euomphali does, certainly

[1]) Angelin & Lindström. Fragmenta Silurica p. 12 pl. XVII f. 19—20.

[2]) See the works of Klipstein and Laube.

not harmonize with that of the palæozoic Euomphali. As Stoliczka has shown[1]), most of the Jurassic forms belong to the genus Discohelix, of which there probably already is a representative in the Devonian strata of Nassau[2]). It is possible that this genus has continued during the Tertiary times and still survives in the Mediterranean and Atlantic seas.

As to the species here described in this genus, E. tuba n. may be only provisionally included in it, as it deviates somewhat in its form and possibly rather is an Oriostoma. On the other hand, it must by future researches be decided whether Oriostoma angulatum Wahlenberg rather not is an Euomphalus.

1. Euomphalus Gotlandicus n.

Pl. XIII fig. 19—31.

Shell disciform, involute or disjointed, at the highest with five whorls. These are cylindrical and nearly triangular in section, the slit and its concomitant ridge being on the apical side. The oldest mutation or variety, which occurs in the shale beds, has only the nucleus left and is generally involute (figs. 19—22) with a wide and open umbilicus showing all whorls. The aperture is in the best specimens triangular, the ridge forming an angle, the outer lip thin, a little reflexed outwards. The tendency to disjoint can be traced in specimens where the whorls are coiled in, but have some free space between them, to those where they are quite uncoiled as in figs. 23—25. From the same geological horizon the specimens figured in figs 30—31 have also been obtained. In the uppermost limestone strata near Wisby hitherto only uncoiled specimens have been found as shown in figures 26—29. In them the aperture is more triangular than in the involute forms from Wisby *a*. The ornamentation of the surface is nearly alike in all, consisting of thin, transverse threads bent in an angular line curved backwards from the apertural slit. This slit is situated nearly in the middle of the lower edge of the aperture and forms a highly obtuse angle. The three oldest whorls are filled with solid calcareous deposit, figs. 22, 29, and the uppermost surface of this stratum is deeply concave.

H. 20 mill., br. 42 mill. of involute specimen.

H. 15 mill., br. 39 mill. of uncoiled specimen.

The involute variety is found in great numbers in the lowest shale near Wisby, and also at Westergarn and Stormyr in Rute. The uncoiled variety is found in the same localities and moreover in the uppermost limestone beds of Kyrkberget in Wisby and at Kålens Qvarn, Hogrän, the shore of Slite, Weskinde.

From the shale of Wisby some nuclei have been obtained in all particulars resembling the common involute one, excepting in having some slight longitudinal ridges along the apical side. They are, however, not in a sufficiently good state of preservation for description and delineation.

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[1]) Gastropoden der Hierlatz Schichten. Sitzungsberichten der Ak. Wiss. Wien, Bd 43, 1, p. 180.
[2]) Euomphalus rota Sandb. Nassau p. 212, pl. 25 f. 5.

2. **Euomphalus triquetrus** n.

Pl. XIII, fig. 32—35.

Shell discoid, of triangular section, with four whorls, of which the older are contiguous and the body whorl free through almost its whole length, rapidly widening, much more so than in E. Gotlandicus and it is broadly expanded at the aperture. The three smaller whorls, which form the apex, are filled with a homogenous, calcareous deposit, only interrupted by a transverse diaphragma in the second whorl. On the interior side of the umbilical surface the nucleus of the body whorl has a shallow, longitudinal groove, being the impression of some internal ridge. The umbilical side is the largest, nearly flat, and the two other shorter sides meet in an obtuse angle on the apical side. The aperture is transversally triangular, broader than high, the inferior corner acuminated. It is oblique and the superior lip more prominent than the inferior one. The notch in the inferior lip is broadly triangular, fig. 35, and deeper than in the preceding species. H. of aperture 16 mm., br. 22 mm., diameter of the shell 51 mm.

Specimens have been obtained from the shale and limestone of Slite, from Boge, Westkinde and Hogrän.

3. **Euomphalus tuba** n.

Pl. XVIII fig. 6—8.

Shell globular, with a low, though prominent spire and four tubular whorls. They are ventricose, with slightly elevated ridge in continuation of the apertural indentation. The suture is deep and the whorls sink much abruptly towards it. The ornamentation consists in narrow longitudinal threads, which are crossed by indistinct, transverse lines of growth, coarser and finer, forming an obtuse angle in the same line as the slit is situated. The aperture is circular and the lips thin, the umbilicus is narrow, but open.

H. 7 millim., br. 10 m.

A single specimen from the limestone of Samsugn in Othem. A nucleus from Martebo of larger dimensions may possibly also belong to this species.

4. **Euomphalus præcursor** n.

Pl. XVIII, fig. 9—11.

Shell discoid, spire moderately prominent, of five whorls, rapidly increasing in size, the body whorl in breadth surpassing all the others. The narrow characteristic keel is seen a little below its median line, having inside it towards the suture a flat surface. On the umbilical side of the body whorl there is a narrow, sharp keel nearer to the umbilicus than the exterior margin, on the inside of which a scooped out belt is formed, being bordered by a sharp edge where the umbilicus begins. The striation on the surface is only transversal, slightly bent in a sinus where it crosses the keel. The striæ are narrow, elevated and thread like. The aperture is transversally ovate, the umbilicus rather narrow. H. 6 mm., br. 17 mm., diameter of umbilicus 5 mm. Another specimen: H. 5 mm., br. 11 mm., umbilicus 3 mm. Two specimens from the shale of Wisby. From Dalhemså, near Nya Slitegårds, the museum possesses a single specimen, which perhaps is only a variety of this species. It is, however, different in not having the inferior keel so prominent and the whorls are convex, not flat between the keel and the suture. On the umbilical side it is more conformed to the former.

The shape and sculpture of E. præcursor remind of the far larger species from younger palæozoic formations.

5. **Euomphalus Walmstedti** n.

Pl. XVIII fig. 12—14.

Shell discoid, spire on a level with the body whorl, whorls seven. On the apical side a blunt ridge is running longitudinally and the surface of the whorl inside it and the suture is sloping towards the suture or even a little scooped out. The median line of the whorl, on the dividing line of the apical and umbilical side, is obtusely carinated. A little inside the longitudinal axis of the umbilical side there is a sharp, narrow keel, from which the side slopes gently inward. A narrow, sharply defined groove marks the suture on the umbilical side. The transverse striation, the only one extant, is extremely fine and the striæ are slightly angulated when crossing the inferior ridge. The aperture is transversally ovate, angulated, the umbilicus wide and open. H. 4 mm., br. 13 mm., umbilicus 4 mm. Several specimens have been obtained from the red limestone of Sandarfve kulle. There are also specimens from Samsugn in Othem and Klinteberg, which probably are only varieties of this species. They have the whorls more rounded and the keels blunt or nearly evanescent. The wider umbilicus and the conformation of the whorls around it, as well as the quite different striation, distinguish this species from the former.

Gen. **LOXONEMA** Phillips.

1841 *Loxonema* Phill. Palæozoic Foss. Cornwall, p. 98.

Shell turriculate, with long, slender spire of ventricose whorls; a shallow indenture occurs in the exterior lip of the aperture. The lines of growth and also the ornamental ones are bent in an obtuse angle, the apex of which is situated in a line with the apertural indentation. The axis is solid and the oldest whorls are filled with an organic deposit of homogenous calcite as in the preceding genus.

Of the species first included within this genus almost all have the characteristic features of »the oblique prominent thread like striæ which cover the surface in all the typical species» and as also the etymology of the name implies. In spite of such expressly given characteristics by the first author later naturalists have placed within the limits of this genus shells which are ornamented in a quite different manner, and rather should be regarded as belonging to other genera. Only such shells, in which the ornamental striæ form an angle along the median line of the whorls or near that line conformably to the first typical species, should be placed here.

Michelia of AD. FERD. ROEMER[1]) comprises shells with nearly the same ornamentation as in Loxonema, but with whorls and spire more like those in Trochus or Terebra.

Species of Loxonema have been found in the Silurian and Devonian formations.

A few have also been found in the Carboniferous limestone, though a great many have been introduced in this genus without showing the distinctive characteristics. But of all those described as Loxonema by LAUBE[2]) from the Triassic strata of St. Cassian not a single one can be regarded as appertaining to that genus.

In the Silurian of Gotland five species have been found, differing from each other in the shape and relative size of the whorls as well as in the position of the insinuation and the character of the angular striæ.

1. **Loxonema sinuosum** SOWERBY.

Pl. XV fig. 1—5, 7.

Terebra? sinuosa	1839.	SOWERBY in Sil. Syst. 619 tab. 8, fig. 15 (not SALTER in Mem. Geol. Survey II, I, 357, pl. 14 f. 2, which is = Murch. cingulata HIS., Loxonema sinuosa PHILLIPS Pal. Foss. Cornwall 99 pl. 38 f. 182 is a Devonian species distinct from the Silurian and has to be renamed as it is of later date).
Loxonema sinuosum	1848.	BRONN Nomenclator, 670.
	1850.	D'ORBIGNY Prodrome I, 29.
	1854.	MORRIS Catal. Brit. Foss. Ed. 2, 255.
	1859.	SALTER Siluria 3 Ed., 549 tab. 24 f. 3.
	1873.	ID. Catal. Cambr. Foss., 172.
Holopella (*obsoletæ* Sow. aff.)	1867.	LINDSTRÖM Nomina, 23.

Shell elongate, turriculate, with eight whorls, which are transverse, broader than high, ventricose, constricted in a narrow belt close at the suture and the lowest edge of the whorl hiding and covering the suture. Suture crossing the axis of the shell in a very acute angle. The surface is covered by very fine, elevated lines, which are bent in a nearly rectangular curve, along a line somewhat below the transverse median axis of the whorl corresponding with the position of the obtuse indentation of the aperture. The striæ are finest on the body whorl, being more and more coarse and changed into elevated, angular ridges on the older whorls. The aperture is ovate, the columellar lip having besides it only a narrow, umbilical fissure open, which is

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[1]) Palæontographica Bd. 3, p. 73.
[2]) Denkschriften der Ak. d. Wiss. zu Wien 1868 Zweite Abth., p. 60.

completely closed in the interior, the columella being solid, fig. 4. The apex is a homogenous mass of calcareous spar, fig. 4, and consequently the nuclei, fig. 5, are ending in an obtuse truncation. H. 24 millim., width of body whorl 12 millim.

Size of the whorls in two specimens.

Spec. A.			Spec. B.		
Whorls.	H.	Br.	Whorls.	H.	Br.
1	8 mm.	12 mm.	1	8 mm.	12 mm.
2	5 »	9 »	2	5 »	9 »
3	5 »	6 »	3	4 »	7 »
4	3 »	5 »	4	3 »	5 »

Very common in the shale at Djupvik in Eksta and also in few specimens from Wisby.

2. Loxonema attenuatum n.

Pl. XVIII fig. 3—5.

Shell elongated, turriculate, of 8 – 9 whorls, nearly as high as broad and in some specimens exactly so, moderately ventricose or even approaching to a cylindrical shape with straight sides, a little constricted around the inferior edge and slightly covering the shallow suture. The apex of the angular and very fine striæ is situated a little higher than those of the preceding species or near the median line. The corrosion of the surface has caused a false appearance as of a slit band. The aperture is longer than broad, oval, the interior lip broad and reflexed; no umbilicus is visible. Length of a fragment 27 millim., breadth of body whorl 9 mill., probable length of complete specimen 35 mill. Dimensions of whorls in four specimens:

A, whorls.	H.	Br.	B, whorls.	H.	Br.	C, whorls.	H.	Br.	D, whorls.	H.	Br.
1	10 mm.	11 mm.	1	8 mm.	10 mm.	1	9 mm.	9 mm.	1	wanting.	
2	7 »	8 »	2	6 »	8 »	2	7 »	7 »	2	7 mm.	8 mm.
3	5 »	6 »	3	4 »	—	3	5 »	5 »	3	5 »	6 »
			4	3 »	—				4	4 »	4 »
									5	3 »	3 »

Nine specimens have been found in the limestone of Samsugn in Othem.

A fragment of a large Loxonema from Follingbo somewhat reminds of this species but cannot be defined with certainty.

3. Loxonema intumescens n.

Pl. XV fig. 6.

Shell turriculate, with a slowly tapering spire, of which six whorls are left. These are ventricose, larger than high in the following ratio.

Whorls.	H.	Br.
1	10	14
2	7	11
3	5	8
4	4	6
5	3	5
6	2	4

The increase is consequently more rapid in the youngest whorls. The suture is moderately deep and the whorls are regularly rounded down to it, without any constriction. The apices of the angular striæ are placed on the middle of the whorls and resemble those of Lox. sinuosum. H. 32 millim., br. 14 mm.

Only one specimen has been found in the upper limestone near Wisby and there are also some from Westergarn.

4. **Loxonema strangulatum** n.

Pl. XV fig. 8—10.

Shell turriculate, long and slender, of at least six whorls. As may be seen by the dimensions, given below, the whorls are of nearly double the height against the width. They are only moderately ventricose, as to appear almost cylindrical, the suture is oblique, more so than in the other Gotland species. The lowest part of the whorls is constricted in a rather broad belt just above the suture. The ornamentation consists of the usual striæ, bent backwards on the middle of the whorls in a sharp rectangular sinus.

Height of longest specimen from Östergarn 47 millim., br. 8 mill. Height of second whorl in the Klinteberg specimen figured 8 millim., breadth 5 millim.

Found in the limestone of Östergarn and Klinteberg.

5. **Loxonema ? fasciatum** n.

Pl. XV fig. 11, pl. XX fig. 7.

Shell slender, elongate, turriculate, with about 16 slightly convex whorls, glossy, though covered with exceedingly minute transverse striæ, which are curved backwards in an angle. The apex of this angle is obliquely arched and taken together the apices of all striæ form, exactly above the median line of the whorl near the upper suture, a relatively large band, somewhat resembling the slit band in Murchisonia, as for instance M. crispa. It is however not clearly defined from the ambient surface, through bordering lines and the species may, untill further information is gained, be left with Loxonema. The whorls are a little longer than broad. The aperture is ovate. H. 13 millim., br. 2 mm.

A few specimens have been found in the red limestone of Sandarfve kulle.

Fam. VIII. TROCHIDÆ D'Orb.

Gen. **TROCHUS** L.

1758 *Trochus* L. Syst. Nat. ed. X, 756.
1879 *Palæotrochus* J. Hall Pal. N. York vol. V pt. II, 133.
1881 *Flemingia* De Koninck Faune II, iii, 94.
1882 *Eotrochus* Whitfield Bullet. N:o 3 of American Museum of Natural History p. 77.

It is with great diffidence the following species have been described as belonging to the old genus Trochus. The only reason for placing them there is the general exterior shape of the shell, it having not been possible to find any evidences from the microscopic structure of the shell nor from any traces of a nacreous stratum or an operculum. On the other hand, there are so many genera of shells which have persisted from the Silurian age through all the following and still continue, and it may therefore not be thought an impossibility that also the Trochi existed already in the Silurian times. Moreover, it is generally adopted that species of Trochus have been found in the Devonian rocks, where they, however, as well as in the Carboniferous limestones, not are numerous. Most of these palæozoic Trochi are nearest allied to that division, where the inner lip is thin or only slightly thickened, and the umbilical side flat. A few, as Tr. profundus and Tr. cavus [1]) evidently belong to a section of Palæozoic Trochi, out of which Whitfield (l. c.) has established his genus Eotrochus. They have exactly the same cup shaped conformation of the umbilical side, which has led some authors [2]) to place similar ones from the Jurassic formations with the Phoridæ in the genus Onustus. I think, however, that the Palæozoic may, at least for the present, be retained in Trochus. On comparing the beautiful figures of Tr. lamellosus for instance in D'Orbigny's Pal. Française, Terr. Jurass. pl. 311 fig. 11—13, the remarkable similarity with the Silurian Tr. cavus and profundus is evident. There is in all the same cup shaped umbilical surface, the thin, lamellar border around it and the open umbilicus. There are no traces of any nacreous stratum. The columella, probably solid in some, is in many replaced by a wide, open, funnel shaped axis. The apex of the whorls is filled up with a calcareous deposit.

Sixteen species have been discovered in the limestone beds of Gotland, none having hitherto been found in the subjacent shales. These species may be divided into the following groups.

I. **TRANSVERSI,** transversally ornamented by oblique lines.

1. Tr. Gotlandicus n.
2. Tr. fulminatus n.
3. Tr. mollis n.

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1) Probably also Tr. Stuxbergi and undulans.
2) Hudleston Contributions to the Pal. of the Yorkshire Oolites. Geol. Mag. 1884, p. 293.

4. Tr. Stuxbergi n.
5. Tr. undulans n.
6. Tr. profundus n.
7. Tr. cavus n.
8. Tr. Lundgreni n.
9. Tr. Kolmodini n.

II. **CARINATI** with longitudinal keels.

10. Tr. Dalli n.
11. Tr. Wisbyensis n.
12. Tr. lamellosus n.

III. **INCISI** with angulately impressed suture.

13. Tr. incisus n.
14. Tr. gyrans n.
15. Tr. densestriatus n.

IV. **SPINOSI** with spiny processes along the suture.

16. Tr. astraliiformis n.

No species has as yet been found in the Lower Silurian beds of Sweden.

Div. I. TRANSVERSI.

1. Trochus Gotlandicus n.

Pl. XIV fig. 1—11.

Shell broadly conical, sides even, only slightly convex, whorls seven, transversally striated by the oblique, backwards directed, lamellar, wavy lines of growth, which overlap each other and consequently give the surface an imbricated appearance. They vary finer (fig. 1) or coarser (fig. 6). Where the umbilical and apical faces of the last whorl meet they form an acute angle which often is prolonged into a horizontal, solid keel. The umbilical surface is nearly flat, smooth, striated by minute, dense lines. The aperture is oblique, almost triangular. The outer lip is thin and sharp, the inner lip reflexed. The umbilicus is closed and there is a marked circular depression around it, defined by a narrow, thread like ridge. The columella is solid. The suture is shallow, often covered by the lamellar keel of the preceding whorls, and the outlines of the different whorls run in a continued profil without any interruption. The apex of the shell is filled up with solid calcareous matter. A peculiar reticulated structure is shown, fig. 9, in thin, transparent cuts of the shell.

H. 18 mill., br. 35 millim.

It occurs plentifully at Lansa and Lutterhorn on Fårö, in the limestone of Slite, Hall near Westöös, in the coast all along the shore from Likkershamn to Wisby. A single nucleus has been found in the shale near Wisby and probably belongs to this species.

2. **Trochus fulminatus** n.

Pl. XIV fig. 12—13.

Shell small, broadly conical with five ventricose whorls and deep suture. The ornamentation is peculiar and characteristic. The distantiated, transverse lines are a little below the middle of the whorls suddenly bent in an obtuse angle, thus forming, as it were, a lower field of striæ on the belt next above the suture. The aperture is transversally obovate, the lips thin, the umbilicus closed and the central part of the umbilical face deeply depressed and surrounded by a low ridge. H. 10 millim., br. 10 mm.

A few specimens of this characteristic little shell have been found in a white crystalline limestone north of Wisby, along the shore of Westkinde and Lummelund.

3. **Trochus mollis** n.

Pl. XIV fig. 14—17.

Shell large, broadly conical, of six tumid whorls, which are only obtusely carinated between the apical and the umbilical surfaces. The sculpture differs totally from that of the preceding ones and consists only in microscopically minute, transverse striæ, very regularly distantiated from each other. The aperture is obliquely elliptical, the outer lip thin and sharp, the interior lip strongly reflexed or thickened. The umbilicus is almost hidden through it and is only discerned as a narrow slit.

H. 21 millim., br. 27 millim.

Some specimens have been found in the limestone of Klinteberg and Samsugn, and also in Lilla Carlsö, from where the Mineralogical Museum of Copenhagen has obtained a specimen.

4. **Trochus Stuxbergi** n.

Pl. XIV fig. 59—69.

Shell small, obtusely conical of five or six whorls, which are ventricose, most tumid near their inferior edge and the sides above nearly vertical. The ornamentation consists of sigmoid, obliquely transverse, laminar striæ. The umbilical and the apical sides are separated through a horizontal ridge, the extreme, thin margins of which are much broken and jagged and are left behind in their old place on the older whorls, having coalesced with the shell. The thin edges of this ridge form an upwards directed rim around the umbilical surface giving it a saucer-shaped appearance, elevated in the centre around the narrow, but completely open umbilicus. The aperture is circular or obovate, fig. 59. The outer lip is, when entire, thin, but thickens towards its uppermost corner, where the horizontal ridge is situated. H. 11 mill., br. 13 mm. Another specimen h. 7 mill., br. 9 mill.

Several specimens have been obtained from Klinteberg and Samsugn, and also from Kyrkberget in Wisby.

It reminds, as to the ornamentation, of Trochus Gotlandicus, but the transverse striæ are more straight in that species and sigmoid in Tr. Stuxbergi, moreover the umbilical side and the shape of the whorls is quite different in both.

5. **Trochus undulans** n.

Pl. XVI fig. 8—10.

Shell small, obtusely conical of five tumid whorls, bulging out near their inferior part and with the sides above straight and vertical, whence the body whorl acquires a cup shaped appearance or also they are of a concave outline, fig. 8. The oblique, transverse lamellæ of growth are distantiated, and have their projecting edges much wavy and folded in a great number of sinuosities, quite peculiar to this species. The umbilical side is nearly flat, in the centre excavated into a deep funnel, on the bottom of which the opening of the narrow umbilicus is seen. The horizontal ridge which all around borders this surface is thin and wavy. The aperture is circular, enclosed within thick lips, the outer one being especially large and in its uppermost corner angulated.

H. 8 mill., br. 12 mill.

Only three specimens have been found, two from the upper limestone beds of Slite and the third from Samsugn in Othem.

6. **Trochus profundus** n.

Pl. XVI fig. 11—13.

Shell of moderate size, broadly conical with large periphery of the umbilical side and short spire. Six whorls of somewhat concave contour. The ornamentation consists of oblique, transverse striæ or rather steplike gradations following each other at wider distances than the striæ in the preceding species. When seen in a section, cutting them transversally they have a serrated appearance. The umbilical side is quite smooth and glossy, excavated or cup-shaped, through the large, very thin, upwards directed borders, which encircle the upper side of the whorls and the aperture. This is circular and lies at some distance inside the border of the shell. A shallow, curved groove in direct continuation with the aperture, indicates the place the animal occupied when protruding itself from the shell. The outer lip is thin and sharp, the interior one thicker and straight. The umbilicus is open and wide; the axis is open as seen in the annexed woodcut. H. 13 mm., br. 16 mm.

Longitudinal section of Trochus profundus, natural size.

Two specimens have been found in the limestone of Samsugn in Othem. In this, as well as in the following species and Tr. Stuxbergi and Tr. undulans, the formation of the umbilical side in some way reminds of the appearance of the same side in Trochita and Galerus, but perhaps more so of that in Onustus or Phorus (f. inst. Ph. exutus). Their great accordance with such Jurassic forms as Trochus lamellosus D'ORBIGNY is also already above indicated. There is also a Lower Silurian genus Clisospira, first described by BILLINGS in Canada, and also found in the beds of the red Trinucleus shale of Östergötland, nearly allied to these forms.

7. **Trochus cavus** n.

Pl. XVIII fig. 15—17.

Shell broadly conical, with a large periphery of the umbilical side and obtuse apex. Whorls five or six, of faintly concave outline, transversally striated, striæ gently arched, distantiated with smooth interstices. Section of whorls transversally elliptic. The suture is completely hidden by the superior borders of the whorls, which have coalesced with the younger whorls and thus form an even apex. The umbilical side is a deep, cup shaped hollow, more like that of a Phorus than that of the preceding. The encircling borders of the shell are higher and thinner. In a shell of 17 millim. in length there is a vertical height of 10 millim. for this umbilical hollow. Its surface is almost smooth, only with indistinct, transverse striæ. The bottom, a gently elevated belt around the umbilicus, is formed by the upper side of the body whorl, which is more flat and expanded than in Tr. profundus. It is separated from the thin lips of the border through a slightly elevated, narrow, annular stripe. The aperture is ovate, lips thin and sharp, the umbilicus is open and wide. Height 9 millim, br. 20 mm. Another specimen h. 14 mm., br. 22 mm. Fragment of a large specimen 30 mm. in breadth.

Some specimens have been obtained in the red and gray limestone beds of the hills of Linde and Sandarfve.

8. **Trochus Lundgreni** n.

Pl. XIV fig. 46—53.

Shell large, broadly conical, whorls eight, rapidly increasing, slightly convex, superior border enlarged into a broad lamellar ridge, horizontally outstanding and separating the umbilical surface from the apical. This ridge is visible on all whorls and projecting beneath the shallow suture. As seen in the magnified section of this ridge, fig. 52, its interior cavity has been divided through about five, transverse diaphragms. On looking at fig. 47 and the magnified corner of the aperture, it can be questioned whether these apparent interior, transverse diaphragms are not rather to be regarded as the sections of several such apertural edges, as seen in fig. 47, formed inside each other, every new one smaller than its predecessors. In fig. 53, showing a weathered edge, there are also some such apertural corners brought forward. The ornamentation consists of narrow oblique sigmoid striæ. On the slightly convex umbilical side the striæ are still finer. The aperture is nearly circular, only widened into a small angular wing in the superior corner. The outer lip is thin and narrow, the inner lip strong, reflexed back towards the umbilicus and partially concealing it. The columella is open for a little more than half its total length, solid towards the apex. The shell which is thickest around the narrow but open axis, consists of two distinct layers of which the interior one is dark and transparent, the exterior pale and opaque. H. 26 mm., br. 38 mm.

It occurs at Samsugn in Othem, from where some twenty specimens have been found and also in the limestone of Lutterhorn in Fårö, where a smaller and more conical variety occurs.

9. **Trochus Kolmodini** n.

Pl. XIV fig. 32—34.

Shell elongated, acuminately conical, of six whorls, with slightly concave outline. The ornamentation consists in lines of growth regularly curved backwards and equally distantiated, their edges elevated into a fine and sharp lamina. The interstices are smooth. The umbilical side is flattened and finely striated. An obtuse angle is formed between it and the apical side. The suture is acutely impressed and deep. The aperture is transversally elliptical, the outer lip thin and sharp, the inner lip folded back and hiding the umbilicus. H. 12 millim., br. 10 mill.

A single, but complete specimen has been obtained from the limestone of Stor Wede in Follingbo.

Divisio II. **CARINATI.**

10. **Trochus Dalli** n.

Pl. XIV, fig. 18—21.

Shell turbinated, ventricose, with five whorls, which are minutely and densely striated. Along the middle of the whorls there are two longitudinal ridges close to each other, not much prominent, softly convex; the aperture is circular, outer lip thin, inner lip reflexed along its entire length and hiding the umbilicus. The suture is moderately deep. H. 13 mill., br. 15 mill. Specimen, fig. 21, is of a variety with broader whorls.

Several specimens have been found in the limestone of Kyrkberget in Wisby.

11. **Trochus Wisbyensis.**

Pl. XIV fig. 35—43, 45.

Shell of much variable shape, obtusely or elongately conical, with long tapering spire, whorls six or seven, ventricose and broader than high. The ornamentation is also highly variable, transversally oblique lines running either uniformly as in fig. 36 and 39 or distantiated and elevated at their edges into thin lamellæ. In a longitudinal direction there are in most specimens (fig. 36, 40) two keels on both sides of the middle of each whorl, much distant from each other. In others again, as specimen fig. 39, there is only one ridge, the uppermost one, and in such as fig. 41, 43 there are no less than three keels, a third placed just above the suture. A fourth is following the outer edge of the umbilical surface, fig. 42. The aperture is transversally oblongate, with thin lips, of which the inner one is reflexed and hides the umbilicus. H. 23 mill., br. 19 mill.

From the limestone of Kyrkberget in Wisby, where many specimens have been found, from Samsugn in Othem, from the limestone of Ar, and from Lutterhorn in Fårö.

12. **Trochus lamellosus** n.

Pl. XIV fig. 44, pl. XV fig. 52—54.

This species differs from the preceding chiefly in the ornamentation. The transverse lines are much distantiated and elevated at their edges to projecting laminæ. At the suture they intercross with the pointed continuations from the striæ of the next whorl. It has been found in the canal near Westöös in Hall. H. 12 mm., br. 10 mm.

Another extreme form of this species has been found in the limestone of Samsugn in Othem by Professor P. T. Cleve, the only specimen of which belongs to the Mineral Cabinet of the University of Upsala and has been delineated on plate XV fig. 52—54. It is elongate, turriculate of seven whorls, which taper rather rapidly towards the apex. On the body whorl there are two longitudinal keels as in the former, having between them an excavated zone. The uppermost keel of the lower whorls is almost hidden, coinciding with the suture and partially covered by the lowermost border of the following whorl. There are distantiated, transverse lines running obliquely and by being folded in projecting thin laminæ they form the keels. The aperture is obliquely elliptical and the interior lip which is thin, nearly hides the umbilicus, of which only a narrow slit is to be seen. The umbilical side is almost flat, covered by densely set, transverse, thin laminæ. H. 13 mill., br. 9 mill.

Divisio III. **INCISI.**

13. **Trochus incisus** n.

Pl. XIV fig. 22—31.

Shell regularly conical of six gradually increasing whorls evenly sloping, with slight concavity or even in some specimens of convex outlines. Body whorl ventricose with the umbilical side moderately convex, a narrow slightly elevated keel encircling its middle line. This keel is situated just below the suture in the older whorls, which are hidden as to their upper part. The surface is striated by oblique, exquisitely fine, a little serrulated lines, directed backwards. The deeply incised suture is most characteristic though there are variations as to its depth. For instance a shell from Follingbo, fig. 19, same locality as fig. 26—27, has rather no incision at the suture or one only very shallow, the inferior border of each whorl beginning further down on the next preceding. The aperture is circular, the outer lip thin, the inner lip reflexed. The umbilicus is narrow, but open. H. 17 mill., br. 17 mill. Length of aperture 9 mill., width 10 mill. Several specimens have been found at Kyrkberget in Wisby, Samsugn in Othem, Stor Wede in Follingbo; from Likkershamn there are specimens in the Mineralogical Museum of Copenhagen.

14. **Trochus gyrans** n.

Pl. XVIII, fig. 18—20.

Shell regularly conical of eight tumid whorls, which are carinated along their median line and just above the suture form a horizontal, flat surface like a narrow band along the inferior part of the whorls, bordered upwards by a narrow ridge. The sculpture consists in fine striæ, which are somewhat more irregular than in the preceding. The aperture is circular and the outer lip thin, the inner one thickened and there is the appearance of a sinus where both lips meet at the lower end of the aperture. The structure of the umbilicus is peculiar. It is a wide, funnelshaped opening, limited partially by the inner lip and partially by a sharply defined wall, which is encircled by a narrow ridge and is continued spirally down to the more narrow and deeper opening. H. 19 millim., br. 15 mill.

Two specimens have been found on Kyrkberget in Wisby together with the preceding, to which it is nearly related. It differs, however, chiefly through its peculiar and characteristic umbilicus.

15. **Trochus densestriatus** n.

Pl. XVIII fig. 21—23.

Shell minute, elongately conical of six whorls with slightly concave outline. Beneath the shallow suture there is a low, elevated ring around the upper edge of the whorls, which on the body whorl is situated exactly where the apical and the umbilical surfaces meet. There are regular, dense, microscopically fine streaks, running nearly vertical on the whorls, slightly arched. The aperture is rather obovate and the lips thin and sharp, the outer one bent inwards and the inner one narrowly reflexed, no umbilicus is visible. H. 5 millim., br. 3 mill. Four specimens have been collected in an earthy, bituminous limestone at Hessle in Östergarn.

It comes near to Tr. incisus, but is sufficiently well distinguished through its peculiar striation and the angular aperture.

16. **Trochus astraliiformis** n.

Pl. XIV fig. 54—58.

Shell conical, tapering to a narrow apex from a broad body whorl. Eight whorls. Their upper border lacerated, as it were, by thick, spinous projections, the base of which completely conceals the adjoining suture. These processes are formed by reflexed folds of the successive lines of growth, as may best be seen on the umbilical surface of the shell. A little beneath this edge there is a longitudinal bulging out of the whorls. Between the lines of growth the convex surface of the shell is smooth or most finely, transversally striated. The aperture is nearly circular, apiculated in the superior corner, the lips thick and reflexed, the umbilicus is scarcely visible. The sculpture of the umbilical side consists in thick and coarse callous lines of growth at a regular distance from each other. H. 12 millim., br. 18 mill. A few specimens have been collected at Klinteberg.

Fam. IX. UMBONIDÆ Adams.

Gen. **PYCNOMPHALUS** n.[1])

Shell thick, trochiform or globose, the inner lip of the aperture with a thick callosity, which like a ridge surrounds the umbilicus.

This genus has been placed amongst the Umbonidæ in consequence of the callosity, which encloses the wide umbilicus. Most of the other genera have the umbilicus completely covered by a far larger callosity as in Umbonium (= Rotella).

There is a genus Rotellina De Koninck Faune II, III p. 92 from the Carboniferous formation of Belgium, which according to the figure given, seems to agree nearly with our, but as the descriptive letterpress expressly states that there is no umbilicus, I have not been sure of the identity and could not refer the Gotland species to it.

Pitonellus Montfort has also been placed with the Umbonidæ, but they have the umbilicus completely covered up. The same is also the case with Umbonium heliciforme Goldfuss from Paffrath.

As to the identity of this genus with Platyschisma see below in Pychn. acutus.

Of the genus Pycnomphalus I have found the following three species in Gotland.

1. **Pycnomphalus obesus** n.

Pl. XV fig. 64—67.

Shell helicoid, with five ventricose whorls in a short spire. There are no ornaments excepting some indistinct, transverse lines, which are curved backwards. The aperture is circular, the outer lip thin, the inner lip thickened through an accumulation of the shelly matter, nearly five times as thick as in the outer lip. The umbilicus

[1]) Πυκνός, dense, thick, ὀμφαλός, umbilicus.

is open, narrow at its mouth, most widened in the midst of the shell. The columellar tube is consequently of unequal width, being more narrow where the callosities are opposite, and widening below them and in consequence its contours form zigzag lines as shown in fig. 65. H. 16 millim., br. 23 millim.

Found in the limestone of Wialmsudd near Fårösund and at Lansa in Fårö.

2. Pycnomphalus acutus n.

Pl. XVI fig. 1—6.

?*Platyschisma helicites* Sow. Siluria 4th Ed. pl. 34 f. 14—15.

Shell, trochiform with short spire of seven whorls. The surface is covered by fine, densely set, equal striæ, meeting in an acute angle from both the apical and the umbilical sides, where the sharp, dividing keel is projecting on the median line of the whorls. At regular distances there are deeper or more distinct transverse furrows, dividing the small striæ in narrow fields. The umbilicus is open and much wider than in the preceding species. The aperture is transversally elliptical. The outer lip widened into a prominent angular apex, forming the keel, the inner lip thickened in its upper part, nearly thrice as thick as the outer lip. A very indistinct spiral line accompanies the keel on its inferior side. H. 10 millim., br. 25 mill. Several specimens have been found in the Trimerella limestone of Wialmsudd together with P. obesus. It has also been found in the shales of Westergarn and Djupvik in Eksta and in the limestone of Östergarn, Ardre, Wisby (Kyrkberget) and Nyhamn in Lummelund.

It is possible, that this species is identical with the Silurian Platyschisma helicites Sow. Sil. Syst. But I have not been able with any certainty to make out this identity, as there are such conflicting opinions in the fourth Edition of Siluria, where on page 162 a figure of it is given, quite different from that on plate 34 fig. 14—15. Both can hardly represent the same species. The first figure rather resembles a variety of Euomphalus Walmstedti, and the second, again, which, however, consists of mere nuclei, seems to coincide more with P. acutus. But if this be the case, that species cannot be retained in the genus Platyschisma, as it is expressely stated that this genus has »a very wide, shallow sinus in the middle of the outer lip»[1]). There is not the least trace of any sinus in the Gotland specimens.

3. Pycnomphalus trochiformis n.

Pl. XVI fig. 7.

Shell large, broadly conical, of at least seven whorls, slowly increasing in height[2]). Sides even, without any convexity, of rectilinear outline. Surface of the only specimen

[1]) Mac Coy Pal. Foss. p. 533.

[2]) The ratio of increase in the only specimen is:

Whorls.	Height.	Breadth.
1	8	31
2	6	26
3	5	20
4	4	14
5	3	10.

extant so much weathered, that no sculpture can be discerned, excepting some indistinct, crescent formed transversal lines. Along the upper border of the whorls a narrow, slightly elevated string is seen, being the uncovered portion of the acuminate ridge, that divides the apical side from the umbilical. The later is almost flat. The aperture is transversally elliptical and the umbilicus wide, surrounded by the elevated callosity, which emanates from the thickening of the inner lip. H. 28 millim.; br. 32 mill. Only one specimen is known, belonging to the collection of the school of Wisby, derived probably from the upper limestone near that town.

Fam X. TURBINIDÆ Alder.

In following the precedence of S. P. Woodward[1]) and partly also of Zittel[2]) I place the following five genera within this family. Some of the shells, which I have comprised within the genus Oriostoma, have by Deshayes and most authors after him been numbered with the Solariidæ. One of the latest authors, Stoliczka[3]), does it on account of the presumed similarity of its operculum to that of Torinia and the more so to that of Omalaxis, with which recent genus also some of the palæozoic forms have been regarded as identical. But besides, that nearly similar forms of opercula also occur in other families, as the Siliquariæ, the Vermetidæ and the Turritellidæ, there is another circumstance which makes it probable that the palæozoic shells under consideration cannot belong to the Solariidæ. It consists namely in the important feature that several of its species have retained the most evident traces of a nacreous layer, both in the genus Oriostoma as well as in Cyclonema. Moreover the operculum is solid and shelly not chitinous as in the former genera. These genera, which thus closer agree with the Turbinidæ than with the Scalariidæ are the following.

Oriostoma Munier-Chalmas, with short spire, surface richly ornamented by longitudinal carinæ, crossed by variously sculptured, transverse striæ. Operculum conical, solid and shelly with narrow coils. Umbilicus large and open.

Cyclonema Hall, with high spire, ornamentation of fine, slightly prominent longitudinal keels, crossed by equally fine, transversal striæ. Operculum depressedly conical with large coils and hollow inside. No umbilicus or a very narrow one.

Trochonema Salter, turbinate, whorls angular through several distantiated sharp keels, umbilicus large, open.

Eunema Salter, small, turriculated, with one or several narrow keels and other sculpture, umbilicus closed.

Craspedostoma n. gen., shell globose, naticoid, with the lips widened to a broad frame around the aperture, lower end of interior lip enlarged into an aliform appendix.

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[1]) Manual of Moll. 2d Ed. 263.
[2]) Handb. Palæont. 1,2, 187.
[3]) Palæontologia Indica V, 249.

Gen. **ORIOSTOMA** MUNIER-CHALMAS.

1814 *Euomphalus* Sow. p. p. Min. Conch. vol. 1, 97.
1864 *Omphalotrochus* MEEK. Rep:t. Geol. Survey of California, Palæont. vol. I, 16.
1876 *Oriostoma* MUN.-CHALMAS Journal de Conchyliologie vol. XVI, 103.
1881 *Polytropis* DE KONINCK Faune Carbonif. II,III 107.

Shell discoid, with short spire, rarely high, whorls tubular, ventricose, joined, seldom a little disjointed near the aperture, longitudinally sculptured with prominent keels, aperture with thin lips without any sinus, generally continuous, umbilicus wide and open. In several species the nacreous lustre of the interior shell strata is retained on the nucleus. The operculum is calcareous and solid, on the inner side smooth with a thick, elevated rim around the margins, outside conical, sometimes higher than broad, covered by a number of spiral coils ornamented with exceedingly thin lines. Mostly large shells, but some species also small.

Besides the above, in the list of synonyms enumerated genera, which have exclusively or almost so been applied to the species of this genus, there is also a number of other genera, in which some of them have been included as in Turbo by PICTET, Delphinula by HISINGER and others, Trochilites and Helicites by SCHLOTHEIM, Turbinites by WAHLENBERG and SCHLOTHEIM. Straparolus MONTFORT might, according to several authors, embrace species of this genus, but the first species described are not known to have had any operculum and their ornamentation differs. If we strictly confine ourselves to the species, which SOWERBY, when he at first established his genus Euomphalus, included into it, we must find that later created species such as E. discors, E. rugosus, E. funatus etc. essentially differ from the former in having an entire aperture without any slit as in those, which form the genus Euomphalus *sensu strictiori* and must be ranged near the Pleurotomaridæ. Delphinula, employed by HISINGER, is now applied to species from later formations and generally regarded as a synonym for Omalaxis, which has a chitinous operculum. Omphalotrochus MEEK may in some degree be related to or even contain species of this group, but the name indicates an affinity, which is not borne out by the evidence given by the operculum of the Silurian specimens. Polytropis DE KON. seems, to judge of the expressions of this author, at first to have been intended instead of Inachus (In. sulcatus HIS. is a Pleurotomaria), but DE KONINCK then cites Euomph. discors as the typical species and consequently the name is synonymous with Oriostoma. The Devonian Oriostomata lately described by OEHLERT, as far as I am able to judge by specimens kindly sent from him, belong to the same generic group as the Silurian, which formerly had been confounded with the Euomphali and both consequently must be placed in the same genus Oriostoma. The Devonian species however are all small and no operculum has as yet been found with them.

The distinction between Oriostoma and Cyclonema, the next genus, is not quite as clear as desirable, when the operculum is wanting. When an Oriostoma varies in having a long spire, it nearly resembles a Cyclonema, but these never have the umbilicus as large as the former.

In certain species of Oriostoma, which have a single longitudinal keel near the suture, there is at first sight some resemblance with species of Euomphalus, but the apertural sinus is here reduced to a short notch, which through the folding of the aperture originates the keels. These notches never attain to such large dimensions as the sinus in the Euomphalidæ and moreover they disappear in the body whorl of many.

The shells of this genus are amongst the most common in the Silurian strata of Gotland and through their large numbers they offer a great variety of forms, which make it a most difficult task to distinguish specific groups neatly from each other. The great variability of the ornamentation and the almost imperceptible passages from one form to another highly increase this difficulty. The oldest notions of the Swedish Oriostomata are those given by Bromell in his Lithographia p. 32, 36, where several are described under the name of Cornu Ammonis, but only one clearly enough to be identified, viz. № 21, »Ejusdem generis Neritit æ majores» which is Oriostoma sculptum.

In the Lower Silurian formation of Sweden hitherto not a single species has been found belonging to this genus. In Gotland the following sixteen species and varieties have been detected and they may be divided in two groups.

A) with spire moderately prominent and the umbilicus deep and open.

1. Oriostoma discors Sow.
2. » var. rugosum Sow.
3. O. contrarium n.
4. O. globosum Schloth.
5. O. » var. sculptum Sow.
6. O. coronatum n.
7. O. acutum n.
8. O. Wisbyense n.
9. O. angulifer n.
10. O. Roemeri n.
11. O. helicinum n.
12. O. alatum n.

B) with short spire and planorbiform shell, the whorls on the umbilical side quite as much visible as on the apical one.

13. Oriostoma angulatum Wahlenberg.
14. O. lineatum n.
15. O. nitidissimum n.
16. O. dispar n.

Besides these species there is evidence of at least three species more through their opercula, described below, but as no shell has been found to match them, they must for the present be left undeterminated.

1. **Oriostoma discors** Sow.

Pl. XVI fig. 20—36, pl. XVII fig. 1—5.

Euomphalus discors 1814. Sow. Min. Conch. vol. I, 113, pl. 52 f. 1.
1837. Agassiz in Sowerby Gross Brit. Mineral Conch. 61, tab. 36.

	1839.	Sow. Sil. System, 626 pl. 12 f. 18.
	1843.	Morris Catal. Brit. Foss., 144.
	1847.	Murchison Qu. Journ. Geol. Soc., 29.
	1848.	Bronn Nomenclator, 479.
	1854.	Morris Catal. 2d Ed. 247.
	1855.	Mac Coy Palæoz. Foss. 298.
	1858.	Fr. Schmidt Estland, 204.
	1859.	Salter in Siluria 3d Ed. 548, pl. 24. f. 12.
	1867.	Lindström Nomina, 23.
	1873.	Salter Catal. Cambr., 156.
Turbinites cornu arietis	1818.	Wahlenberg Petref. Suec., 68, pl. III fig. 9, 10.
	1828.	His. Anteckn. IV, 257.
Delphinula cornu arietis	1829.	His. Tabl. 10.
	1831.	Id. Tabl. ed. 2, 8.
	1831.	Id. Anteckn. V, 113.
Euomphalus cornu arietis	1837.	Id. Leth. Suec., 36, tab. XI fig. 6.
	1841.	Id. Förteckn., 55.
	1848.	Bronn Nomencl., 479.
	1858.	Fr. Schmidt Estland, 204.
	1867.	Lindström Nomina, 23.
Straparollus discors	1850.	D'Orbigny Prodr. I, 29.
Turbo cornu arietis	1850.	Id. ibid., 30.
Polytropis discors	1881.	De Kon. Faune Carbon. Belgique. II,iii, 107.

Shell discoid, spire short, or, in the variety called E. cornu arietis by Wahlenberg, prominent, with six whorls, which are carinated on their inferior surface by blunt, longitudinal keels of varying number and prominence, from three to eight in the typical form. In the elongated variety there are three on the inferior surface, but as many as eight on the umbilical one. The surface slopes from the lowest keel towards the suture which is shallow. The keels are crossed by narrow, transverse, undulated lines of growth, giving the surface an imbricated appearance. The transverse striæ of the umbilical surface are curved sigmoidally and have grown out into thin, prominent lamellæ. The great amount of variation as to the ornamentation in these shells may be gathered from the numerous figures given. The aperture is transverse, its superior margin sigmoidally bent, the outer lip thin and notched or angulated where the keels are formed, the inner lip is thick. The umbilicus is wide and open and all whorls are visible. H. 23 mill. br. 73 mill.

It occurs at Lansa on Fårö, at Wialmsudd on Fårösund; in the upper limestone beds of Wisby and in the shale of Wisby and most plentifully at Westergarn.

In the variety »cornu arietis» the umbilicus is relatively less wide and the course of the striæ on the umbilical surface is more straightly directed backwards. The aperture is also more circular. H. 28 mill., br. 39 mm. Largest diameter of the aperture 16 mill. It has been found at Lansa and Lutterhorn in Fårö, also at Alnäse by Prof. P. T. Cleve, in the crystalline limestone of Wialmsudd, in the canal near Westöös in Hall, Samsugn in Othem, Follingbo, Bara, Kristklint in Kapellshamn, Hörsne, Martebo, in Kyrkberget in Wisby, at Walve ref, Westergarn and Klinteberg, thus chiefly n the higher strata. The rule holds good in these, as in so many others, that the spiral ridges are more prominent in small specimens or on the old whorls of the larger ones and are apt to disappear on the larger and younger whorls.

The variety figured pl. XVII f. 4 is in some way a transitional form to the following.

2. **Oriostoma discors** Sow. var. **rugosum** Sow.

Pl. XVII fig. 5—10.

Delphinula	1811.	Parkinson Org. Rem. III, 77, pl. VI f. 7—8.
Euomphalus rugosus	1814.	Sow. Min. Conch. I, 113, pl. 52 f. 2.
	1839.	Id. Sil. Syst., 626, pl. 12 f. 19.
	1843.	Morris Catal., 145.
	1847.	Murchison Qu. Journ. Geol. Soc., 29.
	1848.	Bronn Nomenclator, 481.
	1854.	Morris Catal. 2d Ed., 248.
	1855.	Mac Coy Palæoz. Foss., 298.
	1867.	Salter Siluria, Ed. 4, 532, pl. 24 f. 13.
	1871.	Baily Charact. Br. Foss. pl. 21 f. 8.
	1873.	Salter Catal. Cambr. Foss. 157.
Euomph. angulosus	1814.	Sowerby Min. Conch. vol. I, 114, pl. 52 f. 3.
Helicites catenulatus	1818.	Wahlenb. Petref. Suec., 72.
	1828.	His. Anteckn. IV, 237.
Delphinula catenulata	1829.	Id. Tableau ed. 1, 10.
	1831.	Id. Tabl. ed. 2, 8.
	1831.	Id. Anteckn. V, 114, tab. 1 fig. a.
Euomphalus catenulatus	1837.	Id. Lethæa. 37, tab. XI f. 9.
	1840.	Id. Förteckn., 55.
	1858.	Fr. Schmidt Esthland, 204.
	1867.	Lindström Nomina, 23.
	1876.	Ferd. Roemer, Leth. Geogn. pl. 14 f. 8.
	1883.	Quenstedt Petrefaktenkunde Deutschlands, 1e Abth. 7r Bd, 397, pl. 200 f. 90 (not fig. 91).
Straparollus rugosus	1850.	D'Orb. Prodr. I, 29.
Straparollus catenulatus	1850.	Id. Ibid. 30.

Shell nearly discoidal, spire only a little prominent or turbinated, whorls six, carinated by eight or ten longitudinal keels, interrupted on pretty equal distances by large, sinuous lines of growth, which are elevated in a backwards reflexed fold at the point where they meet the keels, giving in their totality an imbricate or roughly scaly appearance to the surface. Between the larger lines, which are much distantiated, the surface is sculptured by minute lines, parallel with them. The umbilicus is open and the aperture circular with a continuous peristome of thin lips. H. 37 mill., br. 68 mill. The lips of the aperture are much unequal, the exterior one being prominent, the interior, deeply insinuated, expecially at its superior corner, the distance between both amounting to 28 millim. in one of the largest specimens. It occurs frequently, though not so common as the former, in Fårö, at Wialmsudd, Samsugn in Othem, Lännaberg in Slite, Möner in Boge, Stor Wede in Follingbo, Martebo, Kålens Qvarn and Galgberget near Wisby, in the shale beds of that town, Östergarn both in the shale and the limestone, Ardre, Bara hill, Linde, Klinteberg and Fröjel.

The range of variability is very wide within this group. Along with shells of short spire, long spired or turbinate shells occur, and together with those of rare transverse imbrication, there are others which have it dense. The specimens from Östergarn and Klinteberg are commonly almost disciform, those from Samsugn with long spire and transverse imbrication dense. The oldest form from the lowest beds of the marly shale of Wisby (Pl. XVII f. 5—7) is turbinate, with only three longitudinal keels and a low one around the umbilicus. The ornamentation is for the rest the same.

This Or. rugosum differs from Or. discors in the more distantiated, transverse laminæ and in their folds being considerably reflexed backwards on the keels. Such a variety of O. discors as that figured pl. XVII f. 1—2, connects both.

3. **Oriostoma contrarium** n.

Pl. XX fig. 8—15.

Shell sinistral, turbinate, with six terete whorls. The apex is sunken and the extreme tip is hidden beneath the next whorls, fig. 15. The surface is transversally and obliquely striated by regularly distantiated lamellar ribs, often dividing in two and again uniting, a little wavy in their edge, which is sharp and thin. They are curved sigmoidally upwards towards the umbilicus. The aperture is obliquely ovate or even circular with thin lips and continuous peristome. The inferior part of the exterior lip is folded in and thus narrowing the aperture. The umbilicus is wide and large. It is defined by a narrow ridge, which is most prominent in young or small specimens, fig. 13, indistinct or only as a swelling in the older. The shell substance is thick, especially in the body whorl. Owing to the different state of preservation the aspect of the surface varies, being corroded in some and only the basal lines of the lamellæ left, fig. 14. H. 24 millim., br. 41 millim. Another specimen has in h. 24 mill., br. 23 mill.

It has been obtained from the shale of Wisby, from the limestone beds of Lansa and Lutterhorn in Fårö, Wialmsudd, Samsugn in Othem, the canal of Westöös in Hall, Kyrkberget in Wisby and Hoburg.

4. **Oriostoma globosum** Schlotheim.

Pl. XVII, fig. 24, 25, 29—31, pl. XVIII, fig. 24, pl. XX, fig. 16.

? *Valuata sulcata*	1776.	Walch, der Naturforscher, Neuntes Stück, 278, tab. IV f. 5.
Delphinula	1811.	Parkinson Organic Remains, 78, tab. V. f. 18.
Trochilites globosus	1820.	Schlotheim Petrefactenkunde, 162.
Euomphalus funatus	1823.	Sowerby Miner. Conch. vol. V, 71, tab. 450 f. 1 & 2.
	1839.	Id. Sil. Syst., 626 pl. 12 f. 20.
	1843.	Morris Cat. Brit Foss., 144.
	1848.	Bronn Nomenclator, 479.
	1849.	Brown Illustrations of the fossil Conchology of Great Britain and Ireland, 81, pl. XLII figs. 24, 25.
	1854.	Morris Catal. 2d Ed. 248.
	1855.	Mac Coy Pal. Foss., 298.
	1858.	Fr. Schmidt Geol. Estl., 202.
	1862.	M'Coy Sil. Foss. of Ireland, 13.
	1867.	Salter Sil. ed. 4, 531, pl. 25 fig. 3.
	1871.	Baily Charact. Brit. Fossils, pl. 21 f. 9a, 9b.
	1873.	Salter Catal. Cambr. Foss., 90, 157.

Skenea funata	1828.	Fleming Brit. Anim., 314.
Delphinula subsulcata	1829.	His. Tableau ed. 1, 10.
	1831.	Id. Anteckn. V, 114, tab. I f. bb.
	1831.	Id. Tabl. ed. 2, 8.
Euomphalus subsulcatus	1837.	His. Leth., 37, tab XI fig. 10.
	1840.	Id. Förteckn. 55.
	1867.	Lindstr. Nomina, 23.
Straparollus subsulcatus	1850.	D'Orb. Prodr., 30.
Turbo funatus	1850.	Id. Ibid. 30.

Shell moderately elongated, globular, with six ventricose whorls. The longitudinal carinæ vary in a high degree as to their number, size and ornamentation according to the different localities and to the size of the specimens. On the body whorl there may be as many as 14, of which those on the apical side are the largest. As a rule it holds good that each alternate keel is of the same size, one more narrow, sometimes scarcely perceptible, being situated between a larger one. Each keel is composed by a succession of imbricated, more or less crowded folds, which at the outer lip have the aspect of shallow notches. The smaller longitudinal striæ are thread fine, seldom imbricated. Sometimes there are two of equal size beside each other. In young specimens the keels are smooth, not imbricated. The interspaces are crossed by transverse lines, fine and coarse. In a variety from Hammarudd in Kräklingbo the keels are low and sharp and the lines of growth continue more sharply defined than in the typical forms, at regular distances. The same variety also occurs in Fårö.

The aperture is circular, the lips are thin, the umbilicus is very narrow but deep and confined within a sharp and prominent keel, outside which there is one still larger, with a broad groove, scooped out between them. In several specimens the nacreous lustre is still preserved on the nucleus, where the shell has peeled off. H. 37 mill., br. 53 mill.

The operculum, which has been found *in situ* in some instances, is disciform and of a perfectly circular outline. See fig. 24. Its inner surface is bordered by an elevated, narrow edge, section magnified pl. XVII f. 25. Inside this edge the smooth surface is more or less excavated near the centre, for the rest it is flat. The exterior surface is more or less elevated near the centre in an obtuse top, having, when seen from the side, a faintly concave outline. The different relations in size may be found from the following dimensions. Operculum from Westergarn: height 4 mill., diameter 13 mill. Operculum from the hill of Sandarfve: h. 4 mill. diamet. 14 mill.

In the sculpture of the spiral lines they all nearly agree with those figured on pl. XVII fig. 25 and pl. XVIII f. 24. These are very tightly wound and their spirality is evident only by following one of them, else they look as if concentric. They are at least twenty whorls. The surface of these coils is obliquely crossed by a great number of smaller, also elevated lines or coils; the uppermost are highest and more prominent, the others decreasing regularly. This peculiar ornamentation is best shown in thin sections, enlarged under the microscope as seen in the figure 24 pl. XVIII. It is then evident that the spiral coils form narrow ridges, which are nearly vertical to the diameter of the operculum and that the ornamental lines are most numerous on the lower surface of the coil, the uppermost being largest and more wide apart. As to its chief mass the operculum consists of a compact, dull, gray limestone nearest the outside, but the interior mass is converted into clear, crystalline calcareous spar and distinct lines in this indicate special strata of growth of which it is made up.

As seen in fig. 25 pl. XVII thin and narrow coils are alternating with larger and the partitions are more deeply cut, than in any of the other forms of opercula and the lobes directed vertically.

O. globosum has been found in the shale beds of Wisby, Westergarn, Stora Carlsö, Petesvik, Burge in Fardhem, at the canal from Wisne myr, Ejmunds å, Slite, Hall, Lutterhorn and Lansa on Fårö, Hammar in Kräklingbo, in the limestone beds of Gothemshammar, Ganthem, Rute, Wialmsudd, Samsugn, Martebo, Hörsne, Klinteberg, Lilla Carlsö and Sandarfve kulle, Fröjel.

The operculum has been found in the shale of Wisby, Follingbo, Sandarfve kulle, Eksta (Djupvik), Westergarn, Linde klint and Slite.

It seems that this common and widely spread shell has been first described by WALCH as cited above, when he writes »Von der versteinten valuata sulcata des RUMPHS.» »Das Original des gegenwärtigen kommt... mit der unter Num. 5 daselbst (in RUMPH's work) befindlichen valuata sulcata sehr genau überein. Das Petrefact ist aus dem Mecklenburgischen, weiss von Farbe und hart versteint». The accompanying figure may well be accepted as representing Or. globosum. Through the liberality of Professors BEYRICH and DAMES of Berlin I have had for inspection the very original specimen of SCHLOTHEIM's Trochil. globosus, which is kept along with his other collections in the Museum of the University of Berlin. On the original label is written »aus Gothland in Überg (angs) Kalkstein». It is badly preserved, to a great part imbedded in the rock, a ball of limestone from the shale beds, possibly of Wisby or Stora Carlsö. It belongs to a variety with only few keels on the umbilical side and the transverse striæ much distantiated. It is indeed quite the same which later by SOWERBY was named E. funatus, which name, although long used, must give way for the older of SCHLOTHEIM.

I cannot decide whether Euomph. funatus EICHWALD Leth. rossica I, 2 p. 1152 belongs to this species or not.

5. **Oriostoma globosum**, var. **sculptum** SOWERBY.

Pl. XVII fig. 41—42.

Nerititæ majores, striati et juxta longitudinem spirarum quasi sulcati, BROMELL 1738 Lithogr. Suec. p. 36.

Delphinula funata	1829.	HIS. Tabl. ed. 1, 10.
	1831.	ID. Ibid. ed, 2, 8.
	1831.	ID. Anteckn. V, 114.
Euomphalus funatus	1837.	ID. Lethæa, 37, but not the figures pl. XI fig. 11, which are copied from SOWERBY's E. funatus Min. Conch. pl. 450.
	1840.	ID. Förteckn., 55.
Euomphalus sculptus	1839.	Sow. in Sil. Syst., 626, pl. 12 fig. 17.
	1843.	MORRIS Catal. Brit. Foss. 145.
	1848.	BRONN Nomencl. 481.
	1854.	MORRIS Catal. Brit. Foss., 248.

Euomphalus sculptus	1855.	Mac Coy Palæoz. Foss. 299.
	1862.	Id. Sil. Foss. Ireland, 14.
	1867.	Salter Siluria 4th Ed. 532, pl. 9 f. 27, pl. 25. f. 2.
	1873.	Id. Catal. Cambr., 90, 157.
Turbo momus	1850.	D'Orb. Prodr., 50.
Euomphalus lautus	M. Coy, Sil. Foss. Ireland, 14, pl. 1 fig. 12 belongs possibly also to this species.	

Shell with short or only slightly prominent spire of five ventricose whorls. The surface is covered by numerous, closely set, revolving lines, alternately large and narrow, the larger attaining twice the size of the lesser. They are generally so densely packed that there is no space left between them. The transverse lines of growth form on them crescent shaped notches, one for each line. The aperture is circular, the lips are thin and the umbilicus is narrow and open. H. 34 mill., br. 44 mill.

There are so many transitional forms, connecting this species with the former that it is indeed a necessity to merge them into one and same species. In Siluria, 3d Ed. p. 236 Salter says that Eu. sculptus »appears to be only a variety of Eu. funatus». R. Etheridge jr (Ann. Mag. N. H. 5th Ser. vol, 7 p. 31) also inclines to regard both forms as identical, though his opinion that »sculptus» may only be the young condition of Eu. funatus cannot be upheld, as we have specimens of sculptus quite as large as »funatus». Moreover the opercula are not different. I have such from Djupvik in Eksta and they only slightly differ from that figured on Pl. XVII f. 25. The dimensions are in one specimen: height 3 mill., diam. 9 mill.

The chief distinguishing feature of this Or. sculptum from Or. globosum is the great number of its revolving keels, which in some specimens amount to as many as fifty. Through their proximity or their distance many gradations in sculpture arise. The same is the consequence of the different fineness or coarseness of the transverse striæ. In some these striæ are prominent and distantiated, in others fine, perhaps corroded, the first coinciding with the presence of distantiated revolving keels, the later with the narrow and numerous keels. But however dissimilar in sculpture, they all have the same operculum and around the narrow umbilicus there are two elevated keels as in Or. globosum. The more globose shells have a greater number of keels, closely crowded and there is consequently a continuation of frills on the surface.

In specimens from the same locality the amount of variation, especially in the sculpture of the revolving keels, is very great, nay, even in the same specimen sculptured keels alternate with almost smooth ones. But these, especially in the »sculptum» forms, show a very fine and microscopically minute, transverse ornamentation, which of course is through corrosion destroyed in exposed localities and thus causing a smooth surface. Of the »sculptum» group there may be thus discerned at least two minor subdivisions.

1. The shell has no less than fifty longitudinal keels, but in common with the other varieties a belt near the suture without any revolving keels and in the wide and deep umbilicus, environed by keels. This has been found in the canal near Westöös in Hall, at Fårösund, and in some specimens at Samsugn, Othem. A nearly similar variety occurs in the shale of Djupvik in Eksta and Wisby, with some 25 longitudinal

ridges and more finished sculpture than in the former. Also found at Lansa and Lutterhorn in Fårö, Sändvik at Fårösund, Klinteberg and the shales of Stora Carlsö.

2. There is an intermediate variety between this sculptum and Or. globosum from Martebo, and from the marly limestone beds above the shales of Eksta and also Lilla Carlsö. It has the ridges distant on the apical surface, crowded on the umbilical, thus combining both the funatus and sculptus characters in the same specimen. This has also been found in Martebo, Samsugn, Slite, Medebys in Hall, Sproge and Hoburg.

Although Hisinger copied Sowerby's figures of E. funatus, as seen by comparing their figures[1]), he, in his own collection, partly gave that name to the shell which Sowerby later denominated as Eu. sculptus. The English authors refer to »sculptus» specimens with numerous crowded keels, but in that number possibly several different species may have been confounded. M'Coy Brit. Pal. Foss. p. 299, says »that the absence of the transverse scale like sculpturing and the ... more numerous ridges, easily separate this from the E. funatus». It is indeed most bewildering to discern in all this mass of similar and yet, as their opercula prove, specifically different forms and mistakes can scarcely not have been avoided in my arrangements of them.

6. **Oriostoma coronatum** n.

Pl. XVII fig. 11—16, 18—22.

Shell large, globular, turbinate, spire short, whorls five, ventricose, angular through the many projecting keels with perpendicular walls between them. On the body whorl there may be seen as many as seven or even nine keels on the exterior side from the suture to the highest point of the umbilical side and on that side at least five. Smaller keels intervene between them. The large keels are crenated by blunt spines, formed by regularly distantiated, oblique folds, causing the often ocurring cone in cone structure. Where these folds are perfect, their edges are considerably thin, a little forward bent or generally having the shape of small crescents. The interstices, which are nearly five times as large as the keels, are almost smooth, transversally striated by microscopically minute lines, directed obliquely, or nearly perpendicular, backwards from the suture to the umbilicus. The aperture is circular, the outer lip thin, the inner lip thickened, almost reflexed. Around the umbilicus there is a deep and broad groove (fig. 14) bounded by two high and prominent keels, of which the interior one is short and forms the nearest enclosure of the narrow, spirally wound umbilicus. H. 40 mm. br. 53 mm.

The operculum is very frequent and has in some instances been found *in situ*. It is button shaped, perfectly circular, more or less elevated. The dimensions are in four specimens from Östergarn as follows:

1)	Diam.	20	mm.	Height	8	mm.
2)	»	20	»	»	10	»
3)	»	15	»	»	6	»
4)	»	21	»	»	6	»

[1]) Sowerby Miner. Conchol. pl. 450 fig. 1 (the uppermost one) and fig. 2 (but reversed and restored in Lethæa l. c.),

The inside is bordered by an annular callosity (fig. 18) and the enclosed area is glossy, sculptured by numerous, microscopic striæ, concentric in a zone nearest the border, in the centre spirally curved, where also the surface is somewhat excavated. On the outside the numerous coils are rather flat and broad, as shown in fig. 16, on their inferior face ornamented with some fine, concentric striæ below a larger one. Their appearance in a transverse section is given in fig. 22, to be compared with that of Oriost. globosum in fig. 25. The lobes of the sectioned coils are broad and short, with low divisions between them and their tops only finely jagged by the parallel lines.

This shell, as well as its operculum, has been found most numerous in the lower limestone beds of Östergarn, also in Ardre, Gothem, in the Rhizophyllum beds near the church of Lau, and in the limestone beds of Lindeklint.

It is distinguished from its congeners through its more richly sculptured keels, nearly smooth interstices, only finely sculptured and by the peculiar operculum.

From the subjacent shale beds, such as they are in the canal of Wisne myr in Fardhem, I have obtained specimens of a shell nearly resembling O. coronatum. In some, however, the sculpturing is intermediate between this and O. funatum.

From Martebo numerous specimens of an operculum have been obtained, which, however deviating, still, through certain common details of shape, prove to be related to the operculum of Or. coronatum. Pl. XVII figs. 32—35. The shell to which it has belonged is for the present not known, though the operculum is far from being rare. In its form it resembles as nearly as possible the modern artillery projectiles, being elongately conical in outline, fig. 32. They commonly have the same height as the diameter or sometimes higher. Some are constricted transversally along the median line. The dimensions of three specimens are:

1)	Diam.	13 mill.	Height	16 mill.
2)	»	13 »	»	11 »
3)	»	11 »	»	10 »

The coils on the outside are directed obliquely outwards or nearly parallel with the diametral axis of the operculum and are considerably shorter and broader than those of Or. globosum.

The narrow, ornamental lines which are crowded on these coils, fig. 34, are most numerous and prominent on the inferior side, short and scarce on the upper half of the coils. On the inner side the annular edge is prominent, the centre deeply excavated and the spiral distinct. A similar operculum has also been found in the upper limestone beds of Slite.

Mr Rob. Etheridge jr has described and figured[1]) several opercula of which some are identical with the Gotlandic. Figures 9 and 9a really represent one of the conical opercula from Martebo which I once sent to the British Museum. In fig. 12 an operculum is seen, nearly corresponding with that from Westergarn, figured in my plate XVII fig. 24. Fig. 14 probably represents one of the »sculptum» varieties, as Etheridge also believes, though with some hesitation. But it is only the impression of the inner

[1]) Ann. Mag. N. H, 5th Ser. vol. 7, p. 25 pl. II.

side of the operculum on the limestone or shale, which forms the nucleus of the shell. That it is only a cast and not the operculum itself, may be found by comparing the inside, drawn in fig. 9 of ETHERIDGE's plate, with fig. 14. Quite similar impressions have been found in several specimens in Gotland. The Oriostomata figured by the ETHERIDGE in figs. 10—11, much resemble O. sculptum, but the opercula seem to deviate in shape as well as in sculpture from that, which with absolute certainty is known as belonging to that species. The operculum, fig. 13, is possibly identical with one from Hogrän. Mr FRED. SMITHE has also given a notice with figures »On the opercula of the Silurian Gastropoda» in the Proceedings of the Cotteswold Naturalists Field Club for 1877—78 p. 62. The specimens figured are evidently badly preserved and belong to some unknown species, the shell of which resembles Or. sculptum, but the sections given of the operculum show (figs. 3—4) that it cannot belong to that species.

BAILY [1]) has given a figure of the operculum of »Euomphalus funatus SOWERBY» but it seems to be different from that described above, and rather more loosely coiled, resembling that in fig. 44 pl. XVII of the present memoir.

Lately WHITEAVES [2]) has described two opercula, of which, at least one, pl. III f. 11 & pl. VII f. 7, comes near to that of Or. coronatum. The second operculum, pl. III f. 10, again, is nearly related to those of Cyclomena described below.

7. Oriostoma acutum n.

Pl. XVII fig. 37—40.

Shell globose, turbinate, with spire of six ventricose whorls, angular through the projecting, narrow, revolving keels. On the apical surface there are three keels, separated by large interspaces, on the umbilical side they are much crowded, amounting to ten before the first umbilical ridge is attained. Between this and the interior umbilical ridge some five or six smaller ridges lie in a gently excavated, large groove. The innermost ridge closely environs the deep and narrow umbilicus. All these revolving keels are almost smooth, with sharp or rounded edge, only finely notched by minute, transverse striæ. These are in the interstices directed backwards and so fine that only a few, regularly distantiated ones are perceptible without a lens. Between them the surface looks nearly smooth, but is in reality finely striated. The aperture is circular and both lips are thin. H. 37 mill., br. 45 mill.

But for the find of the operculum of this shell *in situ*, it might easily enough have been mistaken for a variety of O. globosum, from which it, however, differs through the minute, transverse striæ, the regular angularity of its apical side and the regularity of the umbilical funnel. The operculum is acuminately conical, nearly of the same height as breadth. The inner side is almost flat, the bordering edge is narrow and low, the central whorl is nearly on a level with the other surface and through corrosion any sculpture, if formerly extant, has been destroyed. The coils on the outside are exceedingly narrow and close. They are formed like the sharp, thin, knife like

[1]) Figures of Charact. Brit. Fossils pt. III pl. 21 fig. 9 b.

[2]) Geol. Survey of Canada. Palæoz. Fossils, vol. III pt I, p. 33.

whorls of a screw, giving the outline of the operculum a serrated appearance as shown in the sections 39 & 40. They are directed rectangularly to the longitudinal axis of the operculum or only slightly curved upwards. They are quite smooth without any smaller, ornamental lines. The dimensions of the operculum are in two specimens:

A. Height 11 mill. Br. 12.
B. » 10 » » 14.

In Martebo almost the same type of operculum has been found detached without any shell pertaining to it. Pl. XVII fig. 36. It deviates, however, in having the coils more distantiated.

Or. acutum has been found in many fine specimens in a seam of marly limestone at Slite, along with several opercula, of which one *in situ*. It has also been found in a few specimens at Lännaberget of Slite.

With an operculum so deviating from that of the other Oriostomata, it may indeed be questioned whether this species does not belong to another generic or subgeneric division, what must be left for future researches to decide.

8. **Oriostoma Wisbyense** n.

Pl. XVII f. 26—28, 45—46.

Shell globular, turbinate, small, of six ventricose whorls. There are only few longitudinal keels, two larger on the apical surface, the lowest leaving a smooth belt between itself and the suture. They are sharp, narrow and prominent, a little jagged by irregular notches. Next them follow at equal distance two smaller keels around the median line of the body whorl and then on the umbilical side a large belt intervenes, with only faint indications of a few longitudinal lines. Around the umbilicus two large keels leave between them a nearly smooth zone, only finely transversally striated. The transverse striæ are gently inclined backwards, somewhat thick, swollen, in other parts fine. All specimens, found in two localities, agree in all particulars and are thus constant in their characters. The umbilicus is wide and deep, showing all whorls. H. 18 mm., br. 18 mm. Spec. B. H. 14 mm., br. 17 mm.

The operculum, which has been found *in situ* in one specimen and in several detached specimens, is in the largest specimen of a combined cylindrico-conical shape, being from the base and a while upwards cylindrical, then at the top changing into a conical shape. The inner side is bordered by a rather broad and elevated edge, the enclosed surface smooth, deeply sunk towards the centre, where the whorl is situated. The numerous coils of the outside are more distantiated than in the preceding, with their edges directed upwards. All striæ decorating them have now disappeared, if once present, and in a section the whorls consequently only show as distantiated, blunt teeth. H. 5 mill., br. 12 mill. One specimen, pl. XVII f. 47, possibly belonging to a different species is elevated and regular, acuminately conical, h. 6 mill., br. 7 mill. From the shale of Wisby numerous opercula have been found, closely resembling those now described, pl. XVII f. 43—44, and almost entirely changed into iron pyrites. Their coils are however more thick and less numerous. When seen in a section they are nearly horizontal, triangular. The contour of the whole operculum is also more cylindrical. The inside is a little more deepened than in the others. The shell to which it has belonged is not yet known. H. 8 mill., br. 8. mill.

Oriost. Wisbyense has been found in the middle limestone stratum of Wisby and at Kålens Qvarn.

9. **Oriostoma angulifer** n.

Pl. XX fig. 17—21.

Shell turbinate, globular with moderately elongated spire, of six angular whorls, the lower surface of which forms the spire into an evenly sloping cone, intersected by the narrow and deep suture. There are from three to four fine and acute keels on the body whorl, one near the sutural groove, one a little below the median line of the whorl and one around the umbilicus. Between the two later there are on smaller specimens one more and indications of yet smaller ones. The transverse striation of the surface is microscopically minute and consists of nearly vertical, straight striæ. The aperture is polygonal, higher than broad with thin lips. The umbilicus is wide and open. H. 6 mill., br. 8 mill.

Six specimens have been found in a soft, gray limestone from a canal near Herrevik in Östergarn. This little shell comes near to Or. Wisbyense through its few keels and the deep umbilicus and also reminds of Oriostoma angulatum with its angular contour, fine ornamentation and deep suture.

10. **Oriostoma Rœmeri** n.

Pl. XVIII f. 22—29.

Euomphalus cornu arietis	1838.	ANGELIN Museum Palæont. Svecic. № 10.
Euomphalus funatus	1867.	LINDSTRÖM Nomina, 23.
	1876.	FERD. ROEMER Leth. Geogn. Atlas pl. 14 f. 12.

Shell turbinate, globular, with six ventricose whorls. The longitudinal ornamentation predominates entirely and the surface is consequently covered by chord like keels, going close from the suture to the umbilicus, as many as 43 in some specimens. They are all nearly of the same size, only a few narrow are mingled with them. They continue without interruption close to the suture, without there leaving any zone free. The transverse striation is visible as scaly, crescent like indentations on the revolving lines, which sometimes are as if cut up in a great number of thin laminæ. These transverse imbrications vary much as to proximity and shape, being, when close together, only as lamellar crescents, when more wide apart, as longitudinal tubes, cone in cone shaped. There are no ridges around the umbilicus, more elevated than the other ridges. The umbilicus is narrow and partially hidden by the reflexed border of the inner lip. The aperture is circular and both lips are thin. The shell is very thin and it is almost impossible to find a specimen which is not crushed or distorted. On the nucleus fine traces of the interior nacreous coating are seen. H. 30 mill., br. 36

mill. This is the common proportion, but in a few instances the shell is so much elongated, as to be higher, than broad, fig. 25, h. 40 mill., br. 34 mill.

Of the operculum of this species the State Museum in Stockholm possesses three specimens *in situ*, of which two are too fragmentary for description. In one shell there is the impression of the interior side on the nucleus. A cast in plaster of Paris shows that this side nearly resembles that figured on plate XVII fig. 35, the central whorl being larger, the marginal rim flattened and the central concavity not so deep. It is probable that the outer side, which is not preserved in any specimen, also resembles that of Or. globosum.

This species is very common and is indeed the most characteristic one in the shale beds around Wisby and also in the overlying limestone. A few specimens have also been found in the shale beds of Gnisvärd and Westergarn, proving the contemporaneity of these strata with those of Wisby. There are also single specimens from the upper and lower strata of Hallshuk.

Or. Roemeri, which easily might be confounded with some of the varieties of Or. sculptum, differs from them through the continuity of the longitudinal ridges close to the suture, while they are somewhat more distantiated in the later and there is a space left free without any revolving lines between the lowest keel and the suture. The umbilicus is narrow in Or. Roemeri, wide and open in O. sculptum and environed by two higher ridges, while in Or. Roemeri all ridges are of the same size.

Besides the opercula, which with absolute certainty can be referred to the preceding four species or are most nearly related to them, there are some others which belong to unknown species of other genera, also unknown, but probably of the same family. They may be described here in connection with the former.

1. Pl. XVII fig. 53—55. Four specimens of this variety have been found in the middle limestone beds of Wisby. They are regularly circular, depressed, nearly flat, thin, attaining their largest thickness around the borders and at thinnest in the centre. Section fig. 54. The coils on the outside are rather irregular or, as it were, occasionally evanescent, thick and coarse around the margins, narrower and more indistinct near the centre. The marginal coils are obscurely ornamented by finer, concentric lines. On the inside, which is shallow and concave there is no elevated annular rim as in the preceding type, the whole surface is sloping without interruption, smooth and glossy, to the centre, where a broad, faintly distinguished whorl is seen. Diam. 13 millim., thickness of margin 2 millim.

2. Pl. XVII fig. 56. A single specimen with the inside affixed to the rock has been obtained from Samsugn in Othem. It is of obovate outline, flat, the numerous coils are coarse and angular. A section, fig. 56, reveals that they are narrow lamellæ, inwards bent, at largest near the margin and diminishing towards the centre. It is thickest along the margin. Longest diameter 18 millim., the shortest one 15 mill., thickness at the margin 2 millim.

3. Two specimens from the upper limestone of Hogrän. The outline is obovate, the outer side, the only one accessible, is entirely flat, without any prominence

near the centre. It is extremely thin, more so than in the preceding two forms. The coils are narrow, numerous and regular. Their sides are ornamented by numerous, thin and narrow lines, nearly parallel with the coils, but sectioning them in slight obliquity. Longest diameter 12 millim., shortest diam. 10 mill. Thickness of margin scarcely 1 millim.

If these three forms of opercula belong to a common generic type, as I think, the following one differs so essentially from them, that it must be regarded as belonging to an other genus, which for the present is quite as unknown as the former.

4. Pl. XVII fig. 57. From the shale beds near Wisby four specimens of the largest operculum known in Gotland, have been obtained. But only the outside is visible, the extremely thin shell firmly adhering with the inside to the soft shale. It is circular, flat, covered by thick laminar, elevated, spirally wound coils, in all twelve. They have broad bases and obtuse tops. They leave between them deep interspaces, nearly as large as themselves and they lean with their tops towards the centre. The largest diameter is 32 mill. and it must consequently have appertained to a very large shell, possibly to Cyclonema? giganteum, of which a few specimens are found in the same beds.

The opercula of the Oriostoma pattern have sometimes been compared with those extant in several recent genera as Torinia and Omalaxis. The operculum of Torinia is, however, constructed upon a quite different plan, its inside is wholly dissimilar, protruding in the centre in a rod like prolongation, while the operculum of the palæozoic shells is sunken in the centre. Moreover, both Torinia and Omalaxis have entirely chitinous opercula, whilst the palæozoic ones evidently from the beginning were shelly. I have not found any other opercula resembling the palæozoic ones more than that figured by D'Orbigny in his »Paléontologie Française, Terrains Crétacés», pl. 186 bis, f. 13—17 and which, according to him, l. c. p. 228, has belonged to unknown species of Turbo. It comes nearer to those of Cyclonema, than those of Oriostoma. D'Orbigny remarks that the coils are »très rapprochés, comme chez les Trochus proprements dits». And, in fact, the opercula of Cyclonema, of which see below, in a nigh degree resemble the operculum of the Trochoid Livonia as to the outside, especially in the ornamentation by fine, oblique lines.

11. **Oriostoma helicinum** n.

Pl. III fig. 27—31, Pl. XX fig. 30—33.

Shell globular, heliciform, with short spire ending in a blunt point, whorls four and a half, convex; suture shallow. Ornamentation consisting only of a succession of fine, transverse lines bending backwards on the median line of the last whorl and then again forwards on the umbilical side, very close and with smooth interstices. They are arranged as it were in small groups divided through shallow furrows which give the shell a wavy contour. There are absolutely no traces of any longitudinal lines even in the best preserved specimens and the surface of the whorls is glossy and shining with a brownish tint. In other specimens again there are very distinct bands of the original colour left, transverse, at regular distances, brown on the white surface of the shell, parallel with the sculptural lines. The aperture is circular and its rim not continuous, interrupted at the interior lower corner. Outer lip thin, the interior one with a somewhat callous border, umbilicus narrow and deep, entirely open and defined along its periphery by a low and narrow ridge, which inwards sinks perpendicularly and meets the sloping funnel of the umbilicus.

Dimensions: height 15 millim., breadth 18 millim. Aperture: high 11 millim., broad 10 millim.

From Samsugn in Othem, the canal near Westöös, Halls huk, in the uppermost stratum and from Wialmsudd.

12. **Oriostoma alatum** n.

Pl. XVI fig. 14—19.

Shell disciform, whorls rather transversally dilatated, increasing rapidly in width from the minute apex of three whorls. Whorls in all six. A narrow, laminar, sharp edged keel divides the umbilical and the apical surfaces and thus gives the shell a slight resemblance to Pleurotomaria alata and the allied species. But in this species the laminar keel is solid and the transverse striæ continue in the same direction on both sides of it. Parallel with the keel there run some five narrow, thread fine lines, equally distantiated on the apical side and, likewise on the umbilical side, five, though more indistinct. The transverse striæ are distinct, rather coarse and regularly directed backwards. The aperture is transverse, obovate, the outer lip on the middle of its height thickened by the keel, else thin, the interior lip thin, only expanded and thicker, where it joins the whorl. The umbilicus is wide and so open that all whorls are seen inside it. Specim. A, h. 14 mill., br. 23 mill.; B, height 10 mill., br. 24 mill.; sp. C, h. 14 mill., br. 44 mill. One specimen has been obtained from the middle limestone strata near Wisby and three from the higher strata of Kyrkberget in Wisby.

13. **Oriostoma angulatum** Wahlenberg.

Pl. XX fig. 34—41.

Helicites supra-angulatus	1818.	Wahlenberg Petref. Tell. Sv., 72[1]).
Helicites angulatus	1818.	Id. ibid., 73.
	1828.	His. Anteckn. IV, 237.
Euomphalus angulatus	1829.	Id. Tableau ed. 1, 10.
	1831.	Id. ib. ed. 2, 9.
	1831.	Id. Anteckn. V, 114.
	1848.	Bronn Nomencl., 478.
Inachus angulatus	1837.	Hisinger Leth., 37, tab. XI f. 12.
	1840.	Id. Förteckn., 55.
	1867.	Lindstr. Nomina, 23.
Euomph.? supra-angulatus	1837.	His. Leth., 37.
	1848.	Bronn Nomencl., 482.
Straparollus angulatus	1850.	D'Orb. Prodr., 30.

[1]) Errore *Helic. supragranulatus* pro *Hél. supraangulatus* apud Bronn Nomenclator p. 572, 1848.

Shell discoidal, planorbiform, spire of eight whorls, depressed or only slightly prominent. Whorls cylindrical, terete with several sharp keels, which are more prominent and distinct in young specimens than in older, where they are more or less obliterated. On the apical side there are two sharp and prominent, narrow keels, leaving a flat band between them, one close to the suture, the other and larger on the outside. Between the interior keel and the next whorl a deep, narrow groove is going and the innermost apical whorls are in many instances sunk as a shallow depression. The middle of the body whorl and also of the others is encircled by a highly acute keel and on the umbilical side there are at least three such, forming between them sharply marked facets, of which the lowest is abruptly turned down. On the umbilical side there are thus at least four different faces. The apical keels disappear during the continued growth of the shell and instead of the seven original keels there are on the body whorl finally only four or five on the umbilical side. The contour of the whorls is, when all keels are present, a regular octogon, fig. 37, as the surface between the keels is nearly straight or only slightly concave. The fine, transverse striæ run almost straight down over the keels, only a little bent forwards on the keels. In fullgrown or large specimens the aperture is circular and the umbilicus is wide and open, more so than in most of the other shells. There is some variability, for instance in several specimens from Follingbo, where the whorls on the apical side are so much sunk, that there is a spire on the umbilical side. In some there are no keels at all on the larger whorls, not even near the umbilicus, and the whorls are uniformly tubular. There is also a tendency in the body whorl to disjoint itself from the other whorls, as remarkable in specimens from Fårösund. Br. 66 mill., h. 18 mill.

The figure given by HISINGER of his Inachus angulatus is bad and exaggerated. There are four specimens with HISINGER's hand named thus in his own collection, of quite the same variety as mine. But the type specimen of his figure is not amongst them, it is probably from the Museum of Upsala. That WAHLENBERG's Helicites supra-angulatus is identical with this species, is corroborated through his type specimen, which I have been able to see through the kindness of Prof. CLEVE and it quite agrees with the large specimens from the limestone of Wialmsudd.

SALTER[1]) says that »Inachus angulatus HISINGER, is probably an extreme form of the group (of Trochonema) with a greatly depressed spire». This statement can hardly be accepted and the fossil in question is here retained within Oriostoma. It may through future researches be decided whether it should not rather be placed with the Euomphali, from which it, however, differs in the want of any notch in the last whorls and the concomitant ridges. The transverse striæ are, moreover, bent *forwards* on the keels, not backwards.

This is a very abundant and well preserved shell in some localities: Lansa and Lutterhorn of Fårö, Wialmsudd and Sändviken at Fårösund, Länna near Slite, Samsugn in Othem, Qvarnbacken of Slite, Kylley, Enholmen, Barabacke, Follingbo, Kålens Qvarn, Wisby in the uppermost limestone, Klinteberg, Stora Carlsö near Altaret. It thus occurs exclusively in the uppermost, crystalline limestone.

[1]) Geol. Survey of Canada, Canad. Org. Remains, Decade I, 27.

14. **Oriostoma lineatum** n.

Pl. XX fig. 42—44.

Shell discoid or nearly so, with short spire of five ventricose whorls. The suture is deep and the surface is uniformly lineated by thread fine, elevated, narrow, longitudinal ridges continuing without interruption from near the suture to the upper margin of the umbilicus. They are a little larger and more distantiated on the rounded, middle line of the shell. The interstices between them are nearly smooth and the transverse lines which cross them are straight and minute, only in the umbilical opening they are more prominent. The aperture is circular with thin lips and the inner one closely moulded to the preceding whorls, the umbilicus is wider than in any of the other species, with all whorls visible. H. 16 mill., br. 44 mill.

In the Palæontological State Museum of Stockholm twelve specimens are preserved, all from the limestone of Klinteberg, and four from the uppermost limestone of Fröjel. From the limestone beds nearest above the oolite in Wamlingbo I have obtained a fragmentary Oriostoma, which somewhat resembles the preceding. The transverse striæ are wavy and coarse, and there seems to be a deep groove along the suture on the apical side. It forms probably a new species.

15. **Oriostoma nitidissimum** n.

Pl. XXI fig. 4—10.

Shell small, disciform, apex on a level with the outer whorls; five whorls in all, evenly rounded without any keels or longitudinal striation at all. They are transversally and most finely striated by straight lines, running to the open umbilicus. The suture is shallow. The aperture circular and the lips thin. H. 3 mill., br. 8 mill.

It is very common in the red limestone of the hills of Sandarfve and Linde and a few specimens also from the gray limestone. A shell occurring in the limestone of Stor Wede in Follingbo is probably only a variety of this. It is more ventricose in the body whorl, the umbilicus is more narrow, and the perpendicular striation is not so dense as in the other form.

16. **Oriostoma dispar** n.

Pl. XXI fig. 11—14.

Shell planorbiform, low on the apical side as well as on the umbilical one and excavated on both sides. Whorls five and a half, rounded on the apical side, flattened on the umbilical one and there provided with a prominent keel in the margin. The transverse striæ are distantiated on the umbilical side, finer on the apical side, and directed at first backwards near the suture, then straight down, past the keel and on the umbilical side forwards. The aperture is nearly circular, a little angular through the outgoing keels. H. 2 mill., br. 7 mill. A single specimen has been found in the limestone of Follingbo.

Gen. **CYCLONEMA** Hall.

Cyclonema 1852. Hall Pal. N. York vol. II, 89.

Shell turbinate, whorls ventricose, finely striated or carinated by longitudinal ridges, which are more developed than the transverse ones, which often are wanting. The shell has been nacreous, as can be seen by the traces left by the interior stratum on the nucleus. The operculum is broadly conical, with some ten large coils outside, impressed by a shallow groove along their superior border and streaked by oblique, transversal lines.

This genus comprises Litorina like shells, which differ from Oriostoma chiefly through their operculum and through the regularly predominating, longitudinal ornamentation. In consequence of their characteristic operculum, which so much resembles that of the Turbinidæ, they cannot any longer be regarded as Litorinæ as Stoliczka has proposed.

In the strata of Gotland twelve species have been found and in the Lower Silurian of Dalecarlia and of Öland there have been detected some well preserved specimens of this genus.

1. **Cyclonema delicatulum** n.

Pl. XV figs. 27—44.

This shell, being one of the most common and characteristic of the Silurian formation of Gotland, is, as may be seen by the many figures and by the dimensions below, one of the most variable, with forms ranging between elongate Murchisonia like shells to depressed globular ones like Natica. But the many transitional forms and above all the characteristic ornamentation unite them. They are, moreover, found in the same stratum and often on the same locality. The most common variety is figured on plate XV fig. 28. It has four or five whorls, ventricose, with deep suture. The body whorl is almost as long as all the others taken together. The ornamentation of the surface is a most delicate net work of fine, sharply elevated spiral lines and equal sized transverse lines, which intercross them and at the meeting point form a small blunt tubercle. The surface of each quadrangle, enclosed by these lines, is with the aid of a magnifying lens seen to be minutely and transversally lineated. The figures 42—44 on pl. XV, show how the form of these quadrangles varies in different species according to the distance and position of the crossing lines, being elongate or equal sided or transverse. Besides the now mentioned, prevalent type of the shell, there are more elongated ones, of 6 or 7 whorls, the body whorl being equal to a third of the whole length. The most extreme of the elongated ones is figured. In figures 40—41 the outlines of its antipodes are given, almost globular with enormously large body whorl and short spire. The specimen figured on pl. XV fig. 45 is probably only a corroded specimen of this form from the shale of Wisby.

The aperture is rounded, the exterior lip sharp and thin, entire, the inner one thin, reflexed. There is no umbilicus. The common variety has in length 12 mill., br. 10 mill. One of the extreme varieties is in length 14 mill., br. nearly 14 mill., height of aperture 10 mill. Another, the opposite extremity is 26 mill. in height and it has probably, when the apex was entire, attained 30 mill. in height, br. of body whorl 14 mill. height of aperture 11 mill.

This is one of the most abundant Silurian Gastropoda from the neighbourhood of Wisby in the middle limestone (b) and also, though not so common, from the shale. From the sandstone of Bursvik a small specimen has been obtained, which highly resembles the Wisby specimens as to their ornamentation, but it is not certain that it belongs here.

Cycl. delicatulum may, possibly be the shell designated by ANGELIN in his Museum Palæontol. Suecicum as № 49 Littorina? striata, but I have not succeeded to find a complete series of that collection, containing this species with the others.

2. Cyclonema? apicatum n.

Pl. XVIII fig. 36.

Shell elongate, conical, whorls five, the body whorl more than double the size of the others. They are moderately convex and the suture only slightly impressed. On the body whorl there is a blunt angle, where the umbilical surface begins. It is there the semblance as of a slit band, like that in the Pleurotomariæ of the division Multicarinati, but not sufficiently clear enough to decide if the shell really is a Pleurotomaria. The surface is finely cancellated and the transverse striæ are below the angle bent backwards. The band like sculpture is visible only on the body whorl. The aperture is elongate, ovate, the lips are thin and sharp, and there is no trace at all of any umbilicus.

The peculiar elongate, succinoid shape sufficiently distinguishes this shell from similar. H. 7 mill., br. 5 mill.

This shell has been found in two specimens in the red limestone of Sandarfve hill.

3. Cyclonema cancellatum n.

Pl. XVIII fig. 25—27.

Shell moderately large, turbinate, with seven ventricose whorls, of which the body whorl is nearly twice as large as the spire. The surface is evenly rounded without any prominent keels and it is regularly cross bared by thread fine, longitudinal lines and not quite so prominent, transversal ones, covering the whole surface with minute quadrangles. Some of the longitudinal lines are at irregular distances rather more prominent. The transverse lines have uniformly the same size and take in several specimens a gentle curve backwards, run else straight and near the umbilicus directed forwards. The aperture is obovate, the lips thin, the outer one in some specimens with a shallow, gently curved notch which also is clearly indicated by the above mentioned course of the transverse striæ. There is no umbilicus. H. 36 mill., br. 42 mill.

Several specimens found in the limestone of the hills at Sandarfve and Linde.

Besides its size and shape this species is distinguished from the nearly allied C. delicatulum through its ornamentation, which is different as to its direction and size.

4. **Cyclonema distans** n.

Pl. XVIII fig. 37.

Shell small, turriculate, of five whorls, of which the body whorl is nearly as high as the spire. There are eighteen sharp, distinct, distantiated keels and the transverse lines which intersect them are also distantiated but narrow. They are directed slightly backwards, but converge on the umbilical side. H. 8 mill., br. 6 mill.

Only a single specimen has been found in the limestone of the hill of Sandarfve.

5. **Cyclonema striatum** His.

Pl. XVII fig. 48, pl. XVIII fig. 39—42.

Turbo striatus 1837. Hisinger Anteckn. VI, 109, pl. VIII f. 2.
1837. Id. Lethæa, 38, tab. XII fig. 5.
1840. Id. Förteckn., 55.
1867. Lindstr. Nomina, 23.
Turbo Leda 1850. D'Orb. Prodr. I, 30.
Turbo striatus 1877. Krause Zeitschr. d. deutsch. Geol. Gesellsch., 23, can only with doubt be referred to this genus.

Shell turbinate, with six ventricose whorls, suture deep and immersed; there are only spiral, closely set lines, which vary in their distance from each other, but generally leave an interstice smaller than themselves. Around the umbilicus they are more distant and more prominent. The last whorl is free near the aperture, which is quite circular without any reflexed lips, which are sharp all around. The original specimen of Hisinger is figured here anew; it is fragmentary and the revolving lines are more distant than in other specimens. In his collection there are two specimens thus denominated, the smaller one is only a cast without shell from the shale of Högklint. The larger specimen, the figured one, is from Klinteberg and the Palæontological Museum also has specimens from that locality as well as from Östergarn, Samsugn in Othem and the shale beds of Wisby. H. 16 mm., br. 14 mm., diam. of the aperture 6 mm. Turbo corallii Sow., and Trochonema pauper Hall 20:th Rep. p. 343, pl. 15 f. 5, 6 (= Cyclonema pauper Hall 20:th Rep., Docum. Ed. p. 395 pl. 15 f. 5, 6) come near to this shell. The largest specimens somewhat resemble smaller specimens of Or. globosum or sculptum. The narrowness or total want of any umbilicus, the elevated spire of rounded whorls, the circular, nearly free aperture, however, distinguish them sufficiently.

From the limestone of Samsugn a specimen has been obtained with an operculum in reversed position in its aperture. It has no doubt belonged to the shell, being of exactly the same size as the aperture. It is of quite the same shape as that delineated on plate XVII fig. 48. It is depressedly conical, of about twelve coils and perfectly circular outline. The coils are large, convex, with the superior border bent out in a thin, laminar edge, the suture between them is shallow. The transverse, oblique striæ are distinct. The inside is deeply concave and in well preserved specimens almost all the coils are seen, the outermost forming the elevated bordering rim. Dimensions: diameter 6 millim., height 3 mill., thickness of margin 1 millim.

In the crystalline limestone near Westerby in Ardre there occur numerous nuclei, which through some fragments of the shell with its sculpture make it evident that they have been nearly allied with Cycl. striatum. There seems to have been some variability in the size and distance of the longitudinal, threadlike striæ. The whorls are six, tubular. Along with these shells, the only ones found there, lie a great number of detached opercula of a type, quite corresponding to that of Cycl. striatum, though modified in details. Its size also tallies with that of the shell. It is figured on plate XXI fig. 66. It is of perfectly circular outline, moderately and obtusely conical. Coils on the outside about twelve, large and broad, proportionately more so than in Cycl. striatum. A little below the upper rim a shallow groove runs. The thin edges of the coils are cloven by a narrow slit running along them. The interspace between the adjoining coils is very shallow. The outer sides are ornamented by densely crowded, exceedingly fine and minute, oblique and transversal streaks, reminding of the somewhat larger ones on the outside of the operculum of many of the recent Trochidæ and Turritellidæ. On the inside the centre is environed by a thick, callous whorl which encircles the innermost concavity. Around the whorl the surface is smooth and there is no annular rim. This great dissimilarity of the interior surface indicates a different specific type, which, however, can, for the present, not be succinctly enough described as the shell is so imperfectly preserved. Dimensions of the shell: H. 23 mill., br. 18 mill. H. of operculum 5 mill., diameter 11 mill.

In connection with the forms of opercula, now described, two more may here be mentioned, because they evidently belong to the same generic type.

1. Pl. XVII, fig. 50—52. From the lower strata of Östergarn found in a few specimens. These resemble, as to their exterior, those from Ardre with their large, eight or nine coils which also have a shallow groove running along their superior border. The minute, transverse striæ are not conspicuous and the top of the coils is more lacerated by longitudinal slits. The inner side is also more excavated, fig. 50, and the central whorl not so prominent. An annular rim is formed by the inside of the outermost coil. H. 3 mill., diam. 8, thickness of the margin 1 mill.

2. Pl. XVII, fig. 49. This is acuminately conical, higher than broad, the base is crushed, but it has probably had a circular outline. The coils are broad, band like, ascending like steps, about fifteen. There are indistinct, oblique, transverse lines, nearly parallel with the edges of the coils. A single specimen has been found in the uppermost limestone of Lännaberg in Slite. Diameter 10 mill., height 17 mill. It has to all appearance been still longer.

6. **Cyclonema zonatum** n.

Pl. XVIII fig. 43—44.

Shell small, turbinate, with obtusely elevated spire of six whorls. These are evenly rounded, the body whorl of the same size as the spire. The keels are longitudinal, rounded, with interstices of equal size. The keel which is situated a little below the median line of the body whorl is larger than the others and more distantiated from the nearest and there thus originates a zone or a belt around the whorl. Microscopically minute, transverse lines are crowded on the keels, deviating only slightly from a vertical direction. Near the suture the longitudinal lines also are larger and they leave a smooth zone between them and the suture. The aperture is obovate and the umbilicus is narrow. H. 15 mm., br. 14 mill.

Four specimens derived from the red limestone of the hill of Sandarfve. There is also from the same locality a very large specimen (h. 18 mm., br. 18 mm.) which perhaps belongs to this species. The longitudinal keels, however, are, below the middle of the whorl, not so distinct, nor is the zone so definite. A shorter variety with larger striæ has been obtained from the shale beds north of Skäret in Fröjel.

7. **Cyclonema adstrictum** n.

Pl. XV fig. 49.

Shell turbinate, of three whorls. The body whorl more than double the size of all the others. It is nearly of elliptical outline, suddenly constricted in a more narrow neck just above the suture; the next whorl is conically rounded without any constriction. The surface is smooth and only through the magnifying lens a fine longitudinal striation is revealed, as of engraved lines, crossed by irregular short, arched lines. The aperture is obovate with thin lips. There is no umbilicus. H. 15 mm., br. 16 mm.

Some specimens have been found in the red limestone of the hill of Sandarfve. This is possibly identical with Naticopsis concinna MAC COY Sil. Foss. Ireland p. 13, pl. I f. 10.

8. **Cyclonema carinatum** SOWERBY.

Pl. XVIII fig. 28—30.

Turbo carinatus	1837.	Sow. Sil. Syst., tab. 5 f. 28.
	1843.	MORRIS Catal. Brit. Foss. 165.
	1848.	BRONN Nomencl., 1358.
Turbo octavia	1850.	D'ORB. Prodr. I, 30.
	1854.	MORRIS Brit. Foss., 283.
Litorina octavia	1855.	MAC COY Palæoz. Foss., 305.
Cyclonema octavia	1859.	SALTER ap. Siluria ed. 3, 548, pl. 24 f. 4.
	1873.	ID. Cat. Cambr. Foss., 156, 172, 185.

Shell turbinate, acuminate, with six ventricose whorls, the five inferior whorls with two sharp keels each. On the body whorl there are a variable number of 8 or 10 keels of which the lowest two are largest and most prominent, the most inferior leaving a larger zone between itself and the suture than the space to the next keel. There is also a low keel near the suture. The surface between the keels is finely and transversally striated by dense, obliquely backwards slanting streaks. The aperture is almost ovate, higher than broad and the umbilical opening is narrow, being in some specimens covered by the inner lip, which is reflexed towards the columella. H. 30 millim., br. 25 mill., height of aperture 15 mill.

It has been found at Djupvik in Eksta, Samsugn in Othem, north of Skäret in Fröjel and at Follingbo, Slite and Petesvik in Habblingbo.

8 a. **Cyclonema carinatum** Sow. var. **glabrum** n.

Shell small, turbinate, acuminate, five ventricose whorls with three or four longitudinal, distantiated keels on the apical side of the body whorl. They are entirely wanting on the umbilical side which is almost smooth, only ornamented with the same sort of faint, transverse striæ as on the apical side. Around the umbilical cavity a short, sharp ridge starts from the upper edge of the aperture, which is obovate, acuminate below. The umbilicus is narrow. H. 8., br. 6 mill. It has been found together with the typical specimens in the shale of Djupvik in Eksta.

8 b. **Cyclonema carinatum** Sow. var. **multicarinatum** n.

Pl. XVIII f. 31—32.

This differs chiefly from the main species through the numerous and small longitudinal keels, the nearly circular aperture and the large and open umbilicus. The keels are as many as 14 on the body whorl and from five to seven on the whorls next in size. On the body whorl the keels are more distantiated a little above the suture. As many forms connect it with Cyclon. carinatum, forma typica, there is no cause to represent it as a species of its own. H. 19 mill., br. 17 mill. Several specimens have been obtained from the shale of Djupvik in Eksta.

9. **Cyclonema nodulosum** n.

Pl. XVIII fig. 33—35.

Shell variable with long or short spire, with deeply impressed suture, whorls six, nearly disjointed, as seen by section fig. 35, with 8—10 distantiated keels. It differs from Cycl. carinatum in the peculiarity that the transverse oblique striæ at regular distances are more elevated than the others, and where they cross the keels, they form a small tubercle or nodule through which the surface acquires a retiform aspect. All specimens have a wide umbilicus and the axis is hollow. The aperture is circular with thin lips and almost free from connection with the next whorl. H. 20 mill., br. 16 mill. It has hitherto been found only in the shale of Djupvik in Eksta and Fröjel.

10. **Cyclonema? tenuissimum** n.

Pl. XVIII fig. 38.

Shell globose with six whorls, the body whorl several times as large as the spire. The ornamentation consists of narrow spiral lines, very fine and closely set, especially on the umbilical side. The suture is partly filled up by the overlying whorls. The aperture is transversally ovate and the lips thin. The umbilicus is deep and funnel shaped. H. 10 mill., br. 11 mill.

There is only one specimen as yet found from the limestone of Follingbo.

11. **Cyclonema? giganteum** n.

There exist only some fragments of the nucleus, by which it can be concluded that this shell was turbinate with much ventricose whorls, of which three are extant in the same specimen. There are also impressions of fourteen moderately elevated longitudinal keels, the interstices between which are finely and transversally striated. This fossil which in its size so much surpasses the other Cyclonemata, as well as almost all other Silurian shells, can only hesitatingly be referred to this genus with which it else coincides as to the ornamentation of the surface. H. 86 mill., breadth of body whorl 95 mill. It has been found in the shale beds near Wisby and in Lummelund.

12. **Cyclonema perversum** n.

Pl. XXI fig. 55—56.

Shell sinistral, to judge by the only existing fragment of three ventricose whorls, elongated or turreted, ornamented by numerous thread like, somewhat irregular and unequal, longitudinal striæ. These are crossed, especially near the aperture by coarser, elevated lines of growth and for the rest by narrow, impressed lines. The suture is moderately deep, the aperture is elongate and angular, acuminate in its upper and inferior corners and on the middle of the inner lip. The lips are thin and straight. The umbilicus is visible as a narrow slit. Size of the fragment: height 16 millim., br. 12 mill.

The single specimen has been found in the upper gray limestone beds of the hill of Linde.

Gen. **TROCHONEMA** Salter.

1859 Salter Canad. Organ. Remains Dec. 1, 27.

Shell turbinate, elongated, keeled, with wide and open umbilicus, surrounded by an elevated keel.

I have adopted this genus for a widely spread shell, which cannot aptly be united with any of the previously known. Salter thinks that Inachus angulatus Hisinger (Oriostoma angulatum) probably is an extreme form of this group, but I cannot find that there is any foundation for this supposition. Trochonema differs from Oriostoma through its elongate spire and from Cyclonema in the sculpture and the wide and open umbilicus.

1. Trochonema turritum n.

Pl. XXI fig. 15—19.

Shell elongated, turbinate, of seven whorls, angulated through the prominent keels of which there are six on the body whorl, besides the sharply eminent one around the umbilicus. The three lowest keels are sharper than those on the umbilical side. The transverse lines of growth are thin, lamellar, with sharp edges, more or less distantiated, the interstices varying in breadth from nearly two mill. to close contiguity of the lamellæ. On the keels they are bent in a little tubular fold. The interstices are finely and minutely striated by lines parallel with the enclosing lamellæ. On the umbilical ridge the transverse lamellæ are crowded and the striæ converge in the interior of the umbilicus. The aperture is obovate, the longitudinal axis being the longest. Its outer lip is angular through the shallow notches, which cause the longitudinal keels. The inner lip is straight and not reflexed. H. 37 mill., br. 29.

A great number of specimens has been found at Samsugn in Othem and also a few in Martebo, in the limestone of Kyrkberget, Wisby, and on Galgberget near Wisby. There is a more slender variety from Klinteberg, small, with the lamellæ more numerous and crowded and the umbilicus narrow, reduced to a slit.

2. Trochonema muricatum n.

Pl. XVIII fig. 52—53.

Shell turriculate, acuminate, upper whorls rapidly increasing in size. Whorls six, angular, body whorl with four large keels, the uppermost around the umbilicus. They are lacerated with broad, acuminated points at regular distances all round. Each of them is, as it were, a complex of the folded edges of several transverse lamellæ, which have a nearly straight direction. The aperture is elongate, angular through all the keels in the outer lip. The inner lip is curved and thin. The umbilicus is wide and open. H. 14 mill., br. 12 mill. A single specimen has been found in the middle limestone strata of Hoburg.

In the list of the distribution of the species I had placed this shell in the genus Eunema Salter, but I now find, on closer consideration, that it cannot be kept there, but rather corresponds with Trochonema.

Gen. CRASPEDOSTOMA gen. nov.[1])

Shell globular, naticoid, commonly with transverse lamellar ribs. Aperture circular, enclosed within an enormously enlarged and thickened border, formed by successive, thin strata, in the superior, inner corner elongated in an acute spur and a smaller, corresponding one in the inferior corner. The inner lip is bifurcated. The umbilicus is deep and narrow.

[1]) Κρασπέδον, collar, στῶμα,. mouth, aperture.

This is a well characterized genus with its peculiarly framed lips and lamellar ornaments of the shell. I have placed this genus with the Turbinidæ in consequence of the congruence of its shell with several of the Liotidæ of which group there are some representatives not only recent and tertiary, but also in secondary strata. What STOLICZKA says[1]) of Liotia is wholly applicable to the Gotlandic fossils in question. He says: »The Liotidæ are usually of small size, sub-orbicular, with short spire, transversally and spirally ribbed, often umbilicated, with the aperture circular, having more or less thickened and continuous margins». In the figure of Liotia Gervillei, given by S. P. WOODWARD[2]), there is seen an acuminated spur projecting from the lower or median edge of the inner lip quite as in ours. Strange enough no similar shells seem to have been hitherto found in the Devonian and the Carboniferous Formations, as I cannot find any mention made of such in the works of GOLDFUSS, SANDBERGER and DE KONINCK.

D'ORBIGNY[3]) has described and figured a »Delphinula reflexilabrum», which comes very near to our genus through its »bouche ronde, avec un bord fortement épaissi, et réfléchi en un large péristome tranchant». It is derived from the Middle Lias of France.

In the Upper Silurian of Gotland I have found six species and in the Lower Silurian hitherto not a single one has been discovered.

1. **Craspedostoma spinulosum** n.

Pl. III fig. 32—34.

Shell globular, naticoid, last whorl several times as large as all the others. Whorls four, of which three form the short spire. Suture shallow. The surface is richly ornamented by transverse ribs, situated at regular distances and there provided with blunt spines. These spines, being regularly distantiated, form rows which also continue on the reflexed outside of the lip and give its extreme edge a serrated outline. The aperture is ovate, inferiorly somewhat more narrow. The outer lip with a broad border forming an expansion at right angle to the outside of the last whorl, projecting above it to the length of two millimetres. It is evident that there has been a spur or processus on the interior, upper edge, and probably also beneath the inferior corner of the aperture but both have been broken. It is imbricated by the wavy lines of former lips, resting in their place, while the aperture has been more constricted. The inner lip is straight, bifid, thin and smooth, but does not cover the narrow and deep umbilicus. H. 14 millim., br. 15 millim., length of aperture outside the lip 13 millim., inside 7 millim.

From the limestone of Hoburg, between the oolite and crinoidal limestone strata, where I found one specimen.

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1) Palæont. Indica, Gasteropoda of the Cretac. Rocks, 351.
2) Manual of Shells, pl. 10 f. 14.
3) Paléont. Franç. Terr. jurassiques, 317, pl. 323 f. 14—16.

2. **Craspedostoma elegantulum** n.

Pl. II fig. 58, pl. XXI fig. 20—29.

Shell globose, naticoid, whorls five, body whorl enormously developed, the others forming a small, obtuse spire. The thin, transverse ribs are densely packed, running obliquely, directed backwards toward the umbilicus. Their edges are minutely frilled in a succession of diminutive wave lines and bent backwards, as to resemble hooks in longitudinal sections. In older specimens, at least from some localities, the ribs are distantiated, with smooth interstices near the aperture. Thread fine, longitudinal lines cross them, especially distinct on the smaller whorls. They are usually more distantiated than the transverse ones, though there also is variability and the longitudinal striæ are more close and numerous, pl. II fig. 58. The aperture is obovate, rounded above, pointed below, the outer lip is large and bent obliquely outwards, thin, and its interior corner, where it meets the inner lip, is prolonged in a triangular, acuminated tooth which stretches far backwards and nearly reclines on the body whorl. The inner lip is narrow, straight, near the umbilicus divided in two diverging branches through a triangular slit between them. Of these the shorter one ends on the inner wall of the umbilicus, while the longer borders the umbilicus on the outside. The umbilicus is narrow and deep. H. 20 mill., br. 25 mill.

Several specimens have been found in the upper limestone strata of Slite, Samsugn, Stor Wede in Follingbo, Nya Slitegårds in Dalhem and Klinteberg.

3. **Craspedostoma elegantulum** var. **brevispira** n.

Pl. XXI fig. 30—34.

This variety is small, globular, with five whorls, spire short as not to be visible when the shell is seen from the side. The aperture is large and widened. The superior spur is relatively shorter than in the former, more narrow and pointed. The ornamentation of the surface is finer and more reticulate, the edges of the transverse ribs only a little outstanding and obtuse. The umbilicus is wide and the two branches of the interior lip widely diverging. H. 5 mill., br. 7 mill.

A few specimens have been found in the limestone of the hill of Sandarfve.

4. **Craspedostoma filistriatum** n.

Pl. XXI fig. 35—38.

Shell globular, helicoid, body whorl considerably enlarged, the spire prominent, though obtuse, whorls four. The surface is smooth, nearly glossy, without any peculiar ribs, of which there only are a few distantiated traces. The ornamentation consists of minute and closely set transverse, nearly straight striæ, crossed by more irregular, wavy, impressed, longitudinal lines. The aperture is obovate, almost as in Cr. elegantulum, but situated deep beneath the outgoing frame, which above is prolonged in the characteristic spurlike process and below in an obtuse lappet. The interior lip is bifid in the same manner as the others. On the outside of the body whorl near the aperture there is a transverse, shallow groove dividing the enlarged apertural frame from the deeply hidden aperture proper. This frame is here as in Craspedostoma elegantulum very thin and sharp edged. H. 10 mill., br. 13 mill.

Two specimens have been obtained from Klinteberg and one from Samsugn.

5. **Craspedostoma involutum** n.

Pl. XXI fig. 39—42.

Shell small, globose, helicoid, whorls five, spire short but prominent, the transverse ribs numerous, close, with frilled edges where they meet the longitudinal striæ, which resemble those of the other species. The aperture is obovate, acuminate below, the broad frame is broken away. The inner lip is bifid as in the others, its outer branch straight and somewhat thickened, but its inner branch does not continue straight down as in the others, it is convoluted around the central axis of the conical hollow which it forms and thus hiding the umbilicus: h. 9 millim., br. 11 millim.

Four specimens have been found in the highest limestone stratum of Wisby on Kyrkberget.

6. **Craspedostoma glabrum** n.

Pl. XXI fig. 43—54.

Shell globular, small, naticoid, thin, whorls five, with short, though prominent spire and the body whorl many times surpassing the others in size. Surface apparently smooth with only a few, much distantiated, transverse sigmoid ribs, which are faintly prominent with an obtuse edge. Between them the surface is most distinctly longitudinally striated by somewhat wavy and graduated lines and transversally to them and parallel with the ribs there are microscopically minute lines. The aperture is circular or obovate, environed by exceedingly broad, reflexed lips, forming a large frame around it, of such enormous size that in relation to it the shell looks as an appendix. This frame is prolonged in a large, acuminated spur near the umbilicus, which it nearly completely covers and its lowest corner near the spire is also elongated in a triangular spur. The surface of the frame is finely lineated by the parallel, superimposed strata of growth of successive lips, giving it an imbricated appearance. The umbilicus is narrow. Only the largest specimens are provided with an inner branch of the inner lip. H. 13 mill., br. 13 mill., breadth of aperture 11 mill.

Most abundant in the red and gray limestone of the hill of Sandarfve.

Fam. XI PHORIDÆ Gray.

Gen. **AUTODETUS** nov. gen.[1])

1884 *Anticalyptræa* Quenstedt Handbuch der Petrefaktenkunde, 3e Aufl., 673.

Shell broadly conical, sinistral, affixed with the truncated apex to other marine bodies, whorls externally not visible, no suture, aperture narrow, transverse, with a blunt, toothlike projection near the centre of the flat, umbilical surface. There is no umbilicus, the axis is solid. The shell is interiorly subdivided in bladderlike compartments along the exterior wall.

This curious little shell has by its first describers been referred to several recent genera as Calyptræa, Capulus and Trochita, with none of which it, however, on closer inspection can be regarded as related. This is chiefly found through the aspect of the volutions in the interior, the characteristic sculpture of the umbilical surface and its peculiar way of fixing itself with the apex to the hard structures of other animals. In outward appearance it has certainly a great similarity to species of the recent genus Galerus and also in some degree in the form of the aperture, which in some species of Galerus have a tooth like prolongation. There seems, however, to be more reason to regard it as a precursor of the recent Phoridæ. The shape of the aperture as well as the ornamentation of the umbilical surface justify this comparison. But instead of fixing other objects to its shell, as its recent relatives, it fixed itself to larger objects.

This is, perhaps with exception of Clisospira, the oldest known representative of this curious family, as there is before none older known than Xenophora or Pseudophorus antiquus Meek[2]) and Phorus Bouchardi Eug. Deslongschamps[3]) both from the Devonian formation. Then none is found before the Jurassic time. Perhaps also Trochita antiqua? Meek[4]) belongs to this family. But, as surmised above, it may be questioned whether such Silurian shells as Trochus cavus, Tr. profundus etc. do not rather belong to the Phoridæ and to the genus Onustus.

Autodetus calyptratus Schrenk.

Pl. I fig. 17—24, pl. XXI fig. 57—60.

Capulus calyptratus	1854.	Schrenk Uebersicht des Schichtensystems Liv- und Esthlands, 83.
	1858.	Fr. Schmidt Geol. Esthlands, 206, but not Patella mitreola Eichw. Bull. Moscou 1854, I, 94.
Calyptræa calyptrata	1860.	Eichwald Leth. rossica I,II, 1104, pl. 51 f. 13.
	1867.	Quenstedt Handbuch der Petrefaktenkunde 2e Aufl., 526, f. 117.
Trochita calyptrata	1867.	Lindström Nomina fossil. Gotl., 23.
Anticalyptræa calyptrata	1884.	Quenstedt Handb. d. Petref. 3:e Aufl., 673.

Shell irregularly conical, sinistral, with the truncated and affixed apex forming a flat surface. A few large specimens from Lau and Hoburg seem to have freed themselves at an early stage of growth and have a bluntly pointed apex, without

[1]) Ἀυτόδετος, who has bound himself.
[2]) Geol. Survey of Ohio, vol. I, 221.
[3]) Bull. Soc. Lin. de Normandie VI, 151.
[4]) Proceed. Ac. Nat. Sc. Philad. vol. 23, 82.

any scar of the attachment. The whorls are in most specimens not apperceptible on the outside, but through sections it has been made out that there with certainty are six. They are almost smooth, not separated by any regular suture and are finely and transversally striated by exceedingly narrow lines. These, which run in an oblique direction, are crossed by more conspicuous, though minute lines and parallel with these or with the umbilical border there are irregular ridges or constrictions or even edges of the lines of growth. The affixed apex has often been strengthened by radiciform offshoots, which give the shell a strange, nearly corallian aspect, and this is also the case when two Autodeti have grown close together and, as it were, clasp each other with their roots. In the youngest specimens the ornamentation, pl. XXI f. 58, is better preserved and we see that the oblique, transverse lines are by far larger than the delicate, longitudinal ones. The umbilical surface is much more distinctly circumscribed in this shell than in any other, excepting, perhaps, such forms of Trochi as T. cavus and T. profundus. Its borders are very thin and seldom entire, but broken and fragmentary. Inside the surface is moderately concave, elevated in the centre around the axis in a faint convexity. Around this or as far as the thin margins reach, a wreath of small bladders, of much unequal size in different specimens, as seen by figs. 18 and 22 pl. I, is stretching. These and the whole central surface are covered by minute, wartlike prickles, amongst which curved striæ radiate from the axis to the periphery. There is no umbilicus and the axis is solid. The aperture is a narrow, transverse slit with the upper lip laminar and ending in a blunt, broad, triangular spine, which is bent a little upwards near the centre of the umbilical side. The inner lip is thick and is distinctly separated from the surface. Around the inferior side of the aperture the shell has, as in the recent Phoridæ, a covering of a thin, glossy stratum of porcellaneous shell matter.

A longitudinal section, pl. I fig. 23, through the axis reveals five or six whorls of elliptical shape and nearly similar to those seen in other regular shells and not at all analogous to the spiral laminæ in Calyptræa and Trochita. But there is a characteristic feature in it, worthy of attention, and consisting in an accumulation of small bladder like cells along the inferior corner near the wall of the whorls. These bladders, in some cases amounting to as many as six above each other, are thus comprised in an angle between the roof of a lower whorl and the floor of the next. They form the circle along the inside of the umbilical border, described above, and may there be seen in their original shape when uncovered. In pl. I fig. 19, rows of these bladders are seen in a corroded specimen, indicating the wanting lines of the suture. These bladders are then evidently formed on the top of the whorls along the thin rim of the umbilical surface and are again covered during the growth of the shell by the new whorls. By pl. I fig. 18 it can be found that they originate, as could be expected, near the outer corner of the upper apertural lip and thus had been formed along with the aperture. As to the nature and homologies of these bladders, I can for the present only compare them with the interior partitions through transverse laminæ in several shells as in Triton corrugatus LAM.[1]). But there is the essential dif-

[1]) WOODWARD Manual of Shells, ed. 1, 100.

ference that in this and similar (species of Conus etc.) the partitions are *inside* the whorls and only near the apex, whilst in Autodetus they are decidedly *outside* the whorls and everywhere along the suture.

The apical whorls are often filled with shelly matter and solid. H. of a specimen 6 mill., br. 8 mill. Another specimen from Lau, h. 5 mill., br. 9 mill.

The smallest or youngest specimens might easily be mistaken for young annelid tubes. A few have been delineated on plate XXI figs. 57—60. Specimen, fig. 59—60, is the youngest, nearly 2 millim. in diameter, broadly affixed, of nearly three whorls, without the thin, umbilical border and with the centre of the axis prominent as a point. Next we have, figs. 57—58, larger specimens, nearly 3 millim., where the thin border just is beginning to appear. In this, as well as in the yet smaller, previous shell, the ring of bladders is already present on the bottom of the aperture.

This characteristic shell is distributed nearly over the whole island and has been met with in all strata, in the lowest shale beds, as well as in the uppermost limestone. It is, however, more abundant in the southern localities. It has been found in the shale beds of Halls huk, of Djupvik in Eksta and in the contemporaneous sandstone of Bursvik. The State Museum has further obtained it from the limestone beds at Medebys in Hall, Likkershamn, Slite, Wisby, Östergarn, Grötlingbo, Lau, from the oolite of Bursvik and the middle and uppermost limestone of the hill of Sandarfve and Hoburg. It has also been found in the isle of Oesel in corresponding strata, where SCHRENK first discovered it.

Fam. XII. LITORINIDÆ GRAY.

Gen. **HOLOPEA** HALL p. p.

?1845 *Cyclora* HALL p. p. Sillim. Journ. vol. 48, 294.
1847 *Holopea* ID. p. p. Pal. N. York vol. I, 169.
1866 *Litiopsis* EDW. FORBES according to SALTER in Mem. Geol. Survey, III, 346.

Shell globose, naticoid, with short spire, smooth whorls with faint, transverse striæ, outer lip thin, inner lip reflexed, peristome interrupted, umbilicus deficient or narrow.

According to the first definition given by HALL these shells were difficult to distinguish from Cyclonema, as he states that the surface is cancellated. But in his later descriptions in Palæont. of N. York vol. III p. 294, species have been described which are similar to the Gotlandic ones, enumerated below and also correspond with those referred to Holopea by SALTER in Mem. Geol. Survey vol. III p. 347, where also species with high spire are included, which probably rather had to be numbered with another genus.

1. **Holopea nux** n.

Pl. XV fig. 62.

Shell moderately large, ventricose, nearly globose, with short spire and body whorl many times the size of the spire. Whorls five, obscurely and transversally striated. H. 17, br. 17. Fragment of a larger specimen 20 mill. broad. In the limestone of Sandarfve kulle, Linde klint and from Samsugn.

2. **Holopea transversa** n.

Pl. XV fig. 59—60.

Shell minute, globose, with acuminate, though short spire, whorls five, ventricose, smooth or glossy, body whorl transverse, aperture obovate, outer lip thin and sharp, inner lip thick, reflexed and hiding the umbilicus. H. 7, br. 7,5 mill. Only a single specimen found in Follingbo.

3. **Holopea perforata** n.

Pl. XVIII fig. 45.

Shell minute, globose, transverse, spire short and acute, whorls five, ventricose, their surface smooth, only transversally wrinkled by a few, depressed lines of growth, directed backwards or nearly vertical. Aperture obovate, or almost circular, both lips thin, the inner one not reflexed. Umbilicus open, relatively wide. H. 12 mill., br. 13 mill. Two specimens from Kyrkberget in Wisby.

This species and the preceding one seem to form part of those shells which compose the genus Cyclora of HALL, but which well may be united with the Holopeæ.

4. **Holopea nitidissima** n.

Pl. XV fig. 50—51.

Shell minute, elongate, with five ventricose whorls, surface glossy, with faint transverse striæ. Suture slightly impressed. Aperture obovate, acuminated below, outer lip thin, continuing on the body whorl without meeting the much shorter inner lip, which is reflexed and hides the umbilicus. H. 8 mill., br. 6 mill. From Follingbo and Kyrkberget in Wisby.

5. **Holopea applanata** n.

Pl. XV fig. 46—47.

Shell elongate with five whorls of nearly conical outline, transversally and minutely striated, somewhat concave above the suture, which lies in a groove on the inferior border of the whorls. Aperture obovate, outer lip thin, continuing on the body whorl, without meeting the inner lip, which is thick and reflexed, hiding the mbilicus. H. 10 mill., br. 7 mill. In all seven specimens from Kyrkberget in Wisby.

Fam. XIII. SCALARIDÆ Broderip.

Gen. **CALLONEMA** Hall.

1865 *Isonema* Meek and Worthen p. p. Proceed. Ac. Nat. Sc. Philad., 251.
1879 *Callonema* Hall. Palæont. N. York vol. V,II, 50.

Shell elongate or short and globular, ornamented by transverse, distantiated lamellar ribs, aperture circular, peristoma continuous.

This genus was established by Hall to include some Devonian and Silurian species which had to that time been numbered with Isonema, though they rather did not correspond to the definition given to that genus by its authors Meek and Worthen. I follow the subsequent authors who have placed the genus Callonema amongst the Scalaridæ. In Sweden it had already appeared in the Lower Silurian times, as there are fine species of it in the Leptæna Limestone of Dalecarlia.

1. **Callonema obesum** n.

Pl. XV fig. 27.

Shell thick, trochiform, of the same length and breadth, with transverse whorls, broader than high, regularly increasing in size. Whorls five, ornamented with oblique, chordlike, lamellar ribs, directed in a gentle curve, going from the suture backwards. The surface acquires through them a fluted appearance, as these chords are more close together than in the next species, finer and more regular. The aperture and the umbilical side are destroyed in the only specimen extant. H. 8 mill., br. 8 mill. This specimen belongs to the Museum of the University of Copenhagen, and has been found by Angelin probably in the limestone of Wisby.

2. **Callonema scalariforme** n.

Pl. XV f. 24—26.

Shell elongate, turriculated and slender, of six moderately ventricose whorls. Surface ornamented by obliquely transverse, thread like lamellæ, and between them with parallel lines of growth. The aperture is ovate and the lips thin. The lamellæ project beneath each other as scales, the younger beneath the older and they may properly be regarded as the edges of successive apertures. H. 15 mill., br. 10 mill. Another specimen h. 10 mill., br. 5 mill., height of aperture 4 mill.

Some specimens from the middle limestone of Wisby.

Gen. **HOLOPELLA** Mac Coy.

Syn. 1852. *Holopella* Mac Coy Brit. Pal. Foss., 303.
1881. *Aclisina* De Koninck p. p. Faune Carbonif. II, 3, p. 86.

Shell elongate, slender, smooth or finely striated, peristome continuous.

This genus should, according to MAC COY be characterized through its remarkably convex whorls, which are ornamented by »slightly arched striæ» or even cancellated by transverse and spiral striæ. DE KONINCK's Aclisina then seems in no particular to differ from Holopella. The specimens are generally small. It has probably occurred in the Lower Silurian of Sweden; at least Loxonema dalecarlicum LINDSTRÖM[1]) may rather be classed with Holopella and it is derived from the Leptæna Limestone of Dalecarlia. In the Upper Silurian of Sweden there are three species, described below. The genus has continued during the Devonian, the Carboniferous and probably also during the Triassic times.

1. Holopella teres n.

Pl. XV fig. 61.

Shell elongate, thick, with seven whorls, which are smooth and transverse, twice as wide as high, with glossy surface. Aperture circular, outer lip thin, the inner lip thick, large and reflexed not only over the umbilicus, but also at the lower edge of the aperture. H. 6 mill., br. 3 mill. Found in Slite.

2. Holopella regularis n.

Pl. XV fig. 12—13.

Shell moderately large, elongate, turriculate, with five ventricose whorls, separated by a deep suture. The surface is smooth, glossy, covered by extremely fine, slightly sigmoidally wound lines, the aperture ovate, below acuminate, with sharp and thin lips. Umbilicus deficient. H. 21 mill., br. 10 mill. The aperture 8 mill. heigh, 6 mill. broad. The specimen figured belongs to Adjunct M. KLINTBERG, who found it in the shale beds of Wisby. It has also been found in the shale of Petesvik in Habblingbo.

3. Holopella minuta n.

Pl. XV f. 63.

Shell one of the tiniest found, being so uncommonly narrow in relation to the length, regularly elongated and slender of eight globose whorls, one and a half time as wide as high, regularly striated with fine, curved lines, having their greatest bend along the median line of the shell. H. 7 mill., br. 2 mill. Occurs frequently in the red limestone of Sandarfve kulle.

Fam. XIII. PYRAMIDELLIDÆ GRAY.

Gen. **MACROCHILINA** BAYLE.

1841 *Macrocheilus* PHILLIPS Palæoz. Foss. Cornw., 103.
1842 *Plectostylus* CONRAD Proceed. Ac. N. Sc. Philad. 275.

[1]) ANGELIN & LINDSTRÖM, Fragmenta Silurica p. 14, pl. XV, f. 19.

1860 *Soleniscus* MEEK and WORTHEN p. p. Proc. Ac. N. Sc. Philad., 467.
1879 *Duncania* BAYLE Journ. de Conchyliologie, vol. 19, 35.
1880 *Macrochilina* ID. ibid. vol. 20, 241.

Shell elongate, bulimoid, terete, aperture ovate, columellar lip considerably thickened toward its base and twisted, often so much that an acute, revolving plait is formed.

I have ventured to place three species of Gotland Silurian shells within this genus, mostly on acconut of their general habitus. But this position seems also justified through the conformation of the inner lip, which, though not showing such a distinct plait as in some of the Carboniferous species, is evidently tortuous as in many of them and the Devonian ones.

The oldest authors placed these fossils with Buccinum as HOENIGHAUS or Buccinites SCHLOTHEIM, and of the subsequent names Soleniscus ought to have the priority, as Macrocheilus as well as Plectostylus were already preoccupied. But as this genus according to the revision of WHITE[1]) contains chiefly species, which, whith their gutter-like prolongation of the superior corner of the aperture, indicate relations with the large division of the Siphonostoma, it can only partly be admitted as synonymic. Duncania, given by BAYLE, had already twice been employed for corals, fossil and recent, and its author consequently changed it into that now prevalent.

1. **Macrochilina cancellata** n.

Pl. XVIII fig. 46—47.

Shell elongate, bulimoid, terete, with seven much convex whorls, the body whorl being nearly of the same length as the spire. The suture is rather impressed in consequence of the globosity of the whorls. The surface is most finely ornamented by minute striæ, which intersect each other longitudinally and transversally, forming small regular quadrangles. The aperture is elongated and ovate, the outer lip is thin, the inner lip thick and slightly twisted in its central part. There is no umbilicus. Height 30 mill., br. 19 mill. Eight specimens have been obtained from the hill of Linde and two from Sandarfve.

2. **Macrochilina bulimina** n.

Pl. XV fig. 14—16, pl. XVIII fig. 48—49.

Shell elongate, bulimoid, whorls seven, moderately ventricose, body whorl in length equal with the spire. Suture slightly impressed. Surface covered only with rather irregular, transverse striæ, finer and coarser intermingled. The aperture is elongate, the outer lip sharp and thin, the interior one thickened towards the base, slightly twisted and hiding the umbilicus. H. 17 millim., br. 10 millim. Another specimen, h. 25 mill., br. 13 mill.

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[1]) Proceed. Un. St. National Museum, vol. VI, 184.

Several specimens have been found in the limestone of the hills of Sandarfve and Linde.

This species comes very near to the Lower Silurian Holopea exserta FORBES, Mem. Geol. Survey vol. III, p. 347, but is rather not so much ventricose.

3. **Macrochilina fenestrata** n.

Pl. XV fig. 17—18.

Shell elongate, slender, conical, with five whorls in the only, fragmentary specimen. These whorls have a nearly conical outline and are very little convex, the suture is shallow. The surface is almost smooth, reticulated by transverse and longitudinal, impressed lines of extreme minuteness, forming regular, fenestrate quadrangles, relatively more quadrate and larger than in M. cancellata. The aperture is elongate, acuminate and narrow below, widened and rounded above. The outer lip is thin, the inner one is thick and somewhat tortuous. H. 12 millim., br. 5 millim.

A single specimen has been found in the limestone of Samsugn in Othem.

Fam. XIV. SUBULITIDÆ n.

Shell elongate, fusiform, aperture oblong, narrow, slightly, but most distinctly canaliculated in the superior corner near the columella and thus a short siphon is formed. Whorls generally straight, conical, smooth and unadorned and the suture very shallow.

In this family I enclose such palæozoic shells as Subulites and Euchrysalis. Bulimorpha WHITFIELD and Fusispira HALL probably also belong here. What characterizes them all, besides the elongate and smooth shells and the narrow aperture with incomplete peristome, is the important feature of a distinct apertural canal, situated exactly as in all Siphonostomata and quite as much developed as in several of them, where it has attained its smallest dimensions. This will be found on comparing such genera as Pisania, Metula, Mangelia and especially Daphnella with Subulites, as will be done more in full further on.

We see, consequently, in this family the most ancient representatives of the great section of the Siphonostomous shells. Hitherto the oldest known species of that group have been found in the Triassic strata of St. Cassian in Austria. Shells bearing affinity to Fusus and Fasciolaria, if not strictly belonging to these genera, but at all events to the section of the Siphonostomata, have been described by LAUBE[1]). The limits of the range of the Siphonostomata in time must then be removed as far back as to the youngest beds of the Lower Silurian, where there are species of Subulites found in the Leptæna limestone of Sweden. In Esthonia species of Subulites have also been discovered in the contemporaneous strata.

[1]) Fauna der Schichten von St. Cassian, III Gastrop. Denkschriften der Akad. der Wissensch. zu Wien, Bd 28, 2e Abtheil., 31.

The systematic place of the species of this family is by far not as easily cleared up as their nature of siphonostomous shells and I think, that this question must for the present be left undecided.

Gen. SUBULITES Conrad.

1842 *Subulites* Conrad Nat. Hist. of N. York, Geol. vol. II, 392, fig. 3.
1843 *Polyphemopsis* Portlock, Rept. Geol. of Londonderry, 415.

Shell slender, elongate and fusiform. Whorls straightly conical or only slightly convex, suture shallow, and on both sides a nearly rectilinear outline is formed. Shell thin, fragile and unadorned, last whorl elongated. Aperture elongate or more than double the length against the breadth. It is narrow, the outer lip thin and its lowest corner prolonged into a small acuminated hook, which is most characteristic. The inner lip is involute, thus forming a central canal around the axis, and it ends above abruptly in a transverse line, from which the apertural edge continues in a rounded arch. They have a tendency to grow obliquely along a curved axis.

On plate XVIII a sketch of the aperture of the recent, siphonostomous Daphnella limnæiformis L. has been given, fig. 64, to compare with that of Subulites ventricosus, figs. 58 & 59, and of Subul. curvus fig. 61. The great accordance, especially between fig. 64 and fig. 59, is striking. In all there is almost the same form of the aperture, on the columellar side the same narrow coating of a thin porcellanous stratum, and, above all, uppermost the peculiar and characteristic notch which indicates where the sipho is protruded in the recent shells and probably also had been protruded in the extinct ones. As far as this evidence goes, there is every reason to conclude that Subulites, as well as the related genera, also have been siphonostomous. The transverse sections of Subulites and Euchrysalis, figs. 62 & 68, show the inflected columellar lip in the same manner as a similar section of Daphnella, fig. 63, while the section of a holostomous, recent Turritella, fig. 69, is quite different.

The oldest specimens of this genus already occur in the Leptæna Limestone of Dalecarlia. In the »Fragmenta Silurica»[1] I have with some hesitation described a species as Subulites elongatus Portlock, but I now think that it is identical with Helicites utricularis Wahlenberg[2]) and that it thence is to be named Sub. utricularis. This genus seems to be restricted exclusively to the Silurian formation.

1. Subulites ventricosus Hall.

Pl. XV fig. 19—21, tab. XVIII fig. 58—59.

Subulites ventricosa 1852. Hall Pal. N. York, II, 347, pl. 83 f. 7.
1865. Id. 20th Rept. N. Y. St. Cab., 346. pl. 15 f. 1.

1) Pag. 13, pl. XV f. 21—23.
2) Petref. Suec. p. 72.

Subulites brevis 1865. Winchell and Marcey, Fossils of the Niagara Limestone of Chicago in Mem. Boston N. H. Soc., vol. I, 100, pl. II f. 19.
1868. Meek and Worthen Geol. Survey of Illinois, III, 362, pl. 5 f. 6.
Subulites ventricosus 1868. Hall 20th Rept. N. Y. St. Cab. Revis. Ed., 398 pl. 15 f. 1.

Shell, short, thick, with five whorls, body whorl in length equal to the other four whorls, with which it forms a small angle. Seen from the side the axis is slightly curved. The aperture is narrow, elongate, inferiorly acuminate, above rounded; lower lip continued downwards in an acuminated point. The outer lip thin and sharp, somewhat inflexed, inner lip involuted, bent in a gentle curve and covered with a thin coat of porcellanous shell matter. The siphonal notch is small, but distinct and directed obliquely towards the outer lip. H. 38 mm., breadth 20 mm., h. of aperture 19 mm., breadth 10 mm. There is commonly only the nucleus left and the few vestiges of the shell and its ornamentation show a smooth surface. Through the exterior resemblance with American specimens, which I owe to the kindness of Messrs S. A. Miller and Worthen, I have thought it most convenient to refer the Swedish specimens to the same species as the American ones.

It occurs in the soft shale at Hallshuk north and south of Wisby, Gnisvärd, Walve ref, Westergarn, also from Fårö and the canal in Rute. Prof. Cleve found specimens in Häftingsklint.

2. **Subulites ventricosus**, var. **curvus** n.

Pl. XVIII, fig. 60—61.

Shell slender, bent in a crescent shaped curve, the body whorl forming with the apical ones a larger angle than in the preceding. Whorls six, elongated, slightly convex, smooth, the suture shallow. The aperture is narrow and nearly elliptical, acuminated below and widened above, where the sipho is situated. The inferior corner of the outer lip is widened in a downwards directed thorn. H. 33 millim., br. 15 millim. This variety which I consider as an evolutional form or mutation of the preceding, has been found only in the upper limestone beds near Wisby at Kålens Qvarn and Kyrkberget and in the limestone of Samsugn.

It differs from Sub. ventricosus chiefly in the more slender shape which is so much curved.

3. **Subulites attenuatus** n.

Pl. XV fig. 22, 23, 48, pl. XVIII fig. 62.

Shell elongate, slender, fusiform, with seven whorls, body whorl nearly twice as long as broad, axis of the shell straight, not curved. Surface of the extremely thin shell smooth, without the least traces of ornamentation preserved on the patches still left. Aperture elongate, narrow, nearly four times as long as broad. Lips thin, lower corner of outer lip prolonged in a little acuminated thorn. Aperture on columellar side gently curved, lip much involute. H. 60 millim., br. 19 mill., length of body whorl 35 mill., width of same 6 mill., length of aperture 29 mill., width of same 8 millim.

Abundant at Lansa and other places in Fårö, at Wialmsudd in Bunge, in the canal from Stormyr in Rute, in Martebo, in the shale beds of Wisby, Westergarn and Gnisvärd.

The specimen delineated on plate XV fig. 48 deviates thus far, that it is more slender and the whorls relatively much longer than wide, but as there is only one specimen as yet found, I cannot ascertain if it is a distinct variety or species.

Gen. **EUCHRYSALIS** Laube.

Euchrysalis 1868. Laube Denkschriften der Akad. der Wissensch. in Wien 2e Abtheil., 69.

Shell elongate, widest at the middle of its length, whorls short and numerous, smooth and glossy, suture shallow, the aperture long, narrow, outer lip sharp and thin, the inner lip involute as in Daphnella, ending upwards in a very shallow notch.

After having compared specimens of Euchrysalis fusiformis Münster from St. Cassian with specimens from Gotland described below, I cannot but think that they all belong to the same genus. The Silurian species deviates, however, from the Triassic ones in having a fine sculpture on the glossy surface. The characteristic form of the aperture and the general shape of the shell itself is quite identical. No species seem hitherto to have been found in the Devonian and Carboniferous formations.

Euchrysalis lineolata n.

Pl. XVIII fig. 65—68.

Shell conical, tapering, slender, acuminated and straightly grown, with nine whorls, regularly increasing in size, the body whorl being only twice as large as the next preceding. The whorls are only slightly convex or tumid around their middle and the suture is not much impressed. The surface is sculptured by perpendicular, equidistant, minute ridges, which have their inner side thrice as large as the exterior one. For the rest the surface is smooth. The aperture is, as far as visible, elongated and pointed below, widened above. The columellar lip is involute and the siphonal notch, above, only just perceptible. H. 13 millim., br. 4 mill. Another specimen: h. 18 mill., br. 4 mill.

A dozen specimens have been found in the beds of the red and gray limestone of the hills Sandarfve and Linde.

Additional genus, the systematic place of which is at present uncertain.

Gen. **ONYCHOCHILUS** n.[1])

Shell ovate, sinistral, aperture narrow as a slit, oblique, outer lip with thick border, the inner lip involute, elongate and curved like a claw, probably with a rudimentary siphonal notch. The umbilical region is excavated and deepened into a funnel, wide above and narrow downwards.

This genus must remain provisional untill more specimens have been collected, apt to further elucidate its structure and systematic place.

1. **Onychochilus physa** n.

Pl. XV fig. 55—58.

Shell tumid, ovate, sinistral, whorls four, the last being of more than double the size of all the others taken together. The surface is transversally striated, parallel with the outer lip, the striæ fine, like ribs, running nearly straight from the suture to the umbilicus. The aperture is obliquely elliptical, the outer lip thick, turned out in a narrow elevated rim, the inner one involute and the whole side narrow. The umbilical region is partly destroyed and partly covered as not to be discernible. H. 4 millim., br. 3 millim. Another specimen is 8 millim. in height.

Two specimens, found in the uppermost limestone of Slite by Prof. P. T. Cleve, are preserved in the Museum of the University of Upsala.

2. **Onychochilus reticulatum** n.

Pl. XXI fig. 61—65.

Shell small, trochoid, obese, whorls four, tumid, body whorl more than twice surpassing the other whorls. Their sides are straight or even, only slightly convex and the suture is shallow. The ornamentation consists of fine, longitudinal striæ crossed by thicker, transverse, elevated ridges, nearly double as large and running obliquely from the suture backwards to the umbilicus. There are small, indistinct tubercles at their meeting. The aperture is oblique and narrow, a little more widened at its superior edge. Both lips are thin and the inner one shows the peculiar, clawlike curvature. The umbilicus is a funnel, wide upwards and narrowing downwards. Sectioned longitudinally the whorls show an elongated kidney like shape, being somewhat impressed on the inner side, turned against the umbilical funnel. H. 4 millim., br. 3 millim. Three specimens have been obtained from the red limestone of the hill of Sandarfve.

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[1]) Ὄνυξ, claw, χεῖλος lip.

3. **Onychochilus? cochleatum** n.

Pl. XVIII fig. 54—57.

Shell small, narrow, sinistral, elongately turriculate. The fragmentary specimens have only five whorls left. These whorls are short, depressed, nearly disciform, with an acute ridge around their median line and another ridge on the umbilical side. Transverse lines, regularly distantiated, cross these ridges in a highly acute angle. To judge by the fragments the columellar side of the aperture has been narrow and curved and the umbilicus open and wide. H. 6 mill., br. 4 mill.

From the limestone beds of Slite and Sandarfve.

APPENDIX A.

Table showing the succession of the Palæozoic strata of Sweden.

I. Cambrian.

1. *Oldest sandstone beds of Westrogothia* etc. Eophyton and Fucoid sandstones at Lugnås.
2. *Paradoxides-schists.*
   a) *Zone* of *Paradoxides Kjerulfi.* Hyolithus. A »Metoptoma» found by SCHMALENSEE according to LNSN.
   b) *Parad. Oelandicus.*
   c) *Parad. Tessini.* »Metoptoma» Barrandei LNSN.
   d) *Parad. Davidis.*
   e) *Parad. Forchhammeri.*
   f) *Agnostus lævigatus.*
3. *Olenus-schists.*
4. *Dictyonema-schists.*

II. Lower Silurian.

1. *Ceratopyge-limestone.*
2. *Lower Graptolite-schists.*
3. *Orthoceratite-limestone.*
   a) *Lower red limestone.* Pleurotomaria.
   b) *Lower gray limestone.* Bellerophon. Euomphalus
   c) *Upper red limestone.* Metoptoma.
   d) *Upper gray limestone.* Conularia.
4. *Middle Graptolite-schists.*
5. *Chasmops-limestone.* Conularia. Tremanotus.
6. *Trinucleus-schists.* Phanerotinus (?).
7. *Brachiopod-schists.* Platyceras.
8. *Upper Graptolite-schists* (Retiolites shale of Borenshult etc.) Conularia. »Patella» antiquissima. Murchisonia.
9. *Leptæna-limestone* of Dalecarlia. Platyceras. Cyclonema. Callonema. Holopella. Subulites.

III. Upper Silurian.

1. *Llandovery-beds* near Wisby in Gotland, also at Stygfors and Nitsjö etc. in Dalecarlia.
2. *Wenlock shale* and sandstone of Gotland. Signed *a*, see page 7.
3. *Limestone beds* of Gotland, Scania and Jemtland, shale and sandstone beds of Scania. The Gotland beds are signed *b* and *c* on pages 7 & 9 and following.

APPENDIX B.

Index to the generic names applied to the Gastropoda of the Palæozoic Period.

Aclis LOVÉN 1846, Ind. Moll. 16, used by WHITE 1881, App. to Rep. U. S. Geol. Survey vol. III, xxxv, for a Carbonif. shell.

Aclisina DE KONINCK 1881, Faune du Calcaire Carbonif. de la Belgique II,III, 86. Like a Holopella.

Acroculia see the next.

Acrocylia PHILLIPS 1841, Palæozoic. Foss. of Cornwall, 93. As the name is derived from ἄκρον apex and κυλίω I roll, it must be written as here. Identic with Platyceras, which is prior.

Acrocyllia HERMANNSEN 1846, Indicis Gen. Malac. primordia, 15. See Acrocylia.

Actita FISCHER VON WALDHEIM 1823, Mém. de la Soc. imp. d. Naturalistes de Moscou vol. VI, 234. Deriv. ακτίτης, living near the shore. Intended not only for the recent genera Capulus and Pileopsis, but, as seen in Bull. de Moscou 1844, 832, FISCHER also included Carboniferous Platycerata in it.

Agnesia DE KON. 1883, Faune Carb. Belg. II,III, 99. A sinistral Pleurotomaria.

Ampullacera QUOY & GAIMARD 1832, Voy. Astrol. Zool. II, 196. Used by DE KONINCK 1843 in Anim. Foss. Carbonif. Belg. 486. One of the Pleurotomaridæ = Scalites according to DE KON. 1881.

Ampullaria LAMK 1799, Prodr. 76, employed by SOWERBY 1828, Min. Conch. VI, 40, for shells of the Belgian Carbon. Form. probably Euomphali.

Anatomus MONTFORT 1810, Conch. Syst. II, 278. = Pleurotomaria p. p.

Anomphalus MEEK & WORTHEN 1866, Proceed. Acad. N. Sc. Philadelphia, 268. Seems to be one of the Umbonidæ.

Anthracochiton ROCHEBRUNE 1882, Ann. Sc. Géol., XIV, 26. Carbonif.

Anticalyptræa QUENSTEDT 1884, Handbuch der Petrefaktenkunde, 3e Aufl., 673. = Autodetus.

Autodetus LINDSTRÖM 1884, Silurian Gastropoda of Gotland, 185. One of the Phoridæ.

Baylea DE KON. 1883, Faune II,IV, 68, Fam. Pleurotomaridæ?

Bellerophon MONTF. 1808, Conch. System. I, 51.

Bellerophus BLAINVILLE 1825, Malac. 477. »Mala emendatio» of the preceding, says HERMANNSEN.

Beloplaxus OEHLERT 1881, Mem. Soc. Géol. de France, 3 Ser. vol. II, 17. A Devonian Chitonid; type Chiton sagittalis SANDBERGER.

Bifrontia DESHAYES 1833, Descript. Coq. Foss. des environs de Paris II, 221. Contains chiefly Tertiary species, but DESHAYES also ranged Euomph. catillus in this genus.

Brilonella KAYSER 1873, Zeitschrift Deutsch. Geol. Gesellsch., 672. A Devonian shell of the Pleurotomaridæ.

Bucanella MEEK 1870, Proceed. Amer. Philos. Soc., vol. 11, 426.

Bucania HALL 1847, Pal. N. York I, 32. A Bellerophon with cancellated ornamentation.

Buccinites SCHLOTHEIM 1820, Petrefactenkunde, 127. Contains, besides others, Devonian Macrochilinæ.

Buccinum L. 1758, S. N. ed. X, 734. HOENIGHAUS and others used it for species of Macrochilina.

Bulimella HALL 1858, Transact. Albany Instit. vol. IV, 29. = Macrochilina? The name is preoccupied by PFEIFFER in 1852.

Bulimorpha WHITFIELD 1882, Bullet. № 3, American Museum Nat. Hist., 74.

Callonema HALL 1879, Pal. N. York vol. V, pt. II, 50. The species of this genus were formerly regarded as belonging to Isonema.

Calyptræa LAM. 1799, Prodr., 78. Autodetus was first considered to belong to this genus by EICHWALD Leth. ross. I, pt. 2, 1104.

Capreolus R. ETHERIDGE Sr 1878, Qu. Journ. Geol. Soc. vol. 34, 603, *lapsu pro* Capulus.

Capulus MONTFORT 1810, Conch. System. II, 54 has been applied by various authors to most species of Platyceras.

Carinaropsis HALL 1847, Pal. N. York, I, 183. Species of Bellerophon and Lepetopsis.

Catantostoma SANDBERGER 1842, LEONH. & BRONN Jahrb. 392. Fam. Pleurotomaridæ.

Centrifugus HISINGER 1835 in a letter to BRONN according to Lethæa Geogn. vol. 1 ed. 1, 96. = Inachus HIS.

Cerithium ADANSON 1757, Seneg. 153. Used by VERNEUIL and others for Silurian shells of different genera.

Chelodes DAVIDSON & KING 1874, Qu. Journ. Geol. Soc., 167, a subgenus of Chiton.

Chemnitzia D'ORB. 1839 in WEBB and BERTHELOT Iles Canar.... HERMANNSEN. Ind. I, 222 identifies Loxonema PHILLIPS and Phasianella p. p. GOLDF. with this genus.

Chiton L. 1758, S. N. X, 667. BARRANDE Syst. Sil. Boh. III, 175 has a species of Chiton, which belongs to Chelodes.

Chonechiton CARPENTER 1882 according to DALL Proceed. Un. States Nat. Museum, 1882, 280. Carbonif. Belgium.

Cirridius DE KON. 1882, Faune, II,III, 101 = Cirrus DE KON. 1843 not SOW.

Cirrus SOWERBY 1816, Min. Conch. II, 93 = Euomphalus according to SOWERBY himself l. c. p. 219.

Clisospira BILLINGS 1865, Pal. Foss. I, 186. A Lower Silurian species probably allied to Autodetus or the Phoridæ.

Codonochilus (not Codonocheilus) WHITEAVES 1884, Geol. Surv. of Canada, Palæoz. Foss. vol. III pt. I, 17. Upper Silurian Canada.

Coelocentrus ZITTEL 1882, Handbuch d. Pal. 1 Bd., 206 = Cirrus DE KON. Euomph. Goldfussi D'ARCH. & VERN is the type.

Conchopeltis WALCOTT 1876, 28th Rept. State Cab. N. Y., 93. A Patelloid or a Pteropod?

Conchula STEININGER 1853, Geognost. Beschreibung der Eifel, 46. Differs from Scoliostoma through the shape of the aperture, which is parallel with the axis of the shell. Devonian.

Craspedostoma LINDSTR. 1884, Silur. Gastropoda of Gotland, 181.

Cryptænia E. DESLONGCHAMPS 1865, Bull. Soc. Linnéenne de Normandie, 424. A Pleurotomaria found in the Carboniferous strata and also in Lias.

Cyclonema HALL 1852, Pal. N. Y. vol. II, 89.

Cyclora HALL 1845, Sillim. Journal, vol. 48, 294.

Cyrtolites CONRAD 1838, Ann. Rep. N. Y. State Cab., 118.

Cyrtonella HALL 1879, Pal. N. Y. vol. V, pt. II, 123.

Delphinula LAMK 1804, Ann. du Muséum IV, 108. GOLDFUSS and HISINGER have referred several of the Oriostomata to this genus. True Delphinula begin to appear in the strata of St. Cassian.

Dentalium L. 1758, S. N. ed. X, 785. The oldest species known are Devonian.

Ditaxopus RAFINESQUE 1839, Bull. Soc. Géol. X, 378. Perhaps a Bellerophon.

Duncania BAYLE 1879, Journ. de Conchyliologie vol. 19, 35, later changed into Macrochilina.

Eccyliomphalus (not Ecculiomphalus) PORTLOCK 1843, Rep., 411. Most species nothing but evolute Euomphali. According to the derivation the name is to be written as above.

Elenchus HUMPHREY 1797, Mus. Calonnianum . . ., according to MAC COY Carb. Foss. Ireland, 42, a species in the Old Red Sandstone of Ireland, but may probably belong to another genus.

Ellipsolithes SOWERBY 1813, Min. Conch., vol. I 81, non MONTFORT, whose genus embraced only Polythalamia. SOWERBY has himself later in Min. Conch. vol. 5 p. 107 corrected his species and indicated two as Cephalopoda and one, Eu. ovatus, as a Bellerophon.

Entalis GRAY 1840, Syn. Brit. Mus. . . . See WAAGEN. Pal. Ind. XII p. 180.

Eotrochus WHITFIELD 1882, Bullet. Amer. Mus. N. Hist. № 3 p. 77.

Euchrysalis LAUBE 1868, Denkschriften Akad. Wissensch. zu Wien, 2:e Abtheil. 69. Silurian and Trias.

Eulima RISSO 1826, Hist. IV p. 123, Loxonema and Polyphemopsis are synonymous according to HERMANNSEN.

Eunema SALTER 1873, Catal. Mus. Cambridge, 156.

Euomphalopterus FERD. ROEMER 1876, Leth. Geogn. Atlas. Taf. 14. f. 9. — Type, E. (Pleurotomaria) alata, Silurian.

Euomphalus Sow. 1814, Min. Conch. vol. 1, 97.

Euphemus MAC COY, 1844 Carbonif. Foss. of Ireland, 25. Although M'Coy himself later, in Brit. Palæoz. Foss., 308, declared that this genus was identical with Bellerophon, the slit band having by oversight been described as deficient, WAAGEN and DE KONINCK have again tried to revive it. But on comparing the species described by both these authors as belonging to Euphemus, it is easily found that the Euphemus of WAAGEN cannot be reconciled with that of DE KONINCK. While the latter author as Euphemi describes E. Urii and other Bellerophons, WAAGEN makes us acquainted with several forms so strange, that it may be doubted whether they are Gastropoda at all or not rather Cephalopoda of some new genus.

Exogyroceras MEEK and WORTHEN 1868, Geol. Survey of Illinois, vol. III, 509.

Fissurella BRUG. 1789, Encycl. method. vol. I p. XIV, palæozoic according to GOLDFUSS and MAC COY, but JHERING, Moll. p. 78, says that they are met with first in Trias.

Flemingia DE KON. 1882, Faune II, III, 94.

Fusispira HALL 1870, 24th Rep. St. Museum N. York p. 229.

Glyptobasis DE KON. 1883, Faune, II, III, 92. Similar to a Trochus.

Glyptochiton DE KON. 1883, Faune II, III, 211.

Gosseletia DE KON. 1883, Faune II, III, 28. The name is already in 1881 preoccupied for a Lamellibranchiate by CH. BARROIS in Ann. Soc. Géol. du Nord VIII p. 176. Pleurotomaria.

Gryphochiton GRAY, 1847, Proc. Zool. Soc. p. 70. Devon. and Carbon.

Gyrotrema BARRANDE 1868, apud BIGSBY. Thes. Silur. p. 167 = Tremanotus. HALL.

Helcion MONTFORT 1810, Conch. Syst. II p. 63, applied by some to palæozoic Patellids.

Helicites SCHLOTHEIM 1813, Jahrb. VII p. 35. Contains species of different genera, as Euomphalus, Pleurotomaria, Oriostoma.

Helicotoma SALTER 1859. Dec. I, Geol. Survey of Canada, 10 = Euomphalus and Pleurotomaria.

Helminthochiton SALTER 1846, Proc. Geol. Soc. Lond, 49, 51, 52, f. 6.

Hercynella KAYSER 1878, Fauna der ältesten Devonabl. d. Harz, 101. = Pilidium BARR. Mss not FORBES.

Holopea HALL 1847, Pal. N. Y. vol. I, 169.

Holopella MAC COY 1852, Brit. Pal. Foss., 303.

Hormotoma SALTER 1859, Canad. Organ. Remains Dec. I, 18. = Murchisonia.

Igoceras HALL 1859, Pal. N. Y. vol. III, 330. = Platyceras.

Inachus HISINGER 1838, Lethæa, 37. Name preoccupied for a Crustacean. Consisted of three species of which one, I. sulcatus, is a Pleurotomaria, I. angulatus, is a Oriostoma and I. costatus a Cephalopodous shell, probably a Trochoceras.

Isonema MEEK and WORTHEN 1865, Proc. Acad. Nat. Sc. Philad., 251.

Lepetopsis WHITFIELD 1882, Bullet. Amer. Museum of Natural. Hist. № 3, 67.

Litiopsis EDW. FORBES accord. to SALTER 1866 in Mem. Geol. Survey III, 346 = Holopea.

Litorina FÉR. 1821, Tabl. System., XXXIV. Several of the palæozoic species, which have been called Cyclonema, were regarded as Litorinæ by PICTET.

Loricites CARPENTER accord. to DALL, Proceed. U. S. Nat. Mus. 1882, 281, A Carboniferous Chitonid from Belgium.

Loxonema PHIL. 1841, Palæoz. Foss. of Cornwall, 98.

Luciella DE KON. 1883, Faune Carbonif. Belgique II, IV, 107. A Pleurotomaria.

Maclurea EMMONS 1843, Geol. N. Y. II, 312.

Maclurita BLAINVILLE 1825, Malac., 424.

Maclurites LE SUEUR 1818, Journ. Ac. N. S. vol. I, 312.

Macrochilus (not Macrocheilus) PHIL. 1841, Palæoz. Foss., 103.

Macrochilina BAYLE 1880, Journ. de Conchyliologie 3 Ser. vol. XX, 241. = Macrochilus & Duncania.

Margarita LEACH 1819, Journ. de Phys. 464, WAAGEN Salt Range Fossils, 111.

Metoptoma PHILL. 1836, Geol. Yorkshire pt. 2, 223.

Michelia F. A. ROEMER 1854, Palæontographica Bd. 3, 73. Near Loxonema.

Microceras HALL 1845, Sillim. Journ. vol. 48, 294.

Microdoma MEEK and WORTHEN 1866, Philadelphia Proceed. 269.

Mitchellia DE KON. 1876, Foss. du Nouv. Galles du Sud I, 128.

Mogulia WAAGEN 1880, Salt Range Foss. Palæont. Indica vol. XIII, 131.

Mourlonia DE KON. 1883, Faune Carbonif. de Belg., 245. = A Pleurotomaria.

Murchisonia D'ARCHIAC & VERNEUIL 1841. Bull. Soc. Géol. XII, 154.

Narica RÉCLUZ 1841, according to D'ORB. Moll. Cub. II, 39, used by DE KONINCK 1844, Anim. Terr. Carbonif., 475.

Nassacites KRÜGER 1823, Gesch. der Urwelt Th. 2, 417. = Machrochilina?

Natica ADANSON 1757, Sénégal., 172. D'ORBIGNY and PICTET consider that this genus is represented in the Silurian formation, probably = Platyceras.

Naticella SWAINSON 1840, Malac., 345. There are species referred to this genus described from the Silurian and Carboniferous formations, but probably belonging to other genera.

Naticodon DE RYCKHOLT 1852, Mélanges paléontologiques, 75, in Mém. Cour. Acad. R. d. Sci. de Belgique 1re pt., 75. Carboniferous.

Naticopsis MAC COY 1844 Synops. Carbonif. Spec. of Ireland, 33.

Natiria DE KON. 1881, Faune Calc. Carbonif. Belg. II, III, 5.

Nerita L. 1758 S. N. ed. X, 776, N. haliotis Sow. Sil. Syst. = Platyceras.

Neritomopsis WAAGEN 1880, Pal. Ind. XII, 106.

Niso RISSO 1826, Hist. IV, 218. Employed by DE KONINCK in Fossiles Pal. de Nouv. Galles du Sud 1876, 127, for a Devonian species.

Odontomaria FERD. ROEMER 1876, Leth. Geogn. 1 Theil. Taf. 29, f. 10, Devonian.

Omphalotrochus MEEK 1864, Rept. Geol. Surv. California. Palæont. vol. 1, 16. Related to Oriostoma, not a Pleurotomarian as DE KONINCK thinks.

Onychochilus LINDSTRÖM 1884, Silurian Gastropoda of Gotland, 196.

Ophileta VANUXEM 1842, Geol. N. Y. vol. III, 36.

Oriostoma MUNIER-CHALMAS 1876, Journal de Conchyl. vol. XVI, 103. Comprises several palæozoic forms which have been regarded as Euomphali, without being provided with the characteristic slit in the aperture.

Orthonema MEEK & WORTHEN 1861, Proc. Acad. N. Sc. Philad., 146, Carboniferous.

Orthonychia HALL 1843, Rept. 4th Distr. N. Y. Geol. Surv., 172. A division of Platyceras.

Orthostoma CONRAD 1838, Ann. Rep. N. Y., 119. Perhaps a disjointed Euomphalus, perhaps a Cephalopod.

Palæacmæa HALL 1873, 23d Rept. N. Y. St. Cab., 242.

Palæotrochus HALL 1879, Pal. N. Y. vol. V, pt. II, 133.

Patella L. 1758, S. N. ed. X, 780.

Patellostium WAAGEN 1880, Pal. Ind. XII, 131. One of the Bellerophons.

Phanerotinus SOW. 1844, Min. Conch. vol. VII, 29. A very interesting form with disjointed whorls, plano-spiral and a large cristate lamina along the dorsal side. Is it related to the alate Pleurotomariæ?

Phasianella LAMK 1804, Ann. du Muséum, IV, 295. According to WAAGEN Pal. Indica XII, 109, Carboniferous.

Phorus MONTFORT 1810, Conch. Syst. II, 158. According to EUDES-DESLONGCHAMPS, Bullet. Soc. Linnéenne de Normandie VI, 146 there is a Devonian species.

Phragmolithes CONRAD 1838, Rept. N. Y. Geol. Surv., 119. = Cyrtolites.

Phragmostoma HALL 1861, 14th Rept. N. Y. State Cab., 94.

Phymatifer DE KONINCK 1881, Faune II, III, 149. Related to Porcellia.

Pileopsis LAMK 1812, »Extrait d'un Cours» etc. according to HERRMANNSEN Index II, 268. Anim. sans Vertebr. 1822, vol. 6, 2 p. 16. The fossil species of LAMARCK are tertiary, the majority is recent.

Pilidion BARRANDE 1865, according to BIGSBY. Thes. Silur. 161, 168.

Pithodea DE KONINCK 1881, Faune II, III, 88.

Pitonellus MONTFORT 1810, Conchyl. System. II, 170.

Platyceras CONRAD 1840, Ann. Rept. Geol. Surv. N. Y., 205.

Platystoma (not Platyostoma) CONR. 1842, Acad. Nat. Sci. Philad. Journ. 1839—42, 275.

Platy(o)stomella R. ETHERIDGE jr 1880, Proc. R. Phys. Soc. Edinb., 163, Carbonif.

Platyschisma MAC COY 1844, Carbonif. Foss. of Ireland, 38.

Plectostylus CONRAD 1842, Journ. Ac. N. Sc. Phil. 1839—42, 275. The name in 1837 preoccupied by BECK for a Helicid shell.

Pleuronotus HALL 1879, Pal. N. Y. vol. V, pt. II, 138. = Euomph. Decewi.

Pleurotomaria DE FRANCE 1821 in FÉRUSSAC, Tabl. Syst., XXXIV.

Pleurotomarium BLAINVILLE 1825, Malac., 429, »male» HERMANNSEN.

Polyphemopsis PORTLOCK 1843, Rept. Geol. Londonderry, 415, probably = Subulites.

Polytremaria D'ORB. 1850. Prodr. I, 122. Carbonif.

Polytropis DE KONINCK 1881, Faune II, III, 107. = Oriostoma.

Porcellia L'EVEILLÉ 1835, Mém. Soc. Géol. de France II, 39.

Portlockia DE KON. 1881, Faune II, III, 81.

Priscochiton BILLINGS 1865, Palæoz. Foss. Canada I, 394. Lower Silurian.

Probolæum CARPENTER according to DALL 1882, Proc. N. S. Nat. Mus. 281, a Devonian Chitonid.

Protalochiton ROCHEBRUNE 1882, Ann. Soc. Géol. XIV, 30, Carbon.

Pseudophorus MEEK 1873, Geol. of Ohio I, 222.

Pterochiton CARPENTER according to DALL 1882, Proc. U. S. Nat. Mus. 281, Belgium, Ireland, Carbonif.

Ptychomphalus AGASSIZ 1837 in Gross-Britaniens Mineral Conchologie von James Sowerby. Deutsche Bearbeit. von Ag., 23 and 222,

Pycnomphalus LINDSTR. 1884, Silurian Gastropoda of Gotland, 153.

Rhabdopleura DE KON. 1881, Faune II, III, 75.

Rhaphistoma HALL 1847, Pal. N. Y. I, 28.

Rhineoderma DE KON. 1883, Faune, II, IV, 103.

Rhombochiton DE KON. 1883, Faune II, IV, 206.

Rotella LAM. 1822, Hist. VII, 6. According to DE KONINCK a fossil species occurs in the Carbonif. form. of Belgium.

Rotellina DE KON. 1883, Faune II, IV, 92.

Sagmaplaxus OEHLERT 1881, Mém. Soc. Géol. de France 3me Ser. Tome II, 15 a Chitonid.

Salpingostoma FERD. ROEMER 1876, Leth. Geogn. Taf. 5, f. 12.

Scævogyra WHITFIELD 1877, Palæontology of Wisconsin, 253.

Scalites CONRAD 1842, EMMONS Geol. Rep., 312.

Scissurella D'ORB. 1823, Mém. Soc. H. N. Par. I, 340.

Schizostoma BRONN 1835, Lethæa, Ed. 1 vol. I, 95.

Scoliostoma M. BRAUN 1838, N. Jahrbuch, 291.

Serpularia A. F. ROEMER 1843, Geol. Harzgebirge, 31. = Pleurotomaria.

Siphonaria SOW. 1824, Gen. of Shells, pl. 143. Used by BARRANDE according to BIGSBY, Thes. Sil., 168 for a Bohemian Patelloid.

Solarium LAMK 1801, Syst. anim. s. vert. 86. DE KONINCK used 1843 this name for Euomphalus or Pleuronotus.

Soleniscus MEEK & WORTHEN 1860, Proc. Ac. N. Sc. Philad., 467, Carbonif.

Spirorbis, STEININGER 1831, Bemerkungen über die Verstein. in der Eifel. STEININGERS Sp. maximus belongs to the Devonian Euomphalus.

Stachella Waagen 1880, Pal. Ind. XII, 132.

Stomatella Lamk 1809, Phil. zool., I, 321. Used by Barrande accord. to Bigsby Thes. Sil., 168.

Stomatia Lamk 1801, Syst. anim. s. vert., 96. Pictet and Jhering think that there are Silurian species.

Straparollina Billings 1865, Palæoz. Foss. of Canada, 223.

Straparolus Montfort 1810, Conch. syst. II, 174. Derived from στραβός, torsus, and Rollus, a barbarous word for the French »Rouleau».

Strobeus De Kon. 1881, Faune II, iii, 25. = Elenchus Mac Coy not Humphrey.

Strophites Dawson 1880, Amer. Journ. Sc. & Arts 3d Ser. vol. 20, 412. A Devonian Landshell?

Strophostylus Hall 1859, 12th Rept. N. Y. St. Cab., 20. Probably a Platyceras.

Subulites Conrad 1842, N. Hist. of N. Y., vol. II, 392.

Sulcochiton Ryckholt 1862, Journ. Conch. X, 259.

Terebra Adanson 1757, Seneg., 49, used by Sowerby for Loxonema sinuosa. Sil. Syst.

Trachydomia Meek and Worthen 1866, Geol. Survey Illin. vol. 2, 364. Carbonif.

Tremanotus Hall 1868, 20th Rept. N. Y. State Cab. 399.

Trochilites Schlotheim 1820, Petrefaktenkunde, 156.

Trochita Schum. 1817, Essai, 184, Mac Coy Carbonif. Foss. Irel., considers a fossil to belong here. There are also other palæozoic species by mistake referred to this genus.

Trochonema Salter 1859, Canad. Organ. Remains I, 27.

Trochotremaria Ryckholt, Carbonif. of Belgium according to Zittel Palæont. Bd 1, 2, 181.

Trochus L. 1758, S. N. Ed. X, 756.

Tropidocyclus De Koninck 1882, Mém. Soc. Geol. de Belg. t. IX, 12.

Tropidiscus Meek 1866, Proc. Chic. Acad. Sc. vol. I, 9. = Cyrtolites.

Tropidodiscus Waagen 1880 Palæont. Indica, XIII, 131, name of the former emendated by Waagen.

Tryblidium Lindström 1880, in Fragmenta Silurica, 15.

Tubina Barr. 1860, in Owen Palæontology, 71.

Turbina De Koninck 1881, Faune II, iii, 67.

Turbinilopsis De Kon. 1881, Ibid. 89.

Turbinites Schloth. 1820, Petref.-kunde 163, Wahlenberg applied it to several species of Oriostoma.

Turbo L. 1758, S. N. X, 761, Pictet and D'Orbigny gave this name to several of the Oriostomata and Cyclonemata.

Turbonellina De Kon. 1881, Faune II, iii, 77.

Turbonitella De Kon. 1881, Faune II, iii, 72.

Turritella Lamk 1801, Syst. anim. s. vert. 89. Used for Murchisonia and other spirally wound shells by several authors.

Tychonia De Kon. 1881, Faune II, iii, 7.

Umbonium Link 1807, Beschreib. Rostocker Samml. III. 136, Devon.

Vasulites Herrmannsen 1849. Index II, 677, cites it as used by Montfort in »Suites à Buffonn-Sonini IV, 298.

Waagenella De Koninck 1883, Faune II, iv. Explic. des planches n:o 38, for

Waagenia De Koninck 1882, Ann. Soc. Geol. de Belgique t. IX, 14, which name had already been preoccupied.

Warthia Waagen 1880, Pal. Indica XIII, 131.

Worthenia De Kon. 1883, Faune III, iv, 64.

Xenophora Fischer von Waldheim 1806, »Museum Demidowianum, 213». Meek and Worthen ranked a Carbonif. species in this genus.

PLATE I.

The originals to the figures belong to the Swedish State Museum of Natural History in Stockholm, unless otherwise stated.

PLATE I.

Fig. 1—3. *Conularia cancellata* SANDB. pag. 42. Fig. 1 spines on the lowest row with broken points, whence the circular openings, f. 2 part of two transverse ridges highly magnified, f. 3 longitudinal section. The long spines are those on the ridges, the short ones are sections of the ridges where no spines are found.

» 4—8. *Conularia bilineata* n. p. 45. F. 4 lateral view, f. 5 section near the upper margin, f. 6 surface near the apex magnified, f. 7 the same higher up between the two median septa, f. 8 ornamentation in lower part of the shell.

» 9—12. *Conularia monile* n., p. 44. F. 11 transverse lines magnified and sectioned longitudinally, f. 12 transverse section of transverse lines.

» 13—16. *Conularia lævis* n., p. 45. Fig. 15 transverse section of specimen fig. 13., fig. 16 surface of fig. 14 enlarged.

» 17—24. *Autodetus calyptratus* SCHRENK, p. 185. Fig. 17 shell in its natural position and grown on a Favosites, figs 17 a — 22 other specimens and details of apex and umbilicus, fig. 24 part of the longitudinal section magnified to show the cellular structure outside the whorls.

» 25—31. *Tryblidium reticulatum* n., p. 55. Fig. 27—28 apex of a young specimen, f. 29 interior stratum with traces of colour bands, f. 30 muscular scars of the inside, f. 31 longitudinal section of the shell.

» 32. *Patella (Olana) cochlear* L. Recent. Inside to show the muscular scars.

» 33—37. *Tryblidium unguis* n., p. 56. Fig. 36 inside of apex with oval pit like a scar, f. 37 inside of shell with muscular scars.

» 38—39. *Nacella deaurata* GMELIN, recent from Foua, to compare the exterior shape with the preceding.

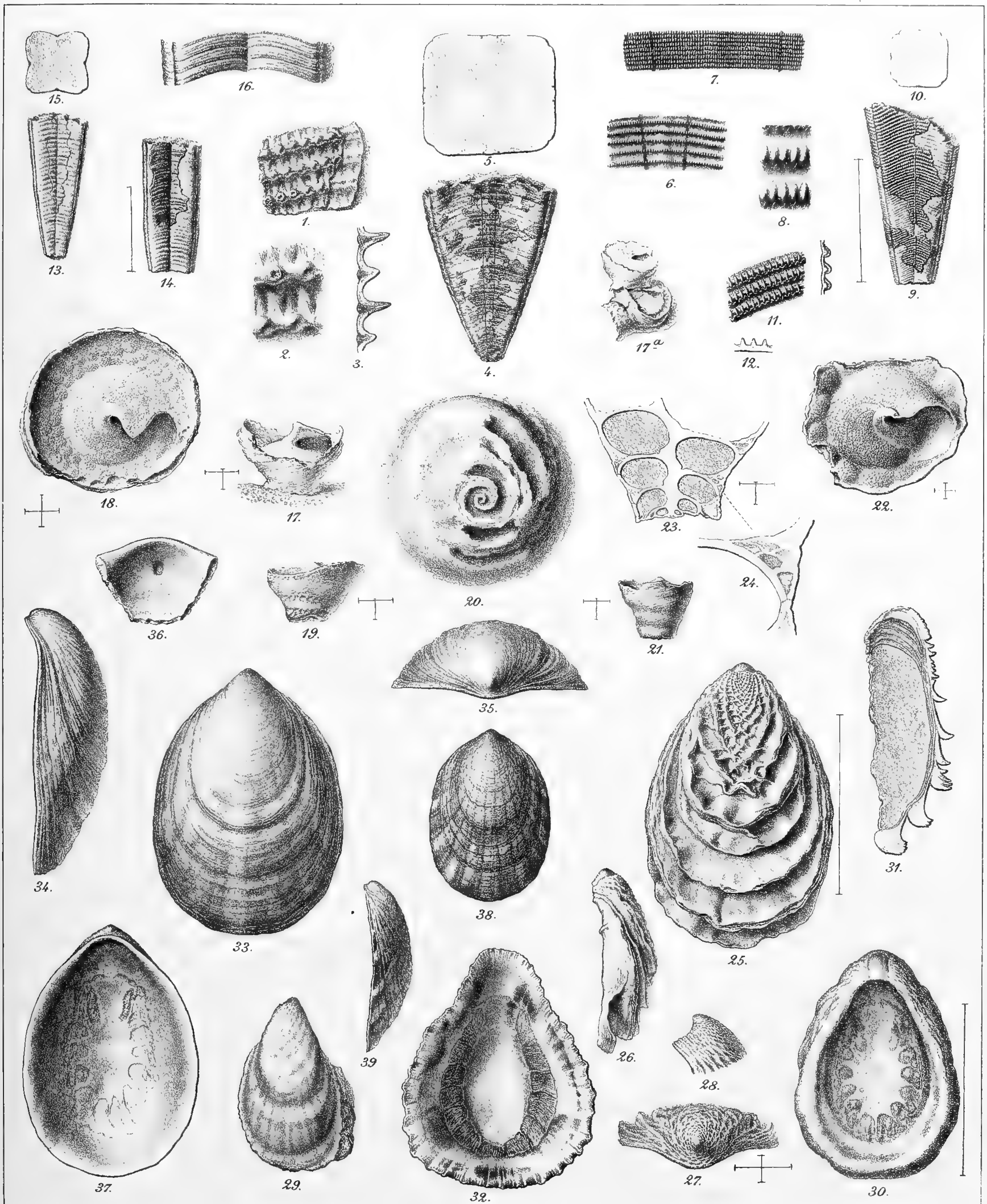
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PLATE II.

PLATE II.

Fig. 1— 4. *Chelodes Bergmani* DAVIDSON & KING, p. 51. Same specimen as figured by DAVIDSON.
» 5— 8. Another specimen also from Klinteberg, 7—8 in natural size.
» 9—10. *Chelodes Gotlandicus* n. p. 52, from Grötlingbo.
» 11—15. A specimen from Grötlingbo, f. 13—14 nat. size.
» 16—17. A specimen from Bursvik, nat. size.
» 18—27. Shorter valves from Grötlingbo, f. 20—21 nat. size.
» 28. *Chiton* sp. indet. Recent. Interior side to compare with fig. 25.

Platyceras cornutum HISINGER p. 63.

» 29—31. From Wisby, details of ornamentation magnified.
» 32—36. From Fårö, f. 32—33 resembling Nerita haliotis Sow., 34—36 like a Ianthina.
» 37—38. From Eskelhem, »Strophostylus».
» 39—40. Large specimen from Fårö, nat. size.
» 41—43. From Klinteberg, with lobate aperture. Compare Plat. niagarense HALL the 28 Rept. N. Y. St. Cab. pl. 28 f. 2—4.
» 44—45. Nucleus from shale beds of Wisby.
» 46—47. From Klinteberg, loosely coiled.
» 48. From middle limestone of Wisby.
» 49—50. From Klinteberg, disjointed whorls.
» 51. Drawn from HISINGER's original specimen to »Pileopsis cornuta» as exact as possible, nat. size.
» 52. Drawn from HISINGER's original specimen to »Pileopsis sulcata» being corroded sample of the following variety, nat. size.
» 53—57. Variety »loricatum» from Klinteberg f. 55 umbilical side, f. 56 the apical one.
» 58. *Craspedostoma elegantulum* n. p. 183.
» 59—72. *Platyceras enorme* n. p. 69, various specimens, with details of ornamentation, all from Rikvide in the parish of När.
» 73—78. *Platyceras disciforme* n. p. 68, from the sandstone of Hoburg in nat. size, ornamentation highly magnified.

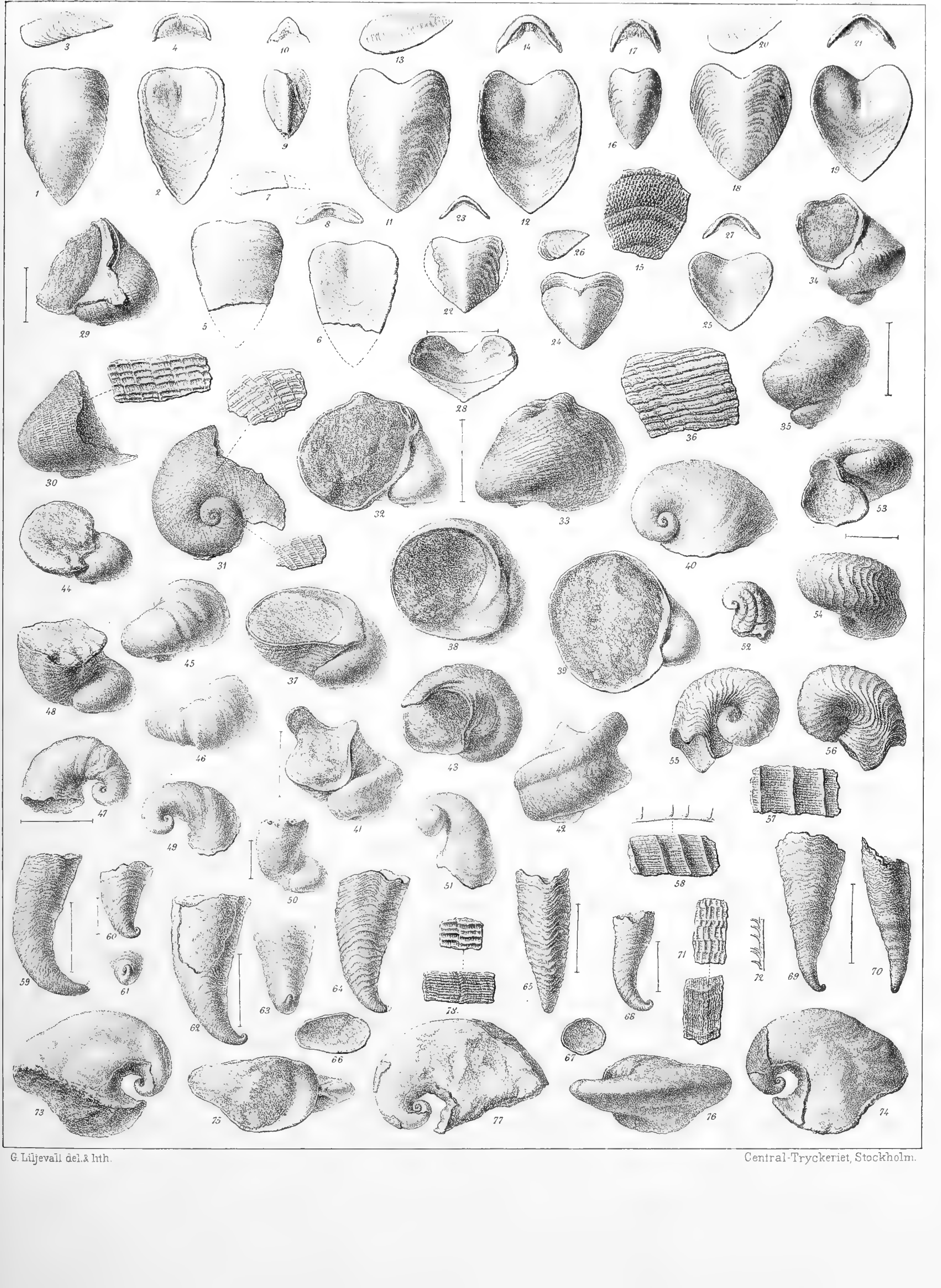

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PLATE III.

Plate III.

Fig. 1—5. *Tryblidium reticulatum* n. p. 55. Fig. 1 & 2 microscopical vertical and horizontal sections of the shell, showing its strata perforated by tubes of unknown, parasitic organism, f. 3 another vertical section, f. 4 vertical section with apparently tubular structure, formed by small depressions or pits on the surface of the shelly strata, f. 5 surface of shell from the margin of the aperture, magnified; the elevated, white dots being the filled up tubes of the parasitic organism.

» 6—9. *Platyceras cornutum* His. p. 63. Fig. 6 from Klinteberg, with aperture evidently moulded after the surface of some other organism on which it had been fixed, f. 7—9 from Wisby.

» 10—18. *Platyceras prototypum* Phill. p. 67. Fig. 10—10 *a* from Klinteberg, f. 11—12 from the shale of Wisby, identical in ornamentation with specimens of Platystoma niagarense, f. 13—14 from the hill of Sandarfve, f. 15 ornamentation of the same and profile of a transverse ridge, f. 16 a pair of its apertural lamellæ, f. 17 vertical section of seventeen lamellæ, as they were left *in situ* imbedded in soft limestone, slightly magnified, f. 18 one of the lamellæ highly magnified to show its intimate structure.

» 19—26. *Platyceras cornutum* His. p. 63. Fig. 19—22 vertical sections of the shell, f. 23 interior surface of the shell seen under the microscope; f. 24 part of the same still more magnified, f. 25—26 horizontal sections of the shell.

» 27—31. *Oriostoma helicinum* n. p. 170, from the canal near Westöös in Hall.

» 32—34. *Craspedostoma spinulosum* n. p. 182, from Hoburg, f. 34 nat. size.

» 35—38. *Bellerophon sphæra* n. p. 74, from the shale of Wisby.

» 39—40. *Tremanotus longitudinalis* n. p. 86, from Lutterhorn in Fårö, with apertural expansions left in situ.

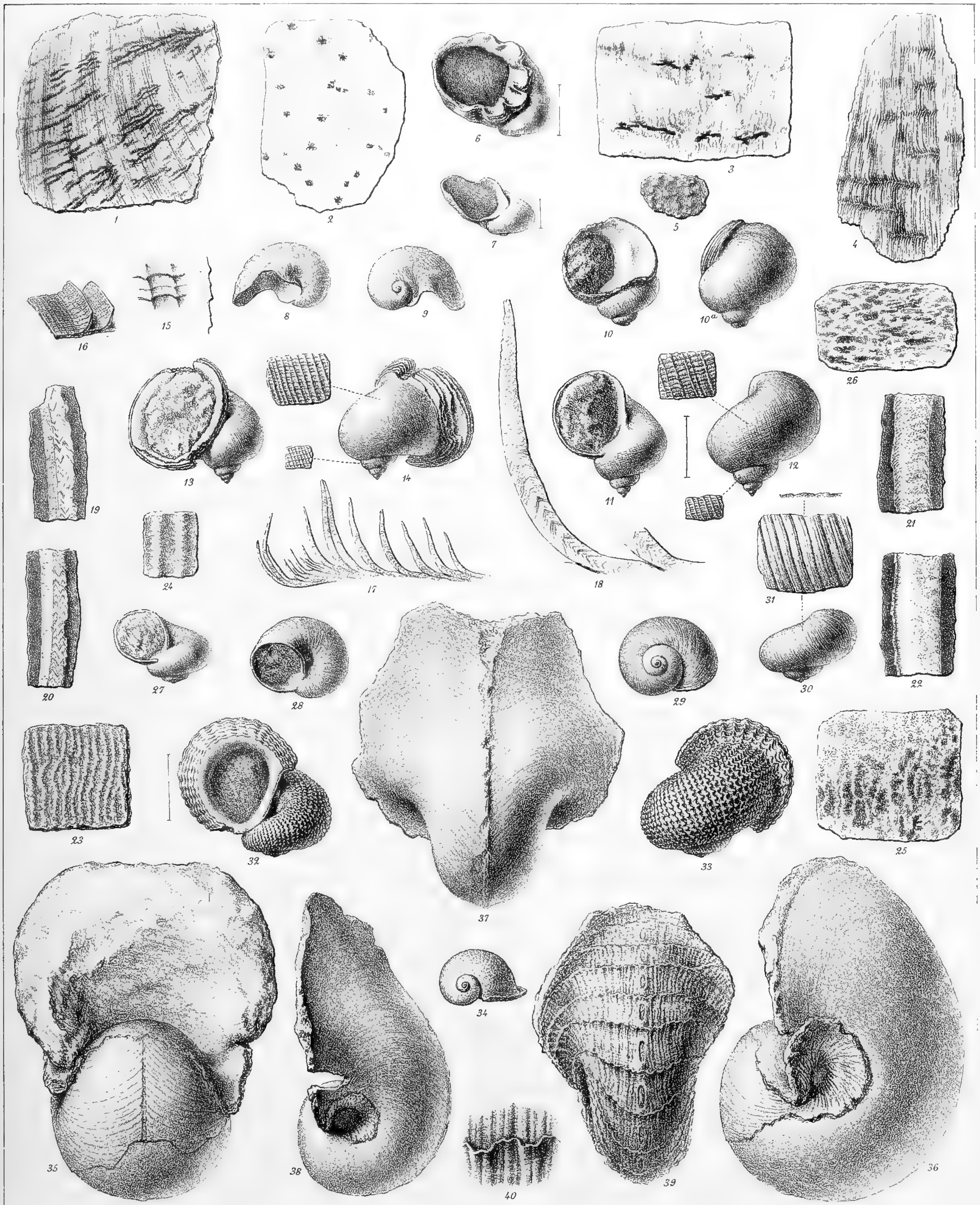

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PLATE IV.

Plate IV.

Fig. 1—7. *Tremanotus longitudinalis* n. p. 86, all specimens from Wisby, f. 5 dorsal keel with apertures, from a cast, f. 6 magnified details of the same, showing septa like, curved lines, going transversally, marking where apertural lamellæ have been situated.
» 8—12. *Tremanotus compressus* n. p. 87, from Östergarn.
» 13—15. *Bellerophon trilobatus* Sow., p. 80, from Petesvik, Habblingbo.

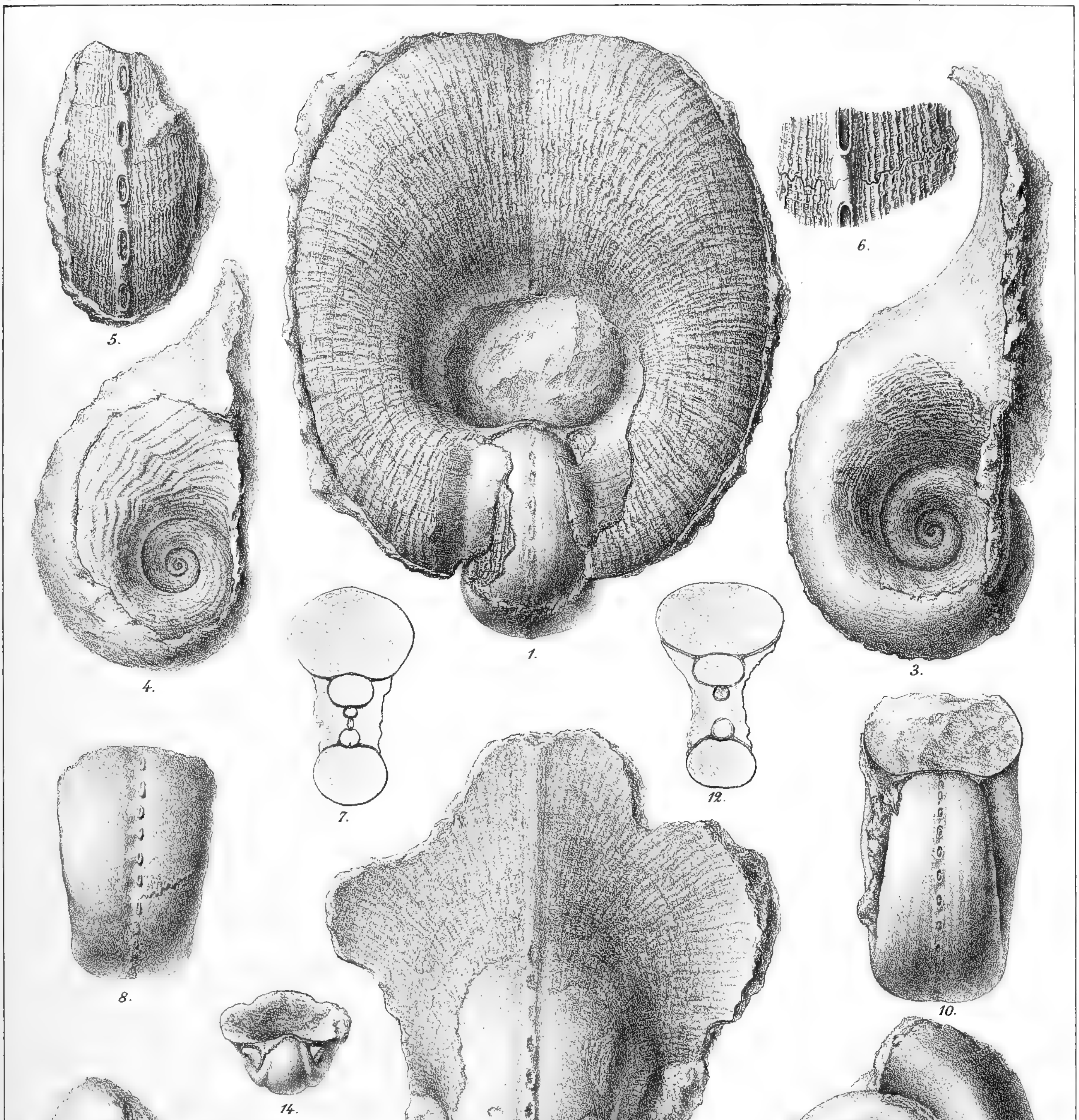
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PLATE V.

Plate V.

Fig. 1—16. *Bellerophon sphæra* n., p. 74. Fig. 3 cast of »dorsal» part with the elevated slit band and section of the same, f. 4 the same from the side, f. 7, surface of a variety with lateral view and section, f. 8 slit band enlarged, f. 10 section of the innermost whorls, with the hooklike lamellæ of the surface, f. 12 section of a large specimen with exceedingly thick walls around the umbilicus, f. 13—16 details of surface sculpture around the umbilicus.

» 17—24. *Bellerophon squamosus* n., p. 78. Fig. 17—19 specimen in nat. size, f. 20 smaller specimen in natural size and its slit band in f. 21, f. 23 section of the shell with the thin lamellar processes from the lines of growth, f. 24 curves formed by the extreme edges of these lines of growth, sectioned horizontally.

» 25—34. *Bellerophon globulus* n., p. 75. Fig. 34 enlarged view of the umbilicus.

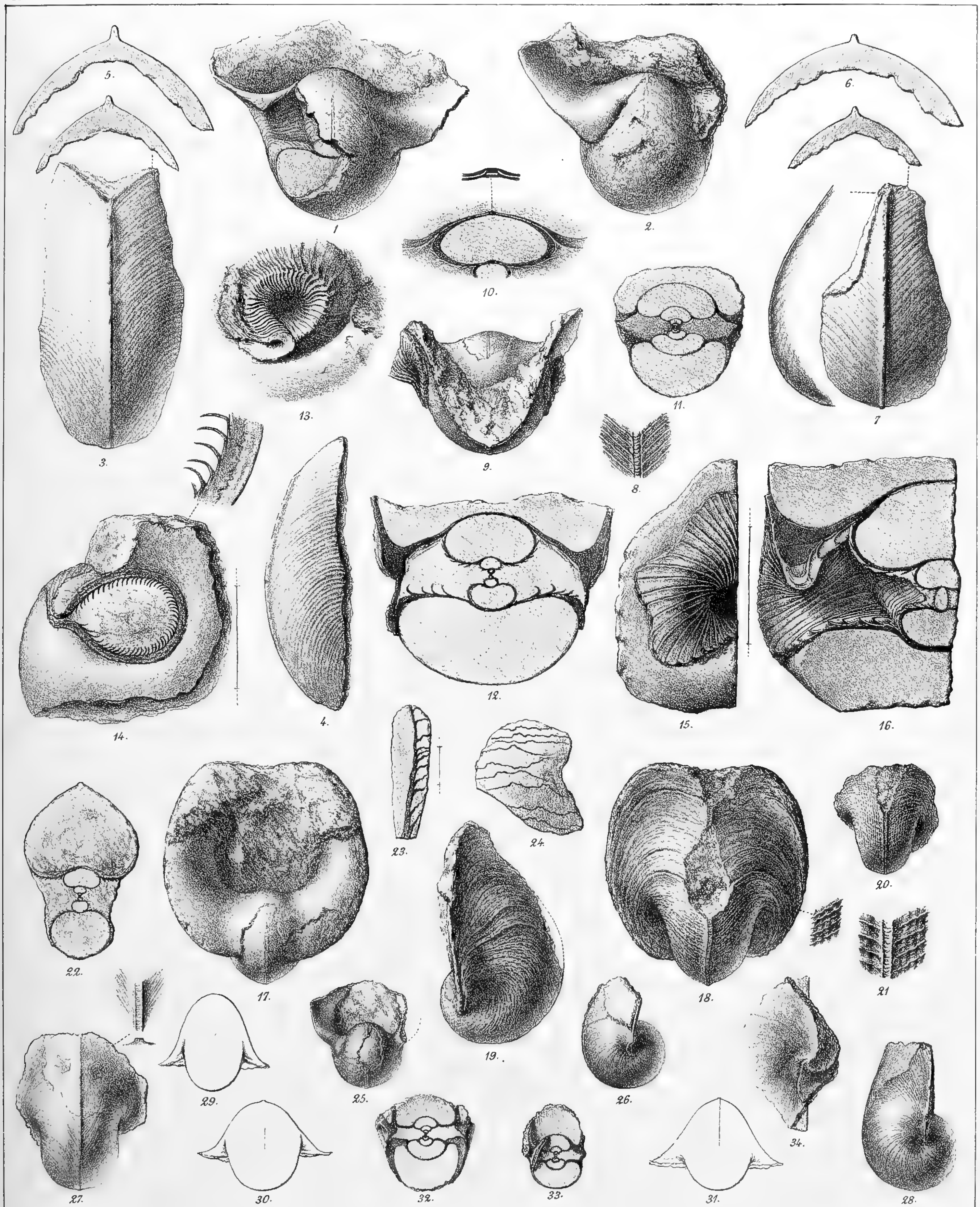

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PLATE VI.

Plate VI.

Fig. 1—10. *Bellerophon fastigiatus* n., p. 76. Fig. 10 side of the largest whorl.
» 11—12. » undeterminated species, p. 77, sections showing the great obliquity of the shell.
» 13—14. » *fasciatus* n. p. 75.
» 15—18. » *elegantulus* n. p. 79.
» 19—21. » *Eiseni* n. p. 78.
» 22—25. » *tænia* n. p. 76. Specimens from Östergarn, original to f. 22 belongs to the Museum of the School of Wisby.
» 26—28. *Bellerophon latevittatus* n., p. 79.
» 29—30. » *pilula* n. p. 80.
» 31—38. *Cyrtolites lamellifer* n. p. 82, f. 37 details of ornamentation and lateral view of the outstanding lamellæ, f. 38 the slit band near the aperture, much magnified.
» 39—51. *Cyrtolites pharetra* n. p. 83. Fig. 39 specimen with traces of colour bands, magnified, f. 43 lower lip of the aperture, f. 50 groove beneath the inferior apertural lip, in which the apex of the shell is lodged.
» 52—53. *Cyrtolites arrosus* n., p. 83.
» 54—55. » *obliquus* n., p. 84.

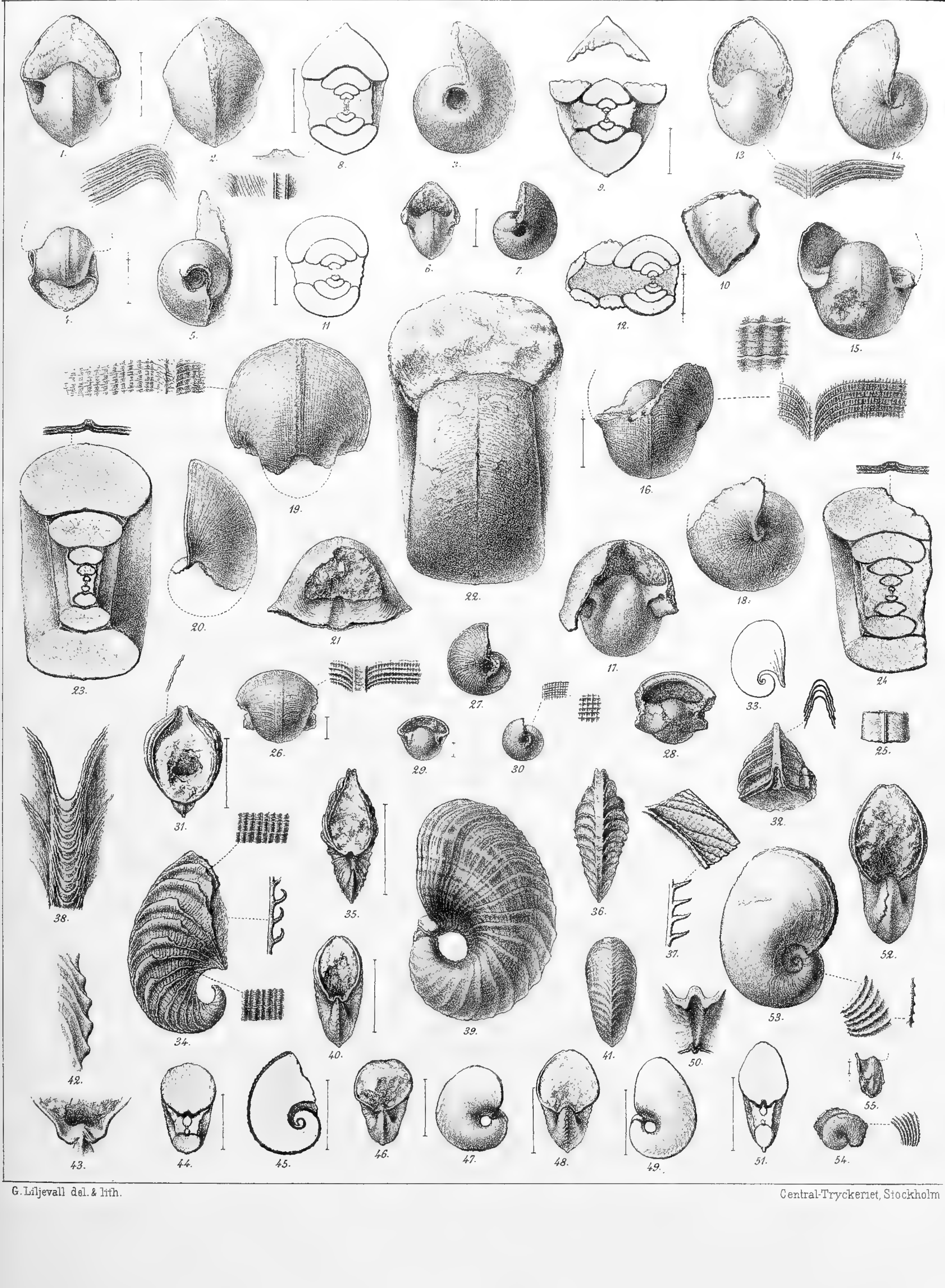

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PLATE VII.

Plate VII.

Fig. 1— 3. *Conularia aspersa* n. p. 46.
» 4— 5. *Bellerophon tænia* n. p. 76. The original specimen belongs to the Mineralogical Museum of the University of Copenhagen, from Östergarn.
» 6— 8. *Bellerophon latevittatus* n. p. 79. Nuclei from the shale of Wisby, with a peculiar, transverse, necklike constriction.
» 9. *Bellerophon sphæra* n., p. 74. Microscopic, vertical section of the shell.
» 10—15. *Cyrtolites euryomphalus* n. p. 84.
» 16—17. » *orbiculus* n., p. 85.
» 18—21. » *discus* n. p. 84, the original specimen belongs to the Museum of the Geological Survey of Sweden.
» 22. *Platyceras cyathinum* n. p. 69.
» 23—25. *Pleurotomaria scutulata* n. p. 95.
» 26—27. » *gradata* n. p. 96.
» 28—30 » *scutulata* n. p. 95. Fig. 28—29 from Samsugn, f. 30 from Follingbo.
» 31—36. » *claustrata* n. p. 97. The original specimen of f. 34 belongs to the Miner. Museum of Copenhagen.
» 37—38. *Pleurotomaria glandiformis* n. p. 98.
» 39—42. » *biformis* n. p. 98. Fig. 42 magnified details of slit band.
» 43—49. » *Lloydi* Sow. p. 101, f. 43—44 from Djupvik, Eksta, f. 45—46 from Petesvik in Habblingbo, 47—49 from Wisby.

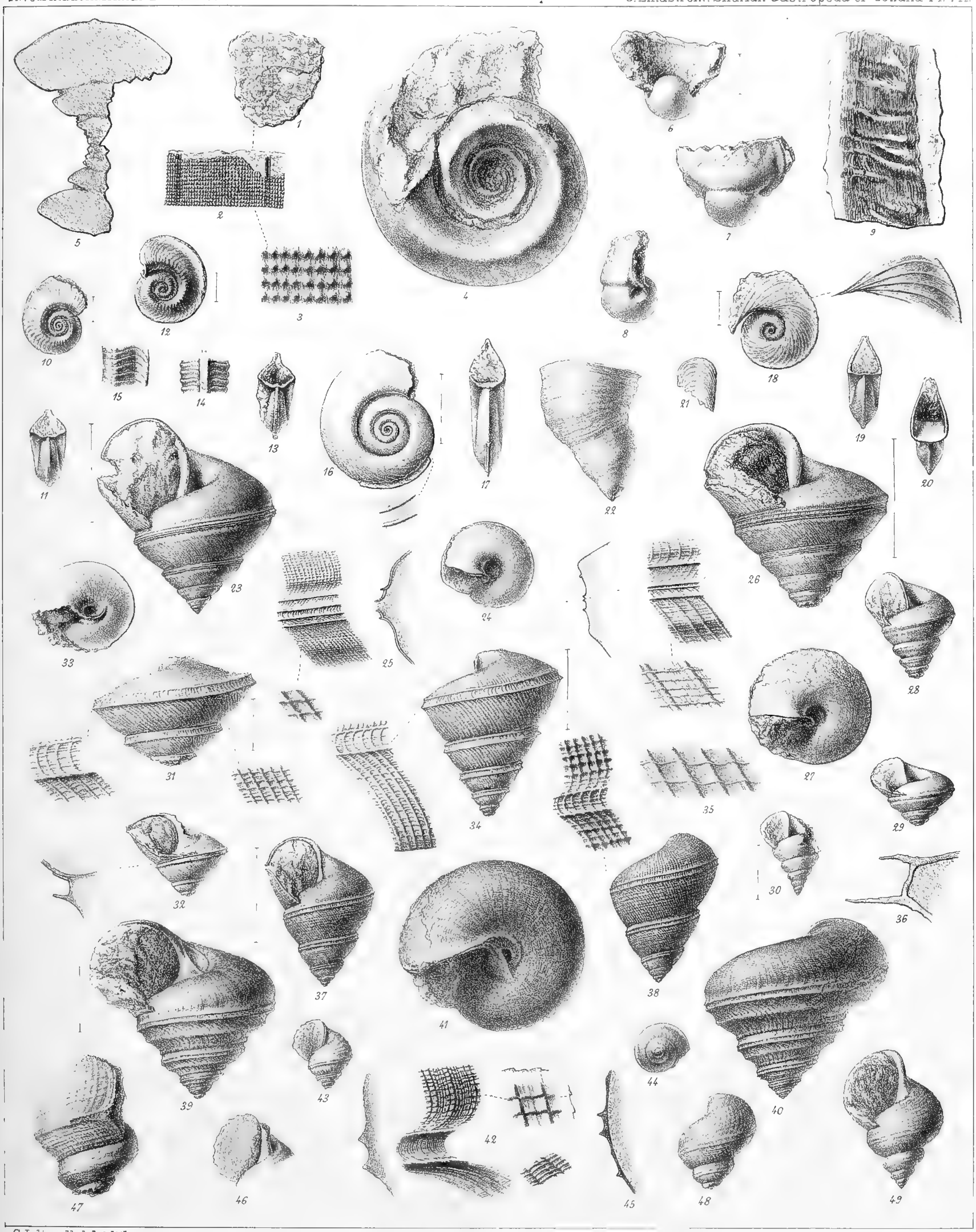

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PLATE VIII.

PLATE VIII.

Fig. 1. *Pleurotomaria Lloydi* Sow., p. 101.
» 2—7. » *robusta*, n. p. 103. Specimen from Eksta.
» 8—9. » » var. *lævissima* n. p. 104.
» 10—14. » *elliptica* His., p. 104, f. 10—11 from Wisby, 12—13 from Östergarn. Fig. 14 slit band magnified and section of it, from Lerkaka in Öland.
» 15—25. *Pleurotomaria bicincta* Hall, p. 106. Fig. 15—16 specimen from Westergarn, f. 17 from Borkholm in Esthonia, belonging to the Mineral Cabinet of the University of Upsala, f. 18—19 large specimen in natural size from the limestone of Slite, belonging to the Marklinian Collection of Upsala, f. 20 specimen natur. size from Ardre, f. 21—22 details of slit band, specimens from Follingbo, f. 23 slit band of specimen from Fårö, f. 24—25 from Gothemshammar.

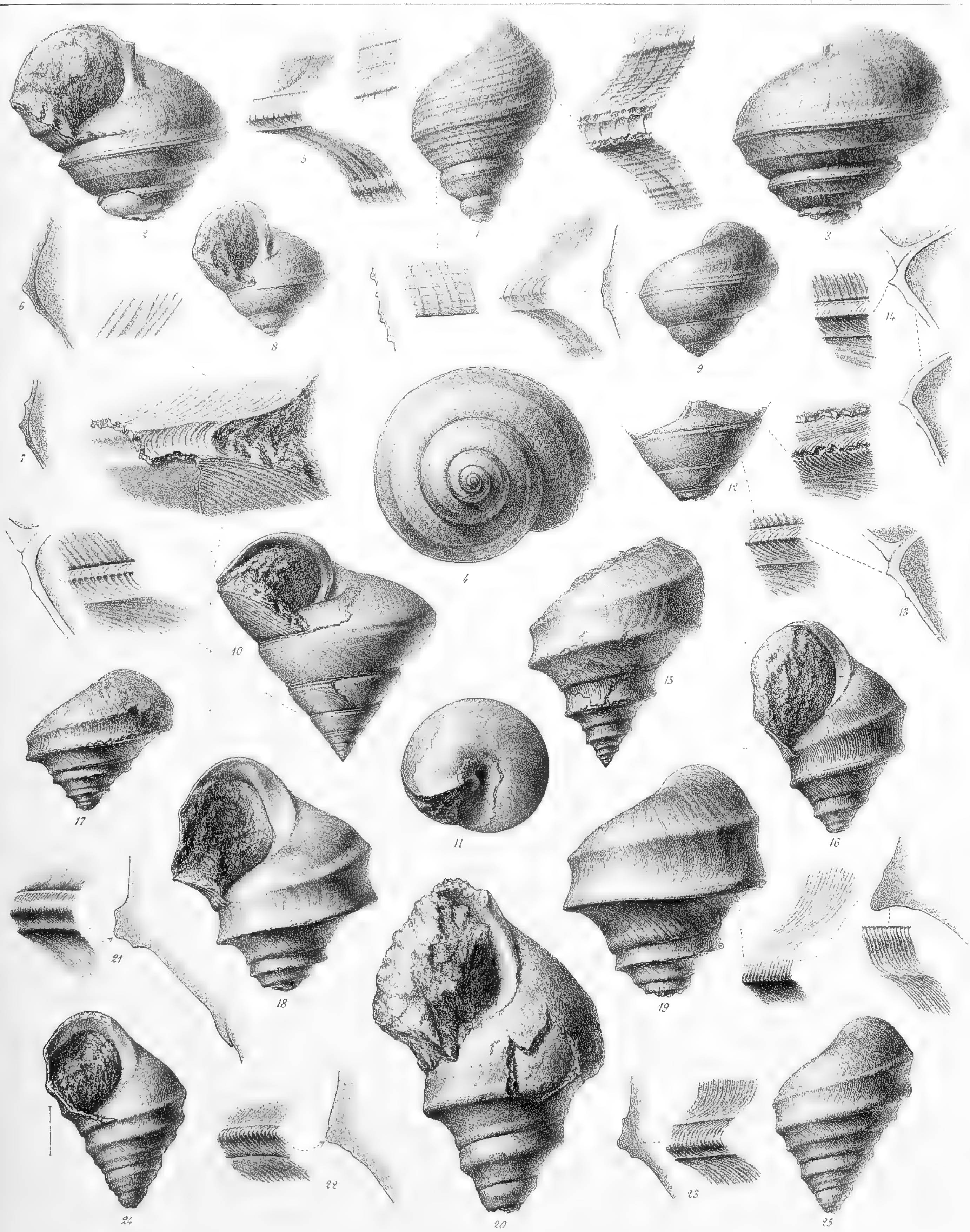
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PLATE IX.

Plate IX.

Fig. 1—3. *Pleurotomaria dolium* n., p. 102.
» 4—6. » *laqueata* n., p. 102, f. 4 the original specimen belongs to the Museum of the School of Wisby, f. 5—6 from Klinteberg.
» 7—10. *Pleurotomaria tubulosa* n., p. 103 from Kräklingbo.
» 11—13. » *valida* n. p. 110.
» 14—17. » *Othemensis* n. p. 111, f. 17 the umbilicus seen from above.
» 18—19. » *comata* n. p. 111 from Eksta.
» 20—29. » *æquilatera* Wahlenberg p. 111, f. 20—22 the original specimen of Wahlenberg from the Mineralogical Cabinet of the University of Upsala, somewhat restored as to the aperture and sections of the slit band, f. 23—24 from Kyrkberget in Wisby, f. 25—26 from the shale of Wisby, f. 27 ventricose variety from Samsugn in Othem, belonging to the Min. Cab. University of Upsala, f. 28 from Samsugn in Othem, f. 29 section of two whorls to show the shape and place of the slit band.
» 30—38. *Pleurotomaria labrosa* Hall, p. 113, fig. 30—36 from Westergarn, f. 37—38 from Klints in Boge. Fig. 36 section along the median axis of the slit band.

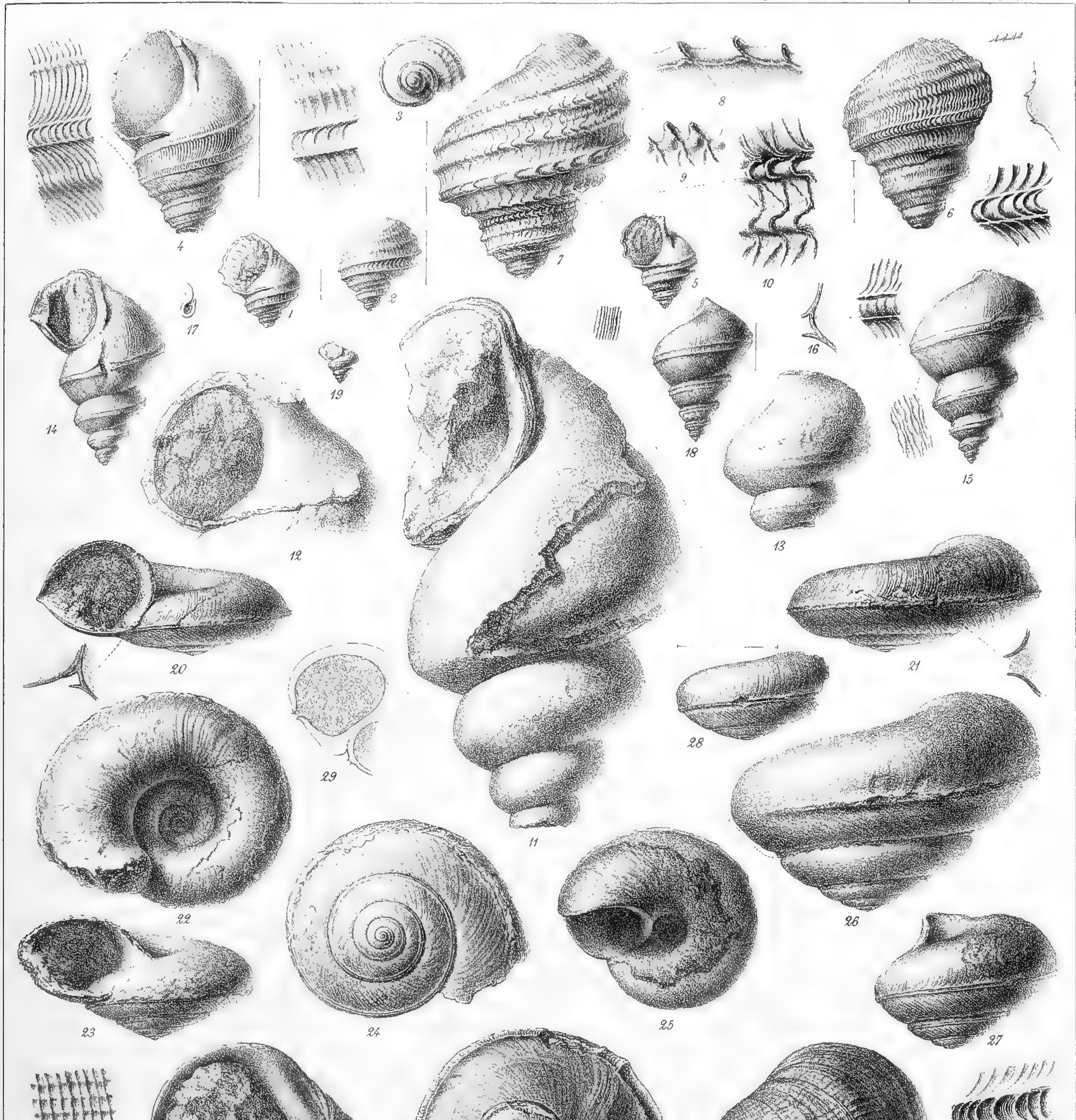

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PLATE X.

Plate X.

Fig. 1. *Pleurotomaria latezonata* n., p. 99.

» 2—17. » *limata* n., p. 114, f. 2—5 from Klinteberg, f. 6—9 from the middle limestone strata of Wisby, f. 10—11 variety from the canal near Westöös in Hall, f. 12 specimen from Wisby seen from the umbilical side with a largely developed slit band, f. 13 details of ornamentation of the slit band and the surface around the umbilicus, f. 14 transverse section of the slit band, imbedded in fine grained rock, f. 15—16 slit band of two different specimens, magnified, f. 17, part of a slit band cloven in two parts along its median line to show how the crescentic lamellæ continue outward to the thin bordering lines.

» 18—32. *Pleurotomaria alata* His., p. 116. All the originals to the figures from Wisby. Fig. 23, near the aperture the crescentic lamellæ between the bordering laminæ are conspicuous as black lines below the surface and they are partially restored by dotted lines where they have been broken away, f. 24 inferior surface showing the wavy edge of the slit band, f. 25 ornamentation of umbilical surface, f. 27 details to elucidate the structure of the slit band, f. 28 ornamentation of apical surface from a specimen with a ridge, f. 30 transversally sectioned slit band, magnified, f. 31 extreme edge of a slit band, f. 32 variety from Wisby with downwards anh inwards curved slit band.

» 33—37. *Pleurotomaria alata*, var. *subcarinata* n., p. 118, f. 33 specimen from Lingsarfve in Näs, enclosed in an oolitic nodule, figs 34—37 from Djupvik in Eksta.

» 38—40. *Pleurotomaria alata*, var. *opposita* n., p. 119, from Habblingbo, f. 39 apical side of body whorl and part of next whorl, f. 40 ornamentation of umbilical side and slit band.

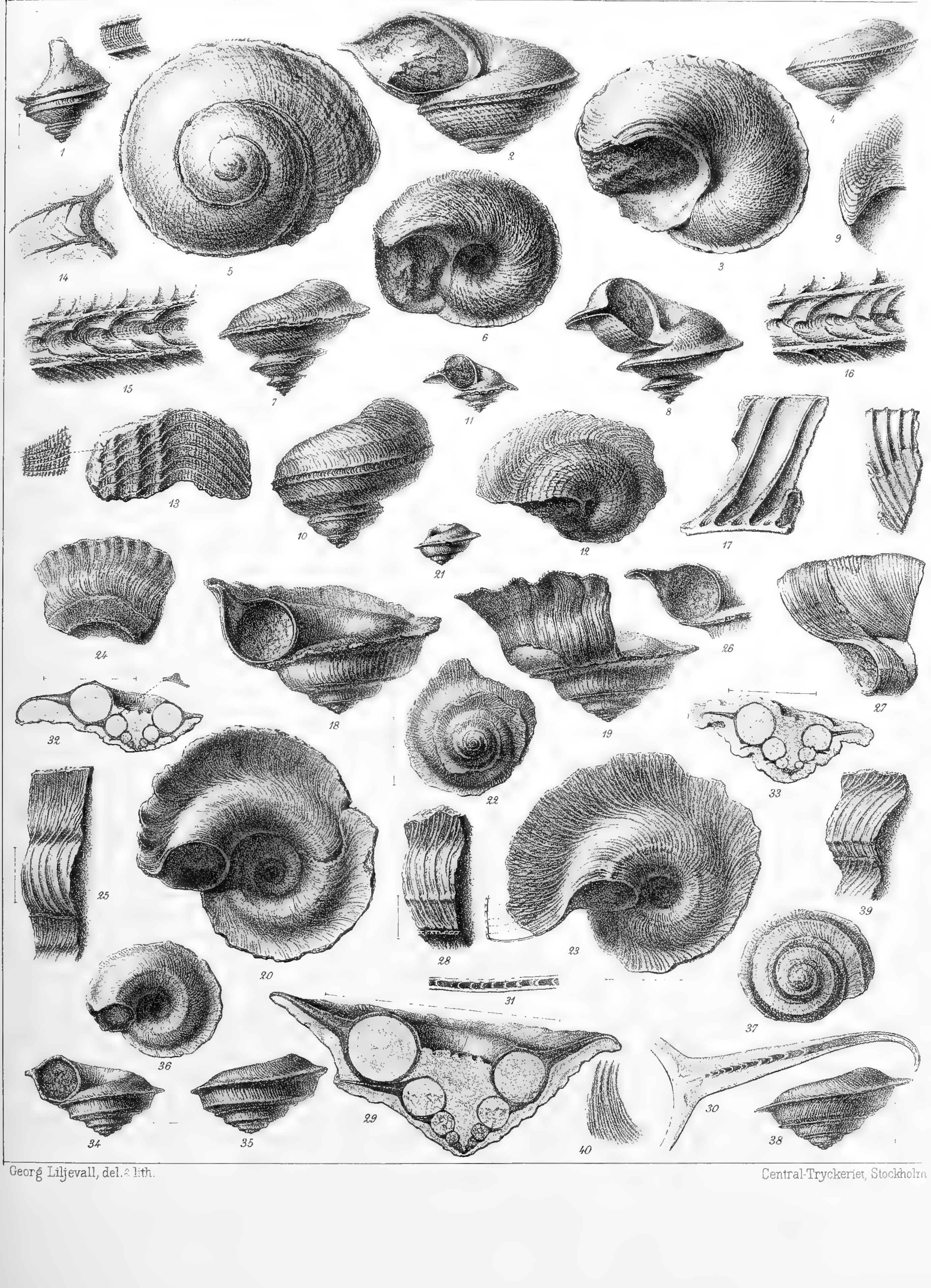
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PLATE XI.

PLATE XI.

Fig. 1—7. *Pleurotomaria prætexta* n., p. 119. Fig. 5 the slit band cloven, the lower stratum shows the oblique, crescentic lamellæ of the slit band. Fig. 7 part of the surface around the slit band and its both parallel ridges.

» 8—13. *Pleurotomaria togata* n., p. 119. Fig 12 part of apical surface from the suture to the rim of the slit band, f. 13 longitudinal section along the whorls.

» 14. *Pleurotomaria frenata* n., p. 120.

» 15—23. » *undulans* n., p. 120. Fig. 21 with details of the structure of the slit band. Fig. 22 slit band sectioned along the outer rim, f. 23 slit band sectioned transversally.

» 24—26. *Pleurotomaria Marklini* n., p. 121.

» 27—29. » *cirrhosa* n., p. 121 longitudinal section, f. 29 part of apical surface with the thin, wavy slit band solded to the body whorl, f. 28 section of the same.

» 30—33. *Pleurotomaria exquisita* n., p. 125, f. 33 section of two whorls showing how the superior one is overlaying the inferior.

» 34—37. *Pleurotomaria helicina* n., p. 124.

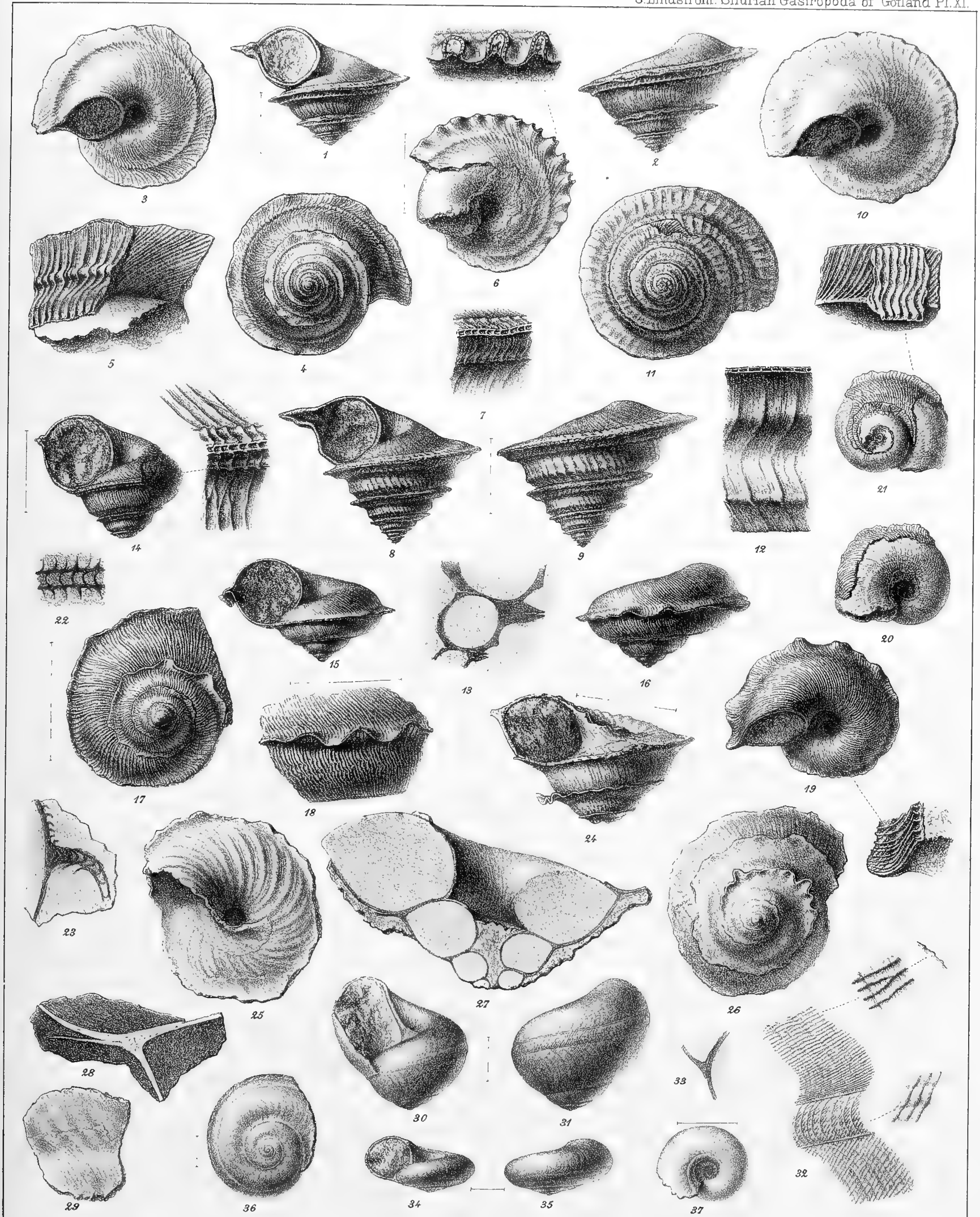

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PLATE XII.

Plate XII.

Fig. 1—3. *Pleurotomaria cirrhosa* n., p. 121, specimen from Östergarn, with details of surface.
» 4. *Murchisonia cava* n., p. 128, from Martebo and details of the slit band.
» 5—6. » *moniliformis* n., p. 128, from the sandstone of Bursvik.
» 7. » *obtusangula* n., p. 128.
» 8. » *subplicata* n., p. 129.
» 9—10. » *cingulata* His. p. 127, f. 9 the type specimen of Hisinger, which he delineated in »Lethæa Suecica» on pl. XI fig. 6 a. In natural size.
» 11—12. *Murchisonia obtusangula* n., p. 128.
» 13—14. » *crispa* n., p. 131.
» 15—19. » *compressa* n., p. 129. Fig. 15, nucleus with traces of sculpture, fig. 17 one of the largest nuclei with an obtuse end above the filled up apex, fig. 18 longitudinal section along the median axis, fig. 19 transverse section of the apex, showing the dark apical whorls, filled with organic deposit, and the lighter nucleus of the younger whorls.
» 20—24. *Murchisonia attenuata* Hisinger p. 130.

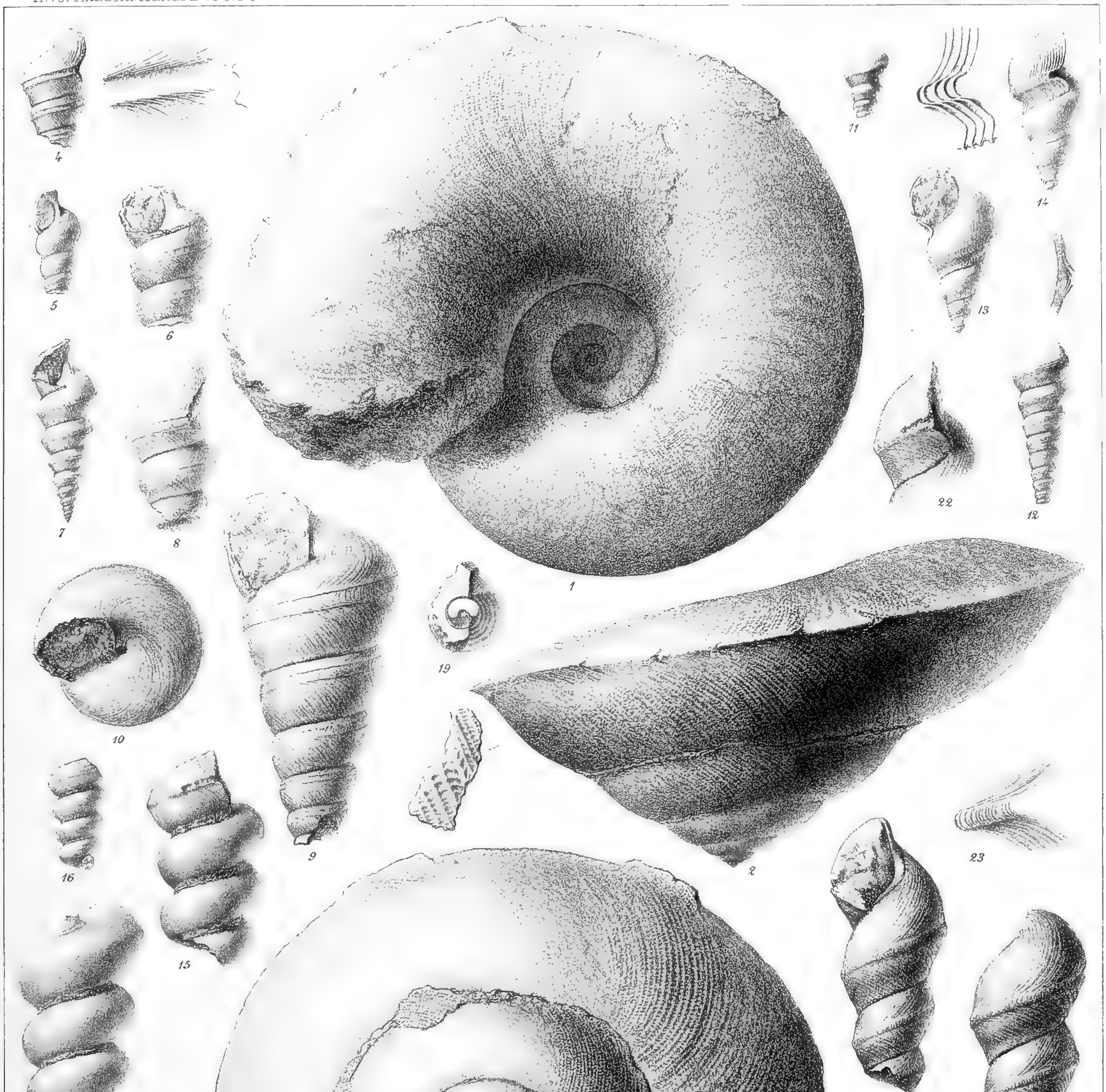

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PLATE XIII.

Plate XIII.

Fig. 1. *Murchisonia cancellata* n., p. 133.
» 2—3. » *cochleata* n., p. 134.
» 4—5. » *tortuosa* n., p. 132.
» 6. » *munda* n., p. 132.
» 7—12. » *imbricata* n., p. 133. Fig. 7 slender, finely striated variety; fig. 8 the thicker and more coarsely striated, f. 9—12 details of aperture, umbilical region and slit band.
» 13—14. *Murchisonia tortuosa* n., p. 132.
» 15—16. *Pleurotomaria qualteriata* Schloth., p. 108. Fig. 15 from the shale of Wisby. Fig. 16 ornamentation and slit band in specimen from Lerkaka, Öland.
» 17—18. *Pleurotomaria obvallata* Wahlenb., p. 108. Fig. 17 section of the shell, f. 18, details of the slit band; lowest figure, slit band on the apical side; middle figure, section of the edge, uppermost figure, slit band from the umbilical side. From specimens belonging to the Museum of the Geol. Survey of Sweden from the upper gray Orthoceratite Limestone at Wångsgärdet in Dalecarlia.
» 19—31. *Euomphalus Gotlandicus* n., p. 139. Fig. 19—25 specimens from the shale of Wisby. Fig. 26—29 evolute specimens from Kyrkberget in Wisby, the mucleus lying beside the shell, the apex of which is filled with organic deposit; fig. 30—31 from Westergarn.
» 32—35. *Euomphalus triquetrus* n., p. 140.
» 36—38. » *Angelini* n., p. 138. Lower Silurian from the inferior gray Orthoceratite Limestone at Utby, Lindgården in Dalecarlia, fig. 38 sculpture on the lateral surface.
» 39—44. *Pleurotomaria replicata* n., p. 116. Fig. 39 from the aperture, apical side downwards, f. 40 from the umbilical side, f. 42 slit band magnified, interiorly the oblique crescentic lamellæ are seen, f. 43 transverse section of slit band, f. 44 slit band along is exterior edge.

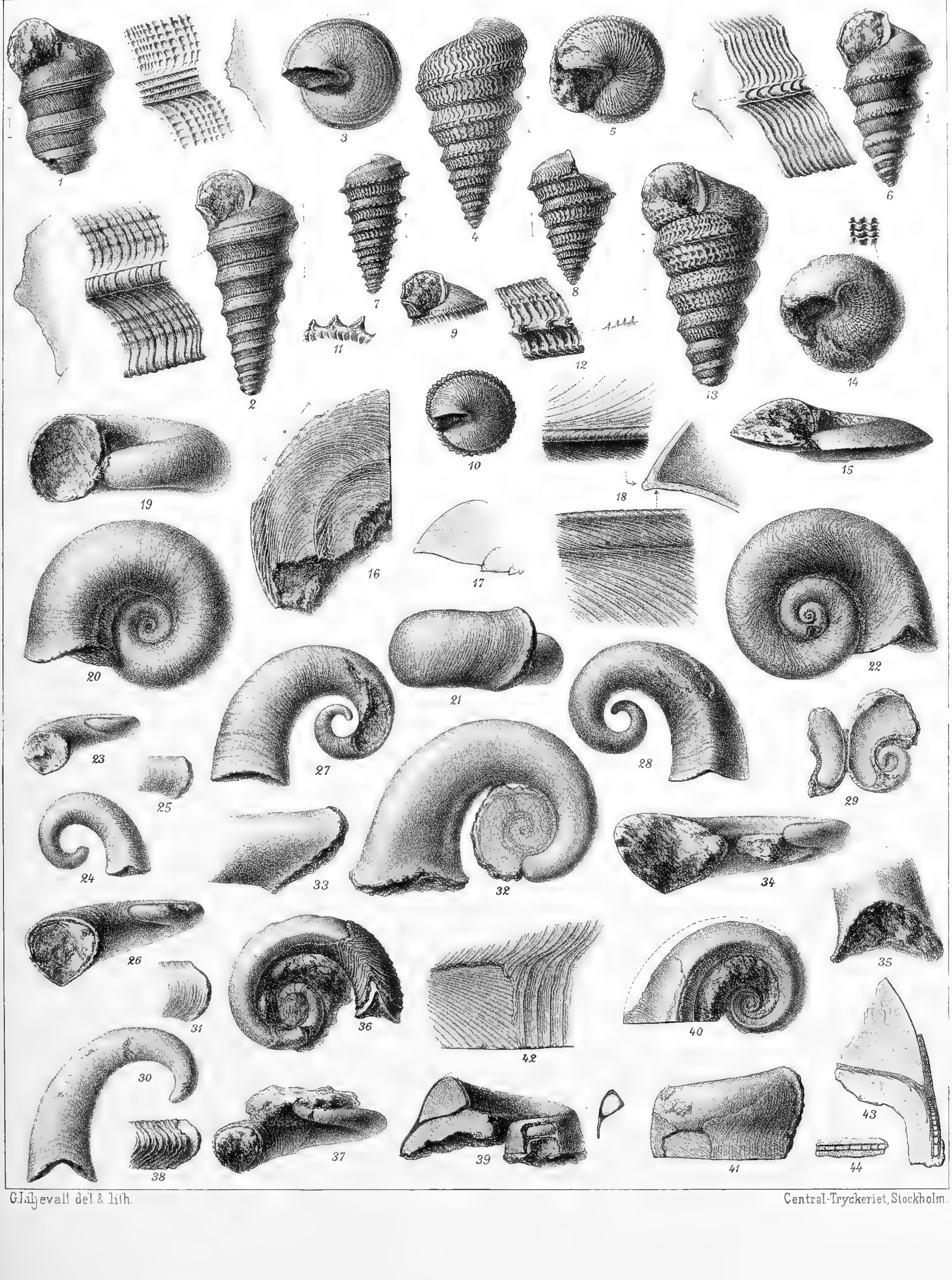
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PLATE XIV.

Plate XIV.

Fig. 1—11. *Trochus Gotlandicus* n., p. 146, fig. 1—2 from Kyrkberget, Wisby, 3 from the limestone (b.) of Wisby, 4—7 from the canal near Westöös in Hall, f. 8, var. without ridge from Kyrkberget in Wisby, f. 9 microscopical section of the shell, f. 10—11 from the limestone of Wisby.

» 12—13. *Trochus fulminatus* n., p. 147.

» 14—17. » *mollis* n., p. 147, f. 14—16 from Klinteberg, f. 17 from Samsugn.

» 18—21. » *Dalli* n., p. 150.

» 22—31. » *incisus* n., p. 151. Fig. 22—23 from Kyrkberget in Wisby; f. 24—25 from Samsugn in Othem; f. 26—30 from Stor Wede in Follingbo; f. 31 from Kyrkberget in Wisby.

» 32—34. *Trochus Kolmodini* n., p. 150.

» 35—43. » *Wisbyensis* n., p. 150. All species from the limestone of Wisby, excepting f. 43 from the canal near Westöös in Hall.

» 44. *Trochus lamellosus* n., p. 151.

» 45. » *Wisbyensis* n., p. 150.

» 46—53. » *Lundgreni* n., p. 149, fig. 46—50 from Samsugn in Othem, f. 51 from Lutterhorn in Fårö, f. 52 transverse section of the keel showing different lines of growth hidden inside it, f. 53 the keel from without.

» 54—58. *Trochus astraliiformis* n., p. 153, from Klinteberg, specimens figures 56—57, belonging to the Marklinian Collection in Upsala.

» 59—69. *Trochus Stuxbergi* n., p. 147. Fig. 59—61 from Klinteberg, f. 62—69 from Samsugn in Othem.

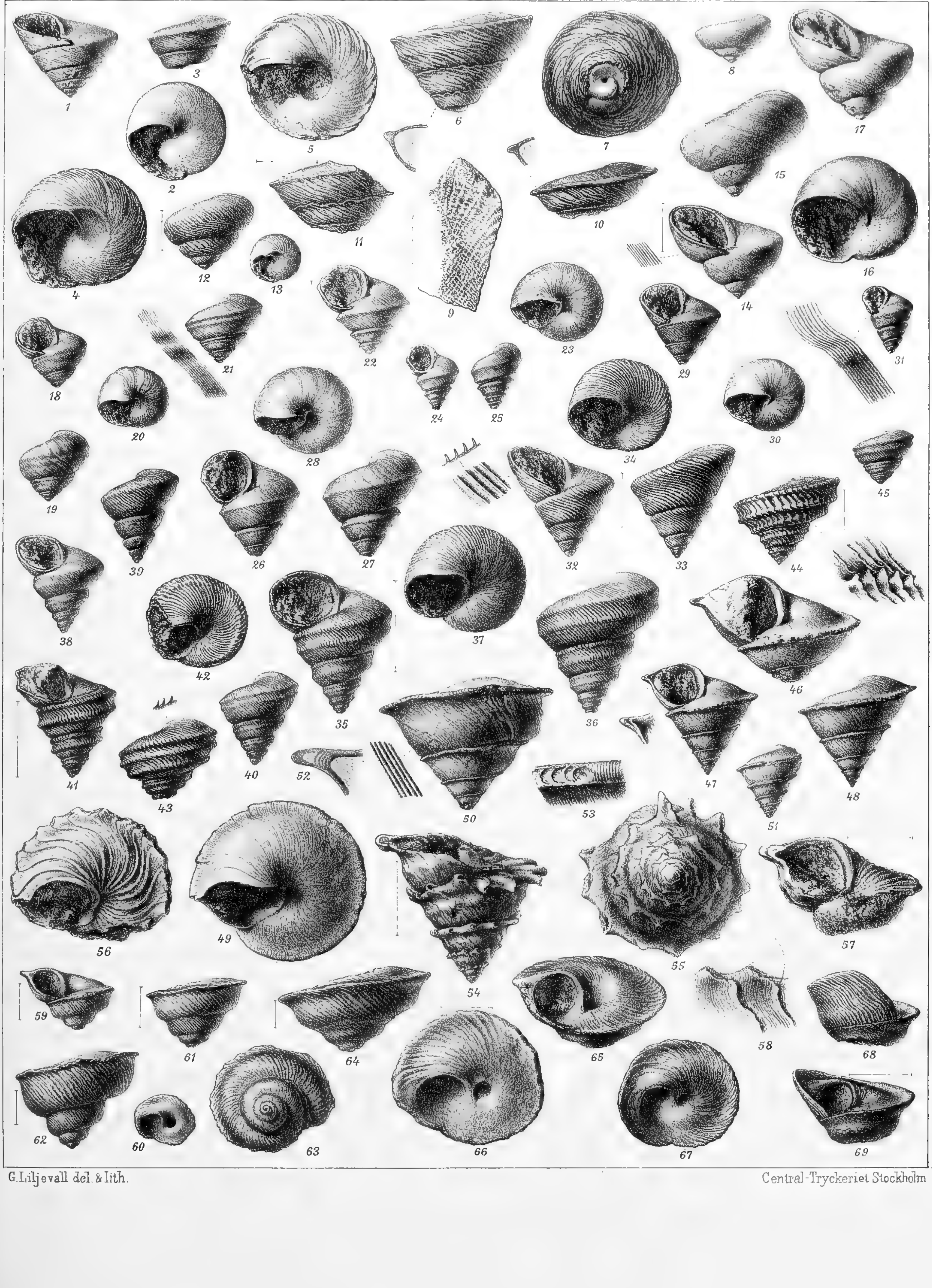

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PLATE XV.

PLATE XV.

Fig. 1 — 5. *Loxonema sinuosum* SOW. p. 142, from Djupvik, Eksta.
» 6. » *intumescens* n., p. 143.
» 7. » *sinuosum* SOW.
» 8 —10. » *strangulatum* n., p. 144, f. 8—9 from Klinteberg, f. 10 from Östergarn.
» 11. » *fasciatum* n., p. 144.
» 12—13. *Holopella regularis* n., p. 190. The original belongs to Adjunct M. KLINTBERG in Wisby.
» 14—16. *Macrochilina bulimina* n., p. 191.
» 17—18. » *fenestrata* n., p. 192.
» 19—21. *Subulites ventricosus* HALL p. 193.
» 22—23. » *attenuatus* n., p. 194.
» 24—26. *Callonema scalariforme* n., p. 189. The original to fig. 26 is preserved in the Museum of the School of Wisby.
» 27. *Callonema obesum* n., p. 189. The original belongs to the Mineralogical Museum of the University of Copenhagen.
» 28—44. *Cyclonema delicatulum* n., p. 174. The original to fig. 30—31 belongs to Hr H. HEDSTRÖM in Wisby.
» 45. Probably a corroded specimen of the former.
» 46—47. *Holopea applanata* n., p. 188.
» 48. *Subulites attenuatus* n., var. p. 194.
» 49. *Cyclonema adstrictum* n., p. 178.
» 50—51. *Holopea nitidissima* n., p. 188.
» 52—54. *Trochus? lamellosus* var. p. 151. The original from the Mineralogical Cabinet of the University of Upsala.
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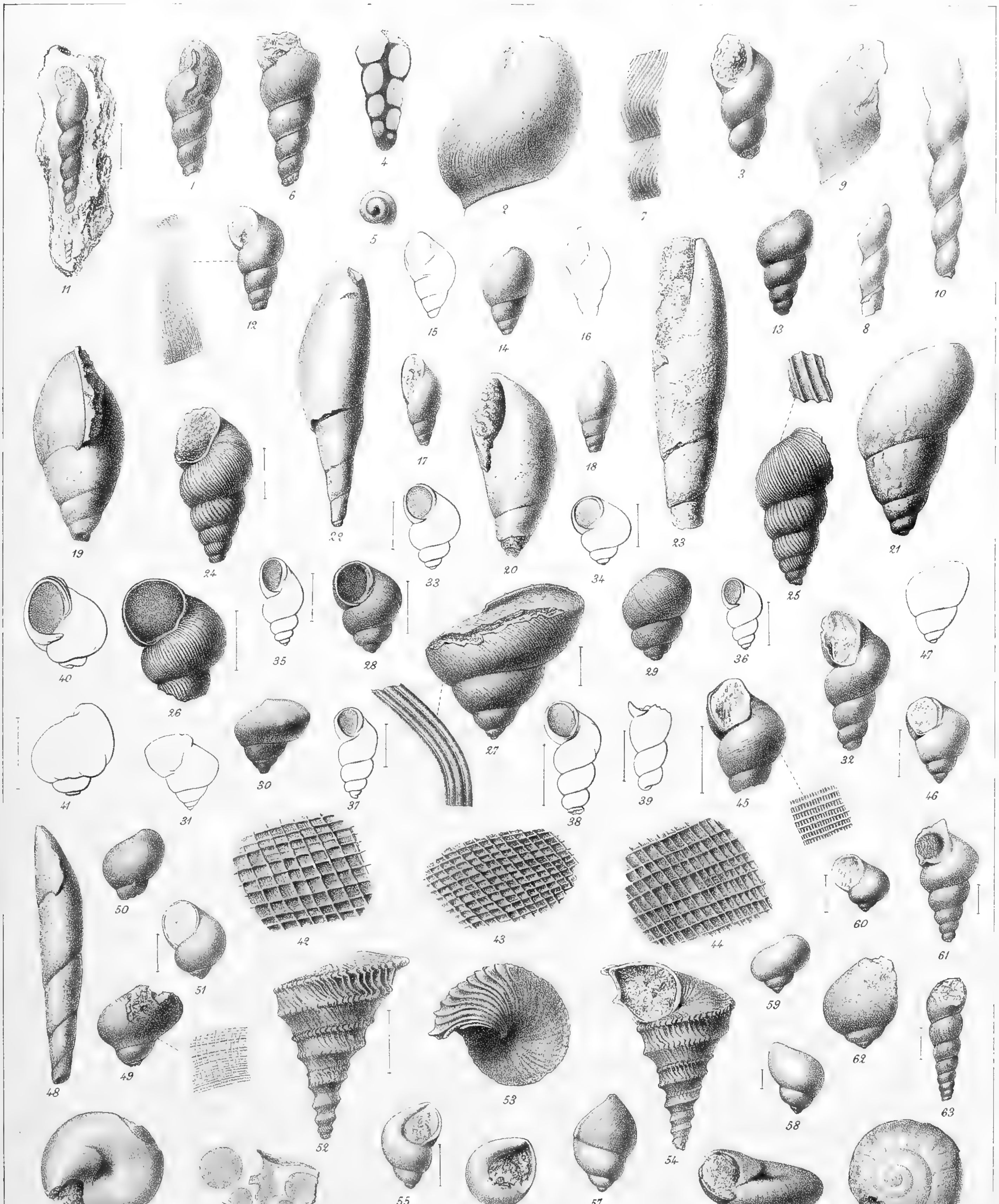

G. Liljevall del. f. 24-26, 28-44. C. Hedelin del. f. 1-23, 27, 45-67.

Lith. W. Schlachter, Stockholm.

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Plate XVI.

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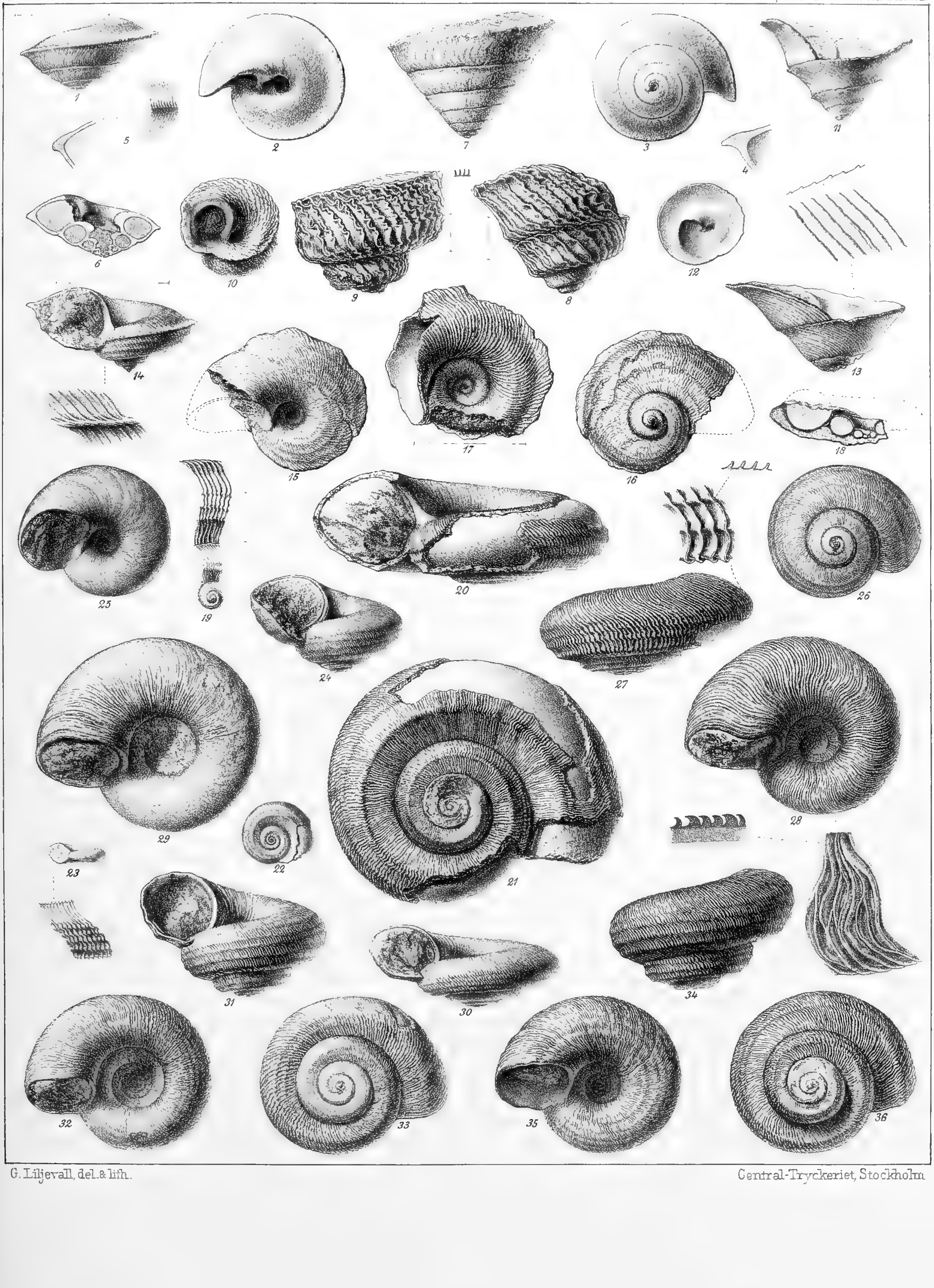
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PLATE XVII.

Plate XVII.

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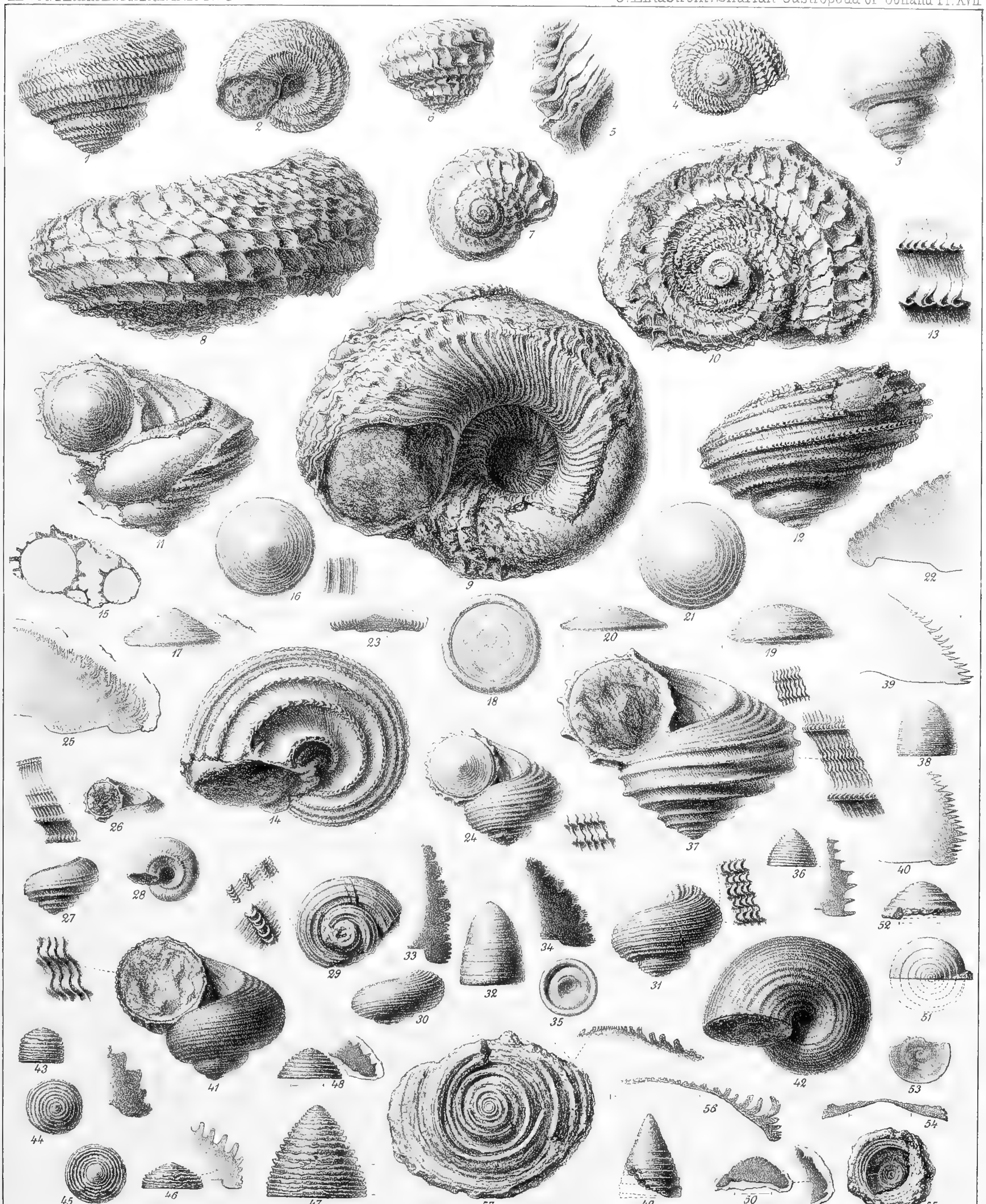

G. Liljevall, del. & lith.

Central-Tryckeriet Stockholm

PLATE XVIII.

Plate XVIII.

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C. Hedelin del. Lith. W. Schlachter, Stockholm.

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Plate XIX.

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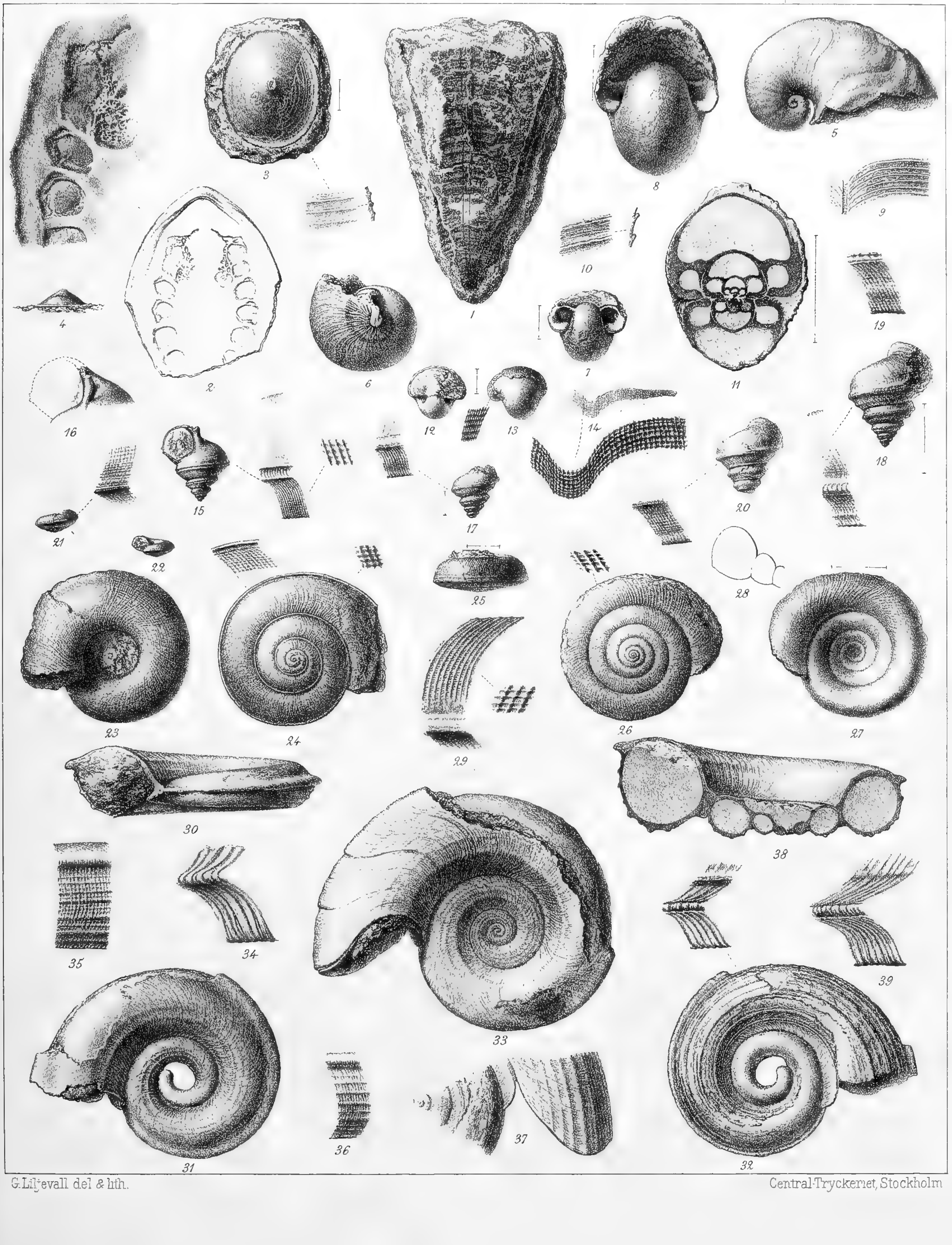
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PLATE XX.

Plate XX.

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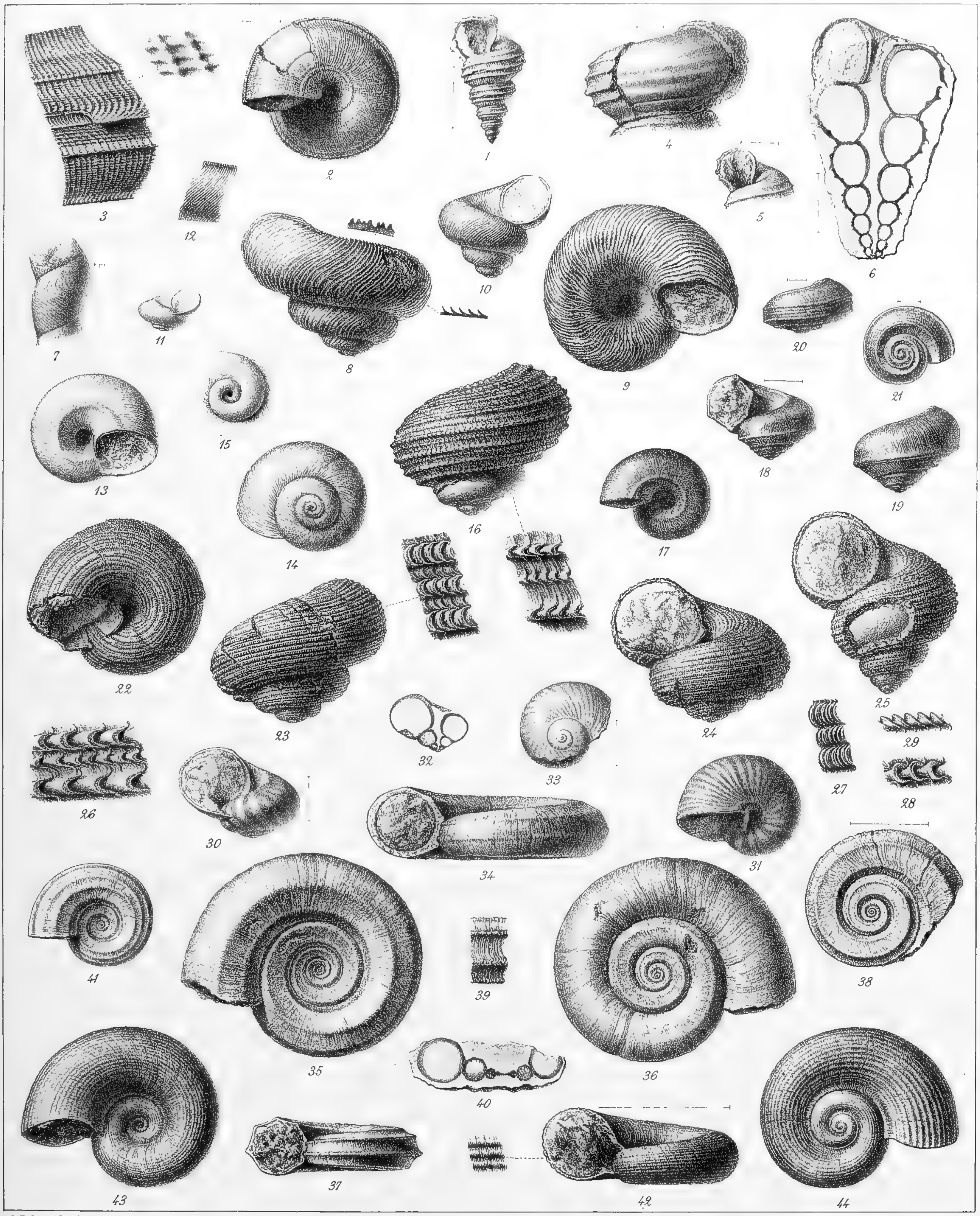

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PLATE XXI.

Plate XXI.

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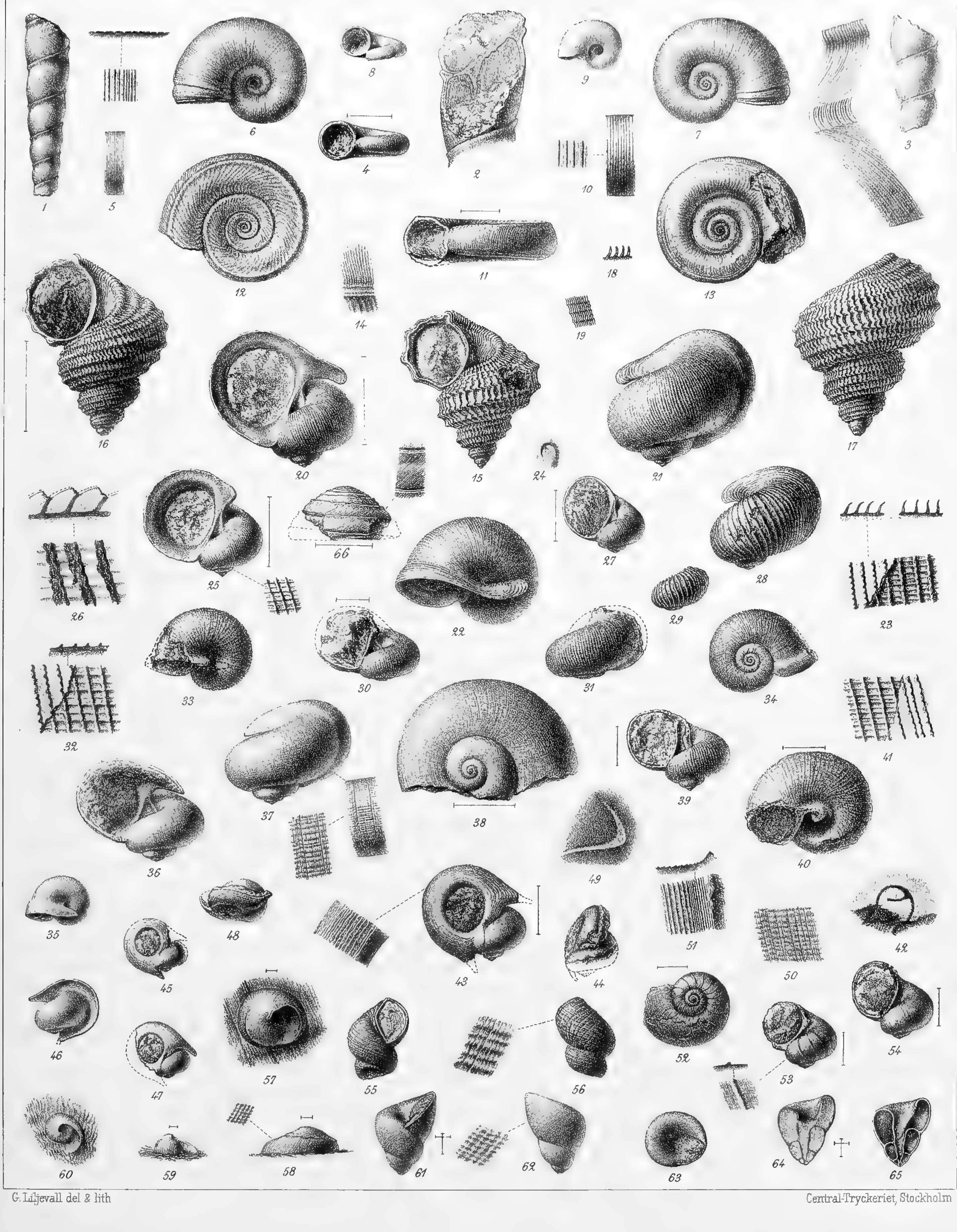

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Names printed in italics are synonyms.

KONGL. SVENSKA VETENSKAPS-AKADEMIENS HANDLINGAR. Bandet 19. N:o 7

ON

POURTALESIA

A GENUS OF ECHINOIDEA

BY

SVEN LOVÉN.

WITH TWENTY ONE PLATES.

COMMUNICATED TO THE R. SWEDISH ACADEMY OF SCIENCES JUNE 11 1879 AND JUNE 7 1882.

STOCKHOLM, 1883.
KONGL. BOKTRYCKERIET,
P. A. NORSTEDT & SÖNER.

When ALEXANDER AGASSIZ made known the results obtained from the dredgings in deep water executed in the year 1868 between Cuba and the Florida Reef by the late Count LOUIS-FRANÇOIS DE POURTALÈS, [1]) there was, among numbers of Echinoidea then for the first time brought to light, none that excited more wonder and curiosity than the very singular animal described under the doubly appropriate name of Pourtalesia miranda AL. AG. Nor was the interest its strange and abnormal aspect awakened in any way lessened, when the same author, in his great work on the Echinoidea, [2]) gave a description, accompanied with figures drawn by himself, and the late Sir CHARLES WYVILLE THOMSON, shortly afterwards, added two new species, Pourtalesia Jeffreysi and P. phiale, and at the same time threw fresh light upon several important points in the structure of the former of these. [3])

ALEXANDER AGASSIZ had the extraordinary kindness to lend me, for inspection and study, his unique specimen of Pourtalesia miranda. Such is, however, the excessive thinness and fragility of this species, that I did not feel warranted to do more than subject it to repeated, but superficial examination, confirming the general accuracy of the original description and figures, and to speculate, during the long time it was allowed to remain with me, upon the presumable morphological relations existing between the parts composing its skeleton and the corresponding parts in the other Echinoidea, which had then for several years been to me a subject of some study.

In the mean time my Norwegian friends, in the course of their well-planned and highly successful survey, on board the Steamer »Vöringen», of the Hydrography and Biology of the North Atlantic, had the good fortune to fall in with a habitat of Pourtalesia Jeffreysi, and, with a liberality I cannot too amply acknowledge, through one of their staff, D:r D. C. DANIELSEN of Bergen, placed at my disposal several more or less uninjured specimens as well as some fragments of that species, and thus afforded me the long wished for opportunity of examining, fully and at leisure, the most extraordinary Echinoid hitherto known.

I have also to express my deep obligations to the late Sir WYVILLE THOMSON, who most kindly came to my aid with a few specimens of Pourtalesiæ collected

[1]) Preliminary Report on the Echini and Starfishes dredged in deep water between Cuba and the Florida Reef, by L. F. DE POURTALÈS, Assist. U. S. Coast Survey; prepared by ALEXANDER AGASSIZ. Bulletin of the Museum of Comparative Zoology, Cambridge, I, N:o 9, Oct. 1869; p. 272.

[2]) Illustrated Catalogue of the Museum of Comparative Zoology at Harvard College. N:o VII. Revision of the Echini by ALEXANDER AGASSIZ, p. 344, Pl. XVIII.

[3]) WYVILLE THOMSON, the Depths of the Sea, p. 108, fig. 12. — On the Echinoidea of the »Porcupine» Deep-sea Dredging Expeditions. Phil. Trans. Roy. Soc. London, Vol. 164, pt. 2. p. 747, pl. LXX, LXXI.

by the Challenger Expedition, and described by ALEXANDER AGASSIZ. [1]) When they arrived, the description of P. Jeffreysi was long finished and the five first plates engraved. Although the specimens were in a very fragmentary condition, they permitted me to add some facts of importance.

In the following pages I have laid down the results of my studies on the materials thus afforded, and also some observations, old and new, on certain particulars in the structure of other Echinoidea that have not hitherto met with the attention they deserve, and the knowledge of which is necessary in order fully to appreciate the remarkable characteristics of the Pourtalesiæ.

I. GENERAL FORM OF THE SKELETON.

The skeleton of the Echinoidea, its terminology, bilateral symmetry, antero-posterior axis, and peristomal formula. The skeleton of Pourtalesia.

In the whole of the Echinoidea the skeleton is a hollow sack inclosing the visceral cavity, and constituted by the three distinct systems: the perisomatic or interradial, the ambulacral, and the calycinal or apical, all simultaneously present in the adult animal, and in view outwardly. Each of these systems is composed of a number of more or less flattened ossicles of definite outline, contiguous and arranged in regular order, rarely imbricated, and consisting in most cases of a calcified, reticular and rigid tissue, continually in a state of resorption and renewal, and extending between the dermal tegument with its dependencies, and the subjacent connective tissue with the peripheral nerves, on the outside, and the peritoneal lining of the visceral cavity, on the inside.

For the sake of brevity I shall here, as in my former work, [2]) designate by numbers the divisions of each of these systems. Thus among the five ambulacra the one which is anterior and frontal will be marked III, the two on its right II and I, and the two on its left IV and V. The interradial areas will be denoted by the numbers 1 to 5, counting from the lateral right hand one, 1, to the posterior odd one, 5. Within the calycinal system the ossicles contiguous to the ambulacra will bear the corresponding numbers of these: I ... V, while those adjoining the interradia will be numbered accordingly, 1 ... 5. It is of course altogether indifferent how these numbers are applied from the first, provided only the order once chosen be adhered to. It seemed convenient to make the recognised frontal ambulacrum of the Exocyclic number III, from its having a medial position relatively to each of the two pairs, II and IV, I and V, and from III being the mean of I + V as of II + IV.

[1]) Proc. Amer. Acad., XIV, 1879, p. 265. — Report on the Echinoidea of the Voy. of the Challenger, p. 124.

[2]) Études sur les Echinoïdées. K. Sv. Vetenskaps-Akademiens Handlingar. Vol. XI, N:o 7. With 53 plates. Stockholm 1874.

As far as the skeleton of the Echinoidea has been subjected to a somewhat accurate and detailed investigation, it has invariably come to light that it is in no wise to be regarded as a radiate structure in the sense of the Cuvierian System, but that its constituent elements are, in reality and fundamentally, arranged bilaterally and symmetrically on the two sides of a mesial plane indicated by its antero-posterior axis. The completely bilateral structure of the larva is in reality never totally discarded in the adult, though profoundly obscured. With the bilateral conformation in the adult we have long been familiar, manifest as it is in the later forms of the Archæonomous [1]) type, for instance in the Clypeastridæ, of Cenozoic origin, and in the whole of the Neonomous [2]) type, as in the Spatangidæ, known to us from the Cretaceous period and onward, and in the other forms called Irregular, that come into view during the Mesozoic time. But when we trace back the Echinoidean type into still older periods, those manifestly symmetrical forms are lost, and the class is represented solely by the Cidaridæ and others, in which the perfectly circular ambitus of the test and the apparent similarity of all the five ambulacra as also of the interradial areas of the perisome to one another, are such as seemingly to exclude any idea of their skeletal elements being subject to bilateral symmetry. Nevertheless, and whatever may have been the case with their predecessors, the little known Perischo-echinidæ, a closer inspection reveals in the antique Cidaridæ and their allies a bilateral mode of conformation concealed beneath the deceptive appearance of radiate disposition, exactly identical with that plainly in force in all the rest of the Echinoidea, recent as well as fossil, at present known. [3]) This is another instance of the validity of one of the laws more than once ascertained to underlie evolution, namely that structures which are to be gradually, but forcibly worked out during the course of geological ages into specialised and highly characteristic features, are virtually present within the fabric of the earlier forms, though dormant and, as it were, lying in abeyance, and to be detected only by a close scrutiny. Such is the case with the antero-posterior axis of the Echinoidean skeleton. In the Exocyclic it manifestly divides lengthwise one of the five ambulacra and the opposite interradial area, and the stomo-proctic axis lies in its plane. In most of these forms the ambulacrum which thus becomes the frontal one, III, at its aboral, that is dorsal termination has on its right the one among the ossicles of the calycinal system which in the adult is permeated by the madreporic apparatus, or through which, in the young, this begins to break out from the interior. Now in the Endocyclic forms, of antique origin, which have the stomo-proctic axis vertical and ending dorsally with piercing in its middle or sideways the dismembered central ossicle, the madreporal filter is invariably and permanently restricted to one of the calycine ossicles alone. To any one believing in the consistency of nature's ways, there is no reason whatever for doubting that this ossicle is strictly homologous to the one which, in the Exocyclic, harbours the madreporite. Acting upon this legitimate supposition Desor and Cotteau in their important works, differing in this point from Johannes Müller, and from Louis Agassiz, invariably adjusted conformably to it all the forms

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[1]) *Ἀρχαιόνομος*, old-fashioned. [2]) *Νεός*, new, *νόμος*, custom, law. [3]) Études, p. 11—46.

described, regular and irregular. And that such and such alone is the true and normal position necessarily to be maintained in every case, and to be neglected only at the risk of creating confusion, is proved beyond the possibility of a doubt by the circumstance, that the peristomal formulæ:

I *a*, II *a*, III *b*, IV *a*, V *b*,
I *b*, II *b*, III *a*, IV *b*, V *a*,

in the third and fifth members of which *a* is changed into *b* and, invertedly, *b* into *a*, and which are of universal validity in the irregular forms, hold good with equal consistency in the Endocyclic, but solely and exclusively on that one of the ambulacra which has the madreporite on its right, being recognised as the front ambulacrum, III, and placed foremost, and in no other position whatever [1]). Then the five ambulacra, similar to one another as they apparently are, separate into the trivium, II, III, IV, and the bivium, I, V, while the peristome, traversed potentially by the antero-posterior axis, though in most genera it remains strictly circular or pentagonal, in others, for instance in Heterocentrus and Colobocentrus, is seen to deviate slightly from the regular form, and that precisely in the direction of this same axis, so as to present a distinctly deeper incurvation between the two ambulacra of the bivium, without regard to the direction of the longitudinal axis [2]).

All this will now be perfectly clear, and it may perhaps seem little worth mentioning that if any two different forms of Echinoids are compared together with regard to their peristomal formulæ, the sequence of the terms of these will invariably be the same in both, provided that the counting is begun at homologous points. If, on the contrary, while in the Exocyclic Echinoid the undisputed frontal is maintained as III, in the Endocyclic any other ambulacrum except that which has the madreporite on its right is tried, the formulæ will disagree all around, until that ambulacrum becômes the frontal, III. Then the two formulæ, the Endocyclic and the Exocyclic, will at once coincide, thereby proving the adjustment to be true. All this is self-evident, and in no way affects the significance of the formulæ relatively to the determination of the antero-posterior axis.

The normal form of the single plates that compose the perisomatic and ambulacral systems is the hexagonal, which regularly manifests itself, whenever the growth of the plate is not affected in consequence of its being appropriated to some special use or by pressure from other plates of its own system or from contiguous plates of other systems.

In regard to these general features: the distinctness of the three systems, their bilateral disposition, the division of the ambulacral in a bivium and a trivium, the normally hexagonal form of the plates, Pourtalesia Jeffreysi and its allies accord with the other Echinoidean types and approach the Spatangidæ.

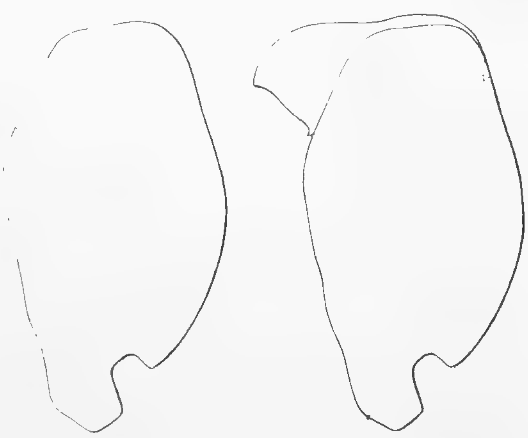
In its general form, *Pl. 1*, Pourtalesia Jeffreysi is very unlike any other Echinoid hitherto met with. When placed with the oral end foremost and so as to be seen in its dorsal, *fig. 1*, or ventral aspect, *fig. 2*, its skeleton presents an outline which

[1]) Études, p. 13, 20, 27, 29, 36. [2]) Ib., p. 26, pl. XVIII, f. 157, 158.

has been well compared to that of an inverted short-necked bottle, while in the side view, *fig. 3*, the front line appears bluntly truncated, and the dorsal line, slightly more convex than the ventral, is separated from it behind by a deep depression, beyond which the test is ventrally produced in a short, contracted, depressed, and truncated caudal prolongation. The back, in nearly its anterior half, is uniformly vaulted from side to side, in its posterior half rather more convex, and raised along the middle-line into a distinct keel, which is continued and somewhat more prominent on the caudal prolongation. The ventral surface is slightly tumid a little before and again a little behind the middle. All around the front the test is suddenly bent inward and backward, *fig. 2*, so as to form a deep ovoidal recess projecting into the peritoneal cavity, *Pl. III, fig. 10, 12; IV, 18, 19;* and, as this incurvation takes place on the ventral side farther back than on the dorsal, or at about one sixth of the entire length and a little behind the stoma, the ventral margin of the recess lies at the hindmost part of a parabolic depression or sinus, the depth of which seems to vary somewhat. At its bottom and close within the ventral margin is the oesophageal opening of the alimentary canal, *Pl. III, fig. 12; IV, 18, 19, 20.*

The excretory opening is at the bottom of the hinder depression, *Pl. I, fig. 4; III, 13,* and the stomo-proctic axis makes an acute angle with the antero-posterior and longitudinal axis.

The whole of this anomalous configuration appears, as though it were the result of the dorsal portion of the body having moved forward beyond the normal measure, and so as to leave behind the subanal part of the ventral portion, and as though its forepart, produced into a rostrum projecting ventrally and compressed from both sides, had been drawn in, by invagination, into the peritoneal cavity, its bridge thereby having become the highest part of the hollow thus formed.



The imaginary rostrum
invaginated protruding.

The vertical transverse section of the test, a little behind its middle, is somewhat elliptic and slightly higher than broad, the dimensions of the whole being

	Specimen 1.	Sp. 2.	Sp. 3.	Wyv. Thomsons sp.
Length	36 mm.	34 mm.	31 mm.	45 mm.
Breadth	18 »	18 »	15,5 »	18 »
Height	19 »	19 »	16 »	20 »

The greatest breadth lies a little higher up than the longitudinal axis, and the greater half of the section therefore belongs to the ventral surface.

The lengthened body and its nearly circular section distantly recall the cylindroid form of the Holothuriæ. Among the Echinoids the Spatangi alone offer anything like it, although the resemblance at last turns out slight enough. Nor is it to their oldest forms that we have to go in search of it. On their first appearance, as the Cretaceous period dawns upon us, the Spatangidæ, universally Adete or Prymnadete, that is: devoid of fascioles or provided with a peripetalous or lateral one only, but never with a subanal fasciole, were of a short and high, or globose form, as though not very far removed from a pristine spheroidal type still unseen by us. Genera such as Hemiaster DESOR, powerfully developed and abundant in species, prevailed in the Cretacean seas; in all of them the vertical dimension was considerable relatively to the transverse, even so as to exceed it, andt he longitudinal dimension did not very largely surpass the transverse. The dorsal and ventral halves of the test were generally conformable in outline, the ventral being even more or less convex, the front ambulacrum was rarely deep, the periproct sub-dorsal, and the stomo-proctic axis made with the longitudinal a not very acute angle. The thickset form of these antique Spatangi strongly contrasts with the elongated build of Pourtalesia Jeffreysi. Nor is it that the contrast becomes less striking, when in a few genera of the middle Cretaceous time the calycinal part of the test is strongly raised, and at the same time drawn forward so as to make the front almost vertical, as is the case in certain species of Cardiaster and the closely allied Infulaster HAGENOW. Of this remarkable form I have been able, through the kindness of Dr C. A. DOHRN of Stettin, to compare a cast [1]). At the first glance there seems to be some little resemblance to Pourtalesia, in the convexity of the ventral surface, in the vertically raised forepart with its slightly sunk ambulacral groove and in the caudal part projecting a little beyond the anal region, a feature shared in a higher degree by some Cassidulidæ. But with these really unessential features the resemblance ceases, and, as will be seen hereafter, Pourtalesia in characteristics of primary importance departs very far from those Cretaceous types. Nor is this dissimilarity diminished in any respect when in the course of geological time great changes are seen going on in the structure and general conformation of the Spatangean type, and other forms are introduced, Prymnadete as well as Prymnodesmic, thoroughly different from their predecessors, in the calycinal system opening posteriorly [2]) for the reception of the restored central piece and costal 5, and in the test discarding the high and thickset build, and assuming more and more the lengthened and depressed form with a flattened ventral surface, prevalent among the Tertiary, and still more among the existing species. But in the whole number of forms, in which this change has been brought about, there is not one that comes near Pourtalesia in the cylindroid build of its skeleton, and the shortness of its frontal part as defined by the paired ambulacra of the trivium, compared to the lengthening of its hinder and by far greater portion.

It is also in vain looking among the older Spatangidæ for anything that may be said to resemble that most striking feature, the bending in upon itself of the test, by which the deep infra-frontal recess is produced, with the oesophageal opening at its bottom. Among those forms that first come in sight, in the oldest Cretacean beds, Anancites [3]) has the five ambulacra all nearly uniform, the front ambulacrum differing

[1]) The collections once made by FR. v. HAGENOW (b. 1797, d. 1865), who was blind during the last eight years of his life, at present form part of the Pomeranian Museum at Stettin. Dr C. A. DOHRN and his son Dr H. DOHRN were good enough to search it for the original specimen of Infulaster, but without success. Casts in plaster of Paris were however found, evidently taken from it.

[2]) Études p. 12, 83. [3]) Ib., pl. XXIV, fig. 181.

very slightly from the four paired ones. In the other Adetes sharing with Anancites the want of a compact sternum, the front ambulacrum is already distinct in outline and in structure; thus in Hemipneustes, Holaster [1]), Cardiaster. Then Prymnadete genera make their appearance, in which the paired ambulacra in their dorsal petaloid portions, subservient to respiration, are more or less deeply sunk, thus setting forth the bilateral structure of the body, while the forepart, which heads its movements, assumes a form of its own, allowing the front ambulacrum, with its more or less specialised, often highly extensible pedicels, to sink more or less deep between the interradia 2 and 3. It was at the close of the Cretaceous time, and in the beginning of the Tertiary period, that this peculiar independence in form of the front ambulacrum was freely developed, and the older times have little comparable to the excess it attains in the species of Schizaster [2]), Tertiary and recent, and in the strangely resembling deep-sea form, Aceste bellidifera Wyv. Thoms [3]). In these a more or less considerable portion of the front ambulacrum is deeply sunk, so as to protrude inwardly into the peritoneal cavity. But this depression begins near the calycinal system, hanging down from the roof, and, bulging in its middle part, continues decreasing towards the vicinity of the mouth. In Pourtalesia, on the contrary, it is the ventral portion, from behind the mouth and onwards, that is inverted so as to rise from the floor of the general cavity, carrying along with it the peristome and the lip, and raising them into a vertical position, so as to make nearly a right angle with the antero-posterior axis.

It is from the skeleton of Pourtalesia Jeffreysi that this description is taken. In its principal terms it applies also to the other species of the group, to the somewhat slenderer P. miranda; the more elongated P. phiale Wyv. Thoms, with its widely gaping infra-frontal recess; the broad P. hispida Al. Ag.; the more tumid P. laguncula Al. Ag. and P. carinata Al. Ag., and even to the stout P. ceratopyga Al. Ag. with its strongly expanded forepart. The two other members of the group, both apparently Adete, the ovoid Spatagocystis Challengeri Al. Ag. with but a short caudal prolongation, and the triangular gibbous Echinocrepis cuneata Al. Ag. with the broad forepart and the subventral periproct, are linked to Pourtalesia by more than one characteristic, but mainly by that most singular one, the deep infra-frontal recess.

Thus with regard to the general form of the skeleton there is not one among all the known genera of Spatangidæ, and still less among the other groups of Echinoidea, to which the Pourtalesiæ bear any closer relation. In that respect, as in most others, they stand alone at present.

[1]) Études, pl. XXV, fig. 182.

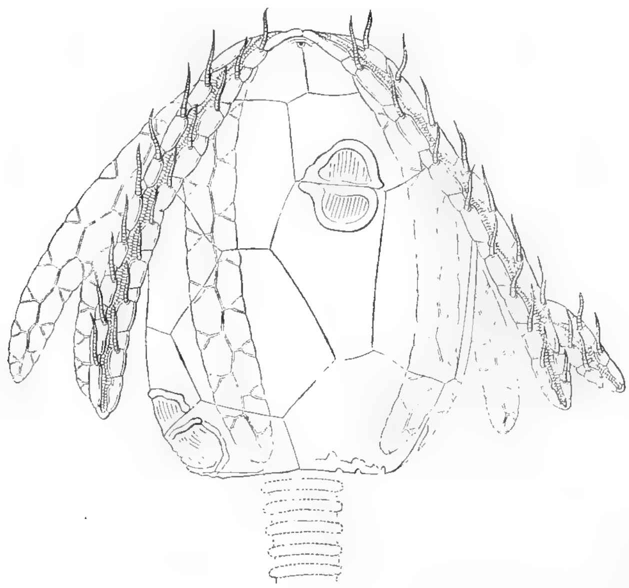
[2]) Comp. Schizaster antiquus Cotteau, Bull. Soc. Géol., VI, 567.

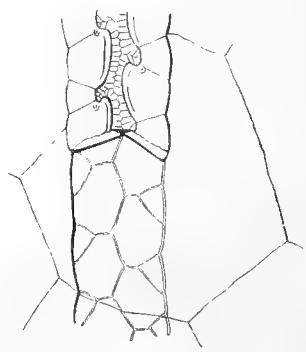
[3]) Voyage of the Challenger, I, 376. — Al. Agassiz, Rep. Chall. Echinoidea, 195, pl. XXXII, fig. 7—11, XXXIII *a* fig. 1—7, etc.

II. THE PERISOMATIC SYSTEM.

The perisomatic system in the Cystoidea and in the Echinoidea. The anomalous disposition of its elements in the Pourtalesiadæ approaching to annulose differentiation; the heteronomy of 1 and 4 maintained; the periproct, its position in Pourtalesia similar to its position in the Cassidulidæ. The fasciola. The spines.

The perisome is the general envelope, and the interradia — the »areæ» of Linnæan terminology — are the portions of it that are exposed to view between the ambulacra and outside the calycinal system. It alone makes up the whole skeletal sack of some Cystoidea. In Callocystites it is easily seen to be continuous under the ambulacra, which are attached solely by their first adoral plates, but otherwise free. Its sutures are clearly observable running under them, and its surface is marked with impressions





Callocystites Jewetti HALL.

Restored: showing the marks left on the perisome by the slightly raised ambulacra.

Ambulacrum broken away to show the marks.

caused by their backs, when at rest and reclining against it. The independent nature of the two systems cannot be more clearly indicated. Supposed then, as seems at present quite lawful, that those movable members, which in the Cystoidea bear the oral grooves issuing from the corners of the mouth, are homologous to the ambulacra — the fettered limbs — of the Echinoidea, the question arises whether it may not be possible some day by skilful manipulation to demonstrate, in some species or other, the uninterrupted continuation, under the ambulacra, of the interradia, as a very thin membrane. But this is only one of the many questions to be taken up by a thorough investigation of the histology of Echinodermata. Another is that concerning the relation of the perisomatic system to the calycinal. In the Cystoidea, — in which every trace of a calyx is wanting, at least in the adult — the basal part of the skeleton is formed by the perisome alone. It is this that has led me to inquire whether in Endocyclic Gnathostomes, where the primitive dorso-central ossicle is broken up in consequence of the eruption of the excretory opening, or, as in the case of Salenia, where a periproct is formed more or less outside that ossicle, the anal membrane which is substituted for the removed parts, may not belong to the perisomatic system, continuous under the calycinal as well as under the ambulacral system, and thus forming by itself the whole of the skeletal sack.

Being thus the principal constituent of the exterior of the Echinoidean skeleton, the perisome has a tendency to assert its supremacy, so to speak, by intervening between the two other, or even infringing upon them. I have shown how largely this takes place among the Star-fishes. [1]) In the young of Asterias glacialis the calycinal system, originally compact and complete in all its parts: central ossicle, five costals and five radials, is broken up owing to the predominant development of the perisome, by dint of which the central ossicle is replaced by an anal membrane, the five costals severed from one another almost past recovery, and the five radials moved far off to the tips of the rays. And among the Echinoidea, when in the Collyrites the ambulacra of the bivium are seen diverging from their normal position, the space left open is found to be filled by expanded interradials. Wherever there is a question of thoroughly making out the relations of the three systems combined in the Echinodermal skeleton, it is of primary importance to keep in view this ascendency of the perisomatic system, in virtue of which it is seen in more than one way, and often in a delusory manner, to mix itself with the other systems, and obscure their relations.

The Perischo-echinida are characterised by the presence in each interradium, at the ambitus, of more than two series of perisomatic plates, out of which the adambulacral alone attain to the peristome and the calycinal system. It was believed that this mode of structure was limited to the Paleozoic era, and that with the single exception of the genus Tetracidaris COTTEAU, of the Cretacean era, all the Mesozoic, Tertiary and existing Echinoidea had only two series of plates in each interradium. To this another exception has lately been added. During the latter part of the Triassic period the sea that covered Southern Tyrol was inhabited by a fauna, preserved at S:t Cassian, [2]) in which survivors from the Palæozoic era, such as Spirigera, Cyrtina, Retzia and Murchisonia, were coeval with numerous Mesozoic and modern types, then, as far as we know, appearing for the first time, and species of Orthoceras lingered among the earliest Ammonites, of an antique aspect. In this assemblage of old and new the Echinoidea were represented by numerous forms referable to Cidaris and a single Hypodiadema, and along with these by the very singular little Tiarechinus princeps (LAUBE) lately described by NEUMAYR. [3]) I am indebted to D:r FRANZ v. HAUER, and D:r DIONYS STUR, of Vienna, for the opportunity kindly offered to exa-

[1]) Études, p. 86, pl. LIII, fig. 256—260.

[2]) LAUBE, die Fauna der Schichten von S:t Cassian, Wiener Denkschriften, XXIV, XXV, XXVIII, XXX, 1868.

[3]) Sitzungs-Berichte d. K. Akad. d. Wiss. Wien, Abth. I, LXXXIV, Juni 1881.

mine carefully the original specimens of this species, and thus fully to confirm the description given by Neumayr, even on points that to him seemed dubious; *Pl. XIII, fig. 150—162.* The ambitus of the test is more or less oval, the relation between length and breadth being as 53 : 50, 48 : 48, 39 : 38. The dorsal face, almost entirely constituted by the calycinal system, is high and hemispherical, the basis flat, even concave. The antero-posterior axis, which coincides with the longitudinal, is determined by two of the ambulacra, those of the bivium, I and V, being notably closer together, almost adjoining one another, while those of the trivium are more widely separated, and by equal distances. The stoma is large, conformable to the general ambitus, and the peristoma, made up of ambulacral and interradial plates, shows no trace of notches. The ambulacra, all alike and equal, are expanded at the peristome, and, as it were, connected there by a narrow somewhat raised margin, then a little contracted, slightly expanding again, while ascending the flanks, and terminating a little above half the total height. Their zones of pores, diverging near the peristome, are simple, the plates being all primary, each bearing near the outer margin a geminous pedicellar pore, placed obliquely, the inner perforation being nearer to the adoral margin. Inside the pore there is a hemispherical tubercle, smaller and perhaps wanting near the peristome; the middle part of the ambulacrum is finely granulated.

Regarding the interradia Neumayr thought he observed, in each of them, a single peristomal plate, followed by three plates separated by vertical sutures. This I have verified, *fig. 152, 154,* the exceedingly fine sutures having been made to come forth distinctly, in all the five interradia of the best specimen, by keeping it immersed in a mixture of spirits and glycerine, a medium that at times is effectual on refractory specimens. The first peristomal plates are single, those of 1, 2, 3, 4 equal in breadth to the ambulacra, that of 5 considerably smaller, all of the same shape, hexagonal. The single peristomal plate is everywhere followed by three very high, laterally contiguous plates, extending to the termination of the ambulacra. Of these the middle one adorally almost equals the two lateral, and narrows upwards, while these expand. The first plate is smooth, and bears a single, central, large tubercle; the three second plates, smooth in their flattened basal portion, are each provided with a tubercle somewhat larger than that of the first, the three tubercles making a transverse row, and being connected by a distinct rounded ridge, which limits the basal surface from the ascending flanks. All the four tubercles consist of a hemispherical imperforate mamelon surrounded by a narrow, not very distinct areola. Laterally, and from a little above the tubercles, the whole dorsal face is thickly covered with oval or roundish granules, which in the interradials partly assume the appearance of vertical rows.

This disposition of the plates of the interradia is completely foreign to the Endocyclic Echinoids. A single peristomal is a characteristic proper to the Neonomous, — the Echinonei excepted —; but the triple row following it is without a parallel in the whole class. The peculiar form of the middle plate recalls, in a distant manner it is true, what is seen in certain Cystoideans, in which however it is barely possible to find out any attempt at order in the disposition of the plates of the perisome.

When from this eminently archaic form we turn at once to Pourtalesia Jeffreysi, so profoundly contrasting in every particular of its build, the five interradia are found to conform to the rule prevailing in the Neonomous Echinoids, of Mesozoic and later origin: they all consist of a double series of plates, *Pl. II, fig. 9.* The two anterior, 2 and 3, considerably smaller than the lateral ones, 1 and 4, are, as usual, enclosed between the frontal ambulacrum, III, and the paired ambulacra II and IV. Occupying the corners of the front, with their inner series of plates drawn in into the infra-frontal recess along with the ambulacrum III, they rise on either side, and terminate dorsally within the angles formed by the trivious ambulacra and the calycinal system. Their plates are, upon the whole, smaller than any other in the whole test. They enter the peristome each with a single plate 2 *b 1*, 3 *a 1*, *Pl. II, fig. 9; III, 12; IV, 18, 19,* belonging to their inner series, a long, rather narrow and flexuous plate, joining anteriorly the *a 1* and *b 1* of the ambulacrum III, extending along the nearly vertical sides of the stoma, and meeting ventrally and posteriorly the minute labrum marked 5, *Pl. II, fig. 9; IV, 16,* thus excluding from the peristome the ambulacra II and IV, I and V. In the same series 2 *b* and 3 *a*, this first plate is followed by a large second plate, joining its entire aboral margin, and preceding a series of ten or eleven sub-hexagonal oblong plates, soon diminished in size, and ending at the calycinal system with a small squarish or sub-pentagonal plate, *Pl. II, fig. 9; V, 25, 26, 27, 28.* The outer series, 2 *a* and 3 *b*, *Pl. II, fig. 9; III, 12; IV, 18, 19,* of ten plates, commences with a middle-sized plate, 2 *a 1* and 3 *b 1*, having its hinder extremity inclosed between the ambulacrals II *b 1, 2, 3,* and IV *a, 1, 2, 3,* and the interradials 2 *b, 1, 2, 3,* and 3 *a, 1, 2, 3,* and thereby excluded from the peristome. It is followed by nine hexagonal plates, somewhat larger than those of 2 *b* and 3 *a*, increasing up to the fourth or fifth, then diminishing, and joining the calicynal system with an irregularly squarish terminal plate, *Pl. V, fig. 25, 26, 27, 28.*

The lateral interradia 1 and 4 are much more expanded, as generally in the Spatangidæ, and especially in the Prymnodesmic genera. They constitute the flanks of the body. On the dorsal surface their plates are the largest of all, and on the ventral inferior to the sternum, 5, 2, alone. By an arrangement hitherto without parallel, they commence, not, as by rule they ought, in the peristome and separately, but apart from it and jointly, in the middle of the ventral surface, *Pl. I, fig. 2; II, 9; III, 10.* As in most Spatangidæ, Prymnadete and Prymnodesmic, the first plate of these interradia, though properly belonging in common to both series 1 *b* and 1 *a*, 4 *b* and 4 *a*, still seems to appertain more especially to the anterior of them, 1 *b* and 4 *a*,[1]) so also in Pourtalesia Jeffreysi it is the first plates of the anterior series that alone are reciprocally contiguous, and this along the entire inner margins of their first plates, 1 *1*, 4 *1*, thus separating from one another the first and second plates of the ambulacra I and V. In the specimens from which the figures *Pl. I, fig. 2, 8; II, 9; III, 10,* were taken, the first plate of the interradium 4 is twice the size of 1, *1*, and alone in contact with the ambulacrals I, *1* and V, *1*. But in this respect there may be some variation. These

[1]) Études, pl. XXVIII—XXXVIII, XL—XLIII.

two first plates of 4 and 1 are followed in the anterior series on either side by ten or nine large oblong hexagonal, finally irregularly pentagonal or squarish plates.

The hinder series, beginning outside the seconds of the ambulacra I and V, contain each seven separate hexagonal plates, *2—8*, among which the 1 *a 3* and 4 *b 3* are lengthened, the following slightly diminishing, and rather squarish.

But, after all, strangely displaced and brought out of their normal position in the peristome as are the lateral interradia 1 and 4 in Pourtalesia Jeffreysi, they still retain a peculiarity eminently characteristic of the Spatangidæ. In my former memoir on Echinoidea [1]) I called attention to the singular deviation invariably met with in the structure of their interradium 1, the one on the right side of the animal. In all the known genera of Prymnodesmic Spatangidæ, from the extinct Micraster of the Chalk to Lovenia, [2]) this heteronomy is so strikingly displayed as not to be overlooked. It is brought about by the constant combination of the plates 1 *a 2* and 1 *a 3* into one single compound plate 1 *a 2 + 3*. It is no less apparent, and effected in a similar manner in most of known Prymnadete genera, in Hemiaster, Abatus, Agassizia, Schizaster, Moira, [3]) and, among the Adete forms, in Echinospatagus. [4]) In Palæostoma [5]), exceptional in other respects also, the plates 1 *a 2*, 1 *b 2*, and 1 *b 3* are all united into one, while Faorina and Desoria [6]) have the plates 1 *a 2* and 1 *b 2* compounded into one single binary plate. This same disposition holds good also in the almost extinct group of Adetes, such as Anancites, [7]), Holaster, [8]) Cardiaster, Offaster, characterised by the plates of the interradium 5 following the labrum not being united into a shield-like double sternum, but separate, transversely pentagonal and wedge-like. In times farther back yet, among the Collyrites, there seems to have been no trace of the heteronomy.

This striking feature presents itself under a new form in Pourtalesia Jeffreysi, *Pl. I, fig. 2; II, 9; III, 10.* If in this species the plates of 4 *a* and 1 *b* are counted, there are ten in the former, and only nine in the latter. This may depend on one plate being wanting in the 1 *b* series, or on two plates having been united into one. That this latter is really the case is seen plainly enough. The two hinder series, 1 *a* and 4 *b*, consist each of eight plates, the first, marked 1, *1* and 4, *1*, belonging in common to the two series 1 *a* and 1 *b*, 4 *a* and 4 *b*. When the plates are compared one by one from side to side, as their numbers correspond, they are found symmetrically conformable and evident counterparts, from 4 *b 8* and 1 *a 8* to 4 *b 3* and 1 *a 3*. But 4 *b 2* is not conformable to 1 *a 2*, the former being distinctly hexagonal, the latter as evidently pentagonal. This is so because the former, 4 *b 2*, has to face adorally the three plates *2, 3, 4* of the series 4 *a*, while the 1 *a 2* has to front two plates only. But the plate *4 a 4* evidently answers to the third in order in 1 *b*, so this latter must be marked 1 *b 4* and the plate between it and the plate 1, *1* set down as 1 *b 2+3*. Pourtalesia laguncula AL. AG., *Pl. VI, fig. 37*, presents exactly the same heteronomous disposition of the identical plates, 1 *b: 1, 2+3, 4* = 4 *a: 1, 2, 3, 4*, and presumably it will be found to pervade the whole group. It seems strange that the plate 1 *b 2+3*,

[1]) Études, p. 49—52. [2]) Ib. pl. XXXII—XLIII. [3]) Ib. pl. XXVI, XXIX, XXX, XXXI. [4]) Ib. p. 58. [5]) Ib. p. 50, pl. XXXII, fig 197. [6]) Ib. pl. XXVII, XXVIII. [7]) Ib. pl. V, fig. 51; pl. XXIV, fig. 181. [8]) Ib. pl. XXV, fig. 182—184.

containing the matter of two plates, is so out of proportion to the plates 4 *a 2* and 4 *a 3* taken together, which it represents, but this is often the case also in the Spatangidæ, and, as in these so in Pourtalesia Jeffreysi, one or two among the following plates in 1 *b* to some extent compensate for the defect. And finally the position of the heteronomy in these very same plates clearly testifies, that the two remaining innermost plates of the series are really the 1, *1* and 4, *1*, and that thus these interradia, though displaced, are complete and normally constituted.

The formulæ of the heteronomy in the different groups are:

Adetes: Anancitidæ	1 *a 2* + *b 2* = 4 *a 2* : 4 *b 2*.
Prymnadetes: Desoria, Faorina	1 *a 2* + *b 2* = 4 *a 2* : 4 *b 2*.
» Hemiaster—Moira	1 *a 2* + *a 3* = 4 *b 2* : 4 *b 3*.
Prymnodesmians: all the genera	1 *a 2* + *a 3* = 4 *b 2* : 4 *b 3*.
Pourtalesia: two species	1 *b 2* + *b 3* = 4 *a 2* : 4 *a 3*.

The union, in 1, of two plates into one, which in the great majority of the Spatangidæ takes place within the *a* series, and in the Adetes and a few Prymnadetes within both series, *a* and *b*, in the Pourtalesiæ is transferred, entirely, to the *b* series, a deviation corresponding with their remoteness in other respects. Everywhere the heteronomy is, on the right, confined to the interradium 1. Evidently connected with the obliquity represented by the axis $\alpha\omega$, it is derived from some point in the larval development not yet understood, a mark, perhaps, recording the heterologous position of the young Echinus in the interior of its Pluteus. [1])

In ascending the tumid flanks of the body, the interradia 1 and 4 in Pourtalesia Jeffreysi slightly incline forward, and terminate in joining again from either side on the back, nearly at the anterior third of the entire length, *Pl. I, fig. 1; III, 11; V, 25—28.* There they end, without attaining their proper position, as by rule they ought, in contact with the calycinal system, being kept apart from it by the intervenience of the terminal plates of the odd interradium 5. Thus, while ventrally they do not, as in all other Echinoidea, take their origin separately, in the peristome, between the ambulacra I and II on the right, and IV and V on the left, so dorsally they do not terminate, as conformable to rule, isolated from one another, and at the calycinal system, but at a distance from it and uniting reciprocally. Below, they break through the bivious ambulacra; above, they disjoin the posterior odd interradium and take up among them its detached plates, and all through the space thus opened, they describe a broad perisomal belt continuously encircling the body around its middle.

Unlike the paired interradia just described, the odd posterior interradium is represented, conformably to the general rule, in the peristome of Pourtalesia Jeffreysi, by a true, though very minute labrum, 5, *Pl. II, fig. 9; IV, 16.* Its position is entirely within the incurved forepart of the test, and there it is wedged in between the first plates of the interradia 2 and 3 and the first of the ambulacra II, IV, and I, V. By the interposition of all these plates the labrum is widely separated from the seconds of 5, which here, as in the Spatangidæ, are formed into a sternum, 5, *a b 2*, *Pl. I,*

[1]) See Études, p. 37—39, pl. XVII, fig. 140.

fig. 2; II, 9; III, 10. But in Pourtalesia this essential constituent of the ventral surface is not composed of two collateral, lengthwise suturally united plates, but compact, all of one single piece, shield-like, slightly bulging, pentagonal, widening a little anteriorly, and having its front margin faintly arcuated. Although, if taken as a whole, surpassing in size all the other plates, it is considerably smaller, relatively to the entire ventral surface, than the sternum of the Spatangidæ, but notwithstanding this and its backward position, it is at once recognised by its mesial position and its numerous crowded spines. It is followed by a pair of well defined and fairly sized episternals, somewhat lengthened, but else not unlike those of Meoma and Brissus [1]), crossed, as they ought to be, by the ventral portion of the subanal fasciola, and contracted a little posteriorly so as to form on either side, with the first pair of abdominals, *5 a 4*, *5 b 4*, an open but distinct episternal angle into which are received the bivious ambulacrals I *a 4* and V *b 4*, *Pl. II*, *fig. 9.* By curving upward rather abruptly, *Pl. I*, *fig. 3*, this first pair of abdominals and of pre-anals constitute the hindermost blunted end of the test, and cause the second and third pre-anals, 5, *5* and 5, *6*, to form the dorsal, flat or even slightly concave surface of the caudal prolongation. Of these the first-named, 5, *5*, is traversed by the fasciola, *Pl. I, fig. 1, 3*; *II, 9.* Then come three pairs of anal plates, 5, *7*, 5, *8*, 5, *9*, *Pl. I, fig. 4*, diverging sideways to give room to the excretory opening, and having their inner margins cut out for the periproct, the two first-named forming its inward sloping sides, *Pl. I, fig. 4; III, 13.* The third, 5, *9*, turns abruptly over on the back, and is there followed by a forwards directed series of seven pairs of dorsal plates, 5,*10* to 5,*16* which gradually contract, *Pl. I, fig. 1; III, 11.* They are at first transverse, then somewhat squarish, at last longitudinal, all irregularly hexagonal, having one of their sides lengthened, and another hinder one very short, thus giving rise to an almost straight-looking middle suture. It is this part of the back which is raised into a distinct mesial ridge subsiding into the simple convexity of the pairs 5, *15* and 5, *16*. In these two pairs the *a* plate becomes distinctly smaller than the *b* plate, in a manner analogous to the checked growth of the corresponding plates observable in certain Spatangidæ [2]). Situated within the anterior third part of the dorsal surface, and separating from one another the terminals of the bivious ambulacra, the dorsals *16* of the interradium 5 are there met by the two lateral interradia 1 and 4, *Pl. I, fig. 1; III, 11*, joining one another from either side, and intervening with their large plates between them and the calycinal system. But it is only at the first collision that the dorsals give way. Taking advantage, as it were, of the intersecting point of the sutures of the four terminal plates of 1 and 4, the odd interradium 5 there reappears as 5, *17*, rather out of shape, and with the *a* plate still more reduced, *Pl. I, fig. 1; II, 9*, or altogether lost in the conflict, *Pl. III, fig. 11.* And when, on the further side of 1 *b 10* and 4 *a 10*, it comes forth again, its two plates, 5, *18*, have resumed their proper size and due proportions, and at the same time have attained their legitimate position in close contact with the calycinal system. Thus, in Pourtalesia Jeffreysi, the sequence of these dorsal plates of the interradium 5 is broken. From

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[1]) Études, pl. XXXIV, XXXV. [2]) Ib., p. 60.

analogy it seems probable that the continuous series of much reduced plates which in the Collyrites connects the periproctal area with the dismembered calycinal system, and keeps asunder the interradia 1 and 4, may be found to consist of true interradials belonging to the odd posterior interradium 5.

It is important to know whether the highly anomalous disposition of the perisomatic system in Pourtalesia Jeffreysi is a peculiarity more or less characteristic of that species alone, or, like the frontal recess, a feature common to all the different forms of the group. In Pourtalesia laguncula AL. AG. [1]), *Pl. VI, fig. 37—40*, the labrum, 5, *1*, much larger than in P. Jeffreysi, excluded from the peristome, expands posteriorly, drives asunder the first plates of I and V, and attains the adoral ends of 1 *b 1* and 1 *b 2+3*, 4 *a 1* and 4 *a 2*, herein very strongly differing from the labrum of that species. But the interradia 1 and 4, expanded as in P. Jeffreysi, exhibit exactly the same disposition by uniting mesially, and forming a continual broad ring passing round the middle of the body, and where they meet dorsally from either side, their junction is completed by the interposition of detached plates of the posterior odd interradium 5, *Pl. VII, fig. 52.*

According to the figures given by AL. AGASSIZ [2]) of Spatagocystis Challengeri, its interradia 1 and 4 unite ventrally as well as dorsally, and by their interposition, and that of the ambulacra I and V, the labrum is separated from the sternum, which is very minute and narrow. Dorsally a row of plates of the interradium 5 separates them from the calycinal system.

These three forms, therefore, Pourtalesia Jeffreysi, P. laguncula and Spatagocystis Challengeri, all agree in the annular disposition of the middle region of the perisome formed by the lateral interradials, 1 and 4; — but they seem to be extreme cases.

For, as far as the fragmentary condition of the specimens available has permitted me to ascertain these points, Pourtalesia carinata AL. AG. [3]) and P. ceratopyga AL. AG. [4]) as well as Echinocrepis cuneata AL. AG. [5]) differ from them in a marked manner. Like P. laguncula they all have the labrum, 5, *1*, expanding aborally. In P. carinata, *Pl. VI, fig. 42, 43, 45, 46*, as in that species, but unlike what is seen in P. Jeffreysi, the ambulacrals I, *1* and V, *1* are bi-seriate, *a* and *b*, but aborally they are not, as in P. laguncula, separated from I *a* and *b 2*, V *b* and *a 2*, but contiguous to them. Consequently the interradials 1 and 4 do not join one another on the mesial line, but are wholly lateral, as they ought to be. They do not, however, form part of the peristome, being excluded from it by the close contiguity of the ambulacra I and II, V and IV, but are to be seen, narrow, deformed and isolated, squeezed in between the I *b 1* and II *a 1* on the right, and the V *a 1* and IV *b 1* on the left, as if forced out of their proper places in the peristome. The fragment examined permits me to observe how the V and IV unite behind the 4, *1*, and how the 4, *2* makes its appearance outside the union of V *a 2* and IV *b 2*, *fig. 42, 46, 45.* On the right side, where the 1, *1* is

[1]) Chall. Rep. p. 137, pl. XXII *a*, fig. 7—15; XXXI, fig. 1—11. [2]) Ib. p. 141, pl. XXVI, XXVI *a*. [3]) Ib. p. 133, pl. XXVIII *a*. [4]) Ib. p. 134. pl. XXVIII, XXXV *b*, fig. 17. [5]) Ib. p. 143, pl. XXVII, XXXV *a*, fig. 9—13.

considerably larger, the broken test shows only the junction, behind it, of I *b* and II *a*. The labrum, like that of P. laguncula, is very narrow adorally, *fig. 42—44*, — it is hard to say whether it reaches the peristome or not, *fig. 46*, — and enlarges aborally, till it meets a pair of plates that occupy exactly the place between the ambulacra I and V, regularly allotted to the sternum, 5 *a b 2*. According to AL. AGASSIZ they seem to carry spines bigger than others, on closely packed tubercles. From all this it follows that in P. carinata the interradials 1 and 4 do not join ventrally in the middle, and consequently do not form a continuous ring. Dorsally they are very much the same as those of P. laguncula.

In Pourtalesia ceratopyga, *Pl. VII, fig. 48, 49, 50*, with its bi-seriate ambulacrals I and V, there also appears between them and II and IV, on either side, a wedge-shaped interradial 1, *1* and 4, *1*, excluded from the peristome, but on the left side, 4, *1*, not very far from being admitted to its legitimate position in it. Dorsally, *fig. 51*, the interradials 1 and 4 unite, broadly separating the last plates of 5, out of which a few are pushed forward so as to infringe upon the calycinal system.

Echinocrepis cuneata AL. AG. [1]) ventrally seems to present the same disposition *Pl. VII, fig. 53*. The first plates of 1 and 4, excluded from the peristome, occupy the same places as in the two preceding species, and probably are contiguous to their respective interradia. The labrum, 5, perhaps without reaching the peristome, is produced aborally, and according to the figure given by AL. AGASSIZ, seems to reach the ambuacrals I *a b 2* and V *b a 2*, which separate it widely from the sternum, 5, *2*. Dorsally, *fig. 54*, the 1 and 4 laterally touch the calycinal system, while posteriorly the ambulacra I and V intervene between it and the last plates of 5.

Thus, within the definite and narrow limits of the little group of the Pourtalesiadæ, consisting at present of only ten species distributed into three genera, and held firmly together by a few essential and constant characteristics, there exists in the perisomatic system a movement at once forcible and anomalous, tending to transform its most important elements into something unlike every precedent. Ventrally the change may be supposed to begin with the withdrawal of the 4, *1* and 1, *1* from the peristome, and their secluded reception between I *b* and II *a*, V *a* and IV *b*, as in Pourtalesia carinata, P. ceratopyga and Echinocrepis cuneata, while these same ambulacrals are left in legitimate contiguity to the respective I *a b 2* and V *a b 2*; — and to end, in Pourtalesia Jeffreysi, P. laguncula and, apparently, in Spatagocystis Challengeri, with the entire removal of 1 and 4 from their old places between I and II, V and IV, to a new position, on the mesial line of the skeleton, where they interrupt the succession of plates in the ambulacra I and V and the interradium 5. Dorsally, while in Echinocrepis the 1 and 4 can hardly be said to join one another, they in all the other species examined unite freely and largely, with the intervenience of plates from the interradium 5. And thus in these three species at least, the interradia 1 and 4 combine to form a continuous ring all around the middle of the body. Once before, early in Mesozoic time, for a while and not unlike a trial soon given up, a structure resembling

[1]) Chall. Rep. p, 143, pl. XXXV *a*, fig. 10.

this was seen, in the Collyritidæ, but imperfect, the ring being open ventrally and closed dorsally only. In these Pourtalesiæ it is complete above as below. This is a feature hitherto unseen among Echinoidea. With it the appearance of a radiate disposition of the skeletal elements, still kept up, to no small extent, in the Spatangidæ, is destroyed in an essential degree, and a tendency betrays itself towards an annulose differentiation of the bilaterally symmetrical constituents of the cylindroid skeleton. When reflecting on the great difference between Tiarechinus and Cidaris on the one hand, represented already in the earliest of Mesozoic times, and Pourtalesia on the other, nowhere recognised among extinct forms, and on the general character of the succession of varying forms separating their epochs, the idea presents itself that, while one branch of the Echinoidea, the Archæonomous, has tenaciously persisted in maintaining its original features, the other, the Neonomous, has been striving all the time to lay aside the radiate sameness of the ancient structure, and gradually to approach a higher standard of organisation endowed with superior appliances for ministering to the varied activities of life; and that something like such a stage of its evolution is on the eve of being touched, among the Pourtalesiadæ, by means of this primitive attempt at an annulose differentiation of some of the skeletal elements.

Each of the different groups of Exocyclic Echinoids, Dentiferous as well as Edentate, on its first appearance, has the excretory opening placed at or near the calycinal system, and from thence, in the course of time, it gradually recedes farther and farther back. Thus, among the Echinoconidæ [1]), in Pygaster, the oldest of them, it is dorsal and still partly calycinal, as though it had just broken through the circle of costals; in Pileus, of the Middle Oolite, it is dorsal, sub-marginal; in the Oolitic species of Holectypus it is marginal or ventral, in the Cretaceous ventral and farther removed; in Discoidea, of Cretaceous origin, it is ventral, in Echinoconus and Anorthopygus posterior, sub-ventral. In this group therefore, the excretory opening is seen early to have broken through the calycinal circle, and, when out of it, to retrograde farther and farther back. But this branchlet of the Dentiferous type was not strong enough to endure all through the Tertiary period and up to the present era, — its sole survivor, the Pygaster relictus of the Caribbean sea, is of very diminutive dimensions —, it is upon the main branch, the Endocyclic, that it has devolved to people the seas of successive geological ages, and at its side the Dentiferous Exocyclics are actually represented by the Clypeastridæ, of all but Tertiary origin. In these the periproct is far removed from the calyx, and they present many a feature foreign to the primary types.

Long before their appearance the other great branch of the Echinoidea, the Edentate, not upon record from Palæozoic time, already formed a conspicuous part of one of the earliest among Mesozoic faunas as yet recognised. From whatever point of the common trunk it may have once originated, whatever may have been its phases of existence previous to its appearance, and still unknown to science, it gives evidence enough of having undergone profound modification, and, in assuming new distinctive features, of having done away with structural formulas deeply characteristic of its elder

[1]) Études, p. 79.

sister-branch. And in the whole course of its development it continues to deviate more and more.

It begins with the Echinoneidæ. Galeropygus and Hyboclypeus, the oldest known, from the Liassic and Oolitic periods, with a rounded ambitus, have the excretory opening close to the calyx; in Galeroclypeus, Pachyclypeus, Desorella, from the Middle Oolite, it is posterior, even marginal. In the Oolitic species of Pyrina it is near the calyx, or at the middle between it and the posterior margin; in the Cretaceous species it is marginal, and it becomes ventral in Echinoneus, Tertiary and recent.

Among the Cassidulidæ the Oolitic genera, Clypeus and Pseudodesorella, have the periproct not far removed from the calyx, and the gap is often filled by a prolongation of the radials I and V. Out of twenty Oolitic species of Echinobrissus nine belong to the older division, and five of these have the periproct sub-calycinal, one not far behind, and three at half the distance between the calyx and the posterior margin; seven species are Middle Oolitic, and it is sub-calycinal in one of these, at one fourth, one third, or one half of the distance in five, behind the middle in one. In the Upper Oolite, of four species, one alone has the vent sub-calycinal, three posteriorly in the middle, and the three Cretaceous species, as also E. recens, of a lengthened general form, all have it posterior, at the middle, or even behind. In all the numerous genera of the Cretaceous and Tertiary periods the periproct is from supra-marginal to infra-marginal, and in those of Tertiary origin ventral, even sub-oral. In general, and with the sole exception of Pygurus, in which, in Oolitic time, it remained marginal or was even infra-marginal, the site of the periproct in the oldest known forms of Edentates was in close vicinity to the calycinal system, and from this point it retrograded farther and farther during the Cretaceous and Tertiary periods, even so as at last to become ventral.

In the Collyrites, of Oolitic existence, the periproct is posterior, and so it is in the Holasteridæ. Among the earlier forms of the Spatangidæ its site is more or les. dorsal, in those of later appearance it recedes, according as the abdomen lengthenss Like other features permanent in earlier forms, transitory in the more recent, this progressive modification is exhibited in the course of the individual development of recent forms.

Philippi, when describing the antarctic Spatangi [2]) for which Troschel afterwards created the genus Abatus, relates that he found, within their deepened petals, some very minute specimens which he suspected to be their young, and this discovery has since been confirmed and extended by Al. Agassiz [3]), who examined specimens collected at the Kerguelen Islands, as well as by Sir Ch. Wyville Thomson [4]) and by Studer [5]), who both at that same locality had frequent opportunities of seeing live specimens. I am indebted to the well-known liberality of the late Professor W. Peters for a present, which cannot be too highly appreciated, of three young ones taken out of the marsupial petals of the unique specimen bearing such, in the Berlin Museum.

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[1]) Études, p. 81. [2]) Wiegm. Arch. XI, 1845, p. 347. [3]) Proc. Amer. Acad., XI, 1876, p. 231. — Rep. Echin. Chall., p. 177, pl. XX *a*. [4]) Journ. Linn. Soc., XIII, p. 67. — Voy. Chall., II, p. 229. [5]) Mon. Ber. Berl. Akad., 1876, p. 457 — Ib. 1880, p. 881. — Zool. Anzeiger, 1880, p. 343.

Only one among them was entire, but taken all together they afforded materials enough for observing some details not noticed before, *Pl. XIV, fig. 163—171.* Although apparently not far from leaving the nursery, they are still without oesophageal and excretory openings. In length they measure 2,3 mm., in breadth 1,9 mm. The general form of their test is very much that of the parent, as is also the dark brown colour. The whole body, spines and all, are tightly enveloped by a thick membraneous covering, the larval covering, closed at every point, and devoid of any opening for the alimentary organs, the animal still subsisting solely on the nutritious matter in store from the previous state of its development. In this stage now, the last one of its evolutional life, a stage of external rest passed through alike by the Cidaridæ and the Echinidæ, and by the Spatangidæ, the future skeleton is being built up, while internally the different organs receive their final structure as demanded by the mode of life of the adult. Under the thick envelope of the young Abatus cavernosus the spines, straight, conic, erect and bristling, look strong like those of an Archæonomous Echinoid, while the calcified plates of the ambulacral and interradial systems are already distinctly visible, and can be followed all the way up to the calycinal system, *fig. 165, 166, 167.* The skeleton, thus laid out in its principal parts, presents two clear spaces, both however overspread by the general covering and both unpierced, the one on the ventral side, not much before the middle, being the pentagonal stoma, *fig. 163, 165,* the other, on the dorsal side, a little behind the middle, being the central part over which the calycinal system is forming, *fig. 164, 164 A.* When the test is cut open horizontally, the intestinal tract is seen to be thick in its middle part, contracted in its oesophageal and rectal parts. Both portions end cæcally, and their closed extremities are seen to touch the wall of the visceral cavity, to which they are attached by the peritoneal lining descending upon them: the oesophageal extremity at the centre of the stoma, *fig. 165, 167,* the excretory at the centre of the clear space of the back, *fig. 166, 168.* Thus, at this stage, while directing its oral end towards a point slightly in front of the middle of the ventral surface, and its excretorial end to the central part of the calycinal region, only a little behind the middle of the back, the intestinal tract for a while has an ortho-proctic position, and recalls its Endocyclic termination in the ancient types. But this is here only a transitory condition, the centre of the calycinal system remains unpierced, and the excretory end of the intestinal tube, still blind, retrogrades, and opens only when beyond the limits of the calycinal system, — a movement, analogous to that known to have taken place, during past geological periods, through a long succession of Exocyclic species. The two large plates of the interradium 5, *fig. 166,* that approach nearest to the calycinal system, are those of the sixth pair, the labrum counting as the first. And, because in the adult the periproct is surrounded by the fifth, sixth and partly the seventh pairs, and, as I have shown in the case of Brissopsis lyrifera [1]), the periproctal plates remain the same in the adult as in a specimen not very much older than this young one of Abatus, it may be presumed that, in consequence of the forward movement of the apical part of the test, and

[1]) Etudes p. 60, pl. XXXVII, fig. 218.

the backward growth of the abdomen, combined with the tendency of the alimentary canal towards an antero-posterior direction, its excretory end, after having opened — which, as far as I have been able to observe, is done simultaneously with the opening of the oesophageal end — is drawn back towards the plates of the sixth pair, and that subsequently the seventh and following subanal plates are added, increasing its distance from the calyx. A young specimen of Echinocardium flavescens O. F. M., 1,7 mm. in length, *Pl. XV, fig. 173,* has the opened periproct high up on the back, near the calyx, from which it is separated by only two interradial plates. It is large, widely elliptic, and the calcified laminæ of the anal membrane are disposed in two rings, surrounding five converging triangular scales. Thus here also the stomato-proctic axis is not very far from vertical.

The manner in which the periproct is formed in Pourtalesia will probably never be known. In the adult of Pourtalesia Jeffreysi it is placed as far back perhaps as in any other species of the Neonomous forms, *Pl. I, fig. 3, 4; II, 9; III, 13,* over the caudal prolongation, in the deep depression between the interradials 5 *a* and *b*, *5* to *9*, and the ambulacrals I *a* and V *b*, *5* to *7*. It is transverse, cut out in the interradial plates *7*, *8*, *9* of 5 *a* and *b*, that form, with *5* and *6*, the circum-anal region, which is expanded and received on either side into the sinus made by I *a* and V *b*, plates *5*–*7*. The anal membrane is divided into two portions, an upper and overhanging one, between the interradials *8* and *9*, and an under and rising one, between *8* and *7*. The upper is broader and covered with smaller laminæ; it is the site of the excretory opening, a narrow transverse slit; the under portion, semi-circular, has larger scales. This structure agrees with what is seen in the Cassidulidæ. In this group the periproct, transverse and reniform, is likewise placed in a depression above the slight caudal prolongation, and the posterior under portion of the anal membrane, filling nearly the whole, is covered with a few large scales, while the upper, with the transverse excretory opening, is very small and drawn up close under the margin of the somewhat projecting post-anal plates. In the Spatangidæ, on the other hand, the membrane is of one piece, with its scales arranged concentrically all around, and the excretory opening, roundish and sub-central, closed by converging laminæ, as in the young of Echinocardium flavescens described above, *Pl. XV, fig. 173,* or in Palæostoma mirabile Gray, *Pl. XVI, fig. 184, 186, 191* [1]).

In Pourtalesia Jeffreysi and its congeners only one fasciola is present, a well-marked subanal fasciola encircling the caudal prolongation, *Pl. I, fig. 1, 2, 3; II, 9.* Like the corresponding fasciola of the Spatangidæ, it crosses the third and the fifth plate of the interradium 5, but, contrary to what is the universal rule in that group, it traverses, not the sixth and certain following plates of the rows I *a* and V *b*, but the fourth plate alone, which by itself fills the episternal angle. It thus marks off, not the fifth, but the third plate of both rows as the hindmost of the ventrals. In Pourtalesia laguncula, *Pl. VI, fig. 38,* it has the same position, which it probably

[1]) Études, pl. XIII, fig. 113, 118; XXIX, 190; XXX, 193; XXXI, 196; XXXII, 199; XXXIV, 204; XXXV, 207; XXXVI, 212; XXXVII, 217; XXXVIII, 221; XXXIX, 226; XLII, 231; XLIII, 234.

maintains in the other species. According to AL. AGASSIZ it is indistinct in Spatagocystis, and absent in Echinocrepis. [1]) Upon the nature of the fasciola no fresh light is thrown from its mode of existence in the Pourtalesia; it remains as obscure as ever. The young of Abatus cavernosus, of 2,3 mm., *Pl. XIV, fig. 164,* already possesses the peripetalous fasciola, minute knobs rather irregularly scattered conformably to the elliptical outline of the test, and traversing the interradia and the trivium, but not the bivium. In the young of Echinocardium flavescens, of 1,7 mm., *Pl. XV, fig. 173,* the star-like heads of the rods of the spinules of both fasciolæ are very apparent, sparse and easily counted, the peripetalous crossing the calycinal system, but not touching the bivium, the ends of which it will traverse in the adult, causing, as it seems, branchial leaflets to be replaced by simple tubular pedicels. Thus the fasciola begins, along the greater part of its future course, with the development of solitary spinules, which however are soon to become densely crowded and equal, like the nap of a velvet. In the course of its growth its position relatively to the underlying parts is altered. In both the young specimens it does not cross the bivium, and in that of Echinocardium flavescens it traverses even the calycinal system. I have elsewhere shown, after a careful comparison between a young, of 4,6 mm., and an adult Brissopsis lyrifera, [2]) that in both the fasciolæ traverse corresponding plates, and that the movement becomes manifest solely from differences in the tracks of the former relatively to the figure and dimension of the plate. Upon the whole therefore the fasciola may be said to become, at an early age, all but stationary, but not absolutely so, as there seems to remain a small amount of reciprocal mobility. I once ventured to show that the fasciola is a structural element independent of the skeletal systems, belonging neither to the ambulacra nor to the interradial areas, but on the contrary, so to speak, dominating them in some manner. No trace of it is to be seen on the inner surface of the plates, and nowhere does it occupy their interstices. It is entirely external to them, forming by itself a layer outside that of the spines, growing amidst these, amidst pedicellariæ and pedicels, removing as much of them as lies in its way, and depositing in its stead its own band, incrusted with minute tubercles bearing the densely packed club-shaped spinules. Sometimes it allows the markings it thus covers to remain discernible through its substance, as in a specimen of Agassizia scrobiculata, [3]) in which the fasciola, intact and entire, like some gauzy tissue, lets clearly perceive the underlying tubercles, which are perfectly recognisable as to place and form and relation to the free tubercles contiguous to its margin, and parts of which it even covers. It is as though the fasciola, having caused the spine to drop, had grown over its tubercle. Sometimes also, as in specimens of Plagionotus pectoralis and Brissus Scillæ, [4]) the fasciola has split, and the underlying tubercles stand forth in the crevice, as though their spines had succeeded in resisting its subversive agression, and in keeping the crevice open, in the one case aided no doubt by the presence of a pedicel, which from its great muscular power was still more competent to check the advance of the spinules.

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[1]) Rep. Chall. p. 141. [2]) Études, p. 62, pl. XXXVII, fig. 213, 218. [3]) Ib., p. 62, pl. XIII, fig. 121. [4]) Ib., pl. XIII, fig. 122, 123.

The spines of Pourtalesia Jeffreysi are generally slender and sparse, but stronger and crowded on the sternum and more particularly on the palatal vault of the buccal recess, *Pl. I, fig. 2; IV, 24.* Within the scrobicular circle of the tubercle, *Pl. V, fig. 31,* rises the perforated mamelon surrounded by a »milled ring». The perforated condyle of the spine, *fig. 30,* is encircled by an undulated ring answering to the milled ring of the tubercle, and the whole surrounded by a wide, radiately waved brim, all these parts being of a dense and glossy, partly homogeneous calcareous substance. Above the brim, *fig. 32,* an apparently confused mass of compact meshy texture begins to rise obconically, forming the thick basal part which ends above in »the collar». There the slender calcareous fibrils of the meshes are seen, bending centrally, to unite, *fig. 32, 33,* into the regular string-like pillars that constitute the shaft, *fig. 36; Pl. XIV, fig. 171,* joining one another all along by giving off, on either side and inwardly, *fig. 32, 34, 35,* at regular intervals, the connecting processes that produce the well-known radiated texture seen in transverse sections. This is, in general terms, the structure of the spines in the Spatangidæ, and, in the main, of all the Echinoidea. In the following it will be seen that an analogous disposition of the constituent parts is met with in the rods which strengthen the filaments of the phyllodean, subanal and sometimes the frontal pedicels, *Pl. VIII, fig. 55, 56, 57, 60, 61, 62* and *64; Pl. XI, fig. 121, 129,* the basal circlet answering to »the collar», with the protruding nave below, its meshes uniting above, to form the shaft which sometimes shows signs of being composed of two or more string-like pillars rudely joined.

Like the fasciolæ the spines stand in no constant and fixed relation, with regard to their growth and position, to the underlying ambulacral plates. In my former work, a series of figures is consecrated to the development of the frontal ambulacrum, III, of Toxopneustes droebachensis [1]). In a specimen of 3 mm., the first primary tubercle in III *a* covers the suture of the primary plates *2* and *3,* in III *b* those of plates *2, 3, 4,* and so it continues in somewhat larger specimens, gradually reduced, till in a specimen of 11 mm., and before that size, it aborts or is shed in III *a,* as later in III *b.* And in the same specimen the primary tubercle is seen to cover more or less completely the sutures of each group of plates: *4—6, 7—10, 11—14* (*15*), of III *a,* and *5—7, 8—11, 12—16,* of III *b.* In a Meoma ventricosa [2]), they are seen to expand across the mesial suture of the interradia, in an Hemiaster expergitus [3]) the upper spines of the interradia 2 and 3 not only extend their bases partly over the terminals of the ambulacra II and III, but even invade the calycinal system. Nothing, in fact, is more easily observed than this independence of the radiolar system. Covered itself by the fasciolar stratum, it overlies the ambulacra as well as the perisome. Its genesis, the order and mode of appearance of its spines, their growth and decay, and their slow change of position, are inviting subjects of research.

The pedicellariæ, which now begin to be properly studied, are in these respects as little known as the spines. On those of Pourtalesia I have nothing to add to the descriptions given by Wyville Thomson and Al. Agassiz.

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[1]) Études pl. XVII, fig. 140—147. [2]) Ib., pl. XII, fig. 106. [3]) Ib. pl. XI, fig. 93.

III. THE AMBULACRAL SYSTEM.

The peristome and the œsophageal opening in the young of Echini and Spatangi. The peculiar structure of these parts in Pourtalesia. The infra-frontal recess an incipient buccal cavity. The bivium and its abnormal structure. The spherids; their ventral position in Pourtalesia. The pedicels; their various forms in the Spatangidæ; the evolution of the phyllodean pedicels; the pores: peripodia. Pourtalesia homœopodous; its pedicels simple.

Like one and another of his predecessors LINNÆUS in some Spatangi overlooked the front ambulacrum, and thus came to attribute to them only four ambulacra, an error that was repeated by LAMARCK, CUVIER, BLAINVILLE and others. In all Echinoids there are five ambulacra, or radii, the frontal one in many irregular forms differing more or less from the rest, and sometimes being but faintly marked.

The young Echinoid, when on the point of assuming its final form, enveloped in the larval membraneous covering, which is closed all around and destitute of any opening, oral or anal, for a while floats beneath the surface of the sea, until, having begun to take food, it sinks, and commences the mode of life of the adult. A minute Echinus[1]), *Pl. XIX, fig. 232, 233*, genus unknown, 0,6 mm. in diameter, astomous and aproctic, presents a spheroidal form and a smooth, unbroken, richly pigmented surface above as below, with the spines standing on their tubercles, and, on the ventral side, the primary pedicels over their pores. Within the envelope the final skeleton is forming, ten paired calcified laminæ, the rudiments of the five ambulacra, each giving passage, through a simple pore, to the circulatory apparatus on its way into the tubes of the pedicels. Outward of these ten laminæ five others are seen, answering to the interstices between their pairs, and thus apparently representing the future interradia. The five primary ambulacra here alone constitute the peristome, and the open space enclosed within them is the future circular stoma. With this stage JOHANNES MUELLER first made us acquainted many years ago[2]). The act of opening outward of the extremities of the intestinal tube still remains to be observed.

In Abatus cavernosus, as in many cases where the young are abnormally reared by the parent or kept within the maternal body, or else under exceptional conditions, the development is abridged[3]), and those phases are left out, in which, as in the great majority of the Echinoidea, the young has to lead a free oceanic life, and to evolve its future permanent structure under the protection of peculiar, transitory, perhaps mimically diverting larval forms. As described above, the development of Abatus ends with a stage analogous to that well-known in the Echinidæ, a resting stage, astomous

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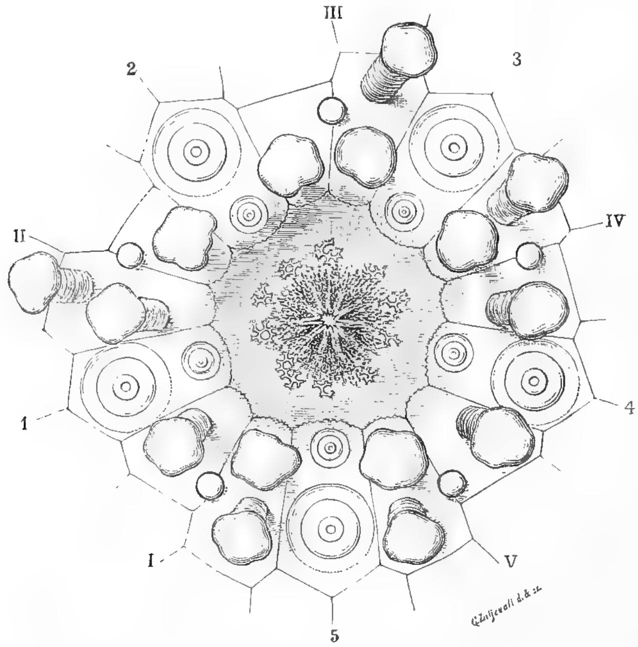
[1]) Études p. 27, pl. XVII, fig. 149. [2]) JOHANNES MUELLER, Metamorphose der Echinodermen: I, Berl. Abhandl. 1848, sep. p. 22, pl. VII; IV, ib. 1852, sep. p. 22, pl. IX, fig. 3, 4; VII, ib. 1855, sep. p. 22, pl. VIII, fig. 9—11. — KROHN, Müllers Archiv, 1851, p. 351. — AL. AGASSIZ, Embryology of Echinoderms, Mem. Amer. Academy, IX, 1864, p. 1; Revision Echin., p. 709, pl. IX, fig. 1; pl. X. — BROOKS Handbook of Invertebrate Zoology, Boston, 1882, p. 99—129, fig. 43—77. [3]) Compare WYVILLE THOMSON, Voyage of the Challenger, II, p. 229.

and aproctic, *Pl. XIV, fig. 163—171.* The stoma, inside the general envelope, is covered over by the pentagonal buccal membrane, *fig. 165,* in which a few crooked and branching spicules indicate the future calcified laminæ, and this membrane, like the whole of the envelope, is entire, the œsophageal end of the alimentary canal, still closed, touching it on the inside, but not piercing it, *fig. 167.* This, however, is soon to be done. Another young specimen of the same species, which I owe to the kindness of Mr JOHN MURRAY of the Challenger Expedition, a little larger than that just described and slightly more advanced, — the phyllodean pedicels just begin to develop their filaments, and the spines to bend and faintly to indicate the partings so characteristic of the adult, — has the membrane of the stoma pierced in its very centre by the œsophageal opening just formed, the pressure from within causing it to protrude a little, while the calcareous spicules, somewhat more numerous, tend to collect in a circle all around. In both of these young specimens of Abatus the peristome is already constituted by five pairs of ambulacral plates and five single interradials.



Peristome of a young specimen of Abatus cavernosus PHIL.

The same is seen in the young of Echinocardium flavescens O. F. M., 1,7 mm. in length, having just acquired the final shape, *Pl. XV, fig. 172—183.* Although smaller than the young of Abatus cavernosus, it is more developed, the alimentary canal being opened at both its extremities. The test presents a pentagonal outline. The stoma is placed somewhat before the middle, *fig. 172,* at the two fifths of the entire length, the periproct, *fig. 173,* at the three fifths of the same. The pentagonal peristome[1]) is composed of the five still narrow ambulacra, forming its angles, and of the five broader interradia, constituting its sides. The meshy tissue of the test is still rather transparent, and that of the ambulacral system more dense and compact, its meshes being markedly smaller and less open than those of the interradial system. It may also be seen, that each plate of the first pair of ambulacrals, close within the peristome and on its internal surface, sends out from its lateral margin on either side, across the adjoining interradium, a somewhat tapering lamina of compact texture. Viewed from the outside by transparency, *fig. 174,* these laminæ seem to form five narrow uninterrupted ridges running across the interradial areas parallel to the peristome, but seen from the inner side, *fig. 183,* they are lost midways under a thick mass of calcareous meshes. These streng-

[1]) Compare Études p. 14, pl. III, fig. 32, 33—35; pl. V, fig. 46, 47.

thening ridges are no longer observed in specimens but little larger, in which the peristome has begun to change form, and are not to be recognised in mature specimens. The nearly circular orifice of the alimentary canal has just opened in the centre of the buccal membrane. In this there are deposited a number of calcified laminæ, in three concentric series, the outermost consisting of by far the largest, ten in number, placed two and two against the interradia, while the median, sub-pentagonal series is composed of about fifteen much smaller laminæ, and the innermost, encircling the opening, is a chain of numerous minute particles of reticular tissue. This calcified incrustation may possibly be found to pertain to the interradial system.

Thus, it is seen, in the true Echinids as in the Spatangi, at a very early age, and at the time when the skeleton assumes its final form, the five ambulacra one and all are constituent parts of the peristome, each by both the two plates of its first pair. And in the adult this is the general rule, found to hold good everywhere in the whole of hitherto known Echinoidea, without exception. Normally the first ambulacrals alternate with the first interradials, which reach the peristome with two plates or with a single compound plate. But between the Dentiferous and the Edentate forms, these last as far, at least, as we know them at present, there is this difference that, in the former, the peristome, central and perfectly circular from the beginning, and divided equally among the five ambulacra as likewise among the five interradia, remains so with very little change during life, whereas in nearly all the Edentates it is at first sub-central and pentagonal, but during growth is drawn forward, and becomes transverse and more or less labiate. In the Spatangidæ these changes are accompanied with very unequal alterations in the constituent parts, by the enlargement of the trivious peristomals, in a few cases to the exclusion of the interradials 1 and 4, or even 2 and 3, the bivious ambulacrals retaining more or less their wedge-shaped outline; by the first interradial, 5, *1*, advancing and arching, so as to form a prominent labrum; and by the œsophageal opening becoming, from an almost circular aperture, a transverse fissure.[1]).

From this a single form alone among the Spatangidæ is an exception, the Palæostoma mirabile Gray, *Pl. XVI, fig. 184—196.*[2]). In all essential points it is a true Prymnadete Spatangean, with an oviform body, inflate posteriorly, the back being raised behind the middle. The peristome is somewhat anterior, at the four fifths of the entire length, rather small, slightly sunk, regularly pentagonal and elabiate even in the adult, being composed of five broad interradials of similar form, constituting its sides, and five equal pairs of ambulacrals at its angles. On the inside, *fig. 188*, it is strengthened by a pentangular ridge running parallel to the margin, and corresponding to that described above in the young of Echinocardium flavescens O. F. M., but here observable, at least, in the half-grown animal. The pentangular stoma is filled, not with a pliant membrane incrusted with calcified laminæ, but with five flat, equal, triangular and contiguous valves, meeting together centrally, each of them composed of an external basal part articulating with the corresponding interradial side of the

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[1]) Études, p. 14, pl. III, fig. 32, 33—37; V, fig. 46, 47; VII, fig. 61, 67.

[2]) Ib. p, 16, 50; pl. XXXII, fig. 197—199.

peristome, and made up of a thicker calcified tissue of coarser meshes, and two narrow, more finely reticular, lateral, perhaps slightly movable pieces.[1])

When any of these various characteristics of the Echinoidean peristome is looked for in Pourtalesia Jeffreysi, it at once becomes obvious, that the exceptional case of Palæostoma no less than whatever there is in the others of conformity to a general law, is set aside in the disposition of the corresponding parts of its skeleton. Its peristome is altogether of a peculiar construction, *Pl. II, fig. 9; III, 12; IV, 15—19.* Out of the five ambulacra one alone, the front ambulacrum, III, with its greater part sharing in the singular incurvation of the whole region, partakes of its formation, the other four are all excluded from it, and, while the front ambulacrum and the two lateral ones, II and IV, each begin with a pair of plates, the two bivious ambulacra each commence with a single plate only. Now it is known that, while in the Archæonomous Echinoidea the peristomal plates generally maintain their entire breadth,[2]) in the Neonomous, and more particularly in the Spatangidæ[3]) they are more or less contracted adorally, especially in the bivium, and more so in the young than in the adult. In Pourtalesia Jeffreysi this feature is carried to an extreme. The front ambulacrum, III, enters the peristome with its entire breadth, while the peristomal plates of the bivium and those of the two paired ambulacra of the trivium, II and IV, are all diminished, cuneiform, narrowing adorally almost to a point. The two pairs that belong to II and IV are very small, half the size of the single ones of the bivious ambulacra, I and V, and all these six plates together have their adoral contracted portions bent over abruptly, at an acute angle, into the hollow of the infra-frontal niche, at the bottom of its ventral sinus, thus forming there a keen edge, strengthened inside by strong partitions, *fig. 17*, reminding of the trabeculæ of the Clypeastridæ. In consequence of this incurvation, while the greater part of their surfaces is visible in the ventral aspect, *fig. 2, 15*, their adoral terminations are not visible, unless their portion of the test be cut out, and placed with its inside toward the observer, *fig. 16*. Then it may be seen, although not without some difficulty, that the narrowing terminations of the two single first plates of the two bivious ambulacra, I and V, as well as the plates II *a 1* and IV *b 1*, of the two paired trivious ambulacra, do not reach the margin of the peristome, but are excluded from it by a single mesial subtriangular plate, 5, which is the labrum, and, as such, belongs to the interradial system, while the terminations of II *b 1* and IV *a 1* are not even visible in that position, being situated on the curvature itself and thereby concealed. Thus, in this extraordinary Echinoid, the front ambulacrum, III,

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[1]) See S. LOVÉN: Om Leskia mirabilis GRAY, Öfversigt af K. Vetenskaps-Akademiens Förhandlingar, 1867, p. 431. In that paper I regarded the five-valved covering of the stoma of Palæostoma as homologous to the »pyramid» of Echinosphæra and Sphæronis. I soon afterwards perceived that this was an error, as LÜTKEN clearly set forth in his memoir: Endnu ett par ord om de gamle Söliliers »Snabel» og Mund, Videnskablige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn, 1869, 160; Geological Magazine, V, 179; Canadian Naturalist, new series, III, 437.

[2]) Études, pl. X, fig. 84, 86, 89, 91; pl. XVII, fig. 140—148; pl. XVIII, fig. 153—158; pl. XIX, fig. 165; pl. XX, fig, 166.

[3]) Études, pl. III, fig. 32—35, 39; pl. IV, fig. 41—43; pl. V, fig. 46—48, 51, 54; pl. VI, fig. 55, 58—60; pl. VII, fig. 61—64, 66, 67; pl. XXII—XLIII.

alone maintains its normal share in the composition of the peristome, while the two paired trivious ambulacra, diminished in size, and the bivious ambulacra, reduced to single plates only, are all excluded from it, and so closely pressed together on its under side, as to occupy, all taken together, considerably less space than the front ambulacrum alone on the upper. The space intervening between the minute interradial 5, *1*, and the large ambulacrals III *a 1* and III *b 1*, is filled by the interradials 2 *b 1* and 3 *a 1*, *Pl. II, fig. 9; III, 12; IV, 18, 19*, and, as these last are very high, the stoma assumes an elliptical form, unseen among the rest of the Echinoidea. For, if in Anancites and its allies the labrum is but slightly developed, and even less so in Collyrites whose stoma is longitudinally sub-elliptical, the constituents of the peristoma are nevertheless normal everywhere. In Pourtalesia Jeffreysi, on the contrary, it has been seen that they are: ambulacrum III, interradials 2 *b 1* and 3 *a 1*, and interradial 5, while the ambulacrals I, II, IV, V, interradials 2 *a 1* and 3 *b 1*, and interradials 1 and 4 are excluded. The plane of the peristoma thus composed is nearly vertical, and perpendicular to that of the longitudinal axis of the body, or somewhat overhanging into the peritoneal cavity; it is not, as in the Spatangidæ in general, all but coincident with the stomato-proctic axis, but, as in the Endocyclic forms, though in an opposite manner, perpendicular to that also. In one of the specimens the two plates *1* of the ambulacrum III, and the interradials 2 *b 1* and 3 *a 1*, in a part of their margins are dissolved into an assemblage of minute rounded laminæ, *fig. 19, 20*, but in two other specimens they are entire.

The buccal membrane, *Pl. IV, fig. 20*, is destitute of calcified deposits. In its middle is seen the œsophageal opening, an oblong slit, with naked, rather tumid and coarsely wrinkled margins. Its direction is that of the vertical longitudinal plane of the body, perpendicular to the direction of the transverse fissure in the great majority of the Spatangidæ.

This description of the peristome and adjoining parts in Pourtalesia Jeffreysi applies upon the whole equally to the same parts in the other species of the group; the differences presented by the ambulacra I, V, II, IV, will be taken up hereafter. The species all agree in the important points resulting in that most striking feature, the deep anterior recess. There can be no doubt that the elliptical frame surrounding the stoma in the Pourtalesiadæ, widely different though it be in its composition, is strictly homologous to the peristome in all the other Echinoidea, and, no less so, that the vertically placed membrane with its longitudinal slit is homologous to the horizontally stretched membrane in the Dentifera and Edentata, with the rounded or transverse orifice of the alimentary canal. But the peculiar structure of these parts in the Pourtalesiadæ is such as to call forth the idea, that what is going on here may be looked upon as the first move, so to speak, towards forming a rudimental mouth, a *cavum oris*, the invaginated parts of which, if they were flexible and provided with muscles, might be protruded like a proboscis, which, owing to the great size of the frontal ambulacrals and interradials, would be directed downwards and backwards. As it is, its rigid and motionless lips are indicated by the line of incurvation all around its entrance, its palate, *sit venia verbo*, *Pl. III, fig. 10, 12; IV, 18, 19; VI, 45*, is made up of the large and unreduced bi-seriate plates of

The imaginary rostrum
invaginated protruding.

the ambulacrum III, while its sides are constituted by the interradia 2 and 3, inferiorly meeting to the right and left of the shortened and compressed intra-labial space, and its innermost portion, together with the elliptical membrane, *Pl. III, fig. 12; IV, 18, 19, 20,* may represent a pharynx, the slit being the œsophageal opening. The vaulted palate is armed with spines, stronger and more closely packed than anywhere, *Pl. IV, fig. 24,* and the site, no doubt, of a powerful ciliary activity, and outside the under lip are seen the spherids in pairs or in clusters, *Pl. IV, fig. 15; VI, fig. 40, 41, 44; VII, fig. 47, 48, 49, 50.* Just as in another part of the skeleton of certain Pourtalesiadæ, as has been suggested above, a movement is introduced in the perisomatic system, directed towards an annulose conformation of the body, thus here also, in the peristome and surroundings, a tendency seems to be exhibited towards a vermiform constitution. This tendency, to be generally surmised already, in the Tertiary and recent Spatangidæ, from the increasing length and flatness of their test, the stomato-proctic axis approaching to horizontality, from the reclining direction of the slender spines, and the forward movement of the peristome, appears heightened, in another and peculiar manner, in the Pourtalesiadæ by the anterior part of the body being definitely marked out by the terminal mouth-like recess, and by a more strongly displayed differentiation of the upper dorsal side of the skeleton from the under, ventral side. In the Spatangidæ the frontal phyllode is still in part ventral, and touches the ground in which the animal is living; in the Pourtalesiadæ it is elevated on the tops of the erect interradials 2 and 3, and thus brought to roof dorsally the rudimentary mouth, therein strongly contrasting with the other four phyllodes, which all of them are ventral, and employed in forming its ground-floor and lower external surface.

In all the known forms of the Echinoidea, Archæonomous and Neonomous, each ambulacrum, from its beginning in the peristome to its termination, is bi-seriate, that is presents an uninterrupted succession of plates, almost invariably arranged throughout in two alternate rows. When the ambulacra of Pourtalesia Jeffreysi are examined in this respect, they are found to differ more widely than those of any other Echinoid, even the most specialised among Prymnodesmiic Spatangidæ.

The front ambulacrum, III, normal in its peristomal origin, continues so throughout to its termination, *Pl. II, fig. 9.* It is shorter than any of the other four ambulacra. It consists of thirteen to fifteen pairs of plates, out of which the second is somewhat broader than the first, and the following eight or nine slowly diminish in breadth, the terminal three to five suddenly becoming very minute. The first five pairs form the roof of the frontal niche, or buccal cavity, *Pl. III, fig. 10, 12,* the sixth, seventh, eighth and ninth curve upwards, and constitute with the last five or six the mesial, moderately impressed part of the blunted front, the small terminal plates closing with the calycinal system just on reaching the dorsal surface.

The two paired ambulacra of the trivium, II and IV, *Pl. II, fig. 9; I, 1, 2, 3; III, 10, 11*, are somewhat larger than the front one. They are slightly curving forward symmetrically, broad in the middle and suddenly contracted at their summits. In the described specimen the number of plates is about fourteen in each. The first two are, as above stated, small and wedge-shaped, the second pairs suddenly expand, and still more so the following pairs, each ambulacrum attaining its greatest breadth before reaching half the height of the test, after which it slowly decreases, the plates of the posterior row in each, the II *a* and IV *b*, surpassing throughout those of the anterior, and both nearly preserving the hexagonal form. The thirteenth and fourteenth pairs suddenly contract, and become very minute, when joining the calycinal system.

Thus the trivious ambulacra, from their beginnings in or near the peristome, conformably to the general rule, present throughout their whole length a continuous double row of plates, and their summits attain the calycinal system. In the bivium all this is different.

As above stated, the ventral surface, *Pl. I, fig. 2, 8; II, 9; IV, 15*, presents anteriorly two contiguous elongated plates, I, *1*, V, *1*, one on each side of the mesial line, having the terminal portions of their gradually narrowing adoral halves bent over into the infra-frontal niche, *Pl. IV, fig. 16*. Their anomalous form and their contiguity to the first plates of II *a* and IV *b* combine to make it more than uncertain how to distribute correctly, to their respective ambulacra, all these six closely joining plates, from external inspection alone. But their relations at once become obvious, when they are examined from the peritoneal cavity, after the test has been cut open longitudinally, *Pl. III, fig. 10, 11; IV, 18, 19*. In the whole of the Echinoidea the neural collar, at each of its five angles, sends off a cord that follows the mesial line of each ambulacrum on its inner surface, and gives off alternate branches which enter the pedicellar pores, and come out again on the outside of the test, there to distribute themselves among the different external organs[1]). The neural collar and the main nerve-cords are closely accompanied by the circular vessel and the great trunks of the aquiferous system, outside emerging along with them from out of the pores, and entering the tubes of the pedicels. When the test of Pourtalesia Jeffreysi is laid open, and the recess is examined on its peritoneal surface, *Pl. III, fig. 10, 11; IV, 18, 19*, it is seen that here also the neural collar and the circular aquiferous vessel respectively send out their five main branches, one for each ambulacrum. Of these an odd one runs along the mesial suture of the vaulted front ambulacrum, III, on the top of its roof, and ascends to the calycinal system, giving off, on every plate, a branch to its pore, but two on the plate III *b 1, fig. 10, 18, 19*. The two paired ambulacra II and IV also each receive two main trunks, one neural, one aquiferous, giving off branches to the

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[1]) Études, p. 8, pl. II, fig. 28—31.

pores of the plates II *a 1*, II *a 2*, etc. and II *b 1*, II *b 2*, etc., on the right side, as also, on the left, to those of the plates IV *b 1*, IV *b 2*, IV *b 3*, etc., and IV *a 1*, IV *a 2* etc. And from these beginnings the main trunks are seen to emit regularly alternate branches to the ambulacral pores, *Pl. III, fig. 10, 11.* It follows from this that these plates were rightly referred, from the outside aspect, to the ambulacra II and IV, as true peristomal plates, although excluded from their legitimate position.

Lastly, the neural collar and the circular vessel each give off two main branches directed backward and slowly diverging, *Pl. IV, fig. 18, 19; III, 10.* Just on their leaving the collar, a first branchlet descends from each of them to the pedicellar pore of one of the two single contiguous plates V and I, *fig. 18*, V, *1*, I, *1*; *fig. 19*, V, *1*, thereby rendering it manifest that these plates are in reality what they were pronounced to be from without, the reduced and displaced peristomal plates of the bivium, V, *1* and I, *1*. But when the further continuation from thence of the bivious ambulacra is looked for from without, *Pl. 1, fig. 2*, the sequence of their plates is found to be broken by the interposition of four longitudinal plates of considerable size evidently not ambulacral, the less so, as none of them presents any trace of a pedicellar pore. They belong, as shown above, to the perisome,being the 1 *b 1*, 1 *b 2+3* and 4 *a 1*, 4 *a 2*, of the interradial system. Viewed from the peritoneal cavity, *Pl. III, fig. 10*, these same plates are seen to be spanned by the two trunks which, after their first branchlets, do not give off a second till reaching, on the farther side, two pairs of plates, contiguous in the mesial line, I *a 2*, I *b 2*, V *b 2*, V *a 2*. There again a branchlet is seen to proceed from each trunk, the first for the inner of the two plates: I *a 2*, V *b 2*, the second for the outer ones: I *b 2*, V *a 2*, and so on alternately and continuously to the summit of the ambulacrum, *Pl. III, fig. 11, 14.* In Pourtalesia Jeffreysi, therefore, not only the first plates of the bivium are single, not double, but they are, moreover, widely separated from the next in order, and the two ambulacra begin, as it were, anew, at about the posterior half of the body, each with the regular double alternate series of plates. But there, as where they commenced witht he two first single plates I, *1* and V, *1*, the two ambulacra are again contiguous in the mesial line, the I *a 2* and V *b 2* touching each other by their foreparts for more than the anterior half of their inner margins, thereby excluding the interradials 1 and 4 from the posterior interradium 5. After that their hind portions separate, bending right and left, to give place to the sternum, *Pl. I, fig. 2; II, 9; III, 10.* The I *b 2* and V *a 2* are shorter, less irregular, but sub-pentagonal, slightly curved, and somewhat broader in front. Of the third pair the I *a 3* and V *b 3* are elongated, irregularly hexagonal and contiguous to the sternum and to the forepart of the episternum, while the I *b 3* and V *a 3* are broader, but much shorter, thus allowing the ambulacrum to bend upward at a right angle, *Pl. I, fig. 3.* Hence the fourth pairs lie at the basis of the ascending portions of the bivium. The I *a 4* and V *b 4* are hexagonal, with their hind-portions widening and extending beyond the posterior limits of the ambulacrum, so as to border inwardly upon the episternum 5 *b 3* and 5 *a 3*, then to fill out on either side the episternal angle, and to join the whole length of the first pre-anals 5 *b 4*, 5 *a 4*, and the greater part of the second, 5 *b 5*, 5 *a 5*. Being thus disposed, the I *a 4* and V *b 4* are traversed by the subanal fasciola, and thereby brought alone to correspond to the group of from two to six or more ambulacral plates of I *a* and V *b*, from the sixth onwards, which, in the Prymnodesmic Spatangidæ, are prolonged and salient inwards, so as to fill, within the subanal fasciola, the reentering episternal angle, and to determine the upward flexure of these ambulacra, and which, by marking off, throughout, as ventral, the foregoing plates and limiting their number everywhere to five, constitute a prominent and most significant feature [1]).

The ambulacrals I *b 4* and V *a 4* of Pourtalesia Jeffreysi nearly equal in size these just described, and are more regularly hexagonal. In the two succeeding pairs, the fifth and sixth, the plates of I *a* and V *b* are shortened, to give place to the circum-anal region of the odd interradium, while the fifth plates of I *b* and V *a* are narrowed anteriorly in connexion with the curvature of the ambulacrum. From the seventh, and onward, the following pairs have their plates nearly equal, only those of the posterior rows slightly smaller, distinctly hexagonal, and slowly diminishing in size. In the specimen described the fourteenth pairs are terminal.

According to an almost universal rule, the ambulacra of the bivium ought to ascend so as dorsally to join the calycinal system. From this the Collyritidæ, of Oolitic existence, make the sole exception hitherto known, having their calycinal system dismembered by the interjacence on either side of the unreduced interradia 1 and 4, which sever from it the radial pieces I and V, and leave them in connexion with the respective ambulacra. And from their erect position and convergence it follows that their tops, with these radials, are brought in close contact, or so near each other, as to be separated only by a narrow plate, which is one of a row of slender, longitudinal, irregularly arranged plates stretching from the periproct to the calycinal system. At a first glance this structure seems to be revived in Pourtalesia Jeffreysi, but on closer inspection notable differences become apparent, *Pl. I, fig. 1, 3; III, fig. 11.* The bivium, far from having a vertical position, leaning backwards, so as to overhang the postern slope, as in Collyrites, stretches forward longitudinally, and converges but slightly, the two ambulacra being separated all along by the odd interradium 5, a pair of whose plates intervenes between their summits, while the lateral interradia 1 and 4, in joining from either side, combined with elements of the odd interradium, 5, keep them widely apart from the calycinal system. Their summits, a pair of moderately sized plates, not abruptly diminished as in the trivium, are situated at about the foremost third of the whole length of the test. Of radial (»ocular») pieces not a trace is seen.

From all this it follows that two of the fundamental and universal characteristics of the Echinoidean ambulacra, their joint participation in the formation of the peristome, and the uninterrupted sequence of their plates, are set aside in Pourtalesia.

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[1]) Études, p. 15, pl. XXXII, fig. 200,—XLII, fig. 232.

The third, no less essential characteristic, the disposition of the ten ambulacral rows, not in conformity with the bilateral arrangement of the ambulacral system, but referable to an axis other than its actual antero-posterior one, is even as fully discarded in Pourtalesia. This disposition is most plainly seen in the Spatangidæ. It is as follows[1]). If a Spatangean of any genus or species is held in supination, that, is with the ventral surface upwards, and with the odd interradium backwards, and if the ten ambulacral plates of the peristome are then counted from left to right, — that is, from the right side of the animal to its left, — beginning with the ambulacrum of the bivium marked I; if, at the same time, in each of the ambulacra: I, II, III, IV, V, thus gone over, the row of plates first touched is marked *a*, the second *b*, it will be found, that the peristomal plates I *a*, II *a*, III *b*, IV *a*, V *b*, are the larger ones, and provided with two pedicellar pores, *i. e.* they are binary, bi-porous, while the peristomal plates I *b*, II *b*, III *a*, IV *b*, V *a*, are smaller, and each provided with only one pedicellar pore, *i. e.* are simple, uniporous. The identical disposition of these same plates is found in the Echinoneidæ, Cassidulidæ, Holastridæ, that is in all the Edentates. In the Dentiferous Echinoids the same law is maintained, though differently expressed. Among the Echinoconidæ[2]) it is manifested by the peristomal plates I *a*, II *a*, III *b*, IV *a*, V *b*, binary in the genus Echinoconus, being always larger, and succeeded everywhere by a single plate, placed between each of them and the first triad, while the peristomals I *b*, II *b*, III *a*, IV *b*, V *a*, are smaller, and directly contiguous to the first triad. In the Echinidæ[3]) its existence is obvious, and the same formula holds true, masked though it be by the seemingly radiate disposition of the parts. Out of the ten peristomal plates, all of them composite, the I *a*, II *a*, III *b*, IV *a*, V *b*, are larger than the I *b*, II *b*, III *a*, IV *b*, V *a*. All Echinidæ possess, on their buccal membrane, five pairs of minute free plates, each plate bearing, in the adult, a pedicellar pore. In the very young Toxopneustes drœbachensis, only two millimeters in diameter[4]), out of these ten plates, those five which correspond to the ambulacral rows I *a*, II *a*, III *b*, IV *a*, V *b*, are larger, but still for a time are without pores, while the five other plates, that answer to the ambulacral rows I *b*, II *b*, III *a*, IV *b*, V *a*, though smaller, already have received theirs. In the Cidaridæ[5]), in other respects so widely different from the Echinidæ, out of the ten ambulacral plates surrounding the œsophageal opening, those five that belong to the rows I *a*, II *a*, III *b*, IV *a*, V *b*, exceed in size the other five that appertain to the rows I *b*, II *b*, III *a*, IV *b*, V *a*, while the plates of these last-named rows are, all around, the first to detach themselves from the margin of the corona, which is thus continually broken up and renewed. Finally, in the Clypeastridæ[6]), the last arrived, in which many a primeval feature is vanishing or even effaced, the peristomal plates of the rows I *a*, II *a*, III *b*, IV *a*, V *b*, are distinguished by their superior size from those of the rows I *b*, II *b*, III *a*, IV *b*, V *a*, the difference, however, in a few cases having become very slight.

Thus, it is seen, in whatever group of the Echinoidea the structure of the ambulacra is examined, out of the ten plates composing the peristome, the five: I *a*, II *a*,

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[1]) Études, p. 13—39, pl. III—IX, XIV, XVII—XX, XXII—LII. [2]) Ib., p. 20, pl. XIV. [3]) Ib., p. 20, pl. XVII, XVIII. [4]) Ib., p. 27, pl. XVII, fig. 148. [5]) Ib., p. 28., pl. XX. [6]) Ib. p. 32., pl. XLIV—LII.

III *b*, IV *a*, V *b*, always differ in a marked manner from the other five: I *b*, II *b*, III *a*, IV *b*, V *a*, be it in size, in outline, or in the number of their pedicellar pores, and the two sets follow each other, all around the stoma, everywhere in the same order. And this invariably recurring biformity of the ambulacra in their peristomal beginnings, of a never failing validity through the whole of the Echinoidea, recent and extinct, that have been examined on this point, is also more or less distinctly recognisable all through the entire length of each ambulacrum, and more so in the older types, in which the seemingly radiate disposition of the parts is predominant, than in those of a later date. In Cidaris the plates of the rows I *b*, II *b*, III *a*, IV *b*, V *a*, in every ambulacrum are in advance of those of the rows I *a*, II *a*, III *b*, IV *a*, V *b*, by an entire plate or half a one[1]), and in the very young and minute Toxopneustes drœbachensis, the seventh plate is begun in each of the rows I *b* . . . V *a*, while there are yet only six in each of the rows I *a* . . . V *b*[2]). But in the types of later appearance, the Neonomous, in which the radiate form largely makes way for a decidedly bilateral disposition, as in the Cassidulidæ, Collyritidæ, Holastridæ, Spatangidæ, the tendency towards a gradually more and more decided symmetry in external outline between the two lateral ambulacra of the trivium, II and IV, and between the two bivious, I and V, seems to invalidate the biformity of their composition, and leave it in full force solely in the peristome. There it, therefore, continues from the antique Cidaridæ till it all but vanishes in the Clypeastridæ, of Tertiary origin, always suggesting, in a manner not yet understood, the previous existence of a skeletal axis diverging from the actual antero-posterior one, being at an angle with it, and dividing lengthwise the ambulacrum IV and the opposite interradium. If five homologous points in I *a*, II *a*, III *b*, IV *a*, V *b*, are connected by straight lines, and also homologous points in I *b*, II *b*, III *a*, IV *b*, V *a*, two irregular pentagons are inscribed within the peristome, disposed in such a manner that each of them is divided by this axis, $\alpha\omega$, into two parts, one trapezoid and the other pentagonular, the areas of which are equal; and that, if one of them is made to revolve half a circle on the axis $\alpha\omega$, it covers the space left by the other[3]).

It results from the arrangement thus detailed, that the two bivious ambulacra are symmetrical towards one another with regard to the disposition of their constituent elements. Within the trivium the front ambulacrum, III, in so far has a medial character, as by its peristomals it is symmetrical on one side towards the ambulacrum II, on the other towards the ambulacrum IV. But these latter, the two lateral ambulacra of the trivium, are, with regard to the disposition of their elements, unsymmetrical towards each other, thus testifying to the inherent obliquity of the Echinoidean ambulacral system. In both the principal types of the Echinoidea, however, this obliquity is outwardly concealed: in the Archæonomous, the dentiferous forms, Cidaridæ and Echinidæ, by the apparently quite circular and radiate arrangement of the skeletal systems, the central position of the mouth, and the verticality of the stomato-proctic axis, all correlatively bound up with one another and rigidly maintained; in the later, the

[1]) Études, p. 30. [2]) Ib., p. 21, pl. XVII, fig. 140. [3]) Ib., p. 37, pl. XVII, fig. 140.

Edentate forms, — contrasting with the former in the pliancy they manifest during their successive appearances and vanishings, — by their progressively developed bilaterality, by the variously inclined, or even horizontal stomato-proctic axis, and by the symmetry, in general outline, between the two paired ambulacra of the trivium, as well as between the two of the bivium.

When Pourtalesia Jeffreysi is examined on this point, *Pl. II, fig. 9; IV, 15, 16*, it is found at once that the two paired ambulacra of the bivium are symmetrical towards each other in their general outlines. This is manifested, as regards the two single plates with which the ambulacra I and V begin, I *1* and V *1*, no less by their outlines than by the condition of their pores. They are therefore in complete accordance with the general rule. But, contrary to that same rule, the two ambulacra of the trivium, II and IV, also present this same symmetry in the disposition of their component elements. The plates II *a 1* and IV *b 1* are evidently counterparts, and so are II *b 1* and IV *a 1*, in size, form, number and character of their pedicellar pores. And yet, according to the law pervading the whole of the Echinoidea, those same plates ought to differ in these respects, belonging, as they do, to different series: II *a 1* and IV *a 1* to the series I *a* . . . V *b*, and II *b 1* and IV *b 1* to the series I *b* . . . V *a*. This is an essential and important anomaly. It is also very remarkable that, in presence of so profound a transformation, the front ambulacrum, III, alone remains intact, presenting the normal external form and internal composition, together with the legitimate condition of the pedicellar pores, bearing a single pore on its smaller peristomal plate, III *a 1*, and two on the larger plate, III *b 1*. While, in all the rest of the Echinoidea, the composition of the peristome is expressed by the common formula:

I *a*, II *a*, III *b*, IV *a*, V *b*: large, biporous;
I *b*, II *b*, III *a*, IV *b*, V *a*: small, uniporous,

in Pourtalesia Jeffreysi the peristomal series, if arranged according to the size of the plates, would be:

I, II *b*, III *b*, IV *a*, V: large;
I, II *a*, III *a*, IV *b*, V: small;

and the different size of the paired trivious ambulacrals has no relation to the number or character of the pores. The seven plates: I, II *a*, II *b*, III *a*, IV *a*, IV *b*, V, are all uniporous, III *b* alone is biporous. It is evident, therefore, that the obliquity hitherto found inherent, everywhere and without exception, to the constitution of the ambulacral system of the Echinoidea, is evanescent in that of Pourtalesia Jeffreysi, its paired radii II and IV, I and V having their elements disposed solely with relation to the antero-posterior axis of the body, and not to a subordinate deviating axis $\alpha\omega$, as in all other Echinoidea. The elsewhere all-pervading obliquity is on the point of disappearing, but a trace of it is still left in the front radius, III, which has, as normal, its *a* plate uniporous, and its *b* plate biporous.

Now, bearing in mind the unvarying constancy of the ambulacral characteristics in all the numerous genera and species so highly diversified in other respects, with which we are familiar, it seems that we might be allowed to expect their contrasts, so strikingly set forth in Pourtalesia Jeffreysi, to possess an equally pervading validity as characteristic of the entire genus and its allies. But a careful examination of the specimens sent me by Sir WYVILLE THOMSON, fragmentary as they are, has taught me that, to a great extent at least, this is not the case. Already in Pourtalesia laguncula AL. AG., *Pl. VI, fig. 37—41*, some important differences present themselves. The front ambulacrum, III, retains its normal structure. The two paired ambulacra of the trivium, II and IV, are very like those in Pourtalesia Jeffreysi, the two first plates of the first pair being minute and wedge-shaped, and each provided with a single pore, the second pair II *a 2*, II *b 2* and IV *a 2*, IV *b 2*, suddenly expanding, so as also to join the aboral margins of I *b 1* and I *a 1*, and V *a 1* and V *b 1*. Both ambulacra continue very broad, until, dorsally, they contract rather suddenly, ending at the calycinal system with a minute terminal plate, *Pl. VII, fig 52*. Thus in this species, as in Pourtalesia Jeffreysi, the trivious ambulacra present throughout their whole extension a continuous sequence of plates, and their summits attain the calycinal system. In the bivium all this is otherwise, yet nearly in the same manner as in Pourtalesia Jeffreysi. Whereas in that species the pairs of plates I *a 1* and I *b 1*, as also V *a 1* and V *b 1*, have respectively coalesced into a simple compound plate, I, V, on either side of the middle line, the same plates are separate in Pourtalesia laguncula, *fig. 37—40*, the joint outline, presented by each pair, corresponding with that of the single plate in Pourtalesia Jeffreysi. But while, in this latter species, the single compound plate is provided with one pore only, in the former the two: I *a 1* and I *b 1*, as also V *a 1* and V *b 1*, each of them retains its pore, that of I *a* as well as that of V *b* being single, not double, as they ought to be. While in Pourtalesia Jeffreysi the I *1* and V *1* are contiguous along the middle line, they are separated in Pourtalesia laguncula by the wedge-shaped interradial 5 *1*, permitting them to come near each other at the very bend only of the ventral margin of the niche, but driving them asunder by its triangular aboral expansion. In the same manner as in Pourtalesia Jeffreysi, these I *a*, *b 1* and V *b*, *a 1* are widely separated from I *a*, *b 2* and V *b*, *a 2*, by the interposition of the interradia 1 and 4; and the I *a 2* and V *b 2*, contiguous in their adoral half, so as to exclude these interradials from the interradial 5 *2*, the sternum, then bend right and left, to give room to that plate, and to the episternum, 5 *a* and *b 3*. The disposition of these plates thus very much resembles that seen in Pourtalesia Jeffreysi, the I *a 4* and V *b 4* being traversed by the fasciola. In like manner, on the dorsal surface, *Pl. VII, fig. 52*, the bivious ambulacra are separated from one another by the odd interradium 5, nor do they join the calycinal system, being kept widely apart from it by the interradia 1 and 4, meeting from either side. They terminate with small, and rather suddenly diminished plates.

In Pourtalesia ceratopyga AL. AG., *Pl. VII, fig. 48—50*, the disposition of the first plates of the ambulacra I and V appears to be identical with that in Pourtalesia laguncula, the labrum 5, *1* separating I *a* and V *b*. Each plate also has only a single pore, but the row of the eight pores is not visible from the ventral aspect, as they are placed on the flattened margin of the incurvation, *fig. 49*. The mode of connexion of the labrum with the rest of the interradial system could not be made out, the specimen unfortunately being broken at the critical point. But, as stated above, there exists a decided peculiarity in the condition of the interradials 1 and 4, of which, on either side, a narrow plate, *1* and *4*, is seen keeping apart the IV from the V, and the II from the I, *fig. 48*, and this plate on the left side is pushed forward so as to approach the flexure and to compress and reduce the IV *b 1;* on the right side it keeps farther back, and the II *a 1* is fully developed.

Echinocrepis cuneata AL. AG., *Pl. VII, fig. 53*, repeats the mode of disposition of Pourtalesia ceratopyga, the interradial 5, *1* separating the two bivious ambulacra, the interradials 1 *1* and 4 *1* being placed between I and II and between V and IV, and all the four ambulacral plates on either side being uniporous.

Pourtalesia carinata AL. AG., *Pl. VI, fig. 42—46; VII, 47*, presents the same arrangement, a small and narrow interradial plate intervening on either side between the first pair of I and that of II, as also between the *a*, *b 1* of V and of IV. Here also, as in Pourtalesia laguncula and Pourtalesia ceratopyga, but unlike Pourtalesia Jeffreysi, the I and V each commence with two plates, and the I *a* and V *b* are biporous, as according to rule. But, what is more, it is plainly shown in the fragment examined, that the *2* of V is not separated from its plate *1* by the intervenience of the interradials 4, but really contiguous to it, *fig. 42, 46*, part of the interradial 4, *2* coming into view between V *a* and IV *b*. It cannot be doubted that the like might be seen on the right side, if the specimen were entire. This diversity is of great moment. The plates I *a*, II *a*, III *b*, IV *a*, V *b* are biporous, while the I *b*, II *b*, III *a*, IV *b*, V *a* are uniporous, which is in complete accordance with the general rule. If I have succeeded in following rightly the very indistinct continuation of the plates beyond the curvature, the labrum, 5 *1*, ought to be extended to the peristome, having all along on either side the I *a* and V *b*, while of I *b* and V *a* the pointed terminations alone are to be seen just inside the margin of the niche, and still less of II *a* and IV *b*, the II *b* and IV *a* ending in the very bend, so that no trace of them is visible inside.

From all this it appears that the old order, reigning among the ambulacral plates of the peristome and their pedicellar pores, is not all at once abandoned by the Pourtalesiadæ. It is exchanged for a new order only reversibly and, so to speak, hesitatingly. Pourtalesia carinata retains unaltered the otherwise universal Echinoidean formula:

I *a*, II *a*, III *b*, IV *a*, V *b:* biporous;
I *b*, II *b*, III *a*, IV *b*, V *a:* uniporous,

while Pourtalesia Jeffreysi, Pourtalesia laguncula, Pourtalesia ceratopyga, and Echinocrepis cuneata, all present a single pore only in each of the peristomal plates I, II, IV, V, which thus, in that respect, become symmetrical on either side of the labrum, the III alone remaining as of old. In none of the five species examined are all the interradials admitted into the peristome. In four of them the labrum, of considerable size, intervenes between I and V, and in three of these the interradials 1 and 4 tend to separate the I from the II, and the V from the IV. In one species alone, Pourtalesia Jeffreysi, the labrum, 5 *1*, is greatly reduced, and the I and V close with one another behind it, so as to exclude it completely from the rest of the perisomal system. All this recalls in a certain degree what is seen among the Clypeastridæ, another type of late appearance. In these[1]), of the peristomal ambulacrals none are biporous, all

[1]) Études p. 32, pl. XLIV—LII.

the ten being uniporous, and much alike in the disposition of their pores, and the peristomal formula is sustained, in the greater number of genera at least, solely by the superior size of the first plates of I *a*, II *a*, III *b*, IV *a*, V *b*, or, more distinctly, of the corresponding second plates, one genus, however, Arachnoides, being exceptional even on that point. The relations between ambulacrals and interradials are also various, the latter preserving their series uninterrupted in Echinocyamus and Laganum [1]), while in Encope and Clypeaster, Echinarachnius and Arachnoides Zelandiæ [2]), the first plate of all is alone admitted into the peristome, as is also in Mellita and Rotula [3]) the first plate of 1, 2, 3, 4, while the interradium 5 remains entire, whereas in the adult Arachnoides placenta [4]) all are excluded, the 5, *1* alone appearing in the vicinity of the peristome.

I have given the insignificant name of Sphæridia [5]), Spherids, to certain sense organs, of function as yet obscure, present in all forms of the Echinoidea, the Cidaridæ, and perhaps Echinothuriadæ, excepted. They are very minute, calcareous, generally globular or pyriform, pedunculated bodies, articulated to little knobs of the test, and composed, like the spines, of an axial reticular tissue, and external compact layers of transparent glossy substance, and covered with a thin connective tissue, an epithel and a ciliated cuticule. They belong exclusively to the ambulacra, and to the adoral portions of these. In the greater number of the Echinidæ they are uncovered and mostly numerous, being found single, one only in each ambulacrum, in the genus Echinocidaris [6]) alone, which, together with the allied form, Coelopleurus, deviates from the Echinidan type in other respects also, in the sub-petaloid ambulacra bearing branchial pedicels, in the quadri-partition of the central piece of the calycinal system, in the anomalous forms of the spines. The Clypeastridæ offer two types: one, represented by the plurality of genera [7]), in which there is only a single spherid for each ambulacrum, more or less concealed in a cavity; and another, to which belong Clypeaster and Arachnoides [8]), having in each ambulacrum two spherids contained in crypts hollowed out in the substance of the test. In a like manner the multiple spherids of Cassidulus [9]), at first free and uncovered, successively become overgrown by the superficial layer of the calcareous substance of the test, until the site of each is marked merely by a very minute opening.

In all these groups, in which the bilateral disposition of the skeletal systems is often but slightly, though unfailingly expressed, the spherids are distributed by equal numbers, or nearly so, between the five ambulacra, which are also nearly of the same structure. In the Spatangidæ [10]), on the contrary, where the bilateral differentiation of the ambulacra in a trivium and a bivium, apparent already in the Holastridæ of the Older Cretaceous period, is gradually carried out in a decided manner,

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1) Études, p. 32, pl. XLIV, XLV. 2) Ib. p. 32, pl. XLVI, XLVII, L, LII. 3) Ib. pl. XLVIII, XLVI. 4) Ib. pl. LI. 5) Ib. p. 1—11, 36, pl. I—V, VII—X, XVII. 6) Ib. p. 7, pl. X, fig. 91, 92. 7) Ib. p. 6, pl. VIII, fig. 68—73. 8) Ib. p. 6, pl. VIII, fig. 74—78. 9) Ib. p. 6, 36, pl. VII, fig. 61—66. 10) Ib. p. 6, 36, pl. III, fig. 32—40, IV, 42—45; V, 48.

the spherids, mostly uncovered, — Lovenia alone having them recondite, — are often more or less unequally disposed, generally with some relation to the distribution of the phyllodean pedicels. Thus they generally are fewer on the front ambulacrum, III, in a greater number, though arranged in the same manner, on the two paired ambulacra of the trivium, II and IV, and most numerous, and not seldom somewhat differently disposed, on the bivium, as may be seen more particularly in Moira, Schizaster, Brissus, Plagionotus. Appertaining, as they do, to the ambulacral system, they obey, in their mode of appearance during the development of the individual, the law governing the growth of that system. Accordingly, in the very young animal the first spherid appears on each of the plates I *b*, II *b*, III *a*, IV *b*, V *a*, the second on plates I *a*, II *a*, III *b*, IV *a*, V *b*, and so forth, and in the same order also they are shed in the Echinidæ[1]), and grown over in the Cassidulidæ[2]). Consequently, in the Spatangidæ, the plates bearing the first spherids are those having a single pedicellar pore, while the second spherids appear on the biporous plates.

All this is very different in Pourtalesia Jeffreysi. There are only four spherids, *Pl. IV, fig. 15.* Of these the two are placed one on each of the two first single plates of the bivium, I *1* and V *1*, not far behind the pedicellar pore, close to the external suture, in a depression partly extending to the adjoining plate of the trivium. In the same manner the two other are placed on the plates II *a 1* and IV *b 1* of the trivium. They are all sub-globular, those of the first pair somewhat larger than those of the second, and all are uncovered. With the spherids of the Spatangidæ they agree also in their proximity to the suture, and in the leaning over it, a feature observable in the first spherids of the young of these, *Pl. XV, fig. 172, 174, 175*, but soon lost[3]). The plates II *b 1*, IV *a 1*, and the whole of III, are devoid of spherids. Of the plates I, *1* and V, *1*, the former represents the two peristomals I *a 1*, I *b 1*, and the latter the two V *a 1* and V *b 1*, in other Echinoids, and as these two pairs are always symmetrical towards one another on both sides of the middle line, in their joint outline as with regard to their component elements, the position of the two larger spherids in Pourtalesia Jeffreysi is fully in harmony with the general law. But, according to that law, the first spherids of the ambulacra II and IV ought to have appeared on II *b* and IV *b*, that is to say: unsymmetrically, whereas in this Pourtalesia they are placed symmetrically towards each other, as detailed above, *fig. 15.* These spherids, therefore, like the rest of the ambulacral elements, are disposed solely in relation to the actual antero-posterior axis of the skeleton. They are also developed exclusively on that reduced part of its ventral surface which is in close contact with the ground on which the animal lives. Their size is relatively considerable. In a specimen of 34 mm. one of the larger spherids measures 0,26 mm. in length, and 0,20 mm. in transverse diameter, and one of the smaller 0,23 mm. and 0,20 mm., in the same dimensions. Compared to a spherid, 0,26 mm. in length, taken from a specimen of Meoma ventri-

[1]) Études, p. 37, pl. XVII, fig. 141—147. [2]) Ib. p. 36, pl. VII, fig. 61—66. [3]) Ib. pl. III, fig. 32, 33, 34.

cosa LAMK. of 160 mm., and to another of 0,15 mm., from an Echinocardium flavescens O. F. M., measuring 28 mm., the relation between the length of the spherid and that of the whole skeleton is

in Meoma ventricosa	as 0,16 to 100,
in Echinocardium flavescens	as 0,53 to 100,
in Pourtalesia Jeffreysi	as 0,76 to 100.

The increased volume of each single spherid appears in some degree to make up for their reduced number, and its efficiency to depend, in some measure, on the extent of its ciliated surface.

The fragments given me by Sir WYVILLE THOMSON enabled me to examine these curious organs in three more species of Pourtalesia: P. laguncula, P. carinata and P. ceratopyga of AL. AGASSIZ, *Pl. VI, fig. 37, 38, 40, 41, 44; VII, 47, 48, 49, 50.* In these, as in P. Jeffreysi, the entire set is brought together on the sub-labial parts of the first plates of the four ambulacra I, V, II, IV, there being none on the frontal, III. P. laguncula has four spherids, one on each of the ambulacrals I *a*, I *b*, V *a*, V *b*, *Pl. VI, fig. 37, 38, 40, 41.* They are pear-shaped, more lengthened in proportion than those of P. Jeffreysi, and placed in slight depressions close behind the first pedicels. In P. carinata, *Pl. VI, fig. 44; VII, 47*, their form is the same. I counted nine in all, one on each of the five first plates of I *b*, V *a*, II *a*, IV *b*, IV *a*, and two on I *a* and V *b*, but it is probable that some more were lost. The pedicellar portion of each plate is raised, and produced aborally into a projecting point, to which the first spherid is attached. In P. ceratopyga, *Pl. VII, fig. 48, 49, 50*, they are likewise pear-shaped, and still more numerous. I counted twenty two of them, twelve on the right, ten on the left, but there had no doubt been twenty four. The plates I *a 1*, I *b 1*, V *b 1*, V *a 1*, had four spherids each, II *a 1* and II *b 1* had each two, and IV *b 1* also two, but on IV *a 1* none could be detected, probably from its two spherids having being lost.

Thus the spherids of the Pourtalesiadæ from one species to another seem to differ more widely in number than those of the other Echinoids. But, whether few or many, they are always found stationed exclusively on a restricted part of the sub-labial region, formed by the ambulacra I, II, V and IV, and absent on the part of the peristome that is elevated above it, ambulacrum III, while in Echinoids generally, in which the whole of the peristomal region is ventral, they are distributed all around, on all the five ambulacra, and missing only higher up, on the sides and on the back. Of whatever nature, therefore, the special changes in the surrounding water may be, that their ciliated epithelium has to watch for, these changes seem to be of essential moment to the animal, solely when they take place in the vicinity of the mouth, or between the under surface and the ground, on which the animal has to find its food.

The pedicels of the Echinoidea, óf paramount importance as organs of touch, of locomotion and prehension, and, in some forms, of respiration, are, however, easily overlooked, and have been much neglected, even in the latest works. RÉAUMUR [1]) was the first who, early in the last century, observed them in a living Echinus and described some of their functions. But he was led to state that every single perforation, »*trou*», of the ambulacrum answered to a pedicel, and consequently that there were as many pedicels as perforations. He also seems to have supposed that they are extended from the interior and drawn in again through the pores. Sixty years afterwards these errors were corrected by J. A. GYLLENHAHL, [2]) in the highly remarkable paper in which he demonstrated the animal nature of the fossils then named »crystal apples», »calcareous nodules», or »Aetites», and ranged by LINNÆUS among minerals, but which he proved to be »petrified animals of the genus Echinus or its nearest allies». He described two species, the Echinus pomum, now Sphæronis pomum, and Echinus aurantium, now Echinosphæra aurantium, both well-known forms of Cystoidea. Of the former he says:

»Tentaculis procul dubio numerosissimis instructum (iisdem licet ipsis, prout mollioris substantiæ, adeoque petrificationis incapacibus, non potuerint non omnino privata fuisse fossilia individua): Cutis enim undique pertusa est poris minutissimis, orbiculatis: Quorum gemini semper collocati sunt intra cancellum minutum; inæquilateri-angulatum; fundo convexum; plerumque oblongum et in singula extremitate pororum altero pertusum».

This he explains thus:

»As »the tentacles» are to be understood those soft and elastic filaments which in all other Echini are attached to the surface of the test, each over a pair of small perforations. All the species of Echinus hitherto known possess cancelli on the surface of the test, corresponding with those described above in outline, in the convexity of the bottom. and in the test being pierced, within every single cancellus, by two minute perforations, one at each of its ends, the cancellus commonly being of an oval form. These two pores afford the communication between the internal parts and the tentacle, the basis of which occupies the entire cancellus, and consequently covers both pores. In the new fossil species now described the cancelli are somewhat deeper than in most other Echini, but in some of the irregular Echini I find those around the mouth to agree with them in this respect also.»

And he adds, against RÉAUMUR:

»I have examined Echini of different species, such as they had been taken out of the sea and afterwards dried, and these I have placed in warm water in order to make their substance swell and resume its natural shape, and thus I found that, instead of there being one tentacle to each pore, there is one tentacle corresponding to each pair of pores.» ... »It follows that the pores are twice as numerous as the tentacles».

It will be noticed, that GYLLENHAHL had an idea that in some of the Echini irregulares of LINNÆUS, the pedicellar pores near the œsophageal opening were somewhat different from the rest. To the eminent Dane OTTO FREDERIC MÜLLER belongs, however, the discovery, as early as in 1776, of the peculiar structure, in Spatangus purpureus, of its circum-oral pedicels, of which, in the following year, he published a magnified figure,

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[1]) Histoire de l'Académie Royale des Sciences. Année MDCCXII. Avec les mémoires de mathématique et de physique pour la même année. Paris 1714, 4:o, Mém. p. 136, pl. 8.

[2]) JOHAN ABRAHAM GYLLENHAHL, in his twenty second year, communicated to the R. Swedish Academy of Sciences the above quoted memoir: Beskrifning på de så kallade Crystall-äplen och kalkbollar, såsom petreficerade djur af Echini genus, eller dess närmaste slägtingar. Kongl. Vetenskaps-Akademiens Handlingar för år 1772, Vol. XXXIII, p. 239. Translated into german in: Der Königl. Schwedischen Akademie der Wissenschaften Abhandlungen aus der Naturlehre, Haushaltungskunst und Mechanik, auf das Jahr 1772. Aus dem Schwedischen übersetzt von Abraham Gotthelf Kästner. Bd. XXXIV, p. 231. Leipzig 1776. — J. A. GYLLENHAHL, elder brother of LEONARD GYLLENHAAL, the eminent author of »Insecta Suecica», was born in 1750 and died in 1788, as Director of the Copper-mines at Åtvidaberg in Ostrogothia.

as good as any given since.[1]) He was also acquainted with another sort of pedicels, namely those belonging to the frontal ambulacrum of Echinocardium flavescens, and possessed figures of these, made by his brother and draughtsman C. F. MÜLLER. These figures, however, were not published till long afterwards, in 1789, by ABILDGAARD[2]) who was well aware of the distinctness of the frontal pedicels from those surrounding the mouth. It will seem that O. F. MÜLLER had regarded both as being of one and the same sort, when he made use of their structure, very happily after all though, as an essential character distinguishing his genus Spatangus: »*tentaculis penicillatis*», from the genus Echinus: »*tentaculis simplicibus*».[3]) This is indeed the first important step towards a rational dismemberment of the great Linnæan genus Echinus, and O. F. MÜLLER is to be considered as the real author of the natural genus Spatangus since adopted by LAMARCK. The name, borrowed from ARISTOTELES, had been in use with the Museographers of the pre-Linnæan era for certain artificial divisions.

It is, however, mainly to the account given by JOHANNES MÜLLER[4]) of the various kinds of pedicels occurring in the Echinoidea, that we have to turn for the principal source of information respecting these important organs. After having remarked that not all the regular Echinoidea are homoiopodous, that is, have the whole of their pedicels terminating in a sucking-disk, as DUVERNOY had presumed, but that certain genera, as Echinocidaris, Astropyga, Diadema, and Colobocentrus, have the dorsal pedicels simply pointed and flattened, and, the last named genus excepted, plaited on the sides, thus suggesting a respiratory function, he proceeds to give the following general description of these organs, as they occur in the Spatangidæ. In this group four different kinds of pedicels may be distinguished: 1) simple locomotive pedicels with truncated or rounded tops, destitute of sucking-disks; 2) locomotive pedicels provided with a terminal circular sucking-disk, either crenulated at the margin and strengthened inwardly with radiating calcified laminæ, or divided into radiating processes containing calcareous rods or lamels; 3) tactual, penicillate pedicels, ending in expanded brushes of club-shaped filaments, inwardly sustained by calcareous rods; 4) branchial pedicels, ambulacral gills, having the shape of triangular leaflets with plaited sides. In one and the same ambulacrum there may be found two or even three of these kinds succeeding one another, between the peristome and the dorsal pole. Wherever a fasciole is present, one kind of pedicels is peculiar to the area it circumscribes. In the genus Spatangus JOH. MÜLLER recognises three kinds: tactual, locomotive and branchial. The circum-oral pedicels of all the five ambulacra are tactual and penicillate, the rest of the ventral ones simple and locomotive. Within the sub-anal fasciole there stand on either side three

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[1]) Zoologiæ Danicæ Prodromus, 1776, p. XXIX. — Zoologia Danica, I, t. VI, fig. 5, 1777; latin letterpress, in 8:o, 1779, I, p. 11; in fol., 1788, p. 5; danish letterpress, in fol., 1781, p. 19. The erratum, Zool. Dan. Prodr. p. XXIX: »ano infero», is here corrected to »ano laterali».

[2]) Zool. Dan. III, p. 17, t. XCI, fig. 4. »Terminantur disco radiato, radiis clavatis, alternis longioribus. Tentacula vero, quæ poros ad circumferentiam oris transeunt fasciculo penicillato filamentis capitatis composito terminantur», ABILDG.

[3]) Zool. Dan. Prodr., p. XXIX.

[4]) Ueber den Bau der Echinodermen. Abhandl. d. K. Akademie d. Wissensch. in Berlin, 1854, sep. p. 26, pl. III.

penicillate pedicels, belonging to the inner rows of the bivious ambulacra, the fasciola traversing their plates. The front ambulacrum, which is never seen to bear gills, has simple locomotive pedicels, continuing all up to the calyx. But then in this genus the peripetalous fasciola is absent. Brissopsis, Schizaster etc., on the other hand, are provided with a peripetalous fasciola, and Echinocardium with an internal fasciola, and, within the boundary of either, the frontal radius presents a set of peculiar pedicels with crenulated or stellated disks, but outside of it only simple locomotive pedicels. In Brissopsis and Schizaster the disks contain radiating laminæ, [1]) as likewise the finger-like processes of Echinocardium. [2]) The internal fasciola of this latter genus traverses not only the front ambulacrum, but also the tops of the four petals, and the apical parts of these that fall within the fasciola, bear no branchial leaflets, only very minute simple pedicels.

The penicillate circum-oral pedicels of the five ambulacra JOHANNES MÜLLER found similar in all the genera examined, and, in all of them, subanal penicillate pedicels, in Brissopsis, as stated above, three on either side within the sub-anal fasciola, in Schizaster canaliferus, which is prymnadete, seven on either side, at a distance from the periproct, not between it and the posterior fasciola, but in front of the latter.

To this account may be added the previous researches of ERDL and VALENTIN, and those of subsequent observers, as AL. AGASSIZ, HOFFMANN and PERRIER. [3])

In my former memoir on Echinoidea I abstained from entering upon any detailed description of these organs, and gave only a short notice of their structure and distribution in Brissopsis lyrifera [4]), and of the primordial pedicels in Toxopneustes drœbachensis [5]). I expected to have, sooner or later, richer materials to examine. Although this hope has but partially been realised, as it is of some importance to compare the pedicels of Pourtalesia to those of the Spatangidæ, in particular, and as I shall have no more occasion to revert to the subject, I here give what has hitherto been attainable to me, from which it will appear that these organs, overlooked as they have been, are well worth a much closer investigation than what I have been able to bestow upon them.

To the whole region around the peristome DESOR gave the name of »*floscelle*» [6]), retaining that of »*phyllode*» for the part of each ambulacrum contiguous to the stoma, often distinguished by a somewhat expanded surface, and always by the presence of

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[1]) l. c. pl. III, fig. 6, 7.

[2]) l. c. p. 29, pl. III, fig. 4, 5.

[3]) VALENTIN, in Agassiz, Monographies d'Échinodermes, IV, p. 37, pl. 4, Echinus; 1842. — ERDL, Wiegmanns Archiv, VIII, 45, Taf. II, »Echinus saxatilis»; 1842. — ALEXANDER AGASSIZ, Rev. of the Echinidæ, I, p. 693, with numerous figures. — HOFFMANN, Zur Anatomie der Echinen u. Spatangen, Niederländisches Archiv für Zoologie, I, 1871, p. 75, 80, pl. X, fig. 78, 88—90. — PERRIER, Recherches sur les Pédicellaires et les Ambulacres des astéries et des oursins; deuxième partie, Ann. d. Sc. nat., 5:me sér., XIII, 1870, p. 1, 61: Ech. irréguliers; pl. 6, fig. 2, 3, 5: Amphidetus; 4, c—e, 7, c: Spatangus; 6, 8, 9: Brissopsis; 10: Brissus; ib. XIV, n:o 8: Echinoneus.

[4]) Études, p. 10, pl. I, fig. 1.

[5]) Ib. p. 27, pl. XVII, fig. 149—152.

[6]) Synopsis des Échinides fossiles, 1858, p. 247. In creating these appellations DESOR had in view the Cassidulidæ alone, but they are equally applicable to the corresponding parts of the Spatangidæ.

conspicuously large pores. The pedicels belonging to this region may be called phyllodean pedicels. In all the species examined the tubular shaft of these pedicels terminally expands into a circular convex disk, which, in the great majority, bears numerous capitate filaments covering its whole surface, *Pl. VIII, fig. 64.* They are disposed in concentric circles, and longer and more closely set at the margin, slightly shorter towards the centre, thus forming, with their tumid tops, almost a section of a sphere. Each filament contains a prolongation of the clear and homogeneous layer of the tube, and, imbedded in it, a slightly arched calcareous rod, by which the filament is kept rigid and in supination, *Pl. VIII, fig. 55, 56, 58, 60.* This rod, in the great majority of species, rises more or less centrally from a circular basis of areolar texture, in its immature state not unlike the wheels so frequent in Holothuriæ, *Pl. XI, fig. 121.* On its under side it presents a prominent nave, *Pl. VIII, fig. 63,* while on the upper side a number of its fibres unite in forming the rod, which in some species is linear, in others at first contracted, then in most cases slightly widening, again attenuated and obtuse at the top, sometimes faintly clavate; dense and smooth, as in Brissopsis, Schizaster, Echinocardium, or presenting internal traces of meshy texture *Pl. VIII, fig. 59, 60,* and a rough, even spiny surface, as in Meoma, Lovenia, Spatangus. In Urechinus Naresianus, *fig. 56,* the rods are rather strong, not solid, but areolate throughout. Generally the conformation of the rods resembles a simplified miniature of that of a spine or radiole.

On the structure of the tumid tops of the filaments in Brissopsis lyrifera, I formerly made some observations, *Pl. IX, fig. 80, 81, 82.* From a thin layer, a plexus surrounding the homogeneous central substance, numerous nervous fibres are seen to traverse the connective tissue towards the inside of the external tegument, and there to form nucleated multipolar cells in close proximity and connexion with the bases of very minute, scattered, rigid and motionless hair-like processes on the external surface, which is devoid of vibratile cilia. From this structure the tactual function of the phyllodean pedicels appears to be fully confirmed; I give it here with a view of inducing further research, and at the same time will draw attention to the peculiar form of the tops of the filaments in Metalia, Lovenia and others, observed in specimens too long preserved in spirits to bear with a closer examination, *Pl. VIII, fig. 61, 62.*

From this description of the phyllodean pedicels, as I have observed them in the greater number of known genera, only three of these have presented exceptions, possibly more apparent than real. In Aceste bellidifera Wyv. Thoms., *Pl. VIII, fig. 67, 68,* which in some of its characteristics shows a certain analogy to Schizaster and Moira, even in the strangely forward position of the œsophageal opening, — an exaggeration of a feature not altogether foreign to them, — I found the disks of the phyllodean pedicels crowned only with a double marginal circle of filaments, leaving the central part naked, and raised into a high, rounded protuberance, which, when seen from above, presents distinct traces of five converging plicatures. Palæostoma mirabile Gray presented forms very similar, *Pl. XVI, fig. 192, 193.* In Palæotropus Josephinæ n. were found, among the regular phyllodean pedicels, some, *fig. 72,* that presented the same aberrant structure. It will be seen further on, that this structure is peculiar to the subanal pedicels, and it may be that in the cases here mentioned it is assumed by the aborally most distant among the phyllodean pedicels.

The mode of development and the growth of the phyllodean pedicels may be seen, partially at least, in very young specimens. In the young Abatus cavernosus, still astomous and aproctic, *Pl. XIV, fig. 163,* there are five in the ambulacra I and V, two of which are in the I *a 1* and two in V *b 1,* one in each of I *b 1, 2, 3,* and of V, *a 1, 2, 3*; in II and IV: two in *a, 1,* one in *a 2,* and one in each of *b 1, 2, 3*; in III: two in *b 1,* one in *b 2,* and one in each of *a 1, 2, 3.* They are all simple, rounded, elevated knobs. The young of Echinocardium flavescens O. F. M., *Pl. XV, fig. 172,* measuring only 1,7 millimeter without the spines, having the pentagonal peristome placed only a little before the middle, with the newly-formed oesophageal opening in its very centre, and presenting the five first spherids, one in each of the uniporous plates *1,* [1]) has fifteen phyllodean pedicels: two in each of the bi-porous plates, one on each of the uni-porous. The following plates are also provided with pores, but the pedicels beginning to form over them could not be discerned, probably from their too great transparency. Each of the fifteen pedicels presents a short tubular shaft, and a simple, tumid, semi-globular head, in the centre of which is seen a roundish, convex lamina of calcified reticular tissue, *fig. 176.* In a specimen only a trifle larger, 1,9 mm., *fig. 175,* the head of the pedicel of one of the uniporous plates, V *a, fig. 177,* has become ovate, and two circular wheels have begun to form on its centre-piece, one of them directed against the small end of the head, the other, smaller, nearly opposite, and on their outer sides the calcified fibres are seen to interlace and protrude. In the pedicel of V, *fig. 175, 178,* two rounded lobes have grown out, and to each of them there is a corresponding wheel, on the point, as it appears, of coming off the central network, and out of its fibres the rod is seen to rise outwardly. Similar changes are seen in the young specimen of Abatus cavernosus, in which the oesophageal opening is just on the point of forming. [2]) In another specimen of Echinocardium flavescens, of 3 mm., *fig. 174,* which has the oesophageal opening moved a little behind the centre of the pentagon, the second pair of plates, in each of the paired ambulacra, presents their newly-formed pedicels. The disk of the older pedicels has now expanded into two or three lobes, *fig. 179, 180,* each containing a wheel, free from the central network, and with a lengthened rod. Underneath are seen the long, arcuated, spiny, transverse spicules of the ring. The central network seems not so large, relatively to the expansion of the disk, as it was at first; in adult specimens it is absent, as generally among the Spatangidæ, a store used up by the growing rods. A specimen of 5,3 millimeters has disks, *fig. 181,* with eight clavate filaments, forming a marginal circle, and one that seems to begin another, inner circle. Their number appears to increase rapidly; a Spatangus purpureus of 14 millimeters already presents the same number as one of 51 millimeters.

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[1]) Études, p. 36, pl. III, fig. 33—35.

[2]) See woodcut p. 26.

It follows from what has been detailed here, that the phyllodean pedicels of the great majority of the Spatangidæ, when forming, begin with a circular top, strengthened by a central calcareous network, that is, by a contrivance like that which is permanent in the Archæonomous Echinoidea, and chiefly subserves locomotion, but that they soon pass through this stage, as transitory, and develop into organs of a higher function, that of touch.

The distribution of the phyllodean pedicels among the five ambulacra, and the form of the phyllodes, are different in the different genera. The two bivious ambulacra I and V always symmetrise with one another in this, as do also the two paired ones, II and IV, while the front ambulacrum III, the odd one, stands alone. Whenever the two series *a* and *b* differ in the number of their phyllodean pores, it is the uniporous series, I *b*, II *b*, III *a*, IV *b*, V *a*, that presents the additional pore, all in accordance with the universal rule. The two paired ambulacra of the trivium, II and IV, present the most highly developed phyllodes, and the greatest number of phyllodean pedicels. In Maretia planulata these are seen to number eleven in each series, in Meoma ventricosa ten, in Brissus Scillæ nine, in Desoria australis eight, in Agassizia scrobiculata seven, in Spatangus purpureus six, in Breynia australasiæ, Plagionotus pectoralis, Faorina chinensis and Schizaster fragilis, five. On the other hand there are only four in Brissopsis lyrifera, Moira atropos and Abatus Philippii, three in Micraster cor anguinum, Kleinia luzonica, Echinocardium cordatum and Lovenia elongata. But still the number always equals, often exceeds that of the corresponding pores in the bivium. In the frontal ambulacrum the number of phyllodean pores is often less than in the bivium, in a few cases it equals them, and in still fewer exceeds them slightly, as in Brissus Scillæ, Plagionotus, Brissopsis, Maretia planulata. It follows from this that the floscelle has its greatest extension in the transverse direction.

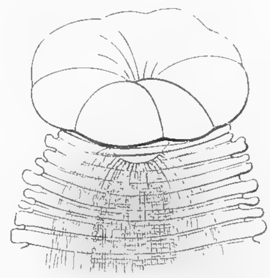
In each phyllode the pedicels are largest in the proximity of the peristome, the more remote gradually becoming smaller, and less rich in filaments. They are, however rather suddenly replaced by simple pedicels, small and slender, terminating in a conical or truncated top, which, in most cases, is surrounded by a waved margin, as in Brissopsis lyrifera, *Pl. IX, fig. 83, 84,* Moira atropos, *Pl. X, fig. 110,* Lovenia elongata Gray, *fig. 107, 108,* Schizaster japonicus Al. Ag., *fig. 111,* and thus somewhat like the pedicels in Rhynchopygus pacificus Al. Ag., *Pl. XI, fig. 118, 119.* These simple ventral and lateral pedicels become very slender and minute, more particularly in the bivium and the paired trivious ambulacra, and their pores are very small, all up to the petal. In the bivium, however, this holds good only with regard to the exterior rows of plates, the I *b* and V *a*. The two interior rows, I *a* and V *b*, very generally have their series of simple pedicels interrupted by the sudden appearance of the stout, peculiar, subanal pedicels discovered by Johannes Müller. Introduced in the earlier Spatangidæ, the Prymnadetes, in an uncertain and, as it were, a hesitating manner, these pedicels become in the Prymnodesmians a constant and striking feature. The subanal fasciola, in traversing the bivious ambulacra, [1]) marks off their five foremost plates, *1—5*, and

[1]) Études, p. 15, 59; pl. XXXII, fig. 200, — XLIII, fig. 232.

never more nor fewer, as ventral, the sixth of the inner row being intermediate, half ventral, half lateral, resembling the preceding in the size and position of its pore and the form of its simple pedicel, but extending itself inwardly like the succeeding, while the seventh + x following, have their pores transferred towards their opposite, inner extremity, and their pedicels, specialised in a peculiar manner, thus brought within the fasciola. This is the momentous modification of the Spatangean skeleton, brought on for the first time in Micraster during the Middle Cretaceous era. Generally, if not throughout, the subanal pedicels are penicillate, as stated by JOHANNES MÜLLER, and, at the first glance, they appear to be like those of the phyllodes, only that the disks are somewhat smaller, the filaments more unequal, as if disposed in five groups, and their terminal heads more tumid. On a closer inspection, however, this similarity is found to exist in but very few genera, as far as is hitherto ascertained, only in Echinocardium, in Lovenia, and perhaps in Breynia. In these the filaments are seen to cover the whole surface of the disk, though not quite so densely as in the phyllodean pedicels. In Echinocardium also the rods are much stronger, more particularly in E. cordatum PENN., *Pl. VIII, fig. 57*, in which species they are rather thin near the base, and from thence increase in thickness, so as to become four times as strong as those of the phyllodes, spindle-shaped, and nearly solid. The heads of the filaments, among which the marginal ones are the longer, are very tumid. So they are in Lovenia also, the rods being likewise stronger than those of the phyllodean pedicels, *Pl. VIII, fig. 59, 60.* But, unlike these, the great majority of other genera present a different arrangement. In Spatangus, Maretia, Brissopsis, Kleinia, Brissus, Metalia, and, as it seems probable, in Eupatagus and Linopneustes, among the Prymnodesmians, in Agassizia, Schizaster, Abatus, Hemiaster among the Prymnadetes, the pencil is made up of a few circles only of filaments, placed round the margin of the disk, so as to leave bare its central part, and within this there rises a cupola-shaped or even subglobular protuberance, surrounded by an open circular space, and commonly presenting on its top a central depression, in which about five folds are seen, indicating about five convergent, more or less distinct lobes. In Brissopsis the central protuberance sometimes shows eight to ten such lobes, nearly closing over the middle, sometimes, when subjected to pressure, taking the shape of a waved brim all around a flattened cup supported by five calcified areolar lamels, *Pl. IX, fig. 85.* So it is also in Brissus. In the like manner, the large central protuberance in Kleinia luzonica presents four or five triangular converging lobes almost closing over the middle, while in Spatangus purpureus it is relatively small, but high, apparently without any distinct lobes, supported by a convex areolar lamina, and surrounded by a broad circular space, and a marginal crown of filaments with very strong rods and very tumid heads.

In Agassizia scrobiculata VAL., *Pl. VIII, fig. 65*, the inner filaments are short, and the central protuberance, rising vertically and convex above, presents five triangular, thin, converging lobes, supported beneath by five coarsely areolar, calcified laminæ. In Schizaster japonicus AL. AG. the whole of the central surface is occupied by the convex protuberance, presenting three to eight subtriangular, convergent, apparently very thick lobes, separated by deep grooves, and in some cases forming in the middle a funnel-shaped depression.

The structure thus described, the central protuberance, provided with flexible lobes resembling lips, sometimes found closed, sometimes open and expanded, in a certain degree calls to mind the sucking mechanism seen in Starfishes and Archæonomous Echinoids, as also in many other Echinoderms. If an Asterias rubens is brought to fasten some of its pedicels on a covering-glass, and this is placed under the microscope after the pedicels have been cut off, their tapering tops, destitute of any calcareous support, are found to be flattened against the glass, thus forming temporary disks, and their central parts are seen to be drawn in conically into the tube, by the action of some of its longitudinal muscles. If covering-glasses are strewn about in a vessel where specimens of Toxopneustes drœbachensis are kept alive, these readily take to lifting some of them, and keeping them hanging on their backs, perhaps mistaking them for fragments of dead shells, like those they are said to make use of in disguising. Preparations for the microscope are thus obtained of the disk in adhesion, the pedicels of this species keeping their hold more persistently after amputation than do those of the Starfish. If the glass is detached by pulling, some disks will let go their hold, each leaving behind a circular mark, a thin film made up of fragments of its cuticula, spread all around a clear spot in the centre, where there had been no adhesion. But other pedicels will part, and their disks, left adhering to the glass, *Pl. XI*, *fig. 112—115*, present within the broad circular and regularly waved margin, a flat surface, *fig. 113*, in whose centre an angular depression is seen to give off radiating, gradually less defined plicatures. Beneath this depression bundles of delicate muscular fibres come in sight converging from below, *fig. 112*, *114*, *115*, by the action of which the central part is drawn in. It will appear that suction is brought about in consequence of the capacity of this depression being thus increased.



Sucking pedicel of Asterias rubens L.

Experiments on living Spatangi are necessary, before it may be safe to conclude from a certain resemblance in structure to a similarity of function, but meanwhile it seems at least allowable to look upon the subanal pedicels, in the genera enumerated above, as a combination of a marginal, tactual, with a central, sucking apparatus, and the whole as a union of a feeler and an instrument of prehension.

For locomotive purposes most of the Spatangidæ, being normally burrowers, chiefly use the strong oar-like spines of the sternum, and are never seen to climb the walls of glass-vessels, as do the true Echinids by means of their powerful pedicels. In close accordance with the amount of muscular exertion thus displayed by the last named, stands the superior solidity of the calcareous lamels and spicules that underlie the adhesive surface of their disk. These have been described by various authors. In Toxopneustes drœbachensis, *Pl. XI*, *fig. 112*, four reticular laminæ, concentric and adjacent to one another, and, if I am not mistaken, united by short muscles, inwardly inclose a circular open space, and outwardly send out strong points, at regular intervals, answering to the reentering angles between the marginal undulations. Their inner margins and their outer circumference are raised above the rest of the surface. Very similar lamels are seen in Echinoneus, *Pl. XI, fig. 116, 117*, which is homoiopodous. Close under this circlet of areolar lamels there lies, in the last named genus, *fig. 117*, as well as in Echinoids generally, *fig. 114, 115*, another set of calcareous ossicles, composing what may not improperly be named the foot-ring. This is for the most part composed of a single series of lengthy and arcuated spicules, outwardly smooth, inwardly areolar and frequently spinose, and placed transversely in such a manner as to overlap one another and to form together a quadrangle, or much more commonly a ring, encircling the tubular shaft. And, lastly, there follows, through the whole length of the shaft, the series of the well-known minute, numerous, arcuated and fusiform spicules.

The pedicels of the Spatangidæ possess calcified tissues answering to those in the Echinidæ just described. Their phyllodean pedicels, however, seem to be devoid, in the adult, of anything comparable to the strengthening lamellæ universally present in the suctorial disks of the Echinidæ. It has been shown above that in the phyllodean disk of a very young Echinocardium flavescens, a calcified network is primarily deposited, evidently corresponding to that seen in the sucking-disk of the young Echinus [1]), but also that it gradually diminishes, being, as it seems, dissolved and converted into the permanent form of the filamental rods, while the tactual function of the disk is preparing by means of the successive development of additional filaments. And long before these have reached their due number, the primary net-work has disappeared, at least I have searched for it in vain in the adult. It seems to be replaced, very generally, if not universally, by radiating vertical septa, *Pl. VIII, fig. 64*, composed of areolar lamels of irregular form, *fig. 78*, in some way connected with the annular spicules to be described hereafter. And likewise, when the subanal pedicels are constructed upon the model of the phyllodean, as in Echinocardium and Lovenia, there is no trace of strengthening horizontal laminæ.

On the other hand, when the disk of the subanal pedicels is provided with a central protuberance, apparently adapted for sucking, as in the genera enumerated above, this protuberance is often, though, as it seems, not always, underlaid with calcified laminæ, which, however, nowhere possess the solidity or the regular form observable in Echinids. Thus in Brissopsis lyrifera, *Pl. IX, fig. 85*, there are five such separate, but contiguous laminæ, in Agassizia scrobiculata, *Pl. VIII, fig. 65*, likewise five, of a somewhat triangular shape, in Brissus compressus Lamk., *fig. 74*, five, minutely areolar, contiguous, outwardly bi- or tri-lobate, while in Brissus mediator n., *fig. 75*, and Maretia planulata Lamk., they seem to form a convex, continuous expansion, outwardly of a more open texture, inwardly closer, supported on the underside by slender radiating ribs. — In the simple slender pedicels, ventral as well as lateral and frontal, the like structure obtains, a terminal combination of about five areolar lamellæ forming a somewhat convex layer, beneath the surface of the top.

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[1]) Études, p. 28, pl. XVII, fig. 149, 150.

It follows from the general description here given, that the subanal pedicels, even in the antique form of Hemiaster, are penicillate, either totally, or, in most cases, partially, semi-penicillate, that is: partly suctorial, partly sensitory, the central space being occupied by a labiate elevation, and the periphery bearing clavate filaments. It is therefore rather surprising to find two genera distinctly different from the rest in this regard.

Palæotropus Josephinæ n. [1]), which deviates so widely from the Spatangean type, by its simple ambulacra, dorsally apetalous, and by the absence of branchial pedicels, — of the usual form at least, — but which is still provided with at least semi-penicillate phyllodean pedicels, presents, within the subanal fasciole, on either side, two plates, *7* and *8*, bearing pedicels, *Pl. VIII, fig. 73*, larger than the rest, but devoid of the usual marginal crown of filaments, and presenting only a circular disk with a waved margin, strengthened by about eight areolar, subtriangular, converging lamels. In Meoma grandis and M. ventricosa a similarly exceptional structure occurs. The phyllodean pedicels are normal, very strong, and rich in filaments. Within the bivium they are such in I *a*, plates *1* and *2*, in I *b*, plates *1*, *2*, *3*; in V *a*, plates *1*, *2*, *3*, in V *b*, plates *1* and *2*. Then come, abruptly, very minute, simple pedicels, each terminating in a small disk, the diameter of which is less than that of the tube. It has a distinct, but thin and rather narrow margin, and within that a convex area, in which are seen four or five converging lobes, leaving a small bare space in the centre, and underlaid with an equal number of lamels of rather coarse and open network. The pedicels continue such in V *b*, as also in I *a*, by the plates *3*, *4*, *5*, *6*. With their respective plates *7* they come behind the incomplete subanal fasciola, but remain unaltered, only very sligtly larger in plates *7*, *8* of V *b*, and *7*, *8*, *9* of I *a*. — These are the only two exceptions known to me, from what appears to be the general rule.

The number of typical or modified subanal pedicels differs in the different genera, and among the species of one and the same genus. If the figures given in my former work, of the skeletal structure of the Spatangidæ are consulted, it will be found that in all the Prymnodesmians figured, [2]) Palæotropus, Micraster, Brissus, Meoma, Spatangus, Brissopsis, Kleinia, Echinocardium, Plagionotus, Breynia, Maretia, Lovenia, the sixth plate of I *a* and V *b*, though extended mesially so as to reach within the fasciola, retains the minute pore of the simple pedicel in its place, near the outer margin and outside the fasciola, while the true subanal pedicels begin in the seventh plate, their large pores being transferred towards the inner end of the plate, and within the fasciola. The same holds good in Metalia and Eupatagus, not figured there, and, in fact, in every species of the Prymnodesmians hitherto examined, from which it may be allowable to conclude that the same conformation is maintained in the genera Cionobrissus, Homolampas, Linopneustes, Argopatagus, of Al. Agassiz. Among the Prymnadetes it is otherwise. [3]) The order is even different in different species of the same genus. Thus, in Schizaster fragilis and Sch. Moseleyi, the subanals begin with the se-

[1]) Études, p. 17, pl. XII, fig. 105; XIII, fig. 108—113; XXXII, fig. 200.
[2]) Ib., pl. XXXII, fig. 200, — XLIII, fig. 232.
[3]) Ib., p. 16, pl. XXVI, fig. 185, — XXXII, fig. 197.

venth, in Sch. japonicus and Sch. gibberulus with the fifth, in Abatus cavernosus with the eighth, in A. Philippii with the seventh. In Agassizia scrobiculata and Faorina chinensis they commence with the sixth, in Hemiaster Fourneli with the seventh, in Desoria australis with the tenth.

Among the Prymnodesmians perhaps the greatest number of subanal intra-fasciolar pedicels occurs in the genus Brissus, they being as many as nine on either side in Brissus carinatus Al. Ag.[1]), and at least five or four in Brissus Scillæ and Brissus Garretti Al. Ag. Breynia australasiæ has six in I *a*, seven in V *b*, the old Micraster cor anguinum five on either side, Plagionotus pectoralis and Kleinia luzonica four. In Meoma ventricosa, Brissopsis lyrifera, Echinocardium cordatum, Lovenia subcarinata, Maretia planulata, there are three, in Spatangus purpureus and Palæotropus Josephinæ only two. Among the Prymnadetes the diversity is greater, Agassizia scrobiculata possessing five or six, Abatus Philippii, Desoria australis, Faorina chinensis three, Hemiaster Fourneli Des. as many as eight.

A very young specimen of Brissopsis lyrifera, measuring only 4,6 mm. in length,[2]) has the plates *6*, *7*, *8*, *9* of I *a* and V *b* extended within the fasciola, and the three: *7*, *8*, *9*, bearing semi-penicillate pedicels, all which is as in the adult. The number of intra-fasciolar pedicels, normal to each species, therefore, seems to be obtained at a very early age, so that specimens, inferior in size and presenting fewer subanal intra-fasciolar pores ought not, on that account, to be taken for juvenile stages of species possessing a greater number of such pores, and to which they in other respects may have some resemblance. At the same time, however, it is not to be overlooked that the number of these pores is sometimes, but rarely, seen to vary slightly in one and the same species, and that even in the same specimen there may be one more in I *a* than in V *b*, or *vice versa*. But these are accidental variations, and, with proper care, the number of subanal intra-fasciolar pedicels may be used, with perfect confidence, as a specific character.

Various, with regard to size and form, as are the pedicels of the bivium, the frontal pedicels, those of the ambulacrum III, are still more so. In this the phyllodean pedicels are soon succeeded by simple pedicels. Wherever their succession is not interrupted by a dorsal fasciola, they continue unaltered and of minute dimensions all up to the calycinal system. Thus it is in Spatangus purpureus O. F. M., Maretia planulata Lamk. and Maretia alta Lütken. In Maretia planulata, *Pl. X, fig. 104*, they taper into a rounded tip, within which are seen reticular lamels. In Spatangus purpureus those next to the phyllodean pedicels rise abruptly from a large and tumid base, while the following, up to the calyx, are slender and very small, and similar to the simple lateral pedicels of Brissopsis, *Pl. IX, fig. 83, 84*, or those of Meoma, *Pl. VIII, fig. 70, 71*, described above, terminating in a small disk, with highly flexible margin. In most cases the dense pigment of the top prevents observing its internal structure, but, when long macerated in weak spirits, it sometimes happens to retain the calcareous skeleton still coherent, *Pl. X, fig. 109*. Then it is seen, that at the base of the flexible margin

[1]) Revision, pl. XXXI, *a*, fig. 3, 4. — [2]) Études p. 16, pl. XXXVII, fig. 218.

there lies a ring of strong, transversal, arcuated and branched spicules, and that the central part is sustained by about five, finely areolar, converging, and convex laminæ.

Among the genera provided with a peripetalous or an internal fasciola, such continuance of simple pedicels all through the length of the frontal ambulacrum has been observed only in Meoma and Lovenia. In Meoma ventricosa and M. grandis, both of which huge species have a well-marked, though narrow peripetalous fasciola, the frontal pedicels, *Pl. VIII, fig. 70,* surprisingly minute, present the same uniform simple structure all along, from the phyllode to the calyx, just as those of I *a* and V *b* do within the subanal fasciola. The central convexity is lobate, much as in the subanals of Schizaster, and the spicular structure is that just described in Spatangus. Very minute are also the simple frontal pedicels within the internal dorsal fasciola of Lovenia, *Pl. X, fig. 107, 108,* and similar in structure to those of Spatangus.

Among the Prymnadetes, Hemiaster expergitus n., *Pl. X, fig. 92,* [1]) the most ancient generic type among recent Spatangidæ, presents, within the peripetalous fasciola, middle-sized pedicels, terminating in a flat disk, slightly waved at the margin, strengthened by ten or eleven elongated, reticular, calcareous lamels, which in their outer, larger and horizontal portion are of a more open texture and lacerated at the margins, in the inner, tapering and feebly rising portion, more compact, smooth-margined and contiguous, leaving a clear space in the centre. Slightly different from this is the terminal disk in Abatus Philippii, *fig. 91,* not much exceeding the tubular shaft, circular and sustained by areolar lamels up to twelve in number, sub-triangular, rather flat throughout, more dense and less rough-margined in their inner tapering portion. But it is in the singular Palæostoma mirabile and in the group formed by Schizaster, Moira and Aceste, that this structure of the terminal disk is more highly developed, the pedicels at the same time attaining unusual dimensions, so as to make their rows form a very striking feature of the frontal ambulacrum. In all of them the disk is wide, and strengthened by numerous radiating laminæ. In Palæostoma, *Pl. XVI, fig. 194,* it is octo-stellate, and the laminæ, outwardly lanceolate, have their inner portions broad and spade-like. In Schizaster fragilis, D. & K., *Pl. X, fig. 100,* its margin is digitate, deeply divided into from fifteen to twenty three rays, expanded at the top, each of them for about half or two thirds of its length supported inwardly by a long, nearly linear lamel, lacerated at its growing end, otherwise nearly smooth-margined, with its inner portion slightly rising, and tapering to an obtuse point. The same reappears in Schizaster japonicus AL. AG., *fig. 101, 102, 103,* in which the margin is less deeply digitate, and the lamellæ, even exceeding thirty in number, are very long and narrow, and have their inner ends slightly dilatated. In Moira atropos, *fig. 94, 95,* on the other hand, the inner contiguous portions of the lamellæ are broad, spade-like and smooth-margined, thus contrasting with the outer portion which is narrow, linear and jagged. In Aceste bellidifera WYV. THOMS., *fig. 96, 97, 98,* which has received its name from the size and singular appearance of these pedicels, the broad expanse of the disk is only slightly waved in front of each of the twenty to twenty seven rod-

[1]) Études, p. 13, pl. XII, fig. 114—120; XI, fig. 93, 94; V, fig. 46, 47.

like, narrow laminæ, with shortened, acutely triangular inner portions, and lengthened, slightly widened, and spinous outer portions. In Aceste, Moira and Schizaster japonicus another peculiarity is met with. The inner portion of each lamella has its margins thickened and compact on the under surface, and produced on either side into a tooth, which in the Schizaster, *fig. 102, 103*, is strong and directed inward, in Moira, *fig. 95*, hardly perceptible. Between the thickened margins the under surface is concave, and the upper, in Aceste, raised into a projecting keel, *fig. 97, 98*. It is worthy of remark that in Schizaster fragilis scarcely a rudiment is to be seen of the whole of this conformation, which no doubt serves to extend the attachment of motor muscles.

Among the Prymnodesmians, Metalia, *fig. 106*, has frontal pedicels nearly like those of Abatus. A conformation, similar to that just described in Schizaster, reappears in Kleinia luzonica Gray, whose long and well-developed frontal pedicels end in a large disk, deeply divided into thirteen to fifteen rays, corresponding to a like number of laminæ, *fig. 99*, resembling those in Moira, only a little broader, of a more open texture, and more spiny at the margins. Their inner extremities are also spade-like, with two distinct marginal teeth. In Brissopsis lyrifera the strong frontal intra-fasciolar pedicels likewise terminate in a large and flat circular disk, *Pl. IX, fig. 86—89*, with a waved margin, the regular undulations of which answer to an equal number of fifteen to eighteen radiating laminæ, resembling those of Schizaster fragilis, subrectangular in their longer, external portions, compact, smooth-margined and tapering to an obtuse point in their internal contiguous portions, and devoid of the marginal teeth seen in Kleinia. The circular space in the centre generally is perfectly clear, — numerous observations had indeed made me assured that it were so invariably, till one specimen turned up, presenting the calcified lamina delineated in *fig. 86*. According to notes taken long ago, accompanying the figures here given of the disk, as it appeared in the living animal, these lamels are inclosed in the homogeneous substance, outside which is seen a complexity of connective tissue and nervous elements, together with interspersed pigmentary nucleated cells, *fig. 88*, some deep red, others yellow. This texture extends to the inside of the epithel. In the interstices between every two laminæ there is seen an oblong granular body, opaque by transmitted light, white by reflected light, having all the appearance of a glandular mass, although, at the time, I could not find an excretory opening. In specimens preserved in spirits it has disappeared almost completely. It may perhaps secrete some viscous substance, by which minute animals are captured that live above the surface of the clay in which the Spatangus is deeply burrowing, while the tops of these highly extensible, prehensile organs are playing freely in the water high above. Alone among the species hitherto examined, Agassizia scrobiculata, *Pl. X, fig. 93*, has frontal intra-fasciolar pedicels similar to the subanal. Almost of the same size with these, they likewise end in a circle of filaments of unequal length, with rods as slender, and tops as tumid, surrounding a cup-like protuberance with five triangular lobes converging into a central depression, and overlying a rosette of radiating laminæ.

Echinocardium presents a rather peculiar form of frontal pedicels. In Echinocardium flavescens O. F. M., *Pl. XI, fig. 127—130*, their structure was observed already by OTTO FREDERIC MÜLLER, and described by his editor ABILDGAARD [1]), as terminating in a stellate disk, the rays, fifteen in number, being clavate and alternately longer. They are robust, straight, obtuse at the top, slightly contracted at the base, and strengthened by an inner calcareous rod of peculiar conformation, conical, not rising from the centre of its basal circlet, but almost directly from its very margin, and made up of numerous longitudinal, linear and straight fibres, with short transverse connecting processes, but becoming compact near the point, *fig. 129.* The central part of the disk is a cup, *fig. 127,* the margin of which sometimes is waved irregularly, sometimes formed into lobes closing over it. In Echinocardium cordatum, *Pl. XI, fig. 120—126,* it likewise bears a cuplike projection, the lips of which present various forms, depending on their different degree of contraction, but it is surrounded by a marginal, single row of numerous, even up to forty, unequal, slender and clavate filaments, each containing a straight or very slightly arcuated, needle-shaped rod, *fig. 121,* composed of a small number of calcareous fibres rising from the margin of the basal circlet of network, but soon contracting, becoming nodular, swelling again, and spiny near the top. Neither of these two species of Echinocardium presents any trace of a central network at the bottom of the cuplike projection. In Breynia Australasiæ LEACH, *Pl. XI, fig. 131,* the long and slender frontal pedicels, within the peripetalous and internal fasciola, are provided at their truncated, not disciferous ends, with a few marginal, very short, conical processes, evidently answering to the filaments of others, each supported by a strong and solid calcareous rod, with traces of reticular texture only at its base, and somewhat resembling the rods in Echinocardium flavescens.

The shafts of the pedicels are prolongations of the external tegument, each rising over a geminous pore. With the exception of the branchial pedicels, they are cylindrical tubes, flexible and extensible in an eminent degree. In Brissopsis lyrifera, *Pl. IX, fig. 90,* I found the wall to be made up of: an external layer, *a;* a thick layer, *b,* consisting of connective tissue and nervous elements, with imbedded pigment cells, red and yellow; a thin, homogeneous, transparent layer, *c,* in which the calcareous spicules are deposited; another, *d,* of delicate, transverse, muscular fibres, and, within that, a much stronger one, *e,* of longitudinal muscles; and, innermost, *f,* a rich plexus of multipolar nucleated cells, the true extension of which I could not make out at the time, and which seemed to occupy, to a great extent, the lumen of the tube. This structure was observed in the tubular shafts of the pedicels of the front ambulacrum, and it appeared to hold good in the others also.

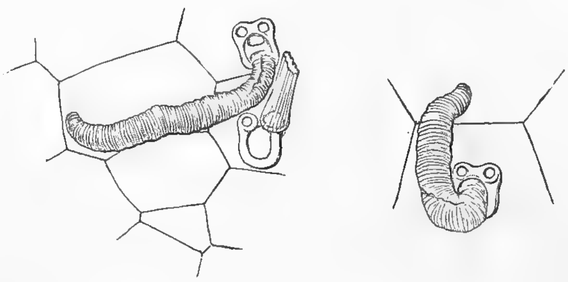
The transverse spicules of the homogeneous layer *c* are disposed into longitudinal rows. Generally they are the most minute of all the various calcified deposits, sometimes numerous, and then densely packed in the contracted state of the pedicel, in other instances rather scarce, even apparently wanting in the phyllodean pedicels, rarely so in the subanal, frontal or ventral. They are more or less arched, sometimes bent, as in Echinocardium cordatum, III, *Pl. XI, fig. 120;* slender, slightly fusiform, nearly smooth, as in Metalia, III, *Pl. X, 105;* Maretia, III, *104;* Palæotropus, subanal,

[1]) See above p. 43.

Pl. VIII, 73; very minute in Moira, ventral, *Pl. X, 110;* muricate, but rarely areolar, in Spatangus purpureus, III, *109;* Meoma, III, *Pl. VIII, 70;* Breynia, III, *Pl. XI, 131;* Brissopsis, ventral, *Pl. IX, 83;* Abatus, III, *Pl. X, 91;* Echinocardium, III, *Pl. XI, 123, 128.* All through the length of the tube they are generally of the same shape, but near the top they regularly all at once assume peculiar shapes, and combine in forming the foot-ring, *annulus*, *psellion*, under the terminal part. In some the elements of this ring are simply enlarged modifications of those of the shaft, presenting an annular complication of lengthened, arched, overlapping spicules, sometimes prickly, Brissus, *Pl. VIII, fig. 74,* sometimes outwardly almost smooth, inwardly spinous and emitting, at regular distances, strong spikes, Brissopsis *Pl. IX, 85,* or connected with centripetal spokes, as in Brissus, *Pl. VIII, 75,* or in the phyllodean pedicels of Maretia, *64, 78,* which are composed of series of irregular flakes. In others the ring consists of areolar prickly lamels, small in Spatangus, III, *Pl. X, 109,* in Lovenia, III, *107, 108,* larger, subtriangular, as in Echinocardium flavescens, III, *Pl. XI, 128,* phyllode, *130.* In others again, as in the subanals af Lovenia, *Pl. VIII, 76,* Abatus, *77,* in the frontals of Breynia, *XI, 131,* and in Rhynchopygus, *XI, 119,* the ring is formed by a single series of detached, irregularly rounded, areolar scales. Echinocardium cordatum in this regard deviates in a most extraordinary manner, not only from its congener E. flavescens, but from all the rest of Spatangidæ. The tubes of the phyllodean pedicels are devoid of spicules, and the ring is represented by a few small sigmoidal ones only; in the shafts of the subanals there is a single row of similar spicules, most of them rather broad in the middle and areolar, and the tubes of the pedicels of the III, within the fasciola, present two rows of similar small and slender, slightly muricate spicules. In the subanals, as well as in the frontals, there is no trace of a true ring, but close under the top one single spicule, or in some cases two spicules, suddenly become of an enormous size, *Pl. XI, fig. 120, 123,* lying across the tube, and even exceeding with their pointed ends the diameter of the crown of filaments, and sometimes simple, sometimes expanded in the middle, areolar and spinous, *fig. 122, 124, 125.* These gigantic spicules, larger generally in the frontal pedicels than in the subanal, are seen as well in the common European Echinocardium cordatum Penn. as in that called E. australe Gray. It is difficult to conceive their probable use, unless they may be some sort of stinging apparatus, a weapon added to the tactual and prehensile parts of the pedicel.

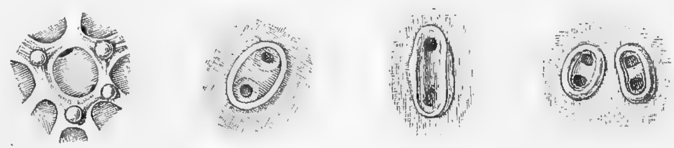
The diversities in form and in function exhibited by the pedicels are represented more or less distinctly by corresponding modifications of those special parts of the skeletal framework which surround the canals, by which they communicate with the ambulacral system in the interior. These parts were called cancelli by older authors; I shall venture to propose for them the appellation of peripodia.

It was, no doubt, a bright thought of J. A. Gyllenhahl, in those days, now more than a hundred years ago, to assimilate the »cancelli» of the »crystal apples» to those of recent Echini, and on that account to transfer their bearers to the animal kingdom, ranging them under the great natural genus Echinus, then recently instituted by Linnæus. And so close is in reality, on either side, the general conformity in structure of the geminous pores, as to cause the lineage of the Archæonomous Echinoidea to gravitate forcibly towards that group of antique Cystoidea of the Silurian era, different as these no doubt were in other respects, in the total absence, — at least in the adult, — of a calyx, and in the distribution of the pores all over the perisome. There seems also to be little reason for doubting the pedicellar character of the geminous pores in Sphæronis, Eucystis, Glyptosphæra, Protocrinus, Mesites, the less so since the want of a decisive proof in this regard is supplied, in some degree at least, by the occasional preservation of the actual pedicels in a contemporary form of Echinoids, Botryocidaris Pahleni FRED. SCHMIDT, of the older Silurian era. A specimen of this most remarkable type, for the inspection of which I have to thank the liberality of its learned author, distinctly shows, in several places, long cylindroid bodies, having one of their ends in close connection with an ambulacral, geminous pore, even so as to cover it, and for the rest of their length lying variously bent across the plates, with their free ends gradually tapering into rounded tips, and thus like the simple pedicels of one of our Echinoids. They even exhibit traces of having had their tubes strengthened by series of arcuated spicules.



Pedicels of Botryocidaris Pahleni FR. SCHMIDT.

The peripodia, so I venture to call them from analogy, of those archaic Cystoidea and of Botryocidaris, and, generally, of the Archæonomous Echinoidea, are built mainly upon the same model: a wall, more or less raised, incloses an elliptical or lengthened depression in which, in the great majority of forms, two nearly equal perforations open, placed on the longitudinal diameter and separated by a septum, or bridge, of varying breadth and form. In the genera of Cystoidea named above, their distribution is somewhat various. In Sphæronis and Eucystis the whole perisome is densely crowded with them, all or nearly all pointing adorally with their longer axis; in Protocrinus they are strewn less densely over the whole exterior, the grooves excepted, and point mainly in the direction of the mouth, still with a tendency to deviate; in Mesites they are confined to the perisome and variously divergent. In Botryocidaris they are confined to the ambulacra, and point all one way. This is also the case with the ambulacral peripodia in all the rest of the Echinoidea, the direction of their longer axis being towards the mouth, those of the branchial peripodia of the petala excepted, which normally are transverse.



Sphæronis pomum GYLL. Glyptosphæra Leuchtenbergi VOLB. Protocrinus fragum EICHW. Mesites Pusirefskii NIK.

Peripodia.

In *Pl. XII, fig. 132—149*, an attempt is made to give a general idea of some important modifications of the peripodia among the Neonomous Echinoidea. The series begins with the homoiopodous Echinoneus [1]), *fig. 132*, which, as in other parts besides, retains an Archæonomous character in the structure of its disciferous pedicels and their peripodia, very like those of an Echinus, geminous, with the pores nearly equal. In the Cassidulidæ, *fig. 133*, the new order has set in, the peripodia of the five petala being branchial, and very different from those of the phyllodes. In Cassidulus these last are deep, oval depressions, with the bottom sloping towards the adoral end, near which is the single perforation. In the Spatangidæ, including the Collyrites and Anancites, the phyllodean peripodia, by their superior size, gradually become more and more prominent, at the same time assuming a character of their own that corresponds to that of their pedicels specialised into organs of sense. They are shown in *fig. 134—148*, all IV *a 1*, ear-shaped expansions, contrasting with the rest of the surface by a compact and glossy texture, generally of an obovate outline, the longitudinal axis pointing adorally, and mostly towards the mesial suture of the ambulacrum. Within this expansion, the boundary line of which is slightly impressed, while its surface is in some forms convex, in others flat or even depressed, the perforations, as long as geminous, are placed on the longitudinal diameter, the adoral perforation, which is always present, mostly being the larger of the two, while the aboral has a tendency to abort. Thus it seems to be the rule, that in the early types, the Adete, Meridosternal [2]) forms, both perforations are maintained. In Holaster scaniensis Cotteau, *fig. 134*, they are separated by the highest part of the convex surface, and in Anancites ovata, *fig. 135*, minute, and kept apart by an ovoid protuberance, — and so it is in both the two peripodia of IV *a 1*. The distal peripodium of Hemipneustes, *fig. 136*, shows only a trace of the aboral perforation, while in the proximal it has disappeared. In Echinopatagus, *fig. 137*, one of the earliest of Amphisternal [3]) forms, the perforations of IV *a 1*, reduced in size, are geminous, the bridge being almost as in the Echini. Among the Prymnadetes the two perforations are maintained in Hemiaster, *fig. 138*, and in Faorina, *fig. 142*, in others the aboral perforation aborts. How this is done may be observed in Schizaster japonicus, *fig. 140*, or in Sch. Moseleyi. The aboral perforation contracts, and is moved towards the adoral, while the bridge gradually narrows, till at last it opens, and the two make one, the trace of the passage being overgrown with calcareous tissue. In fullgrown specimens of Schizaster fragilis there are still some geminous perforations left, in Sch. gibberulus and in Moira atropos they are all simple. So they are also in adult specimens of Agassizia and Desoria, while in Abatus Philippii a process obtains similar to that in Schizaster japonicus. Lastly, among the Prymnodesmians, the latest and the most advanced of Neonomous Echinoids, the geminous pore, strictly kept up even as far as from Melonites, and discarded in a few only of the Prymnadetes, their elders, is replaced, as it seems universally and normally, by a single perforation. So it is in Micraster, Brissopsis, *fig. 143*, Brissus *fig. 144*, Spatangus *fig. 145*, Lovenia *fig. 146*, Maretia *fig. 147*, Echinocardium, *fig. 148*, and in Meoma, Plagionotus, Breynia, Eupatagus. It is a change that implies a certain amount of modification in the vascular apparatus. —

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[1]) Études, pl. IX. [2]) Μερίς, piece. [3]) Αμφίςτερνος, with two breast plates.

Palæostoma mirabile, *fig. 139*, presents deeply sunk phyllodean peripodia, with the two perforations not separated, but united by an open slit. The specimen examined is, however, young and still retains this juvenile character, the pore being at first simple, not geminous. [1])

When the entire series of Adete, Prymnadete and Prymnodesmian Spatangidæ is viewed as a whole, the common characters of their phyllodean peripodia is apparent: their general form, their great size relatively to that of the other peripodia bearing tubular pedicels, the parallel direction of the two peripodia of the biporous plates, the gradually prevailing abortion of their aboral perforation. The similarity is in fact such as to justify the conclusion that the principal characteristic of the modern Spatangidæ, the penicillate phyllodean pedicels, was present already in the earliest Adete forms, in Collyrites, Holaster, Anancites, Hemipneustes, Cardiaster.

Where the penicillate pedicels are succeeded by the much smaller simple pedicels, the peripodia, again with geminous perforations, at once become very minute. In the Meridosternal Adetes, as in Collyrites, Anancites, Hemipneustes, they continue so in the five ambulacra all up to the petala, in Holaster and Cardiaster through the middle part of the front ambulacrum, and in the four paired ambulacra, I and V, II and IV, up to their petala, thus suggesting the probable absence, in these old types, of peculiar subanal pedicels. These appear in the Amphisternal Spatangidæ in I *a* and V *b*, supported by peripodia always larger than the corresponding in I *b* and V *a*, though in a various degree. Already in Echinopatagus, Hemiaster, and in Palæostoma, that of V *b* surpasses that of V *a*, and in the great majority of recent forms, Prymnadete as Prymnodesmian, the difference is more or less marked, *fig. 140—148*. But, as far as my present knowledge extends, the structural differences of the subanal pedicel, penicillate, semi-penicillate, or simple and devoid of filaments, are not distinctly associated with corresponding diversities in the peripodium. The penicillate subanal of Echinocardium is supported by a peripodium not very unlike that of the simple pedicel of Meoma, and the similarities or dissimilarities between the subanal peripodia of different genera appear to bear no very close relations to the resemblances or diversities between their pedicels. The like seems not far from being the case with those of the front ambulacrum. There is some resemblance between those of Hemiaster, *fig. 138*, and of Schizaster, *fig. 140*, — they are lengthened, narrow, and bridged over by a convex protuberance, — and that of Palæostoma, *fig. 139*, is not very different —, and these three genera have frontal pedicels with large radiating lamels in the disk; but the nearly similar frontal pedicels of Brissopsis, *fig. 143*, have very different peripodia. Those of the simple frontals in Spatangus, Maretia, Lovenia and Meoma are minute, those of the more complicated, as in Agassizia and others, are much larger.

In the greater number of Neonomous forms, Cassiduline and Spatangean, the pedicels of the dorsal portions of the ambulacra are transformed into but slightly extensible, generally triangular branchial leaflets. These portions of the ambulacra,

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[1]) Études, pl. XVII, fig. 151.

the petala, are in themselves uninterrupted, »open» continuations of the ambulacral series of plates, thus in Cassidulus, in the Adetes, in Spatangus, Micraster, Maretia, Echinocardium, Lovenia. When, in others, as in Agassizia, Meoma, Brissopsis, Kleinia, Brissus, Eupatagus, Plagionotus, Breynia, they are »closed» inferiorly, this is an accidental feature, the constriction being caused solely by the pressure exerted by the peripetalous fasciola. [1]) The petaline plates are longitudinally narrow, extended transversely, and the peripodium, generally placed towards the external margin, incloses with a narrow rim the always geminous, widely separated, transversely placed perforations, and unites them with a slender compressed ridge or with a furrow, a more or less distinct suture marking the junction of the margins from either side. Upon the whole a structure like this is found prevalent in the great majority of forms coming into view from the first appearance of the Cassidulidæ. But among the Spatangidæ their exists a group, of a few genera, differing widely enough in other respects, but held together by a common character, the absence of petala. They are Apetalous; whether Abranchian further researches will decide. Their ambulacra, instead of being, in their dorsal portions, deepened and crowded with compressed plates, in order to give room to numerous gill-leaflets, are all along even with the general surface, and only gradually contracting up to the top, and their plates, as high as they are broad, or nearly so, are regularly hexagonal, the pores being very minute, placed centrally or subcentrally, and the pedicels small and simple. These genera are Palæotropus, Argopatagus; Urechinus; Cystechinus; Genicopatagus; Aceste, Calymne, Aerope. They are all abyssal.

In the vast majority of Echinoidean forms, Arhæonomous and Neonomous, — and presumably in the whole of them, — it is seen that the adoral and inner perforation of the peripodium is prolonged into a short and narrow slit, cut through the wall, and that this slit widens below into a separate but smaller perforation. This is very distinctly seen in the Cidaridæ, Echinidæ, Echinoconidæ, Echinoneidæ, and, above all, in the phyllodean peripodia of the Spatangidæ. In those of the Cassidulidæ, as generally in the subanal and frontal, as well as petaline peripodia, it is less distinct, but mostly to be recognised as a minute notch in the wall. This is the particular little foramen that gives passage to the branch of the ambulacral nerve which is seen, on the inside of the plate, to enter the pore along with the vessel, and, as easily, on the outside, to emerge from it and distribute its branchlets, all through the connective tissue, to the external organs. [2])

Such is a sketch of the pedicels in the most prominent of Neonomous Echinoidea, as they are variously specialised in order to meet requirements more varied than those essential to the earlier types: developed into delicate organs of touch, or combining with tactual function that of prehension, modified for purposes still obscure, or evidently subservient to respiration. I have dwelt at some length on these diversities, with a view not only to add a few facts more to those known already, but mainly to

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[1]) Études p. 62. [2]) Ib., p. 8, pl. II, fig. 29, 30, 31.

bring out strongly the great contrast exhibited in this point by the Pourtalesiadæ. For while these, in other regards, have not a little in common with the Spatangidæ, and share a few features with the Cassidulidæ, they differ widely from either in being homoiopodous. Their pedicels are all simple, and differ in size only, the phyllodean and the upper frontal pedicels being larger than the rest, which are very minute, *Pl. IV, fig. 16, 21, 22; VI, 40, 41; VII, 50.* They all terminate in a rounded or slightly tumid top, which, in some states, is surrounded by a narrow circular brim, not unlike that of Rhynchopygus, *Pl. XI, fig. 118, 119.* The very dense pigment of their tissues so obscures its structure that I could not even make sure of the existence of calcareous spicules. The peripodia, *Pl. I, fig. 5, 6, 7; IV, 15, 24; V, 27, 29; VI, 44; VII, 47; XII, 149,* not unlike those of the Cassidulidæ, are sunk, and the two perforations confluent in the phyllodean and frontal ones, separated in the minute subanals of V *b*. In the ventral, subventral and lateral plates of the ambulacra the diminution of the peripodium relatively to the entire surface of the plate is carried to the extreme, it being hardly discernible over the greater part of the ambulacrum, and far inferior in size to the smallest of tubercles. The ambulacra are also all apetalous and perfectly even with the perisome, and all this, combining with peculiarities of the interradial areas described above, tends to soften down the elsewhere salient diversities of the two predominant systems, and to give to the whole surface of the skeleton the character of smoothness, which the Pourtalesiadæ have in common with their fellow-habitants of the great depths, the Apetalous Spatangidæ.

IV. THE CALYCINAL SYSTEM.

The homologies of the calycinal system in Crinoidea and Echinoidea. Tiarechinus. Salenia. Its modifications during geological development. Echinoconidæ. Spatangidæ. Its decay in the Pourtalesiadæ.

Years ago it occurred to me, as it had to others, that the general resemblance of the »apical» system in the Cidaridæ, Saleniadæ and Echinidæ, to the calyx of certain Crinoidea, might be a morphological fact of importance with regard to a true perception of the homologies of the skeletal constituents in the Echinoderms generally. For such is in reality the conformity between the respective parts of both structures, that, when once perceived, it must leave a strong impression of some hidden meaning well worth understanding, and often enough it may have called forth reflexions that far less often were recorded. Louis Agassiz [1]) once remarked, as of peculiar interest, »the correspondence between the development of the calcareous central network» of the disk in the young »Starfish and the stem of Pentacrinus»; the arrangement of the five plates »surrounding it and those alternating with them that will form the five

[1]) Twelve Lectures on comparative Embryology delivered before the Lowell Institute, in Boston, December and January 1848—49. Boston, Flanders & Co. 1849; p. 17, 22, 24, 25.

rays, and so on, with successive little plates in all the genera»; »the correspondence between the plates that protect the eyes in the Starfish and the smaller perforated plates of the upper disk of the Echini», as well as that between the »ovarial» plates of these and »the angles between the rays in the Starfish.» AUSTIN[1]) was of opinion that, in Cidaris, the ambulacra — in which he seems to have included the »ocellar» pieces — »terminate near the apex, which is composed of five plates, each of which has a central opening or ovarial aperture. These pieces united may be considered as the dorso-central plate, in the centre of which the vent is situated». He nowhere mentions the five genital plates of the Echinoids as collectively representing the dorso-central plate of Marsupites. ALEXANDER AGASSIZ,[2]) from his study of the »abactinal» system in the young Starfish, arrived at the conclusion that its central plate is a solidified homologue of the basal plates, and that the set of five plates in the angles corresponds to the interradial plates, and the arm-plates themselves to the radial plates of the Crinoid. BEYRICH[3]) considered the apical system, with regard merely to its position, as the analogon of the Crinoidean calyx. But in no instance the comparison was more than mentioned incidentally, well worthy as it seems to be of an examination in detail.

It was at a very remote geological period that the classes of the Echinoderms branched off from their ancestral trunk, at the same time inheriting in common certain important characteristics, the actual presence of which still holds together their diversified forms. Whenever, therefore, we are called upon to compare the leading features of one class to those of another, we do well to trace them back, as near as we can, to that common source, for, close as presumably were, at that starting point of diverging existence, their mutual resemblances, most of their members have ever since been going on modifying themselves, each in its own way, some by slow degrees, others rapidly, every time that a new branchlet of the group has been developed, and it has become a delicate task to parallel features that perhaps have been only slightly altered in some type of long-continued existence, with those deeply changed in another, and that, may be, within the course of a much shorter time.

Typically the »apical» system of the Echinoidea is a radiate structure composed of: a central pentagonal ossicle; contiguous to each of its five sides one of five other, hexagonal ossicles, forming a closed ring; and, in the outer angle between every two of these, one of a second, external, set of five pentagonal ossicles. This is the general formula, which in the Echinoidea has remained, more or less altered, but always recognisable, from Palæozoic to recent time. If we look for it in the Crinoidean calyx, we find it profoundly obscured in the Cenozoic forms, and discernible enough in the Mesozoic, but it is only when we approach the older Palæozoic time that forms come in sight by which we are led to expect to see it clearly expressed in some early genus, coeval in a certain degree with the oldest of the Echinoidea. It seemed to me that

[1]) Ann. Nat. Hist., 2:d Ser., VIII, 285, 288; 1855.

[2]) Proc. Am. Ac. Arts and Sc., 1863, Apr. 14. — Embryology of Starfish. Contributions to the Nat. Hist. United States, V, 1864, 50; Reprint 1877, 62.

[3]) Ueber die Basis der Crinoidea Brachiata, Monatsberichte Akad. Wiss. Berlin, Febr. 1871.

a near approach to a calyx of that simple description was to be seen in Cyathocrinus, and one of its species, Cyathocrinus (Poteriocrinus) geometricus GOLDF. was therefore selected to open a series of figures [1]) by which, — while leaving to others the more difficult task of unravelling the perplexedly diversified composition of the Crinoidean calyx, — I endeavoured to exhibit the homologies between the constituents of the calyx in that Palæocrinoid and those of the apical system in typical forms of Echinoidea. It then appeared that this system is not an assemblage of parts, each contrived for the special purpose of subserving the function of an internal organ, one as a temporary appendage of the excretory opening, another as an accessory of the system of aqueous circulation, others as bearers of the organs of vision, and others again as mere holders of the outlets of the sexual organs, but that, in reality, the apical system is by itself an independent whole, morphologically equivalent to each of the two other systems, the perisomatic and the ambulacral, constituted of three elements, intimately combined and normally disposed radiately in regard to its centre. And these elements, which are rarely seen simultaneously present in the adult, I ventured to point out as homologous: the central one to the whole of the pentagonal Basis (JOH. MÜLLER) of the Crinoidean calyx; the five ossicles of the proximal set called »genital» in the former, to the Parabasalia (JOH. MÜLLER) in the latter; and the five outermost ossicles in the Echinoid, usually termed »ocellar», to the Radialia (JOH. MÜLLER) of Cyathocrinus. [2]) And it was shown that the same homologies hold good in the Asteriadea.

If this view is well based, as I believe it is, it follows that a terminology has to be found, which may be applied equally in the different classes, and which designates homologous parts by identical appellations. Now, among the numerous denominations proposed by authors, three have been more widely used. The constituents of the calyx are termed

in CYATHOCRINUS: by

MILLER:	Pelvis.	Costalia.	Scapulæ.
JOH. MÜLLER:	Basis.	Parabasalia.	Radialia.
HERB. CARPENTER:	Infrabasalia.	Basalia.	Radialia;

in ECHINOIDEA: by

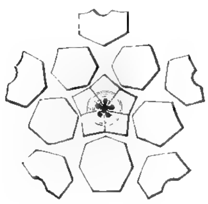
AUTHORS:	Central plate.	Genital plates.	Ocellar plates.

The position of the calycinal system, while basal in the Crinoidea, is culminating in the Echinoidea and the Asteriadea, and consequently any appellation involving the notion of a basal position must be avoided. On the other hand, the terms: genital and ocellar, besides being expressive of incidental relations peculiar to the Echinoidea and partly to the Asteriadea, cannot by any means be applied to the homologous parts in the Crinoid. For these reasons, and to avoid multiplying terms already too numerous, I proposed to retain the old name of costals MILLER — the quaint allusion it implies being long forgotten — for that of parabasals JOH. MÜLLER, and thus to define the calycinal system, or the calyx, in the Cyathocrinidæ, the Echinoidea and Asteriadea,

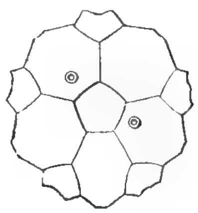
[1]) Études, p. 80. — [2]) Ueber den Bau des Pentacrinus, p. 31.

as typically composed of a *central* ossicle, five *costals*, and five *radials.* [1]) I shall make use of the same terms here, without fear of being misunderstood. When future science shall have lying before her, for comparison, numerous forms now undiscovered, and the perplexities of the present shall have cleared up, the final terminology will come of itself. [2])

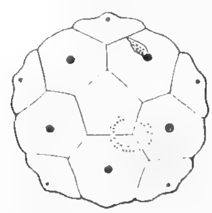
What the calyx is to the antique Crinoid, its homologon is not to the Echinoid, — its constituents were inherited morphologically, not their modes of subserviency to the physiological activities of the animal —; along with the enormous change in conditions of existence there have arisen essential alterations of the entire structure. In the Crinoid, as in the Echinoid, the calyx is normally opposite to the mouth. In the stalked Crinoid, which feeds by means of ciliary agency, the mouth is directed upwards, and the calyx, on the darkened side, is the fundamental support on which the body rests, permanently or temporarily, enclosed on all sides by its perisome, with its radiating grooves. In the Echinoid, when first seen by us already long since adapted to a free and ground-feeding life, with the mouth directed downwards, the calycinal system, permanently adnate, is carried uppermost, towards the light, on the top of the back, and there, covering probably the dorsal part of the perisome, nor-



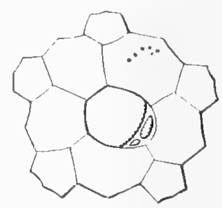
Cyathocrinus alutaceus ANG.



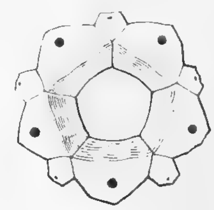
Tiarechinus princeps LAUBE.



Salenia sp.



Echinus sp. young.



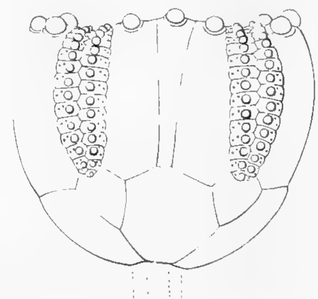
Cidaris Merceyi COTTEAU.

mally meets the ambulacra radiating from the mouth, at their growing extremities, but never lifts or supports them. [3]) In consequence of the thus inverted posture, the inner organs of the Echinoid are to a great extent transposed and brought into relations to the calycinal system widely contrasting with those existing in the Crinoid. Relatively to the other skeletal constituents the calyx holds its legitimate position, but under it, owing to altered conditions, an assemblage is brought together of organs of primary importance: those of vision, — apparently foreign to the Crinoidean type, at least not to be looked for in a homologous place —, those of generation, of aqueous circulation, and of excretion. And thus, in the Echinoid, the calycinal system is rendered, to no small extent, a disputed ground, each of these organs tending to penetrate its substance, and to gain access to the surrounding water.

Of all the Echinoidea at present known Tiarechinus has the most antique looking calycinal system, *Pl. XIII.* It is large enough to cover the greater part of the dorsal

[1]) Études p. 73.
[2]) It is well known that MILLER was inconsistent in the use of the term »costals», but it has always been considered allowable to suggest the use in a strict sense of a term elsewhere vaguely applied.
[3]) Études, l. c.

aspect, and distinct from the interradia by a faint linear impression, discernible in the largest of the specimens examined only; above it the calyx is slightly raised. The central ossicle, or what may have filled its place, is lost, and a nearly pentagonal open space is left in the centre, or rather anteriorly. The five costals are very large, the posterior one, 5, somewhat smaller than the others; they are all hexagonal, with the outward side slightly truncated for the reception of the narrow middle plate of the corresponding interradium. The costals 1 and 3 each bear a slightly tubular pore, apparently sexual, placed towards the inner margin. Water-pores were not to be found. The radials are pentagonal, each contiguous to the top of an ambulacrum; there is no trace of an ocular pore, if this be not marked by a slightly larger granule observable in two or three of them. The whole calyx is covered with a dense granulation similar to that of the interradia, but without any indication of linear arrangement. The whole, costals and radials, appears as if of one piece, the sutures being excessively fine, and to be elicited only by the treatment mentioned above. The relative magnitude of the entire system, the prominent share it takes among the constituents of the skeleton, the forms and proportions of its parts, are such as forcibly to recall the calyx of some Palæocrinoid, and to justify a desire to turn the Echinoid upside down and to see the calycinal system in its imaginary original position, when it formed a part of some remote ancestral type. In this aspect the resemblance becomes still more striking.



Tiarechinus princeps LAUBE, with the mouth upwards.

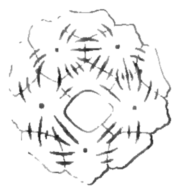
In the remarkable group of the Saleniadæ[1]) the three constituents of the calycinal system, the central pentagon, the costals, and the radials, are all simultaneously persistent in the adult. The madreporite, the sexual openings, and the organs of vision, are in possession of their respective ossicles. The system is generally seen to expand largely, covering a great extent of the dorsal surface, and to exhibit, in forms of Mesozoic existence, a highly elaborate sculpture, repeating almost every characteristic observed in the calyx of Crinoids of preceding, Palæozoic, ages, but apparently of none from later times, as though in token of a common descent, and a yet not very remote epoch of separation. The granulation seen in Acrosalenia, the deep impressions crossing the sutures in Peltastes, the strong straight ridges connecting the centres of the ossicles in Goniophorus, the impressed points at their sutures and angles in Salenia, often continued on either side into parallel lines, are features well known in the Palæocrinoidea and present also in the Cystoidea, but evanescent in the Crinoidea of Secondary and later ages.

In the oldest of the known genera, Acrosalenia[2]), the periproct at first but slightly touches the central disk or even fails to attain it. Placed closely within the posterior margin of the costal 5, its large aperture is widened lengthwise, sometimes leav-

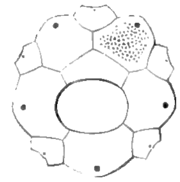
[1]) Études, p. 27, 70, 78, pl. XIX, fig. 177; XXI.

[2]) It is hardly necessary to mention that the figures here given are taken from the works of M. COTTEAU in the »Paléontologie Française» and elsewhere, all unsurpassed models of research and elucidation.

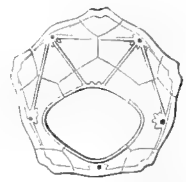
ing anteriorly a part of the costal irregularly fractured, while expanding it posteriorly beyond the other costals[1]). During the next periods the periproct, always placed on the antero-posterior axis and regularly transverse, in Peltastes, which appears in the



Peltastes Studeri
Colt. Cretac.

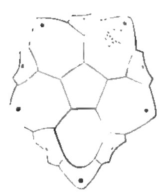


Pseudosalenia aspera
Et. Oolite.



Goniophorus lunulatus
Ag. Cretac.

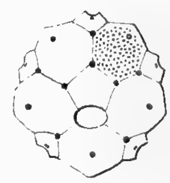
Salenia scutigora
Gr. Cretac.



Acrosalenia spinosa
Ag. Ool.

Acrosalenia angularis Cotta Oolite.

Acrosalenia patella
Des. Cretac.



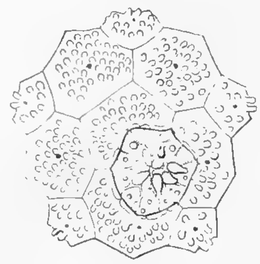
Peltastes Valleti
Des. Oolite.

Middle Oolite, affects slightly and equally the costals 1, 4, 5, and the central disk, while in Pseudosalenia, of the same time, it erodes it deeply, permitting the costal 5 to resume nearly its normal shape. In Goniophorus, of the Middle Cretaceous time, it expands so as to take in great parts of the surroundings. In Salenia proper, which may be followed from early Cretaceous time up to the present period, and in Heterosalenia of the later Cretaceous, the periproct is for the greater part cut out from the costals 1 and 5, and thus, while slightly entering upon the central disk, is drawn over to the right, on the axis 1—3, thus conforming to the rule now prevalent in the majority of the Echinidæ and, partly at least, among the Asteriadea, of having the excretory opening placed excentrically, to the right of the antero-posterior axis. In view af these marks of a gradual advance, in the Saleniadæ, during their geological development, of the periproct, from the hindmost limits of the calycinal system to near its centre, there is some reason for inferring the probable existence, at a remote period, of Exocyclic Salenian forms combining a calycinal system of a nearly intact Crinoidean character with a periproct placed in the interradium of the bivium, perhaps even towards its ventral surface[2])

Be this as it may, in all the known Echinidæ, the Saleniadæ not excepted, in the earliest forms as in those of the present era, the periproct is endocyclic. In one of the oldest groups, the Cidaridæ, the Crinoidean character of the calyx is still strongly

[1]) Compare Acrosalenia miranda Gauthier, Échin. foss. de l'Algérie, II, p. 86, pl. XX, fig. 109, 110.
[2]) The little known Upper Silurian Cystocidaris Zitt. (Echinocystites Wyv. Th.) is described as having the periproct interradial.

marked. One, however, of its three constituent elements is no longer persistent in the adult; the central disk is substituted by a pliant membrane paved with numerous minute ossicles, in the centre of which is the excretory opening. In this strictly orthoproctic group the outline of this membrane still remains pentagonal, as determined by the rectilinear margins of the costals, while in most of the Echinidæ the partial resorption of these margins, combined with the excentric position of the excretory opening, tends to conceal, in no small degree, the original existence of a central disk. Now we know, however, that in the calyx of the Echinidæ, and most probably also in that of the Cidaridæ, during the transitory astomous and aproctic stage of the very young animal, the central disk exists in its legitimate position relatively to the other constituents of the system, but only for a short time, and soon to be resorbed, in part at least, upon which its place is filled by the anal membrane. Its structural and morphological identity with the central disk of the Saleniadæ cannot be doubted, and, like that, it is not in the remotest manner referable, morphologically or physiologically, under the appellation of an anal or subanal supplementary plate, to the digestive apparatus, indeed no more so than, in the Saleniadæ, the portion of the respective costals, which necessarily has been removed in behalf of the formation of the periproct, and in like manner replaced by an anal membrane, which thus coexists with the nearly intact central disk. The difference is, that, in the Cidaridæ and the Echinidæ, unlike what takes place in all the Saleniadæ, the excretory opening breaks out, not wholly or partially outside the central disk, but from under it, and thus induces its destruction as such. The anal membrane supplying its place may possibly be a dependency of the perisome.



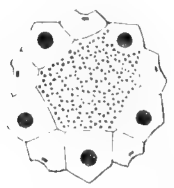
Salenia hastigera AL. AG.
Calycinal system.

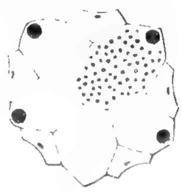
As long as the excretory opening continues endocyclic, a certain degree of stability maintains in the disposition of the calycinal system. Costals and radials are constantly present in the normal number of five, and distinct sutures mark their mutual limits. The water-pores penetrate the costal 2 alone and very rarely exceed it, the sexual organs open regularly by a pore in each costal, and there is an orbit, simple or double, in every radial. It is evident that the internal organs, in sharing among themselves the constituents of the calycinal system, balance each other in an equal manner. In the Cidaridæ and the whole numerous group of Echinidæ it has continued so to the present day.

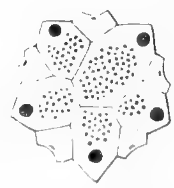
But this state of stability in the calycinal system is broken, as soon as one or the other of the organs it covers begins to move[1]). The excretory opening is the first to alter its position, it is followed by the madreporite and the sexual pores, but the eyes remain stationary. Already in the time of the Lias there existed, at the side of Cidaridæ, Echinidæ and Saleniadæ, the group of the Echinoconidæ[2]), true Gnatho-

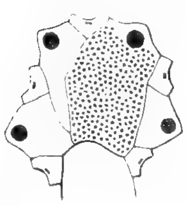
[1]) Études, p. 76.
[2]) Ib., p. 79.

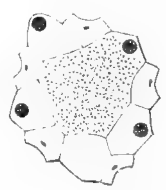
stomous Echinids, — with the ambulacra all alike, and the peristome, central and circular, presenting five pairs of branchial indentations, — but exocyclic, the periproct having passed from its old site at the centre of the system, into the odd interradium. In consequence of this movement the costal 5 had been destroyed, but in the course of time is regenerated, and even its sexual pore returns, all nearly according as the periproct becomes more distant, and has been so for any length of time. Thus in the oldest, Pygaster, with the periproct sub-calycinal, the 5 is completely wanting; in Pileus, of the Middle Oolite, the periproct is dorsal, submarginal, and the costal 5 is restored, but destitute of sexual pore; in the Oolitic species of Holectypus, with the periproct marginal or ventral, it is present, but imperforate, whereas in the Cretaceous, in which the excretory opening is ventral and farther distant from the calyx, the sexual pore exists, and thus the system has once more become normal. In Discoidea, of Cretaceous origin, the periproct is ventral and the costal 5 present, imperforate in the lower beds, perforate in the Turonian; in Echinoconus and Anorthopygus the vent is posterior, subventral, and the costal 5 present, but without a pore.

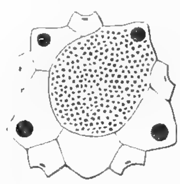

Holectypus macropygus DES. Cretac.


Discoidea conica DES. Cretac. Alb.


Discoidea infera. DES. Cretac. Turon

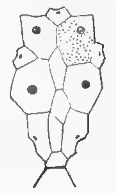

Pygaster umbella L. AG. Ool. Oxford et Corall.

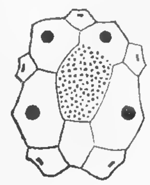

Pileus hemisphæricus DES. Ool. Corall.


Holectypus depressus DES. Ool. Bajoc.

In like manner, among the Ateleostomes, where the excretory opening can be said to have just left the calyx, as in the old Echinoneid genera Galeropygus and Hyboclypus, in the Oolitic Pyrinæ, the central part is irregularly broken up, or compressed; in forms of later appearance it aborts, and the four paired costals and the radials I and V close from either side. In Clypeus, the oldest of Cassidulidæ, the gap left by the retreating periproct is filled by an extraordinary prolongation of the almost always contiguous radials I and V, and there is hardly a trace of the costal 5; when the vent is removed farther back, these radials are again normal. Thus these three groups on their first appearance present distinct marks of the passage of the vent out of the limits of the calyx, and, while in their further development it continues its receding movement, the damage it has caused is at least partly repaired.

Future research will perhaps afford evidence that the filtering apparatus of the aqueous system primordially had its legitimate site in the central disk, and that it was displaced forward through the pressure exerted by the periproct advancing from the posterior interradium. Be this as it may, certain it is that, in the Mesozoic period, the movement, in the opposite direction, of the excretory opening was followed by the beginning of a retrograde movement of the madreporic filter. As early as in Pygaster, the oldest of Exocyclic Gnathostomes, it is seen to have entered the central part of the calycinal system, effacing the suture which limits the costal 2, and such is its condition in all known Echinoconidæ[1]), except that in Discoidea it is seen to spread to all the five costals[2]). When the Ateleostomata make their first appearance, as Echinoneids, the madreporite is restricted to the costal 2; it is more expanded centrally in the Cretaceous Pyrinæ than in the Oolitic; in the recent Echinoneus[3]) it is central, and the sutures effaced. In some few of the oldest of Cassidulidæ, in which the centre is fractured into irregular detached pieces, it is limited to the costal 2; in the great majority of species it occupies the centre, expanding it largely. In the recent Cassidulus all the sutures are obliterated.


Pyrina Guerangeri Cott. Oolite. Bajoc.


Pyrina Durandi P. & G. Cretac. Turon.

The growing deviation from the original Gnathostomous type reaches its highest point in the Spatangidæ. Introduced by the Collyrites, of Oolitic existence, they make their appearance early in Cretaceous time as Holastridæ. Deeply contrasting with the Orthoproctic plan of construction: the circular ambitus; the central and circular peristome not modified during growth, and formed out of ambulacral and interradial plates of both series, at equal parts in either; the seemingly radiate disposition of the areas, ambulacral and interradial; the specious homocentricity of the spines; the general uniformity of the pedicels, only exceptionally or in part branchial; — all features present already in the ancient Cidaridæ, consistently maintained up to the present era by them and by numerous Echinidæ, and but slightly, if at all, modified in a few forms[4])—, the evolution of the Spatangidæ is pervaded by an increased and largely diversified tendency towards the differentiation of the skeletal elements into modifications unseen before, only in part begun by the Echinoneidæ and the Cassidulidæ. The gradual lengthening of the whole framework, the forward movement of the trivium, the increasing growth and differentiation of the abdomen and of the bivium, more and more overcome the inherited globosity; the alimentary canal extends horizontally, its œsophageal opening advancing, while the excretory aperture retrogrades; the bilateral symmetry becomes apparent, betraying a dawning approximation towards a vermiform disposition; the trivium and the bivium are more distinctly constituted: in the former the ambulacrum III is specialised as the front ambulacrum, and provided with pedicels of a peculiar structure, in the later genera at least not subservient to respiration, while the II and IV are paired and made counterparts in outline, though still unsymmetrical with regard to their constituent plates, and the I and V are made symmetrical inwardly as well as in their outlines; the peristome, consisting of biseriate ambulacrals and single interradials, is originally pentagonal, but nearly always becomes modified during growth; of the perisome, the four lateral interradial areas are distinctly disposed into two pairs, the symmetry of the anterior pair, 2 and 3, being perfect, while that of the posterior, 1 and 4, is qualified, in 1 *a*, or in 1 *a* and 1 *b*, by an heteronomous disposition un-

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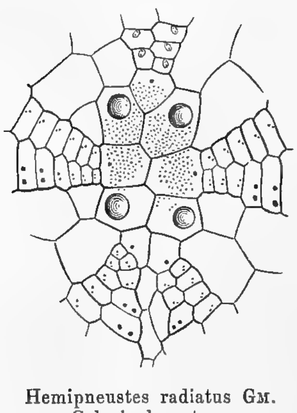
[1]) See woodcut on the preceding page. [2]) Études, p. 81, pl. XV, fig. 133. [3]) Ib. pl. XV, fig. 131. [4]) Ib. p. 26, pl. XVIII, fig. 153—158.

known in the whole of the Gnathostomata as well as in the older Ateleostomata, obscurely marked in the Holastridæ, manifest in the true Spatangi; the odd interradium, 5, at first, in the Holastridæ, nearly similar to the other four, has its ventral plates separate, transversely triangular: Meridosterni, but later, in the higher genera, formed into two large collateral sternal plates: Amphisterni; the fasciolæ, a feature unseen before: Adeti, at first are vaguely extant: Prymnadeti, or marginal alone, then the peripetalous fasciola is added, till, towards the end of the Cretaceous period, the subanal appears: Prymnodesmii, in the higher Spatangidæ always traversing adorally the sixth plate of I *a* and V *b*, and marking off the first five plates as ventral, the following as abdominal and dorsal; the spines are bristle-like, generally curved, tending backward, where not otherwise directed by the fascioles; the pedicels, which in Echinoneus are disciferous and similar to those of the Endocyclic Gnathostomes, and homotypic all over, in Cassidulus simple, in the petals only modified into branchials, attain in the Spatangidæ their highest development as diversely adapted organs, those of the phyllodes penicillate, the subanal mostly sub-penicillate, the lateral simple, the frontal variously constructed, and those of the petals, where these exist, branchial.

While these and other changes are successively introduced in the structure of the Spatangidæ, the two main constituents of their skeleton, the interradial system and the ambulacral, hold their own, and keep up their relative parts in the evolutional labour, their elements gradually assuming novel and almost refined forms [1]). It is not so with the third constituent, the calycinal system.


Hemipneustes radiatus GM.
Calycinal system.

When the Collyrites appear, the first of the Spatangidæ, and after them the Holastridæ, the excretory opening is posterior and distant, and the calycinal system in the condition presented by some Echinoneidæ of the Oolitic period, as *e. g.* by Hyboclypus. It is generally more or less lengthened, and the only trace of the passage of the periproct is the total suppression of the central disk and the costal 5. In this state it remains in the Adete, Meridosternate forms: Anancites [2]) Offaster, Holaster, Cardiaster, Hemipneustes, introduced at the beginning of the Cretaceous period and continued into the Eocene; it is still seen, in the seas of the present time, at great depths, in the Adete Cystechinus AL. AG., and in Urechinus AL. AG., *Pl. XXI, fig. 239—242*, which is said to be provided with a subanal fasciola. It is shortened, but tightly closed by the contiguity of the costals 1 and 4, in the forms with a true, but yet imperfectly developed sternum: Toxaster, Heteraster and Enallaster; it is short and subcircular, closed behind by the costals 1 and 4

[1]) Observe the contrast between the plain and rigid angularity of the plates in Micraster, Études, pl. XXXIII, of Cretaceous existence, and the freedom of outline, even elegance, observable in corresponding parts in later Prymnodesmian types, Tertiary and recent, such as Echinocardium, pl. XXXIX; Plagionotus, pl. XL, Breynia, pl. XLI, Maretia, pl. XLII, Lovenia, pl. XLIII. The contrast is less striking between Hemiaster and the later Prymnadetes, ib. pl. XXVI—XXXII, fig. 197.

[2]) Études, pl. XI, fig. 96, 97, 98.

and the radials I and V, in the old subglobose forms with a normally constructed sternum: Epiaster, Isaster, and the typical species of the abundantly developed Hemiaster, *Pl. XVIII, fig. 221, 222,* while in other species[1]), from the middle Cretaceous era, it is closed also, but solely by the radials I and V, the costals 1 and 4 having separated, in this respect like the calyx of Micraster[2]), the first of Prymnodesmians, continuing from the middle Cretaceous into the Tertiary period. In all these forms the madreporite is strictly confined to the right anterior costal, 2. They may be conveniently comprised under the common name of Ethmophracti[3]). But, of them all, as far as our knowledge extends, no generic type has survived up to the present time save Hemiaster, while the abyssal depths contain some genera of Ethmophracts, as Calymne, Urechinus and Cystechinus, that more or less recall those ancient forms.

For in the latter half of the Cretaceous era an important change took place in the structure of the calycinal system of the Spatangidæ. It has been seen that, when, in the Echinoconidæ, the periproct had retreated far back from the calyx, the costal 5, which had been suppressed, was reinstated again, and that the normal condition returned even so far as to allow the efferent duct of the corresponding sexual gland to perforate it. In a similar manner also among the Spatangidæ, the central disk and the costal 5 make their reappearance, the former separating the costals 1 and 4, the latter disjoining the radials I and V, but never receiving a sexual pore. At the same time the madreporic filter, no more held back by the excretory apparatus, but free to move and expand, spreads its pores, as formerly in the Cassidulidæ, into the now extended space of the central disk, and from thence into the costal 5. The Spatangidæ provided with a calyx of this description may be distinguished as Ethmolysii[4]). The madreporite, while it penetrates the substance of the costal 2, the central ossicle and the costal 5, obliterates the sutures which separated them, as it did the suture between the 2 and the central in the Echinoconidæ, Echinoneidæ and Cassidulidæ, and those three ossicles, so strictly kept apart in the Endocyclic forms, are here united into one unbroken area, contiguous anteriorly to the interradium 2, and posteriorly to the interradium 5. It will appear that Linthia and Schizaster[5]) from the middle Cretaceous time to our time, Prenaster from the end of the Cretaceous period and far into the Eocene, Macropneustes in the Eocene, were the first in which this change took place, and associated with them may perhaps be found some species rightly belonging to Abatus[6]), *Pl. XVIII, fig. 220.* In three of these oldest genera of the Spatangidæ Ethmolysii: Schizaster[7]), Prenaster, Macropneustes, the costal 5 is not extended far beyond the posterior limits of the system, and in Schizaster the madreporite takes its due by more or less crowding with its pores the costal 2, so as to cause the abortion of the efferent

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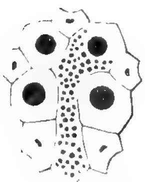
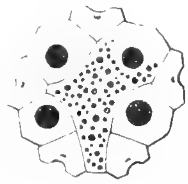
[1]) Mainly, or wholly?, algerian. See COTTEAU, PERON et GAUTHIER, Échinides fossiles de l'Algérie. IV, Cenomanien, VI: Turonien.
[2]) Études, Pl. XI, fig. 95.
[3]) Ἠθμός, filter; φρακτός, fenced.
[4]) Λύσιος, deliverer.
[5]) Schizaster antiquus COTTEAU, Bull. Soc. Géol. VI, 567.
[6]) Compare Abatus Philippii, Études, pl. XI, fig. 99.
[7]) Schizaster fragilis, Ib., pl. XII, fig. 102.

duct of the corresponding sexual gland. In Prenaster and Macropneustes, the next, it will appear, to assume the modified structure of the calycinal system, the costal 5 also keeps within its precincts, while the reduced press of the filter on the costal 2 admits of the normal presence of its sexual pore. But in the great number of genera of later appearance, while this pore is constantly maintained, the cluster of water-pores is seen to have withdrawn from this costal and to have retreated backward, expanding the combined area of the central ossicle and the costal 5, which thus are made to form a prolongation reaching beyond the posterior limits of the calycinal system and far into the interradium 5 [1]). This is the case in the great majority of recent Spatangidæ: Faorina, Agassizia among the Pymnadetes, Brissus, Metalia, Rhinobrissus, Cionobrissus, Meoma, Spatangus, Homolampas, Palæopneustes, Brissopsis, Kleinia, Echinocardium, Plagionotus, Breynia, Maretia, Lovenia, Eupatagus, among the Prymnodesmians.



Macropneustes Pellati COTTEAU.



Prenaster Jutieri DESOR.

The diversity between the calycinal system of the Ethmophracti and that of the Ethmolysii, striking as it is, has nevertheless been overlooked. As long ago as in 1845 PHILIPPI described and figured three species of Spatangus from the antarctic sea of South America, and proposed for their reception a new subgenus: Tripylus, principally characterised by possessing only three sexual openings. He named them Tripylus excavatus, Tr. cavernosus, and Tr. australis. The first was referred by L. AGASSIZ to Agassizia VAL., while TROSCHEL, who examined the original specimens of all three, made it the type of a new genus: Hamaxitus, and GRAY and AL. AGASSIZ retained for it the primitive appellation : Tripylus. For the two other, Tr. cavernosus PHIL. and Tr. australis PHIL., placed by L. AGASSIZ in Brissopsis, by GRAY in Faorina, TROSCHEL created a new genus: Abatus [2]), remarking at the same time, that if only one species had come under

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[1]) Études p. 12, Pl. XII, fig. 100, 101, Brissopsis; 106, Meoma; 107, Echinocardium.

[2]) The following is the nomenclatural history of the species of

Abatus TROSCHEL.

Wiegmanns Archiv. XVII, (1851), 72.

1. Abatus cavernosus PHILIPPI.

1845.	Tripylus cavernosus PHIL.	Wgm.	Arch. XI, 345, t. XI, f. 2.
	Brissopsis » »	1847.	AGASS. & DES. Cat. R., Ann. Sc. Nat., 3:e Sér., VIII, 15, sep., 121.
	Faorina » »	1851.	GRAY, An. Nat. Hist., 2:d ser, VII, 132.
		1855.	GRAY, Cat. rec. Ech. Br. Mus., 57.
	Hemiaster » »	1872.	AL. AGASSIZ, Rev. Echin., 132, 587, t. XXI *c*, f. 1, 2.
		1876.	AL. AGASSIZ, Proc. Am. Ac. Arts a. Sc. Boston, XI, 231.
		1879.	EDG. A. SMITH, Phil. Trans., Vol. 168, 271.
		1880.	STUDER, Zoolog. Anzeiger, 544.
		1880.	STUDER, Mon. Ber. Berl. Akad. 881.
		1881.	AL. AGASSIZ, Rep. Chall. Echinoidea, 179, pl. 20, *a*.
1845.	Tripylus australis PHIL.	l. c.	347, T. XI, f. 3.
	Brissopsis » ›	1847.	AGASS. et DES., Cat. R. l. c.
	Faorina » »	1855.	GRAY, Cat. Br. Mus., 57.
	Hemiaster » »	1872.	AL. AGASSIZ, Rev. 132, 586, pl. XXI *c*, f. 3.

his notice, he doubtless would have referred it to Hemiaster DES. This became also the view taken by AL. AGASSIZ, and since 1872 every author who mentioned these two species, treated them as living representatives of that genus, thus associating them with a host of long known fossil forms that once peopled the seas of the Cretaceous and Tertiary periods, and with their more lately added recent congeners, Hemiaster expergitus LOV.[1]), discovered by SMITT and LJUNGMAN during the cruize of the Josephine in 1869, H. gibbosus AL. AG. and H. zonatus AL. AG., both dredged by the Challenger Expedition[2]). Now these three species of the existing seas are true Hemiasters fully sharing the well-known characteristics of that highly natural genus, the subglobose form, elevated in its posterior region, a calyx of four costals, the madreporite confined to the costal 2, the 4 and 1 and the radials I and V closing from either side, in strict accordance with the mode of conformation universally prevalent within the calycinal system during the older Mesozoic period. These species are, as it were, apparitions from a former world, relics surviving from an evolutional stage long passed through, and very different from the altogether modern Abatus, with its moderately convex test, its calyx with five costals, the 5 being reproduced between the radials I and V and bearing the madreporic filter, thus set free, on its unimpeded retrograde movement. An extraneous form like this[3]), if suffered to remain in the otherwise homogeneous group of true Hemiasters, is sure to vitiate its integrity, and the mixed assemblage thus set up for a natural genus, if taken on trust, cannot fail to mislead when the question is to trace out comparatively its former geological and actual geographical distribution. The few survivors hitherto found of the once numerous genus Hemiaster inhabit temperate and tropical parts of the Atlantic and Pacific oceans, the Caribbean and Brazilian Seas, through that of the Azores towards Madeira and the Iberian peninsula, the Sea of Japan and that between New-Guinea and Australia. Abatus, on the other hand, is an antarctic form.

1851. Faorina antarctica GRAY, Ann. Nat. Hist. l. c. 132.
1855. GRAY, Cat. Br. Mus., 57.
1876. Hemiaster cordatus VERRILL Bull. Un. St. Nat. Mus. Washington, N:r 3, 68.
Hemiaster sp. 1876. WYV. THOMSON, Journ. Linn. Soc. XIII, 67.
1877. Hemiaster Philippii »GRAY», WYV. THOMSON, Voy. Challenger, II, 227.

Obs. Abatus cavernosus PHIL. appears to be the female, Ab. australis the male. GRAY remarks, Cat. Br. Mus. 57, that the three, Faorina antarctica, cavernosa and australis, perhaps are only one species. Tripylus Philippii GRAY is generically different, probably an Agassizia, as also Tr. excavatus PHIL.

2. Abatus Philippii LOVÉN.

1871. Abatus Philippii LOVÉN, Öfversigt af K. Vet.-Akad. Förhandl. N:r 8, 1065, 1070.
1874. LOVÉN, Études s. les Échinoïdées, pl. XI, fig. 99; pl. XXIX, f. 188—190.
Hemiaster » » 1873. AL. AGASSIZ, Bull. Mus. Comp. Zool. III, n:o 8, 189.
1874. AL. AGASSIZ, Zool. Results Hasler Exp. I, 20.

Obs. The synonymy is doubtful, because the sexual pores are said to be »two or three», and »if a third exists it is the right anterior one, usually, but sometimes the left».

[1]) Études, p. 13, pl. XIII, fig. 114—120.
[2]) Rep. Chall. Ech., p. 184, pl. XX, fig. 1—16.
[3]) Another stranger is Hemiaster elongatus of Indian Tertiarics. It is a Palæostoma.

A due attention paid to the development of parts during the growth of the individual animal has more than once reconciled discrepancies as great as that of the calycinal system in the Ethmophracti and the Ethmolysii, the Mesozoic type and the Cenozoic.

In the young of Abatus cavernosus, *Pl. XIV, fig. 164, 164 A*, the calycinal system, relatively large, presents five radials I, II, III, IV, V, each bearing a tentacle, and four costals, 1, 2, 3, 4, among which the 2 has become already the site of the madreporite. The central and open part is overlaid, within the general envelope, by a membrane in which are seen detached minute calcified laminæ, presumably rudiments of the central ossicle and the costal 5, nowhere extant among the Ethmophracti, but here to be developed, *Pl. XVIII, fig. 220*, after the backward passage of the excretory end of the alimentary tube.

Young Spatangi, with the mouth and the vent opened, and living free on the bottom of the sea, very early present a calycinal system completed by the presence of the central disk and the costal 5. Different stages of Echinocardium flavescens O. F. Müller, Spatangus purpureus O. F. M., and Brissopsis lyrifera Forbes, *Pl. XVII, XVIII, XIX*, may serve as examples showing the development of the calycinal system and the movement of the madreporic apparatus in the Spatangidæ Ethmolysii. Of the first-named the calycinal system is represented *Pl. XVII, fig. 197—207*, as it appears in specimens of different dimensions, from mm. 3,5 : 3 to mm. 36 : 32. In the youngest the five radials are present with their ocular pores. The whole system, up to the individual size of mm. 30 : 26, is more or less distinctly pentagonal. The central ossicle together with costals 2, 3, 5 are united into one continuous middle area, extending through the whole length of the system, with the radial III in front, the radials IV and V and costal 4 on the left, and radials I and II together with costal 1 on the right. At first, *fig. 197, 198*, the madreporite is a single pore placed nearly in front, then there are two or three pores, *fig. 199—205*, of which the last added is more towards the middle; in a specimen of mm. 14,5 : 12, *fig. 205*, out of five pores two are posterior. Meanwhile the costals, at the total size of mm. 10,5 : 9 and mm. 12 : 10, *fig. 203, 204*, have been provided with sexual pores, at first so minute as easily to be taken for madreporic pores, but becoming larger according as the reproductive organs are developed. At mm. 30 : 26, *fig. 206*, the swarm of madreporic pores lies more than half behind the middle, and at mm. 36 : 32, *fig. 207*, nearly the whole of it behind the costals 1 and 4, and the costal 5 has been driven backward into the interradium 5; but still its intact margin is seen to limit the pressure of the pores. And during this transference, in this species as in those next to be described, the middle part, expanded as long as occupied by the growing madreporite, contracts again when it has passed, yielding to the pressure exerted by the interradia.

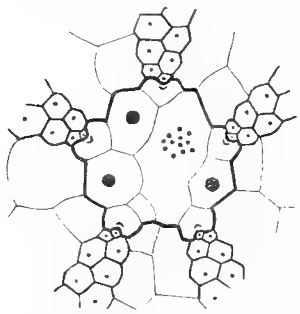
A series of young stages of Spatangus purpureus O. F. M., from mm. 5 : 4 to mm. 24 : 21, presents similar modifications, *Pl. XVIII, fig. 209—219*. There is the same drawing together of the sexual openings and narrowing of the middle area, after the recession of the madreporic filter, which is richer in pores than that of Echinocardium, and much more expansive, so much so as largely to invade, at mm. 53 : 50, the costals 1 and 4, to fill to the very brim the costal 5, stretching it to the utmost and leaving no trace of an intact margin, and even to detach one or other of its pores to the further side, into the interradial area 5, *fig. 219.*

The presence, outside the costal 5 and within the corresponding interradium, of a single pore of the madreporic filter, at first seems nothing more than an accidental anomaly. On a closer inspection, however, it looks otherwise. In a specimen of Brissus canariensis HÆCKEL *ms.* I observe a dense group of six pores within the interradium 5, on the left from the costal, and a set of specimens just at hand of Brissopsis lyrifera presents not a few cases of the same disposition, *Pl. XIX, fig. 223—231.* In the adults of this well-known species the sexual apertures are normally four, and one of them is in the costal 2. In a specimen of mm. 9 : 7, *fig. 223*, the system is made up of the five radials, the costals 1, 3, 4 distinguished by definite sutures, and the costals 2 and 5 together with the central ossicle united into one piece, the madreporic filter here as elsewhere effacing the sutures. Only one minute pore is to be seen, in the direction of costal 2. Next, in a specimen of mm. 11 : 9, *fig. 224*, one more has been added, in the central part; in specimens of mm. 15 : 12, 15 : 13, 16 : 13, *fig. 225—227*, their number increases, occupying the centre and the costal 5. Then, while the central part contracts, the filter, always increasing the number of its pores, expands, and forces the costal 5 backward, beyond the limits of the system [1]). And while it thus takes more room, as the animal grows, it is sometimes seen to prevent the sexual organs from opening in the costal 2, *fig. 229*, sometimes to expand in 1 outside its sexual pore, *fig. 230*, or sometimes to migrate, in no small number, across the limits of the system and into the interradium 5, *fig. 228*, partly even into the ambulacrum I *fig. 231.* In a hundred specimens of Brissopsis lyrifera taken at random, all from one locality, I find ten presenting this anomalous disposition, the expelled pores being in most cases on the right side, in the *b* series of the interradium.

Thus the movement of the madreporic filter, the starting point and the terminus of which have marked different geological epochs, is seen to take place in the living animal within the brief space of a transitory stage of its development. In the adult of Hemiaster and of all the other Spatangidæ of early Mesozoic origin, the calyx presents a structure essentially different from that of the calyx in the adult of a Spatangus, or of any other form, of later or recent appearance, and very rarely a link of connection is found between the two. But in the last-named of these groups an evolutional process actually takes place, showing us how, in the individual, the calyx passes from the one state into the other, and permitting us, however vaguely, to surmise the nature of the modifications by means of which the same change may have been brought about in the species, and the Ethmolysii made to take the place of the Ethmophracti. The contending activities of the internal organs, of sensation, generation and circulation, which, after the removal of the excretory opening, in the earliest Spatangidæ still for a time combined to render permanent the site of the madreporite in the costal 2, and to hold back the restoration of the central disk and the costal 5, entered into a period of alterations that by degrees induced the setting free

[1]) Études, p. 12, pl. XII, fig. 100, 101.

of the regenerative energy of these long suppressed parts, and, in obedience to the predominant tendency of abdominal growth, prepared the recession, by the way thus laid open, of the perforating agency of the madreporitic tubuli. Accompanied by correlative changes in other parts; transmitted, with tendencies enforced, from generation to generation, from embryo to embryo, and resuming innumerable times its plastic work, this evolutional process, simultaneously operating in a number of individuals, always at an early stage never found fossil, resulted in the location of the madreporite in the restored costal 5 of the adult. Then a period of rest followed in the calycinal system, during which innumerable specimens were preserved recording the transformation, which thus may seem to have been accomplished in a relatively short space of geological time, and, as it now appears to us, suddenly. The seas of the present era harbour at least one transitional form, the antique looking Genicopatagus affinis Al. Ag., in which the central disk and the costal 5 are reinstated, separating the I and V, and preparing the way for the madreporite, which still however remains in the aporous costal 2. It is an abyssal form, and such are probably all the recent Ethmophracti, while the Ethmolysii, which have but few representatives in the great depths, are littoral animals κατ' ἐξοχήν. It is among these that the madreporite, after a period of rest, in our days seems to show signs of once more moving, and of transgressing its latest line of demarcation.



Genicopatagus affinis Al. Ag., Calycinal System.

Further research, extending over a large number of specimens of these and other species, from different localities, will decide whether there be valid reasons for regarding this regression of the filtering apparatus beyond its old boundary as an evolutional stage and not as something accidental, as an instance of monstrosity. It is fully in accordance with what has been going on for ages within the calycinal system, through long series of succeeding species, only it is here carried a step farther, as though leading into a new phase of the morphological labour. In Mesozoic time the excretory opening moved out of the system into the odd interradium, and was seen to increase more and more the interjacent distance. After a while the madreporic filter followed its track, attaining, near the close of Cretaceous time, the costal 5. With the aid of a little imagination we might surmise that we actually witness how it exceeds the old terminus and begins its exodus, and indulge in the idea that, in a future geologically not very distant, the whole of the madreporite, in some species or other, will have settled within the odd interradium, while the central disk, together with the costal 5, cleared of the invading porosity, will have resumed their normal condition. Then this gradual displacement of the madreporic filter, combined with other correlative modifications of the external parts, accessory to internal changes of more directly vital importance, will have originated a new type of Spatangidæ. But this by the way, as mere speculation. One point alone is established beyond any doubt by what has been detailed here, namely that in reality the madreporite is not an integral element of the calycinal system, but an extraneous accessory, and that there exists no such thing as a »madreporic plate».

In like manner the conception of the costals as »genital plates» on a closer inspection ceases to be tenable. Subsequently to the appearance externally, in the young Echinid, of the madreporic filter, when the reproductive glands approach maturity, their efferent ducts penetrate from within the costals, and, in the adult state of the great majority of species, a sexual pore is found in each of these. To this there are but rare exceptions, such as Goniopygus, but in the Clypeastridæ not a few forms have their sexual apertures outside the costals, in the respective interradia [1]). In the Endocyclic Gnathostomes all the five costals are perforated, but four only in the earliest among the Exocyclic, in Pygaster, the fifth having disappeared along with the costal 5, at the outbreak of the periproct. And, though in Oolitic species of Holectypus the costal is restored, it is not until in the Cretaceous era that its pore reappears [2]), just as in Discoidea, of early Cretaceous origin, it reverts only in the Turonian time,—and this is the last instance known of its reinstatement, for among the Echinoneidæ and Cassidulidæ it never reappears. In these last-named the four sexual pores are far asunder, owing to the central expansion of the madreporite, they are drawn near together laterally in the narrowed and lengthened calycinal system of the Collyrites and in the Meridosternous Spatangi, such as Anancites, Hemipneustes and others, and they are squared again in the shortened system af the Amphisternous Ethmophracti. In the Spatangidæ Ethmolysii, also, four is their normal number. In some cases, for instance in Spatangus purpureus, they seem to make their appearance very irregularly, all four being present in a specimen of the stage mm. 15 : 14, *Pl. XVIII, fig. 213*, but wanting in another of mm. 16 : 15, *fig. 214*, almost so even at mm. 19 : 18, *fig. 216*, highly developed at mm. 23 : 22, *fig. 218*, while the two anterior are only indicated in a specimen of mm. 24 : 21, *fig. 217*,—anomalies that possibly are apparent only, and may depend upon difference of sex. During the growth, also, one or even two of the pores are liable to give way in the struggle against the madreporite. In the costal 2, the old site of the filter, this not seldom prevails and causes the sexual pore to abort, sometimes accidentally, as in Brissopsis lyrifera, *Pl. XIX, fig. 229*, but regularly in certain species of Schizaster, as Sch. fragilis D. & K. [3]), Sch. Moseleyi Al. Ag., in Tripylus, and in Abatus cavernosus Phil., *Pl. XVIII, fig. 220*. In Abatus Philippii n. [4]), in Moira atropos Lamk., and in some other species of Schizaster, as Sch. canaliferus Lamk., Sch. japonicus Al. Ag., it has disappeared in the costal 3 also. But among the Spatangidæ the sexual organs are never deprived of their outlets in the costals 1 or 4

Thus the madreporite, with its internal apparatus of cavities, passages and canals combined into a solid calcified structure, by its expansion and regressive movement determines, in the Spatangidæ, the closing up of one or more of the sexual openings, and constantly that of the costal 5. In earlier types, when this same costal, uppressed for a time in consequence of the retrograde passage of the excretory ori-

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[1]) Études, p. 80, Pl. XVI, fig. 136. Ib. p. 69. Cotteau Peron et Gauthier, Échinides de l'Algérie, V, p. 223, Pl. XVI, fig. 1—12.

[2]) See above, woodcut p. 68.

[3]) Études, pl. XII, fig. 102. In Sch. gibberulus Ag. all four sexual pores are present.

[4]) Ib. pl. XI, fig. 99.

fice, had reappeared again, the corresponding sexual gland also, in the course of subsequent ages, was seen, in some forms, to recover its outlet. This could not have taken place, had not the sexual gland, though checked in its development, and kept back in a rudimentary state, continued, during a genetic succession of forms, its dormant life, ready to begin its work whenever the repressing influence should have passed. In the Ethmolysic Spatangidæ, as long as the madreporite is crowding its pores in the restored costal 5, there is no chance for a sexual outlet; but,—assumed that its movement across the old boundary is in earnest the beginning of a migration,—if a form should be discovered anywhere, in which this migration were accomplished, and the madreporite settled, as a whole, in the interradium 5, it will be a great point to look for the return of the sexual outlet. Meanwhile the problem is near at hand of demonstrating the hidden existence of the fifth sexual gland, in a still embryonic condition abiding its time.

Organs of vision,—in the whole animal kingdom seen to come forward at places of commanding situation, irrespectively of morphological relations—, appear to be foreign to Crinoidean organisation. In the Asteriadea, on the other hand, their existence has been proved beyond any doubt by EHRENBERG, their discoverer, by HÆCKEL, GREEFF and others. A group of crystalline cones surrounded by pigment is seen at the extremity of each ambulacrum, and, connected with it aborally, a finger-shaped tentacle, both sheltered under the radial, which has been removed from its original site in the axillary angle between two costals, by the interposition of the largely developed perisome [1]). In the Echinoidea organs apparently identical, but not yet properly studied, are seen in corresponding places, each of the five radials presenting a pore serving as an orbit to the eye [2]), and close over it a simple tentacle. There both these organs appear very early, even before the madreporic filter, and the tentacle perhaps before the eye, *Pl. XIV, fig. 164, 164 A*, and there they are found, out of the field of contest, —for the madreporic filter scarcely ever attains the radials—, in forms geologically old and new, with a tenacity recalling that of the eyes of the Podophthalmous Crustacea, which maintain so invariably their station at the top of the appendages of the first somite, arrested in their development. When in the Collyrites [3]) the bivium is severed from the calycinal system through the interposition of the enlarged interradia 1 and 4, the radials I and V adhere to the respective ambulacra, on the insides of which the nerves descend from the central collar to the eyes.

These are the two principal forms of the calycinal system prevalent in the great majority of the Spatangidæ: the Ethmophracti and the Ethmolysii. A third modification is of much less frequent occurrence. Palæotropus [4]), which by its general outline, its ambulacra all apetalous, similar and level with the perisome, in some degree re-

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1) Études p. 86, pl. LIII, fig. 256—260.
2) Ib. p. 66, pl. XI, XII, XV, XVI, XVII, XIX, XXI.
3) Ib. pl. XI, fig. 98.
4) Ib. p. 17, pl. XIII, fig. 108—113; XII, 105; XXXII, 200.

calls certain ancient types, and at the same time is so like its contemporaries in the structure of the peristome, the sternum, and the episternum traversed by the subanal fasciola, as also in the regular heteronomy of 1, *a*, presents a calycinal system, *Pl. XVII, fig. 208*, of a nearly pentagonal outline, in which the radials are distinct, the I and V being widely separated, while the costals are all coalesced into one piece devoid of sutures, and in which the madreporite opens anteriorly in the middle by a small fissure and some pores, while the genital ducts are only two, having their outlets at the tops of two large tubular eminences placed transversely against the interradia 1 and 4.

Palæostoma mirabile GRAY, *Pl. XVI*, deviates in a strange manner from nearly all the rest of the Spatangidæ [1]), by the fusion into one single plate of the second plates of the interradia 2, 3, 4, the heteronomy of 1 being effected through the union of the plates *a 2*, *b 2* and *b 3;* by the very irregular interradium 5, and by the pentagonal peristome with its five valves, and from Palæotropus in particular, by its distinct petals and by the absence of a subanal, the presence of a peripetalous fasciola. But with all this, Palæostoma offers a calycinal system evidently constructed upon the same model as in that genus, *fig. 184, 190*, with the five radials distinct, the I and V widely separated, and out of the costals the 3 alone defined by a suture, all the rest being coalesced into one piece; with the madreporic filter represented, in the young specimens examined, by a few punctures placed before the middle, and with the two huge sexual outlets, mammiform and prominent, occupying a considerable portion of the system, and placed transversely against the interradials 1 and 4, so as to prevent the retrograde passage of the madreporite. These two genera, Palæotropus and Palæostoma, are, therefore, in a general sense Ethmophracti, but after a peculiar manner, entirely different from that which characterises the older Spatangidæ comprised under this appellation. They may be called Perissogonea [2]). There is not in any other genus of the Echinoidea, recent and fossil, anything strictly comparable to this structure. In some points it recalls what is seen among the Exocyclic Gnathostomes and the earlier Ateleostomes. The radials I and V are kept asunder by the interposition of the costal 5, and the madreporite spreads its pores over the entire central area, without any tendency to move backwards or out of the calycinal system. Thus it is in Holectypus and Discoidea [3]), of Oolitic origin, in most of the Cretaceous Echinoconi, in the recent Cassidulidæ [4]), in the Clypeastridæ [5]), of Tertiary origin. In these two last the sutures have a tendency to be obliterated. But in all of them the sexual pores are five or four in number, and placed against their respective interradia, into which they not seldom are transferred.

[1]) Études, p. 12, 50, Pl. XII, fig. 103, 104; XXXII, fig. 197—199. — A fossil species of this genus, from the Nummulitic strata of Western Sind, has been described as Hemiaster elongatus DUNCAN and SLADEN, Mem. Geol. Surv. India, Tert. etc. Ser. XIV; Vol. I, 3, p. 78, pl. XIX, fig. 7—15. Calcutta 1882.

[2]) *Περισσός*, excessive, *Γονή*, generative organ.

[3]) Études, p. 81, pl. XV, fig. 133, 132.

[4]) Ib., fig. 130.

[5]) Ib., pl. XVI, fig. 135—139.

The calycinal system of the Pourtalesiadæ is much more anomalous, and at the same time not a little unsettled. In the specimen of Pourtalesia Jeffreysi, *Pl. I, fig. 1*, the calycinal system is brought out of contact with the interradia 1 and 4 through the interjacence of the detached plates of 5. Its general form is that of an irregular pentagon. Its constituents are all coalesced into one piece, the madreporal filter spreading its pores over its central forepart. The radials are not to be distinguished. The four sexual apertures are displaced, not answering to their respective interradia, moved forward, those of 2 and 3 being near the ambulacrum III, and those of 1 and 4 almost opposite the II and IV. Another specimen, *Pl. V, fig. 27, 28, 29*, not very different from the first, has the madreporic filter occupying the hinder part of the central space, the anterior pair of sexual pores nearly answering to the interradials 2 and 3, the posterior being pressed forward so as to front the ambulacra II and IV. An impression, not unlike an orbit, near the end of ambulacrum III, *fig. 29*, possibly indicates the existence of a radial. In a third specimen, *Pl. V, fig. 25, 26*, the disordered condition of the system is still more obvious. The costals 1 and 4, separated from the rest by distinct sutures, adjoin the ambulacra II and IV, and are driven widely apart by an advanced plate of 5.

In Pourtalesia laguncula, *Pl. VII, fig. 52*, much the same holds good. There are no traces of radials. The costals 1 and 4, bounded by distinct sutures, adjoin the ambulacra II and IV, the costal 1 being partly in contact with the interradial 1 *b*, there being only one advanced plate of 5, and that intervening between the costal 4 and the interradial 4 *a*. The sexual pores of the costals 2 and 3 nearly answer to their respective interradia. The madreporic filter occupies the central space.

In Pourtalesia ceratopyga, *Pl. VII, fig. 51*, the water-filter spreads over the greater portion of the system, partly to its outermost margins. The costal 1 is completely united to the rest, but on the left side the costal 4 is wholly separated, by the interposition of three plates detached from the interradium 5, and both costals adjoin the ambulacra II and IV, while the hind margin of the system is contiguous to the interradials 1 *b* and 4 *a*. The biviary ambulacra I and V, as in the foregoing species, terminate dorsally far apart from the calyx, and without any trace of radials.

The calycinal system of Echinocrepis cuneata, *Pl. VII, fig. 54*, is an irregular pentagon. The madreporite spreads nearly over the whole, excepting the costals 1, 3 and 4, which are however completely united to the rest, provided with sexual pores and not much displaced. The costal 2 is completely invaded by the filter, some of whose pores are seen on its very edge, even in the suture. The radials II, III, IV are absent, but the I and V very distinct, of a fair size, pentagonally lengthened, contiguous to each other as in the Ethmophract Spatangi, and to the terminations of the ambulacra I and V. They seem to bear eye-spots.

Thus in Echinocrepis the calycinal system still presents somewhat of a Spatangoid character, such as this is exhibited by Palæotropus and Palæostoma, in the disposition of the water-pores and the obliteration of the sutures, while, at the same time, another feature peculiar to the older members of the group [1]), the contiguity of the

[1]) Comp. Echinoconus conicus, Études, Pl. XV, fig. 134.

radials I and V, again presents itself. It is in Pourtalesia Jeffreysi, P. laguncula, P. ceratopyga that the disordered and unsettled condition of the system is brought to a degree not reached in any other Echinoid, recent or fossil. The smallness and irregular outline of the whole, the frequently total obliteration of the sutures, the abortion of the radials, the displacement of the costals 1 and 4, consequent upon the general forward movement of the parts, and accompanied, no doubt, internally by a displacement of the sexual organs, the severance of one of the costals, and the abnormal contiguity of 1 and 4 to the terminations of the paired trivious ambulacra, otherwise the legitimate site of the radials, all these more or less abnormal features are as many signs of approaching ruin. During the long range of geological time that lies between the Triassic Tiarechinus with its ancestral, large, and regularly radiated calycinal system, and Pourtalesia with that same system degraded, shrunk, and dismembered, the evolutional process is marked by the successive appearance of forms unseen before, each bearing in the condition of the calyx the criterion of its geological age. The large, regular and intact calyx of the Endocyclic forms, with five costals and five radials equally balanced, points back to the earliest aspect of Mesozoic, and even Palæozoic life, when their joint-heirs, the Palæo-Crinoidea, were in existence; the Exocyclic system, broken up posteriorly by the egress of the excretory opening, to Oolitic time; and, among the Spatangidæ, the Ethmophract system, of four costals, with the 1 and 4, and the radials I and V, or these last alone, closing from either side, is a badge of seniority, as the other one, the Ethmolysic, with the restored costal 5 separating the I and V, and the madreporite retrograding, is a sign of juniority. Future researches will decide whether we should be right in seeing in the dissolving calyx of the Pourtalesiæ an indication of a still later origin.

These, I believe, are some of the leading features in the history of the calycinal system, as one of the constituents of the Echinoidean skeleton. A large and powerful structure, closely specialised for a function of fundamental importance in the economy of some remote ancestral type, is inherited, in an early state, by a descendant in which, from a total change in the mode of life, the very purpose no longer exists for which it was originally contrived, and to which its parts were adapted. It long retains certain marked features which even to this day reveal its origin, but—unlike its Crinoidean sister-structure which, with functions unaltered, multiplies its components—it remains simple as from the beginning, and, superfluous as it has become, gradually declines in intrinsic vigour, and is given up to subserving activities that had no share in its previous existence. Invaded by contending organs and yielding to their various tendencies, it has its parts deeply modified and even to some degree suppressed, and, although still true to its type, and asserting, so to say, its unimpaired independence by redintegrating its injured frame, it dwindles nevertheless from age to age in every succeeding form, and is seen to fall into decay and dismemberment, and to lose one by one its characteristics, till at last little remains of its original constitution.

V. THE POURTALESIADÆ.

The characteristics of their skeleton. They constitute a distinct family equivalent to that of the Spatangidæ and the Cassidulidæ. Their geographical and bathymetrical distribution.

Eight species comprised in the genus Pourtalesia, one Echinocrepis and one Spatagocystis, make the whole of what is known at present of the little group discussed in the foregoing pages with regard to its skeletal morphology. It remains to expose its characteristics in a comprehensive form, and to determine its systematic position. In this attempt I feel all the inconvenience of being able to speak, from immediate observation, of but a single species in an entire condition, of three others in a fragmentary state only, and of having had before me no specimen at all of Spatagocystis. It so happens, moreover, that Pourtalesia Jeffreysi, the only species examined with some degree of completeness, appears to be, in certain respects, of a more advanced character than the rest, and therefore, as being less in harmony with their mode of conformation, perhaps not rightly to be regarded as embodying the typical features of the group. However, notwithstanding these shortcomings, and with the reservation therein implied, and calling to mind that this is not the first occasion, nor will be the last, when a species that chances to be the most familiar to us, is put forward as the type of its kind, I venture on the following description, with Pourtalesia Jeffreysi in the foreground.

The general form of the skeleton of the Pourtalesiadæ is more lengthened than that of most other Neonomous Echinoids, sub-cylindroid or ob-conical; anteriorly more or less truncate, sometimes broad; in the middle slightly tumid; posteriorly tapering; dorsally convex, sometimes even raised into a hump; ventrally rather flat. Below the slightly overhanging front the forepart is invaginated into the peritoneal cavity, so as to form a deep infra-frontal recess, a rudimentary mouth and buccal cavity, opening anteriorly and ventrally, having at its bottom the peristome, — a disposition unexampled anywhere else in the whole class, an incipient feature approximating to what obtains in worms. Posteriorly the body, in most of the species, terminates in a caudal prolongation, and then the periproct is subdorsal, as among the Cassidulidæ, or at least posterior; in one species, Echinocrepis cuneata, the body is simply pointed behind and the periproct subventral. The stomatoproctic axis is nearly parallel to the ventral plane.

The bilateral symmetry of the constituent elements is highly developed, while, at the same time, the dorsal side contrasts with the ventral in a strongly marked manner. In these points the Pourtalesiadæ depart from the Archæonomous type more widely than any other group.

The three skeletal systems, forming together an unbroken surface, are all present, in different states of development: the perisomatic system predominates; the ambulacral presents its five rays, while the calycinal system is seen to lose its character, and to verge upon decay.

The ambulacrum III with the interradia 2 and 3 constitute the shortened and blunted front part. They are of a relatively small size, normal in outline, adorally involuted and elevated above the ventral level, and thus, contrary to what obtains even in the majority of the Spatangidæ, excluded from touching the ground. The paired ambulacra II and IV, with the interradia 1 and 4, combine to form the lengthened middle part, the ventral surface, wholly post-oral and making nearly the half part of the total length. They are expanded and more or less anomalous in outline, and so is the bivium, which, along with the odd interradium 5, makes up the abdominal portion of the body. Thus far the Pourtalesiadæ upon the whole resemble the Spatangidæ, but, at the same time, present an amount of peculiar modification unparalleled among even the most advanced of these.

The peristome is built up solely of the first plates of III *a b*, 2 *b*, 3 *a* and 5, involuted and raised above the ventral plane. It is upright, nearly vertical to the ventral surface, and the oesophageal opening a longitudinal slit in the buccal membrane. The II and IV, having their first plates excluded from the peristome, attain the calycinal system with the terminal plates of their continuously double series. The bivious ambulacra, I and V, are dismembered; in each of them the first plates, not received into the peristome, are united into one single plate, and the two compound plates thus formed, by being contiguous to each other and to the plates II *a 1, 2* and IV *b 1, 2,* intervene between the labrum and the interradia 1 and 4, while they themselves are aborally widely separated from I, *2* and V *2,* which, like the following, are double, their continuous series embracing the sternum and episternum, 5, *2, 3,* filling with their plates I *a 4* and V *b 4* the episternal angle, surrounding with I *5, 6, 7* and V *5, 6, 7* the periproctal region, and forming the flanks of the abdomen, but dorsally not reaching the calycinal system.

This breach of continuity in the ambulacra I and V, without parallel in the whole class, is seen only in Pourtalesia Jeffreysi, P. laguncula, and Spatagocystis Challengeri. It is brought about by the interradia 1 and 4, which close together ventrally from either side and meet again dorsally, forming, between I, *1* and V, *,1* and II and IV, anteriorly, and I and V posteriorly, a broad, unbroken, vertical ring all around the middle of the body, a structure unexampled among Echinoidea, and, combined with the rudimental buccal cavity, expressive of a tendency towards an annulose differentiation, latent, or but faintly developed elsewhere among Neonomous forms. But, as said above, a few only of the species present this striking peculiarity. In Pourtalesia carinata, P. ceratopyga, Echinocrepis cuneata, the interradia 1 and 4 do not join ventrally in the middle, and consequently do not form a continuous ring. Dorsally they meet together from either side in P. carinata and P. ceratopyga, but in Echinocrepis they are separated by the ambulacra I and V, almost as in the Spatangidæ.

The heteronomy of the interradium 1, so eminently characteristic of the Spatangidæ, and particularly of their later forms, is distinctly maintained, at least in Pourtalesia Jeffreysi and P. laguncula, but wholly transferred to 1 *b*, its formula having become $1\ b\ 2 + 3 = 4\ a\ 2 : 4\ a\ 3$.

The obliquity indicating an imaginary discordant axis $\alpha\omega$, IV—1, and manifested, throughout the whole class, in the disposition of the ambulacral plates of the peristome, is fully maintained in one species only, Pourtalesia carinata, but discarded in P. Jeffreysi, P. laguncula, P. ceratopyga and Echinocrepis cuneata, in which the first plate of the III, uni-porous in *a*, bi-porous in *b*, alone presents a remnant of the otherwise universal formula, while the first plates of the paired ambulacra II and IV, I and V, are all symmetrical on either side of the mesial line, thus conforming to the growing tendency towards a strict bilaterality, and a gradually more decided contrast between the ventral side and the dorsal.

The posterior interradium, 5, is dismembered in Pourtalesia Jeffreysi, P. laguncula and Spatagocystis. Ventrally the *1* of I and V, the *1* of 1 and 4, and the *2* of I and V, are interposed between 5, *1*, the labrum, and 5, *2*, the sternum. In P. carinata, perhaps also in P. ceratopyga and in Echinocrepis cuneata, the labrum is contiguous to the sternum. In P. Jeffreysi the labrum is very minute, in the rest of species observed large and expanding aborally. The sternum is all of one piece in P. Jeffreysi, the plates *a 2* and *b 2* having coalesced, while in P. carinata they appear to be separate. It is followed in P. Jeffreysi by the regular double Spatangean episternum, 5 *a 3*, 5 *b 3*, the pre-anals 5 *a 4—6*, 5 *b 4—6*, the expanded periproctal series, 5 *a 7—9*, 5 *b 7—9*, and by the dorsal sequence of plates gradually narrowing, and in P. Jeffreysi, P. laguncula, P. carinata, P. ceratopyga, and Spatagocystis, reaching the calycinal system, but by means of detached pairs of plates only, *enclaves* between the 1 and 4, where these close mesially, thus distantly recalling Collyrites.

The calycinal system, somewhat Spatangean in Echinocrepis by the radials I and V being distinct, contiguous and closing, and the sexual pore of the costal 2 abortive, in the other species, at least in Pourtalesia Jeffreysi, P. laguncula, P. ceratopyga, is subject to a degree of degeneration seen nowhere else. Its outline is irregular, the sutures obliterated to an extent unknown elsewhere, the radials have disappeared, and, while there is no trace of a restored costal 5, the 1 and 4 are displaced forward nearly beyond the ambulacra II and IV, and the costal 4 even occasionally severed from the system by detached plates of the fifth interradium; and while thus the structural consistency of the system is giving way, its relative size is reduced, and it is drawn forward and widely removed from the bivious ambulacra.

Alone — with the Echinoneidæ — among the whole of the Neonomous Echinoids, the Pourtalesiadæ are homoiopodous. The pedicels, all ambulacral, are uniform, simple, not disciferous, none of them formed into branchial leaflets, the sub-oral and upper frontal pedicels larger than the rest, which are very minute.

The spherids are uncovered, more various in number than usual, but always stationed exclusively on a restricted part of the sub-labial region, on the first plates of the ambulacra I, II, IV, V, and absent on the frontal, III, — a characteristic without parallel.

The single fasciola present is sub-anal, but holds not the same relation to the plates of the bivium, as in the Prymnodesmic Spatangidæ. In one species it aborts.

The spines are Spatangean, partly curved and oar-like, partly almost straight, all rather slender, not crowded, except on the sternum and on the palate of the buccal cavity.

These are the leading features that characterise the skeleton of the Pourtalesiadæ. They combine to make them eminently Neonomous, and different from the oldest of these, the Echinoneidæ. With the Cassidulidæ, of Oolitic origin, they have in common the caudal prolongation, the structure of the proctal part, and, in some degree, the simple form of the pedicels. With the higher Spatangidæ, the Prymnodesmians, they share in the abdominal lengthening of the body, the forward position of the oesophageal opening, the heteronomy of the interradium 1, the sternum and episternum, the fasciola, the form of the spines. They fail to attain the high standard of the Spatangidæ by the frequent abortion of the organs of vision, by the pedicels uniformly simple, not specialised into tactual, prehensile, branchial organs distributed on differently modified parts of the ambulacra. The line of modification followed by their special development goes in another direction, indicated by the cylindroid form of the body, the forward position and the degradation of the calycinal system, the incipient feature of a rudimentary mouth and buccal cavity, with the oesophageal opening and the peristome vertical, by the peristomal part of the frontal ambulacrum and the interradials 2 *b 1* and 3 *a 1* being raised above the ventral plane and out of contact with the ground; by the contrast between the dorsal and ventral segment heightened by this disposition as, also, by the entire set of spherids and the larger pedicels being stationed on the sub-labial area; by the symmetrical disposition of the parts on either side thus being to a certain degree realised, almost to the disappearance of an otherwise universal obliquity indicating the existence of an axis $\alpha\omega$, IV—1; by the annular disposition of the interradia 1 and 4, forming a closed ring all around the middle of the body, and, as a consequence, the dismemberment and backward transposition of the fettered hind-limbs, the ambulacra I and V. These are characters in the Pourtalesiadæ, pointing, though remotely, towards animal forms of another and higher type, animals of annulose differentiation. The sum of these features, those shared with other groups as well as those in which they stand alone, demand the creation for them of a distinct family, systematically equivalent to that of the Cassidulidæ and the Spatangidæ: THE POURTALESIADÆ.

Geographically the Pourtalesiadæ are distributed over the whole of the oceans. P. Jeffreysi seems to belong to the Norwegian Sea, having been found by the Porcupine halfway between Færöe and Shetland, and by the naturalists of the Vöringen at Lat. 63° 6′ N., long. 1° 20′ W.; Lat. 63° 10′ N., long. 5° E.; Lat. 67° 20′ N., long. 9° E. P. miranda was dredged by DE POURTALÈS and by the Blake in the Straits of Florida. P. phiale was first found by the Porcupine in the Rockall Channel, then again in the Antarctic Sea, by the Challenger. P. laguncula and P. rosea are from the Pacific; P. hispida, P. ceratopyga and P. carinata Antarctic, the two last reaching the coast of Chile. Echinocrepis cuneata and Spatagocystis Challengeri are Antarctic.

Bathymetrically the Pourtalesiadæ have been found at depths from 442 to 5300 metres, the average depth being 2900 m. Seven species were met with from this point and downwards, in Globigerina ooze, grey ooze, and red clay: Pourtalesia phiale, two habitats, mean depth 2900 metres; P. hispida, two habitats m. d. 3300 m.; P. carinata three habitats, m. d. 3500 m.; P. ceratopyga, three habitats, m. d. 3800 m.; P. rosea at 4750 m.; Echinocrepis cuneata at 2900 m.; Spatagocystis Challengeri, two habitats, m. d. 3250 m., the medium of their average depths being 3800 metres. Above the general medium depth of 2900 metres and up to 442 m., from the Globigerina ooze to the sandy mud mixed with pebbles, were found two species: Pourtalesia Jeffreysi, in four habitats, at a mean depth of 1300 metres; P. miranda, two habitats, m. d. 1200 m.; and one species alone, Pourtalesia laguncula, from 630 m., sandy mud, 5° C., down to 5303 m., red clay, 1° C., in five habitats, mean depth 3000 metres. At one locality, in the Antarctic ocean, half-way between the Cape and Kerguelen Island, at a depth 2926 m., four species were found living together at one locality, Pourtalesia hispida, P. carinata, Echinocrepis cuneata, Spatagocystis Challengeri; half-way between Kerguelen Island and South Australia, in one locality, depth 3576 m., three species, P. ceratopyga, P. carinata, Sp. Challengeri were found with one another; two species, P. phiale and P. hispida not far from there, at more than 62° S., depth 3611 m.; and two others, P. ceratopyga and P. carinata near the coast of Chile, at 4069 m. The rest were found single.

Thus, as far as our present knowledge goes, three species are Atlantic, and one of these also Antarctic; two were found in the Pacific and five in the Antarctic Sea; and of the ten species hitherto known none comes nearer to the surface than by 442 metres, while two descend to 1000 and to 2000 m., one to near 3000 m., three to between 3000 and 4000 m., three to between 4000 and 5000 m., and one to beyond 5000 metres.

The littoral region comprises the favoured zones of the sea, where light and shade, a genial temperature, currents changeable in power and direction, a rich vegetation spread over extensive areas, abundance of food, of prey to allure, of enemies to withstand or to evade, represent an infinitude of agents competent to call into play the tendencies to vary, definite in kind and limited in number, which are embodied in each species, and always ready by modifying its parts to respond to the influences of external conditions. In this region the great majority of marine forms are at home, of the Echinoidea all the highest types, the Cidaridæ, Echinidæ, Clypeastridæ, Echinoneidæ, Cassidulidæ and the Spatangidæ, Prymnadete and Prymnodesmian, and there live, with rare exceptions, the recent representatives of the fossil types of preceding geological periods. But not one among the known living species, not a single fossil [1]) among the multitudes imbedded in the sediments of former seas, had suggested the possibility of a combination of characters like that realised in the Pourtalesiadæ, and science was not aware of its existence, until, a few years ago, dredge and trawl descended into the vast regions of the great depths, where life endures on hard terms, far beyond the

[1]) Al. Agassiz, in the list of known recent species, Rep. Chall. Echinoidea, p. 208, doubtingly adduces as possibly a Tertiary representative of the Pourtalesiadæ, the fragment described by Edw. Forbes as Echinarachnius Woodii, Echinodermata of the British Tertiaries, Palæontographical Society, 1852, p. 12, pl. II, fig. 6 *a*, 6 *b*. Professor F. Jeffrey Bell has had the kindness to examine for me the original specimen of Forbes, now in the British Museum. There seems to be no reason whatever for regarding it as having being part of something like a Pourtalesia. I arrived at the same conclusion from the inspection of another fragment, also from Crag, lent me by Mr Robert Bell, Chiswick.

furthermost limits of solar light and of vegetation, in stillness and cold all but unvaried, and where much of the available nutriment is contained in the sediment that sparingly and slowly sinks down from the richer zones. Such are the abysses where the Pourtalesiadæ have to lead their simple life, unapproached by many of the powerful agents at work above, and well may it be allowable to surmise that the very poorness of the conditions surrounding them, while leaving unawakened, and thus eliminating a variety of tendencies forcibly active in the inhabitants of more favoured regions, has set free one deep-seated tendency, all but dormant in them, the one towards a structural differentiation typical of a higher and different order, of the Annulate Animals.

The Pourtalesiadæ are not alone among Echinoids to impart a peculiar aspect to the abyssal fauna. Like them the Phormosomas are eminently deep-sea forms, the ten species found by the Porcupine, the Challenger, the Blake and the Knight Errant ranging from 219 metres to 5030 m., the average depth of the genus being 2625 metres. In five out of the eleven Challenger stations where Pourtalesiadæ were dredged, they were found associated with Phormosomas. Higher up these are represented by species of Asthenosoma.

As, among land animals and those of the sea that live near the shore, certain types, properly belonging to and richly varied within the tropics, are found represented in our temperate and even cold regions by one or the other of their forms, perhaps somewhat modified, but still recognisable, thus also in the oceans, in a bathymetrical sense, certain types, properly littoral and highly developed in the favoured zones of light, have outposts in the dark depths, sharing with true abyssal forms their reduced conditions of existence.

In the adult state most of marine Evertebrates remain at their native station, wandering within its precincts. Their embryonic and larval age is their period of dispersal. Of numerous littoral forms, of different classes, tribes and orders, currents must occasionally carry away the free swimming larvæ from the vicinity of land far into the sea, and during the course of succeeding generations early stages of many a species will in this way have reached the wide ocean. There they will have sunk, their development accomplished, all through depths full of dangers and more and more ungenial, and a few of them will have settled on the bottom of the abyss, and fewer still will have come to thrive there. Among these some will have long retained their original character, and but slowly been modified, while others will have exhibited a latitude of variation unknown or rarely seen where they came from, but upon the whole there will be reasons for assuming the less altered forms to be newcomers, the more deviating to be old inhabitants of the deep. At present it is too early to enter into these questions, — when the whole of the materials now on competent hands shall have been worked out, and a general view of the facts obtained, the time will have arrived for knowing, whether the abyssal fauna may be derivable, in the way mentioned, as a whole, from the fauna of the littoral region, as from its original stock, both being recent and coeval, though widely separated, or, in part, from littoral forms no more existing, but fossil not far off. The results then arrived at will perhaps come to throw some light upon the relations of certain fossil forms now regarded as characteristic of separate geological periods.

Among Archæonomous genera, Goniocidaris, Aspidodiadema, Echinus are represented within the deep-sea habitats of the Pourtalesiadæ, and along with them a few littoral Spatangidæ. Among the Prymnodesmians Kleinia, Maretia, Cionobrissus descend to associate with Pourtalesia laguncula at depths of 630 and 1460 metres, and well-known species of Brissopsis, Echinocardium, Spatangus, and a species of Macropneustes, were brought up from considerable depths by the Challenger and the Blake, as also some genera and species unknown before. Linopneustes Murrayi AL. AG. [1]), found to live at 630 m. with Pourtalesia laguncula, has the elongated labrum and short, angulate sternum of Maretia planulata, its episternum, its broad and naked ventral bivium with the three extended subanal plates, the same form of the plate *1* and *2* + *3* of the interradium 1, but its whole body is more convex, not so much tapering posteriorly, the petals, level with the perisome, are more open and gradually narrowing upward, and there is a narrow, peripetalous, peripheral fasciola of only three or four minute tubercles in the transverse row. The two species of Homolampas [2]), from 60 to 4500 metres, according to the figures and descriptions given by AL. AGASSIZ, also come near to Maretia, but the gradually narrowing petals are still more open, their plates are much longer in relation to the breadth, and their pores are minute and placed diagonally. Argopatagus AL. AG. [3]), an associate of Pourtalesia laguncula at 1460 metres, to all appearance is not remotely akin to the foregoing, but apetalous, the dorsal ambulacral plates being nearly equilateral hexagons with the pores almost central. Palæotropus [4]), which lives in depths from 150 to 686 metres, is eminently apetalous.

Among the Prymnadetes the ancient Ethmophract genus Hemiaster descends from 300 to 1463 metres, and there joins Pourtalesia laguncula. The Ethmolysians are represented by two very remarkable forms of the group of Schizaster.

Aceste bellidifera WYV. THOMS. [5]) appears to be a true deep-sea form, its habitats being at 3500 and 5000 metres, the last shared with Pourtalesia rosea. Thanks to Mr JOHN MURRAY I can give, from actual observation, a description of its skeleton, *Pl. XX*. The pedicels have been described above, *p. 53, Pl. X, fig. 96—98*. In the dorsal aspect the outline of the body is ob-cordate, frontally drawn in so as to form a deep sinus, continuous with the large, broadly lanceolate depression that occupies the middle part of the anterior slope. The dorsal surface gradually rises backward to far beyond the middle; then the calycinal system, for a small apical space, is horizontal, the part behind it declining into the almost abruptly vertical, high, nearly flat, elliptical anal surface. The ventral side, level along the middle line, posteriorly suddenly bends upward at the suture between the sternum and the episternum; laterally it

[1]) Rep. Chall. Echin., p. 167, pl. XXV, XXV *b*.
[2]) Ib., p. 164, pl. XXIV.
[3]) Ib. p. 160, pl. XXII, fig. 1—6.
[4]) Études, pl. XXXII, fig. 200.
[5]) Voy. Challenger, I, p. 376. — AL. AG., Rep. Chall. Echin., p. 195, pl. XXXII, fig. 7—11, XXXIII, *a*, fig. 1—7.

gradually passes into the rounded flanks. These general features are those of Schizaster canaliferus, the frontal sinus that of Sch. fragilis. — The perisome, upon the whole disposed like that of Schizaster [1]), is in some points considerably modified. The interradials 2 and 3, which, as in that genus, form the ridge bounding on either side the great dorso-frontal depression, enter the peristome, as normal, each with a single small plate, followed by a pair of larger ones, of which the outer one is broad, the inner narrow. Then come, in 2 *a* and 3 *b*, two fair-sized plates, and a terminal row of eleven or twelve very minute plates, that look as if coalescent into three or four slender and compressed, articulated plates, making the very top of the ridge. The 2 *b* and 3 *a*, of nearly equal breadth throughout, with the last four or five plates lengthened, form the inner slope of the ridge, adjoining the frontal ambulacrum. The interradia 1 and 4 are very much as in Schizaster canaliferus, Sch. japonicus and Sch. fragilis, the plate *1* being subtriangular and internally extended so as to reach the *2*, while in 1 *a* the heteronomy is effected by the union of *2* and *3* into a single plate. In the interradium 5 the labrum is somewhat longer than in Schizaster or Moira. The sternum is less broad, the episternal angle distinct, the abdominal *a* plates a little behind the *b* plates, the periproct being formed by *b 5, 6, 7, a 4, 5, 6;* the anal membrane, *fig. 236*, covered with rounded scales, has the excretory opening somewhat above the centre. — In the ambulacral system the III, sunk in the large and open depression of the forepart, is lanceolate, very broad, even more so than in young Schizasters, and expanding aborally. The II and IV are narrow, their first seven pairs of plates of a fair size; they terminate, not with a petaloid, sunken expansion of transverse plates, but with a strongly compressed double series of minute plates, longer than they are broad, level with the adjoining interradia, and bearing pores placed adorally and diagonally throughout, indistinct or perhaps partly wanting in the intra-fasciolar portion of the inner row. The bivious ambulacra I and V are rather broad in the ventral part, I *a 2, b 3* and V *b 2, a 3* being larger than the rest, I *a 5* and V *b 5* entering the episternal angle, the terminal part gradually tapering, apetalous, the plates about as broad as they are long, sub-hexagonal, the minute pores placed near the adoral margin. — The peristome is normal, *fig. 235*, transversely oval, altogether anterior, upright, vertical, not ventral. The scales covering the buccal membrane are larger frontally, the oesophageal opening transversely oval, somewhat below its centre. — The calycinal system, *fig. 237*, placed on the apex of the body, a little behind the three fourths of the total length from the front margin, comes more near to that of Schizaster canaliferus, *fig. 238*, than to that of Moira, in which the distortion of the system is carried very far. It is a little broader than it is long, the 1 and 4 being prominent. In the specimen described the 1 and 2, and the 3, 4, 5 are united severally, only one suture being visible, connecting the radials I and III. The 1 and 4 each have a large sexual pore. The madreporite is central. — The single fasciola, simple and undivided all around, answers to the peripetalous fasciola of Schizaster. Very nearly as in that genus it traverses III, *3, 4,* 2 *b 4,* 2 *a 4, 5,* 3 *a 4,* 3 *b 4,* II *7* and IV *7, 8,*

[1]) Études, pl. XXXI fig. 194.

ascends lengthwise 1 *b 4, 5, 6*, 4 *a 4, 5, 6*, thus attaining 1 *a 6*, 4 *b 6*, and crosses I and V at *11* or *12*, and the odd interradium on its eighth pair of plates.

With the evidently Schizasterian Aceste bellidifera for a guide it is not difficult to see the affinity, though distant, of the very extraordinary Aerope rostrata WYV. TH.[1]), another inhabitant of the great depths, from 1460 to 3200 metres. According to the figures and descriptions given, its body is much more elongate, the frontal ambulacrum much less sunk, the peristome elabiate and subcircular, not anterior, but ventral, at the third of the entire length; the labrum is very long, the sternum occupies the posterior third, the periproct is dorsal; the calycinal system has four sexual pores; the madreporite is central. The pedicels of III are those of Aceste and Schizaster, the fasciola has the same course, and the heteronomy of 1 appears to be the same. It is likewise apetalous.

Recent Echinoids coming near to the earliest Spatangidæ, Adete, Ethmophract, Meridosternous, were unknown to science, and indeed do not seem to exist in the littoral belt. It was the good fortune of the late Sir WYVILLE THOMSON to bring to light, near Fayal, from a depth of 4850 metres the very singular Calymne relicta[2]), and to have to indicate, by a *nomen triviale*, the significance of the discovery. It looks indeed like a relic from the Older Cretaceous or even the Oolitic period, combining with a perfectly ethmophract calyx a general form like that of Collyrites elliptica or ovalis, a bivium widely separated from the calyx, a sternum composed of several plates. But it is provided with a peripheral fasciola, a feature not foreign, it seems, to Cardiaster. It is apetalous. Its near ally, Cystechinus AL. AG., a deep-sea form from 1900 to 4070 metres, at 2900 m. an associate of Pourtalesia hispida, Echinocrepis and Spatagocystis, at 3950 m. of P. ceratopyga, at 4070 m. of that species and P. carinata, Adete, Ethmophract, Meridosternous and Apetalous, has its bivium dorsally joining the calyx.

Of the no less characteristic Urechinus Naresianus AL. AG.[3]), *Pl. XXI, fig. 239—242*, I can speak from direct observation, thanks to the liberality of my English friends to whom I am obliged for the inspection of duplicate specimens from the Challenger Expedition. This species was brought up in the Southern Pacific and the Antarctic from depths of 2500, 2600, and 3300 metres, from 2926 m. in company with Pourtalesia hispida, P. carinata, Echinocrepis cuneata and Spatagocystis Challengeri, and by the Blake among the Lesser Antillæ, from 772 and 2200 metres. In the dorsal aspect its outline is oviform, tapering behind, the surface entirely smooth, the calycinal system nearly central; the ventral surface almost flat, the interradium 5 slightly rising and convex, the subanal part somewhat prominent; the peristome, *fig. 240*, is slightly sunk, sub-pentangular, with the small oesophageal opening in the centre of the buccal membrane, which is covered with three circles of triangular scales, the outermost of which are by far the largest. The periproct, *fig. 241*, rather wide, sub-orbicu-

[1]) Voy. Challenger I, 380. AL. AGASS. Rep. Chall. Echin. p. 192, pl. XXXIII, XXXIII *a*, fig. 8—12.
[2]) Voy. Chall. I, p. 396. AL. AGASS. Rep. Chall. Echin. p. 155, pl. XXXIV.
[3]) Report Chall. Echinoidea p. 146, pl. XXIX, fig. 1—4, XXX, XXX *a*, fig. 1—14. Report Blake Echinoidea. p. 52, pl. XXVI, fig. 1—3.

lar, is posterior, somewhat sub-ventral; the excretory opening occupies the centre of the anal membrane which is covered with about five concentric rows of scales.

The ambulacral system is normal and closely resembling that of Anancites by its lanceolate, nearly uniform radii, all level with the perisome. The peristomal formula is normal. In the bivium the plates I *a 2, 3, 4,* I *b 3, 4, 5,* and V *b 2, 3, 4,* V *a 3, 4, 5,* are lengthened, and the I *a 4* and V *b 4* slightly expanded interiorly, so as to fill up the feeble re-entering angle offered by the corresponding plates of the posterior interradium, a structure commonly met with also in Holaster and other Meridosterni, and in the Prymnadetes, that is, in forms devoid of a subanal fasciola, and in no wise to be compared with the well-known wedge-shaped, extended plates $6 + x$, present in all Prymnodesmic Spatangidæ. Its deficiency in Urechinus is a sure sign of the absence of a subanal fasciola, of which not one of the several specimens carefully examined showed the least trace. There is, close under the periproct, a dense accumulation of ordinary miliary tubercles, not unlike that seen in the same position in some Brissi; it has no relation to the fasciola.

In all the five ambulacra, the plates, from *4* or *5*, are very much alike, up to *9* at least twice as broad as they are long, then longer in proportion to the breadth, and finally, from *12* or *13*, approaching to a somewhat equilateral hexagonal form. The minute pore, from *9* or *10*, becomes more distant from the adoral margin, gradually nearing the centre. Thus all the ambulacra are apetalous.

The perisome presents the almost exceptional peculiarity of having the paired interradia perfectly symmetrical, the two plates *a 2* and *b 2* of 2 and 3 being, as observed hitherto in Palæostoma mirabile alone, united into single plates, and likewise the plates *a 2* and *b 2* of 1 and 4. By this last unique mode of coalescence these interradia have become symmetrical towards one another, and the heteronomy of 1 is discarded. Hitherto Collyrites apparently was alone in presenting this regularity, a feature that seemed to approximate it to the Cassidulidæ. In the Holastridæ, on the other hand, in Holaster, Anancites, Offaster [1]), Cardiaster, the heteronomy, rendered by the formula 1 $a\ 2 + b\ 2 = 4\ a\ 2 : 4\ b\ 2$ [2]), is distinctly seen in well preserved specimens, though in others it may be difficult to make out. Of Hemipneustes striatus Gm. [3]) several specimens were subjected to repeated and careful scrutiny without yielding decisive evidence of the presumable heteronomy, and now, being convinced of the perfect regularity of the corresponding parts in Urechinus, I venture, though always with some doubt, to give the figure, on the next page, of that species, as another example of perisomal symmetry in that early group of the Spatangidæ, the Meridosterni, among which the asymmetry is still unsettled and, as it were, in its beginning, and far from presenting the definite and constant character it gradually assumes in the Prymnadetes and the more recent Prymnodesmians.

The odd interradium, 5, is rather narrow; the labrum, expanded aborally, is contiguous to I *a 1, 2* and V *b 1, 2.* The plate 5 *b 2* simulates, as it were, by itself

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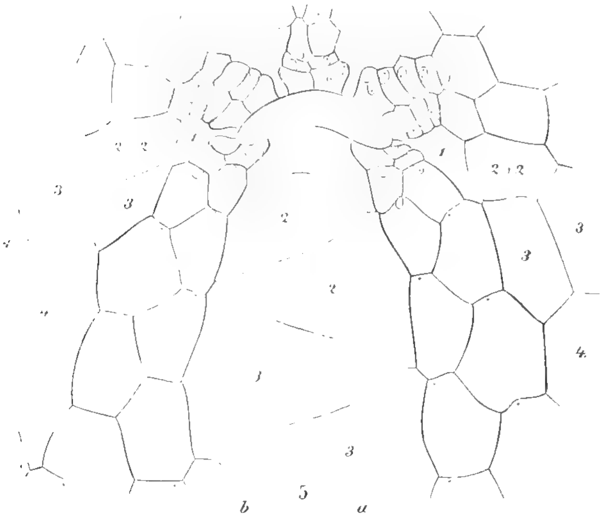
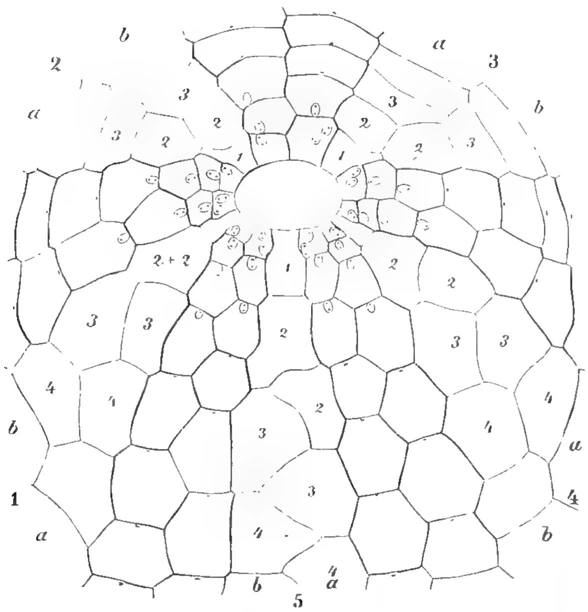
[1]) See the woodcut on the next page.
[2]) See above p. 15.
[3]) See the wood-cut.

a small sub-pentangular sternum, contiguous to I *a 3* and V *b 3*, followed by 5 *a 2*, which is entirely separated from *1*, while *a 2, 3, 4* and *b 3, 4, 5* form together a slight re-entering angle, and *a 6—9, b 5—8* are periproctal, *10—16* dorsal, lengthened, sub-hexagonal.

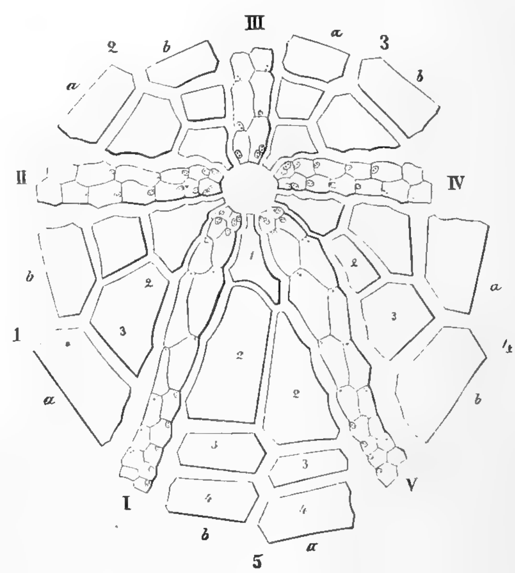


Hemipneustes radiatus Gm.

When the successive modifications of the interradium 5 of the Spatangidæ are followed from the first appearance of the group to our days, it is seen that in the earliest, Collyrites [1]), after the labrum there begins a double row of alternating plates, in which the plates of the *a* series are posterior to those of the *b* series, the same order of sequence that holds good throughout the whole of the Spatangidæ. There is no appearance of a true sternum. In Hemipneustes the ventral plates of either row, from the *b 2* inclusively, extend triangularly across the interradium, so as to bring their points within a short distance from the opposite ambulacrum, and



Offaster corculum Goldf.



Echinospatagus Ricordeanus Cotteau.

to leave only a minute part of *a 2* in contact with the labrum, the middle suture thus becoming a zig-zag line of very wide turns. In Holaster [2]), Cardiaster, Anancites [3]), Offaster, this structure is so far modified that the *b 2*, still more expanded trans-

[1]) Études pl. XXIII.
[2]) Ib. pl. XXV.
[3]) Ib. pl. XXIV.

versely, occupies the whole breadth of the interradium, assuming a trapezoidal form, and fully attains the ambulacrum V, to which it becomes largely contiguous. By this means the *a 2* is pushed back, widely out of contact with the labrum, but retains, like the two or three pairs of ventral plates, the triangular, pointed shape and the very oblique alternation, while the pre-anal, abdominal and dorsal plates, in proportion as they are distant aborally, and become shorter and broader, hold a less oblique position.

The large sternum of the higher Amphisternous Spatangidæ so universally consists of two equal symmetrical halves in regular juxtaposition, as to seem hardly to give room for a query whether it may not, after all, owe its form to a direct modification of that of the Meridosterni. However, it will seem to me, — notwithstanding the incompleteness of my materials, — that there really are indications of such a possibility, of its having originated through a gradual transposition of the obliquely placed *a 2* and *b 2* of the Meridosterni. The Adete Echinospatagus no doubt is rightly numbered among the Amphisternous Spatangidæ, but the plate *a 2* of its sternum, inferior in size, triangular and asymmetrical, hangs behind the *b* plate, as if retarded in its growth, and anteriorly would not attain the labrum, did not this come to meet it with a lateral prolongation of its aboral margin. It may be allowable, from the whole of this singular feature to look back for the existence of earlier forms, perhaps undiscovered yet, still more evidently transitional, showing how the *a 2,* moving forward, first began to interpose itself between the *b 2* and the ambulacrum V, at the same time exchanging its transversely cuneate shape for one more fitting its work and the place it was striving to occupy. If so, the two halves of the sternum of the higher Spatangidæ ought not to have been formed simultaneously, but in such a way that the *b 2* alone had first been transformed into the future right plate, and, after that, the *a 2* into the left one. And this supposition appears to acquire some degree of probability, when, leaving Echinospatagus behind, we look forward at the modifications displayed by the Spatangidæ of later appearance and higher order, modifications all of which are continuations of what has been observed in those of a lower. Thus among the Prymnadetes, some genera, as Palæostoma [1]), Hemiaster [2]), Agassizia, Schizaster, are seen to exhibit what may be regarded as marks of this movement, in the *a 2* being behind and attaining adorally with a narrow point only the meeting labrum. Among the Prymnodesmian forms the earliest, Micraster [3]), still shows these traces of the asymmetry, but through the whole series of the higher, Tertiary and recent genera [4]), the symmetry and the exact juxtaposition of *a 2* and *b 2,* of the episternals *a 3* and *b 3* the pre-anals *a 4, b 4,* and even of one or other of the anal pairs of plates, as *a 5, b 5,* is thoroughly established: their sutures have become rectilinear by the disappearance of the posterior inner truncation, and the angular middle suture is confined solely to the still alternating rows of abdominal and dorsal plates.

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[1]) Études pl. XXXII.
[2]) Ib. pl. XXVI, XXX, XXXI.
[3]) Ib. pl. XXXIII.
[4]) Ib. pl. XXXIV—XLII.

I have hazarded here this attempt to explain the origin of the Spatangean double sternum in the hope that other observers, more fortunate in possessing richer materials, will deem it worth a strict examination. At present, this theory may eventually be found to stand the test or not, the plate marked 5 *b 2* in the skeleton of Urechinus Naresianus AL. AG. is to be set down as homologous to the 5 *b 2* in that of Offaster, Anancites, Holaster, Hemipneustes, and its 5 *a 2* homologous to their 5 *a 2*, This striking character of the interradium 5 in the earliest among the Spatangidæ, thus met with again in Urechinus; its calycinal system, ethmophract and lengthened as in Collyrites and the Holastridæ; the absence of any heteronomy in 1, and the complete symmetry of the interradia 1 and 4, recalling Collyrites and apparently Hemipneustes; the coalescence of *a 2* and *b 2* known hitherto in the certainly very old-fashioned Prymnadete, Palæostoma, alone; the similarity of the five ambulacra, all of them level with the general surface; the subcircular form of the peristome; the narrow adoral margin of the labrum not expanded transversely, and protruding as in the higher Spatangidæ, — all these features combine to set forth the genus Urechinus — along with Cystechinus and Calymne — as a true living member of the group of the Meridosterni, by which the Spatangean type was first introduced, in the seas of the Mesozoic period, and which was long believed to be extinct. If Urechinus Naresianus — or, for what we know, a Cystechinus or a Calymne — had been found fossil in some Secondary or Tertiary stratum, any zoologist would have referred it, without hesitation and rightly, to the »Ananchytidæ»; — but at the same time one feature would have caught his attention as strikingly peculiar and distinctive, the total absence in the ambulacra of any trace of petaloid structure.

The recent Spatangidæ that live in the littoral belt, and the allied fossil forms of Prymnadetes and Prymnodesmians, all have, for a common character, the dorsal portions of their paired ambulacra, II and IV, I and V, transformed into more or less developed petala, within which the plates are crowded, shortened while transversely extended, and frequently more or less deeply sunk beneath the perisome, all this in order to afford as large a space as possible to the increased number of pedicels changed into triangular, compressed leaflets, evidently subservient to respiration. Now, it will have been remarked that in certain generic forms of Prymnadetes and Prymnodesmians found to inhabit the great depths, the petals, when compared with those of the properly littoral forms, are seen to be but feebly or not at all developed. In Homolampas their plates are but slightly shortened, and the minute perforations of their pores are placed diagonally, not transversely; — and Argopatagus and Palæotropus are entirely apetalous. The littoral forms of the Schizasters are provided with highly developed, deeply sunk petala, while their representatives in the great depths, Aceste and Aerope, in this point absolutely contrast with them, having the paired ambulacra wholly apetalous, narrowed in their dorsal portions, and level with the perisome. Thus, while in the littoral Spatangidæ a tendency universally prevails towards having their dorsal ambulacra with their pedicels modified for branchial functions, there seems to obtain, in the abyssal forms, within this part of their vital economy, a quiescence, that leaves these same ambulacral plates and pedicels in undifferentiated simplicity, — a peculiarity, the significance of which perhaps will be found, when the researches are brought to a close that are just begun, on the gases contained in the abyssal waters.

Urechinus, Cystechinus and Calymne, Abyssal, Ethmophract, Meridosternous, and true members of the ancient group of Adetes, are most decidedly apetalous. Are there, among the genera of that group, any forms extant that, from the structure of their dorsal ambulacra, may be put forth as the littoral or sub-littoral main stock, of which Urechinus and its living allies may be the deep-sea representatives? Anancites and Offaster had the paired ambulacra level with the perisome. On the flanks the pores have their perforations close together, rather diagonal, a little below the centre; in the dorsal portion the crowded plates, at least twice as broad as they are long, with the perforations transverse, larger, separated, nearer to the outer and the adoral margins, make very open and somewhat rudimentary petals, that evidently were the sites of branchial leaflets. Hemipneustes, combining with the ancient character of an exquisite zig-zag sternum an impressed III bearing peculiar peripodia, a produced and laterally expanding labrum, a madreporite widely spreading within the strictly ethmophract calyx [1]), has its paired ambulacra semi-petaloid, the pores of I *a*, V *b*, II *a*, IV *b*, being large, transverse, with the outer perforation a slit nearing the posterior margin, while the pores of I *b*, V *a*, II *b*, IV *a* decrease dorsally, as the former increase, and become very minute and sub-median, finally diagonal. Holaster, also, has the I, V, II, IV, semi-petaloid, but the pores of the anterior series not nearly so minute relatively, and diagonal only very near the calyx. In Cardiaster the petala are almost completely developed, the anterior pores somewhat less, but transverse and evidently branchial.

On the analogy thus clearly offered by the Prymnadete and Prymnodesmian Spatangi, the conclusion to be drawn from this difference, in the structure of their ambulacra, between the recent abyssal and those ancient Meridosterni, seems lawfully to be, that these latter, Anancites, Offaster, Hemipneustes, Cardiaster, and others, among which at least Anancites and Offaster lived in a polythalamian sediment comparable to that of the great depths of the actual seas, were not truly abyssal, but inhabitants of less deep, though oceanic parts of the Mesozoic sea. If they still survive in generically allied or altered forms, these are to be looked for on the sloping bottom between the littoral and continental shelves and the great depths. But whether extinct or still living, they once had or yet have, in Urechinus, Cystechinus, Calymne, or in ancestors of these, their representatives in the abysses of the ancient ocean, which are those also of our days.

It may be that the known species of the Pourtalesiadæ, with apetalous ambulacra, are the abyssal representatives of other members of their family provided with developed petaloid branchial apparatus, and living nearer to the light and the air, in the littoral zone or in the vast regions interjacent between that and the great depths. In a fossil state such forms may possibly one day be met with, in Cretaceous layers enclosing Anancites and Echinothuria.

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[1]) See woodcut p. 70.

PLATE I.

Plate I.

Pourtalesia Jeffreysi Wyv. Thoms.

The ambulacral system coloured.

Fig. 1. The skeleton, denuded; dorsal aspect.
Fig. 2. The same, ventral aspect.
Fig. 3. The same, side view.
Fig. 4. The periproct and the anal membrane.
Fig. 5. A pedicellar peripodium and tubercles.
Fig. 6. A lateral plate of an ambulacrum, with a pedicellar pore marked *.
Fig. 7. The same from the inside.
Fig. 8. The sub-labial area of another specimen.

Fig 1

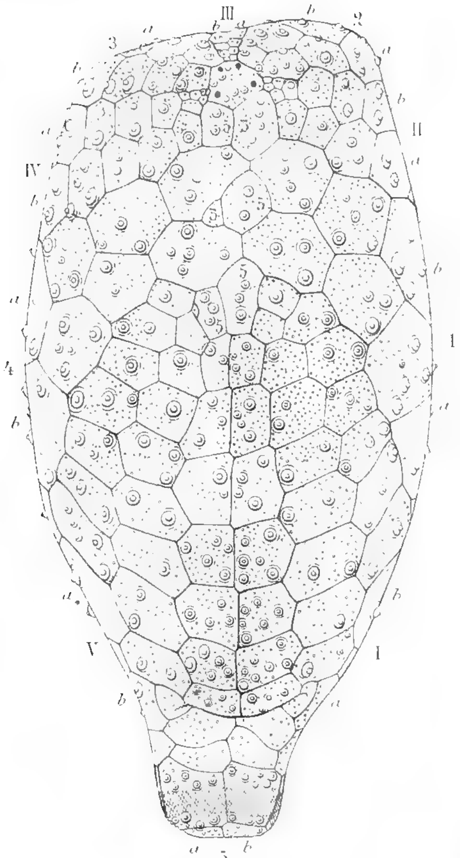


Fig 2

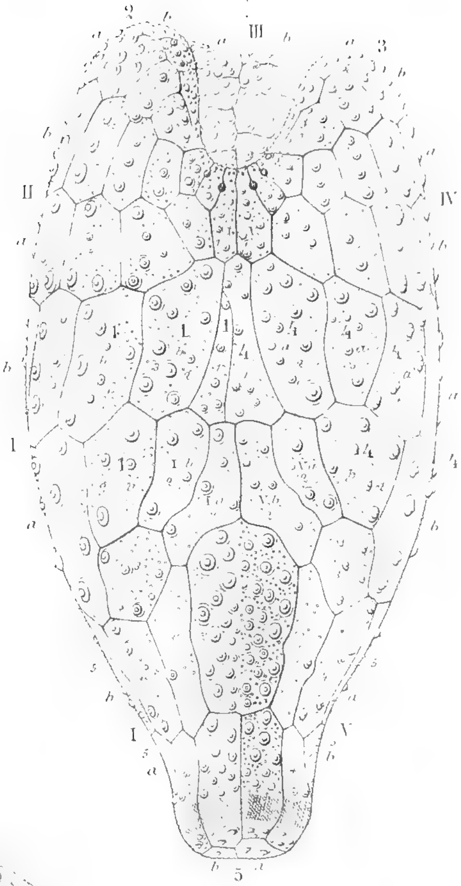


Fig 5

Fig 3

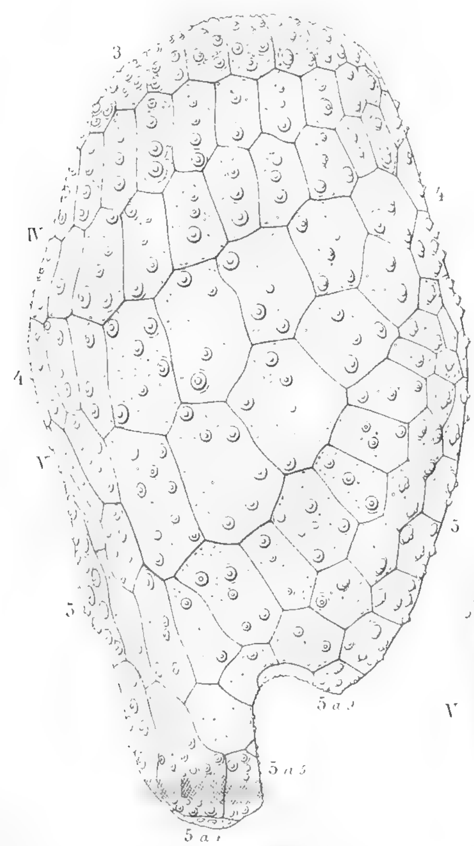


Fig 7

Fig 8

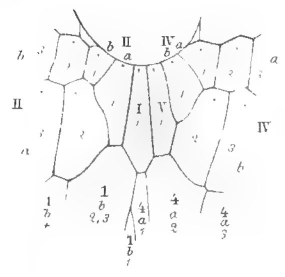


Fig 4

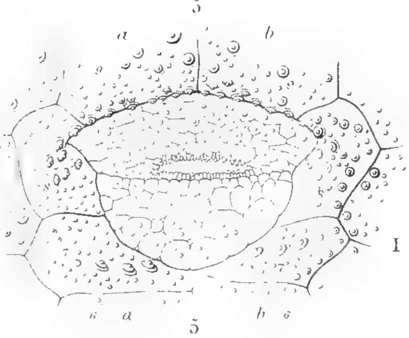
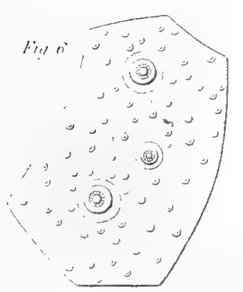


Fig 6



M Westergren lith. Lovén dir Lith W Schlachter Stockholm

1-8. Pourtalesia Jeffreysi WYV. THOMSON.

PLATE II.

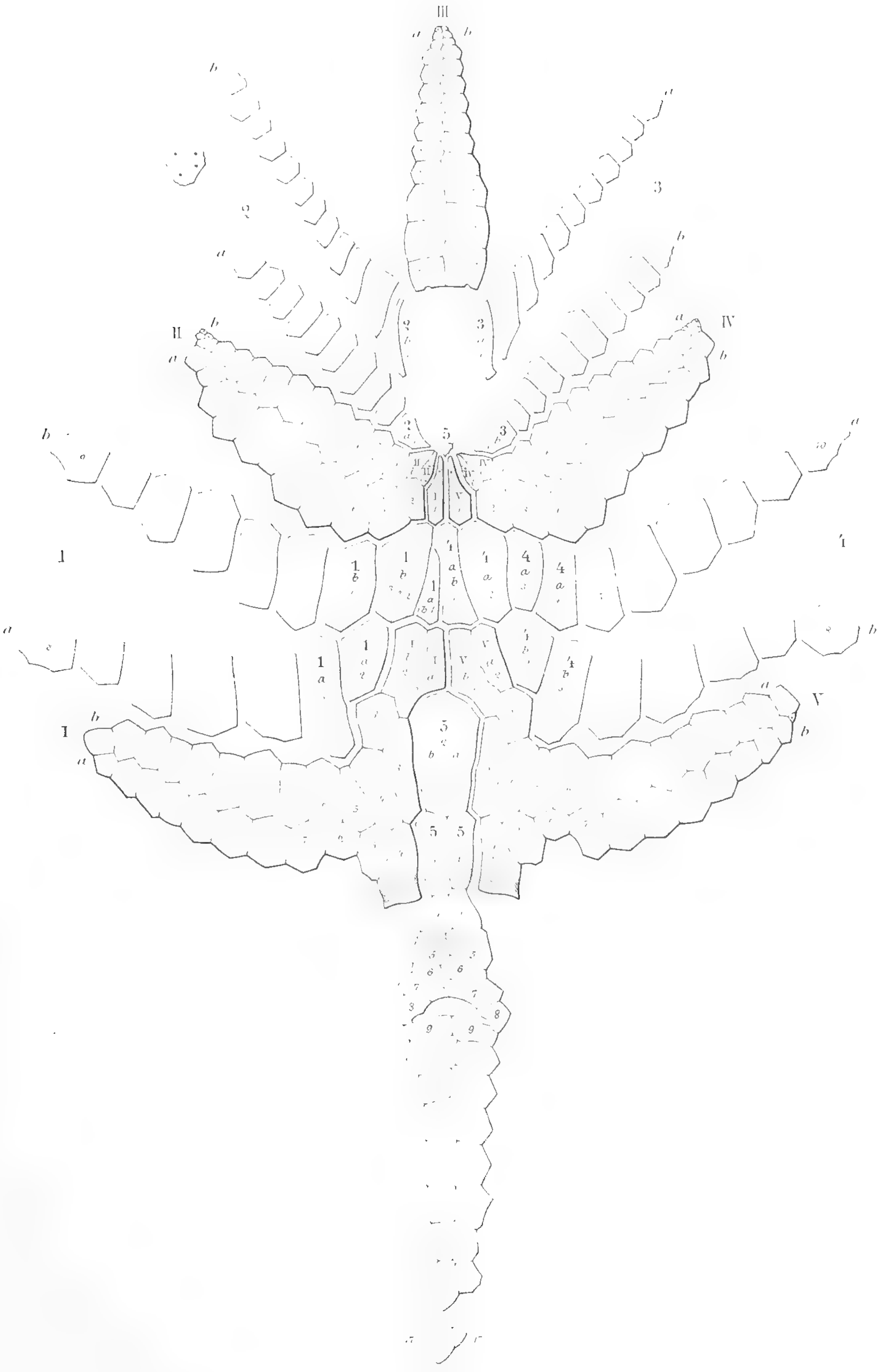
Plate II.

Pourtalesia Jeffreysi Wyv. Thoms.

The ambulacral system coloured.

Fig. 9. The skeleton, laid out. The plates 2 *b 1* and 3 *a 1* are necessarily foreshortened. The heteronomy of the interradials 1, *b 4* and 1, *b 3+2*, p. 14, as also the corresponding plates 4 *a 2*, 4 *a 3*, 4 *a 4*, are marked with arched, dotted lines.

Fig. 9



A. M. Westergren del. Lovén dir. Lith. W. Schlachter Stockholm

9. Pourtalesia Jeffreysi WYV. THOMSON.

PLATE III.

Plate III.

Pourtalesia Jeffreysi Wyv. Thoms.

The ambulacral system coloured.

Fig. 10. The ventral half of the skeleton, seen from the inside. The heteronomy marked as in fig. 9.
Fig. 11. The dorsal half of the skeleton, seen from the inside.
Fig. 12. The infra-frontal recess seen from the peritoneal cavity, and from the left.
Fig. 13. Longitudinal section of the hindmost part of the skeleton, the caudal prolongation, the periproct, and the anal membrane: *am*.
Fig. 14. The dorsal termination of the ambulacrum V, from the inside.

Fig. 10

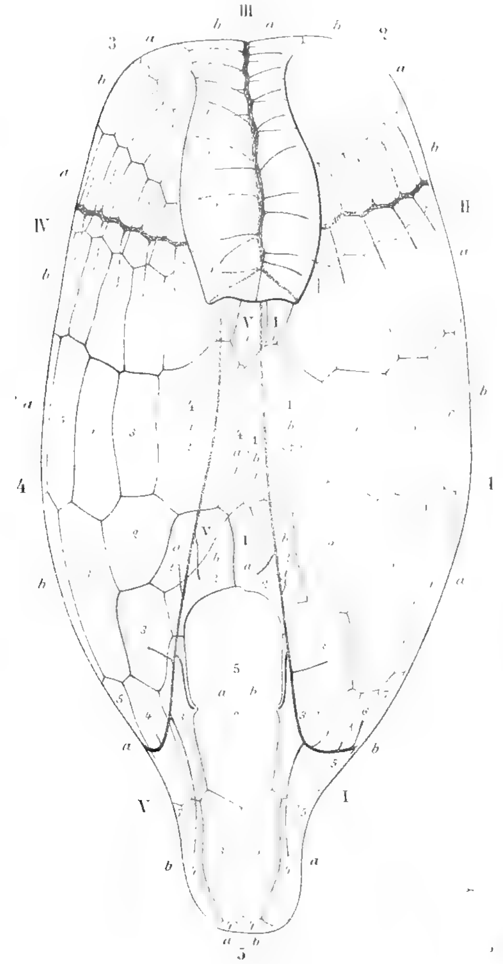


Fig. 11

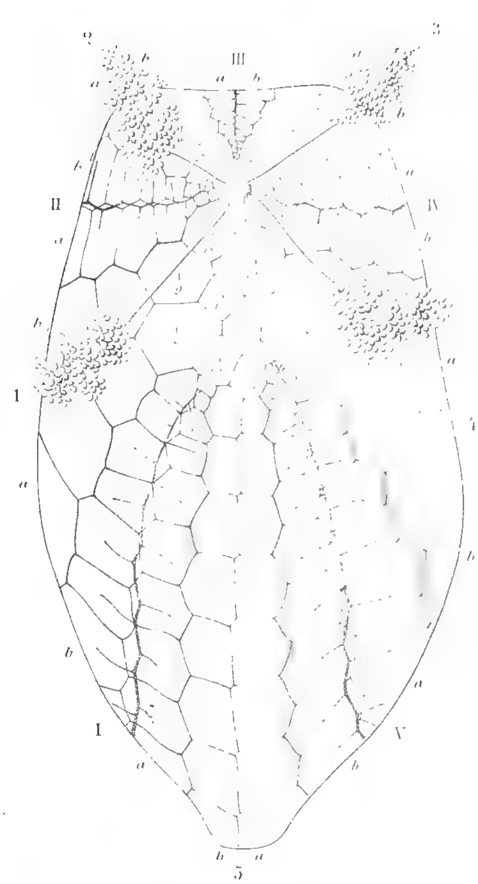


Fig. 14

Fig. 12

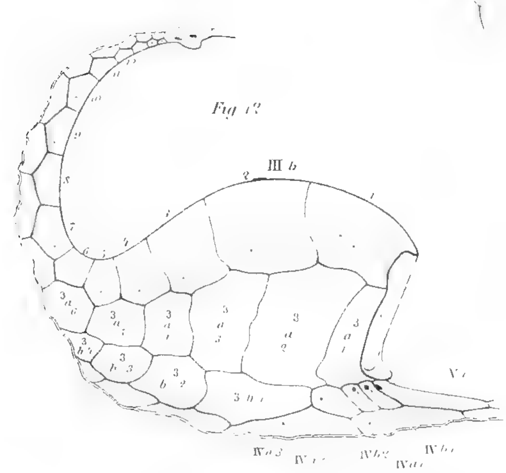
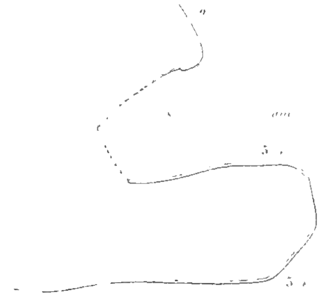


Fig. 13



A. M. Westergren. del.　　Lovén dir.　　Lith. W. Schlachter. Sth.

10–14. Pourtalesia Jeffreysi WYV. THOMSON.

PLATE IV.

Plate IV.

Pourtalesia Jeffreysi Wyv. Thoms.

Fig. 15. The sub-labial region, from the outside, showing the ambulacrals I *1* and V *1*, II *a 1* and *b 1*, IV *a 1* and *b 1*, the four spherids, p. 40, and the four pedicellar peripodia.

Fig. 16. The same from the inside, showing the part bent in into the infra-frontal recess, the minute labrum, 5, and the four pedicels.

Fig. 17. Part of the same, placed so as to show the internal trabecules.

Fig. 18. The infra-frontal recess, p. 7, 28, seen from the peritoneal cavity, and from behind, showing the peristome with the buccal membrane and a part of the oesophagus, the neural collar (and vessel) and the main trunks proceeding from it.

Fig. 19. The same, from the left side.

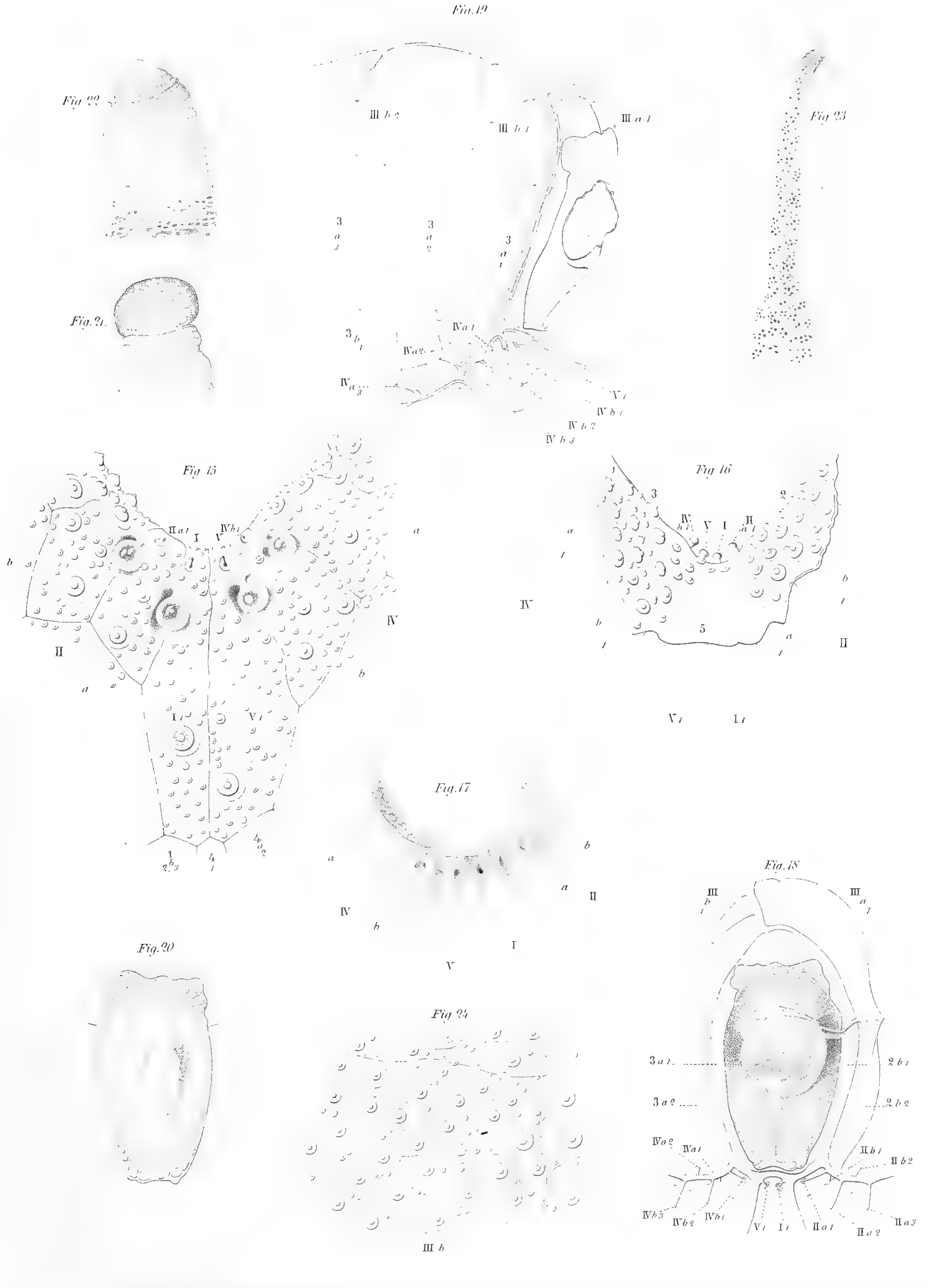
Fig. 20. The buccal membrane, with the oesophageal opening, p. 29.

Fig. 21. The top of a sub-labial pedicel.

Fig. 22. The same, in a state of contraction.

Fig. 23. One of the sexual tubes.

Fig. 24. A part of the palate of the infra-frontal recess, showing its crowded tubercles and a minute pore.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

15–24. Pourtalesia Jeffreysi WYV. THOMSON.

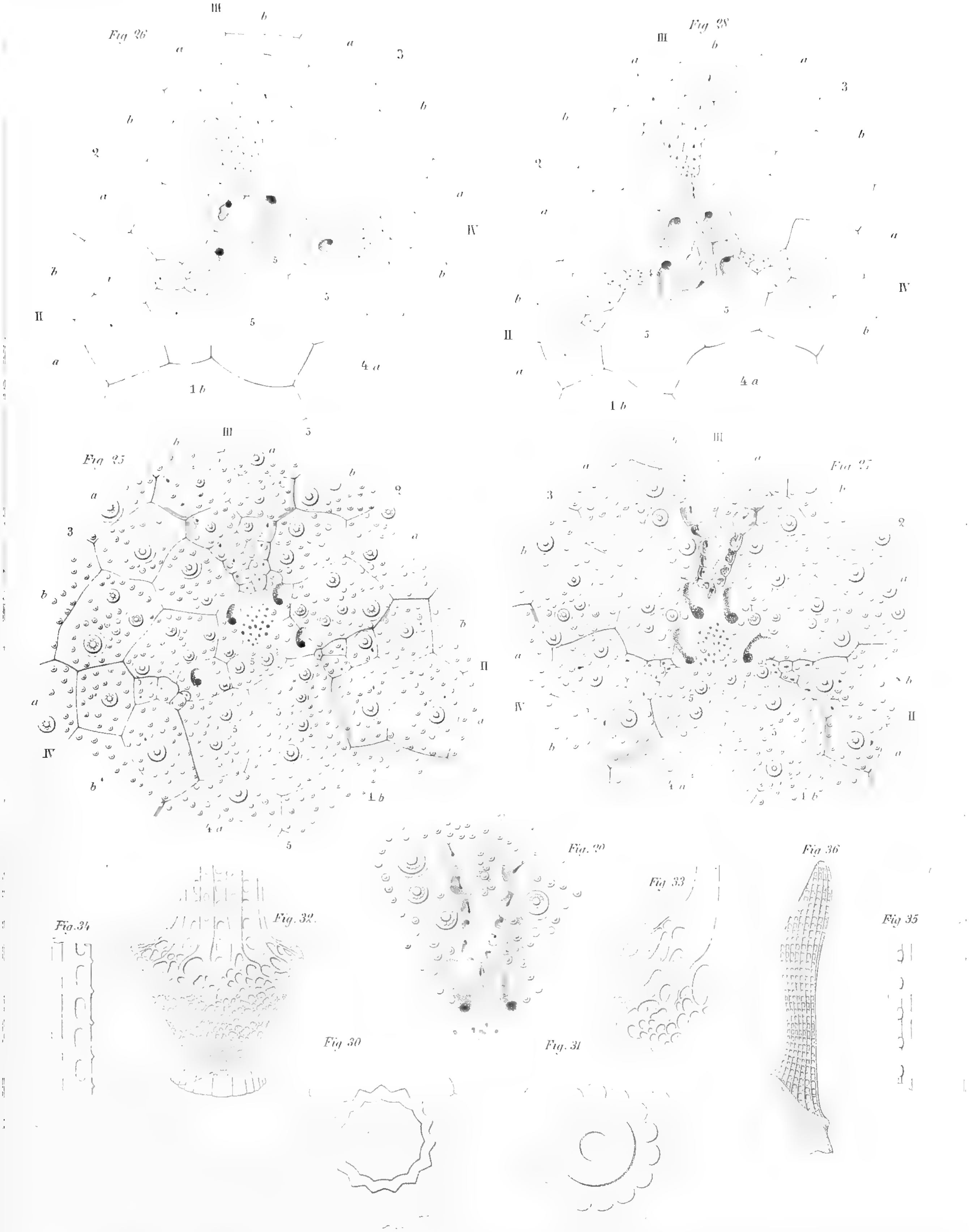
PLATE V.

Plate V.

Pourtalesia Jeffreysi Wyv. Thoms.

The ambulacral system coloured.

Fig. 25. The calycinal system and the surrounding area, p. 79.
Fig. 26. The same from the inside.
Fig. 27. The calycinal system and surrounding area, in another specimen.
Fig. 28. The same from the inside.
Fig. 29. The termination of the front ambulacrum.
Fig. 30. The articulating end of a spine, p. 24.
Fig. 31. The corresponding tubercle.
Fig. 32. The lower end of a spine.
Fig. 33. A calcareous fibre rising from the collar.
Fig. 34. A fibre with its processes, side view.
Fig. 35. Another fibre, front view.
Fig. 36. An oar-like spine; shortened.



A. M. Westergren del. — Lovén dir.

25–36. Pourtalesia Jeffreysi WYV. THOMSON

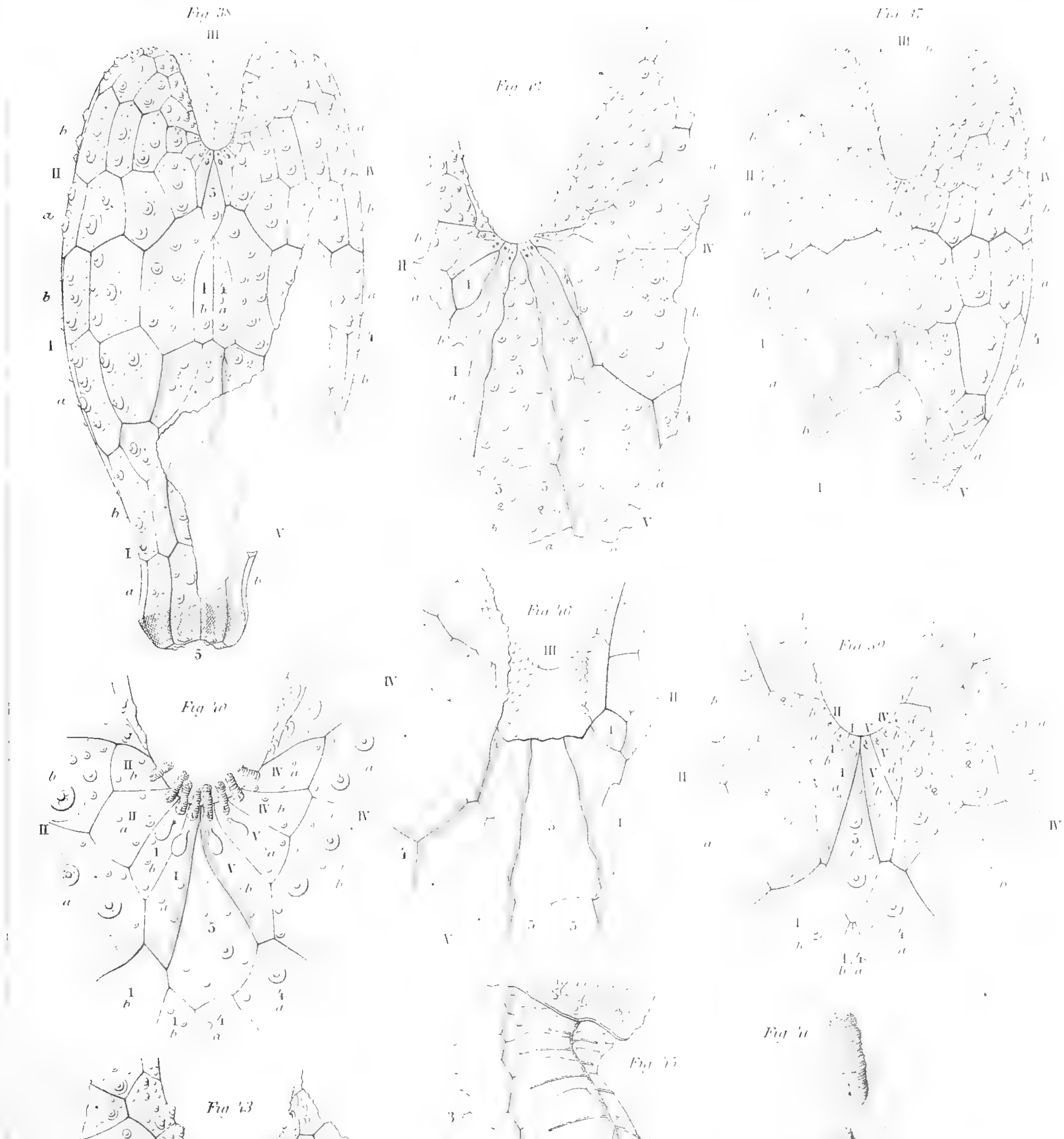
PLATE VI.

Plate VI.

Pourtalesia laguncula Al. Ag. **Pourtalesia carinata** Al. Ag.

The ambulacral system coloured.

Fig. 37. The skeleton of P. laguncula, ventral view, p. 17.
Fig. 38. The skeleton of P. laguncula, another specimen, ventral view.
Fig. 39. The sub-oral region of the same.
Fig. 40. The sub-oral region of the specimen fig. 37.
Fig. 41. A peristomal pedicel and spherid, of the same.
Fig. 42. The sub-oral area of P. carinata.
Fig. 43. The same, from another specimen.
Fig. 44. Peristomal part of the same area, from the specimen fig. 42.
Fig. 45. The infra-frontal recess, seen from the peritoneal cavity; left view.
Fig. 46. The involuted part of the labial region.



A M Westergren del

Lovén dir

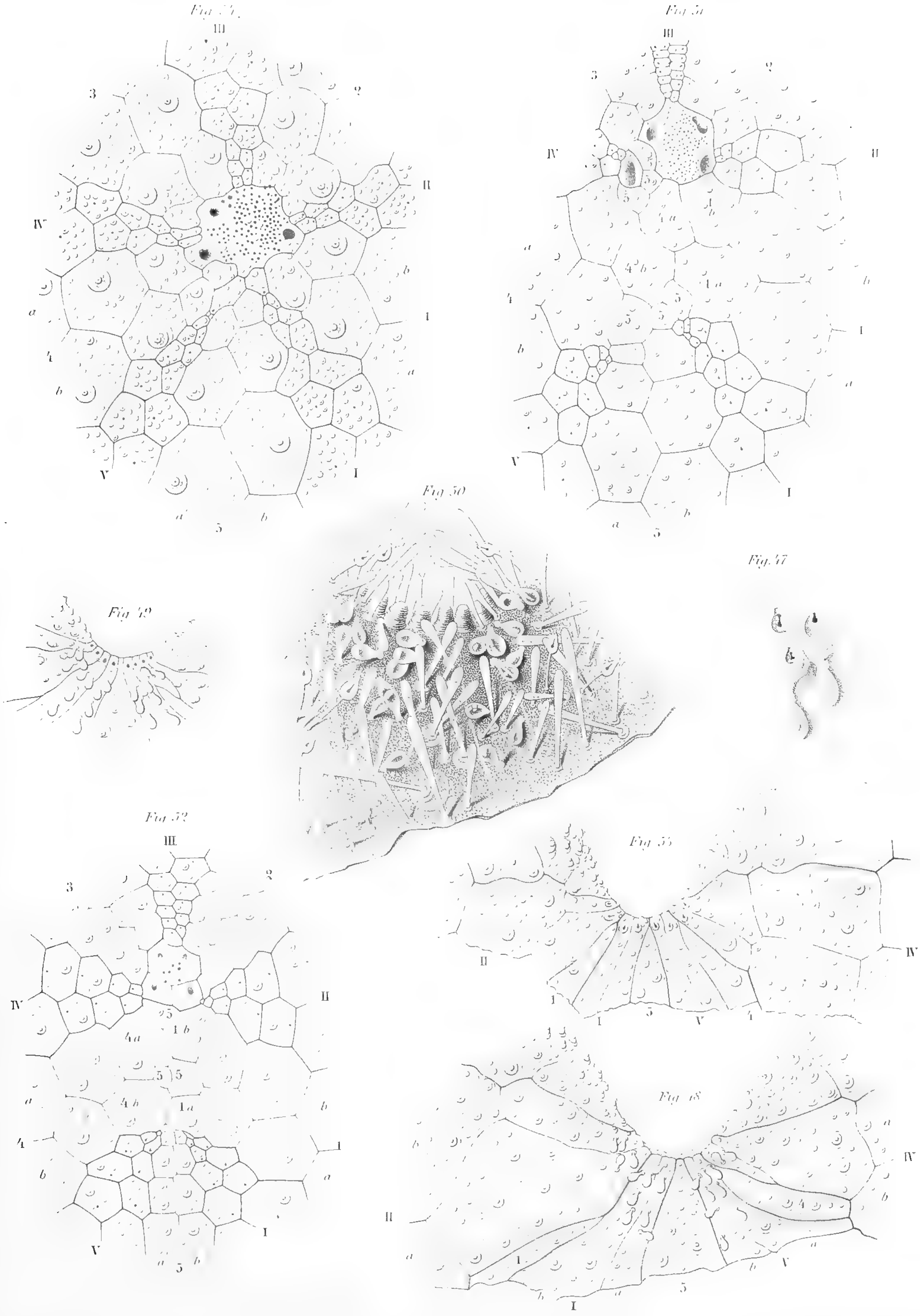
37_41. Pourtalesia laguncula AL. AG. 42_46. Pourtalesia carinata AL. AG.

PLATE VII.

Plate VII.

Pourtalesia carinata Al. Ag. **P. ceratopyga** Al. Ag. **P. laguncula** Al. Ag. **Echinocrepis cuneata** Al. Ag.

Fig. 47. Peripodia and sphæridia of the ambulacrals V *a 1* and V *b 1* in P. carinata.
Fig. 48. The sub-oral region of P. ceratopyga; ambulacrals coloured.
Fig. 49. A part of the same, in a different position.
Fig. 50. A part of the same with pedicels, spines, and spherids.
Fig. 51. The calycinal system of the same, with the surrounding region, p. 80.
Fig. 52. The same parts in P. laguncula.
Fig. 53. The sub-oral region of Echinocrepis cuneata; ambulacrals coloured.
Fig. 54. The calycinal system and surrounding area in the same.



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47. Pourtalesia carinata AL. AG. 48_51. Pourtalesia ceratopyga AL. AG. 52. Pourtalesia laguncula AL. AG.
53_54. Echinocrepis cuneata AL. AG.

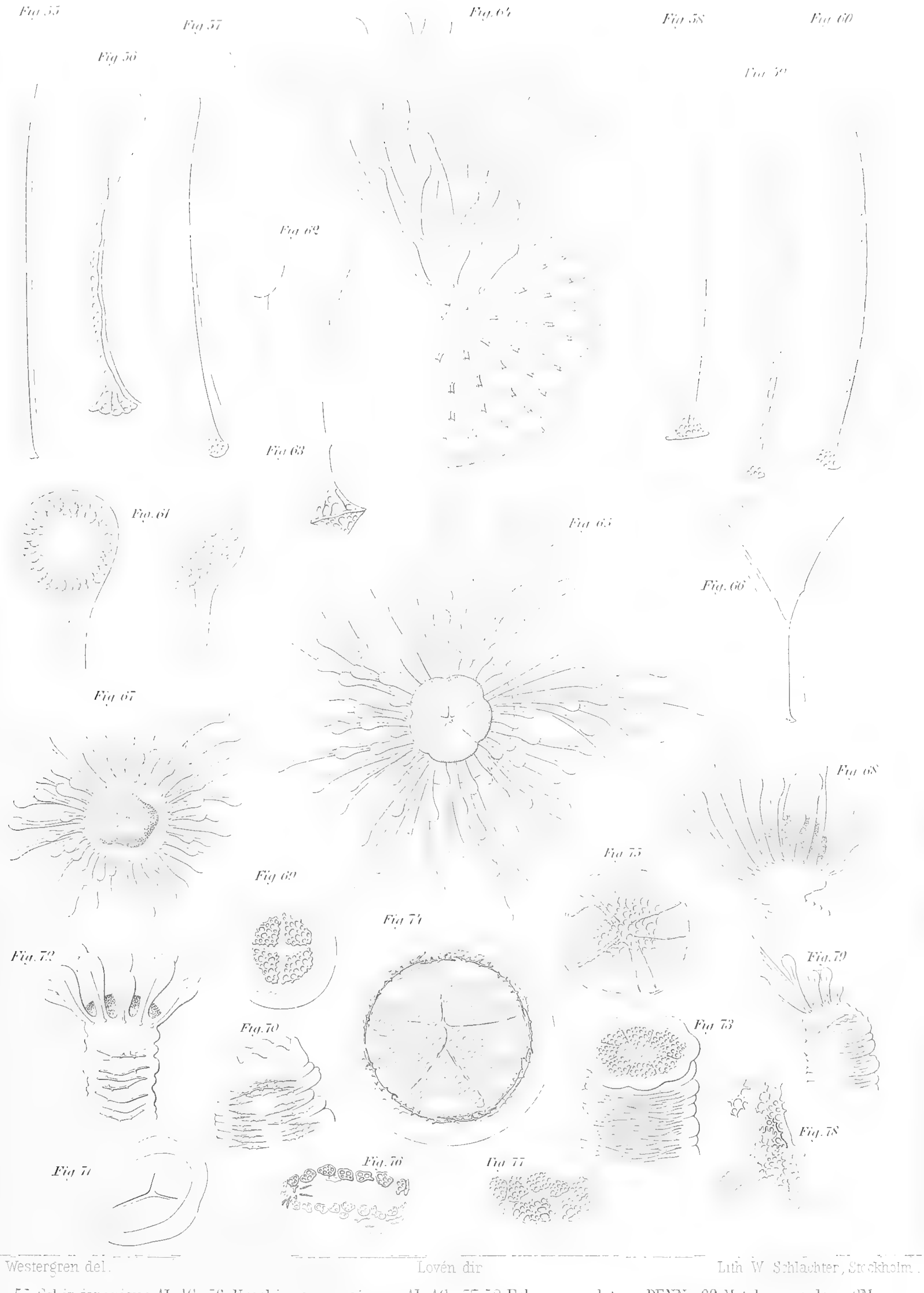
PLATE VIII.

Plate VIII.

Pedicels of Spatangidæ.

P. 45—56.

Fig. 55. A filament with its rod, from a phyllodean pedicel in Schizaster japonicus Al. Ag.
Fig. 56. The same, in Urechinus naresianus Al. Ag.
Fig. 57. The same, from a sub-anal pedicel in Echinocardium cordatum Penn.
Fig. 58. The same, from a phyllodean pedicel in the same species.
Fig. 59. The same, from a sub-anal pedicel in Lovenia elongata Gray.
Fig. 60. The same, from a phyllodean pedicel in the same species.
Fig. 61. Tips of filaments from phyllodean pedicels in the same.
Fig. 62. The same, in Metalia maculosa Gm.
Fig. 63. The basal part of the rod in a filament of a phyllodean pedicel in Abatus Philippii Lov.
Fig. 64. The circular disk of a phyllodean filament in Maretia planulata Lamck. The filaments are only partially left entire, and cut down in the greater portion of the half.
Fig. 65. The disk of a subanal pedicel in Agassizia scrobiculata Val.
Fig. 66. Monstrous bifurcation of a filament, from a sub-anal pedicel in Brissopsis lyrifera Forb.
Fig. 67. The disk of a phyllodean pedicel in Aceste bellidifera Wyv. Thoms.
Fig. 68. The same, lateral view.
Fig. 69. The top of a ventral pedicel, V, in Meoma grandis Gray.
Fig. 70. The terminal part of a frontal pedicel, III, in the same; side view.
Fig. 71. The same, from above.
Fig. 72. The disk of a phyllodean pedicel in Palæotropus Josephinæ Lov.
Fig. 73. The terminal part of a sub-anal pedicel in the same.
Fig. 74. The top of a sub-anal pedicel in Brissus compressus Lamck, seen from the under side.
Fig. 75. The same, in Brissus mediator n., seen from the under side.
Fig. 76. A ring, *psellion,* from a sub-anal pedicel in Lovenia elongata Gray.
Fig. 77. The same, in Abatus Philippii Lov.
Fig. 78. Laminæ from the phyllodean disk in Maretia planulata Lamck.
Fig. 79. A sub-anal pedicel of the same, mutilated.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

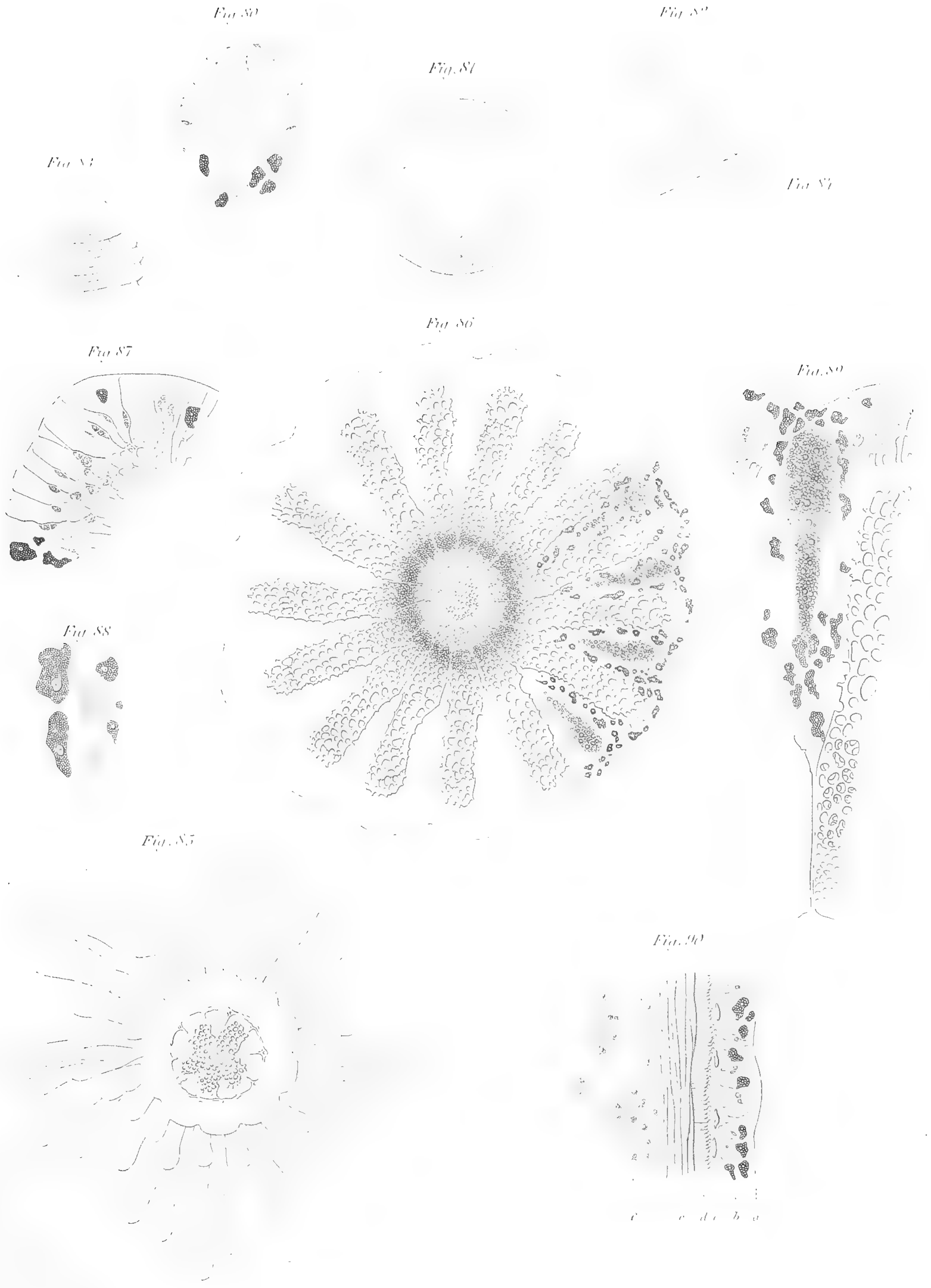
55. Schiz. japonicus AL. AG. 56. Urechinus naresianus AL. AG. 57, 58. Echinoc. cordatum PENN. 62. Metalia maculosa GM. 64, 78, 79. Maretia planulata LAMK. 59–61, 76. Lovenia elongata GRAY. 63, 77. Abat. Philippii n. 65. Agass. scrobiculata VAL. 66. Brissops. lyrifera FORB. 67, 68. Aceste bellidifera W. THOMS. 69–71. Meoma grandis GRAY. 72, 73. Palæotrop. Josephinæ n. 74. Brissus compressus LAMK. 75 Brissus mediator n.

PLATE IX.

Plate IX.

Pedicels of Brissopsis lyrifera Forbes.

Fig. 80. The tip of a filament from a phyllodean pedicel, side view, p. 45.
Fig. 81. The same, end view, seen from above.
Fig. 82. Optical section of the same, highly magnified.
Fig. 83. Terminal part of a simple, ventral pedicel, p. 47.
Fig. 84. The same of another specimen.
Fig. 85. The top of a sub-anal pedicel, p. 48.
Fig. 86. The disk of a frontal pedicel, p. 54.
Fig. 87. Optical section of the margin of the same.
Fig. 88. Pigment-cells from the same.
Fig. 89. Optical section of an intra-lamellar part of the disk.
Fig. 90. Longitudinal section of the wall of the tube of a frontal pedicel, p. 55.



A M Westergren del. Lovén dir. Lith W Schlachter, Stockholm

80_90. Brissopsis lyrifera FORB.

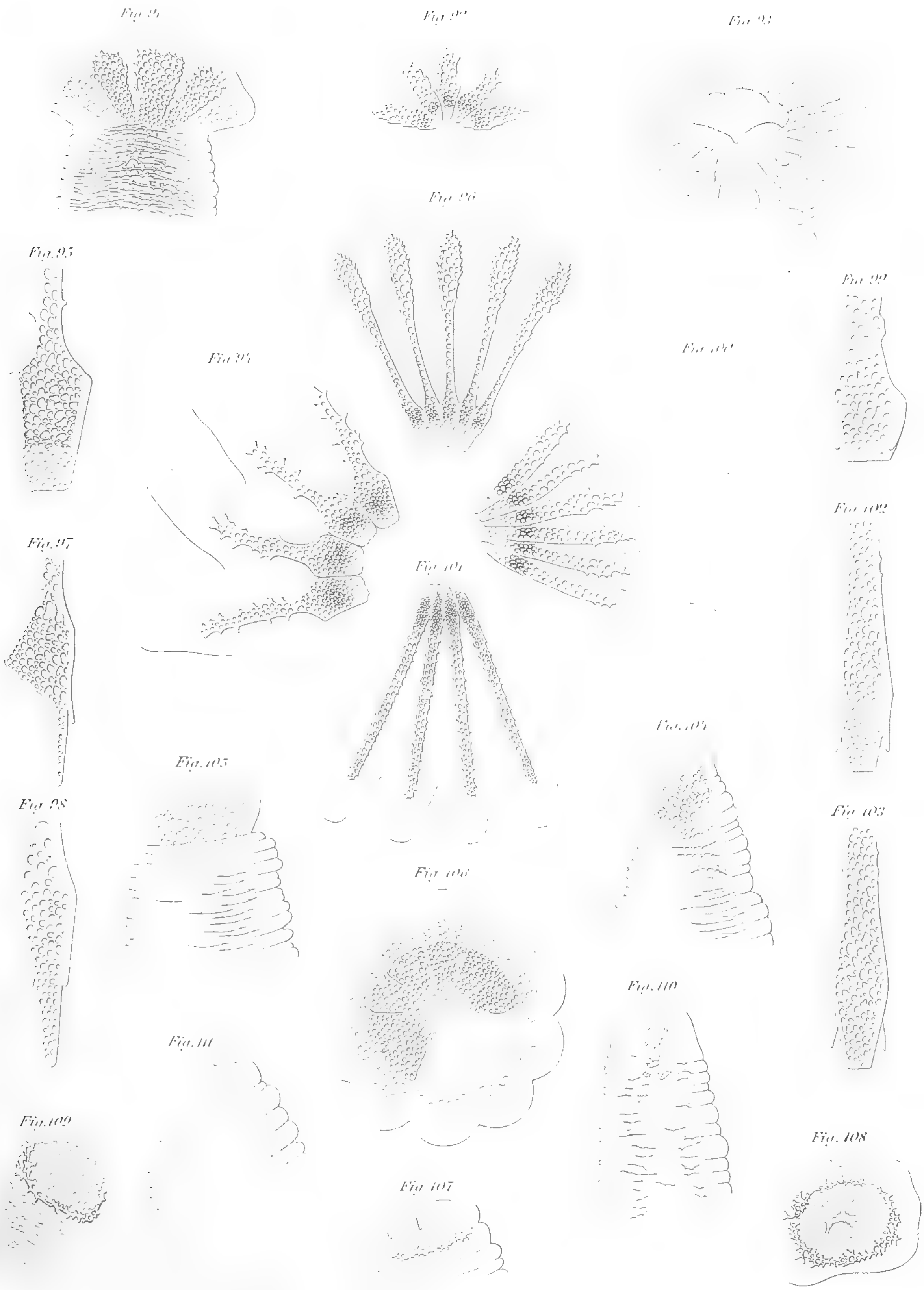
PLATE X.

Plate X.

Pedicels of Spatangidæ.

P. 52—56.

Fig. 91. The terminal part of a frontal pedicel in Abatus Philippii Lov.
Fig. 92. Half the disk of a frontal pedicel in Hemiaster expergitus Lov.
Fig. 93. The terminal part of a frontal pedicel in Agassizia scrobiculata Val.
Fig. 94. A quadrant of the disk of a frontal pedicel in Moira atropos Lamck.
Fig. 95. The basal part of one of its laminæ.
Fig. 96. A part of the disk of a frontal pedicel in Aceste bellidifera Wyv. Thoms.
Fig. 97. The basal part of one of its laminæ; side view.
Fig. 98. The same, seen from the under side.
Fig. 99. The basal part of a lamina from a frontal pedicel in Kleinia luzonica Gray, from the under side.
Fig. 100. A quadrant of the disk of a frontal pedicel in Schizaster fragilis Düb. & Kor.
Fig. 101. A part of the disk of a frontal pedicel in Schizaster japonicus Al. Ag.
Fig. 102. The basal part of one of its laminæ, from the under side.
Fig. 103. The same, from above.
Fig. 104. The tip of a simple frontal pedicel, in Maretia planulata Lamck.; side view.
Fig. 105. The same, in Metalia maculosa Gm.; side view.
Fig. 106. The top of a frontal pedicel in Metalia frontosa n.; seen from above.
Fig. 107. The same, from Lovenia elongata Gray; side view.
Fig. 108. The same; end view.
Fig. 109. The same, spicular framework, in Spatangus purpureus O. F. M.; side view.
Fig. 110. The tip of a simple, ventral pedicel, V, in Moira atropos Lamck.
Fig. 111. The same, in Schizaster japonicus Al. Ag.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

91. Abatus Philippii n. 92. Hem. expergitus n. 93. Agass. scrobiculata VAL. 94, 95, 110. Moira atropos LAMK. 96_98. Aceste bellidifera W. THOMS. 99. Kleinia luzonica GRAY. 100. Schiz. fragilis D.& K. 101, 102, 103, 111. Schiz. japonicus AL. AG. 104. Maretia planulata LAMK. 105. Metalia maculosa GM. 106. Met. frontosa n. 107, 108. Lov. elongata GRAY. 109. Spatangus purpureus O.F. M.

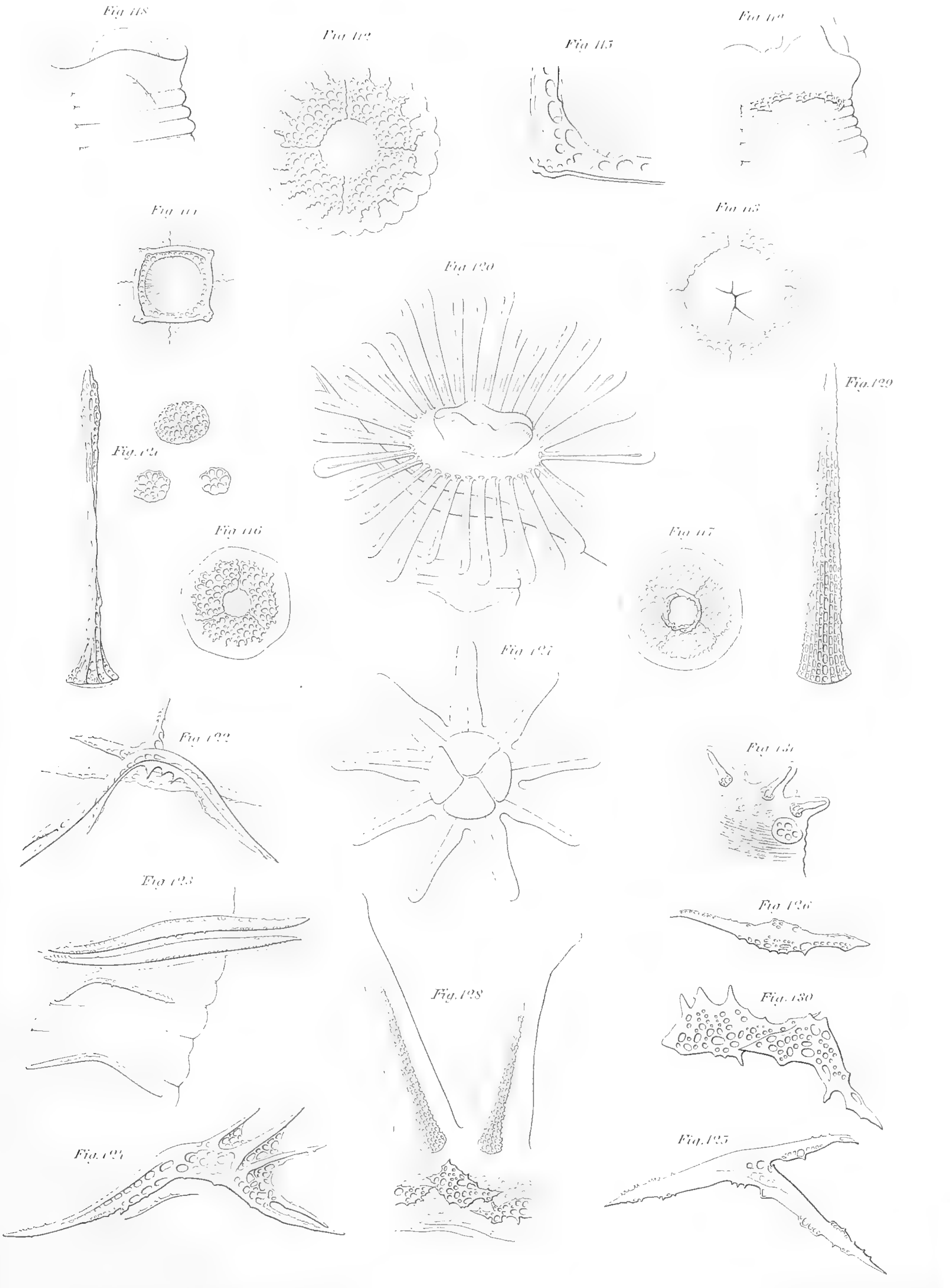
PLATE XI.

Plate XI.

Pedicels of Echinidæ, Echinoneidæ, Cassidulidæ and Spatangidæ.

P. 47, 49, 54.

Fig. 112. The disk of a pedicel in Toxopneustes droebachensis O. F. M., showing the laminæ and the converging muscular fibres; p. 49.
Fig. 113. The central circular space of the same, showing the angular depression and the plicatures of the surface.
Fig. 114. The same seen from the under side, showing the *psellion*.
Fig. 115. A part of the same more highly magnified.
Fig. 116. The disk of a pedicel in Echinoneus semilunaris Lamck., from above; p. 50.
Fig. 117. The same, from the under side, with the *psellion*.
Fig. 118. The terminal part of a pedicel in Rhynchopygus pacificus Al. Ag., p. 56.
Fig. 119. The same, in a different state.
Fig. 120. The disk of a frontal pedicel in Echinocardium cordatum Penn., with the enormously developed spicule; p. 56.
Fig. 121. A rod from one of the filaments of the same, somewhat shortened, with the basal circlet.
Fig. 122. Another form of the large spicule under the disk, in the same species.
Fig. 123. The same spicule, double.
Fig. 124. Another, spinous form of the large spicule.
Fig. 125. Another form of the same.
Fig. 126. Another smaller form of the same.
Fig. 127. The disk of one of the frontal pedicels in Echinocardium flavescens O. F. M.
Fig. 128. Two of its filaments with part of the ring, *psellion*.
Fig. 129. The rod from one of its filaments.
Fig. 130. Spicules from its ring.
Fig. 131. The terminal part of a frontal pedicel in Breynia Australasiæ Leach.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

112–115. Tox. Dröbachensis O. F. M. 116, 117. Echinon. semilunaris LAMK. 118, 119. Rhynchopygus pacificus AL. AG. 120–126. Echinocardium cordatum PENN. 127–130. Echinocardium flavescens O. F. M. 131. Breynia Australasiæ LEACH.

PLATE XII.

Plate XII.

Peripodia of Neonomous Echinoids.

P. 56.

Echinoneidæ.

IV *a 1*; III *a*.

Fig. 132. Echinoneus semilunaris Lamck.

Cassidulidæ.

Phyll. IV *a 1*; Sub-an. V *a*, V *b 22*; Front. III *a*.

Fig. 133. Pygorrhynchus pacificus Al. Ag.

Spatangidæ.

Phyll. IV *a 1*; Sub-an. V *b*, V *a*; Front. III *a*; Petal. II *a*.

Adeti.

Fig. 134. Holaster scaniensis Cotteau.
Fig. 135. Anancites ovata Leske.
Fig. 136. Hemipneustes radiatus Gm.

Prymnadeti.

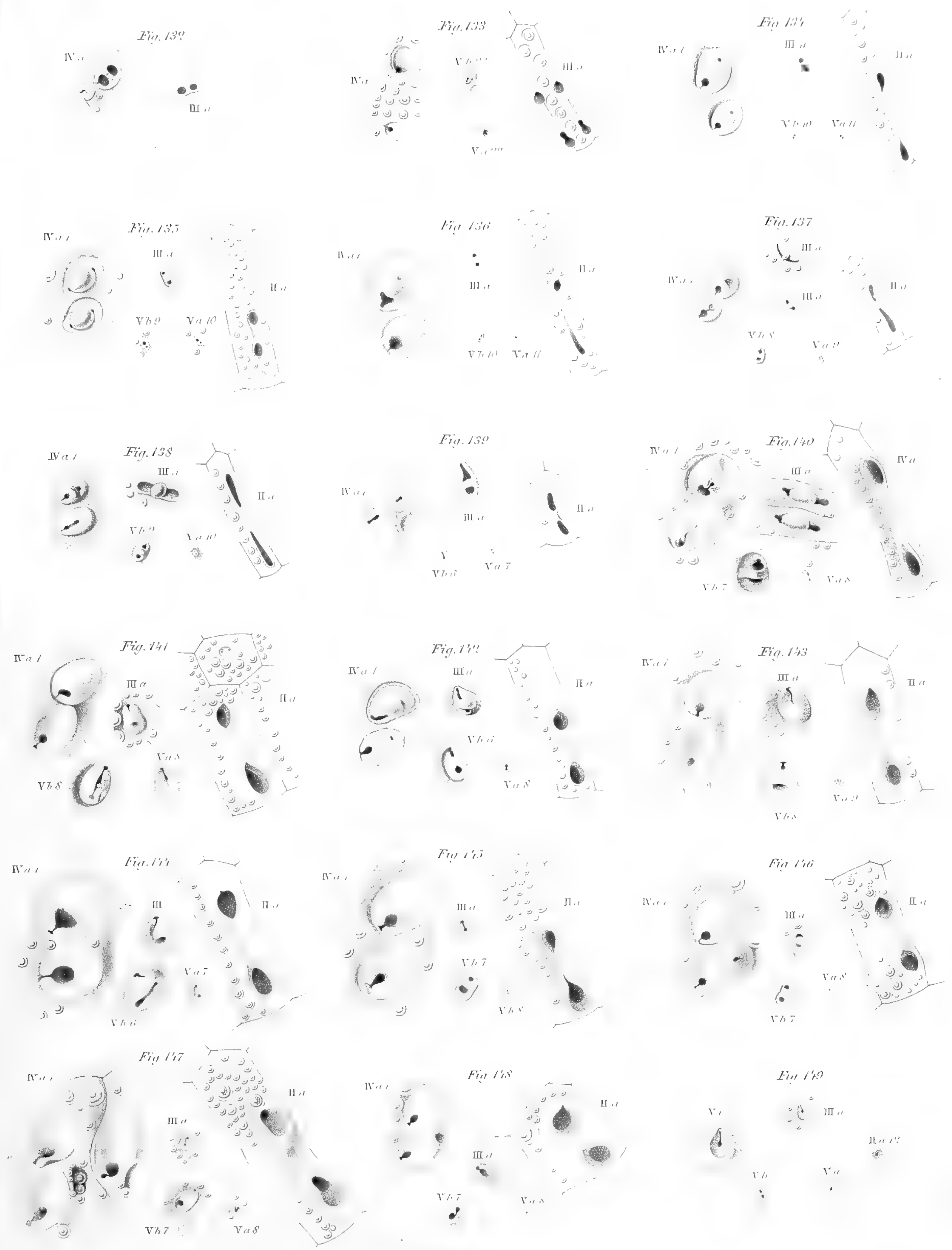
Fig. 137. Echinospatagus Ricordeanus Cotteau.
Fig. 138. Hemiaster Fourneli Cotteau.
Fig. 139. Palæostoma mirabile Gray.
Fig. 140. Schizaster japonicus Al. Ag.
Fig. 141. Agassizia scrobiculata Val.
Fig. 142. Faorina chinensis Gray.

Prymnodesmii.

Fig. 143. Brissopsis lyrifera Forb.
Fig. 144. Brissus Scillæ Lamck.
Fig. 145. Spatangus purpureus O. F. M.
Fig. 146. Lovenia elongata Gray.
Fig. 147. Maretia planulata Lamk.
Fig. 148. Echinocardium cordatum Penn.

Pourtalesiadæ.

Fig. 149. Pourtalesia Jeffreysi Wyv. Th.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

Peripodia: 132. Echinoneus. 133. Cassidulus. 134–148. Spatangea. 149. Pourtalesia.

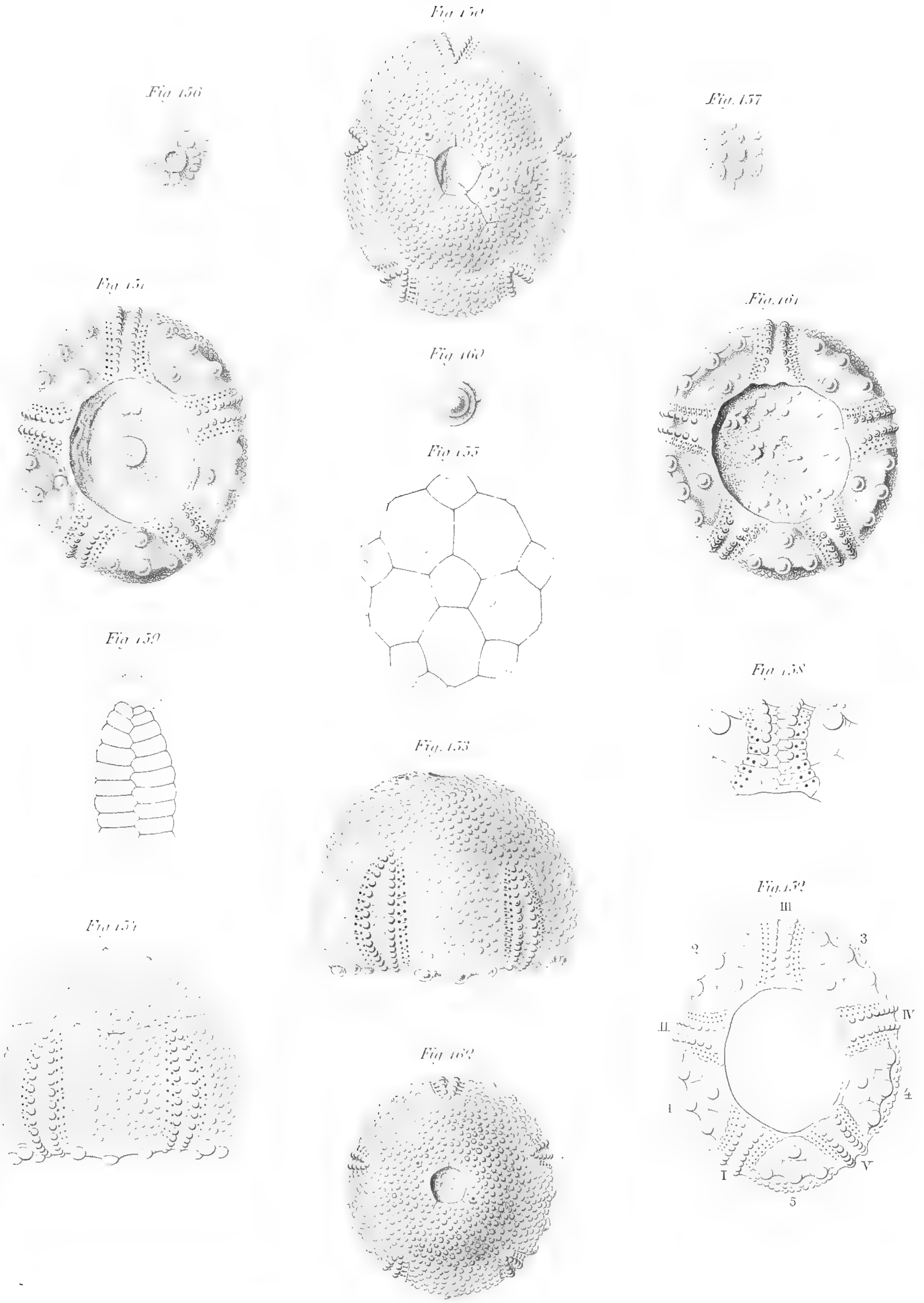
PLATE XIII.

Plate XIII.

Tiarechinus princeps Laube.

P. 11, 64.

Fig. 150. The specimen from the "K. K. Geologische Reichs-Anstalt", Vienna, dorsal view; magnified abont nine times.
Fig. 151. The same, ventral view.
Fig. 152. The same, showing the plates.
Fig. 153. The same, side view.
Fig. 154. The same, showing the plates.
Fig. 155. The calyx of the same.
Fig. 156. One of the sexual? pores.
Fig. 157. Granulation of the interradia.
Fig. 158. The adoral part of an ambulacrum.
Fig. 159. The aboral part of the same.
Fig. 160. One of the large tubercles of the interradia.
Fig. 161. The specimen from the "K. K. Hof-Mineralien Cabinet" Vienna, ventral view.
Fig. 162. Another specimen, from the same collection, dorsal view.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

150_162. Tiarechinus princeps LAUBE.

PLATE XIV.

Plate XIV.

Abatus cavernosus Phil.

P. 20, 25, 46. 74.

Fig. 163. A young specimen, measuring 2,3 mm., taken out of one of the deepened petala by the late Professor Peters of Berlin. It is jejune, astomous, aproctic. Ventral view.

Fig. 164. The same, dorsal view.

Fig. 164, A. The calycinal region.

Fig. 165. The buccal membrane, entire, unpierced, the œsophageal end of the alimentary canal with its lumen appearing on its inside. To be compared with the woodcut p. 26, representing the same parts in a specimen a little more advanced, in which the oesophageal opening has pierced the buccal membrane centrally.

Fig. 166. The calycinal region from the inside, showing the blind excretory extremity of the intestine touching the closed membrane centrally.

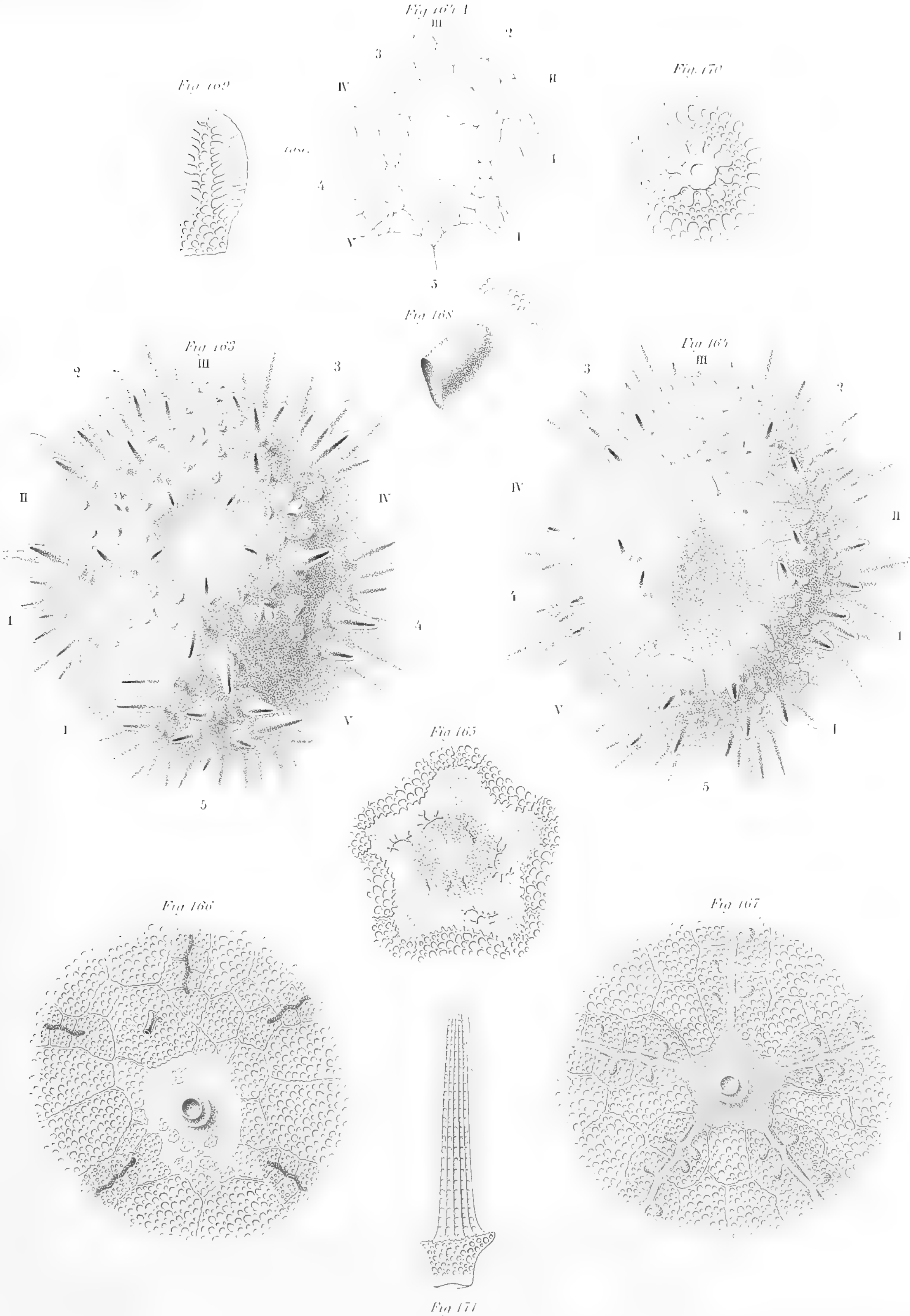
Fig. 167. The peristomal region from the inside, showing the blind oesophagus resting against the buccal membrane.

Fig. 168. The blind excretory end of the intestine, suspended to the peritoneal lining.

Fig. 169. A spherid, optical section.

Fig. 170. A tubercle.

Fig. 171. A spine with the larval envelope.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

163_171. Abatus cavernosus PHIL.

PLATE XV.

Plate XV.

Echinocardium flavescens O. F. M.

P. 26, 46.

Fig. 172. A young specimen, measuring 1,7 mm., denuded of its spines; ventral view. The oesophagus has already pierced the buccal membrane.

Fig. 173. The same; dorsal view. The periproct, just formed, high up on the back. The fasciolæ have begun to appear. In the frontal ambulacrum, III, a single pedicel, others being probably lost. The details of the calycinal system were obscured by some opaque substance contained in the intestine, and could not be made out properly.

Fig. 174. The peristomal region of a specimen measuring 3 mm.

Fig. 175. A part of the peristomal region of a specimen between fig. 173 and 174.

Fig. 176. The top of a phyllodean pedicel in the early state, fig. 172.

Fig. 177. Another with two rods beginning to form.

Fig. 178. The filaments with their rods a little more advanced.

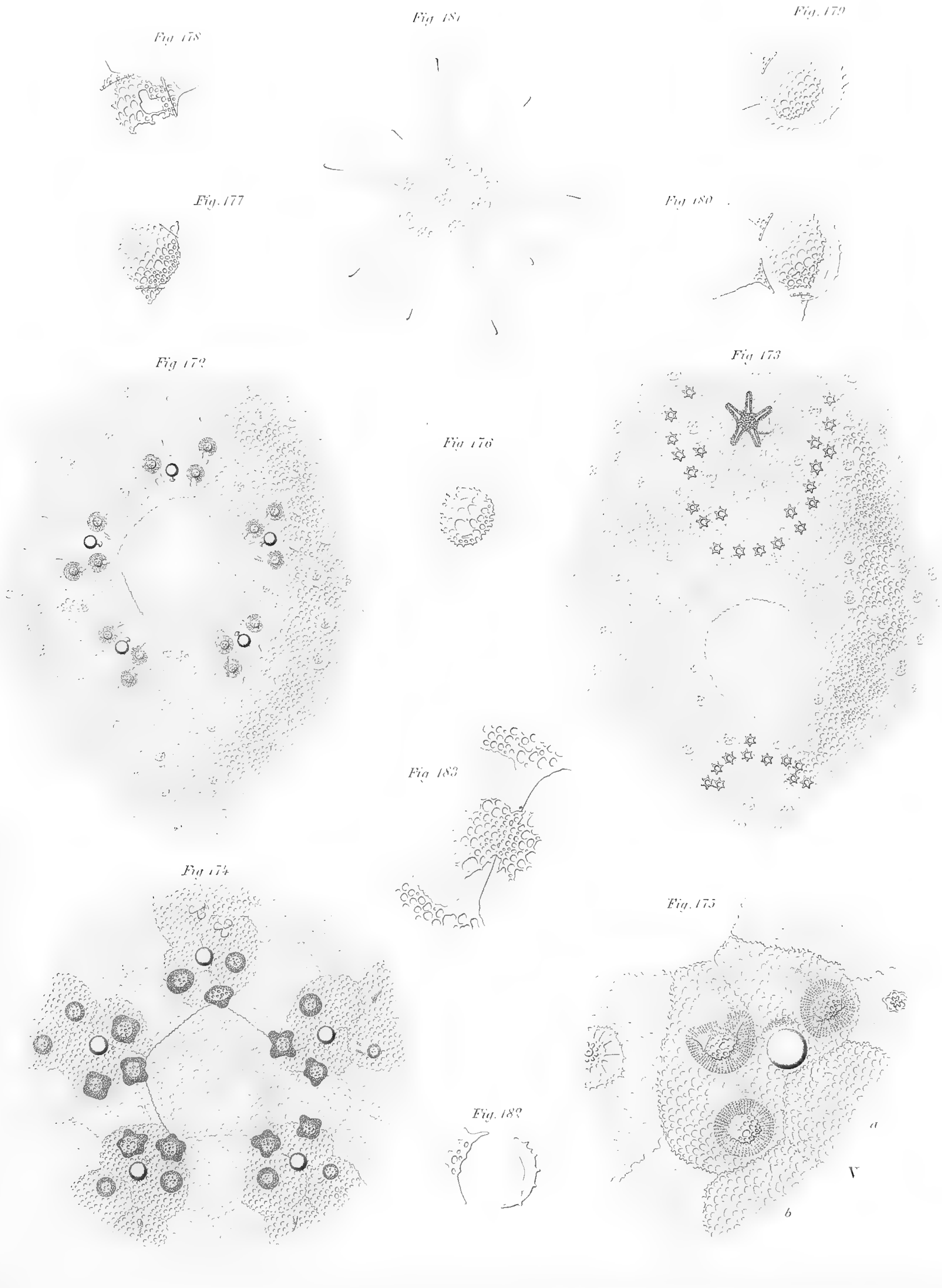
Fig. 179. Another with the *psellion*.

Fig. 180. Another with the rudiments of three filaments.

Fig. 181. The disk of a phyllodean pedicel in a young specimen measuring 5,3 mm., with eight filaments in a circle and a ninth filament beginning an inner series.

Fig. 182. Spicules from its *psellion*.

Fig. 183. The peristomal part of an interradium from the inside, showing the transverse laminæ, p. 26.



A. M. Westergren del. Lovén dir. Lith. W. Schlachter, Stockholm.

172–183. Echinocardium flavescens O. F. MÜLLER.

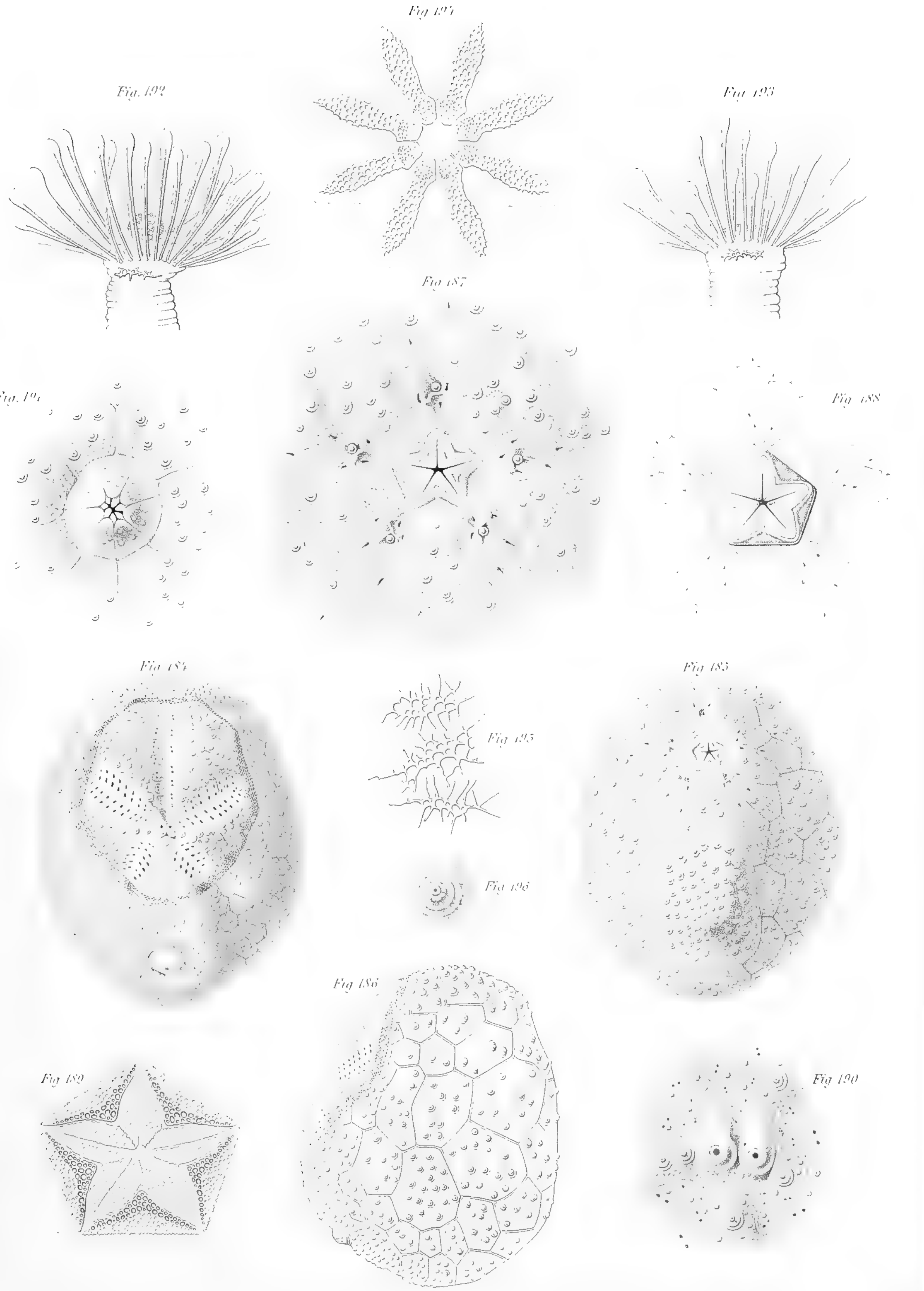
PLATE XVI.

PLATE XVI.

Palæostoma mirabile GRAY.

P. 27, 45, 53.

Fig. 184. A half-grown specimen, dorsal view.
Fig. 185. The same, ventral view.
Fig. 186. The same, side view.
Fig. 187. The peristomal region, with the pentangular stoma, the valves, the first spherids etc.
Fig. 188. The peristome, with the valves, from the inside.
Fig. 189. The valves, from the outside.
Fig. 190. The calyx with the two sexual pores.
Fig. 191. The excretory opening with its valves.
Fig. 192. A phyllodean pedicel.
Fig. 193. Another phyllodean pedicel, both showing what seems to be a central protuberance.
Fig. 194. The disk of a frontal pedicel, p. 53.
Fig. 195. Spicules from a pedicellar tube.
Fig. 196. A tubercle.



A. M. Westergren. del. Lovén dir. Lith. W. Schlachter, Stockholm.

184–196. Palæostoma mirabile GRAY.

PLATE XVII.

Plate XVII.

The Calycinal System of Spatangidæ.

P. 74.

Fig. 197. The calyx of a specimen of Echinocardium flavescens O. F. M., measuring 3,5 : 3 mm.
Fig. 198. The same, at 7 : 6 mm.
Fig. 199. The same, at 8 : 6 mm.
Fig. 200. The same, at 9 : 7,5 mm.
Fig. 201. The same, at 9,5 : 8 mm.
Fig. 202. The same, at 10,5 : 9 mm.
Fig. 203. The same, at 10,5 : 9 mm.
Fig. 204. The same, at 12 : 10 mm.
Fig. 205. The same, at 14,5 : 12 mm
Fig. 206. The same, at 30 : 26 mm.
Fig. 207. The same, at 36 : 32 mm.
Fig. 208. The calyx of Palæotropus Josephinæ Lov.

Fig. 197

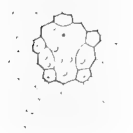


Fig. 198

Fig. 199

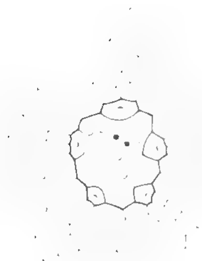


Fig. 200

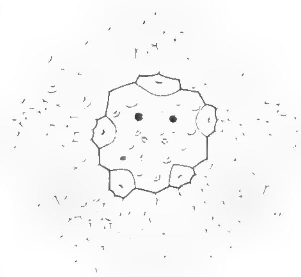


Fig. 201

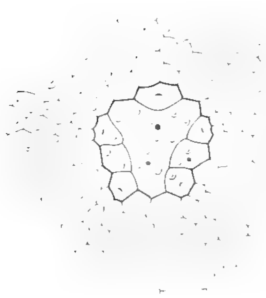


Fig. 202

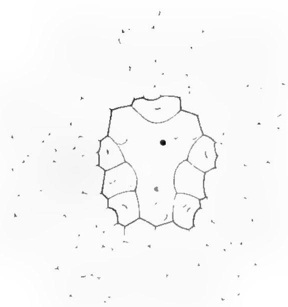


Fig. 208

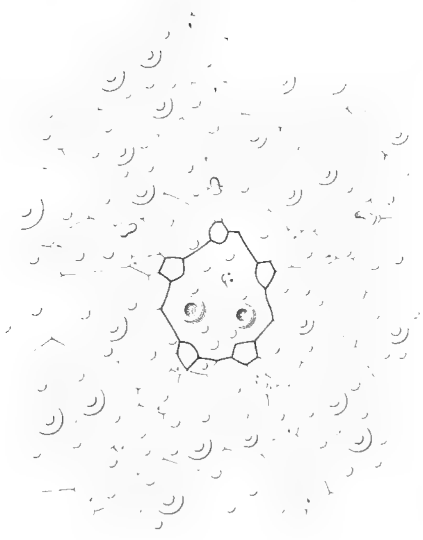


Fig. 203

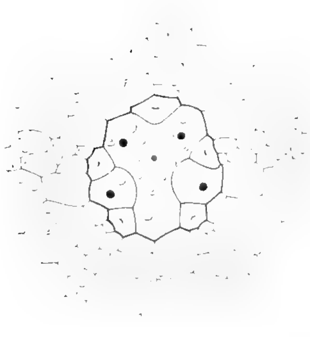


Fig. 204

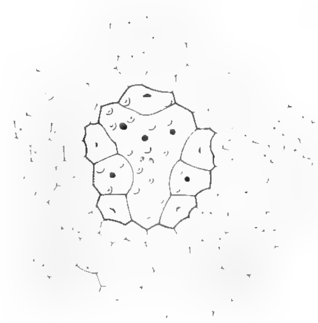


Fig. 205

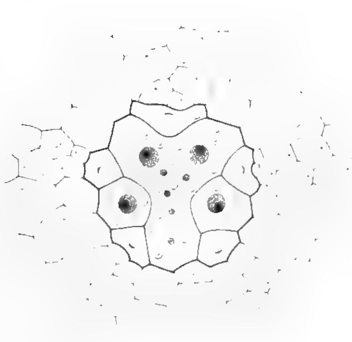


Fig. 207

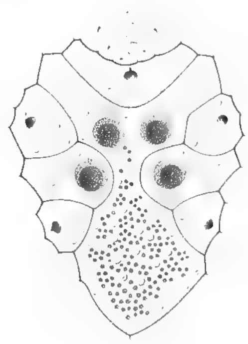
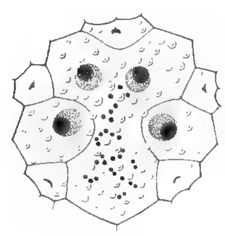


Fig. 206



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197–207. Echinocardium flavescens O. F. MÜLLER. 208. Palæotropus Josephinæ LOV.

PLATE XVIII.

Plate XVIII.

The Calycinal System of Spatangidæ.

P. 74.

Fig. 209. The calyx of a specimen of Spatangus purpureus O. F. M., of 5 : 4 mm.
Fig. 210. The same, at 13,5 : 12 mm.
Fig. 211. The same, at 14 : 13 mm.
Fig. 212. The same, at 15 : 14 mm.
Fig. 213. The same, at 15 : 14 mm.
Fig. 214. The same, at 16 : 15 mm.
Fig. 215. The same, at 18 : 16 mm.
Fig. 216. The same, at 19 : 18 mm.
Fig. 217. The same, at 24 : 21 mm.
Fig. 218. The same, at 23 : 22 mm.
Fig. 219. The same, at 53 : 50 mm. A single madreporic pore, marked *, outside the calyx.
Fig. 220. The calyx of Abatus cavernosus Phil.
Fig. 221. The same of Hemiaster bufo Al. Brogn.
Fig. 222. The same of Hemiaster expergitus Lov.

Fig. 210

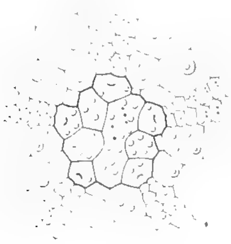


Fig. 209

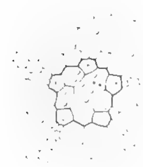


Fig. 211

Fig. 213

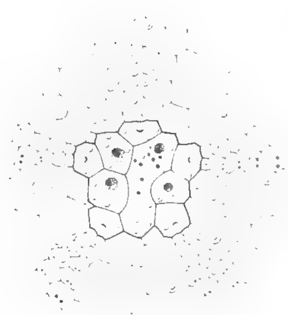


Fig. 212

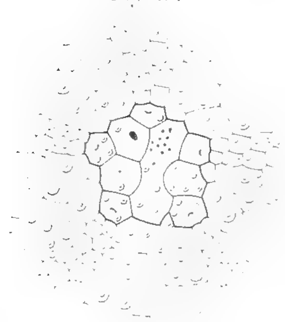


Fig. 214

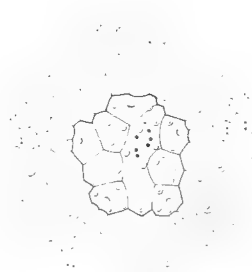


Fig. 220

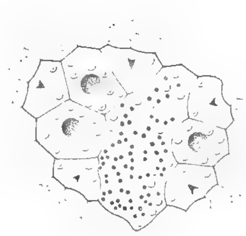


Fig. 215

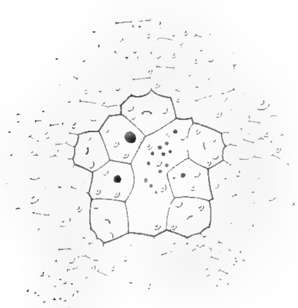


Fig. 216

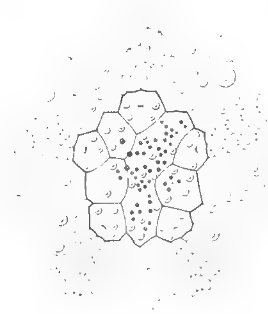


Fig. 221

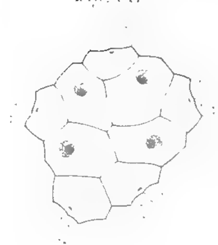


Fig. 222

Fig. 217

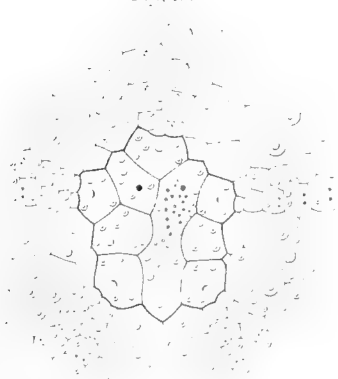


Fig. 219

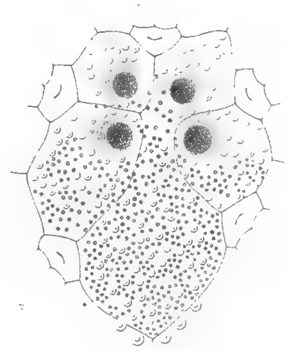
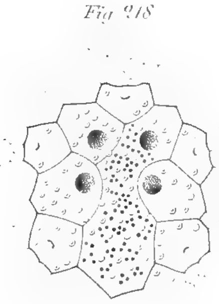


Fig. 218



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209–219. Spatangus purpureus O.F.M. 220. Abatus cavernosus PHIL. 221. Hemiaster bufo DESOR. 222. Hemiaster expergitus LOV.

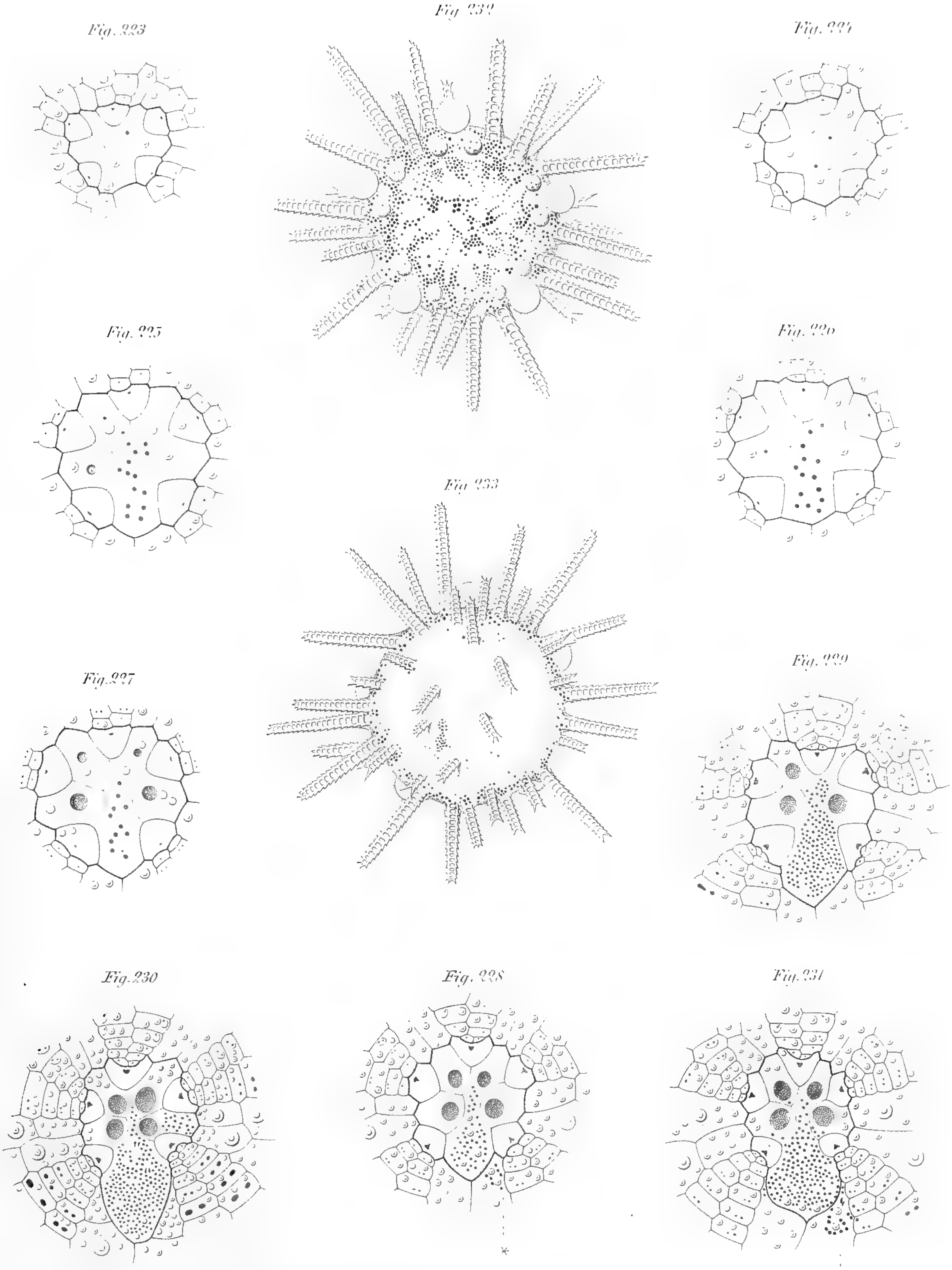
PLATE XIX.

Plate XIX.

The Calycinal System of Brissopsis; young of Echinus.

P. 75.

Fig. 223. The calyx of a specimen of Brissopsis lyrifera Forb., of 9 : 7 mm.
Fig. 224. The same, at 11 : 9 mm.
Fig. 225. The same, at 15 : 12 mm.
Fig. 226. The same, at 15 : 13 mm.
Fig. 227. The same, at 16 : 13 mm.
Fig. 228. The same, at 38 : 35 mm., having a number of madreporic pores in the interradium 5.
Fig. 229. The same, at 42 : 38; the costal 2 without sexual pore.
Fig. 230. The same, at 44 : 40; the madreporite spreading outside the sexual pore in the costal 1.
Fig. 231. The same in a nearly full-grown specimen, with a larger number of madreporic pores in the interradium 5, and a few in the ambulacrum I.
Fig. 232. Echinus sp. young, 0,6 mm., astomous, aproctic, jejune, same specimen as that described in Études p. 27, pl. XVII, fig. 149—152; dorsal view; p. 25.
Fig. 233. The same, ventral view.



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223_231. Brissopsis lyrifera FORB. 232_233. Echinus sp.

PLATE XX.

Plate XX.

Aceste bellidifera Wyv. Thoms. **Schizaster canaliferus** Lamck.

P. 88.

Fig. 234. The skeleton of Aceste bellidifera Wyv. Thoms., laid out.
Fig. 235. The buccal membrane of the same.
Fig. 236. The anal membrane of the same.
Fig. 237. The calycinal system of the same.
Fig. 238. The calycinal system of Schizaster canaliferus Lamck.

Fig. 234

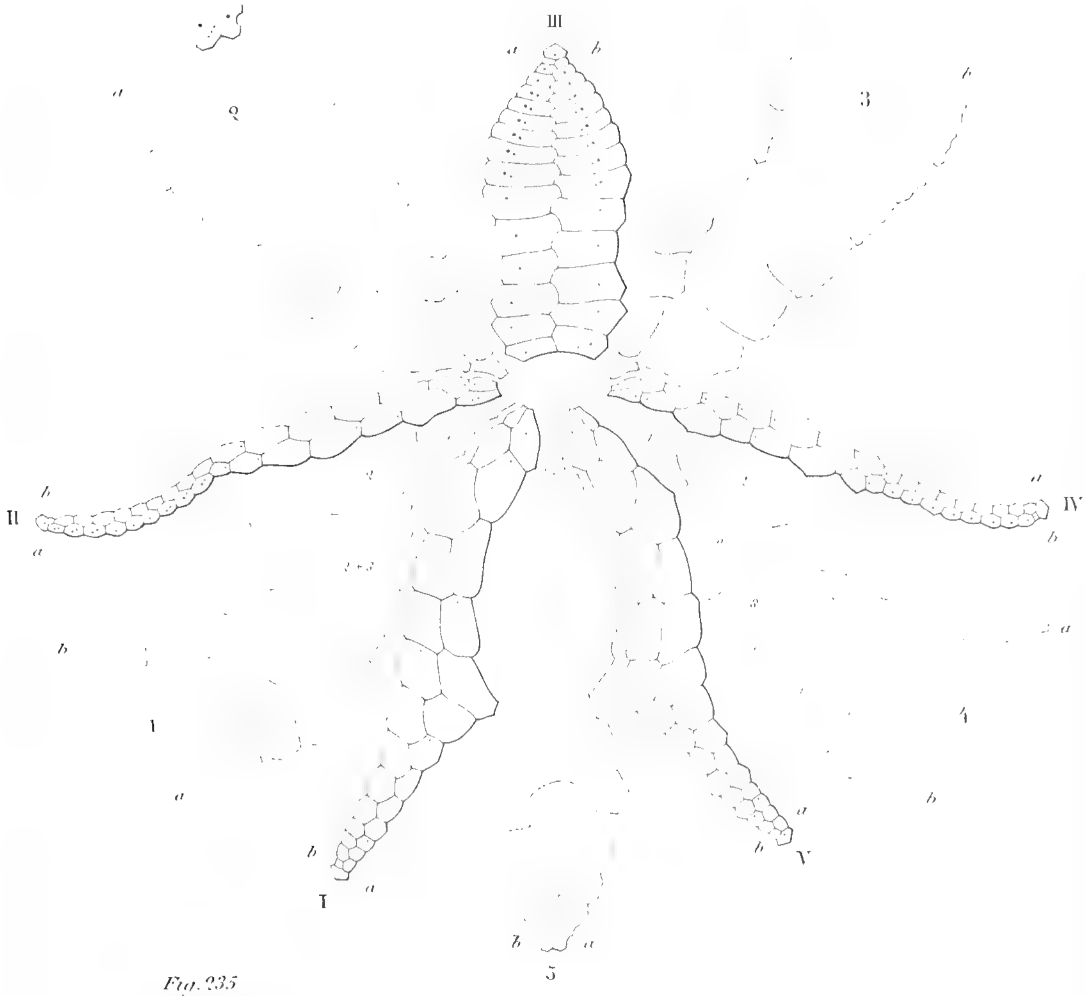


Fig. 235

Fig. 236

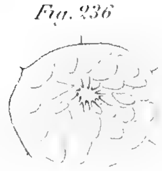


Fig. 238

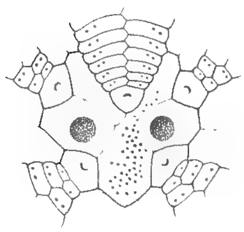
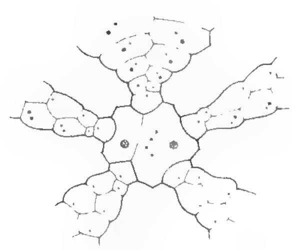


Fig. 237



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234_237. Aceste bellidifera WYV. TH. 238. Schizaster canaliculatus LAMK.

PLATE XXI.

Plate XXI.

Urechinus Naresianus Al. Ag.

P. 90.

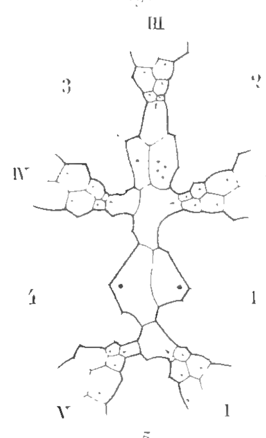
Fig. 239. The skeleton of Urechinus Naresianus Al. Ag., laid out.
Fig. 240. The buccal membrane of the same.
Fig. 241. The anal membrane of the same.
Fig. 242. The calycinal system of the same.

Fig. 239.

Fig. 240.

Fig. 241.

Fig. 242.



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239–242. Urechinus Naresianus AL. AG.