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REPORTS

ON THE

RESULTS OF DREDGING,

UNDER THE SUPERVISION OF

ALEXANDER AGASSIZ,

IN THE GULF OF MEXICO (1877–78), IN THE CARIBBEAN SEA (1878–79), AND ALONG THE ATLANTIC COAST OF THE UNITED STATES (1880),

BY THE

U. S. COAST SURVEY STEAMER "BLAKE,"

LIEUT.-COM. C. D. SIGSBEE, U. S. N., AND COMMANDER J. R. BARTLETT, U. S. N., COMMANDING.

XXIV. PART I.

Report on the Echini. *By* ALEXANDER AGASSIZ.

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WITH THIRTY-TWO PLATES.

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INTRODUCTION.

The Preliminary Reports on the Echini of the Blake Expeditions for 1877–78, for 1878–79, and for the summer of 1880, were published in Vol. V., No. 9, Bull. M. C. Z., and Vol. VIII., No. 2, Bull. M. C. Z. In the former Report will be found all the Stations occupied in the Gulf of Mexico and Straits of Florida; in the latter, the Stations explored along the West India Islands and the Atlantic coast of the United States. I give in this Report, therefore, only principal localities in sufficient number to indicate the geographical range and bathymetrical distribution of each species as determined by the dredgings of the "Blake." In the Report on the Echini of the Challenger Expedition I have given a list of the bathymetrical and geographical distribution of all the species of Echini then known, including the species collected by the Blake Expeditions. The Preliminary Reports on the Deep-sea Echini, collected by Mr. Pourtalès off the Florida Reefs, were published in the Bull. M. C. Z., Vol. I., No. 9. The final Report was incorporated in Part II. of the Revision of the Echini under the name of "East Coast Echini," Ill. Cat. M. C. Z., No. VII. Mem. M. C. Z., Vol. III., 1872–74.

The importance of the collection of the Echini brought together during the cruises of the "Blake" is well shown by a comparative statement of our knowledge of the Caribbean Echinid Fauna before and after the explorations undertaken under the auspices of the United States Coast Survey.

There are now known eighty-three species of Sea-urchins from the Caribbean Fauna. Of these, eleven were added by the dredgings of Count Pourtalès in the "Bibb" and "Hassler," nineteen were discovered by the "Blake," and thirteen species previously known from other districts were dredged for the first time in the Caribbean and adjoining seas by the Coast

Survey Expeditions, so that the list of species has been more than doubled by the dredgings made since 1876.

In consequence of the great delay in preparing the illustrations of the more minute structure of the Salenidæ, the Echinothuriæ, and many of the less well known Spatangoids, the concluding Part of this Report will appear on their completion.

The details of the geographical distribution of the Echini of the "Blake" having already been given in the Preliminary Reports (Bull. M. C. Z., Vol. V. No. 9, 1878, Vol. VIII. No. 2, 1880), to avoid repetitions I merely refer to the previously published records, as well as to the list of the dredging stations occupied by the "Blake" (Bull. M. C. Z., Vol. VI. No. 1, 1879, Vol. VIII. No. 4, 1881). These give the position, the depth, the temperature, and the character of the bottom. On the completion of the Reports by the different specialists, who have kindly consented to work up the collections of the "Blake," including the examination of the bottom samples, I hope to make a revision of the geographical and bathymetrical distribution of the various groups, so as to give a good picture of the animals associated at the principal localities which make up the Fauna characteristic of certain well-defined regions. Nothing can be more different, for instance, than the animals found associated on the rocky bottom along the southern slope (in deep water) of the Florida Reef, on the Pourtalès Plateau, with its predominance of Corals, Rhizocrini, and Starfishes, from those found in the calcareous ooze of the trough of the Gulf Stream (Lamellibranchiates, Holothurians, &c.); and again from the association of the masses of Gorgoniæ, Saleniæ, and Terebratulæ, off the north coast of Cuba, brought up in a single haul of the trawl. Nor can there be a greater contrast between the inhabitants of the Pteropod ooze in deep water off the west end of Santa Cruz, with its preponderance of Phormosomæ, of Asthenosomæ, and Hyalonemæ, and those of the forests of Pentacrini and Gorgoniæ, and the accompanying Comatulæ and Ophiurans, living in such abundance on the windward coast of St. Vincent.

We may contrast, again, the deep-water Fauna off the Tortugas, in the coral ooze, mainly made up of a most remarkable association of Fishes and Crustacea, with the hauls in deep water, at special localities, made up entirely of thousands of specimens of single species, either of Ophiurans, of Echini, of Comatulæ, of Crustaceans, or of Gorgoniæ.

Take again the bottom along the ridges between the West India Islands, or along the course of the Gulf Stream off the Carolinas, which are swept nearly clear of all animal life, and compare that to the rich and varied Fauna found at the same depths along the continental shelf farther north, and along the western shelf of the Windward Islands, on the lee side, in the Caribbean; or compare these Faunæ in turn with the mass of animal life, mainly composed of Gorgoniæ, of Calcareous and Horny Sponges, found upon the great plateau on the west of Florida and on the Yucatan Bank; there can be no greater contrasts within the narrowly circumscribed areas I have mentioned, all belonging to the West Indian Fauna taken as a whole. This clearly indicates great faunal contrasts in very limited areas, differing principally in the character of the bottom, and where the physical conditions, such as temperature, depending mainly upon currents and winds, are in striking opposition within comparatively moderate distances.

ALEXANDER AGASSIZ.

CAMBRIDGE, MASS., September 1, 1883.

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SPECIES ARRANGED SYSTEMATICALLY.

NOTE. — Species marked * were discovered by the "Blake"; those marked P were first dredged by Mr. Pourtalès; species marked °* and °P were previously known from other localities, and subsequently dredged in the Caribbean and along Florida by the "Blake" or Mr. Pourtalès. The species without any notation were previously known from the Caribbean region.

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Cidaris tribuloides BL.

Off St. Kitts, 250 fathoms. Flanegan Passage.
Lat. 24° 44′ N., Long. 83° 26′ W. 37 fathoms.

* **Dorocidaris Bartletti** A. AG.

Dorocidaris Bartletti A. AG. Bull. M. C. Z., VIII., No. 2, p. 69, 1880.
Montserrat to Barbados. 88–398 fathoms.

Pl. II. Figs. 16–27.

At St. Vincent and at Martinique were first collected a number of remarkable spiny transversely banded radioles (Pl. II. Figs. 18, 19, 26, 27) similar to those of *Goniocidaris bispinosa*, and which I had already noticed in the earlier Preliminary Reports of the Blake Expedition for 1877–78. From Barbados a few specimens of Cidaris were dredged, showing these radioles to belong to a species of Dorocidaris differing from *D. papillata* and *D.*

* Species marked * were discovered by the "Blake."

Blakei in the shape of the plates of the abactinal system (Pl. II. Fig. 17). The ocular plates are in contact with the extremities of the large anal plates inserted between the genital plates; the other plates of the anal system are of a more uniform size than in the other species of the genus. In a specimen measuring 50 mm. in diameter, there are 7–8 primary interambulacral plates; these are covered by a comparatively coarse, irregularly arranged secondary granulation. The poriferous zone is somewhat flexuous, the furrows more distant, and the median ambulacral granulation finer, than in the other West India species of the genus. The ambulacral papillæ and those at the base of the primary radioles of *D. Bartletti* are nearly of uniform size; in *D. papillata*, those surrounding the radioles are somewhat larger, and in *D. Blakei* they are still more different, being comparatively much wider and flatter than the narrow ambulacral papillæ.

*Dorocidaris Blakei A. Ag.

Dorocidaris Blakei A. Ag. Bull. M. C. Z., V., No. 9, p. 185, Pl. IV., 1878.
Dorocidaris Blakei A. Ag. Bull. M. C. Z., VIII., No. 2, p. 70, 1880.
Off Havana, 175–450 fathoms.
Santa Cruz to Barbados, 163–270 fathoms.

Pl. I., Pl. II. Figs. 1–15.

This species (Pl. I.) is perhaps the most interesting of the recent Cidaridæ. Thus far the living Cidaridæ known have not shown any great or striking variety in the form of the radioles. With the exception of some of the recent species of the genus *Goniocidaris*, the radioles as a whole are characterized by their great uniformity, while among the fossils of the family the great variation in the shape and size of the radioles of some of the Jurassic and Cretaceous species is most remarkable. In the description of species of the recent Cidaridæ, it has not been unusual to lay great stress upon the differences noticed in the shape and ornamentation of the radioles. Comparative studies of recent and fossil types have shown the practice to be dangerous, and the discovery of *D. Blakei* plainly proves that hereafter we must proceed most cautiously in the determination of species from the characters of the radioles alone, no matter how strikingly they may appear to differ. Certainly, if the present species had been dredged without its two or three huge fan-shaped spines, it would have been unhesitatingly placed in the genus Dorocidaris, and been perhaps referred even to *D. papillata*, although there are differences in the coronal plates of the test and in the abactinal system (Pl. II. Figs. 1, 2) which would undoubtedly lead to their being considered specifically distinct. Yet, if the isolated huge fan-shaped radioles had alone been dredged, radioles (Pl. II. Figs. 7–10) nearly identical in shape with those of the Jurassic *Rhabdocidaris remus* Des. (Phyllacanthus Br.) few palæontologists would have hesitated to refer them to that genus.

A comparison of the differences in the test of this species and of *D. papillata* shows that the coronal plates (Pl. II. Fig. 1) have a comparatively larger and more elliptical scrobicular area, surrounded by a single row of larger secondary tubercles; the tubercle and boss are much smaller, and the tuberculated spaces of the median interambulacral area are also narrower. In a specimen measuring 37 mm. there are 6–17 primary interambulacral plates, while in a smaller specimen of *D. papillata*, measuring 35 mm., there are 7–8 primary interambulacral plates. In the ambulacral areas the poriferous zone is nearly as broad as the median ambulacral spaces (Pl. II. Fig. 1), while in *D. papillata* it is narrower; the secondary ambulacral tubercles are also smaller than in that species. It also differs from *D. papillata* in having a smaller anal system, but this is covered by a larger number of plates inside the outer row (Pl. II. Fig. 2) than in *D. papillata*. The ornamentation of the radioles is the same on the long fusiform, or cylindrical, or the more or less fan-shaped radioles of the test (Pl. II. Figs. 3–10); these figures show well the gradual passage from a long, sharp-pointed, cylindrical radiole (Pl. II. Fig. 3) to a huge fan-shaped radiole (Fig. 10), through the successive stages of Figs. 4–9, in which the radioles become little by little more flattened and spreading at the extremity. As the radioles become more fan-shaped, the rows of spinules are gradually changed into minute serrations, spreading more and more, and becoming somewhat less prominent towards the extremity, rows of smaller serrations being intercalated as the extremity of the radioles becomes more and more fan-shaped. The broad end of the fan-shaped radioles is sometimes slightly concave.

In the first specimens of this species, dredged by Captain Sigsbee, there were no radioles showing the intermediate stages here figured between the long, sharp, cylindrical radioles of Plate II. Figs. 3, 4, and such fan-shaped ones as are figured in Plate II. Figs. 9, 10. Enough has been shown from the examination of this species to show how little we are as yet able to determine among the Cidaridæ the value of either generic or specific characters. Before we can hope to make the much needed accurate revision of this family we need a large mass of material, especially from the fossil species, in the way of spines associated with their respective tests.

When alive these Echini were of a brilliant vermilion color.

Among the specimens of *D. Blakei* there are a number without fan-shaped radioles; others, in which there were only one or two of the slightly flattened radioles similar to those of Plate II. Fig. 5; others again, in which there were a few radioles like those of Plate II. Fig. 7; and others, in which a few of the fan-shaped radioles took the extraordinary development we find figured in Plate I.

Dorocidaris papillata A. Ag.

For localities see Bull. M. C. Z., V., No. 9, p. 185, 1878; Bull. M. C. Z., VIII., No. 2, p. 70, 1880.

On our coast this species has been found by the "Blake" as far north as Lat. 32° 33′ N., Long. 77° 30′ W. Along the Florida reefs, in the Gulf of Mexico, and along the West India Islands, it is the most common sea-urchin found from about 100 to 300 fathoms. I have dredged it to a depth of 842 fathoms off the Grenadines.

* **Porocidaris Sharreri** A. Ag.

Porocidaris Sharreri A. Ag. Bull. M. C. Z., VIII., No. 2, p. 71, 1880.
Nevis, Barbados, 122–356 fathoms.

Pl. III., Pl. IV. Figs. 1, 2.

This species differs from its Atlantic congener, *P. purpurata* Wy. Th., in having a comparatively larger number of ambulacral plates, — no less than fifteen for the median interambulacral plates (Pl. IV. Fig. 1) in the largest specimen collected, while in a specimen of *P. purpurata* of nearly the same size there are only ten; the ambulacral granulation is also much finer, and the large areolar ring of comparatively large granules is flanked by smaller granules arranged in irregular lines parallel to the suture. We find no such arrangement in the coarse granulation of the interambulacral plates of *P. purpurata*.

This is a larger species (Pl. III.) than either of the other recent ones thus far known. The two largest specimens collected were males; a single small female, measuring slightly over an inch in diameter, shows that in this species, as in *P. elegans*, the genital openings are placed within the genital plates (Pl. IV. Fig. 2).

The abactinal system (Pl. IV. Fig. 2), which is but sparsely covered by papillæ, is remarkable for the size of the anal system, comparatively larger than in the other species of the genus, and for the elongate genital and ocular plates.

The primary radioles are smooth, and uniformly tapering; in one of the specimens, which was of a light greenish pink color when alive, the spines are white with a delicate brownish-pink base. In the other large specimen they vary greatly in shape, from the peculiar serrated, short, flattened spines, surrounding the actinostome, characteristic of this genus, to long, slender, cylindrical spines, straight, or sometimes slightly curved, equalling in length twice the diameter of the test, and finely fluted for the whole length, or to the shorter radioles, gradually becoming thicker towards the tip, with coarser fluting; we also find some spines with slightly cupuliform tips, as in Goniocidaris. The largest specimen measures fully 72 mm. in diameter.

* Salenia Pattersoni A. Ag.

Salenia Pattersoni A. Ag. Bull. M. C. Z., V., No. 9, Fig. 1, p. 187, Pl. V., 1878.
Salenia Pattersoni A. Ag. Bull. M. C. Z., VIII., No. 2, p. 72, 1880.
Off Havana, Caribbean, West Indies.

Pl. IV. Figs. 3–23; Pl. V.; Pl. VI. Figs. 18–23.

This is the most exquisitely colored of the living Salenidæ thus far known. When alive the test is of a light cream-color. The shafts of the primary spines are banded alternately with cream-color and brilliant vermilion, the colors being nearly equally divided. This coloring at first glance gives to this species very much the appearance of the Florida species of Cœlopleurus. The secondary spines are also cream-colored, separated at the base by dark violet belts, extending from the apical to the actinal system along both the median ambulacral and interambulacral lines. Similar dark violet lines separate the genital plates and the superanal plate from one another, the dark lines of the median ambulacra and interambulacra extending some distance into their corresponding genital and ocular plates. The primary spines are from three to four times in length the diameter of the test, and carry minute, sharp, irregular serrations; these are frequently worn off, the radiole then presenting a nearly smooth surface, slightly granular. These spines are remarkably uniform in their appearance, differing merely in length, and we do not find among them the great variation so characteristic of the primary spines of *S. varispina*, the only exceptions being the Porocidaris-like spines found near the actinostome. The papillæ or secondary spines are long, with a rounded slightly concave extremity. The outer edge of the abactinal system and the median line of the ambulacral area are thickly studded with minute globular pedicellariæ. The plates of the abactinal system are covered by a coarse granulation; this towards the outer edge of the genital plates becomes minute sessile spines. The sutures between the genital plates, as well as the lines separating them from the abactinal part of the ocular plates, are deep. The anal system carries short, stout, pointed spines. None of the genital pores, with the exception of the madreporic genital, are very distinct; the madreporite consists of a few minute pores adjoining the large genital pore. The ocular plate opposite the superanal plate nearly touches the anal system, approaching it much closer than is the case in *S. varispina.*

In specimens measuring 12 mm. in diameter, there are usually from five to seven primary tubercles in the interambulacral area. The secondary tubercles, carrying the flat papillæ, are arranged vertically in open arcs round them; and these arcs, running together along the median interambulacral line, form two wavy vertical rows of tubercles, closely packed, which gives to the median interambulacral area a somewhat sunken aspect, as in Goniocidaris. The ambulacral tubercles, as in *S. varispina*, resemble in their arrangement those of Hemicidaris, forming two vertical rows; they are largest near the ambitus, diminish rapidly in size towards the actinostome, and more gradually towards the apical system. The largest ambulacral tubercles are not larger than the secondaries surrounding the primaries of the interambulacral area. The ambulacral zone is narrow; the pores are arranged in a slightly undulating line, following irregularly the outline of the primary plates in the interambulacral area. Smaller and larger specimens differ only in the size of the primary tubercles, those towards the actinostome increasing but slowly in size as the diameter of the test enlarges. The principal differences to be noticed are in the greater number of imbricating plates which cover the actinal membrane in the older specimens, as compared with the more simple arrangement of the plates and their smaller number in earlier stages. In younger specimens the five pairs of large buccal tentacles cover nearly the whole actinostome; they next become separated from the actinal edge of the test by a few irregularly arranged imbricating plates, and as the rows of plates increase they form also narrow zones between the pairs of buccal plates in extension of the interambulacral areas, until in the older stages collected the pairs of buccal plates are quite distant. In the abactinal system the differences due to age are quite marked. The plates covering the anal opening are few in number, and comparatively large in the younger stages; with increasing size the plates become more numerous and relatively smaller, and carry from one to two minute tubercles. The granulation of the genital and ocular plates becomes also more distinct with increasing size, forming more or less regularly radiating lines; the outer edges of the plates of the genital ring become also somewhat indented, the inner edges of the ocular plates are grooved in the extension of the radiating lines of the granules of these plates. The gills of *S. Pattersoni* are stouter and less branching than the gills of *S. varispina*, and the few sphæridia noticed are remarkable for their small size and globular outline; one or two sphæridia are placed in the ambulacral areas close to the edge of the ocular plates.

Salenia varispina A. Ag.

This species, of which only a single young specimen had been collected by Mr. Pourtalès, has been found from Lat. 24° 36′ N., Long. 84° 5′ W., as far as Granada and Barbados, in depths of 334–1,200 fathoms. It is most abundant in depths between 400 and 600 fathoms.

For other localities, see Bull. M. C. Z., V., No. 9, p. 186, 1878; VIII., No. 2, p. 71, 1880.

Pl. VI. Figs. 1–17.

How far the obliquity of the axis of the apical system is a structural feature of sufficient importance to be considered a generic difference, it is difficult to decide. In Salenia we undoubtedly have in the asymmetrical arrangement of the plates of the apical system a feature somewhat prominently developed, which is found in all Echinoderms, and which is due to the original mode of growth of the plates of the embryo Echinoderm in a spiral curve. Traces of this are plainly to be seen in the unequal development of the genital and ocular plates throughout the group of Echini, in no one of which do we find the five plates either of the genital or ocular system symmetrically developed, or exactly symmetrically arranged in relation to a longitudinal axis. We find this in the apical system of the Palæchinidæ, the Echinothuriæ, the Cidaridæ, the Echinidæ, the Clypeastroids, and the Spatangoids, as well as in the asymmetrical test of all young Echinoidea; and perhaps we may trace the different degree of development of the five series of ambulacral and interambulacral zones throughout the group of Echini to such a primitive differentiation. As Neumayr has suggested, the appearance of the suranal plate in Salenia may not have the meaning or importance which has been attached to it from a morphological point of view when compared to the single large anal plate of young Echini. Yet, while it may perhaps not be an embryonic feature of the Echini which runs back through the Echinoid series of the earlier palæozoic times, it may yet be one of those cases of the sudden reappearance of an ancient structual feature after a long period of time, as is also perhaps the five-valved actinal opening of Palæostoma. I am inclined to look upon the suranal plate of Salenia as strictly homologous with the central plate of the dorsal surface of Starfishes, which, while it recalls the Crinoidal affinities of the Echini, yet has not played the important part in the development of the Echinoid series which it did in the Starfishes or Crinoids.

As far as the plates of the anal system are concerned, the embryonic type of many plates arranged in more or less irregular concentric rows round the anal opening, such as we find it in the oldest palæozoic Echini, has remained remarkably persistent throughout the group to the present day. Even in the Spatangoids and Clypeastroids, in which the anal system has become disconnected from the apical system, the same general embryonic type has been retained in nearly all the principal groups, with the exception of a few types, such as Echinocidaris, and some of the Clypeastroids and Spatangoids, in which the number of anal plates has become reduced, and they form a pyramid over the anal system; a structural feature, however, which we should remember is already found in some of the earliest known Crinoids. From what I have shown of the mode of breaking up of the anal system* in some very large specimens of Arbacia, the pyramidal anal covering may have been the earliest type of plates of the anal system in Crinoids, and the splitting up of the plates of the anal system, at first few in number, may be a feature characteristic of the more recent Echini. Such a splitting up actually takes place in the growth of the plates of the anal system of Salenia. In very young stages of *S. Pattersoni* we have a suranal plate and five anal plates covering the anal system; while in old specimens the anal system is covered by a number of smaller plates, due to the splitting up in part of the original plates at their apex, and in part to the formation of new plates round the anal opening with the increase in size of the anal system.

How far we are justified in considering the anal plates of the recent Desmosticha as homologous with the dorso-central plate of young Starfishes and of Comatula, seems somewhat doubtful. P. H. Carpenter † has well discussed some of the difficulties to be met in adopting the view Lovén and myself have

* Challenger Echini, p. 56.

† Quart. Journ. Mic. Soc., XVIII. 357.

taken of the homologies of the apical system of Echini and of the plates of the embryonic Comatula in its Pentacrinus stage. Neumayr's suggestion of the morphological value of the anal plates of the Palæchinidæ and Cidaridæ has thrown considerable light on this question, and shows us the possibility of a number of anal plates in Echini, say five for instance in Echinocidaris, being the homologue of the dorso-central plate of the Pentacrinus stage of Comatula. Of course we should remember that, in making this homology, we are comparing plates, which while they occupy the same structural position, have a very different physiological value. As I have already stated, we have the most positive proof of the origin of the dorso-central plate of Starfishes and Ophiurans as a single Y-shaped rod appearing simultaneously with the five basals; but we have no such definite data either for the Echini or for the Comatulæ while within the Pluteus. Such information would go far towards settling this disputed homology, for at present we are obliged to draw our conclusions from a comparison of the more advanced stages of development. The discovery of a pedunculated Starfish by the "Travailleur," the Caulaster of Perrier,* may throw important light on the homology of the centro-dorsal plate of the Starfishes and of the Crinoids.

The discovery by Laube in the Trias of the genus Tiarechinus of Neumayr shows that the pyramidal anal covering, composed of a few large plates, which appears in some of the earliest Crinoids known, has persisted or reappeared after a long lapse of time, during which the greater part of the Palæchini were provided with an anal system protected by one or two concentric rings of numerous plates; this last structural feature characterizing nearly all the modern Echini, only a few Clypeastroids and Spatangoids, and among the Desmosticha the Echinocidaridæ, still retaining the antique structure of the anal system, while in nearly all Echini from the oldest to those of the present day we may imagine the numerous anal plates to have been the result of the splitting up of the five (or more?) plates of the anal pyramids into numerous smaller plates. Where this splitting up took place regularly, we have the anal system of the Palæchinidæ, Cidaridæ, etc.; where, on the contrary, one plate resisted, we have what exists in Salenia and all the recent Echini, in which one of the anal plates has a great prominence over the others. The Salenia-like structure, therefore, may appear at any time, and disappear again, without perhaps having so important a morphological value as I was at first inclined to give it when I called attention to the

* *Comptes Rendus*, December 26, 1882.

existence of a large permanent anal plate in the young of many Echini among the Desmosticha.

I was in hopes that the examination of the series of young Saleniæ dredged by the "Blake" might throw some light on the formation of the suranal plate, and its homology with the single large anal plate of the early stages of young Echini belonging to other families. On examining these young Saleniæ I find that the abactinal system occupies a comparatively much greater space of the abactinal surface of the test than in the larger specimens. But in all the young stages, even when not measuring more than 1.5 mm. in diameter, the arrangement of the plates of the abactinal system does not differ from that of the older specimens, the suranal plate being only proportionally somewhat smaller. In the youngest Salenia collected (1.5 mm. in diameter) the sutures between the genital and ocular plates are, as in all young Echini, somewhat indistinct, and it is difficult to define the exact limits of the abactinal system. As I have already shown in other young Echini (Strongylocentrotus, Echinus, Arbacia, Diadema, etc.), the coronal plates of the test and the plates of the abactinal system are very indistinct in the stages immediately following the resorption of the Pluteus, while the actinal system is well defined. It is only later that the separation of the ambulacral and interambulacral areas can be traced; at about the same time the limits of the abactinal system become defined; and still later, the separation of that system into its component plates surrounding the anal system, which from the earliest stages is readily recognized. In the youngest stage of Salenia the anal system is distinctly pentagonal, and covered by eight large triangular plates with rounded tips; the plates carry small granules supporting minute sessile papillæ similar to those found on the genital and ocular plates, but smaller.

As in other young Echini, the anal system is comparatively large; the suranal plate is at first quite small, a narrow plate on the side of the anal system opposite to the nearest ocular plate. It appears to gain in size at the edges adjoining the genital plates. As fast as the plates of the genital ring increase, the pentagon they form round the suranal plate enlarges, and the outer edges of this plate keep pace in their growth with that of the inner edges of the adjoining genital plates. The genital and ocular plates carry three or four large granules irregularly placed on the plates, with a row of granules forming a line round the edge of the anal system. There are as yet no traces of the genital or ocular openings. The whole of the abactinal ring is striated, the lines forming irregularly lozenge-shaped figures, arranged as they have been figured by Lovén for *Salenia goësiana* (Lovén, *Études sur les Échinoïdées*, Pl. XIX.). The limits of these figures, both in the smallest specimen and in one measuring 2 mm. in diameter, are somewhat indistinct, owing to the coarse, spongy granulation of the limestone tissue of the plates of the abactinal system. In the majority of the young specimens examined, this striation could not be detected at all, and in older specimens, measuring from 4–8 mm. in diameter, I was unable to do more than trace portions of this striation on account of the granulation of the plates.

I am now inclined to consider *Salenia goësiana* of Lovén as identical with *S. varispina ;* it certainly agrees very closely with the young of *S. varispina* of the same size (3.5 mm.) collected by the "Blake" in the West Indies. These young specimens show, as I have stated above, the peculiar striation of the abactinal system of *S. goësiana,* though the size of the tubercles of the ambulacral system is somewhat smaller in the young of our *S. varispina* than in the figure given by Lovén. The abnormal position of the madreporic body in the original type specimen of *S. varispina* is also accounted for in the description which follows.

As regards the actinal system, in young specimens we find ten large plates in the continuation of the ambulacral system, spreading laterally so as to form a continuous ring. The space between the inner edge of these plates and the teeth is filled with small plates irregularly arranged. The ten large buccal tentacles are sometimes reduced to five, one in each ambulacrum being frequently atrophied or much smaller than the other. In these young specimens, the sphæridia first detected in this genus by Duncan * stand out very prominently between the first and second pair of ambulacral tentacles. I have only observed one in each ambulacral area in the smaller specimens; in older ones, we find sometimes as many as three at the base of the ambulacral area. The sphæridia of the younger Saleniæ are nearly hemispherical with a rather long peduncle; in older specimens, they become more ellipsoid, and are supported upon a comparatively shorter stem.

The primary spines of the youngest Saleniæ are very remarkable; the short, sharp spiny processes of the main shaft, which have been figured as characteristic of the primary spines of Saleniæ, are in these specimens replaced by long, slender, curved filiform processes, arranged on each side of the shaft, and equal in length three times the diameter of the shaft.

* Ann. and Mag. of Nat. Hist., XX. 70.

These delicate processes appear, however, to be soon either worn off or broken, as in specimens measuring from 2 to 3 mm. in diameter we generally find only an occasional primary spine still retaining the filiform processes, or a trace of them. As the spines become older, these processes are little by little changed to the sharp spiny processes figured as characteristic of *S. varispina.* The primary spines of these young stages are also marked for the single prominent verticillation formed near the base of the shaft by the somewhat stouter filaments of that portion of the radiole.

The young spines found on the small primary tubercles near the abactinal system on the ambulacral and interambulacral areas have a striking appearance. They recall somewhat the fan-shaped, short spiny radioles found on the test of very young specimens of Strongylocentrotus; they also recall the peculiar umbrella-shaped spines of Aceste, and of some deep-sea Ophiurans. The primary spines, when the shaft has as yet but a single pair of filaments, could readily pass for modified pedicellariæ; they also resemble the hook-like appendages of the Ophiurans. In the next stage the radioles carry from four to five processes, when the central part of the shaft begins to increase in length; with this increase commences also the formation of the filaments, so characteristic of the large primary interambulacral spines of the young stages. The primary interambulacral spines are usually similar, but shorter, slender-pointed radioles, with from six to eight processes and a ring of filaments near the base of the shaft. In the youngest stages there are as yet no papillæ; these appear only later, in larger specimens, and at first show no trace, in the interambulacral areas, of their regular Cidaris-like arrangement round the base of the primaries, as in the older stages. The papillæ when they first appear are short slender-pointed spines, with short, sharp processes, covered by lines of pigment-spots of dark violet. With the growth of the test these papillæ become club-shaped, curved, and finally flattened and fan-shaped, as they appear in the older Saleniæ. The papillæ of the anal plates are articulated in the older specimens; at first they are sessile, like the embryonic spines (club-shaped sessile papillæ) covering the plates of the genital ring; with the increasing size of the young Salenia they resemble more the coronal papillæ. These abactinal sessile papillæ are interesting, as they develop exactly as do the embryonic spines in young Echini, from the general granulation of the plates; but they remain, as in the Arbaciadæ, always sessile.

As I have stated, the genital openings are not yet formed in young specimens, and in the older ones there seems to be considerable variation in the position of the madreporic body; so that the position of the madreporic genital can certainly not be taken as expressive of any generic value in this family, if we are to judge by the recent species. It is not uncommon (five specimens) to find two genital plates which carry traces of the madreporic body; and though the right genital is the one which is most commonly the madreporic, yet in the first specimen of this species of Salenia described it was the left genital plate which carried the madreporic body. This induced Duncan * to refer this species to Peltastes.†

The crenulation of the tubercles can be traced in the earliest stages examined, but its distinctness varies greatly in different individuals. It is quite distinct in the large primary tubercles near the abactinal region, it becomes indistinct near the ambitus, and at the actinostome the tubercles are smooth. The large primary pedicellariæ, both in the ambulacral and interambulacral areas, are not numerous. We do not find more than two large, short-stemmed, long-headed, slender-pronged pedicellariæ in each of these areas. The others, very numerous, are quite small, short-stemmed, stout-headed pedicellariæ. In the ambulacral system these small trifid pedicellariæ are thickly placed throughout the area; and in specimens measuring 7 or 8 mm. in diameter there are six or seven similar pedicellariæ in each of the large buccal plates of the actinostome.

The plates of the actinostome are more numerous than in *S. Pattersoni*, and are not as regularly arranged as in that species, in which the actinal imbricating plates resemble the actinal plates of the Cidaridæ, both in their regular arrangement and in forming the continuation of the ambulacral and interambulacral coronal plates on the actinal membrane. In a specimen of *S. varispina* measuring 7 mm. in diameter, there are four or five concentric rows of actinal plates between the large buccal plates and

* Ann. and Mag. of Nat. Hist., XX., 1877.

† This species is retained in the genus Salenia, although Dr. Duncan has proposed to remove it to Peltastes. As I have already stated in the Revision of the Echini, and in the Bulletin of the Museum (I., No. 9), when first describing this species, it differs somewhat from Salenia proper, but it does not seem to me to belong to the group of Salenidæ with which Peltastes is associated, in which the suranal plate is placed directly opposite one of the genital plates, while in all the recent Salenidæ thus far described they at least all agree in having an ocular plate opposed to the median line of the suranal plate, the adjoining genital plates uniting just in front of this imaginary median line so as to separate the ocular plate more or less from the anal system. (Vide A. Agassiz, Revision of the Echini; S. Lovén, *Échinoïdées;* M. P. Duncan, Ann. and Mag. of Nat. Hist., 1877, 1878; Wyv. Thomson, Voyage of the Challenger; A. Agassiz, Echinoidea of the Challenger.)

the actinal edge of the test. In a specimen of *S. Pattersoni*, measuring 14 mm. in diameter, we find only two or three rows. The granulation of the actinal plates is coarser in *S. varispina* than in *S. Pattersoni*.

The gills in specimens measuring 7–8 mm. in diameter are well developed as a short five-forked appendage covered by few pigment cells. In smaller specimens measuring 3 mm., the gills only fork once.

The more we examine the Saleniæ, the more we are inclined to consider the group as holding a position intermediate between the Cidaridæ and the Echinidæ. For while the general structure of the coronal plates of the actinal and abactinal system, of the spines, and of the papillæ, recalls the Cidaridæ, yet the structure of the teeth, the presence of gills with actinal cuts for their passage, and the existence of sphæridia, are all features which associate them with the Echinidæ proper.

Arbacia punctulata Gray.

Yucatan Bank. 14–84 fathoms.

Podocidaris sculpta A. Ag.

Off Morro Light. 250–400 fathoms.

It is not out of place while speaking of Podocidaris to call attention to the remarkable genus Tiarechinus of Neumayr,* one of the most characteristic embryonic genera I know. This diminutive Sea-urchin from the Trias of St. Cassian represents the young stages of Podocidaris at a time when neither the abactinal system nor the plates of the interambulacral area have become specialized. The whole abactinal part of the test appears from the figures of Neumayr to be still in the condition preceding the division of the abactinal system into an anal system and a genital ring, before the formation of the plates of the anal system or the division of the anal ring into its component parts. There are very faint indications of what I take to be the dividing lines between four genital plates in the figure of Neumayr. The actinal surface, on the contrary, is far more developed; the large primary tubercles of the interambulacral areas, and the structure of the ambulacral system, agree most strikingly with the condition of the actinal surface of young stages of Podocidaris and Arbacia. Compare the figures I have given in the Revision of the Echini, Plates IV., V., and Figs. 68, 69, p. 734.

* See the figure given in Plate II., Vol. LXXXIV. 1 Abth. p. 169, Sitzungsb. d. K. K. Akad. d. Wiss. Math. Nat. Cl., Wien, 1882.

* **Podocidaris scutata** A. Ag.

Podocidaris scutata A. Ag. Bull. M. C. Z., VIII., No. 2, p. 72, 1880.
Off Santa Cruz. 580 fathoms.

Only one specimen of this species was collected. It is much larger than either of the others of the genus. Test depressed, remarkable for its large abactinal system. The whole abactinal surface of test covered by small, distant, fine, slender fixed spines contrasting with the corresponding coarse granulation of *P. sculpta;* fewer large primary tubercles close to the ambitus on the actinal surface. Actinal membrane entirely covered by prominent imbricating plates; five anal plates, as in *P. priomigera,* to which it is most closely allied. Test light grayish brown when alive.

Cœlopleurus floridanus A. Ag.

Lat. 23° 52′ N., Long. 88° 5′ W. West India Islands, — Barbados. 56–1,323 fathoms; most abundant from 100–200 fathoms.
For other localities, see Bull. M. C. Z., V., No. 9, p. 188, 1878; VIII., No. 2, p. 73, 1880.

Pl. VII., Pl. VIII.

Many of the specimens of this species dredged in the Caribbean, off the Windward Islands, are much larger than the small specimens from which the species was first described. (Pl. VII. Fig. 1.; Pl. VIII. Figs. 1–6.) Quite a number of specimens measured 18 mm. in diameter and a few 28 mm. This species, however, does not seem to attain the size of the large *C. Maillardi.*

When alive it is most brilliantly colored, the test varying from a rich light chocolate in the interambulacra to the brilliant orange or yellow ambulacral areas. The primary radioles vary greatly in color, from a delicate straw, often nearly white, to a bright carmine or orange, the base of the spines being usually colored and the shaft more or less irregularly banded.

On Plate VIII. are given figures of specimens of different sizes, showing the changes they pass through due to growth. The larger specimens (Pl. VIII. Figs. 1–6), when compared with specimens of *C. Maillardi* of the same size, show that the Florida species differs from it in having a larger anal system, in the shape of the genital and ocular plates, which is quite different, being nearly triangular in the Florida species, in having a much wider bare interambulacral area, and comparatively larger primary ambulacral tubercles, concentrated nearer the ambitus; these tubercles do not extend to the genital ring, as they do with *C. Maillardi* in specimens of the same size.

The deep pits at the base of the median ambulacral area are larger and more numerous than in the Indian species. (Pl. VIII. Figs. 2, 3, 5.) The most striking features due to changes of growth are the comparatively late period at which the genital pores are developed, even specimens measuring 11 mm. in diameter (Pl. VIII. Figs. 7, 8) showing no trace of such openings. The genital plates of earlier stages are markedly pentagonal (Pl. VIII. Figs. 11, 12, 15, 18); the granulation of the anal edge of the genital plates is a character not found in the younger stages. In these young stages the primary tubercles extend also but little above the ambitus. (Pl. VIII. Figs. 7, 11, 15.) In Figure 15 the primary interambulacral tubercles are limited to the actinal surface, and the primary interambulacral tubercles extend at first but little towards the abactinal part of the ambulacral area. Compare Plate VIII. Figs. 7, 11, 15, and Plate VIII. Fig. 1, with their corresponding profile figures. The resemblance of these young stages of Cœlopleurus to some of the Cretaceous and Jurassic Echini, such as Tiarechinus, etc., is very striking.

The tendency to breaking up of the anal plates already noticed in some of the species of Arbaciadæ is shown in some of the younger stages by the ill-defined subdivision lines, such as are represented in Plate VIII. Figs. 15, 18.

The function of the ambulacral pits of this genus I have been unable to ascertain. The sutures present no trace whatever, in the specimens I have examined, of the remarkable dovetailing observed by Duncan in the pitted Temnopleuridæ.

Diadema setosum Gray.

Littoral to 115 fathoms. Florida and West India Islands.

ASPIDODIADEMA A. Ag.

A marked feature of this genus is the nearly uniform size of the secondary radioles, both in the ambulacral and interambulacral areas. This character is a structural feature which Aspidodiadema has in common with the Cidaridæ in addition to their similar abactinal system, to the structure of the ambulacral areas, etc.; features to which I have already called attention in the Preliminary Report of the Challenger Echini,* and in the final Report (p. 64).

I did not notice while examining the Challenger species of the genus

* Proc. Am. Acad., XIV. 199, 1879.

a remarkable and interesting type of pedicellariæ, which in *A. Jacobyi* are quite large and numerous, and are found scattered over the whole of the abactinal part of the test, especially in the ambulacral area. These are sheathed pedicellariæ, if I may call them so. The shaft consists of a long, slender radiole, distinctly articulated, surrounded by a huge fleshy sheath, swelling out into three large bags on the sides, covering a little more than half the length of the shaft. This sheath extends from the base, where it covers the articulation, to the extremity of the pedicellariæ, at the tip of which is placed a small head enclosed within this sheath. The sheath at the extremity expands into a three-lobed cupuliform tip. These pedicellariæ recall at once the remarkable sheathed secondary spines which I have described in *Asthenosoma Grubei*, they form an additional link in the chain, proving that pedicellariæ are only modified spines. The diminutive heads of these pedicellariæ, if completely resorbed, would leave us a sheathed spine identical with the sheathed spine of the Echinothuriæ; the existence in that family of club-shaped primary spines, as in *Phormosoma bursaria*, the tip of which is still sheathed to a certain extent, shows how close is the relation of the sheathed spines to true pedicellariæ.

How far this sheath is analogous to the peculiar gland discovered by Sladen * in some of the types of pedicellariæ, I am unable to state positively at present, but I am inclined to consider it as a modification of this gland. If this be so, the sheathed pedicellariæ are only an extreme modification of the simple extension of the muscular system of the test over the shaft of the spines, and over the stem of the ordinary type of pedicellariæ; this extension being either modified into a sheath covering the whole of the secondary or primary spines, or merely a part of the shaft; or into a gland; or into a sheath, such as we find it in Aspidodiadema and the Echinothuriæ.

* **Aspidodiadema antillarum** A. Ag.

Aspidodiadema antillarum A. Ag. Bull. M. C. Z., VIII., No. 2, p. 73, 1880.
Aspidodiadema microtuberculatum A. Ag. Bull. M. C. Z., V., No. 9, p. 188 (non Chall. Echinoidea).

Southeast extremity of Cuba, Santa Cruz to St. Vincent. 451 to 1,568 fathoms; most abundant between 400 and 800 fathoms.

Pl. IX.

The genital ring of *A. antillarum* is comparatively larger than that of *A. Jacobyi*. The plates of the genital and ocular system are of nearly uniform

* W. P. Sladen, Ann. and Mag. of Nat. Hist., August, 1880.

size; the former carry larger miliaries than the latter; the ocular plates are somewhat pentagonal, while the genital plates appear more rectangular with rounded corners.

The anal system is covered with minute irregularly arranged plates; those immediately surrounding the anal system are larger, and in older specimens soldered together to form an irregular calcareous ring round the opening. This ring carries larger miliaries than the other anal plates. The anal tube itself extends as a sort of proboscis beyond the general level of the anal system. It is strengthened by delicate longitudinal calcareous plates. In *A. tonsum* we find six plates nearly covering the anal system; in *A. microtuberculatum* there are a number of smaller plates arranged irregularly round the anal opening.

The actinal system is strengthened by ten large buccal plates, as in *A. microtuberculatum*, covering nearly the whole of the actinostome. The gills appear in the youngest specimen I have examined (3.5 mm. in diameter) as one-forked digits; they do not even in larger specimens take a great development, judging from alcoholic specimens.

We do not find in younger specimens any marked differences from the adult in the structure either of the actinal or of the abactinal system. The primary spines are proportionally larger and longer, but with the exception of the smaller number of coronal plates the differences due to growth do not seem to be important.

The sphæridia of this species when fully grown are large, globular, short-stemmed; they are placed mainly in the abactinal region of the test, but are also found near the actinostome and scattered over the whole length of the ambulacral system. Their number varies from two to four, and sometimes as many as six are found in each area.

The pedicellariæ are similar to those previously described as characteristic of the genus; they are either long narrow-headed and long-stemmed, or short-headed and stout-stemmed, or short-stemmed and pyramidally headed; the last are not numerous. The sheathed pedicellariæ are smaller and comparatively more slender than those of *A. Jacobyi*, the shaft is very slender, and the head quite diminutive; the sheathed pedicellariæ are most numerous in the ambulacral area above the ambitus near the abactinal region; those of the interambulacral areas are slightly larger and far less numerous.

In a specimen measuring 11 mm. in diameter, there are six interambulacral plates; in one measuring 7 mm. there are five. The secondaries and miliaries are less numerous in this species than in *A. microtuberculatum*; it also differs from it in having three or four ambulacral plates (in the median region of the test) to each interambulacral plate, while there are no less than five or six in *A. microtuberculatum*. The proportions of the spines to the test and the general appearance recalls more *A. tonsum*, while the coloring when alive is more that of *A. microtuberculatum*, with a light violet or grayish pink test and the spines of the same tint but lighter. The primary spines are slender, as in *A. tonsum*, but they are more curved than in that species. The abactinal part of the test of *A. antillarum* is more flattened (Echinostrephus-like) than is the case in either of the species collected by the Challenger.

The largest specimens of this species collected did not measure more than 13 mm. in diameter.

In a specimen measuring 7.5 mm. in diameter, the anal system measured 3 mm., the abactinal 5 mm., and the actinal 3.75 mm. in diameter; the height of the test measured 3.75 mm.

In a specimen measuring 11 mm. in diameter, the anal system measured 3.6 mm., the abactinal 6.50 mm., and the actinal 5.50 mm. in diameter; the height of the test measured 6 mm.

* Aspidodiadema Jacobyi A. Ag.

Aspidodiadema Jacobyi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 74, 1880.

Cayman Brac, Lesser Antilles. 95 to 297 fathoms.

Pl. IX^a.

The largest specimen of this species collected by the Blake measured 32 mm. in diameter. As in *A. microtuberculatum*, the primary spines are rather stout, curved, and comparatively short, they are somewhat more closely packed than in that species, from the greater number of primaries in the interambulacral areas, a specimen measuring 28 mm. in diameter having 11 : 12 primary tubercles. The miliaries are more distant than in that species, forming a belt of distinct irregularly arranged miliaries in the median interambulacral space. We find in this species, as in *A. tonsum*, large primary ambulacral tubercles, extending nearly to the abactinal system; all the largest tubercles being placed above the median line of the test, and gradually increasing in size from that point to the abactinal region, much as they do in Echinostrephus.

There are not more than three ambulacral plates to each interambulacral plate. The miliaries extend in horizontal lines between the pores, and form a narrow irregular vertical line, separating the ambulacral from the interambulacral region. The primary spines of the two areas are similar, those of the ambulacral areas being smaller and more slender. The secondaries, though not numerous, are remarkable for their uniform size in both areas, and their arrangement recalls to a certain extent that of the papillæ of the Cidaridæ. In life the test is of a light greenish pink color, the areolas darker; the secondary spines are of a light pinkish tint, darker at the base; the primary radioles yellowish green, with a greenish chocolate base. In some specimens the test is also of this greenish chocolate color, the spines more whitish, or tending towards a dirty yellow.

The sheathed pedicellariæ are most numerous above the ambitus toward the abactinal region; the shaft of the pedicellariæ is nearly as long as that of the secondary spines; from their size the sheathed pedicellariæ are very prominent objects on the test.

The actinostome is covered by ten large buccal plates, as in *A. microtuberculatum* and *A. antillarum*, but these plates form a ring round the actinal opening, leaving a bare ring between them and the edge of the test.

There are eight large elliptical plates round the anal opening, somewhat as in *A. tonsum*, but having a larger ring covered by minute plates between them and the genital ring. The anal plates are closely tuberculated by miliaries nearly of the same size as the miliaries of the ocular plates; the genital plates are coarsely and closely tuberculated by miliaries.

Smaller specimens differ from the larger ones mainly in the lighter coloring of the test and spines, and the more flattened abactinal region of the test, which loses its peculiar Echinostrephus-like shape as it increases in size, becoming more regularly arched, as in Amblypneustes. The plates of the actinal and anal system cover a comparatively larger space in younger specimens.

In a small specimen measuring about 3 mm., the anal plates appear as forming close to the genital ring; the difference in size of the genital and ocular plates is already apparent. The anal proboscis is quite long at that stage, equalling in length the diameter of the anal system.

In a specimen measuring 28 mm. in diameter, the anal system measured 5.50 mm., the abactinal 10 mm., and the actinal 9 mm.; the height of the test was 20 mm.; and there were eleven and twelve plates in the interambulacral areas.

In a specimen measuring 12 mm. in diameter, the anal system measured

3.25 mm., the abactinal 5.50 mm., and the actinal 5 mm.; the height of the test was 9 mm.; with nine and ten plates in the interambulacral areas.

In a specimen measuring 5 mm. in diameter, the anal system measured 1:25 mm., the abactinal 3 mm., and the actinal 2 mm.; with seven and eight plates in the interambulacral areas.

Asthenosoma hystrix A. Ag.

Asthenosoma Reynoldsii A. Ag. Bull. M. C. Z., VIII., No. 2, p. 75, 1880.
Montserrat, Santa Cruz, Barbados. 103–373 fathoms.

Pl. XIII., Pl. XIV.

The differences which I noticed (Preliminary Report on the Blake Echini, Bull. M. C. Z., VIII., No. 2, p. 75) in some of the larger specimens of Asthenosoma collected by the Blake, seemed to be of sufficient importance to separate them from *A. hystrix* under the name of *A. Reynoldsii*. A more careful examination of the large series of Asthenosoma collected by the Blake has satisfied me that the differences, striking as they appear at first sight, are merely due to age, and that what I had called *A. Reynoldsii* in the Preliminary Report are only large specimens of *A. hystrix*. Specimens measuring about 125 mm. in diameter are figured by Thomson in the Porcupine Echini, Pls. LXIV., LXV.; and by me in Pl. II. of the Hassler Echini (70 mm. in diameter). I have figured on Pls. XIII. and XIV. two specimens 165 mm. in diameter, showing the features characteristic of the largest *A. Reynoldsii* collected, which measured about 170 mm. in diameter.

In the smaller specimens, less than 70 mm. in diameter, the coronal plates of both areas are relatively narrower than in larger specimens, and while the general arrangement of the primary tubercles does not differ greatly in specimens of different sizes between 50 and 120 mm. in diameter, in the ambulacral areas, or in the two areas above the ambitus, yet there are very considerable differences to be noticed in the interambulacral areas on the actinal side. We find in larger specimens a third, and sometimes even a fourth, vertical row of primary tubercles extending from near the actinostome to above the ambitus. Compare Pl. XIV. Fig. 4, with the figures of Thomson in the Porcupine Echini, and those of the Hassler Echini quoted above.

The smaller specimens less than 70 mm. in diameter are usually of a brilliant claret-color, but often of a light pink color with only darker patches of deep claret on the actinal side; we find larger specimens usually of a paler color tending to pinkish brown, with dark claret patches on the actinal side; these patches often disappear completely, and the test is then of an ashy light-brownish pink, with spines of a lighter color and of a greenish tint.

The sharp, small secondary spines which cover the test, as has already been noticed by Thomson and Moseley, cause very severe pain to the hands and arms if these urchins are handled carelessly, and nothing can be more disagreeable than the sharp pain which shoots up one's arm on rashly taking hold of these prizes as they are first brought up by the trawl. The after effects resemble those produced by nettles; the disagreeable feeling often does not disappear for twenty-four hours.

Phormosoma placenta WYV. THOMS.

Phormosoma Sigsbei A. AG. Bull. M. C. Z., VIII., No. 2, p. 75, 1880.
Lesser Antilles, — Lat. 41° 29′ 45″ N., Long. 65° 47′ 10″ W. 154–1242 fathoms.

Pl. XII., Pl. XV. Figs. 3–19.

To the leeward of the Lesser Antilles this species is found between 150 and 400 fathoms. On the east coast, in the Atlantic, it has been dredged from 810 to 1242 fathoms.

I owe to Mr. Murray the opportunity of examining an excellent series of specimens of *P. placenta* collected by the "Knight-Errant" in the Faroe Channel. The single specimen collected by Thomson in the "Porcupine," and from which his description was made,* was quite imperfect, and I was misled in describing this species again under the name of *P. Sigsbei* from specimens collected by the "Blake" in the Caribbean and off the east coast of the United States as far north as Lat. 41° 30′ N. This species has also been collected by the U. S. Fish Commission off Martha's Vineyard.

In the younger stages of this species we find great differences in the thickness of the test, and the relative size of the abactinal and actinal systems as compared with the diameter of the test. We find the same sort of differences, so marked in Toxopneustes from different localities, as regards the permanence of the primary tuberculation and the number of principal vertical rows. The tuberculation of the actinal surface does not differ greatly in specimens of different size; but in some specimens the tuberculation of the abactinal surface may be limited to a couple of principal vertical

* Transactions of the Royal Society, Vol. CLXIV. Pt. 2, p. 732, Pls. LXII., LXIII.

rows along the outer edge of the interambulacral plates, or the plates in specimens of the same size may carry the same vertical rows nearly to the apical system, but placed in the central part.

This arrangement, together with the greater thickness of the test, gives to these specimens a very different facies, closely resembling in the arrangement of the tubercles *P. rigida* and other small Echinothuriæ, which, when writing the Report on the Echini of the Challenger, I could not refer to any of the species collected by that expedition.

The color of the specimens with a thick test is of a deep claret, while usually the majority of the specimens of *P. placenta* with a thinner test are of a brick color, or of a yellowish orange, darker on the actinal side, and near the ambitus on the abactinal side, and becoming quite light-colored, either pinkish or yellowish, towards the apical system.

In the youngest specimen of Phormosoma collected by the Blake, measuring 8 mm. in diameter, the plates of the actinal system have already assumed the characteristic arrangement of the adult, although there are as yet but three rows of imbricating plates. We do not find in this species, as in two of the species of the Challenger collection (*P. tenuis* and *P. uranus ?* Challenger Echini, Pl. XVIII^{c}. Figs. 7, 12), that the buccal tentacular plates differ in size from those following them, recalling the general arrangement of the buccal plates of young Echinidæ proper. On the contrary, although the Blake specimens were no larger than the corresponding stages of the Challenger species, they show that in this species of Phormosoma the characteristic structural features of the Echinothuriæ are already developed. This, as I have already shown, we also find to be the case in young Cidaridæ. It thus appears that in some of the species of Echinothuriæ the Echinid features of the actinostome seem to be retained much longer than in others, and do not even seem always to be developed, if we may judge from the young stages of the West Indian Phormosoma here described.

The mode of formation of the coronal plates, and of the actinal and abactinal systems, is well shown in the series of the young of Phormosoma I have had occasion to examine. As I have suggested before, the Echinothuriæ are the most embryonic of the Echini. The coronal plates when they first appear, somewhat indistinctly defined, in young specimens measuring about 8 mm. in diameter, show very clearly that there is no special line of demarkation to be drawn in the young stages between the abactinal and coronal system. From seven to nine of the coronal plates appear at the same time, the division line of the sutures being traced with difficulty in young specimens measuring 8 mm. in diameter, but becoming well defined in somewhat larger specimens of from 17 to 20 mm. in diameter.

In the youngest stage (8 mm. in diameter) the actinal plates are separated from the coronal plates, and are developed, as I have shown, in the same manner as the imbricating plates of the Cidaridæ, independently of the coronal plates; new plates forming on the distal surface of the actinostome, which are intercalated between the old plates and the coronal plates. On the abactinal system, on the contrary, while the plates of the genital ring are well defined and seem to be distinctly separated from the coronal plates, yet new interambulacral plates are not added independently, as in the ambulacral system, and as in the interambulacral system of other young Echinoids where the genital ring remains permanently closed. The new interambulacral plates are found to be pushing out from the plates of the anal system on each side of the genital plates. As the ocular and genital plates of the genital ring become separated, with increasing size, the additional anal plates formed in the intervening spaces are pushed out, and become a part of the abactinal portion of the interambulacral area.

This mode of growth of the interambulacral areas combines to a certain extent the modes of formation of the plates of the abactinal system of young Starfishes and of young Ophiurans, in which the interambulacral plates are derived directly from the plates of the abactinal system. This shows a far closer relationship between the young of some of the Sea-urchins of the present day with Starfishes and Ophiurans on the one side, and Holothurians on the other, than had been suspected formerly. The plates are formed by a close-meshed reticulation of small, comparatively thick Y-shaped rods, with bare interstices for the joints of the plates. The tubercles of the miliaries and of the pedicellariæ are built up by a close accumulation of these meshes, forming what appears a fine granulation. The small tubercles are formed by the clustering together of five or six larger cells, arranged concentrically round a central space, which eventually forms the perforation of the tubercle; as this increases in size, the mammary boss is gradually formed from a similar concentration of the limestone meshes, and finally the edge of the boss becomes indistinctly crenulated. The tubercles, when arrested in their development in any one of these successive stages, form what are known as miliary, as secondary small primary, and as primary tubercles.

The characteristic pedicellariæ of the genus appear early. A few pedicellariæ of the different kinds noticed in the adult of this species are found in young specimens scattered over the test, mainly on the actinal surface. Sphæridia are also present in these youngest stages; they are found extending from the plates of the actinal membrane, close to the teeth, to the abactinal area, along a line at the base of the ambulacral tentacles, usually one for each tentacle; in older stages they are rarely seen, being probably broken off. If the Cidaridæ possess sphæridia, we may perhaps look for them, in the young stages, on the imbricating plates of the actinal membrane.

In the early stages of growth the plates of the genital ring are in contact along their edges; as the young become older, the space between the ocular and genital plates increases, and they become separated by a number of anal plates. The anal system is at first, in the youngest specimens, covered by plates of a nearly uniform size, with only a few smaller ones occasionally intercalated between them; with increasing size the number of these intercalated plates becomes larger, and the original larger anal plates are then separated by a greater number of accessory ones. The large original plates retain their prominence in later stages of growth, and, much as the single embryonic anal plate of young Echinoids, can easily be traced, in older stages, among the other anal plates of subsequent growth.

I do not quite understand Neumayr's statement that in the young Glyphostomes the anal plate is first formed, and that the plates of the genital ring are formed later and become detached from it laterally. That certainly is not the case in any of the young Echini I have had occcasion to examine. While undoubtedly the anal plate is the first plate to appear, yet the genital and ocular plates are formed outside and independently of it, just as much as in the young stages of Comatula the basalia arise independently of the dorso-central plate, and just as independently as the same plates arise independently in the young Starfishes. See my Embryology of the Starfishes, and Lovén's figures.

As I have previously shown in speaking of the apical system of the Palæchinidæ and Echinothuriæ, the plates of the apex of the anal system hold a very different relation to the interambulacral system in those groups from what they do in the Echinidæ, in which the genital ring is closed, a condition of things which begins only with the Echini of Mesozoic times, and is represented in the Cidaridæ by their having still a number of plates, no one of which becomes more prominent than the others. This is the case only in the Saleniæ and in the young stages of Echinidæ, and does not seem to have reached as yet its greatest development in the Echini of the present period. Unfortunately there is no Pluteus of Echinus figured in a stage showing the first appearance of the calcareous rods. Such an observation might throw very important light on the homology of the Echinoid apical system.

The apical system of two specimens of *Asthenosoma varium*, figured by Ludwig,* is interesting, as it is the only species of Echinothuria in which the genital ring is closed, connecting the structure of the apical system with that of the Diadematidæ proper. It is true that the specimens of which Ludwig figures the abactinal system were not fully grown, and were much smaller than the specimens of the allied species *A. Grubei*, figured in the Echini of the Challenger Report, Plates XV.–XVII., in which the genital ring is less open than in any other species of Asthenosoma I have had occasion to examine. It will be seen, on examining the figures of young Echinothuriæ in the Report on the Echini of the Challenger, that, while the plates of the genital ring are placed nearer together in the young stages than in older specimens, yet they are more or less separated even in the earlier stages by the anal plates, which force their way between the ocular plates and the two sides of the genital plates in the two zones of the apical part of the interambulacral area.

In the early stages (8 mm. in diameter), the ambulacral tentacles are arranged in a single vertical row, extending from the actinal opening to the ocular plate. It is only in specimens measuring from 28 to 40 mm. in diameter that we can find the characteristic generic arrangement of the ambulacral tubes. In specimens measuring from 17 to 25 mm. in diameter, the actinal imbricating plates have increased to four, the gills are well developed, and the final arrangement of the primary tubercles both of the actinal and abactinal surface is indicated in a general way on the plates adjoining the ambitus, in both the ambulacral and interambulacral areas. The marginal fasciole can already be made out in specimens measuring about 28 mm. in diameter; in specimens of 50 mm. in diameter it is quite prominent.

The lapping of the coronal plates takes place at a later stage of growth than that of the plates of the actinal membrane; the latter are distinctly

* Zeitsch. f. Wiss. Zool., XXXIV., Pl. II.

imbricated towards the actinal opening from their first appearance. It is only when the young Phormosoma has attained a diameter of from 35 to 45 mm. that the lapping of the coronal plates of the ambulacral and interambulacral areas becomes distinct.

As in the young of other Echini the genital and ocular plates are not perforated in the youngest stages, nor can the madreporic genital be distinguished from the others, owing to the similarity of the calcareous meshes of the young genital plates to the openings of the madreporic canal. In somewhat older stages, however, the madreporic genital is readily distinguished from the others (in a specimen measuring 20 mm. in diameter). This is also the stage at which the other plates of the abactinal system begin to show the perforations for the genital and ocular pores.

It is interesting to compare the structure of a young Astropyga (Pl. XV. Figs. 1, 2), measuring 13 mm. in diameter, with these young stages of Phormosoma (Pl. XV. Figs. 3–19). This comparison clearly brings out the striking difference between the structure of the actinal and abactinal systems in the Diadematidæ and Echinothuriæ. In Astropyga the genital ring always remains closed, and the actinal system is provided with the ten large buccal plates characteristic of young Echinidæ, and with an irregular imbricating system of small imperforated plates forming a regular ambulacral and an irregular interambulacral series. The peculiar forked band of pigment cells of the abactinal part of the coronal plates so characteristic of Astropyga seems to be the remnant of the pigment spots which are irregularly scattered over the test of young Echinothuriæ, and which in the Diadematidæ have a regular arrangement. These large pigment spots are eminently an embryonic character, for we find the test of the young stages of regular Echini thickly covered with large prominent patches of pigment.

Phormosoma uranus Wyv. Thoms.

Phormosoma Petersii A. Ag. Bull. M. C. Z., VIII., No. 2, p. 76, 1880.
Lesser Antilles,—Lat. 39° 45′ 40″ N., Long. 70° 55′ W. 399–1224 fathoms.

Pl. X., Pl. XI.

Thomson figured in the "Voyage of the Challenger" (I., p. 146, Fig. 33, p. 147, Fig. 34) a small specimen of Phormosoma which he called *P. uranus*. It differed very strikingly from specimens of a closely allied species collected by the Blake, which I had provisionally named *P. Petersii*. The principal structural feature of *P. uranus* consists in the extreme tenuity of the test, and in the fact that "there is but little difference in character between the upper and lower surfaces of the test, and the species thus holds a place intermediate between the genera Phormosoma and Calveria." While this is true of specimens of the size of that figured by Thomson, and of younger ones, it does not hold good for larger specimens, in which we find that the larger tubercles of the actinal surface are comparatively small, and not limited to a narrow band of the actinal and abactinal surfaces immediately adjoining the ambitus. But, on the contrary, in older and larger specimens the primary tubercles of the actinal surface become larger with age, extending at the same time over a greater portion of the actinal surface from the ambitus towards the actinostome, as in other species of the genus Phormosoma. Of *P. uranus* I had on former occasions only the opportunity of examining the very imperfect specimen described by Thomson. Since that time Mr. Murray has sent me for examination the Echini collected by the Knight-Errant in the Faroe Channel. Among them was a specimen of *P. uranus* intermediate in size between the smaller specimen described by Thomson and the larger and older specimens collected by the Blake from the West Indies and off the southern part of the Atlantic coast of the United States, which I had named *P. Petersii.* A renewed comparison of the specimens with this additional material plainly shows that the differences which had been noticed between them were merely due to age, and that in this species the great development of the large primary tubercles of the actinal surface takes place at a late period of growth. The abactinal system also seems to increase more rapidly in size in proportion to the rest of the test, as the specimens grow larger; so that in younger specimens the abactinal system is relatively smaller compared with the diameter of the test than in the larger ones. The specimens collected were all of a brilliant claret-color.

Echinometra subangularis Desml.

Florida, West India Islands. Littoral to 250 fathoms.

Strongylocentrotus Dröbachiensis A. Ag.

(East Coast of United States,) Lat. 41° 30′ N., Long. 66° W., in 73 fathoms.

TEMNOPLEURIDÆ.

Duncan * has, in interesting articles on the pits and sutures of Temnopleurus and on the structure of Pleurechinus, called attention to the important differences existing between the Temnopleuridæ of the type of Temnopleurus proper and its allies, and such genera as Temnechinus and Trigonocidaris, which have been associated with them.

He proposes to place on one side the genera Pleurechinus, Temnopleurus, Salmacis, and Amblypneustes, which have true pits, and on the other side the genera Temnechinus, Trigonocidaris, Paradoxechinus, and Glyphocyphus, which have raised ribs.

The structural difference so well pointed out by Duncan is an important one ; he says he was unable to find, in the specimens of Temnechinus from the Crag which he examined, any trace of the remarkable "deep inward undermining or penetrations of the test" of Temnopleurus. The specimens of *Temnechinus maculatus* of different sizes which I have examined show no trace of pits, nor of this system of dowelling at the junction of the plates. I have also again examined specimens of the recent *Trigonocidaris albida*, and do not find in that species either the sunken pits of Temnopleurus proper or the dowelling.

Duncan and Sladen † have figured in the fossils of Western Sind two other genera closely allied to Trigonocidaris: Dictyopleurus and Arachnopleurus, in which the grooved and pitted ornamentation of the test is produced entirely by ribs and elevations. The peculiar structure of the ornamentation of the genus Progonechinus shows how difficult it may become to maintain the distinction suggested by Duncan.

I had already called attention in the Revision of the Echini, p. 286, to the character of the ornamentation of the test of some of the Temnopleuridæ, and to its probable derivation from a more simple type of ribbed ornamentation, such as is formed by the radiating arrangement of miliaries and secondaries round the primary tubercle of some of the Triplechinidæ and

* P. M. Duncan, On some Points in the Morphology of the Test of Temnopleuridæ, Journal Linn. Soc. London, 1882, Vol. XVI. p. 343. On the Genus Pleurechinus, L. Agassiz, Journal Linn. Soc. London, 1882, Vol. XVI. p. 447.

† Mem. Geol. Survey of India, Ser. XIV., Vol. I., The Fossil Echinoidea, Fascicul. II. Calcutta, 1882.

Arbaciadæ. The next stage being the formation of low radiating spokes round the primaries formed by the running together of flattened miliaries or secondaries. From this type of ornamentation the passage is an easy one to the marked and prominent ridges of Trigonocidaris, Dictyopleurus, and the like. But, as I have shown when speaking of the changes due to growth in young Temnopleuridæ, the presence of pits and sutures is a feature only developed with age, and the transition is insensible between the types in which the pits and sutures are formed by the modification of a flat surface due on one side to the thickening or elevation of nearly the whole plate, or, on the other, of only a portion of it. This still leaves, however, as characteristic of the Temnopleuridæ and their nearest allies as limited by Duncan, the remarkable dowelling of the sutural faces.

The peculiar sunken pits of the Clypeastroids extending around the primary tubercles reach deep into the thickness of the test; they are not to be regarded as merely sunken areolas. In some of the Nucleolidæ we have a similar sunken area round the primaries; on the actinal side, round the actinostome of such genera as Rhynchopygus, these pits are independent of the tuberculation, and form very deeply sunken and irregularly shaped grooves in the thickness of the test. In Goniocidaris, another genus in which we have pits and sutural bands, they are not deep, and do not extend into the thickness of the test.

Temnechinus maculatus A. Ag.

Lat. 26° 31′ N., Long. 85° 53′ W. Lesser Antilles, Florida. 73–229 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878 ; VIII., No. 2, p. 76, 1880.

This species has also been dredged by the U. S. Fish Commission off Newport in deep water.

Trigonocidaris albida A. Ag.

Lat. 24° 15′ N., Long. 82° 13′ W. Florida, Lesser Antilles. 124–450 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878; VIII., No. 2, p. 77, 1880.

Echinus gracilis A. Ag.

Straits of Florida, West Indies, East Coast of U. S., and as far north as off Martha's Vineyard, by the U. S. Fish Commission. 93–200 fathoms.

Echinus norvegicus Düb. o. Kor.

Off Newport, in Lat. 39° to 41° N. Very common in 1242 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 77, 1880.

It seems almost hopeless to attempt to distinguish the species of Echinus known as *E. elegans*, *E. norvegicus*, *E. melo*, and *E. Flemingii.* While the specimens from the same localities usually vary but little, those of adjoining or distant localities vary to such an extent that they generally combine more or less the specific features by which we have become accustomed to separate the above-named species.

A large series of *E. norvegicus* from 1242 fathoms shows but the slightest possible variation among the different individuals; yet they all have the anal system which thus far has been considered characteristic of *E. elegans.*

The largest specimens I have seen of this species were collected by the "Porcupine," but they differ in no marked way from the typical *E. norvegicus.*

* Echinus Wallisi A. Ag.

Echinus Wallisi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 77, 1880.
Atlantic Coast of U. S., Lat. 31°–41° N., Long. 65°–74° W. 257–1047 fathoms.

This species is evidently closely allied to, if not identical with, *Echinus Alexandri*, subsequently described (1882) by Danielssen and Koren. They have given a very characteristic and excellent figure of this species in Plates III. and IV., Figs. 7–16, of Nyt. Mag. for Naturvid., XXXVII. For their description, see page 294 of the same article. *E. Alexandri* was dredged from a depth of 536 fathoms, Lat. 69° 18′ N., Long. 14° 32′.7 E.

This is a large species allied to *E. Flemingii* and *E. elegans.* The test is somewhat depressed. It is readily distinguished by the close secondary tuberculation surrounding the primary tubercles, and by the arrangement of the pairs of pores in sets of two. The primary spines are long and sharp, like those of *E. Flemingii.* The anal system is intermediate in size between that of *E. Flemingii* and that of *E. elegans.* When alive it was of a brilliant dark reddish pink color, the test of a darker shade than the spines; these are darkest at the base and pinkish at the tip. The smallest specimen collected measured about half an inch in diameter. A fine large specimen of this species, measuring three and a half inches in diameter, was collected. It has also been found off Newport by the U. S. Fish Commission.

Toxopneustes variegatus A. Ag.

Yucatan Bank, Florida, Lesser Antilles. Lat. 32° 25′ N., Long. 77° 42′ 30″ W. 14–300 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 78, 1880.

Hipponoë esculenta A. Ag.

Yucatan Bank, Cuba, Florida, Lesser Antilles. 14–451 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 78, 1880.

Echinocyamus pusillus Van Ph.

Florida Bank, Florida, Cuba, Lesser Antilles. 98–805 fathoms; most abundant between 150 and 400 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878; VIII., No. 2, p. 78, 1880.

An immense number of dead tests of this species were dredged in the Caribbean, the Gulf of Mexico, and the Straits of Florida. It has not yet been found to the northward of the Straits of Bemini. The number of living specimens brought up is small. It is interesting to note, in this connection, that the dead tests of species of Clypeaster, of Echinanthus, of Encope, of Schizaster, of Macropneustes, of Agassizia, of Echinolampas, of Linopneustes, of Toxopneustes, of Trigonocidaris, of Temnechinus, of Salenia, and of Cidaris, were also frequently dredged, and sometimes in considerable numbers. This has an important bearing as indicating the species which are likely hereafter to be preserved as fossils, and shows us how difficult it may become, even when we have such an abundant and characteristic Echinid fauna as that of the West Indies, to reconstruct it from the future fossils. It is also interesting to note that the genera (except Echinocyamus) of which we so frequently find the dead tests are the same which have been known as characteristic of the West Indies since the earliest tertiary. Evidently, except under the most favorable circumstances, we cannot expect to find represented as fossils the Echinothuriæ, Pourtalesiæ, and many of the Echinidæ, which after death readily fall to pieces, and may be dissolved by the excess of carbonic acid at great depth before they become protected by a covering of deep-sea ooze.

Clypeaster latissimus A. Ag.

Laganum latissimum Hupé, 1856, Castel Voy. Am. Sud., p. 98 (non Lam.).

Yucatan Bank, Lesser Antilles. Santa Cruz, 248 fathoms; Dominica, 98 fathoms; Montserrat, 88 fathoms; Lat. 18° 12′ N., Long. 64°, 1952 fathoms; Granada, 92 fathoms.

Pl. XV^b. Figs. 3, 4; Pl. XV^c. Figs. 3, 4.

The Blake dredged a number of specimens of the flat Clypeastroids. With this additional material I have made a renewed comparison of the species I had been led to unite under the name of *Clypeaster subdepressus* in the Revision of the Echini. I am now inclined to recognize three West Indian species of the genus Clypeaster, all of which had been before described on what I presumed to be insufficient data, and from the great variations I had observed in the shallow-water *C. subdepressus* of Florida I was induced, at the time of writing the Revision, to consider these so-called species as all belonging to the common Florida species. The remarkable constancy of certain characters, however, in the series I have collected, has led me to return to the old specific distinctions, and to recognize three well-marked specific types in the genus.

The typical *Clypeaster subdepressus*, with a large rosette, a thick rounded edge, and the test but slightly arched in the petaloid region, and with close, remarkably uniform tuberculation extending over the whole of the actinal surface of the test, close to the ambulacral furrows, which disappear in the tuberculation near the edge of the test. On the abactinal side the whole surface is covered by a close tuberculation, smaller than that of the oral surface, and the tubercles are separated by a fine granulation.

The second species, *C. latissimus*, is marked for its thin test, and for its small ambulacral rosette, which does not extend more than half-way from the apex to the edge of the test; the whole abactinal surface is covered by a close pavement of minute miliary granulation, with the exception of a small part of both the ambulacral and interambulacral areas adjoining the apex, where we find a few large distant primary tubercles. On the actinal side the tuberculation is very striking; primary tubercles similar to those of the apex extend around the edge of the test, as they pass towards the actinostome diminishing rapidly in size on the ambulacra towards the median part of the furrow, which is covered by fine miliary granulations. Along the edge of the furrow there are small primaries passing into larger primary tubercles with three or four still larger primaries towards the outer edges of the ambulacral plates. The interambulacral plates carry huge primary tubercles, three or four to each plate, arranged in irregular concentric rows. These tubercles increase in size towards the central part of the interambulacral area, and then diminish again in size towards the actinostome. The intertubercular space is closely packed by a minute miliary granulation. The miliary granules of the actinal and abactinal surface carry short, sharp, straight miliary spines; these are somewhat larger, and curved on the edges of the furrows and over the petaloid ambulacra. The large primary spines of the interambulacral areas of the actinal side are long, stout, curved, slightly spathiform, and recall somewhat for Clypeastroids the Lovenia type of spines and of tuberculation.

The color of these flat Laganum-like specimens is bright yellowish green when alive; the large spines are of a lighter yellow color. This species is undoubtedly the one Hupé referred to *Laganum latissimum.*

The third type, which I have figured on Plate XI[c]. of the Revision, and described under the name of *Stolonoclypus Ravenellii*, is characterized by the thick-swollen edge and the high central part of the test, by the large open petals with the distant pairs of pores, succeeding pairs being about twice as far apart as in *C. subdepressus* and *C. latissimus*, and by its distant uniform primary and coarse intertubercular granulation. As in *C. subdepressus*, the granulation covers the abactinal surface uniformly. On the actinal side it is coarser, more distant, the tuberculation becoming smaller as it passes into the ambulacral areas, leaving the greater part of the ambulacral plates merely covered by a fine miliary granulation.

The figures I have given in the Revision of the Echini as characteristic of the young stages of *Clypeaster subdepressus* are on Plate XIII. Figs. 10–18; these, however, all belong to the swollen-edge type, *C. Ravenellii;* the other, Plate XII[d]. Fig. 4, is a young of *C. latissimus.* An excellent series of the young stages of *C. latissimus* shows that in these very flat Clypeastroids the needle-like or separate lamellar pillars forming the inner partitions become united together at their extremity, either simply at the base or along the whole height of the pillar, so as to form more or less irregular concentric and dendritic partitions or isolated pillars arranged in concentric rows.

The structure of the partitions in *C. latissimus*, and the presence of ambulacral furrows, show a close relationship between the flat Clypeastroids and the

Laganidæ.* Among the specimens I have had occasion to examine I do not find any marked difference due to age in the width of the marginal edge which is occupied by the pillars. The structure of the test of the flat Clypeastroids shows that they are closely connected with Conoclypus, the ambulacral furrows and the teeth specially showing these groups to have an intimate connection. Echinolampas, on the contrary, although superficially more closely related, in reality differs more from Conoclypus than do the flat Clypeastroids.

Clypeaster Ravenellii A. Ag.

Stolonoclypus Ravenellii A. Ag. Bull. M. C. Z., I. p. 265, 1869.
West Florida Bank. 14 fathoms. Yucatan Bank. 84 fathoms.

Pl. XV^b. Figs. 1, 2; Pl. XV^c. Figs. 1, 2.

Clypeaster subdepressus Agass.

Florida, Yucatan Bank, Lesser Antilles. 84–1952 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 79, 1880.

Pl. XV^a.

Echinanthus rosaceus Gray.

Yucatan, Cuba, Lesser Antilles. 14–118 fathoms.

The specimens dredged by the Blake show the usual differences in the comparative height and length of the test.

Echinarachnius parma Gray.

Lat. 40° 59′ N., Long. 71° 22′ 30″ W. Lat. 41° 30′ N., Long. 66° W. Off Newport. 71–306 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 79, 1880.

The genus Echinarachnius extends to a greater depth than Mellita. The former was very common beyond the 100 fathom line north of New York, and on the George's Bank, but to the south it was not found at the same depth, nor were any of the species of Mellita, and but one of Encope, dredged by the Blake beyond the 100 fathom line in the very districts in which these genera are the most typical littoral species.

* I would refer also to an article on the Laganidæ in Ann. and Mag. Nat. Hist., No. 62, for February, 1883. I do not propose to discuss the statements made by Prof. F. J. Bell.

Encope Michelini AGASS.

Yucatan Bank. 14 fathoms.

Echinonëus semilunaris LAMK.

Cuba. Littoral to 80 fathoms.

Neolampas rostellata A. AG.

Florida Bank. 229 fathoms.

Pl. XXII.

A number of specimens of this interesting genus, of all stages of growth, having been collected by the Blake in the Straits of Florida, I am able to add considerably to our previous knowledge of the genus. As in all Cassiduloids, the affinities of the family to the Clypeastroids is more or less marked. In the young specimens from Florida the changes taking place in the actinostome, in the ambulacral system, and in the shape of the test, as well as the structure of the pedicellariæ and of the abactinal system, all show strikingly the close affinities of the family with the Clypeastroids.

In the youngest stage examined, measuring only 2.5 mm. in length, the test, instead of being globular, as is the case in the Spatangoids proper, is quite flattened, its outline is elliptical, the anal system is covered by few large plates, and the general aspect of the young Neolampas at this stage and in the following one, when it measures about 4.5 mm. in length, closely resembles the young of some of the true Clypeastroids which I have had occasion to examine, such as Echinocyamus, Mellita, or Echinarachnius.

On their first appearance the bourrelets and phyllodes are with difficulty made out, and in the earliest stages the actinostome shows no trace whatever of them. The ambulacral suckers are, like those of the Clypeastroids, provided with powerful suckers near the actinostome, which are but slightly developed above the ambitus; we find no fimbriated actinal tentacles, even in the largest specimens collected, measuring 12 mm. in length, so characteristic of the Spatangoids proper. The bourrelets are well developed in specimens of 10 mm. in length, and in the largest specimen (12 mm. long) they have become very prominent. The lateral crowding of the ambulacral plates near the actinostome to form the phyllodes is well shown on comparing the arrangement and size of the plates as seen from the interior of the test in two specimens, one of which measured probably 7–8 mm. in length, the other from 10 to 11 mm. The interambulacral spines of the bourrelets are slender and longer than those of the tubercles of corresponding size in other parts of the test. The somewhat distant primary radioles, are short, sharp, slender, and the intertubercular space of the whole test is thickly covered by secondary tubercles, carrying small, slender, straight radioles, usually having a slight cup-shaped extremity, which have been well figured by Thomson in the Echini of the Porcupine Expedition; he has also figured the pedicellariæ characteristic of this species. The principal large pedicellariæ are more closely allied by their structure to the Clypeastroid than to the Spatangoid types; in addition to these, there are also in the ambulacral areas more numerous pedicellariæ with short stout stems, quite similar to the secondary radioles but somewhat more slender, carrying a small trifid head set closely upon the cup-shaped extremity of the stalk. Minute long-stemmed, small-headed pedicellariæ are found near the actinostome in the ambulacral and interambulacral areas.

As the test increases in size its outline becomes more angular, the posterior extremity more elevated, and the Spatangoid features of the genus more apparent. There is, however, even in the largest specimen collected, no trace of petaloid ambulacra on the abactinal surface; the ambulacra retain as far as we know their simple embryonic structure. The apical system is compact, the genital openings are large, the left anterior and posterior genitals are atrophied. This was not the case either in the specimens collected by Thomson or in those previously dredged off Florida, in which the left anterior genital pore was wanting, in addition to the odd posterior one. In a specimen measuring 10 mm. in length there are two or three madreporic openings in the space between the genital openings. In Thomson's specimens, which are larger than any I have dredged, there are two such openings. I was unable to distinguish the line of sutures between the different genital plates. When covered with spines, the genital openings are protected by long secondary spines, and genital tubes are seen to project through the large openings beyond the level of the spines. Two or three, and sometimes four, sphæridia are found near the actinostome in each ambulacral area.

Echinolampas depressa GRAY.

Yucatan Bank, Lesser Antilles. 82–101 fathoms.

Pl. XVI., Pl. XXIV. Figs. 1–5.

The Blake dredged in the Caribbean a number of specimens of this species. They are interesting as showing that the important modifications in the petaloid region of the ambulacral system, which characterize this and allied species in different stages of growth, make their appearance very early. In the younger stages I have figured (Revision of the Echini, Pl. XVI. Figs. 6, 7, 17, 18, 19, 21), the early development of the petaloid ambulacra and the unequal growth of the different poriferous zones of the ambulacra are quite striking. In a specimen measuring 37 mm. in longitudinal diameter, the left petaloid poriferous zone of the odd anterior ambulacrum is four pairs of pores shorter than the right. The anterior zone of the anterior ambulacra is fourteen pairs of pores shorter than the posterior zone, and the posterior zone of the lateral posterior ambulacra is seventeen pairs of pores shorter than the anterior zone. In a specimen measuring 45 mm. the difference in the number of pairs of pores between the same poriferous zones was greater by three in the anterior ambulacra, and less by four in the posterior ambulacra. This striking numerical difference still existed in specimens measuring no less than 50 mm. in length (Pl. XVI. Figs. 1, 3, 6), but is by no means constant, the difference between the number of pairs of pores in the anterior and posterior zones of the lateral ambulacra or in the right and left zones of the odd ambulacrum sometimes varying from the ratio stated above as much as four to six pairs. Similar differences in the length of the zones of the ambulacral petals are known in several recent and fossil species of the genus. This naturally suggests the propriety of subdividing the genus Echinolampas. This has been attempted in part by Bell, who has separated as Palæolampas a species of Echinolampas with straight ambulacral zones, and in which the outer rows of pores are the largest, and form with their rudimentary furrows embryonic petals. De Loriol has shown the difficulty of taking this character alone as basis for a generic division; but it would be convenient were we to take the living types alone, and subdivide the genus Echinolampas proper into sections, one containing the ovoid forms with distinctly petaloid ambulacra of equal length, another containing those in which there is a marked difference in the length of the poriferous zones of the ambulacral petals, and a third, which Bell has called Palæolampas, characterized by the straight apetaloid ambulacral zones. The differences in the petaloid ambulacra are accompanied by other structural features, such as the position and outline of the anal system, and the character of the phyllodes and bourrelets, forming combinations of characters which a revision of the genus may show justify this subgeneric division. But as has been already pointed out by Cotteau and De Loriol, such a subdivision is impracticable if we take into account the numerous fossil species of Echinolampas. The subdivision of the genus to which *Echinolampas depressa* belongs is also marked by the absence of intercalated plates in the formation of the phyllodes (Pl. XVI. Fig. 4), and by the prominent apical button formed (Pl. XVI. Fig. 5) by the madreporic body, much as in Conoclypus. The characteristic uniform tuberculation of the test of *E. depressa* is seen in the different figures of Plate XVI. On the actinal surface there is a narrow band in the median ambulacral areas towards the actinostome. The abactinal surface of the test is covered by slender radioles; the radioles of the abactinal region are slightly shorter, increasing in length towards the ambitus, and becoming somewhat longer on the actinal side. The miliary spines are about a third of the length of the primary spines. When alive, the spines are of a greenish yellow color; the test, of a dirty yellow color. It is interesting to note that, of the many fossil species of Echinolampas described by Cotteau* from the West Indies, only two, *E. Castroi* and *E. Anguillæ*, show any marked difference in the length of the poriferous zones of the petaloid ambulacra.

On Pl. XXIV. is figured the youngest stage of Echinolampas I have seen. It measures 5 mm. in longitudinal diameter. The apical system is already eccentric; but in this stage the ambulacra are simple, showing no trace at the apex of rudimentary petals. The actinal system is circular, and the anal system is still on the posterior face of the test; the bourrelets are in the simplest form possible, a slight swelling of the ambulacral area at the actinostome, but the tuberculation is not different from that of the other part of the ambulacra.

* Cotteau, Ann. Soc. Géol. de Belgique, 1881, IX., Pl. II. Échinides Tertiaires des Isles St. Barthélemy et Anguilla, K. Vet. Akad. Handl., B. XIII., No. 6, Pl. IV., 1875.

Conolampas A. Ag.

Conoclypus A. Ag. Bull. M. C. Z., V., No. 9, p. 190, 1878 [non auct.].

* **Conolampas Sigsbei** A. Ag.

Conoclypus Sigsbei A. Ag. Bull. M. C. Z., V., No. 9, p. 190, Pls. I., II., 1878.
Yucatan Bank, off Havana, Lesser Antilles. 76–450 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 80, 1880.

Pl. XVII.

This magnificent species is by far the most striking Sea-urchin I have seen. I shall always remember the particular haul, when, on the edge of the Yucatan Bank, the dredge came up containing half a dozen of these huge brilliant lemon-colored Echini.

The test is covered by small primary tubercles of uniform size, quite regularly arranged on the plates of the test, both on the ambulacral and inter-ambulacral areas. The tubercles on the actinal side are similarly arranged, with the exception of the vicinity of the ambitus, where they are more closely crowded together. The primary tubercles are surrounded by a deeply sunken scrobicular area, much as in Echinolampas and Rhynchopygus. The miliary tubercles are uniformly scattered between the primaries, and are separated by irregular transparent glassy ridges and elongated pits, much as we find them on the actinal side of Rhynchopygus; but near the ambitus on the actinal side, where the primary tubercles are most closely crowded, they are separated by closely packed secondary tubercles. The actinal bourrelets are very prominent; the floscelle is large, broad, well defined, extending nearly one third the distance from the actinostome to the ambitus. There are small, elongate, short-stemmed, slender pyramidal pedicellariæ scattered irregularly over the actinal surface; they are much less numerous on the sides of the test. The primary spines are short, slender, cylindrical, rapidly tapering at the extremity; the miliary and secondary spines are similar to the primary ones, but smaller. The apical system is compact, the genital plates all coalesce, the centre of the apex is occupied by the madreporic body, which is developed into a prominent knob, on the sides of which the ocular plates rise. There are four large genital openings; the odd posterior genital is wanting. The ambulacral zones are all identical in structure, two rows made up of distant pores extending two thirds of the distance from the apex to the ambitus, forming the rudimentary petaloid ambulacra. At the extremity of these petals, the pores suddenly come close together, the poriferous zones becoming extremely narrow, and continue thus narrowed to the ambitus, and over to the actinal side, until they meet the floscelles. The anal system is covered by an outer row of three large plates and one smaller one, with a few smaller plates closing the outer edge of the anal system.

It was with considerable hesitation that I referred this species, when first described, to the genus Conoclypus. While it undoubtedly agreed with it in having a central apical system, a high conical test, and the five ambulacra of the abactinal side equally developed, yet the arrangement of the pores (Pl. XVII. Fig. 7) and the development of the phyllodes and of the bourrelets (Pl. XVII. Fig. 5), the transversely elliptical anal system (Pl. XVII. Fig. 6), and the structure of the apical system (Pl. XVII. Fig. 3), seemed to ally it more closely to Echinolampas. From the latter genus it differed, however, in the arrangement of the petaloid ambulacra, which do not form open petals as in the species of Echinolampas thus far known, but merely straight poriferous zones, not furrowed (Pl. XVII. Fig. 2), extending close to the ambitus. This feature alone would perhaps seem insufficient as a generic distinction, for we find in *E. depressa* of Gray that the ambulacral petals are modified somewhat from the characteristic Echinolampas type (*E. oviformis*), and besides not having closed petals, the poriferous zones of the different ambulacra are all of unequal length, somewhat as in *E. Alexandri* De Lor. (see Pl. XVI. Fig. 1), one of the characters by which Prof. F. J. Bell* attempted to separate the genus Palæolampas from Echinolampas. De Loriol† is of opinion that the characters on which Mr. Bell attempts to establish the genus Palæolampas are insufficient, yet we may find it convenient from the great variation we find in the petaloid areas of Echinolampas to adopt Palæolampas as a subgeneric type.‡

Zittel was the first to show, in his *Handbuch der Palæontologie* (I. 515), that some species of the genus Conoclypus possessed teeth. This led De Loriol to make an examination of this genus, and he found that it really contained two generic types, one with phyllodes, which was edentate, and another in which there is no trace of phyllodes, but an enormous development of the bourrelets, which is provided with teeth. For the first type

* Proc. Zoöl. Soc. London, 1880, p. 43.

† Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, 1880, XXVII. 88.

‡ See page 46.

De Loriol has proposed the name of Phylloclypeus.* These discoveries led me to make a renewed examination of *Conoclypus Sigsbei.* On opening a specimen I found that it was edentate, as had been suggested by De Loriol from the presence of the well-developed phyllodes (Pl. XVII. Fig. 5) characteristic of Echinolampas and of the edentate Conoclypus type he called Phylloclypeus. On comparing the structure of the actinostome in *Conoclypus Sigsbei,* as seen from the interior, with that of Echinolampas, I found very striking differences. As is well known, in *Echinolampas Hellei* (Pl. XV. Fig. 9, Rev. Echini) the test immediately round the actinal opening rises slightly, in a conical shape, above the general level of the actinal floor. This is also the case in *E. depressa,* but in both cases the edges of this conical elevation form a smooth ring round the actinostome, the cone being in fact merely the turning up of the outer edges of the last plates immediately adjoining the actinostome. In *Conoclypus Sigsbei,* on the contrary, the structure of the ring of plates round the actinostome is quite similar to that described by Zittel and De Loriol in Conoclypus with teeth; the processes which support the jaws, although wanting (Pl. XVII. Fig. 4), are still indicated by slight angular knobs, and we also find the deep pits described by these authors in the interambulacral areas at the base of this elevated ring.

This structural feature is one of the most interesting found among Echini, as it seems to show us the direct passage, as it were, between the edentate Echini and those provided with teeth. We have no full description as yet of the jaws of Conoclypus, but enough is known to show us how closely allied they are to those of the Clypeastroids. In Conoclypus they are evidently held in place by vertical processes, very similar to those which thus far have been considered as characteristic of the Clypeastroids. With the diminution in size of the jaws in these types we must expect to find genera in which the supporting processes alone are left, and we may look for them in the forms allied to the genus Phylloclypeus of De Loriol. The next stage will be the practical disappearance of these processes, their former presence being indicated by mere knobs, as in *Conoclypus Sigsbei,* until we get the typical modern Echinolampas, in which the plates forming the actinal ring rise only as a low cone above the general level of the actinal floor, and all traces of these processes and of the interambulacral actinal pits have disappeared. It may be convenient for the present to call this modern rep-

* Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, 1880, XXVII. 79.

resentative of the Conoclypei, with its central apex and characteristic ambulacra, by the name Conolampas, until we know more of the structure of the interior of the actinostome of the Cretaceous genus Phylloclypeus of De Loriol, as well as of the species of Echinolampas with high test, to which this species of Conolampas may perhaps be more closely related than now appears. Cotteau has figured such a species of Echinolampas (*E. semiorbis*, Guppy) from the Eocene of St. Barthélemy, and he likewise calls attention to its resemblance to several species of Conoclypus.

As I have already stated in the Preliminary Report of the Blake Echini (Bull. M. C. Z., V., No. 9, p. 191), I described in the Revision of the Echini, and figured on Pl. XVI. of that work, several stages of the young of Conolampas (*Conoclypus Sigsbei* A. Ag.) as the young of Echinolampas. I had not at that time dredged Conolampas, and was thus misled, by the examination I had made of only a few young stages either of Echinolampas or of Conolampas, to consider them all as belonging to the same genus.

Additional young specimens of Echinolampas and of Conolampas having been obtained in the Caribbean by the Blake, I am now able to rectify my error, and, by referring to the figures given on Plate XVI. of the Revision, to indicate those which belong to Echinolampas, and those which represent young stages of Conolampas.

It will be seen that in corresponding stages of growth of these two genera we find in one case, in young specimens of Echinolampas, already the first trace of the peculiar petaloid development of the ambulacra characteristic of this species (Pl. XVI. Figs. 6, 7, Rev. Echini); while in the corresponding young stages of Conolampas (Pl. XVI. Figs. 4, 11, 12, Rev. Echini) the ambulacra have the characteristic structure of the genus. To recapitulate, Figs. 6, 7, 17, 18, 19, 21, of Plate XVI. of the Revision, belong to Echinolampas, while Figs. 1–5 and 8–16 of the same plate belong to the young stages of Conolampas.

The Pygaster or Echinoconus * stage, if I may so call it, of both Echinolampas and Conolampas, appears to be a most characteristic stage of these genera, and it is possible that the recent species mentioned by Lovén as *Pygaster relictus*, may after all only be a young stage either of Echinolampas or of Conolampas. This is very probable judging from the size of Lovén's specimen, 3 mm. in diameter, and from its origin, the Virgin Islands.

* See the excellent figures of a fine series of Echinoconus given by Cotteau in Bull. Soc. des Scien. Hist. et Nat. de l'Yonne, (2,) IV., 1881, Pl. I.

Pourtalesia miranda A. Ag.

Off Havana, Grenada. 242–576 fathoms.

The fragments of other Pourtalesiæ, dredged principally off the Barbados, to which I referred in Bull. M. C. Z., VIII., No. 2, p. 80, 1880, belong probably to the genera Cystechinus and Spatagocystis. The fragments are too imperfect for determination, and have no value beyond the fact that they indicate the presence of other species of the group in the West Indies.

Urechinus naresianus A. Ag.

Lesser Antilles, Lat. 41° 24′ 45″ N., Long. 65° 35′ 30″ W. 422–1242 fathoms.

Pl. XXVI. Figs. 1–3.

The greater part of the specimens collected by the Blake measured about 30 mm. in length, but varied greatly in height. They agree quite closely with what I have designated as the normal stage in the Report of the Challenger Echini. (See Chall. Ech., Pl. XXX^a. Figs. 7–9, p. 146.) The specimens examined all show but three genital openings. The structure of the subanal fasciole shows that in this genus it assumes all the stages of development intermediate between a well-defined subanal plastron, such as is figured on Plate XXX^a. of the Challenger Echini Report, and a stage in which this fasciole is indicated merely by irregular accumulations of miliary tubercles. So that the genus Urechinus is the representative of the oldest Spatangoids with a disconnected apical system, large ambulacral and interambulacral plates with simple linear ambulacral pores, in which the subanal fasciole (the only one existing) is still in process of formation; this type of Spatangoid leading us little by little to Spatangoid genera in which the ambulacra become more or less petaloid, as in Homolampas, Paleopneustes, and the like, till we get the modern type of Spatangus proper, with well-defined petaloid ambulacra, and a highly developed subanal fasciole, the lateral fasciole existing in some of these genera, Paleopneustes, Linopneustes, Calymne, Maretia, etc., in a rudimentary form, as accumulations of miliary tubercles along the ambitus. On the other hand, a slender peripetalous fasciole is in some genera, Paleopneustes, Homolampas, Rhinobrissus, etc., developed as a slender thread, or as a more or less well-defined fasciole extending across the termination of the more or less rudimentary petals.

We find the lateral fasciole developed from the peripetalous fasciole in such genera as Hemiaster, Rhinobrissus, Linthia, Schizaster, etc., on the one side; and on the other, in such genera as Paleopneustes, Maretia, Linopneustes, Homolampas, etc., we find the more or less rudimentary lateral fasciole plainly developed from the anal or branches of the subanal fasciole, or independently.

This corresponds fairly well with the two series we find among the fossil genera, in one of which the lateral fasciole is the appendage of the peripetalous fasciole, and in the other of the fasciole of the anal system, or has arisen entirely independently as an ambital lateral fasciole, if I may so call it.

Palæotropus Josephinæ Lovén.

Off Havana, Lesser Antilles. 82–242 fathoms.
For list of Stations, see Bull. M. C. Z , VIII., No. 2, p. 81, 1880.

Pl. XXIII. Figs. 5–14.

A small specimen 10 mm. long did not differ from that figured by Lovén (Pl. XIII. Figs. 108–113, *Études sur les Échinoïdées*). Older specimens measuring 23 mm. in length, figured on Plate XXIII., are comparatively less globular and more flattened, but otherwise do not vary greatly in appearance from the younger specimens. In the Preliminary Report * on this collection I had referred a few larger Spatangoids to this species; but on denuding them from spines I find that they have nothing in common with Palæotropus, and they are described in this Report as belonging to a new genus (Palæobrissus) intermediate between Platybrissus and Argopatagus.

The test of this species is comparatively bare (Pl. XXIII. Figs. 5–11), carrying but few primary spines; these are generally straight, with a smooth shaft, only a few of the very largest spines being slightly serrated. The miliaries and secondaries are more numerous, generally club-shaped at the extremity, often curved, and many of them with serrated shafts. The miliary tubercles of the anal fasciole carry comparatively long, slender, slightly club-shaped spines.

The coloring of small specimens is of a greenish violet, the whole test being irregularly covered with distant dark violet pigment-spots. With increasing size these spots become less numerous, concentrating mainly about the base of the primary spines.

* Bull. M. C. Z., VIII., No. 2, p. 81.

There is little difference in the arrangement of the ambulacral plates in older or younger specimens. The two large genital openings, already present in the youngest specimens known, have greatly increased in size, and the madreporic openings are better developed in larger specimens (Pl. XXIII. Fig. 12). The mode of formation of what has been called a compact abactinal system is admirably shown in the structure of the apex of Palæotropus, in which the exterior sutures of all the plates adjoining the interambulacral areas are most distinct, while the interior junction of the genital plates has become completely obliterated (Pl. XXIII. Fig. 12), they being still separated by the odd imperforate genital plate which is intercalated between them, and of which the posterior and lateral sutures are still well marked, while the interior anterior sutures are no longer visible. In Palæobrissus the sutures of all the plates of the apex can be distinctly detected.

In the youngest stages, as well as the larger, we find near the actinostome in each ambulacral area one or two unusually elongate sphæridia. They have a comparatively long reticulated stem, and it is interesting to note that in some of the larger specimens we find near the ambitus on the actinal side peculiar miliary spines which I am inclined to consider as modified sphæridia. These peculiar spines have the shaft of a miliary, but the tip is swollen out to a clear sphere resembling in all respects the head of sphæridia, of which the base of attachment is usually merely rudimentary, as described by Lovén; in addition we have such types as the sphæridia typical of the actinal side of the genus Palæotropus. This would seem to show that the sphæridia, like the pedicellariæ, the spines of the fascioles, and perhaps other appendages of the test of Echini, are only modified forms of spines.

Danielssen and Koren * have figured peculiar spines of Hymenaster, which also throw considerable light on the nature of the sphæridia. They are clusters of reticulations at the base of a central shaft, much like the reticulations figured by Lovén as characteristic of the base of sphæridia. These spines are surrounded by a bag-like pouch representing undoubtedly for Starfishes the bag-like appendages of certain spines of Asthenosoma and Aspidodiadema, which in their turn seem to have close affinities with the peculiar gland of certain Echinid pedicellariæ described by Sladen and others, as I have already noticed in the description of some remarkable spines occurring on the test of Aspidodiadema.

* Plate II. Figs. 2, 3, Nyt. Mag. for Naturvid., XXVIII.

In the larger specimens of *Palæotropus Josephinæ* there is a slight tendency to the formation of very rudimentary bourrelets. The larger outer plates of the actinal system carry a few minute miliary tubercles and spines. (Pl. XXIII. Fig. 14.) On the abactinal surface the ambulacral suckers are slender, surmounted by a small indistinct sucker, the tentacles increase in size towards the ambitus, and near the actinostome there are four or five large fimbriated tentacles in each ambulacral area.

The pedicellariæ are most varied, representing types characteristic of the Clypeastroids as well as the Spatangoids. On the actinal side there are in the ambulacra, near the outer edges, minute slender, long-stemmed, two-jointed pedicellariæ with small pear-shaped trifid heads. At the ambitus, interspersed among the preceding, are short-stemmed, large-headed, stout pedicellariæ resembling the Clypeastroid types. In the bare interambulacral spaces there are a few large-headed, short-stemmed, trifid pedicellariæ, some with short prongs, others with long crossing prongs. Scattered irregularly over the abactinal surface are few distant triangular-headed trifid pedicellariæ, with long, slender stems, and short, flexible head-joints. The heads of these last pedicellariæ are of two very different sizes, but otherwise they do not differ.

* **Palæotropus Thomsoni** A. Ag.

Palæotropus Thomsoni A. Ag. Bull. M. C. Z., VIII., No. 2, p. 80, 1880.
Lat. 32° 43′ 25″ N., Long. 77° 20′ 30″ W. 233 fathoms.

At Station 321 a single broken specimen of this species was collected, which differs most strikingly from all the other specimens of Palæotropus. It is closely covered by uniform tubercles on the abactinal side. It has a proportionally greater number of coronal plates, and a high test, with a keeled posterior interambulacral median line. Apex more posterior than in *P. Josephinæ*.

The color of the test is yellowish white when alive. The large *P. Josephinæ* are of a dirty greenish red color, and when young more pinkish. This species is also remarkable for its broad, bare posterior lateral ambulacra on the abactinal side, and for its prominent keeled, very elongate actinal plastron, and its longitudinally elongate anal fasciole, still very prominent at a time when in *P. Josephinæ* the posterior extremity has become flattened, and the fasciole quite indistinct.

* **Palæobrissus Hilgardi** A. Ag.

Station No. 300. 82 fathoms, Barbados.
Station No. 295. 185 fathoms, Barbados.

Pl. XXIV. Figs. 6–15.

At the time of writing the Preliminary Report on the Echini of the Blake cruise in the Caribbean, the specimens of this species were not distinguished in the first examination from *Palæotropus Josephinæ*, to which they have, when covered with spines, a general resemblance both in shape and coloring (Pl. XXIV. Figs. 6–8). Palæobrissus is one of the most interesting generic types collected by the Blake. From the structure of its ambulacra it is closely allied to both Platybrissus, Nacopatagus, and Argopatagus. The ambulacra are not petaloid, as in the former genus. The pores of the lateral ambulacra are arranged in straight, double, diverging rows (Pl. XXIV. Fig. 10). The pairs of minute pores of the abactinal region increase rapidly in size towards the extremity of the rudimentary petals, the last four pairs being large and well separated, the outer pore of each pair slightly larger than the inner one; the lateral ambulacral petals extend nearly to the ambitus (Pl. XXIV. Figs. 11, 12). The odd anterior ambulacrum is not as prominently developed as the lateral ambulacra, the pores remaining all small (Pl. XXIV. Fig. 10). There are four genital pores (Pl. XXIV. Fig. 15), the anterior pair the smallest, separated from each other by the well-marked madreporic pores, which conceal the sutures between the anterior genital plates. The posterior genital plates are comparatively large, adjacent, becoming intercalated with the median posterior interambulacral plates. The anterior part of these genital plates is perforated by the large elliptical posterior genital pores. The structure of the apical system of this genus shows how the abactinal interambulacral plates are derived from the terminal plates of a compact apical system; these are not necessarily the genital plates, but may be intercalated plates formed from the subdivision of any of the abactinal interambulacral plates at the apical junction of the posterior lateral interambulacra with the odd interambulacrum.

The upper part of the test (Pl. XXIV. Fig. 10) is covered by small primary tubercles of uniform size, somewhat distant, quite regularly arranged on the plates, increasing in number towards the ambitus. The intertubercular space is filled by distant miliaries, also quite uniformly scattered over the test. The primary spines are small, slender, and straight. The miliary spines, similar in structure to the primaries, are not more than a third to a quarter their length. When covered with spines, the coloring is of a dark greenish violet; denuded, the test is of a pinkish gray.

On the actinal side (Pl. XXIV. Fig. 9) the primary tubercles are more closely packed in the interambulacral areas and on the actinal plastron, but the anterior ambulacral plates towards the actinostome, as well as the posterior lateral ambulacral areas on each side of the actinal plastron, are left bare. The posterior lip of the actinostome is but slightly developed (Pl. XXIV. Figs. 9, 13); there is a tendency to the formation of rudimentary bourrelets from the crowding of small secondary tubercles on the interambulacral edges of the actinostome (Pl. XXIV. Fig. 13). The anterior part of the actinal opening is covered by eight large polygonal plates of irregular outline; the remaining space on the posterior part of the actinostome along the actinal lip (Pl. XXIV. Fig. 13) is covered by smaller irregularly arranged plates. The actinal plates all carry minute secondary tubercles.

The anal system (Pl. XXIV. Fig. 14) is circular, surrounded by two or three concentric rows of irregularly arranged plates.

The large actinal tentacles are fimbriated; towards the ambitus and beyond it, until they reach the extremity of the petals, they become simple with a slight sucker. The tentacles of the petaloid region are broad, flattened, with an indistinct sucking disk.

The ambulacra carry, as in Palæotropus, short-stemmed, stout-headed, and short-stemmed, large-headed trifid pedicellariæ. Scattered irregularly over the test are long-stemmed, large, slender, open-headed trifid pedicellariæ.

Homolampas fragilis A. Ag.

Homolampas fragilis A. Ag. Bull. M. C. Z., V., No. 9, p. 191, 1878.
Florida Bank, Lesser Antilles. 734–1920 fathoms.

Fragments of a large specimen of Homolampas, very probably the adult of *H. fragilis* A. Ag., of which young specimens were dredged by Mr. Pourtalès (see Revision of the Echini, Pl. XVII. Figs. 13–21). These fragments show *H. fragilis* to be closely allied to the large species of the same genus (*H. fulva*, A. Ag.) described and figured in the Report on the Echinoidea of the Challenger (Pl. XXIV.). The Caribbean species differs from it, however, by the closer tuberculation of the miliaries, the larger number of primary tubercles in the interambulacral areas near the abactinal system, and the coarser tuberculation of the odd anterior groove above the ambitus; also in having a larger number of primary plates. No part of the anal system or of the actinal system was found among the fragments.

Paleopneustes cristatus A. Ag.

Off Havana, S. side of Cuba, Lesser Antilles. 56–450 fathoms.
Most common to the leeward of the West India Islands, between 90 and 150 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 81, 1880.

Pl. XXI.

A number of specimens of this species have been collected by the Blake, which are interesting as throwing additional light on the variability of the so-called lateral fasciole of this genus, and in showing the changes due to growth. Thus far only large specimens of this genus had been described, both from the Hassler and the Challenger expeditions. I have added to the figures of two of the principal stages of growth given on Plate XXI. Figs. 6–14, details of the actinostome (Fig. 5), of the apical system (Fig. 3), of the termination of the lateral petaloid ambulacra (Fig. 1), of the edge of the test near the ambitus from the abactinal side (Fig. 2), taken from a large specimen of this species measuring nearly 150 mm. in length and 80 mm. in height, as these details could not be very clearly seen in the photographic illustrations of this species in the Memoir on the Echini of the Hassler Expedition (Pl. IV. Figs. 1–3, Ill. Cat. M. C. Z., No. 8).

A small specimen measuring 45 mm. in length (Pl. XXI. Fig. 7) differed from the specimen figured in the Hassler Echini merely in size, and in having an indistinct lateral fasciole extending obliquely from the abactinal end of the anal system to the edge of the test, reaching the ambitus at the anterior lateral ambulacra, and extending faintly across the anterior part of the test along the ambitus. See Plate XXI. Fig. 7, and Fig. 8, which shows a small part of this fasciole close to the ambitus across the anterior ambulacral area. This can hardly be termed a lateral fasciole; it reminds us of a similar fasciole in Calymne, and it is difficult to decide in these cases whether this single fasciole should be called peripetalous as it passes across the posterior extremity of the test above the anal system, or a lateral fasciole occurring isolated from a peripetalous one; or whether it represents a rudimentary stage of the peripetalous fasciole, not crossing the ambulacra at the extremity of the petaloid ambulacra or the petals themselves, as in one of the species of Rhinobrissus, but crossing them below the petals at an indefinite place of the test; so that we might have an interior fasciole, as in Lovenia; a true peripetalous fasciole, as in Hemiaster; a transpetaloid fasciole, as in Gualteria and Rhinobrissus; or a marginal fasciole, as in some stages of growth of Paleopneustes and in Linopneustes; all representing different stages of development or modification of a petaloid fasciole. This simple series becomes complicated with the possible simultaneous existence of an internal and peripetalous fasciole or of a true peripetalous fasciole with a more or less marginal fasciole, forming in that case a lateral fasciole proper. In a specimen of this species measuring about 85 mm. in length, the marginal fasciole is traced only with difficulty near the ambitus across the anterior lateral ambulacra (Pl. XXI. Fig. 8), and it seems to disappear completely in somewhat older specimens. But in all the stages of growth that part of the ambitus and of the test adjoining the course of the marginal fasciole is thickly studded with miliaries and small secondary tubercles (Pl. XXI. Figs. 2, 6, 8).

In Linopneustes this marginal fasciole has assumed practically all the characters of a peripetalous fasciole crossing the posterior lateral ambulacra just at the end of the petals, while it still crosses the anterior ambulacra a short distance below the end of the petals. Neither in *Paleopneustes cristatus* nor in *P. hystrix* do we find any trace of a rudimentary subanal fasciole, either as an indistinct band or a part of a band, or even as accumulations of miliary tubercles; and it is interesting to note that in species so closely allied as *P. cristatus* and *Linopneustes Murrayi* there should be so striking a distinguishing feature as the presence or absence of a subanal fasciole, while in other genera of Spatangoids, Palæotropus, Urechinus, and Schizaster, in specimens of the same species, such as *Urechinus naresianus*, we should have a complete series passing from a well-defined subanal fasciole to a mere accumulation of miliary tubercles.

The smallest specimen collected, measuring about 16 mm. in length, is somewhat more flattened than the older stages, and shows as yet no trace of petals, the ambulacral plates and pores extending uniformly from the apex to the ambitus and actinostome without the specialization of any portion. (Pl. XXI. Figs. 9–11.) In this stage I could see no indication of a marginal fasciole. The apex was compact, but there was no trace as yet of any genital openings, and the madreporic body was very faintly indicated (Pl.

XXI. Fig. 12). In the apical system of the large specimen figured here (Pl. XXI. Fig. 3), the madreporic body covers nearly the whole of the space between the genital plates; the two left anterior plates, as well as the right posterior plate, are adjacent and perforated.

In the specimen measuring 45 mm. in length the apical system, as well as the anal system and the actinostome, had already assumed all the characteristic features of the larger and older specimens.

In the smallest specimen the actinostome is quite pentagonal (Pl. XXI. Fig. 13), and the posterior actinal lip only slightly indicated. The plates covering both the actinal opening and the anal system do not differ greatly in number in the older and very young specimens (compare Pl. XXI. Figs. 13, 14, and Figs. 4, 5). The few comparatively large and distant primary tubercles of the interambulacral plates (Pl. XXI. Figs. 9, 10) give to the young Paleopneustes a very different facies from its older stages.

* **Paleopneustes hystrix** A. Ag.

Paleopneustes hystrix A. Ag. Bull. M. C. Z., VIII., No. 2, p. 82, 1880.
Saba Bank, Guadeloupe. 21–208 fathoms.

Pl. XVIII., Pl. XIX. Fig. 2 (lower figure).

Seen in profile (Pl. XIX. Fig. 2) this species is flatter and has a more conical outline than *P. cristatus*. I know of no Spatangoid which has such large, stout primary spines as those which cover the interambulacral areas of the abactinal side of the test, though in Lovenia they are longer, and in Linopneustes they are as long but not as stout. They resemble more in appearance the spines of a large specimen of *Echinus acutus* than of a Spatangoid. They are straight, comparatively stout, some of the primary spines measuring in length nearly a fourth of the test. These large spines are carried on distant tubercles, not more than three in each of the larger interambulacral plates of the abactinal surface near the ambitus, and only two towards the apical system. Four or five small secondary tubercles irregularly placed on the plates, with distant minute miliary tubercles, compose the whole tuberculation of the interambulacral part of the test (Pl. XVIII. Fig. 2). The ambulacra carry no primary tubercles, only distant miliaries and a few small secondary tubercles in the median interpetaloid space. Below the petals the ambulacral plates carry one large primary tubercle surrounded by four or five secondaries with the same scattering of distant miliaries.

The secondary spines of the abactinal surface are small, slender, sharp, short, slightly curved, about 5 mm. in length ; the delicate miliary spines are about half that length. Toward the ambitus the tuberculation becomes closer, and on the actinal side (Pl. XVIII. Fig. 5) the primary tubercles are somewhat smaller and arranged in three irregular horizontal rows, quite closely packed on the interambulacral plates, with only a few scattered secondary tubercles and less numerous miliaries than on the abactinal surface. This tuberculation extends also over the ambulacral plates on the actinal side, so that in this species there is nothing of the broad bare ambulacral avenues, extending from the ambitus to the actinostome found in other species of this and allied genera. On the actinal side the spines are proportionally smaller, more slender, shorter, slightly curved and spathiform, as in other Spatangoids.

The phyllodes (Pl. XVIII. Figs. 5, 6, 7) are remarkably prominent in this species, and the actinostome is larger in proportion to the diameter of the test than in *P. cristatus*. In a specimen measuring 115 mm. in length, the actinal opening measures 25 mm., while in a specimen of *P. cristatus* measuring 144 mm. in length the actinostome measures only 27 mm. The other principal differences of *P. hystrix* from *P. cristatus* are seen in the abactinal system and the ambulacral petals. There are four genital openings; but in some specimens the left anterior genital is not as fully developed as the others. It is therefore probable that in some cases we may find only three genital pores, as in *P. cristatus*. The ambulacral plates are comparatively higher and wider than in *P. cristatus;* in addition, the pairs of pores are placed nearer the outer edges of the ambulacral plates than in *P. cristatus*, where they are situated nearly in the centre of the plates. This causes the semi-petaloid part of the ambulacra to diverge more rapidly than in the other species of the genus, the pairs of pores at the lower extremity of the petals being nearly twice as distant as in *P. cristatus*. There is considerable variation in the size of the pores of the petaloid ambulacra; as a general rule, on the outer rows, the pores are comma-shaped and much larger than the comparatively small pores of the inner rows, but in other specimens this difference is not so striking. When alive the color of the test varies greatly; it is in some specimens of a rich light chocolate color, from which stand out in striking contrast the long yellowish gray primary spines of the abactinal surface; in others, the test and spines are of a greenish purple, the most common coloring of the test being a light Indian-red with primary spines of the same tint.

* **Linopneustes longispinus** A. Ag.

Linopneustes longispinus, A. Ag. Bull. M. C. Z., VIII., No. 2, p. 82, 1880.
Eupatagus longispinus A. Ag. Bull. M. C. Z., V., No. 9, p. 191, 1878.
Off Havana, Lesser Antilles. 38–250 fathoms.

Pl. XIX. Fig. 1 (upper fig.); *Pl. XX.*

This species was first noticed as *Eupatagus longispinus*, from a number of somewhat imperfect fragments, showing this large Spatangoid to be related to Eupatagus, Platybrissus, and Paleopneustes. A number of specimens since collected off the West India Islands show that it is closely allied to *Linopneustes Murrayi*.

The test of this species is depressed, apex slightly anterior. It holds in the genus Linopneustes the same relation to *L. Murrayi* which *Paleopneustes hystrix* holds to *P. cristatus*. Both *P. cristatus* and *L. Murrayi* are covered on the abactinal side with a close tuberculation, carrying comparatively small, stout, slender primary spines; while *P. hystrix* and *L. longispinus* both are characterized by the few and comparatively large primary tubercles seated on the plates of the interambulacral areas of the abactinal surface. In all the specimens I have examined, varying from 65 to 110 mm. in length, the marginal fasciole (Pl. XIX. Fig. 1) is most prominent, forming a narrow band carrying minute dark-colored miliary spines all round the abactinal ambital edge (Pl. XX. Fig. 8) of the test, passing at the posterior extremity close to the upper part of the anal system. In this respect the course of the fasciole of this species of the genus Linopneustes differs strikingly from the tertiary Pericosmus, in which the marginal fasciole follows the same course close to the ambitus, but its posterior extremity passes under the anal system. Desor has called attention to the variability of this fasciole, which in the fossil species of the genus Pericosmus appears to be often as ill defined and as variable as in the recent species of Linopneustes.

The subanal fasciole of *Linopneustes longispinus* (Pl. XX. Fig. 8) is transversely elliptical, irregularly hexagonal with rounded corners, and narrower than the corresponding fasciole of *L. Murrayi*. The anal system is also comparatively smaller, and covered by smaller plates than in that species, and is transversely elliptical. The apical system in both the species of Linopneustes is more compact than in Paleopneustes.

The odd anterior ambulacrum of *L. longispinus* is more sunken at the ambitus than in the Japanese species. The lateral ambulacra are more petaloid than in any other species of either Linopneustes or Paleopneustes thus far known; in some specimens they end at the extremity much as they do in Eupatagus. (Pl. XX. Fig. 1.) The petaloid pores of the two rows are of nearly the same size, placed close together on the outer edge of the ambulacral plates. The petals extend somewhat more than half-way from the apex to the ambitus. The secondary tubercles are small, of uniform size, and the whole surface of the test is uniformly covered by minute miliaries. The primary spines of the abactinal surface are long, slender, curved, (Pl. XIX. Fig. 1, Pl. XX. Fig. 1,) some of them measuring nearly a quarter of the test in length. The thin slender and straight secondary spines are not more than 3 or 4 mm. long; the thin hair-like miliary spines are nearly as long, and are generally curved.

On the actinal side of the test the primary tuberculation is close in the posterior lateral interambulacral areas on one or two plates near the ambitus, but towards the actinostome the primary tubercles increase in size (Pl. XX. Fig. 5), and at the same time become less numerous. The tuberculation of the actinal plastron is smallest along the median line, the tubercles increasing in size towards the outer lateral edge adjoining the broad bare posterior interambulacral areas. The spines of the actinal surface are shorter and more slender than those of the abactinal surface; they are curved, and those adjoining the bare posterior ambulacral zones are more spathiform than the spines on the rest of the actinal surface. The actinostome of this species is comparatively smaller (Pl. XX. Fig. 6) than that of *L. Murrayi*, measuring only 10 mm. in longitudinal diameter in a large specimen of 105 mm., while in one of *L. Murrayi* of 85 mm. the actinostome measures nearly 15 mm.

When alive, the test is pinkish or flesh-colored, the large primary spines of the abactinal surface having a yellowish tint with a whitish silvery lustre.

* **Macropneustes spatangoides** A. Ag.

Spatangus purpureus A. Ag. (non Leske nec auct.). Bull. M. C. Z., VIII., No. 2, p. 83, 1880. Lesser Antilles. 82–373 fathoms.

Pl. XXVII.

The fragments of the Spatangoid which I referred in the Preliminary Report to *Spatangus purpureus*, I find on closer examination to belong to the genus Macropneustes. Although no complete living specimen was dredged, yet a sufficient number of dead broken tests were collected to enable me to restore this species satisfactorily, with the exception of the part near the anal system. In general appearance and outline, as seen from above, this species resembles *Spatangus purpureus;* but it can at once be distinguished by the high anterior part of the test, which in the abactinal part of the odd ambulacrum rises above the apical system.

The anterior ambulacrum is deeply sunken at the ambitus, in a groove similar to that of *Linopneustes longispinus*. In old specimens the abactinal part of the ambulacral petals are disconnected, much as in Echinocardium, within the internal fasciole. On the actinal surface the tuberculation is quite uniform in specimens of very different sizes. The larger primary tubercles are found on the anterior part of the test, and in the posterior interambulacral area they diminish gradually in size towards the posterior extremity, and become more closely crowded. The tubercles of the actinal plastron are smaller and of uniform size. On the abactinal surface the primary tubercles are limited to the interambulacral areas within the peripetalous fasciole, except along the line of the middle of the posterior interambulacral area, along which the V-shaped angular lines of primary and secondary tubercles extend, gradually diminishing in size towards the anal system. Within the peripetalous fasciole the arrangement of the primaries varies greatly. In some specimens there are not more than nine or ten large tubercles in the apical part of the interambulacral areas; in others the primary tubercles form V-shaped figures in each plate, the smaller tubercles on the lower side of the plates. In other specimens, again, the large tubercles form merely irregular horizontal lines. The rest of the surface of the test within the petaloid area to the actinal side is closely packed with small miliary tubercles, often concentrated more or less on the lower part of the coronal plates so as to form V-shaped areas. The petaloid ambulacra are closed at the extremity, the anterior pair is considerably larger than the posterior pair. The outer rows of pores are the largest in both lateral petals. The pairs of pores are sunken. The odd anterior ambulacrum consists of lines of single pores, one for each ambulacral plate. Apical system compact, with four genital openings and small madreporic body.

The most interesting structural feature of this genus is the composition of the peripetalous fasciole, and the light which this throws on the possible origin of the fascioles as a whole. As is well known, in Macropneustes the peripetalous fasciole forms a clear, simple narrow band around the extremity of the petals. This we find to be the case also in some specimens of this species of Macropneustes. In others, the anterior part of the fasciole beyond the extremity of the anterior petals becomes indistinct or disappears. In still other specimens, the posterior part of the fasciole across the odd interambulacral area widens, forming elongated V-shaped areas: sometimes there are two or three such areas. In other cases a similar structure extends across the lateral ambulacra. In other cases, again, only a few such disconnected V-shaped areas take the place of the fasciole; as these become less numerous and more indistinct, the fasciole disappears completely. These V-shaped areas form as it were secondary posterior and lateral branches of the peripetalous fascioles, similar to the anterior bands observed by Troschel in Tripylus. Across the anterior ambulacrum there are sometimes no less than six or seven such secondary fascioles, some of the upper branches uniting again with the main fasciole, others extending parallel to the ambitus across the ambulacra into the lateral ambulacra, where the extremities die out in the crowded miliary tubercles covering that part of the test. In some of the specimens the miliaries of the lateral ambulacral and interambulacral areas below the peripetalous fascioles show a tendency to be crowded towards the lower edges of the plates, thus forming indistinct V-shaped areas resembling somewhat the V-shaped areas of the secondary fascioles, but made up of course of larger tubercles. This suggests the question whether the bare sutural bands characteristic of some of the genera of Cidaridæ, Arbaciadæ, Temnopleuridæ, and other Echinoids, are not the first trace of fascioles. So that we may consider the concentration of the miliary and secondary miliary tubercles on the edges of certain plates, or in the centre, so as to form bare sutural lines or bands along certain parts of the test, either in the ambulacral or interambulacral areas, as the first indication of the formation of fascioles, or as rudimentary or disconnected fascioles.

This concentration of the secondary miliaries seems in some other genera to take place in old specimens. This is particularly well shown in large specimens of *Metalia pectoralis* (see Pl. XXI. Fig. 5, Revision of the Echini); in small specimens measuring not more than half the size of the one figured, this structure is very indefinite. In some large specimens of *Spatangus purpureus* a slight tendency to a similar concentration of the secondary miliaries could also be detected.

The anal system is transversely elliptical, measuring 16 mm. in a specimen of 95 mm. in length. In the same specimen, the subanal fasciole is broad, enclosing a somewhat heart-shaped area vertically elongate, measuring about 17 mm. along its greatest diameter.

* Hemiaster Mentzi A. Ag.

Hemiaster Mentzi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 83, 1880.
Lesser Antilles. 170–626 fathoms.

This small species is characterized by the globular outline of the test, and by the narrow, comparatively elongate space included within the peripetalous fasciole. It has a larger number of buccal plates than *H. gibbosus.* The tuberculation is coarser and more distant than in that species, more as it is in *H. zonatus* and *H. expergitus.* As in the latter species, the posterior extremity of the test is vertically truncated nearly flush with the rest of the test, the anal system but slightly sunken, with a mere trace of an anal groove. The test forms over the abactinal part of the anal system a very rudimentary hood. This species is also remarkable for the great development of the suckers of the odd anterior ambulacrum. In a specimen measuring 17 mm. in length the suckers still retain the prominence they have in very young Spatangoids. (See the figure of young Brissopsis in Rev. Echini, Pl. XIX. Figs. 1, 2.) This embryonic character is not the only one this species retains; its globular form, the position of the peripetalous fasciole near the abactinal system, the short comparatively simple petaloid lateral ambulacra, are all features it has in common with the young of other Spatangoid genera. In the only other species of the genus of which the changes due to growth have been traced (*Hemiaster cavernosus*, Challenger Echini, Pl. XX[a]. Figs. 7–14), the odd anterior ambulacrum does not assume the great prominence it has in the young of this species. In a small specimen of *H. Mentzi*, measuring 7 mm. in length, the peripetalous fasciole is broad, elliptical, and the greater part of the space it encloses is filled by the huge suckers of the odd anterior ambulacrum. The close resemblance of this stage of Hemiaster to an Aërope is very marked, and the permanence of the unusual development of the tentacles of this odd anterior ambulacrum up to the adult stage is an important link in tracing the affinities of such widely separated genera as Hemiaster, Brissopsis, Agassizia, Aërope, Aceste, and Schizaster.

The structure of the larger interambulacral spines in the young stages (7 mm. long. diameter) well shows the manner in which the fantastic shape of some of the Spatangoid spines is produced. The outer sheath of calcareous rods becomes solidified as thin lamellæ, forming in one case in the primary interambulacral spines of the anterior part of the test on the abactinal side, above the ambitus, a spearlike head to the shaft of the radioles; this may have a more or less lobed edge, or if the radiole is curved it forms a somewhat shallow spoon-like extremity with spiny processes; in the shorter radioles of the actinal plastron the lamellæ all develop into this spoon-shaped extremity, which may be perfectly symmetrical, or else developed unequally on one side, according to the position of the radioles on the actinal plastron.

In the earlier stages the fascioles are already covered by the same kind of pavement which we find in the adult, made up of short-stemmed, club-shaped spines closely packed together. There were in some of the larger specimens a few large, short-stemmed, globular pedicellariæ, irregularly scattered over the abactinal surface of the test.

Rhinobrissus micrasteroides A. Ag.

Rhinobrissus micrasteroides A. Ag. Bull. M. C. Z., V., No. 9, p. 192, 1878.
Off Havana, 175 fathoms.
Station 321, Lat. 32° 43′ 25″ N., Long. 77° 20′ 20″ W. 233 fathoms.

Pl. XXIII. Figs. 1–4; Pl. XXVI. Fig. 4.

It is with considerable hesitation that this species is retained in the genus Rhinobrissus, the only specimen obtained by the Blake being a somewhat damaged young stage. From what is known of the modification of the Spatangoids due to growth, there are no characters in this single specimen which are not probably merely modifications due to age. The ambulacra are all flush with the test, and remind us of the earliest

Spatangoids in the geological series. The thin, narrow, ill-defined peripetalous fasciole crosses the petals without affecting their structure, as it does in all the recent Spatangoids. The ambulacra are not petaloid, the ambulacral plates are large, the pairs of pores are distant, and extend nearly to the ambitus. *Homolampas fulva* A. Ag., among the Challenger Echini, has similar embryonic lateral ambulacra, with large plates, and flush with the test, Gualteria alone among the fossils representing a similar stage of this structure in Rhinobrissus.

The indefinite peripetalous fasciole existing with a well defined broad and prominent subanal fasciole indicates that in Spatangoids the fascioles either may have become developed from the peripetalous fasciole, first making its appearance in such genera as Hemiaster, in which, however, the subanal, lateral, and anal fascioles are wanting; or may have developed mainly from the subanal fasciole in such genera as Micraster; Rhinobrissus in the stage here figured (Pl. XXIII. Figs. 3, 4) representing a Micraster stage to which has been added an indistinct peripetalous fasciole, while Periaster would represent the Hemiaster stage with rudimentary subanal and anal fascioles. Another species of the genus collected by the Challenger represents a later stage of development, with sunken lateral ambulacra, a peripetalous, an anal, and a subanal fasciole indicating affinities with the more specialized recent Schizasteridæ.

In a fragment of the upper part of the test, which undoubtedly belonged to a specimen of this species measuring at least 30 mm. in length, the lateral ambulacra were as yet scarcely sunken, and almost flush with the test, the anterior ambulacrum, however, towards the ambitus, being indented and sunken, much as in the genus Homolampas. This fragment is interesting, as it shows that the peripetalous fasciole is not continuous, disappearing in the anterior interambulacral areas before it reaches the odd ambulacrum. The subanal fasciole, judging from a fragment of that part of the test, must have been remarkably prominent.

It is possible that a young Spatangoid which I figured in the Revision of the Echini (Pl. XIV. Fig. 11) may turn out to be the young of this species of Rhinobrissus. It has, like this species, a peripetalous fasciole crossing the petals without modifying their structure; and large ambulacral plates. It differs from it, however, in having a continuous lateral fasciole passing under the anal system, as in Agassizia.

This species of Rhinobrissus (*R. micrasteroides*) will probably form the basis of a subgenus of Rhinobrissus, which will hold to it very much the same relation which Periaster holds to the true Schizaster. It will represent the embryonic stage of Rhinobrissus and recall to us the earliest true Spatangoid genera of the Chalk still having ambulacra nearly flush with the test, with a well-developed subanal and a rudimentary peripetalous fasciole.

Brissopsis lyrifera Agass.

Lesser Antilles, off Havana. Lat. 28° 51′ 30″ N., Long. 89° 1′ 30″ W. Off the mouth of the Mississippi. Lat. 41° 29′ 45″ N., Long. 65° 47′ 10″ W. 118–1394 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 83, 1880.

Pl. XXVI. Figs. 7–18.

Brissopsis lyrifera appears to be one of the most widely distributed species of the Atlantic fauna, and is also found in the Caribbean and in the Gulf of Mexico.

I have already, in the Revision of the Echini (p. 354), spoken of the great variation I had observed in the course of the petaloid ambulacra of this species, as well as of the variations found in the subanal fasciole. An extensive series of specimens of this species has now been brought together by the dredging of the Blake. These throw additional light on the changes we may expect to find among Spatangoids of this group in one and the same species. I had already observed considerable difference in the outline of the test. Specimens dredged off the mouth of the Mississippi were generally quite globular, and presented the extreme form in that direction, while the specimens collected along the east coast of the United States as far north as George's Bank, and in the Eastern Caribbean and the Straits of Florida, although varying considerably in outline, yet presented no very marked differences except such as we have seen were due to growth, and agreed on the whole quite well with the specimens of Brissopsis known from other parts of the North and South Atlantic. Between Jamaica and San Domingo there were dredged three specimens of Brissopsis representing the extreme elongated form, with an anteriorly bevelled flat surface, at the abactinal extremity of which is situated the anal system. These specimens were further characterized by an exceedingly well defined subanal fasciole, with an indistinct anal fasciole extending to the posterior part of the peripetalous fasciole. As mentioned in the Revision of the Echini, the subanal fasciole is quite variable; in many cases the anal branch is clear and well marked, in others it becomes gradually reduced and indistinct, or finally disappears entirely. The subanal fasciole also appears in the American specimens to be subject to great variations. In the globular specimens from off the mouth of the Mississippi, the subanal fasciole was in some cases well defined, in others somewhat indistinct; in others again only very indistinct and disconnected parts could be traced; and finally in others it had disappeared entirely, as is the case in the genus Toxobrissus, which differs from Brissopsis only in having no subanal fasciole and confluent lateral ambulacra, characters which are here distinctly shown to occur in this species of Brissopsis in specimens found in different localities. The specimens with globular test have retained that embryonic feature alone, while the petals and fascioles have developed in what we might call the normal manner. The excessively elongate and flattened forms found off Jamaica retain of the embryological characters the confluent ambulacra and the position of the anal system on the anteriorly sloped surface, a feature recalling the time when the anal system was distinctly placed on the abactinal surface of the test, and not on the vertically truncated posterior extremity as is usually the case.

In Brissopsis, as in Macropneustes and other Spatangoids, the centralization of the tubercles on certain parts of the plates shows how closely this is connected, on the one hand, with the formation of V-shaped fascioles in the interambulacral and ambulacral areas, as in Macropneustes. In the interambulacral areas the absence of tubercles leaves bare the median and horizontal sutural lines, the median spaces and adjoining angular connections being broader than the horizontal lines. The anterior ambulacra are bare from the extremity of the petals, while in the posterior ambulacra the anterior row of ambulacral plates alone is bare, the posterior row being closely crowded with miliaries. The flat surface enclosed within the branch of the anal fasciole is bare in the central region, somewhat coarsely tuberculated at first towards the exterior; gradually the tuberculation becomes smaller, until it passes into the fine miliaries which form the anal branch of the fasciole, extending from the subanal to the peripetalous fasciole along the central line of the posterior row of ambulacral plates.

Agassizia excentrica A. Ag.

Florida, Cuba, Lesser Antilles. 86–391 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 193, 1878; VIII., No. 2, p. 83, 1880.

Pl. XXV.

When alive the test is covered with spines of a delicate pinkish gray color, darkest at the base. The ambulacral areas are covered with slender, long-stemmed, small-headed pedicellariæ, articulated at the base, while in the interambulacral system the miliaries carry slender, straight, or slightly curved club-shaped spines, scarcely stouter than the stems of the pedicellariæ. The fascioles are still more thickly crowded with similar minute pedicellariæ and club-shaped miliary spines, but somewhat shorter, and closely dotted with large pigment spots.

The actinostome of the genus is marked for the irregular arrangement of the buccal plates. The anal plates are few in number, often less than eight, comparatively large, and form in the young stages a regular anal pyramid, as characteristic as that figured by Gray, Lovén, and myself in Palæostoma.

A few of the tentacles of the odd anterior ambulacrum, near the apical system, are fimbriated like those surrounding the buccal system; those immediately following towards the ambitus are simple, with a slight sucking disk like the tentacles of the anterior rows of pores of the lateral petaloid ambulacra. Within the petaloid area the tentacles of the posterior rows are broader, compressed, irregularly lobed at the extremity; the tentacles beyond become, as in the anterior rows, simple towards the ambitus, and remain so till they join the large fimbriated tentacles surrounding the buccal system. The presence of large fimbriated tentacles near the apical system in the odd ambulacral petal shows that Agassizia is itself an embryonic genus. Other features of the same character are the general globular form, and the rudimentary structure of the lateral anterior ambulacra; the anterior rows of pores of the posterior lateral ambulacra appear only after the posterior rows are well developed.

In a specimen measuring 3 mm. in length, the first ambulacral tentacles to appear are those surrounding the actinostome, which were nine in number and already fimbriated. In the denuded test of a specimen of about the same size, no trace of the subdivision of the test into coronal plates could be detected; it consisted entirely of a close network of fine granulation.

The position of the ambulacral and interambulacral areas was indicated by the presence of rows, more or less irregular, of rudimentary, primary, and secondary tubercles; those of the actinal plastron and of the interambulacral areas being generally more closely defined than those of the ambulacral areas. In this stage the actinostome is pentagonal, with rounded corners, the posterior lip being but slightly indicated.

In a specimen measuring 6 mm. in longitudinal diameter, the posterior lip is quite pronounced, and the actinostome has become transversely elliptical, but the number of buccal tentacles has as yet not increased. The granulation covering the test of the youngest stage examined (3 mm. long) is arranged in short parallel lines forming irregular lozenges, perhaps like those figured by Lovén in the actinal system of several other Echini; * but the boundaries of these figures, if they have any regularity, could not be traced. This stage of the test of Agassizia, covered as it is by a fine granulation such as we find characteristic of the granulation of the fascioles in some of the Spatangoid genera, naturally suggests the idea that the fascioles are merely bands formed by the remnants of the embryonic granulation of the test on which tubercles proper have not yet developed. This rudimentary granulation, arranged in more or less regular lozenge-shaped figures, is a very general structural feature of the coronal plates of many Echini, in which we can trace it readily in the younger stages. See especially Salenia and young Echinidæ and Cidaridæ, as well as other Spatangoids. It is also found in the structure of the plates of the calyx of many Crinoids, and of some plates among the Starfishes, and we are justified in regarding this granulation as the typical structural ornamentation of Echinoderms, which has become specialized in recent times to form among the Spatangoids the so-called fascioles. This would explain the presence of detached bands of fascioles parallel to the principal ones, such as we find in Maretia, Homolampas, Paleopneustes, Macropneustes, and Brissopsis.

If this view of the nature of fascioles is correct, we should be justified in considering the papillæ of the Cidaridæ arranged regularly round the primary spines of the interambulacral areas, as well as the ambulacral papillæ, as modified fascioles not occupying special limited areas. The same would be true of the papillæ of the Saleniæ. A similar explanation would hold good for the down-like spines covering the greater part of the test of Aspidodiadema, and the long hair-like spines of Echinothrix, Centrostepha-

* Lovén, *Études sur les Échinoïdées*, Pls. XIX., XXI.

nus, Astropyga, and other Diadematidæ and Echinothuriæ; in the last, there is, as I have shown, even what we might consider in some cases a regular marginal fasciole, as in Phormosoma. The miliary granulation of the Clypeastroids generally, and the comparatively small radioles they carry, may according to this view be considered as embryonic features which have become greatly specialized, the whole test retaining the granular tuberculation characteristic of the earlier Crinoids, with but slight modifications in the fasciolar radioles covering the whole test, if I may so call them, while they become, strictly speaking, minute primary or secondary radioles.

Although in the young stages of such Spatangoids as Hemiaster, Brissopsis, Schizaster, and the like, the fascioles make their appearance very early, yet in this youngest stage of Agassizia there is at a corresponding period no well-defined fasciole band, and it is only in a somewhat more advanced stage (4 mm. long. diam.) that we get a clearly defined fasciole. This seems to affect the character of the spines found above and below it, and we have in the stage just mentioned a well-defined lateral marginal fasciole close to the ambitus. This fasciole is in reality only an extension of the subanal fasciole, such as we find a remnant of in Argopatagus. The peripetalous fasciole is also developed, and its anterior extremity comes down close to the ambitus, as it does in Paleopneustes.

In the youngest Agassizia (3 mm. long. diam.) there are three or four single pores forming the rudimentary petals of the lateral ambulacra. The apical system is represented in this stage merely by the large madreporic body which covers the whole apex. The surface of the test in these younger stages, more especially in the ambulacral areas, is covered by numerous small-headed, short-stemmed pedicellariæ and by minute straight miliary spines, often club-shaped.

In a specimen measuring 6 mm. in longitudinal diameter, the odd anterior ambulacrum was not yet developed at all; the lateral ambulacra consisted of six and seven pores, the anterior ambulacra being composed of single rows of pores, the posterior ambulacra of double rows; the anterior rows of the posterior ambulacra were made up of three small pairs of pores with a couple of single pores near the apex of the ambulacrum.

Meoma ventricosa Lütk.

Florida Bank, and off Havana. 37–127 fathoms.

Schizaster fragilis Agass.

Quite a common species near the 100 fathom line, off the New England coast. 71–362 fathoms. For a list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 84, 1880.

Pl. XXVIII. Figs. 8–14.

There is considerable variation in the distinctness of the lateral fasciole as it passes under the anal system. In some cases it stops suddenly near the level of the anal system; in others it can be faintly traced as an indistinct, irregular anal fasciole; in others the anal fasciole is most clearly marked. These differences do not depend on size, but specimens from one locality are usually similarly affected. Small specimens measuring 6 mm. in longitudinal diameter are but slightly elliptical when seen from above, the anterior ambulacrum scarcely indented, and the lateral ambulacra still flush with the test. The actinal side is slightly convex, the outline seen in profile is hemispherical, the apex being nearly central; the circular anal system, flush with the test, is placed high on the posterior extremity of the test. Both the peripetalous and lateral fascioles are well marked as narrow bands of miliaries, indicating in a very rough way the future indentations of the course of the fascioles. In this stage the posterior ambulacra consist only of two pairs of pores, and are scarcely one quarter the length of the anterior lateral ambulacra. There is no trace as yet of any genital openings. The actinal opening is circular, without a posterior lip, and the posterior edge of the actinostome is placed nearer to the central part of the actinal side than to the anterior edge of the test.

In specimens measuring 10 mm. in length, the posterior lateral ambulacra are still flush with the test, with five pairs of pores; the anterior ambulacra are slightly sunken. The odd ambulacrum is more sunken than in the younger stage described. The madreporic body, which in the preceding stage was only pierced by a single opening, is now marked by five or six small openings. There is as yet no sign of any genital openings. The posterior extremity of the test is more vertically truncated; the anal system is more elliptical, and placed at the upper angle of the posterior level of the test. The fascioles are somewhat broader than in the younger stage; they vary in width, the angles of the ambulacra assuming more clearly already the general course they finally take in larger specimens. The actinal opening is now placed well towards the anterior extremity. The outline of the test from above is still elliptical, with the exception of the anterior re-entering angle of the odd ambulacrum and of the posterior extremity of the test. The apex is now posterior to the abactinal system, the anterior extremity sloping gradually toward the ambitus, while the posterior extremity of the test extends nearly horizontally to the junction of the vertically truncated posterior extremity.

In specimens measuring 23 mm. in length the outline of the test when seen from above shows traces of the angular projections which characterize the full-grown specimens. The test is slightly pointed posteriorly. The odd ambulacrum is deeply sunken nearly to the apical system, while in the preceding stages the odd ambulacral groove extended only a short distance from the ambitus to the apex. The lateral ambulacra are now all sunken, the posterior ambulacra somewhat less than the anterior pair; these have now eleven pairs of pores. There are three large genital openings, the two left anterior ones and the right posterior one. The fascioles have nearly assumed the course and shape they take in the adult. The posterior extremity is bevelled towards the actinal extremity, so that over the anal system the test projects slightly beyond the general outline. The actinal system is now quite flat, the actinostome has a well-developed posterior lip, of which a trace only can be found in specimens measuring about 10 mm. in length. The tuberculation and the corresponding spines have now assumed the general characteristics of the tuberculation at different parts of the test; while in younger stages the tubercles were few in number, comparatively large, and irregularly arranged over the sides and upper surface of the test. The actinal plastron is the first to appear, and in the youngest specimens examined the tuberculation of that area as well as the spines had already become specialized to a certain extent.

In specimens measuring 34 mm. in length, the test, as seen from above and in profile, has assumed the outline of adult specimens; and we find already in specimens of this size as much variation in the closeness of the tuberculation, the depth of ambulacral furrows, the course and shape of the fascioles, the outline of the test as seen from different points of view, and the specialization of the spines of different parts of the test, as we do in the larger specimens.

* **Schizaster orbignyanus** A. Ag.

Schizaster orbignyanus A. Ag. Bull. M. C. Z., VIII., No. 2, p. 84, 1880.
Lesser Antilles. 92–1507 fathoms.

Pl. XXVIII. Figs. 1–7.

This species extends as far north as the New England coast, specimens having been dredged by the United States Fish Commission off Martha's Vineyard in 100 and 130 fathoms. They differ very considerably from the specimens dredged by the Blake in the Eastern Caribbean. The northern specimens, while retaining the characteristic outline of those from the Caribbean, yet differ from them in having a much broader peripetalous fasciole, more like that of *S. canaliferus;* the northern and southern specimens, again, agree in the great width of the actinal plastron at the posterior extremity, and the small size of the anal system as compared with that of *S. canaliferus*, and are covered by a closer tuberculation also, a character which readily distinguishes the specimens of the two species thus far compared. The test from the lower side of the anal system to the edge of the actinal plastron is more bevelled than in *S. canaliferus.* In the few specimens of *S. orbignyanus* I have had occasion to examine, the lateral and anal fascioles vary greatly in distinctness. In the Caribbean specimens the lateral fasciole extends continuously along the sides of the test to the level of the side of the anal system, and there forms a sharp, well-defined triangular anal fasciole. In the northern specimens the lateral fasciole is often indistinct or disappears entirely, only the anal fasciole remaining. It is interesting to note that, in the specimens of *S. fragilis* dredged off our eastern coast, the anal fasciole disappears first, leaving only a part of the lateral fasciole extending from the peripetalous fasciole towards the anal system. The peripetalous fascioles are of a dark violet color, forming a strong contrast to the greenish yellow spines with silvery lustre which cover the upper part of the test. The lateral and anal fascioles can scarcely be distinguished by their color from the spines of the actinal side and those towards the ambitus, which with the exception of the spatula-shaped spines of the actinal plastron are of a darker color than those of the abactinal side of the test, and within the peripetalous fasciole.

Whether the differences here noted between *S. canaliferus* and *S. orbignyanus* are merely local or more important, comparisons of more extensive series of these species alone can determine.

* **Schizaster (Periaster) limicola** A. Ag.

Schizaster (Periaster) limicola Agass. Bull. M. C. Z., V., No. 9, p. 193, Pl. III., 1878.

Pl. XXVI. Figs. 5, 6.

This species belongs to the generic group of Schizaster separated as Periaster by D'Orbigny from the genuine Schizaster. The test is quite globular, when seen from above the outline is somewhat angular, the posterior extremity is vertically truncated, with a slight keel between the posterior petals near the apex; the anterior extremity has a shallow ambulacral groove, and is vertically truncated from the edge of the peripetalous fasciole. The lateral anterior petals are nearly twice as long as the posterior one, as well as broader. The petals are all about equally sunken. The peripetalous fasciole has the shape and position of that of Schizaster proper; the anal fasciole is narrow, extending only a short distance on the sides of the test.

The test is thickly covered with primary tubercles of a uniform size, carrying short, slightly curved spines on the sides; the tubercles are somewhat more crowded within the fasciole and on the abactinal region of the odd posterior interambulacral area. The coronal plates between the fasciole and the anal system are comparatively bare, having only few tubercles on the outer edges. On the actinal side the primary tubercles are larger, more distant, except on the actinal plastron, where they are closely crowded, and carry longer, larger, and curved primary spines. The actinal lip is very sharp and prominent; the actinal membrane carries one large exterior row of plates round the anterior edge of the actinostome, and smaller irregular plates over the rest of the actinal surface. The anal system is comparatively small for so large a species. The separation of this group of Schizaster as a generic type seems very doubtful. It is based solely upon the more globular outline of the test, and the discontinuity of the latero-anal fasciole. It may be convenient to form a subgeneric group with these characters; but when we attempt to draw the line between such forms as *S. ventricosus* and *S. japonicus*, it becomes most difficult, if not impossible, to draw the line of demarkation between the generic and subgeneric types.

We find the same difficulty in attempting to define the numerous generic subdivisions indicated by Troschel for the genus Tripylus and its allied forms, which pass insensibly to Faorina and the like, while in Schizaster the deviations are in the direction of modifications passing into Periaster, Epiaster, Hemiaster, and the like. The structure of the odd anterior ambulacrum of this species has all the characteristics of the odd ambulacrum of such species of Schizaster proper as *S. canaliferus*, *S. fragilis*, and *S. Philippii*, while it has the outline of the test of Hemiaster and the fascioles of Periaster. There are but two genital openings. When brought up in the dredge, this species was of a dirty yellowish-brown color. This species has an extensive geographical range, having been collected by the Challenger in the Arafura Sea.

The Schizasterids which have been united under the generic name of Periaster are interesting as representing a truly embryonic stage of Schizaster proper. As is well known from the study of the young of several species of Schizaster in the earliest stages of growth, they have a globular test, the ambulacral grooves are either indistinct, or only slightly developed, or totally absent. The peripetalous fasciole is broad, but slightly indented; in fact, all the characteristic features of the genus are those which we find in the young stages of such species of Schizaster as *S. orbignyanus*, *S. fragilis*, and *S. japonicus*. If we were to magnify a young *S. fragilis* measuring about 10 mm. in diameter about six times, we should have a fair representative of the genus Periaster, provided we took into account the great variation of the lateral fasciole, which is more or less indistinct as it passes towards and under the anal system to form the anal fasciole in such species as *S. fragilis* and *S. Moseleyi*. The odd anterior ambulacrum is, like all the other ambulacra, but slightly sunken, and indicated by a broad re-entering angle at the ambitus, neither of the lateral pairs of ambulacra being as deeply sunken as in Schizaster proper, the posterior pair being, as in most of the Schizasteridæ, shorter than the anterior pair. The relative proportions of the lateral ambulacra recall to a certain extent the structure of the ambulacra of the older Spatangoids of the Chalk, such as Hemiaster proper. In large specimens of *Periaster limicola* measuring 68 mm. in length, there are two posterior genital openings, as in Hemiaster, the ocular plates are large, and the madreporic body is elongate, extending longitudinally over the greater part of the apical system.

ORIGIN OF THE WEST INDIAN (CARIBBEAN) ECHINID FAUNA.

THE resemblance of the Fauna of the Gulf of Mexico and of the Caribbean to that of the Pacific has been noticed by former writers, even at a time when the materials available for comparison included but little beyond the littoral Fauna. Since the results of the deep-sea dredgings have become known, the extent of this resemblance has become quite striking. In fact, the deep-sea Fauna of the Caribbean and of the Gulf of Mexico is far more closely allied to that of the Pacific than to that of the Atlantic. Before the Cretaceous period, the Gulf of Mexico and the Caribbean were undoubtedly in freer communication with the Pacific than with the Atlantic Ocean; so that, while probably before that time the Fauna of these seas contained a number of Atlantic types, yet the characteristic genera were common to the Pacific. Many of the genera have remained unchanged to the present day since the absolute separation of the Atlantic and of the Pacific by the Isthmus of Panama and the Mexican Plateau, while there have been added to the West Indian Fauna a number of Atlantic types, which, as long as the Gulf of Mexico and the Caribbean were practically a part of the Pacific, probably did not find conditions as suitable to their development as those which now exist, and which have existed since their separation from the time they became merely extensions of the equatorial Atlantic district.

This explanation gives us an apparently good reason for the mixed character of the Fauna of the West Indian seas, showing us at the same time that, however long a period of time may have elapsed since this separation has taken place, it has not been sufficient to effect any very radical change in the Echinid Fauna of the two sides of the Isthmus. The principal differences are due to the immigration of true Atlantic types into the West Indian faunal region during the Tertiary and Post-tertiary period. But as the principal physical conditions of the sea in the tropical regions of the two sides of the Isthmus appear to be so nearly identical, we could not expect any great differences to arise between the Panamic and West Indian Faunæ from physical causes alone.

In order to show the former distribution of the genera of which the Echinid Fauna of the West Indies is made up, we must trace as far as possible the origin of these genera. We find at the outset a few old genera, like Cidaris, Dorocidaris, Porocidaris, and Salenia, dating back to the Jurassic period, and which already in the Tertiary had probably as extensive a geographical distribution as at the present day. Dorocidaris and Porocidaris at the present time are Atlantic and Indo-Pacific genera, while Salenia and Cidaris are confined to the warmer belts of the same oceans.

Hemipedina, which dates back to the Jura, is found fossil in the Tertiary of North America, and has thus far not been dredged outside of the Caribbean Fauna. Pygaster is also a Jurassic genus, but it is most probable that the *Pygaster relictus* is only the young of one of the West Indian Spatangoids with an ancient facies, as has been suggested by De Loriol. The genera which date back to the Cretaceous period, either actually or by closely allied genera, are Podocidaris, Asthenosoma, Phormosoma, Temnechinus, Echinus, Echinocyamus, Conoclypus, Rhynchopygus, Pourtalesia, Hemiaster, and Periaster.

Of these genera, Temnechinus, Echinus, Hemiaster, and Periaster already had during the Tertiary as extensive a geographical range as to-day. At the present time, Echinus extends over the Atlantic, the Indian, and the Pacific Oceans; Temnechinus is a tropical Atlantic and Pacific genus; Hemiaster is characteristic of the Atlantic and of the North Pacific, Periaster of the East American tropical Atlantic and tropical Pacific, and Rhynchopygus appears limited to-day to the American faunal districts of the same oceans, although it has been found in the Tertiaries of Australia and of Europe. Nothing is known of the distribution during the Tertiary of the Atlantic and Pacific genera Pourtalesia, Asthenosoma, and Phormosoma. Podocidaris is a tropical Atlantic and Pacific genus. Echinocyamus extends in the North Atlantic to within the tropics.

The genera dating back to the earlier Tertiary period include by far the greater number of the genera of the West Indian Fauna; they are Cœlopleurus, Strongylocentrotus, Trigonocidaris, Toxopneustes, Hipponoë, Clypeaster, Echinanthus, Echinonëus, Neolampas, Echinolampas, Homolampas, Paleopneustes, Linopneustes, Spatangus, Echinocardium, Rhinobrissus, Brissopsis, Agassizia, Brissus, Metalia, Meoma, Macropneustes, Schizaster, and Moira. Of these the genera extending in the equatorial belt of the Atlantic and Indo-Pacific region are Trigonocidaris, Toxopneustes, Hipponoë, Clypeaster, Echinanthus, Echinolampas, Homolampas, Paleopneustes, Linopneustes, Rhinobrissus, Brissus, and Metalia. The genera having an Atlantic and Pacific range are Strongylocentrotus, Spatangus, Echinocardium, Brissopsis, and Schizaster. Leaving only with a more or less limited range Cœlopleurus, found in the Caribbean, Indian Ocean, and East Indian Archipelago, and with nearly the same distribution in the Tertiary, having only disappeared from the Eastern North Atlantic region where it once flourished. Echinonëus, Cœlopleurus, and Macropneustes have very much the same geographical and geological range. Agassizia, Meoma, and Moira are probably strictly tropical American genera, occurring both on the Pacific and Atlantic sides of the continent; but they formerly had a much wider geographical distribution, Agassizia having been found in the Tertiary of Egypt and Meoma in Australia.

The genera dating back only to the later Tertiary period are Arbacia, Echinometra, Mellita, and Encope. But little is known of their former geographical extension. Echinometra is a tropical Atlantic and Indo-Pacific genus; Arbacia is a tropical Atlantic and Pacific genus, most widely distributed on both sides of the American continent; while Mellita* and Encope are eminently tropical American, occurring on both sides of the continent.

This leaves the genera Diadema, Aspidodiadema, Palæotropus, Palæobrissus, Urechinus, Cystechinus, and Aceste, which have as yet not been found fossil. These genera, with the exception of Cystechinus, limited to the Southern Atlantic and Pacific, and Palæobrissus, which represents Platybrissus in the Atlantic, have an extended geographical range in the tropical belt of both the Atlantic and the Pacific Oceans. The nearest allies of Diadema and of Aspidodiadema date back to the Cretaceous, and Palæotropus, Palæobrissus, Urechinus, and Cystechinus are to-day the old-fashioned representatives of the types of Spatangoids which characterized the Cretaceous seas.

This analysis shows that the Echinid Fauna of the West Indian seas of to-day is made up (1.) of five genera which date back to the Jurassic period; (2.) of ten genera which go back to the Cretaceous period; (3.) of twenty-four genera dating from the earlier Tertiary period; (4.) of only four genera characteristic of the later Tertiaries; (5.) of seven genera which we may look upon as the representatives of the Ananchytidæ and Infulasteridæ, and of the Pseudodiadematidæ of the Cretaceous period. In all these old-fashioned genera we find species having a cosmopolitan range.

* One species of Mellita is said to come from the Red Sea.

Of the so-called American genera, all containing most closely allied representative species, Agassizia, Moira, Meoma, Macropneustes, Arbacia, Encope, and Mellita, which probably flourished in the central American seas soon after the closing of the Isthmus of Panama, the three Spatangoids date back to the Cretaceous, the two Clypeastroids and two Echinidæ to the later Tertiary. We find the nearest allies of the Clypeastroids in the Tertiaries of Western France and of Egypt; the above-named West Indian Spatangoids and Clypeastroids, as well as Cœlopleurus and Macropneustes, first disappeared from the Eastern Atlantic. The past history of the ten West Indian genera already found in the Cretaceous, and of the twenty-four genera descending from the earlier Tertiary, gives us but little assistance in determining their probable mode of appearance in the Caribbean Fauna.

As far as we can now judge, the separation of the Caribbean and the Gulf of Mexico from the Pacific was brought about by the formation of the Florida and Yucatan Banks by their elevation above the level of the sea, in addition to the raising of the Greater and Lesser Antilles, of the Plateau of Mexico, and of the whole of Central America, ending in the complete closing of all connection at the Isthmus of Panama. These elevations have been gradually taking place from the close of the Cretaceous period to the most recent Post-tertiary times, and to the successive changes they have brought about in the physical conditions of the Gulf of Mexico and of the Caribbean Sea we must ascribe in the main the existing state of the West Indian Echinid Fauna as compared with the Echinid Fauna of other geographical districts.

It would be most interesting to be able to make a comparison of the deep-sea Panamic Fauna with that of the Caribbean, and ascertain if in the continental and abyssal regions, at the depths beyond which the effects of light and of heat are not prominent factors, we find as marked a difference in the representative species as in those of the littoral Fauna.

The West Indian Echinid Fauna comprises more than a quarter of all the known species of Echini, and if we take what we might call the tropical Atlantic Fauna it includes a little over one third of all the known species. The known species of the Indo-Pacific realm, which we might call the tropical Indo-Pacific Fauna, are somewhat more numerous; so that we have more than two thirds of all the known species of Echini belonging to this great tropical oceanic belt, the northern and southern limits of which extend somewhat into the temperate regions. This leaves less than one third of the known Echini as representatives of the other faunal districts. There are only at present thirty-four genera characteristic of the Indo-Pacific not found in the Atlantic, and only eight genera characteristic of the Atlantic not as yet discovered in the Pacific,* while the Atlantic and Pacific have thirty-six genera in common. Of the genera they have in common, four date back to the Jura, seven to the Cretaceous, sixteen to the Tertiary; the others belong to the Diadematidæ, which have their nearest allies in the Cretaceous, as well as the five recent genera of Ananchytidæ and Pourtalesiæ.

Of the genera special to the Indo-Pacific, two date back to the Jura, as many to the Cretaceous, twenty-one to the Tertiary; there are left the genera of Diadematidæ, of Ananchytidæ, and of Pourtalesiæ, derived from the Cretaceous. The Echinometradæ genera of the Pacific have no fossil representatives. Of the special Atlantic genera, two are Jurassic, two Cretaceous, one Tertiary; the other has no fossil representative.

Soon after the end of the Cretaceous period the specialization of the great Atlantic and Indo-Pacific marine realms began. Before that time the equatorial currents probably swept nearly uninterruptedly round the globe, and maintained across the Indo-Pacific and Atlantic nearly the conditions existing in the Western Atlantic before the equatorial currents became deflected by the West India Islands and the northern extremity of South America. If the physical causes we now see at work have, as they became changed, also modified the Fauna of the then existing equatorial belt district, we should naturally expect to notice after a long period of time the changes they brought about. We are probably justified in ascribing to the subdivision of this great equatorial belt into an Indo-Pacific and an Atlantic district the marked changes we can trace in the character of the Fauna as affecting the genera which date back to the late Cretaceous, and which become still more marked if we trace them in the genera dating back to the Tertiary period.

How far it is possible for us directly to follow the changes which have taken place, and to trace the gradual passage of the older Fauna into the characteristic West Indian Fauna of to-day, is another question. This involves the necessity of tracing back from the Triassic and Jurassic periods the genera which have appeared in succession, and how far this is practicable I have attempted to show on a former occasion.† I would also

* We should also bear in mind that, of the eight genera characteristic of the Atlantic alone, we find closely allied representative genera in the Indo-Pacific realm.

† Palæontological and Embryological Development, Address at the Boston Meeting for 1880 of the American Association for the Advancement of Science.

refer for details to the List I have given in the Challenger Report * of known species of Echini, where the bathymetrical, geographical, and geological range is given as far as known at that time. To this List should be added the deep-sea species collected by the "Gazelle" and described by Studer, and the necessary additions and modifications which are suggested in this Report.

The following Table, containing a complete list of all the West Indian species of Echini, extended so as to include the few species which thus far have not yet been found in the West Indian district, has been prepared, for the sake of comparing the West Indian species with the Panamic Echini, and with the representative species of Echini found in the American deposits of the Post-Pliocene, Miocene, Eocene, Cretaceous, and Jurassic periods. In the column of the principal localities, the present and past geographical and geological extension of the genus is given, to allow a ready comparison of the actual and former distribution of the present West Indian genera to be made. The geographical range of each species is also given. When several representative species have been described, they have all been enumerated.

* Report on the Echinoidea: Report on the Scientific Results of the Voyage of H. M. S. Challenger, Pt. IX., p. 208, 1881.

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
Desmosticha HAECKEL **Cidaridæ** MÜLL. **Goniocidaridæ** HAECKEL **Cidaris** KL.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene, (Switzerland, Austria, Malta, India, Australia), Upper and Lower Chalk, Jura, Lias, Trias.	G. Dowalini	Galap. A. Ag.				~~C. splendens~~ Ck. C. walcotti Ck. C. texanus Texas
C. tribuloides BL.	S. Carolina, Brazil, Cape Palmas.	C. Thouarsii VAL.	....	....	C. Anguillæ COTT. Anguilla.	C. Alabamensis MORT., Ala. C. Mortoni CON. Georgia.	C. hemigranosus SHUM., La. Pseudocidaris, Mexico. (Leiocidaris) Texas
Dorocidaris A. AG.	Atlantic, Indo-Pacific. — Tertiary (N. Am., Austria), Chalk, Jura.						
D. Bartletti A. AG.	West Indies.	D. Panamensis					
D. Blakei A. AG.	" "						
D. papillata A. AG.	Norway, Mediterranean, Canaries, West Indies, St. Paul Rocks, La Plata, Philippines.	....	....	....	C. mellitensis WR. Anguilla.	C. Loveni COTT. St. Bart.	C. armigera MORT., N. J. (C. splendens)
Porocidaris DES.	Tropical and Temperate Atlantic and Pacific. — Miocene, Eocene (France, Egypt, India, Num.), Jura.	P. Milleri P. Cobosi					
P. Sharreri A. AG.	West Indies.						
Salenidæ AGASS. **Salenia** GRAY.	Atlantic, Tropical Pacific. — Miocene, Eocene (France, Australia), Upper and Lower Chalk (France, England, Germany), Upper Jura.						Salenia texana Cret. Texas " tumida Ck. " bellula Ck.
S. goësiana LOV.	West Indies.	S. [illegible]					
S. Pattersoni A. AG.	" "						
S. varispina A. AG.	West Indies, Brazil, Ascension, Canaries.						
Arbaciadæ GRAY **Arbacia** GRAY	Atlantic, Pacific. — Upper Tertiary, N. Am.						
A. punctulata GRAY	Long Island Sound to Yucatan.	A. stellata GRAY	A. punctulata HOLMES S. Carolina.	Arbacia sp. McCR. S. Carolina.			Coniopygus Zitteli Ck. Texas
A. pustulosa GRAY **Podocidaris** A. AG.	Mediterranean, Liberia, Brazil. Upper Cretaceous (Codiopsis), Cretaceous Oölite (Magnosia).						

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
P. sculpta A. Ag.	West Indies.						
P. scutata A. Ag.	" "						
Cœlopleurus Agass.	Tropical Atlantic, Indo-Pacific. — Eocene, Crag (England), Num. (India), North America, France, Italy.						
C. floridanus A. Ag.	West Indies.	.... D. gemmifera	....	....	....	C. infulatus Des. Santee, S. C.	
Diadematidæ Peters.							
Diadema Schynv.	Tropical Atlantic, Indo-Pacific.	....	....	....	....	....	Pseudodiadema diatremum Des. N. J.
D. setosum Gray	West Indies, Bermudas, Cape Verde Islands, Indian Ocean, Japan, Sandwich Islands, Fiji Islands.	D. mexicanum A. Ag. Astropyga pulvinata Agass.	....	....	....	....	Phymosoma texanum Röm. ~~Diadema texanum Shum.~~, Texas.
Aspidodiadema A. Ag.	Tropical Atlantic and Pacific. — Miocene, Jura (Polycidaris Quenst.)						Pseud. Roemeri "
A. microtuberculatum A. Ag.	Macio, Tristan d' Acunha, No. Brazil, Chili.	.... Cen. globulosum	....	....	Cid. Clevei Cott. Anguilla.		" Hilli "
A. antillarum A. Ag.	West Indies.	" lonidum					Cyphos. speciosum (All M.).
A. Jacobyi A. Ag.	" "						
Echinothuridæ Wyv. Thom.	Chalk (Echinothuria)						
Asthenosoma Grube	Atlantic, Tropical Pacific.						
A. hystrix A. Ag.	Rockall, Cape Finistère, West Indies.						
Phormosoma Wyv. Thom.	Atlantic, Pacific.						
P. placenta Wyv. Thom.	West Indies, Atlantic Coast, Southern and Middle States of U. S., West Coast of Scotland and Ireland.	P. panamensis P. hispidum					
P. uranus Wyv. Thom.	West Indies, Atlantic Coast, Southern and Middle States of U. S., West Coast of Scotland and Ireland, and Eastern Atlantic.						
Echinometradæ Gray							
Echinometra Rond. (Breyn)	Tropical Atlantic, Indo-Pacific. — Miocene, N. A.						
E. subangularis Desml.	Senegal, Ascension, Bermudas, West Indies, Brazil.	E. Van Brunti A. Ag.					

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
E. viridis A. Ag.	West Indies.	…………	…………	…………	E. prisca Cott. Anguilla.		
Strongylocentrotus Br.	Atlantic, Pacific. — Pliocene, Miocene; N. Am., Sweden, Java.						
S. Dröbachiensis A. Ag.	No. European, N. E. Coast of N. Am., No. Pacific.	S. mexicanus A. Ag.	S. Dröbachiensis A. Ag., Drift				
S. Gaimardi A. Ag.	Brazil.						
S. lividus Br.	Europ. Atlantic, Mediterranean, Azores, Brazil.						
Echinidæ Agass.							
Temnopleuridæ Des.							
Temnechinus Forbes	Tropical Atlantic. — Crag; Tertiary (Australia, India); Cretaceous.						
T. maculatus A. Ag.	Azores, West Indies.						
Trigonocidaris A. Ag.	Tropical Atlantic and Pacific. — Tertiary, Australian (Paradoxechinus).						
T. albida A. Ag.	Josephine Bank, West Indies.						
Triplechinidæ A. Ag.							
Hemipedina Wright	Tropical West Atlantic.—Lower Chalk, Jurassic.						
H. cubensis A. Ag.	Straits of Florida.	…………	…………	…………	…………	…………	Echinopedina cubensis Cott. Cuba.
Echinus Rond. (Lin.)	Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene, (Crag) England: France, Malta, Austria, N. Am., India; Cretaceous.						
E. acutus Lamk.	Norway, Mediterranean, Ascension, Halifax to New York, Kermadek Isl.						
E. elegans Düb. o. Kor.	Norway, Mediterranean, Halifax to New York. — Tristan d' Acunha, Papua.						
E. esculentus Lin.	Norway, Ireland, English Channel.						
E. gracilis A. Ag.	West Indies.	…………	…………	…………	E. improcerus Con., Va.		
E. norvegicus Düb. o. Kor.	Norway, Mediterranean, Atlantic Coast of U. S., West Indies, West Patagonia, Japan.	…………	…………	Psam. exoletus McCr., S. C.	E. philanthropus Con., Va.		

sp. now living in Medit. / in W. Ind. [illegible] not list

[illegible]

[illegible]

Psam. [illegible]

Holectypus planus. R. Ing Pyrina Parryi Tex. Not alabama ala OK. form

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
E. Wallisi A. Ag.	East Coast Atlantic States (South America to Southern New England), Norway.						
Toxopneustes Agass.	Tropical Atlantic, Indo-Pacific.						
T. variegatus A. Ag.	Bermudas, S. C., West Indies, Brazil.	T. semitubereulatus A. Ag. T. pileolus Agass.	Ech. variegatus Holmes, S. C.				
Hipponoë Gray.	Tropical Atlantic, Indo-Pacific. — Miocene, France.						
H. esculenta A. Ag.	Bermudas, Florida, Surinam, Brazil.	H. depressa A. Ag.					
Clypeastridæ Agass.	……	……	……	……	……	Discoidea Haldemani Con., Ga. Galerites Agassizii Mort. Ala.	Pyrina Parryi Hall, Texas. Holectypus planatus Roem. Texas.
Echinoconidæ D'Orb.	……	……	……	……	Echinoconus Lanieri D'Orb. Guadeloupe.	E. Lanieri D'Orb. E. antillensis Cott., Cuba.	
Pygaster Agass.	Tropical West Atlantic. — Cretaceous, Jurassic.						
P. relictus Lov.	West Indies.						
Euclypeastridæ Haeckel. **Fibularina** Gray.	……	……	……	……	Sismondia Anguillæ Cott. Anguilla.	Sismondia marginalis Con. S. C. S. crustuloides Des., S. C. S. alta Cott. St. Bart. S. antillarum Cott., St. Bart.	
Echinocyamus Van Phels.	North Atlantic. — Miocene, Switzerland, France, Austria; Upper Chalk, France, Belgium, Sicily.						
E. pusillus Gray.	Norway, Ireland, Mediterranean, Azores, West Indies, Brazil.						
Clypeaster Lamk.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene; N. Am., Italy, Corsica, Java.	……	……	……	……	Mortonia Rogersii Des., Ala.	
C. latissimus A. Ag.	West Indies, N. Brazil.						

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
C. Ravenellii A. AG.	S. C., West Indies.	C. rotundus A. AG.	....	....	....	C. Jonesii DES. Ga.	
C. subdepressus AGASS.	West Africa, S. C., Brazil.	....	....	....	C. Meridanensis MICH., Guad.		
Echinanthus BREYN.	Tropical Atlantic and Pacific. — Pliocene, Miocene, Eocene; Austria, Corsica, Malta, India, Java, Australia.						
E. rosaceus GRAY	S. C., West Indies.	....	....	C. incurvatus DESML., Guad. C. parvus DUCH. Guadeloupe.	C. cubensis COTT. Cuba. C. antillarum COTT. C. concavus COTT. Anguilla.		
Scutellidæ AGASS.							
Echinarachnius LESKE.	Atlantic, Indian, Pacific. — Tertiary N. Am., Patagonia, Australia.	....	....	Scutella Michelini DUCH., Guad.	....	Scutella Lyelli DES., S. C.	Pygurus geometricus AG., Del.
E. parma GRAY.	Labrador to New York., Vancouver, Japan, Australia, Red Sea, India.	E. excentricus VAL.				S. crustuloides Mr. S. Rogersii Mort.	
Mellita KL.	American Tropical Atlantic and Pacific. — Pliocene, N. A.						
M. sexforis A. AG.	S. C. to Brazil.	M. pacifica VERR.	M. hexapora MCCR., S. C.				
M. testudinata KL.	Nantucket to Brazil.	M. longifissa MICH.	M. ampla HOLMES, S. C. M. testudinata S. C.	M. ampla HOLMES, Guad. M. caroliniana RAV., S. C. M. texana, CON. Texas.			
Encope AGASS.	American Tropical Atlantic and Pacific. — N. A. Pliocene, Miocene.						
E. emarginata AGASS.	S. C. to Brazil.	E. californica VERR.					
E. Michelini AGASS.	West Indies.	E. micropora AG. E. grandis AG.	....	Ravenellia macrophora LÜTK. S. C.	R. macrophora LÜTK., S. C. Encope Ciæ DEC., Cuba.		
Petalosticha HAECKEL.							
Cassidulidæ AGASS.							

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
Echinoneidæ Agass.							
Echinonëus Van Phels.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene; N. Am., West Indies.						
E. semilunaris Lamk.	West Indies.	......	......	E. semilunaris, Guad., Cuba. E. cyclostomus D'Orb. non Auct., Guad.	E. semilunaris, Anguilla.		
Nucleolidæ Agass.	......	......	......	......	......	Amblypygus americanus Mich., Jam.	
Neolampas A. Ag.	Tropical Atlantic.	......	......	......	......	Catopygus Conradi Cp., Ga.	Catopygus oviformis C., N. J.
N. rostellata A. Ag.	West Indies, N. E. Atlantic.	......	......	......	......	......	Faujasia florealis D'Orb., Del.
Echinolampas Gray.	Tropical Atlantic, Indo-Pacific. — Tertiary: European, India, Java, Australia, West Indies, N. Am.						
E. depressa Gray.	West Indies.	......	......	......	E. lycopersicus Guppy. E. anguillæ Cott. Anguilla.	E. antillarum Cott. E. ovumserpentis Guppy. E. Clevei Cott. St. Bart. E. Castroi Cott. Cuba.	
Conolampas A. Ag.	Tropical West Atlantic. — Miocene, Eocene, Europe, Crimea, West Indies (Phyllobrissus); Upper Chalk.						
C. Sigsbei A. Ag.	West Indies.	......	......	......	......	Echinol. semiorbis Guppy. St. Bart.	
Rhynchopygus D'Orb.	Tropical American Atlantic and Pacific. — Tertiary, Europe, Australia, West Indies; Gault, India.						
R. caribæarum Lütk.	West Indies.	R. pacificus A. Ag.	......	R. guadeloupensis Duch. Guad.	Cassidulus abruptus C. C. subquadratus C. Cass. sp., Miss.	Echinanth. Mortonis Des. Miss. E. antillarum Cott., St. Bart.	Trematopygus crucifer Des. N. J. Cassidulus aequoreus M., N. J.

+ C. pusillus [illegible]

Echinol. [illegible] CK.
" [illegible] CK. [illegible]

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
R. caribæarum LÜTK. (*continued.*)	West Indies.	....	....	....	....	Pygorhynchus crucifer RAV. P. rugosus RAV. Eocene, S. C. P. Gouldii DES. Ga. P. Jamaicensis MICH., Jam.	Cass. patelliformis DES., Ga. C. micrococcus GABB., Ala. C. entromeus Ctt. Miss. C. ... Ctt. C. Stantoni Ctt. Colo.
Spatangidæ AGASS.							
Pourtalesiæ A. AG.							
Pourtalesia A. AG.	Atlantic, Pacific. — Crag (Echinarachnius Woodi).						
P. miranda A. AG.	Shetland Islands, West Indies, off Martha's Vineyard, U. S. Fish Com.	P. Tanneri					
P. phiale WYV. THOM.	Kerguelen, Australia, N. C.						
P. Jeffreysi WYV. THOM.	Faroe to Shetland Isl., off Martha's Vineyard, U.S. Fish Com.						
Spatagocystis A. AG.	So. Pacific, Caribbean.						
S. sp. A. AG.	West Indies.						
Urechinus A. AG.	South Atlantic and Pacific.						
U. naresianus A. AG.	Antarctic to Australia, Juan Fernandez to Chili, West Indies.	U. giganteus					
Cystechinus A. AG.	South Pacific and Atlantic.						
C. clypeatus A. AG.	Philippines, Tristan d'Acunha to Bahia and Buenos Ayres, West Indies.	C. Loveni, C. Rathbuni, ..., cinctus, Echin. setigera		C. crassus Greg. Barbados.			
Ananchytidæ ALB. GRAS.							
Palæobrissus A. AG.	West Indies.						
P. Hilgardi A. AG.	West Indies.						
Palæotropus LOV.	Tropical Atlantic, W. Indian.	....	....	....	....	....	Holaster simplex SH., La. H. comanchesi MARC., Tex.
P. Josephinæ LOV.	West Indies, Azores.						
P. Thomsoni A. AG.	Atlantic Coast of U. S. (S. C.).	....	....	....	....	....	Ennalaster texanus D'ORB. Texas.
Homolampas A. AG.	Tropical Atlantic and Pacific. — Tertiary, Italy.						
H. fragilis A. AG.	Florida, Brazil, Josephine Bk.	H. hastata					
Paleopneustes A. AG.	Tropical West Atlantic. — Eocene, Italy.	....	....	....	....	Asterostoma cubense COTT. A. Jimenoi COTT. Cuba.	
P. cristatus A. AG.	West Indies.	....	....	....	....	Macropneustes cubensis COTT. Cuba.	Cardiaster cinctus D'ORB. N. J.
P. hystrix A. AG.	West Indies.		Archaeopneustes abruptus Gregory.				

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
Linopneustes A. Ag.	Tropical Atlantic and Pacific.						
L. longispinus A. Ag.	West Indies.	.... Ohy. aculeata	....	....	....	Eupatagus Clevei Cott. E. antillarum Cott. E. grandifloris Cott., St. Bart.	
Spatangina Gray.	....	....	....	....	....	Breynia cubensis Cott., Cuba.	
Spatangus Kl.	Atlantic, Indian, Pacific. — Pliocene, Miocene, Eocene; Europe, Morea.						
S. purpureus Leske.	Norway, Mediterranean, Azores, Bermudas.						
Macropneustes Agass.	Miocene, Eocene.—Switzerland, France, Egypt, Italy, West Indies.						
M. spatangoides A. Ag.	West Indies.	....	....	....	....	M. cubensis Cott. Cuba.	
Echinocardium Gray.	Atlantic, Indian, Pacific. — Pliocene, Miocene, Eocene; N. Am., England, Italy, Switzerland, India.						
E. cordatum Gray.	Norway, Mediterranean, N. C. to Brazil.	....	....	Amphid. amplifloras McCr. S. C. A. virginianus Des., S. C., Va.			
E. flavescens A. Ag.	Norway, Cape Good Hope, S. C. and Florida.						
E. pennatifidum Norm.	Shetland Islands, Straits of Florida.	....	....	....	Amph. gothicus Rav., S. C.		
Brissina Gray.							
Hemiaster Des.	Southern Ocean, So. Pacific and Atlantic, Tropical Atlantic.—Tertiary N. Am.; Cretaceous N. Am., Upper Chalk, India, Europe.	....	....	....	....	Prenaster Loveni Cott., St. Bart.	
H. expergitus Lov.	West Indies, East N. Atlantic.	....	....	....	....	Hemiaster Conradi Bouv., Ga.	H. stella Des. N. J., Ala.
H. zonatus A. Ag.	N. Brazil, Canary Islands.	....	....	H. cubensis D'Orb., Cuba.	....	H. antillensis Cott., Cuba.	H. Humphreysiana, M. & H. Texas.
H. Mentzi A. Ag.	West Indies.					H. Duvalqui Cott., Cuba.	~~[illegible]~~ R.

H. incrassatus Cl. N.J.
(Periaster)?
H. Dalli Cl. Texas.
H. californicus Cl.

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
Rhinobrissus A. Ag.	Tropical West Atlantic and Pacific.—Tertiary (Micraster sp.) Australia.						
R. micrasteroides A. Ag.	West Indies.	....	....	....	....	Schiz. antillarum Cott., St. Bart.	Hemiaster parastaltus Des. Ala., Texas. H. elegans Des. Texas.
Brissopsis Agass.	Atlantic, Indian, Pacific. — Tertiary, Europe, India, N. A., West Indies.	Lovenia cordiformis Lütk.					
B. lyrifera Agass.	Norway, Mediterranean, Greenland, Cape of Good Hope, West Indies.	B. columbaris [illegible] pacificus A. fulva	....	....	B. Jimenoi Cott. Cuba. B. antillarum Cott., Anguilla.		
Aërope Wyv. Thom.							
A. rostata Wyv. Thom.	Arafura Sea, Bay of Biscay, Davis Straits, N. E. coast of U. S. off Martha's Vineyard, U. S. Fish Com.						
Aceste Wyv. Thom.							
A. bellidifera Wyv. Thom.	Sandwich Islands to Low Archipelago, Buenos Ayres to Tristan d'Acunha, Canary Islands.						
Agassizia Val.	Tropical American Atlantic and Pacific. — Miocene, Eocene; Egypt, N. Am., West Indies.						
A. excentrica A. Ag.	West Indies.	Agassizia scrobiculata Val.	....	A. porifera McCr. A. rimulata McCr., S. C.	A. porifera McCr., S. C.	A. Clevei Cott. St. Bart., Anguilla.	
Brissus Kl.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene; N. Am., West Indies, Pyrenees, Malta, Europe, Java.						
B. Damesi A. Ag.	N. Brazil, Azores.						
B. unicolor Kl.	West Indies, Cape Verde Islands, Mediterranean.	Brissus obesus Verr.	....	B. columbaris Ag. Guadeloupe. B. spatiosus McCr., S. C.	B. spatiosus McCr., S. C. B. exiguus Cott. Anguilla.		
Metalia Gray.	Tropical Atlantic, Indo-Pacific. — Tertiary, West Indies, N. Am., Malta, Italy.						Linthia [illegible] ck.

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
M. pectoralis A. Ag.	West Indies, Brazil.	M. maculosa A. Ag.	…………	Plagion. Holmesii McCr. Plagion. Ravenellianus McCr. S. C.	…………	Plag. Loveni Cott., St. Bart.	
Meoma Gray.	Tropical Atlantic and Pacific. — American Tertiary, Australia, West Indies, Cuba.						
M. ventricosa Lütk.	West Indies.	M. grandis Gray	…………	…………	Peripneustes Clevei Cott. Anguilla.	Peripn. antillarum Cott. St. Bart.	
Schizaster Agass.	Atlantic, Indian, Pacific. — Miocene, Eocene; Europe, India, Java, Australia, N. Am., West Indies.						
S. fragilis Agass.	Norway, Maine, East Coast of U. S. (Middle States), West Indies, Cape of Good Hope.	S. latifrons	…………	…………	…………	Sch. subcylindricus Cott. St. Bart.	
S. orbignyanus A. Ag.	West Indies, off Martha's Vineyard, U. S. Fish Com.*	S. Townsendi	…………	…………	Sch. Clevei Cott. Sch. Loveni Cott., Anguilla. Sch. Scillæ Agass. Sch. Parkinsoni Ag., Anguilla.	…………	Spat. ungulata Mort., N.J.
Periaster D'Orb.	West Indies, Arafura Sea. — Eocene, Europe, Egypt, Java, India, West Indies; Chalk, Egypt, France, N. Am.	…………	…………	…………			
P. limicola A. Ag.	Arafura Sea, West Indies.	P. tenuis	…………	…………	…………	P. elongatus Cott., St. Bart.	P. texanus Des. Texas.
Moira A. Ag.	Tropical Atlantic and Pacific. — American Tertiary, West Indies.						
M. atropos A. Ag.	N. C. to West Indies.	Moira clotho A. Ag.	Sch. atropos Auct., S. C. M. lachesis Gir. S. C.				

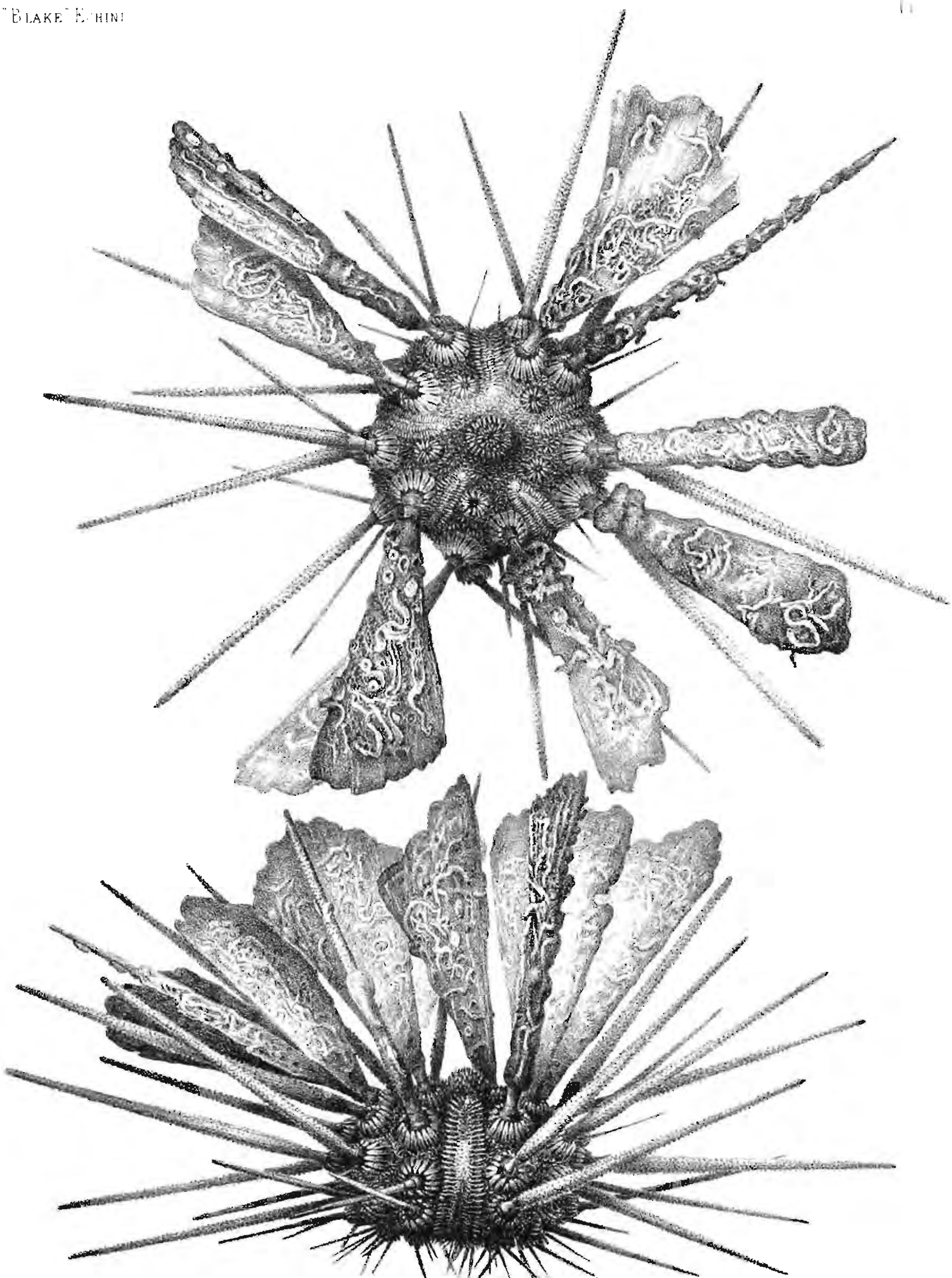
Spat. Diomedeae
East Coast S. Am.

* The Echini collected by the U. S. Fish Com. Steamer "Albatross" have lately been placed in my hands for examination by the kindness of Professors Baird and Verrill. I was unable to examine this small but interesting collection in time to incorporate the results in this Report. — A. Ag.

PLATE I.

Dorocidaris Blakei A. Ag.

Fig. 1. Seen from above. Natural size.
Fig. 2. Seen in profile. Natural size.



H. Roesler del. Printed by A. Meisel

PLATE II.

1–15. **Dorocidaris Blakei** A. Ag.

Fig. 1. Portion of test seen in profile, facing the median interambulacral line, from a specimen 37 mm. in diameter.

Fig. 2. Abactinal system of same.

Fig. 3, 4. Primary elongate radioles, similar to those of *D. papillata.*

Fig. 5. Primary radiole, somewhat flattened at extremity.

Fig. 6, 7. Primary radioles somewhat flattened and slightly fan-shaped at extremity.

Fig. 8–10. Primary radioles still more fan-shaped than those of the preceding figures.

Fig. 11–13. Small interambulacral radioles of the actinal side near actinostome.

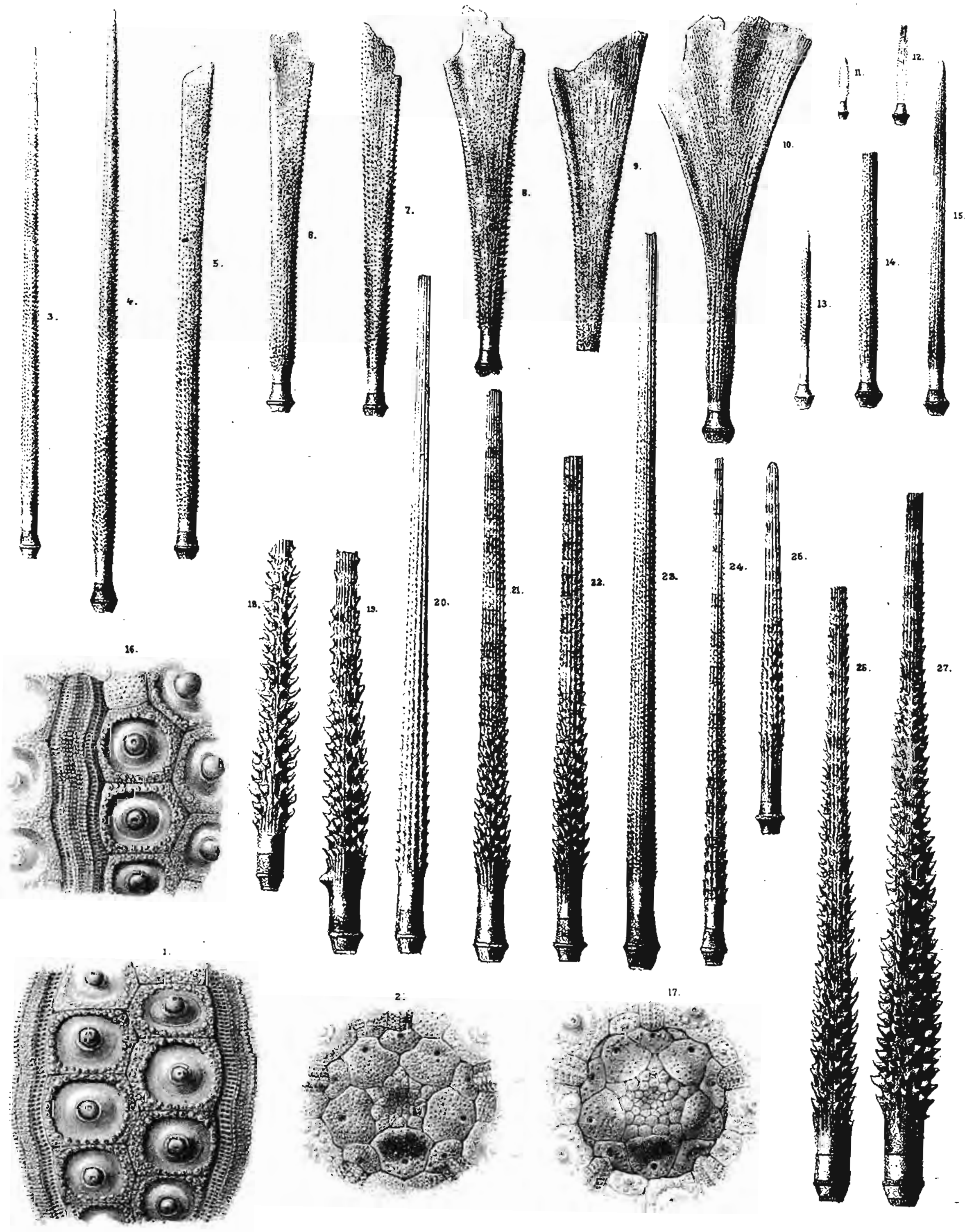
Fig. 14, 15. Larger and stouter radioles of the actinal side near the ambitus.

16–27. **Dorocidaris Bartletti** A. Ag.

Fig. 16. Portion of test seen in profile, showing the ambulacral area and a few primary plates of the interambulacral area, adjoining the apical system, from a specimen 50 mm. in diameter.

Fig. 17. Abactinal system of same.

Fig. 18–27. Different primary radioles taken from a single specimen, showing the more or less serrated structure between the two extremes of Fig. 23 and 27.



A. Meisel, lith.

PLATE III.

Porocidaris Sharreri A. Ag.

Seen in profile. Natural size.

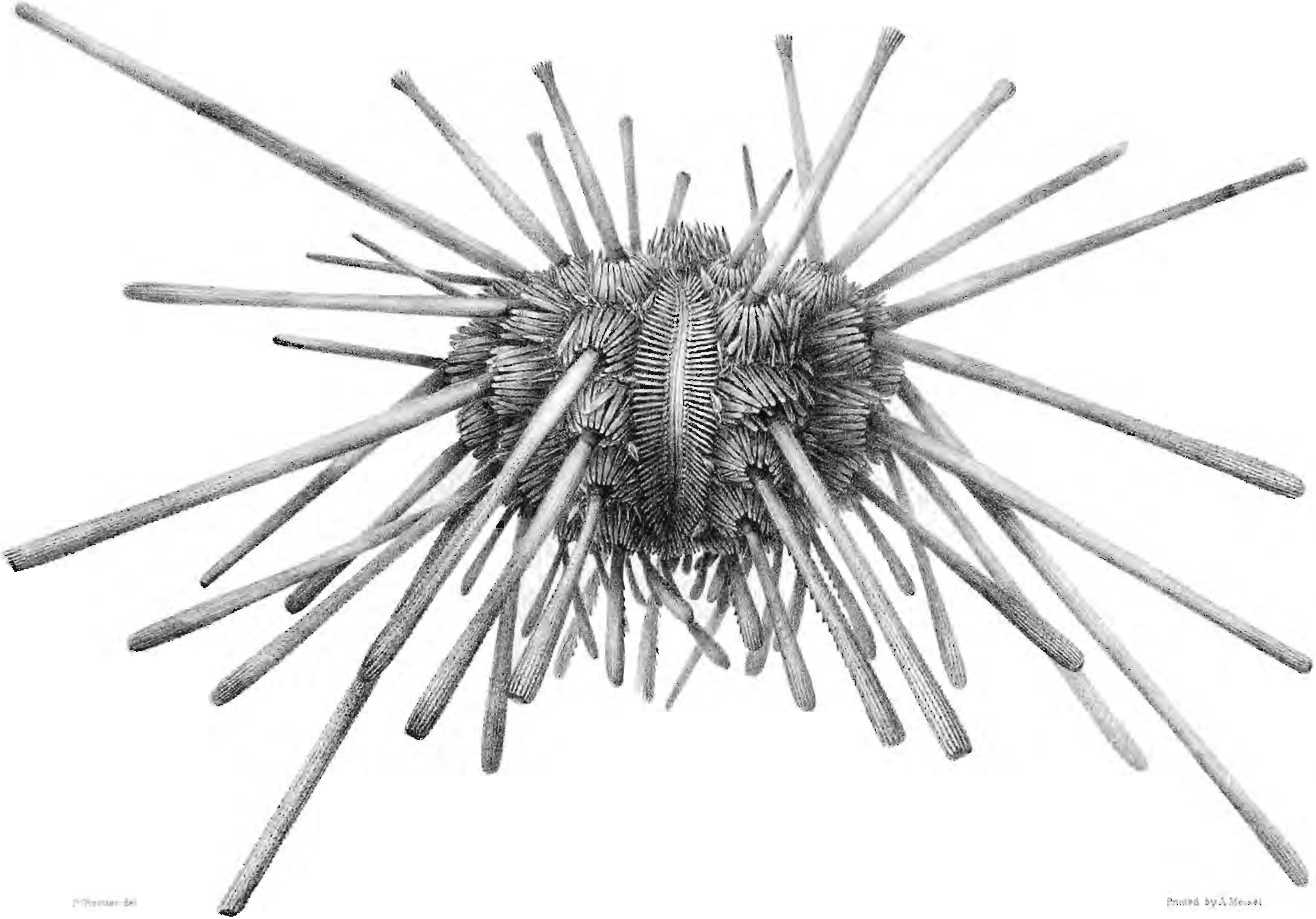


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PLATE IV.

1–2. **Porocidaris Sharreri** A. AG.

Fig. 1. Portion of test of specimen measuring nearly three inches in diameter. Seen in profile.

Fig. 2. Abactinal system of same, both figures somewhat enlarged.

3–23. **Salenia Pattersoni** A. AG.

Fig. 3. Abactinal system of specimen 18 mm. in diameter.

Fig. 4. Actinal system of same.

Fig. 5. Portion of test of same, seen in profile, showing primary coronal plates above ambitus, facing the median interambulacral line.

Fig. 6. Portion of test of same above the ambitus, seen in profile facing the median ambulacral line.

Fig. 7. Portion of ambulacral area of same, showing the Hemicidaris-like arrangement of the tubercles at the base of the ambulacral area near the actinostome.

Fig. 8. Primary spine of same. Natural size.

Fig. 9–11. Ambulacral papillæ of same, magnified.

Fig. 12–14. Porocidaris-like interambulacral spines, near actinostome, magnified.

Fig. 15. Test of specimen 12 mm. in diameter, seen from the abactinal side.

Fig. 16. Portion of test of same, below and at ambitus, seen in profile, facing the median ambulacral line and showing the Hemicidaris-like ambulacral tubercles.

Fig. 17. Actinal system of same.

Fig. 18. Abactinal system of specimen 10 mm. in diameter.

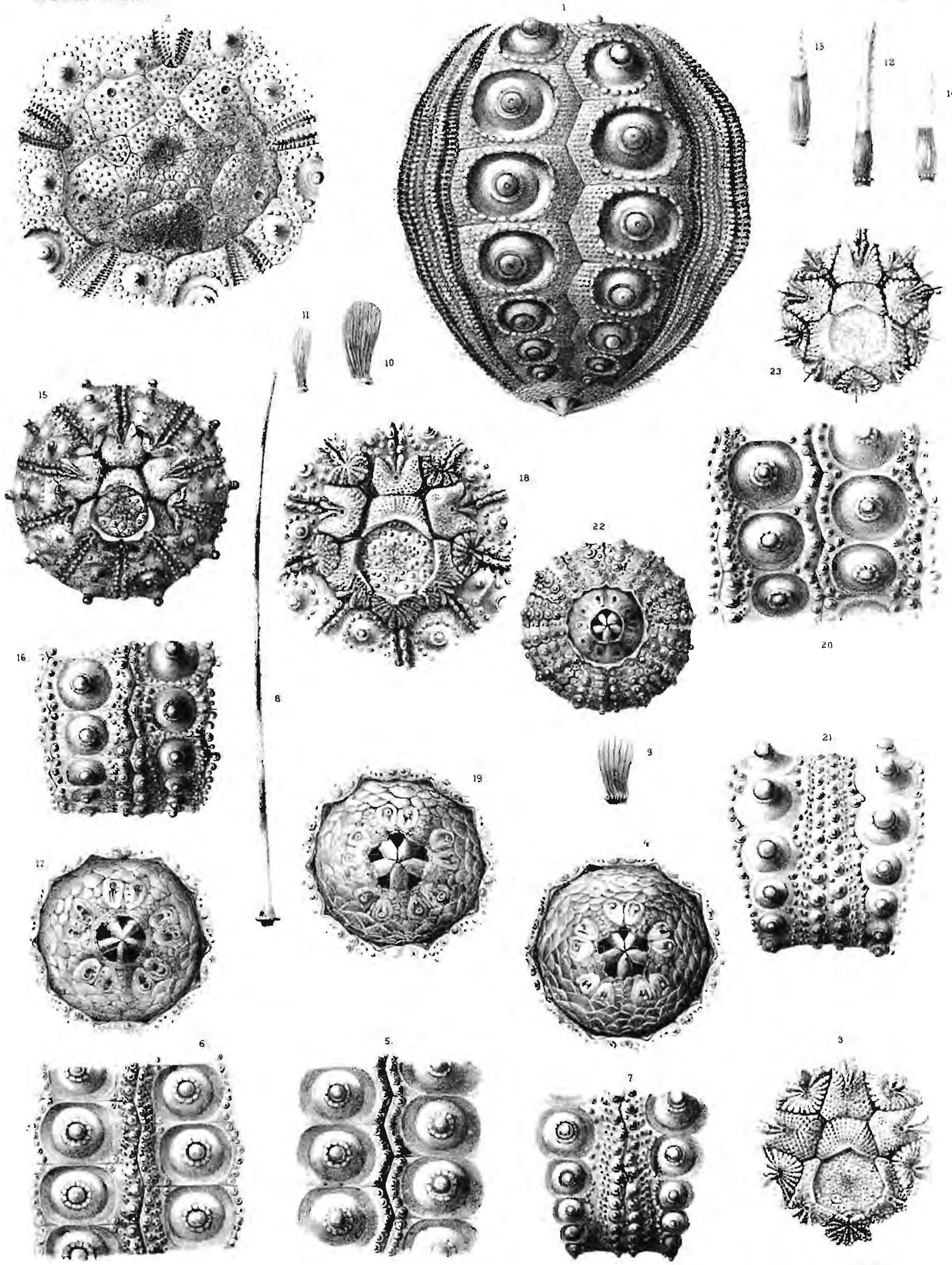
Fig. 19. Actinal system of same.

Fig. 20. Portion of test of same, above ambitus, seen in profile, facing the median interambulacral line.

Fig. 21. Portion of test of same, below and at ambitus, seen facing the median ambulacral line, to show the Hemicidaris-like arrangement of the ambulacral tubercles.

Fig. 22. Young Salenia 6.5 mm. in diameter, seen from the actinal side.

Fig. 23. Abactinal system of same.

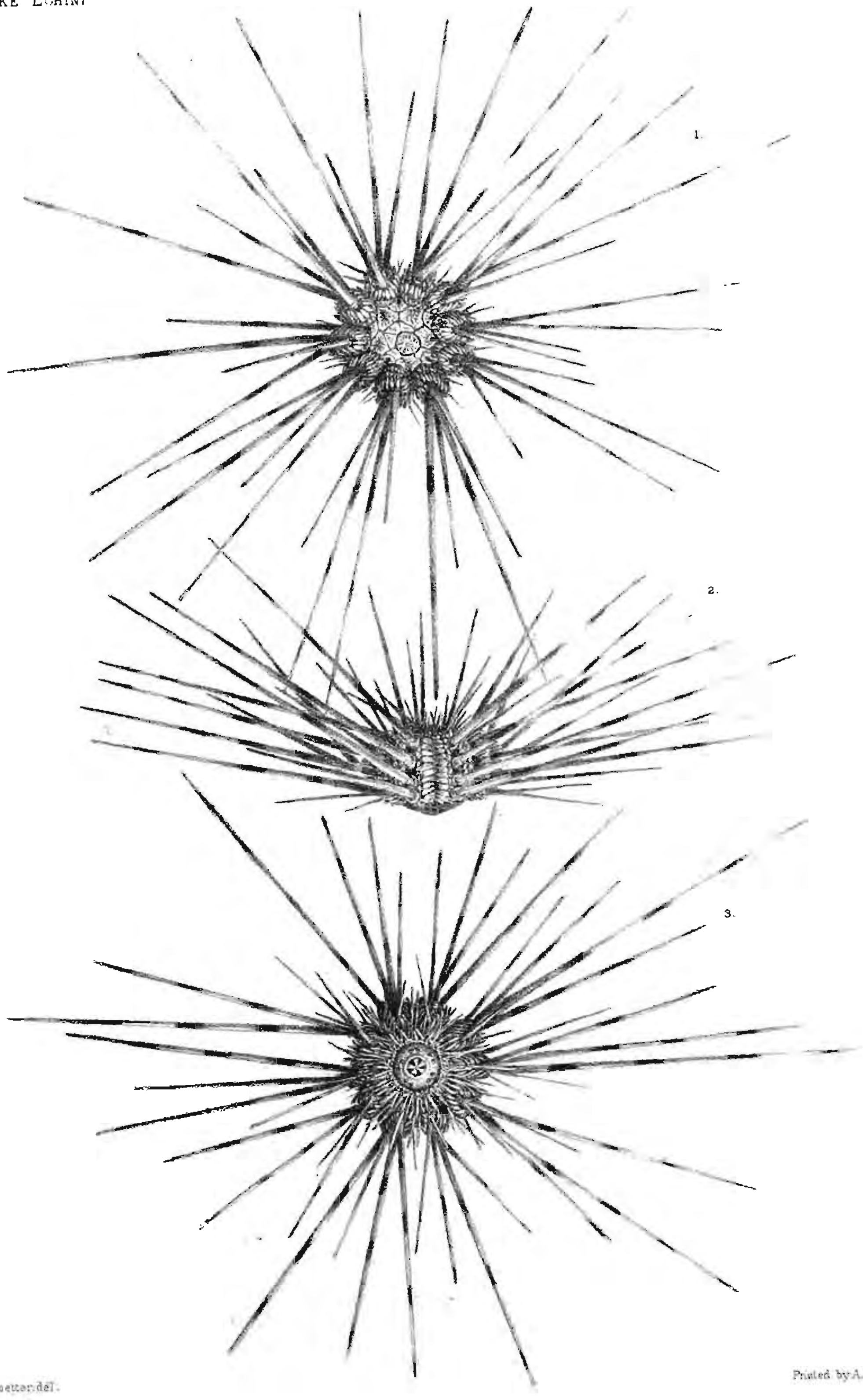


A Meisel, lith.

PLATE V.

Salenia Pattersoni A. Ag.

Fig. 1. Seen from above. Natural size.
Fig. 2. Seen in profile. Natural size.
Fig. 3. Seen from the actinal side. Natural size.



P. Roetter del. Printed by A. Meisel.

PLATE VI.

1–17. **Salenia varispina** A. Ag.

Fig. 1. Young Salenia measuring 1.5 mm. (diameter of test), showing the fimbriated primary spines, and the plates of the anal system.

Fig. 2. Young Salenia 3 mm. in diameter, seen from the actinal side.

Fig. 3. The same as Fig. 2, seen from the abactinal side.

Fig. 4. Inner view of the abactinal system of a Salenia 8 mm. in diameter.

Fig. 5. Part of actinal system, showing the imbricated plates in a young Salenia 7 mm. in diameter.

Fig. 6. Part of the abactinal system of a young Salenia 2 mm. in diameter, showing the indistinct lozenge-shaped arrangement of the primary striation of the test.

Fig. 7. Actinal termination of one of the ambulacral areas, showing the position of the sphæridia and of one of the pairs of buccal tentacles of a Salenia 8 mm. in diameter.

Fig. 7′. Interambulacral actinal area, showing also single sphæridia near the actinal extremity in each of the ambulacral areas.

Fig. 8. Magnified view of one of the pyriform sphæridia.

Fig. 9–11. Magnified views of interambulacral papillæ.

Fig. 12. Sessile papillæ of the anal system.

Fig. 13. Tube projecting beyond the genital opening.

Fig. 14. Young forked primary spines of Fig. 1.

Fig. 15. Stout-headed, short-stemmed trifid pedicellaria of the actinal surface.

Fig. 16. One of the gills of a Salenia 8 mm. in diameter.

Fig. 17. Sessile papillæ of one of the genital plates of the abactinal system, covered with large pigment spots, and still showing the primary striation.

18–23. **Salenia Pattersoni** A. Ag.

Fig. 18. Actinal part of ambulacral area of Salenia 14 mm. in diameter, showing the gills, the imbricating plates, and one of the pairs of the buccal tentacles of the actinostome.

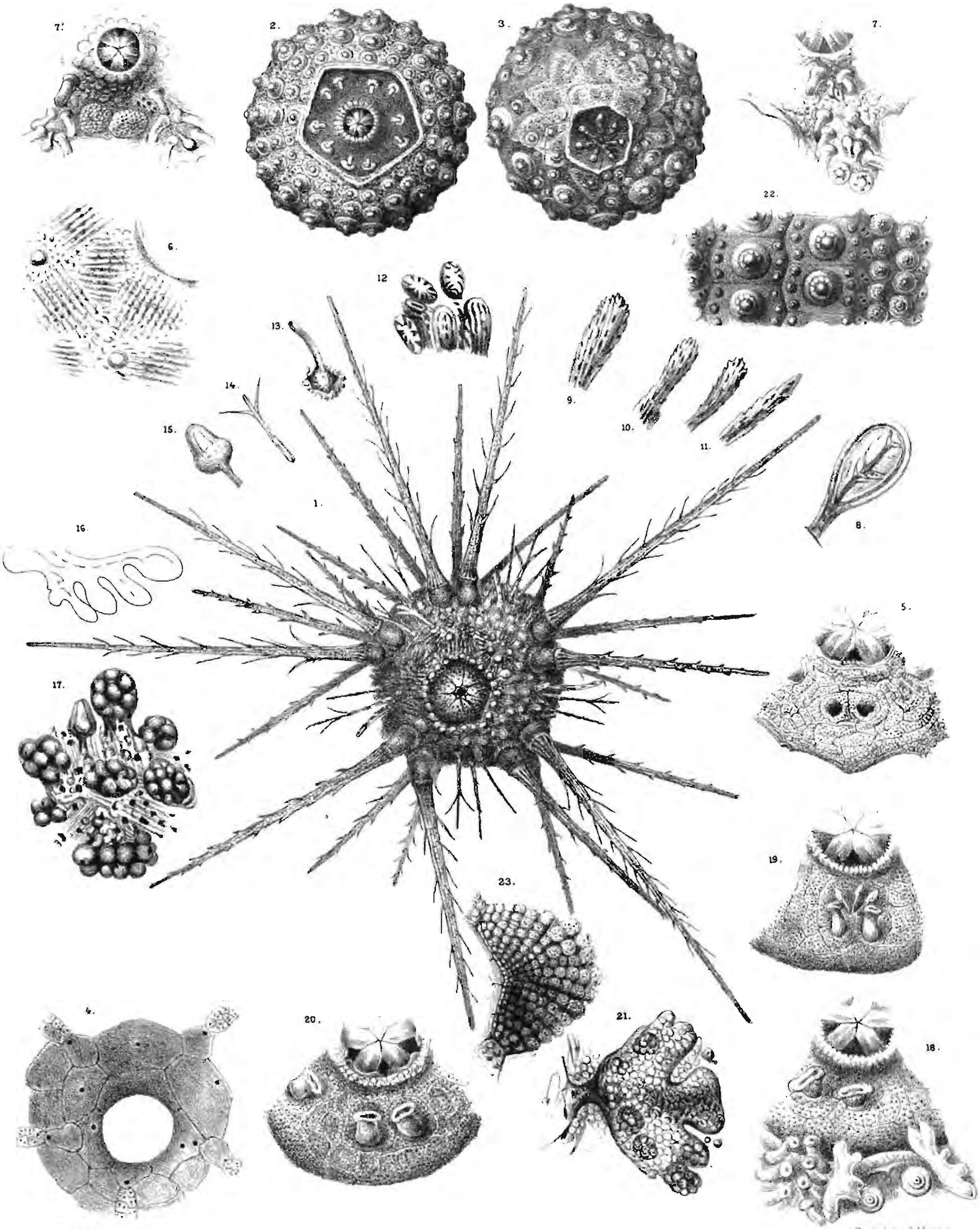
Fig. 19. Interambulacral part of actinostome of another Salenia 14 mm. in diameter, showing the imbricating plates of the actinostome and a pair of the large buccal tentacles, with comparatively slender long-stemmed pedicellariæ.

Fig. 20. Part of actinostome of another Salenia of nearly the same size: the granulation of the actinal plates is coarser.

Fig. 21. The left posterior genital plate, showing the coarse granulation characteristic of the abactinal system of this species, with minute globular sphæridia in the notches of the plates, these globular sphæridia are similar to the pair of small, short-stemmed sphæridia found at the base of the ambulacral tentacles near the actinostome.

Fig. 22. Part of coronal plates of test of Salenia 14 mm. in diameter.

Fig. 23. Granulation of anal plate.



A. Ag. & Roetter del.

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PLATE VII.

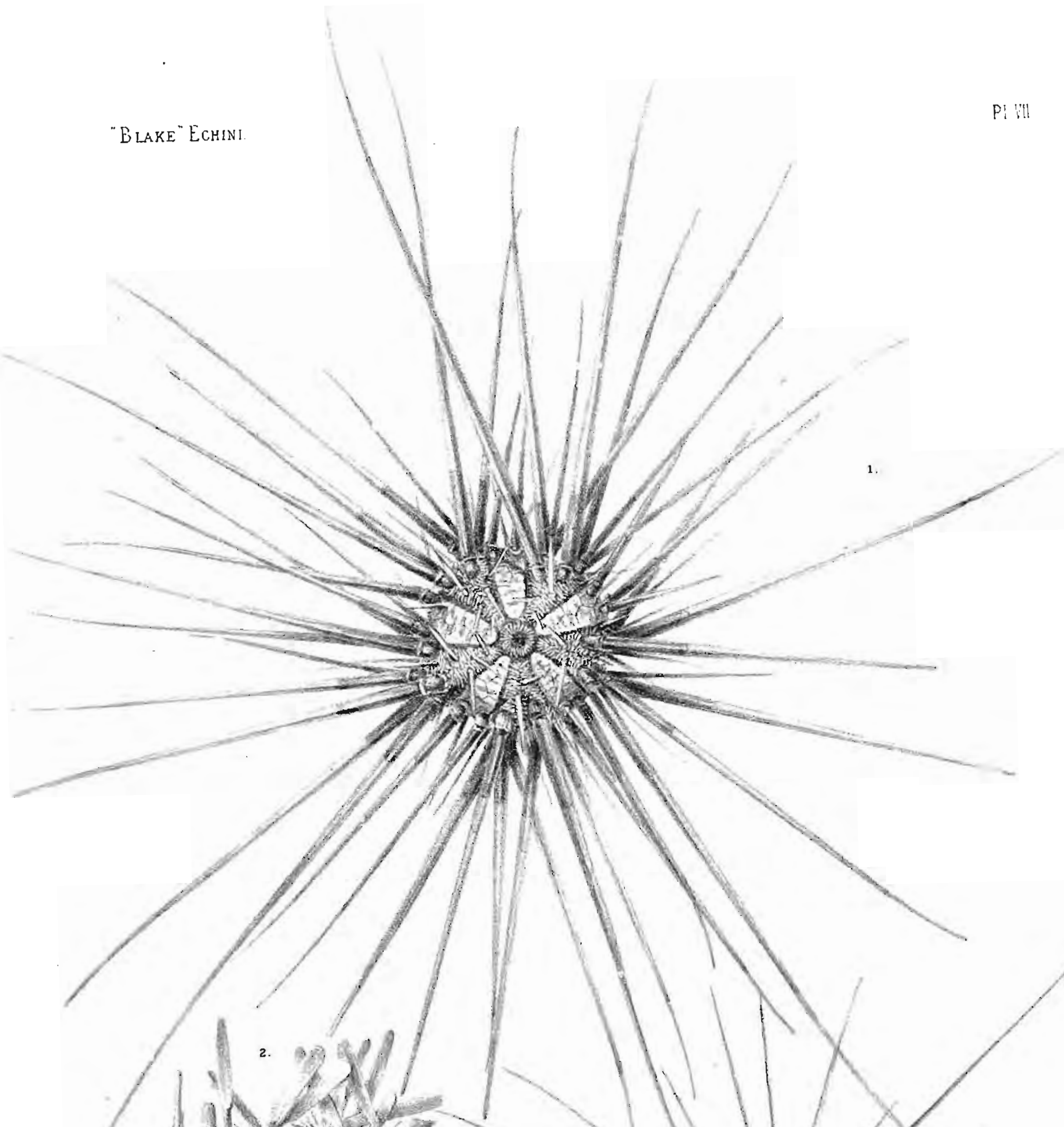
Cœlopleurus floridanus A. Ag.

Fig. 1. Seen from above. Natural size.

Fig. 2. Same, seen from the actinal side, to show the bat-shaped spines of the actinal region.

Fig. 3. A smaller specimen, seen from above. Natural size.

1.



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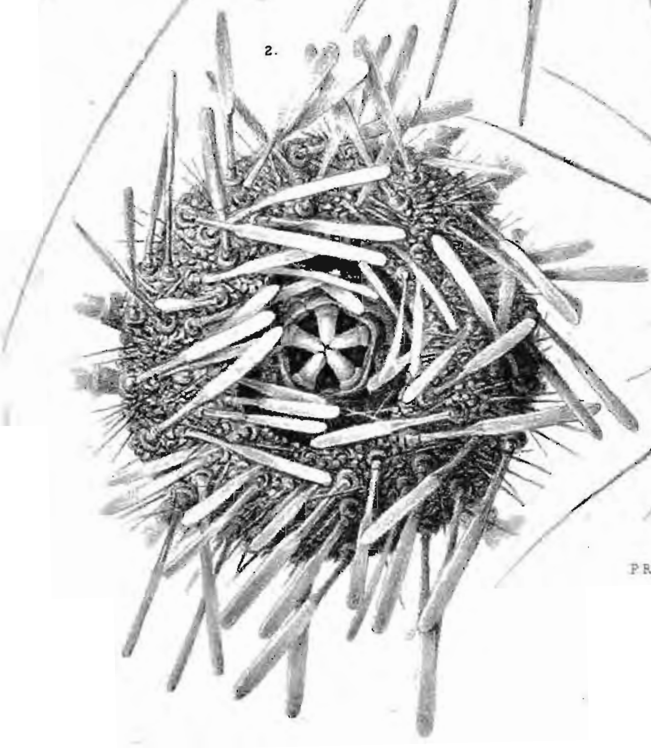
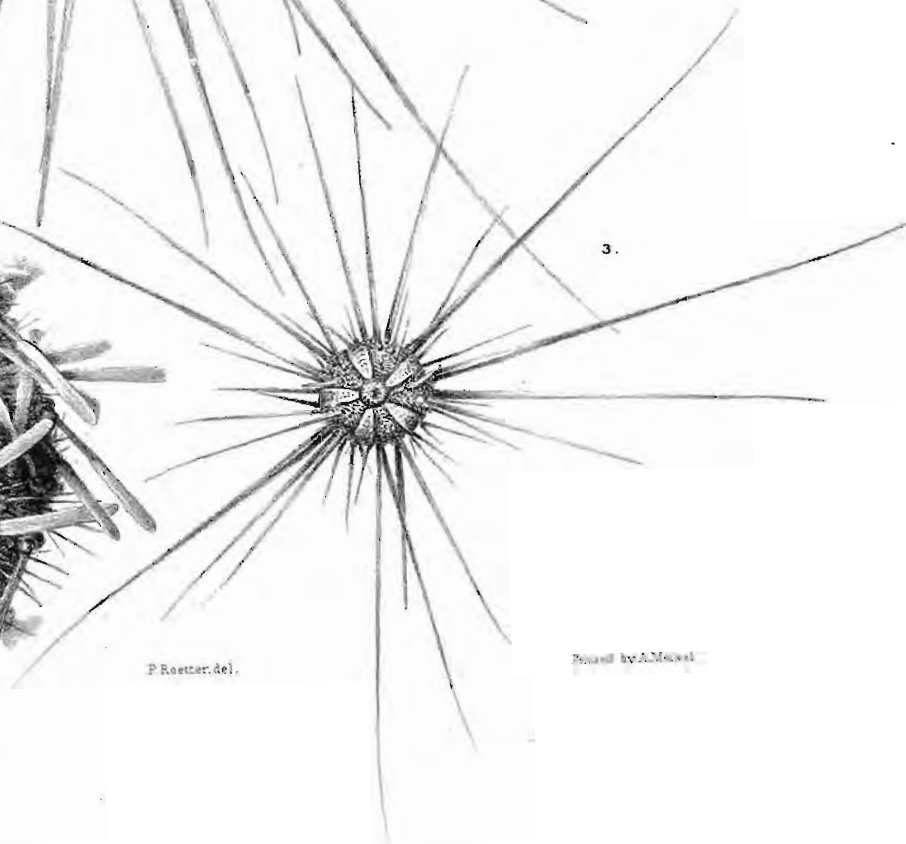


3.



P. Roetter. del.

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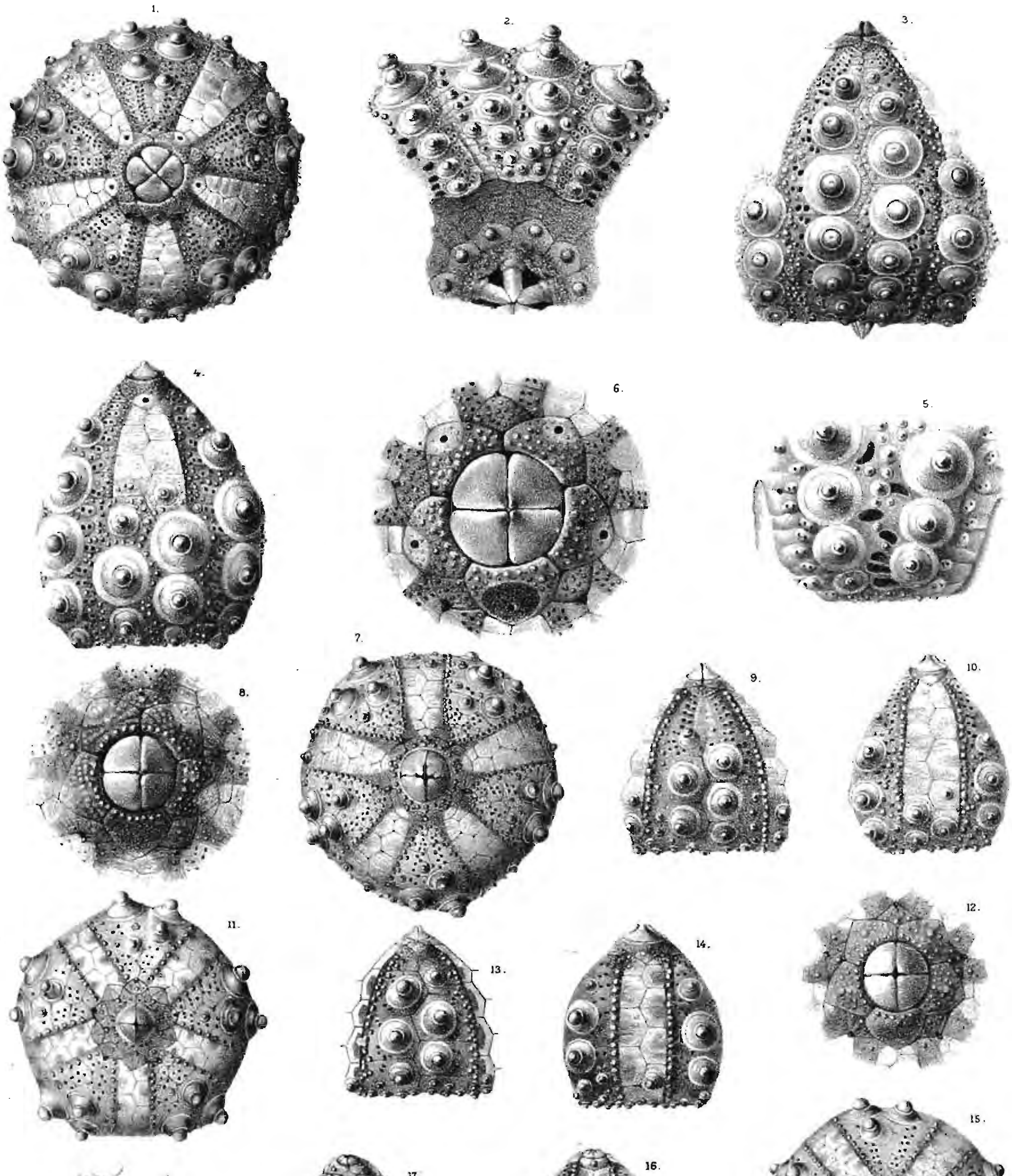
PLATE VIII.

Cœlopleurus floridanus A. Ag.

Fig. 1. Test of specimen measuring 28 mm., seen from the abactinal pole.
Fig. 2. Portion of test of the actinal surface of same, somewhat more magnified.
Fig. 3. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 4. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 5. Portion of test, still more enlarged, to show the pits at the base of the median ambulacral line.
Fig. 6. Abactinal system of same specimen.
Fig. 7. Specimen 11 mm. in diameter, seen from the abactinal pole.
Fig. 8. Apical system of same.
Fig. 9. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 10. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 11. Specimen 9 mm. in diameter, seen from the abactinal pole.
Fig. 12. Apical system of same.
Fig. 13. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 14. Portion of tect of same, seen in profile, facing the median interambulacral line.
Fig. 15. Small specimen 6 mm. in diameter, seen from the abactinal pole.
Fig. 16. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 17. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 18. Apical system of same.



A. Meisel, lith.

PLATE IX.

Aspidodiadema antillarum A. AG.

Fig. 1. Specimen with spines, test 11 mm. in diameter, seen in profile.

Fig. 2. Same with the spines cut off, seen facing an ambulacral area, showing the sheathed pedicellariæ.

Fig. 3. Portion of test of a specimen 11 mm. in diameter, seen from the actinal side ; denuded.

Fig. 4. Portion of test of same as Fig. 3, seen from the abactinal pole ; denuded.

Fig. 5. Actinostome, with termination of the adjoining ambulacral areas, showing the suckers, the gills, and the large buccal tentacles of Fig. 2.

Fig. 6. Portion of denuded test of specimen 11 mm. in diameter, seen facing one of the ambulacral areas.

Fig. 7. The same as Fig. 6, seen facing one of the interambulacral areas.

Fig. 8. Denuded test of specimen 9 mm. in diameter, seen from the actinal side.

Fig. 9. Genital ring of same, somewhat more magnified.

Fig. 10. One of the sheathed ambulacral pedicellariæ, greatly magnified.

Fig 11. Long-stemmed, long-headed trifid flexible pedicellaria, placed above ambitus.

Fig. 12. Magnified view of a piece of the basal part of a primary radiole.

Fig. 13. Large hyaline, globular, short-stemmed ambulacral sphæridia, found near the abactinal system ; magnified.

Fig. 14. Smaller, long-stemmed actinal ambulacral sphæridia ; magnified.

Fig. 15. Young sheathed pedicellaria.

Fig. 16. Small, short-headed, short-stemmed trifid ambulacral pedicellaria.

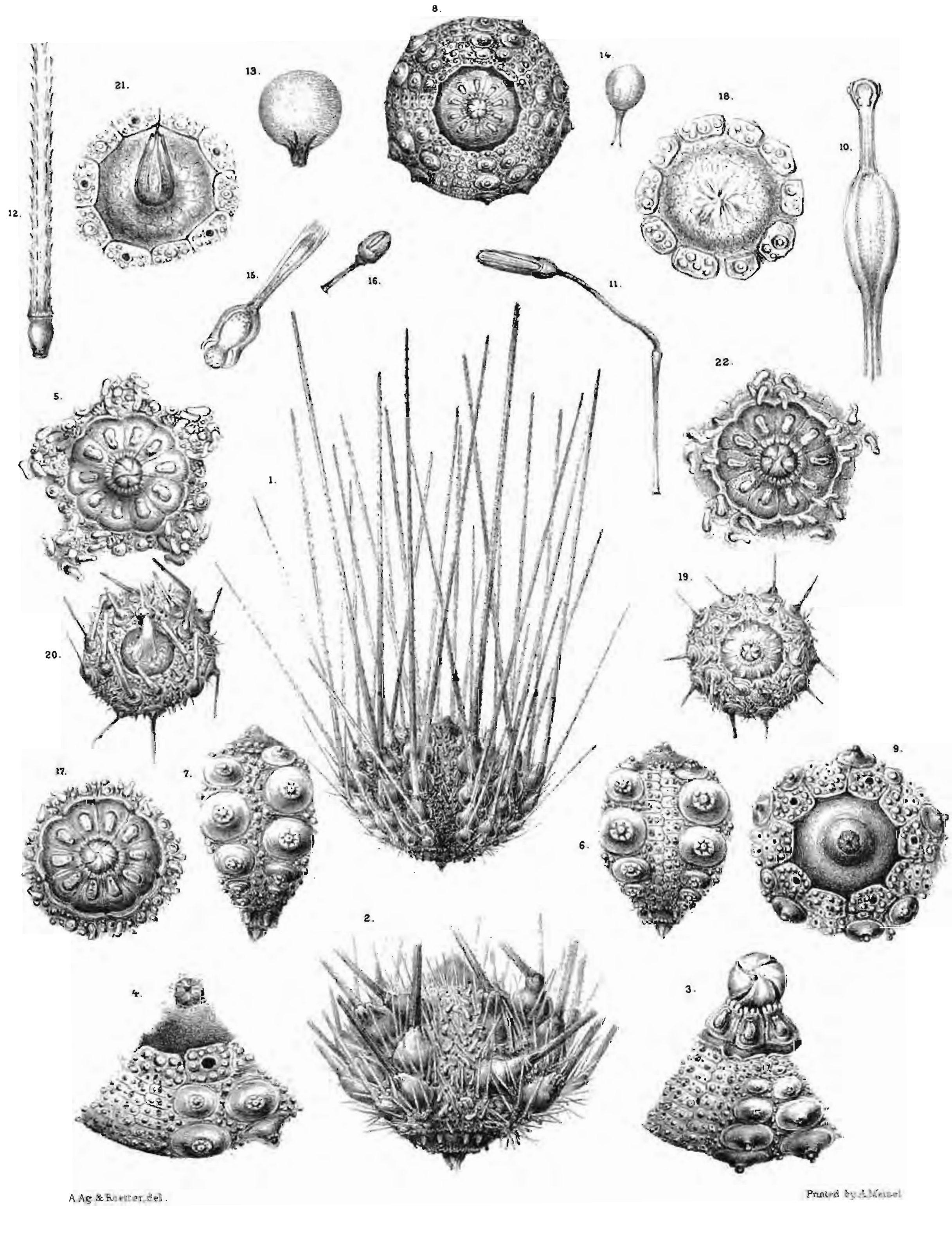
Fig. 17. Actinostome of young Aspidodiadema measuring 5 mm. in diameter.

Fig. 18. Genital ring and anal system of same specimen : neither the ocular nor the genital pores are as yet formed in this specimen.

Fig. 19. Young Aspidodiadema 6 mm. in diameter, seen from the actinal side : the primary spines are cut off.

Fig. 20. The same as Fig. 19, seen from the abactinal pole, showing the anal proboscis.

Fig. 21. Genital ring of small Aspidodiadema 3.5 mm. in diameter : the genital pores are already formed.



A.Ag. & Roetter, del.

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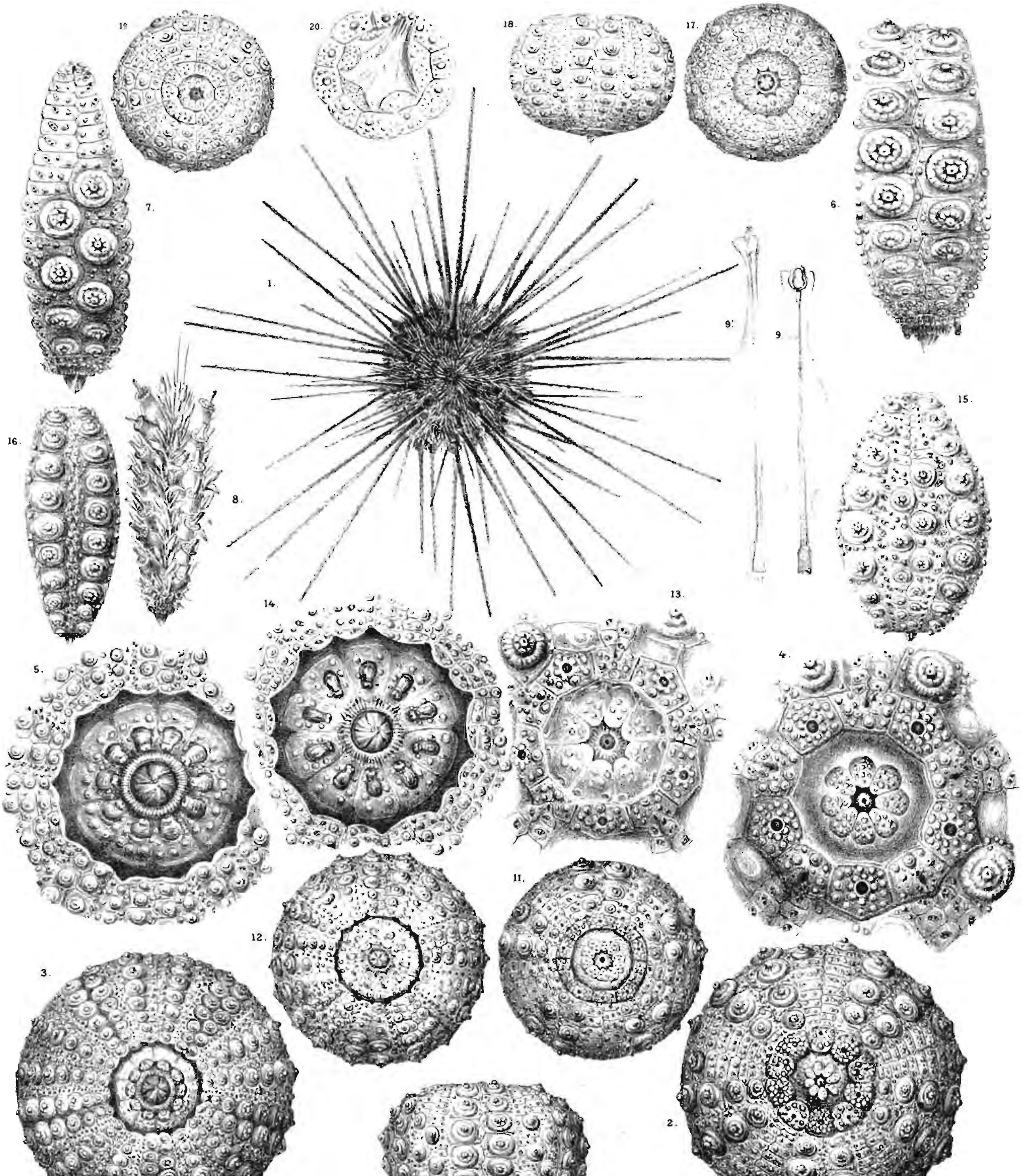
PLATE IX^a.

Aspidodiadema Jacobyi A. AG.

Fig. 1. Specimen covered with spines seen from the abactinal pole, natural size.
Fig. 2. Denuded specimen, 23 mm. in diameter, seen from the abactinal side.
Fig. 3. The same as Fig. 2, seen from the actinal side.
Fig. 4. Abactinal system of same, somewhat more magnified.
Fig. 5. Actinal system of same.
Fig. 6. Magnified portion of test of same, seen facing one of the interambulacral areas.
Fig. 7. Same as Fig. 6, seen facing one of the ambulacral areas.
Fig. 8. Portion of test, seen facing one of the ambulacral areas, showing the suckers and the sheathed pedicellariæ.
Fig. 9. One of the sheathed pedicellariæ, greatly magnified.
Fig. 9′. The same, seen in profile.
Fig. 10. Aspidodiadema denuded, seen in profile, 12 mm. in diameter.
Fig. 11. The same as Fig. 10, seen from the abactinal pole.
Fig. 12. The same as Fig. 10, seen from the actinal side.
Fig. 13. Genital ring of same, somewhat more magnified.
Fig. 14. Actinostome of same.
Fig. 15. Portion of test of same, seen in profile, somewhat more magnified than in Fig. 10, seen facing one of the ambulacral areas.
Fig. 16. The same as Fig. 15, seen facing one of the interambulacral areas.
Fig. 17. Young specimen 6 mm. in diameter, seen from the abactinal side.
Fig. 18. The same as Fig. 17, seen in profile.
Fig. 19. The same, seen from the actinal side.
Fig. 20. Genital ring of a young specimen 3 mm. in diameter, before the formation of the genital or ocular pores, showing the anal proboscis.

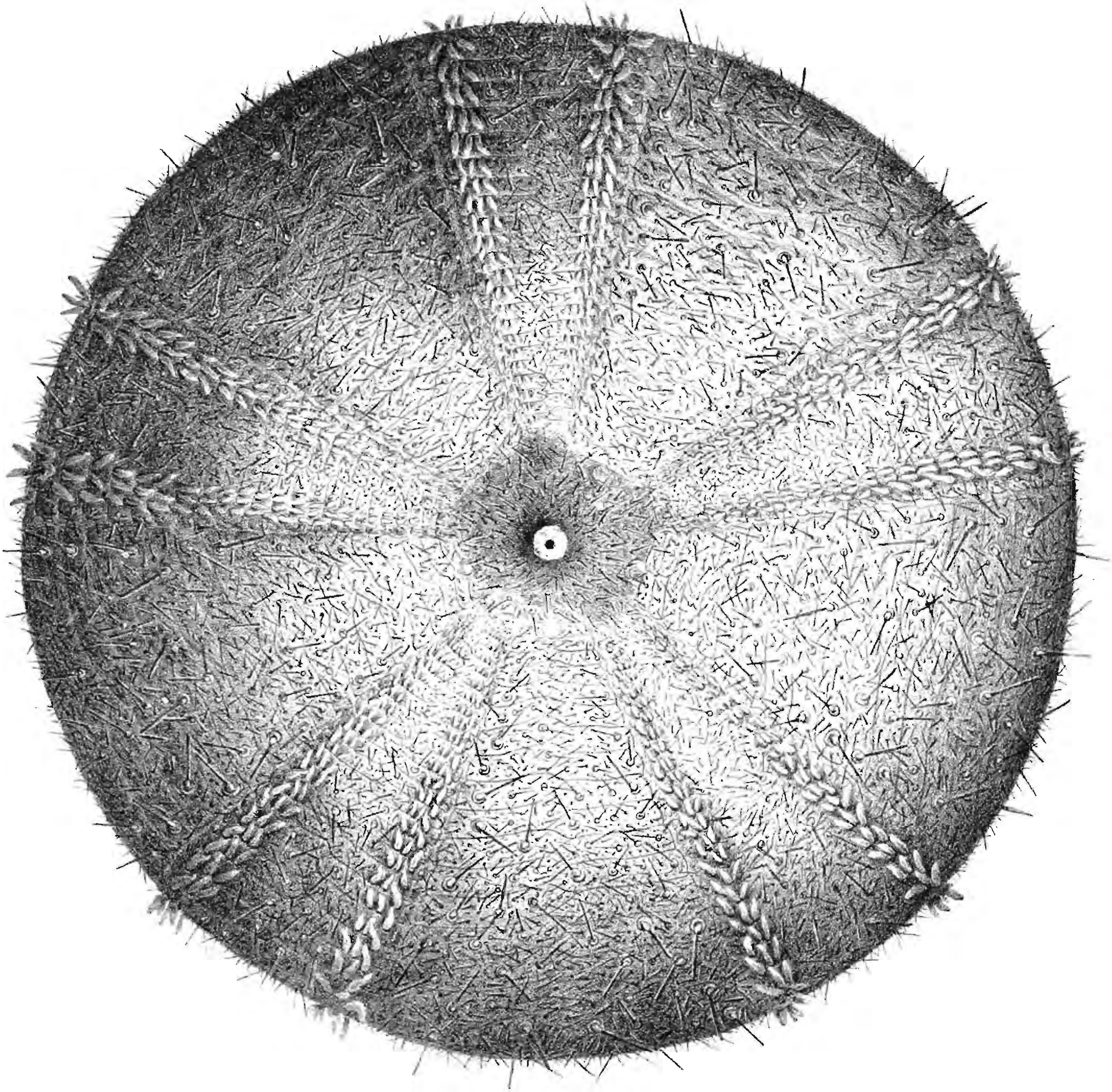


A. Ag. & Roetter del. Printed by A. Meisel

PLATE X.

Phormosoma uranus WYV. THOMS.

Seen from the abactinal pole, fully expanded, natural size.



[illegible] del.
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PLATE XI.

Phormosoma uranus WYV. THOMS.

Fig. 1. Seen in profile, fully expanded, as it comes up in the trawl.

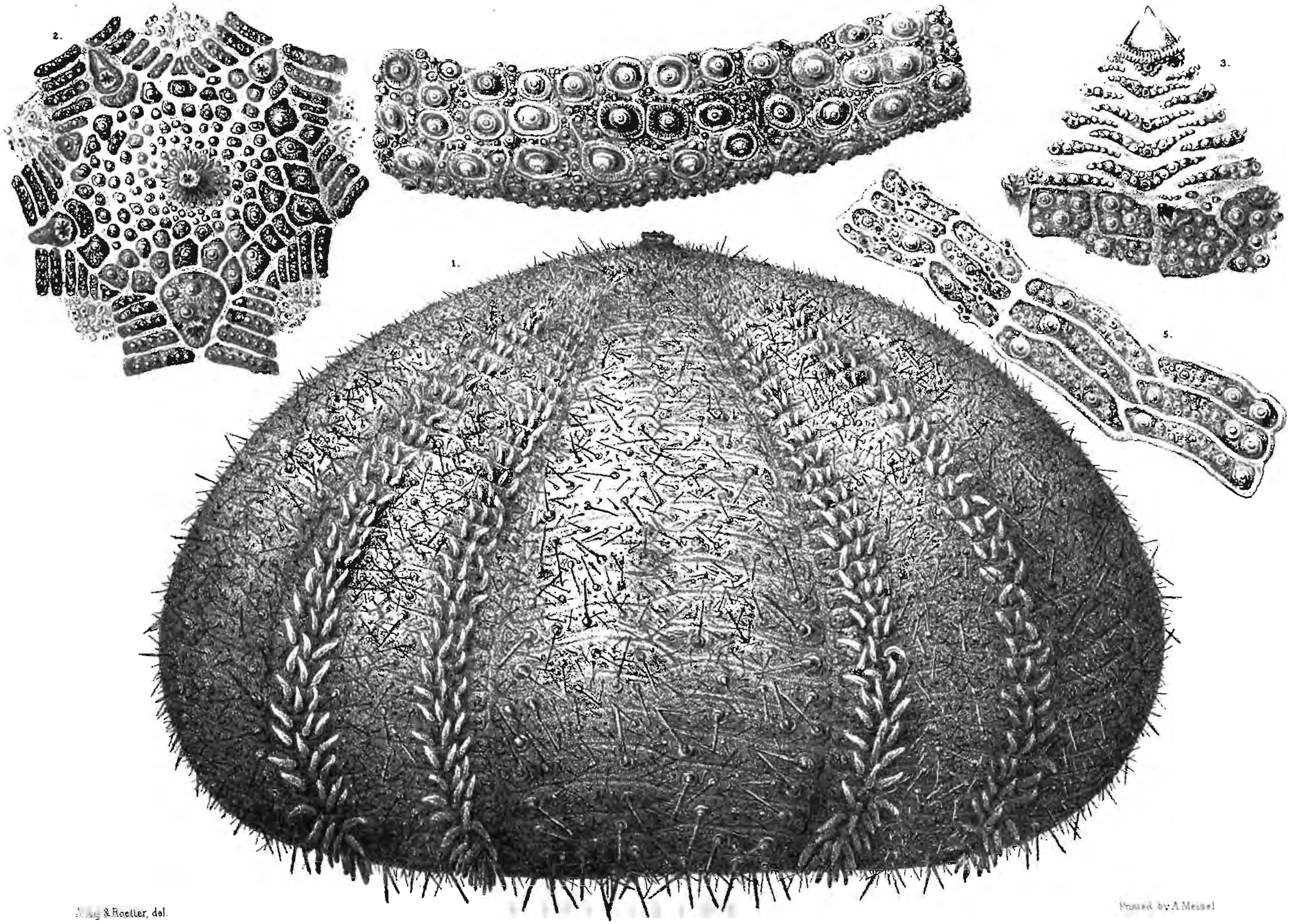
Fig. 2. Denuded abactinal system of specimen about 170 mm. in diameter.

Fig. 3. Actinal system of same.

Fig. 4. Portion of test of actinal surface denuded, close to the ambitus.

Fig. 5. Portion of test of median abactinal surface.

Figs. 2 and 3 are enlarged twice, all other figures natural size.



& Roetter, del.

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PLATE XII.

Phormosoma placenta WYV. THOMS.

Fig. 1. Seen in profile, natural size.

Fig. 2. Same seen from the abactinal side.

Fig. 3. Same seen from the actinal side.

Fig. 4. Portion of actinal system denuded, magnified.

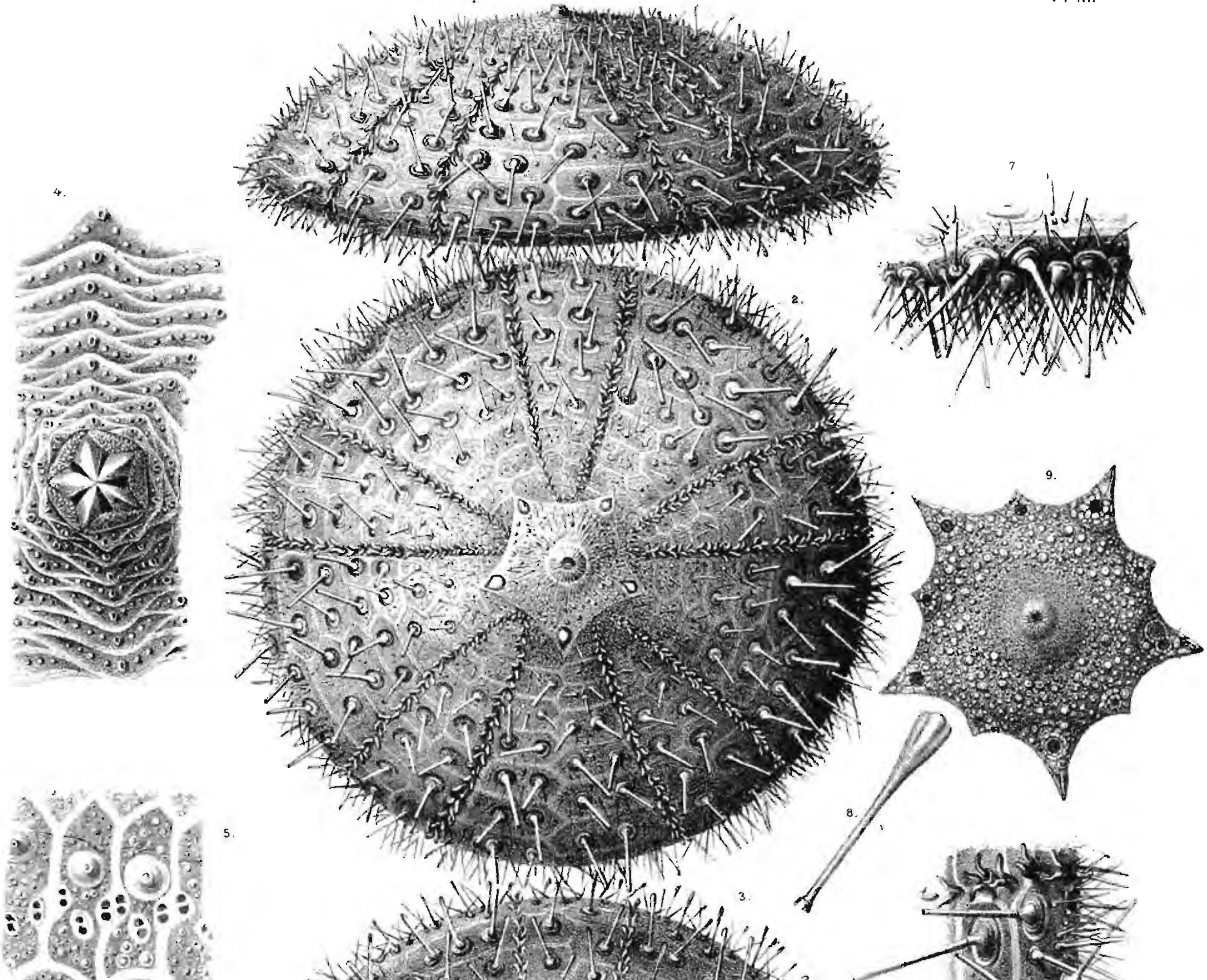
Fig. 5. Coronal plates of the abactinal side, near the ambitus, magnified.

Fig. 6. Edge of test, showing the ambital fasciole from the abactinal side, magnified.

Fig. 7. Portion of test, facing the ambital fasciole, magnified.

Fig. 8. One of the club-shaped spines of the actinal surface, magnified.

Fig. 9. Denuded abactinal system, somewhat magnified.

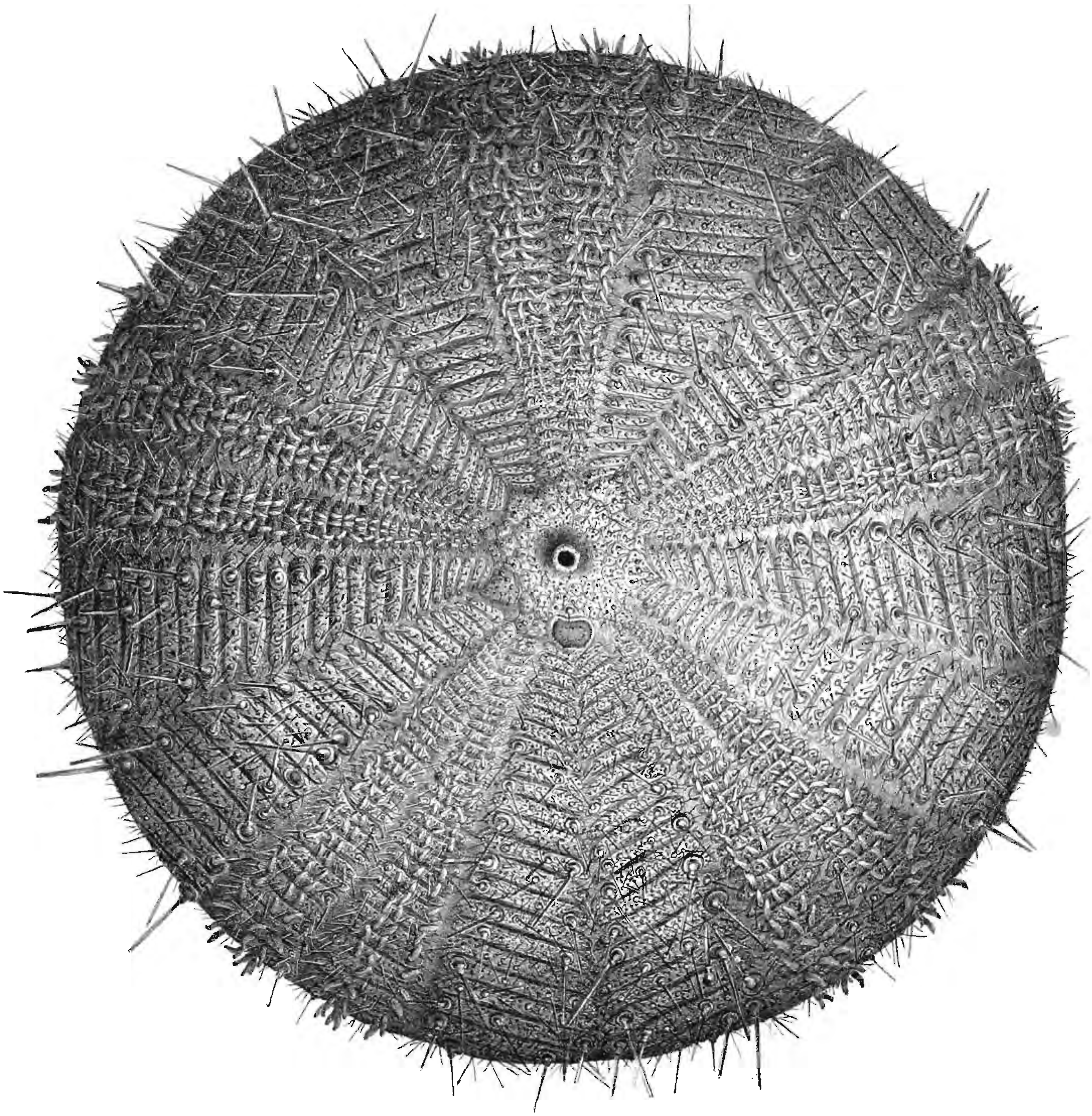


A Meisel lith.

PLATE XIII.

Asthenosoma hystrix Wyv. Thoms.

Seen from the abactinal pole, fully expanded, natural size.



P. Roetter del.

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PLATE XIV.

Asthenosoma hystrix WYV. THOMS.

Fig. 1. Seen in profile, fully expanded as it comes up in the trawl.

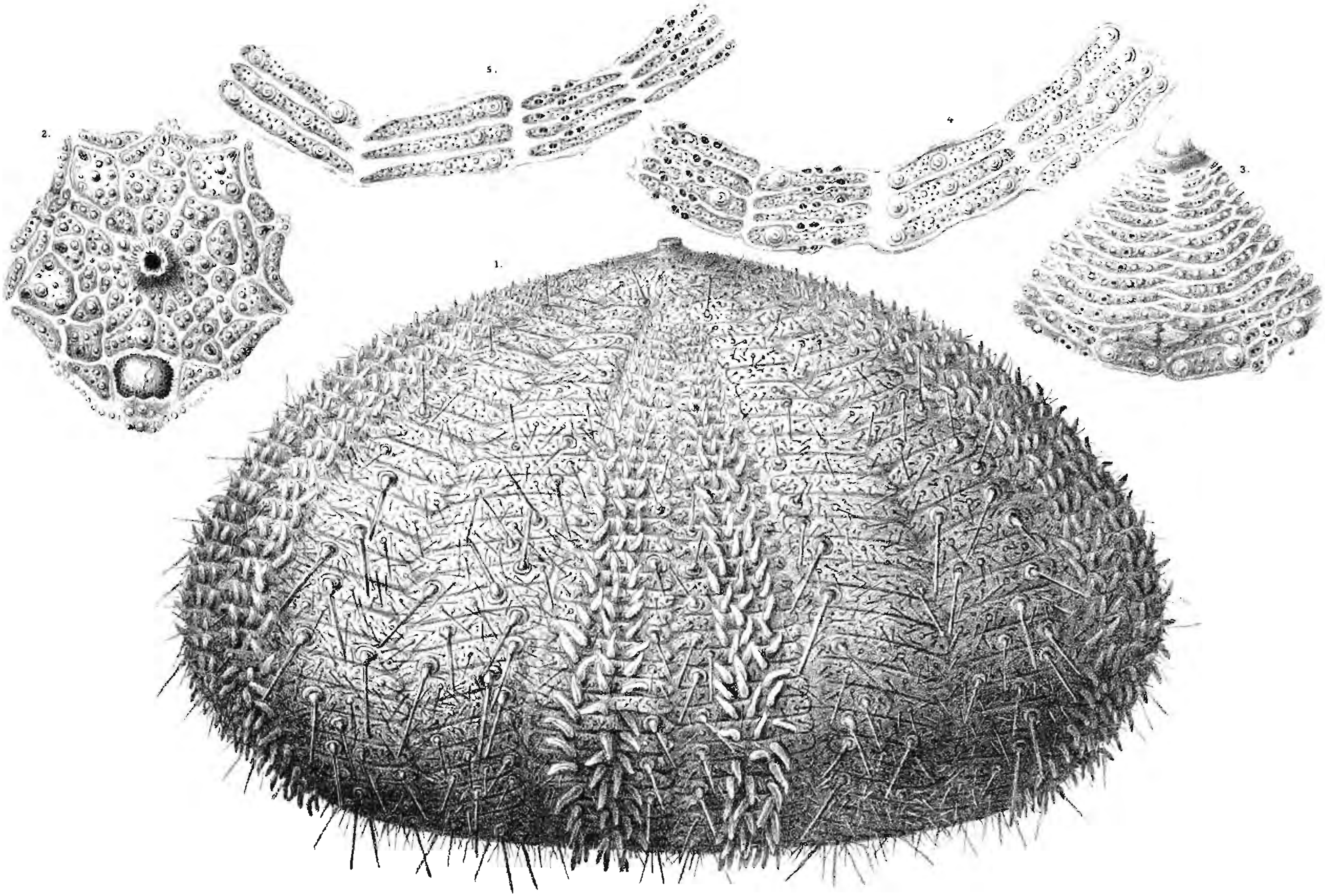
Fig. 2. Abactinal system of specimen about 160 mm. in diameter, denuded.

Fig. 3. Actinal system of same, denuded, showing the arrangement of the actinal plates and the position of the small digitate gills.

Fig. 4. Portion of test of same, denuded, on the median actinal side.

Fig. 5. Portion of test of same, denuded, on the median abactinal side.

Figs. 2, 3, ($\frac{2}{1}$); all others, natural size.



A. Ag. & Roetter del.

PLATE XV.

1, 2. **Astropyga sp.**

Fig. 1. Abactinal system of young Astropyga 13 mm. in diameter.

Fig. 2. Actinostome of same.

3–19. **Phormosoma placenta** WYV. THOMS.

Fig. 3. Young Phormosoma 8 mm. in diameter, showing the abactinal system, and a part of the test.

Fig. 4. Somewhat younger specimen 8 mm. in diameter, seen from the actinal side, showing the sphæridia, suckers, and pedicellariæ of that side of the test.

Fig. 5. Somewhat older Phormosoma 17 mm. in diameter, seen from the abactinal side of the test.

Fig. 6. The same, seen from the actinal side.

Fig. 7. Older specimen 20 mm. in diameter, seen from the actinal side.

Fig. 8. The same, seen from the abactinal side.

Fig. 9. Older specimen 28 mm. in diameter, seen from the abactinal side.

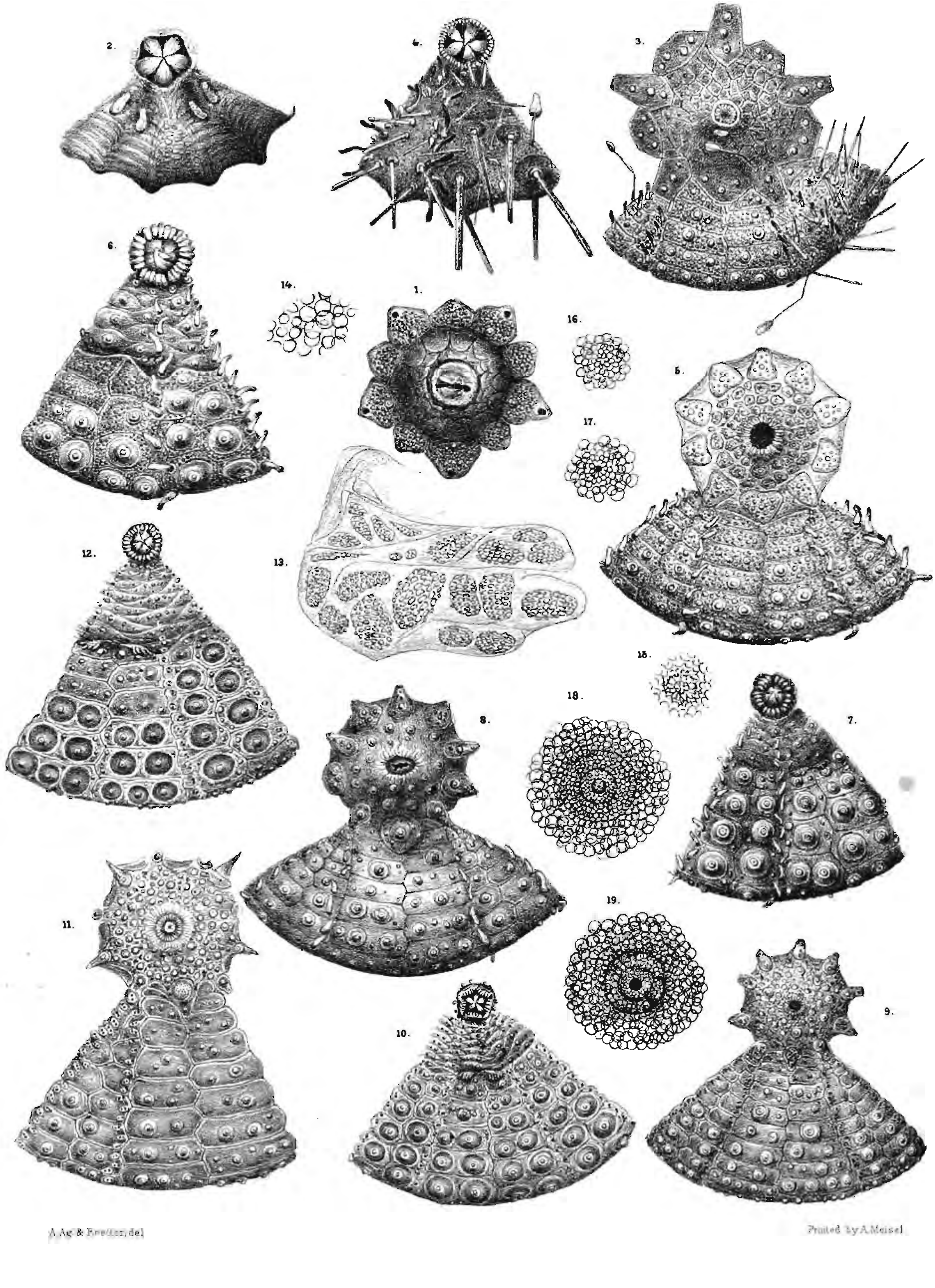
Fig. 10. The same, seen from the actinal side.

Fig. 11. Phormosoma 41 mm. in diameter, seen from the abactinal side.

Fig. 12. The same, seen from the actinal side.

Fig. 13. Portion of anal system of young Phormosoma, 22 mm. in diameter, showing the mode of deposition of the limestone meshes forming the anal plates.

Figs. 14–19 show the gradual passage of mere accumulations of limestone cells, as in Fig. 14, which indicate the first position of the future tubercles, to Figs. 16, 15, 17, 18, and 19, in which the scrobicular ring, the mammary boss, and the perforation of the future tubercles are little by little indicated.



A. Ag. & Roetter del.

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PLATE XV[a].

Clypeaster subdepressus AGASS.

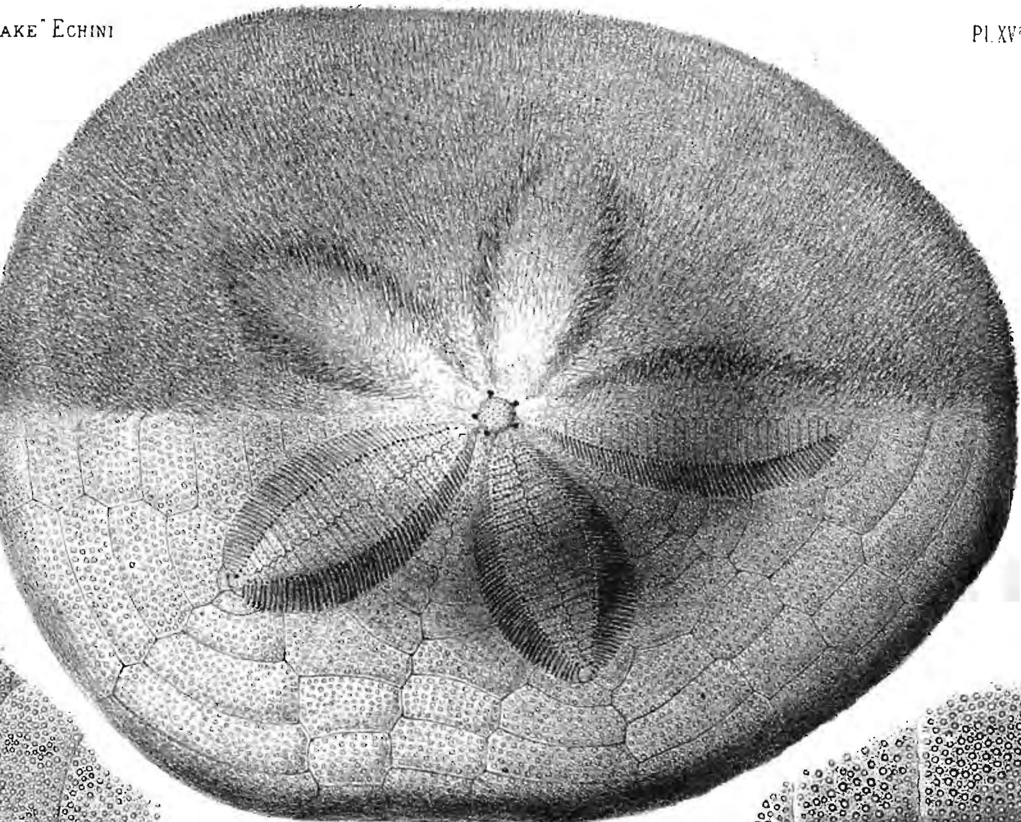
Fig. 1. Seen from above, natural size ; half the test denuded.

Fig. 2. The same, seen from the actinal side.

Fig. 3. Part of one of the median ambulacral zones of the actinal side, somewhat magnified.

Fig. 4. Part of one of the median interambulacral zones of the abactinal side, magnified.

1.



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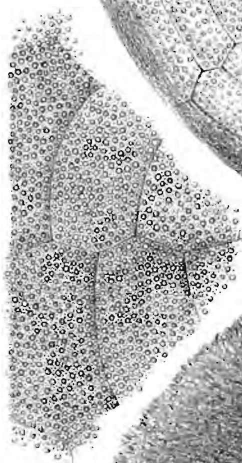
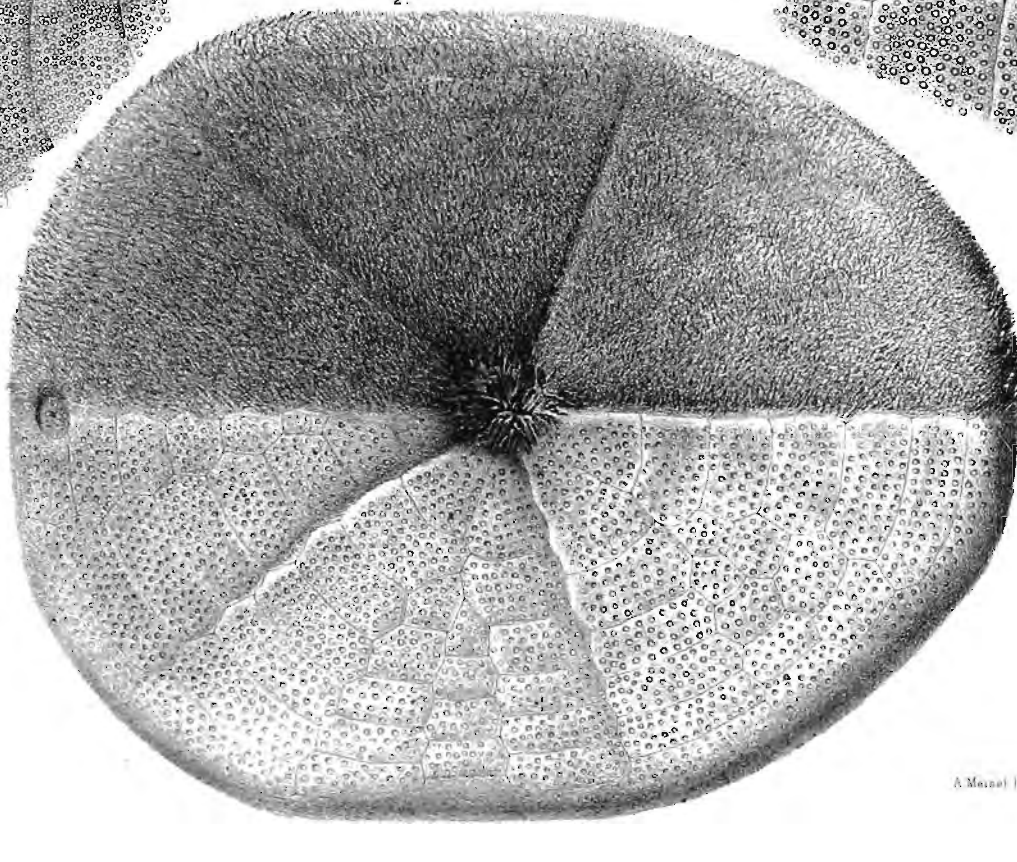


2.



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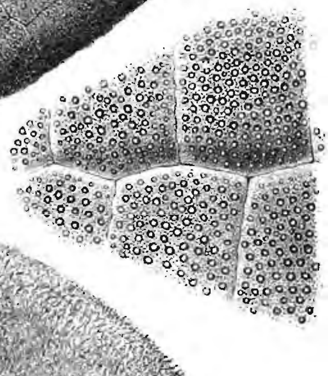


A. Meisel lith.

PLATE XV^b.

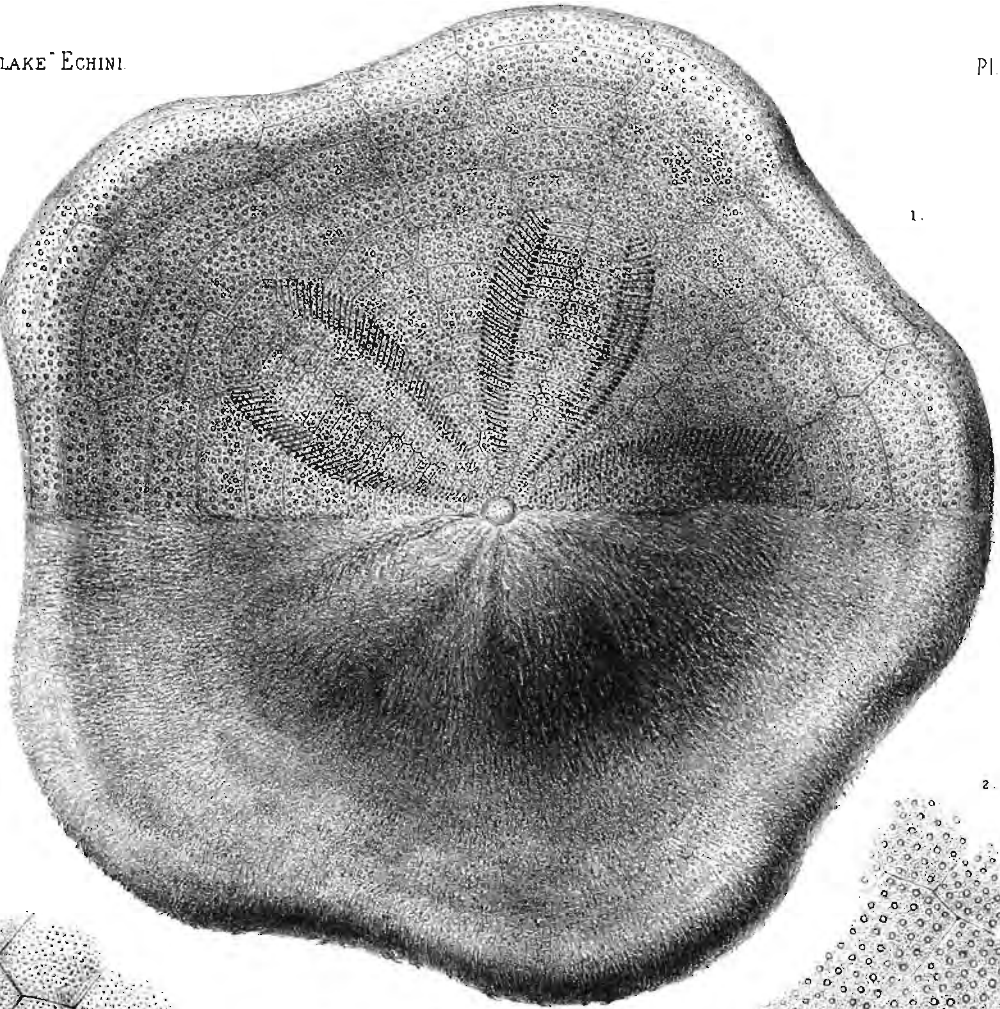
1, 2. **Clypeaster Ravenellii** A. Ag.

Fig. 1. Seen from the abactinal side, natural size, partly denuded.
Fig. 2. Part of one of the ambulacral zones of the actinal side, magnified.

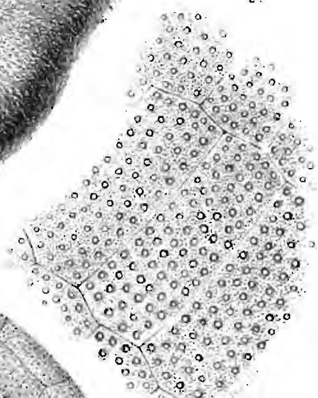
3, 4. **Clypeaster latissimus** A. Ag.

Fig. 3. Seen from the abactinal side, natural size; half the test denuded.
Fig. 4. Part of one of the interambulacral zones of the abactinal side, magnified.

1.



2.



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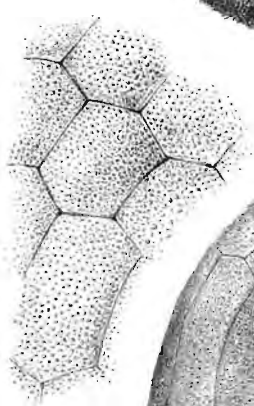
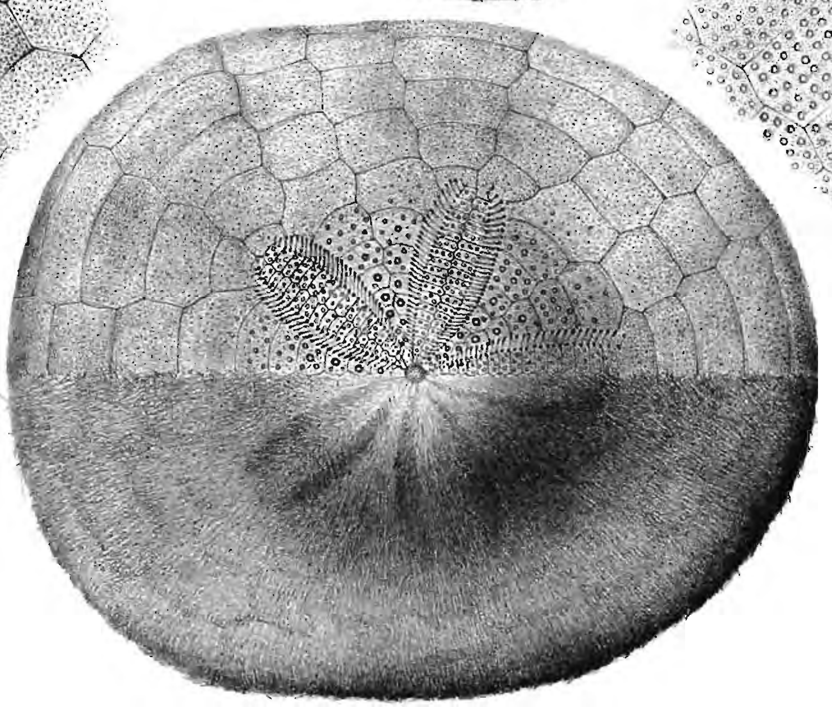


3.



A. Meisel lith.

PLATE XV^c.

1, 2. **Clypeaster Ravenellii** A. Ag.

Fig. 1. Seen from the actinal side, natural size, one half of the test denuded.

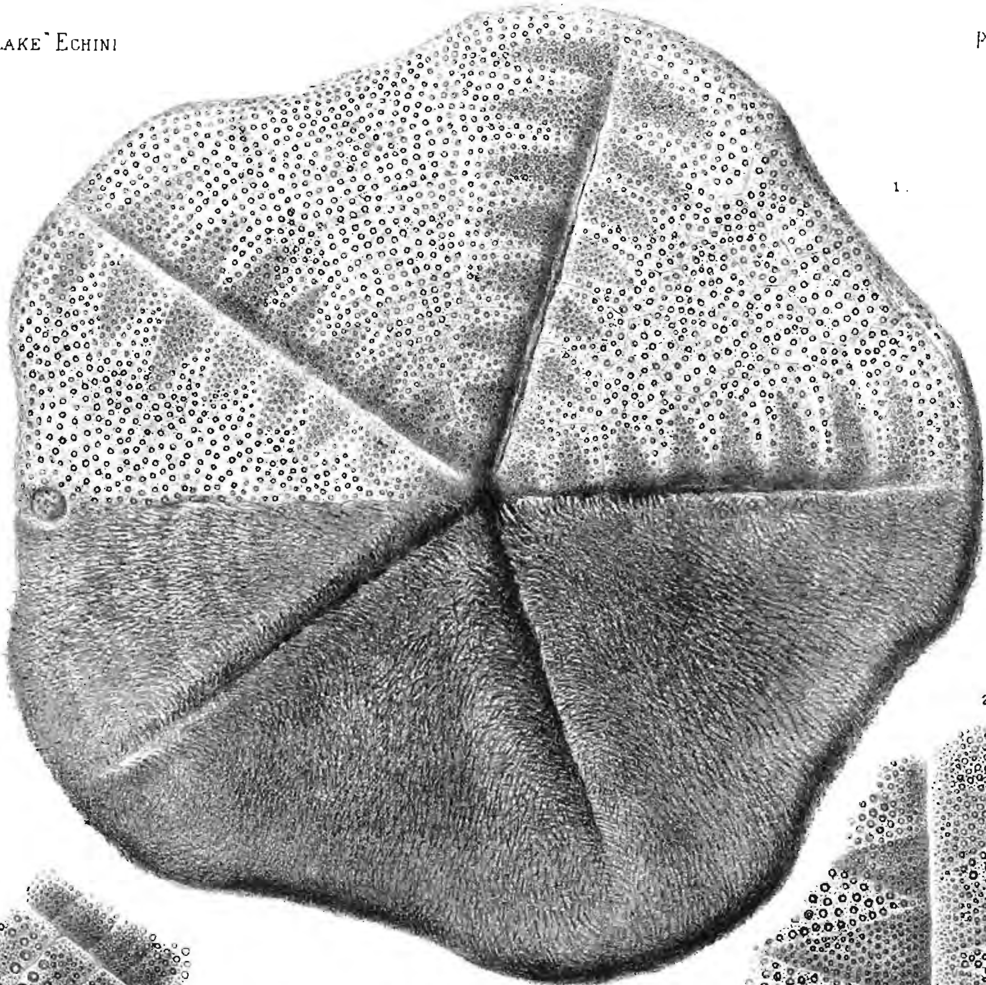
Fig. 2. Part of one of the median ambulacral zones of the actinal side, magnified.

3, 4. **Clypeaster latissimus** A. Ag.

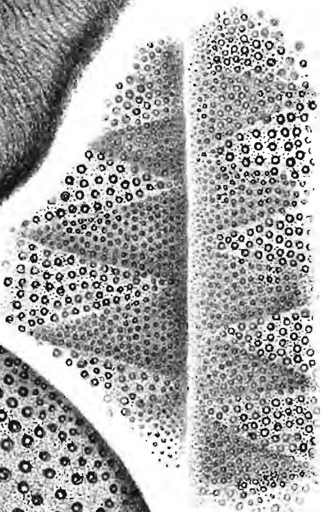
Fig. 3. Seen from the actinal side, natural size.

Fig. 4. Part of one of the ambulacral zones of the actinal side, magnified.

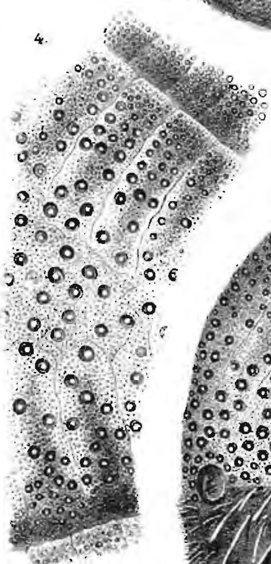
1.

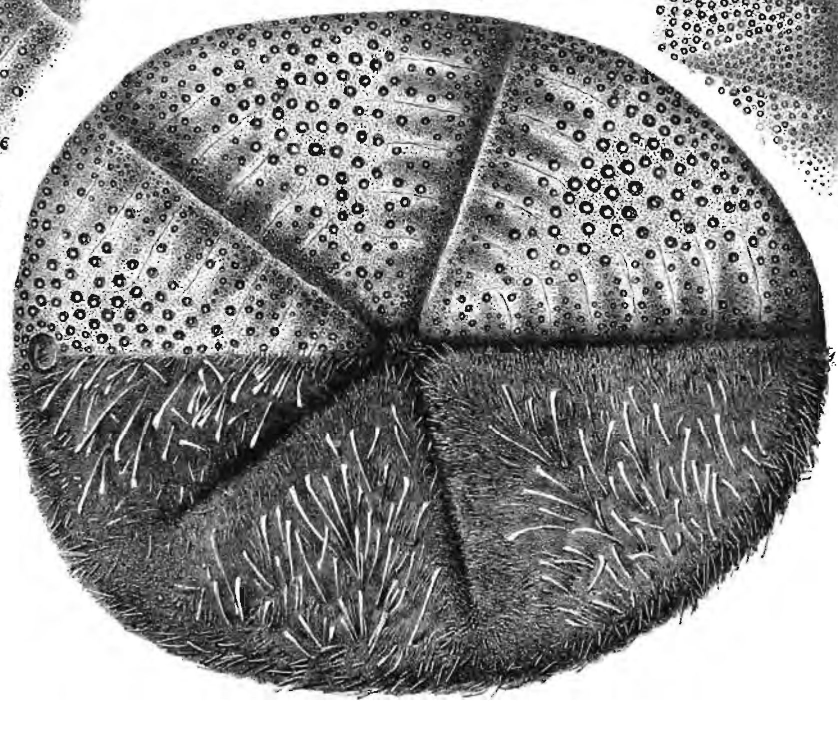


2.



4.





3.

A. Meisel, lith.

PLATE XVI.

Echinolampas depressa GRAY.

Fig. 1. Seen from above, denuded, natural size.
Fig. 2. The same, seen from the actinal side.
Fig. 3. The same, seen in profile.
Fig. 4. Actinostome, enlarged.
Fig. 5. Abactinal system, enlarged.
Fig. 6. Right anterior ambulacrum, enlarged.
Fig. 7. Interambulacral plates from the actinal side of the test.
Fig. 8. Left interambulacral plates from the area above the ambitus.
Fig. 9. Anal system.

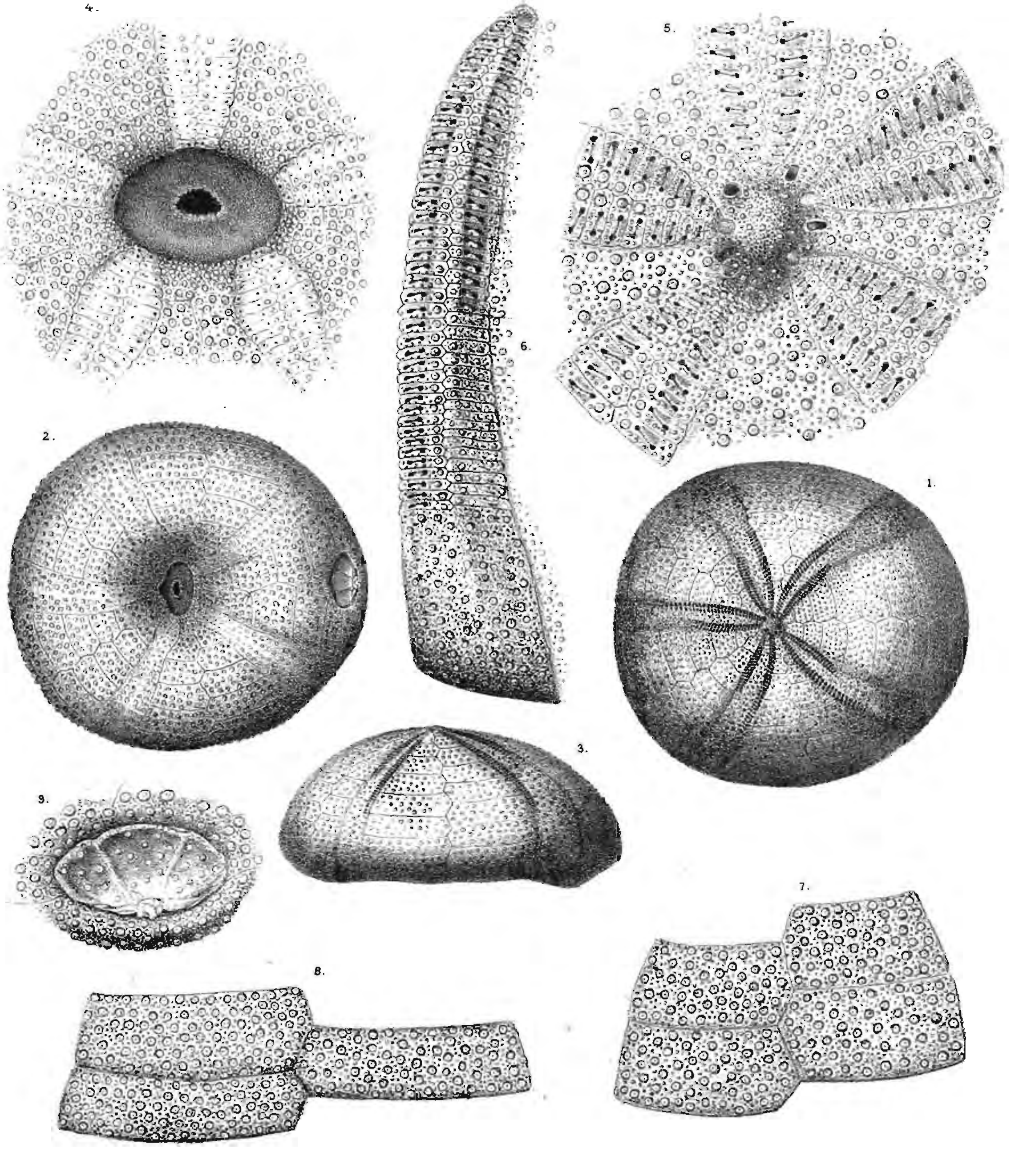


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PLATE XVII.

Conolampas Sigsbei A. AG.

Fig. 1. Seen from the actinal side, denuded, natural size.

Fig. 2. The same, seen from the interior of the test, natural size.

Fig. 3. Abactinal system.

Fig. 4. Actinal system, seen from the interior of the test.

Fig. 5. The same as Fig. 4, seen from the actinal side.

Fig. 6. Anal system.

Fig. 6a. Interior view of the same.

Fig. 7. Portion of the right anterior ambulacrum.

Fig. 8. A piece of the same seen from the interior of the test.

Fig. 9. Plates of the lateral posterior interambulacral region of the median region of the test.

Fig. 10. Plate of the lateral posterior interambulacral region of actinal side adjoining the ambitus.

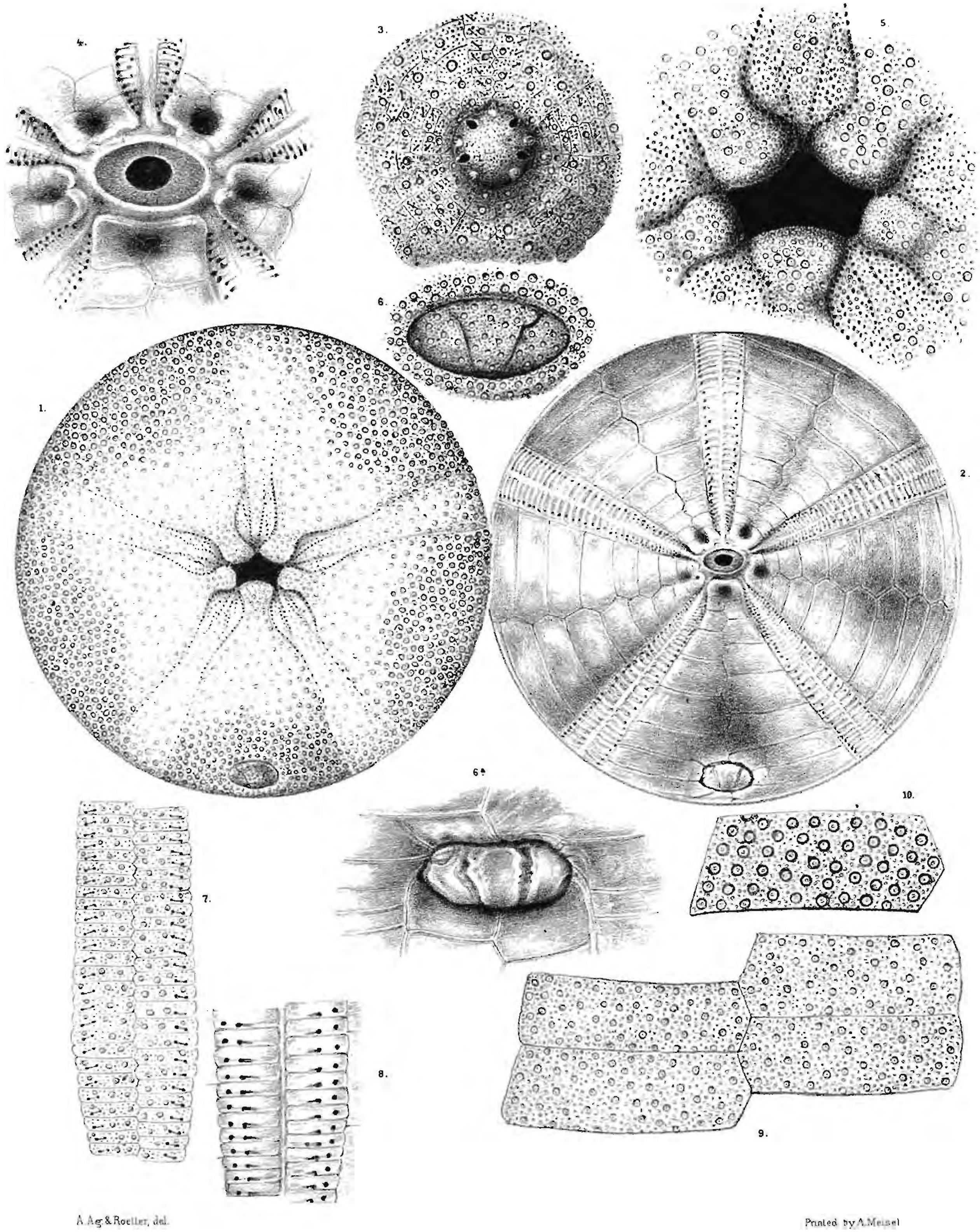

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PLATE XVIII.

Paleopneustes hystrix A. Ag.

Fig. 1. Left half of test covered with spines, seen from above, natural size.
Fig. 2. Right half of test from above, denuded.
Fig. 3. Abactinal system ($\frac{8}{1}$).
Fig. 4. Same as Fig. 1, seen from actinal side, covered with spines.
Fig. 5. Same as Fig. 2, seen from actinal side, denuded.
Fig. 6. Actinostome ($\frac{2}{1}$), seen from actinal side.
Fig. 7. Same as Fig. 6, seen from the interior.
Fig. 8. Anal system ($\frac{2}{1}$).

"BLAKE" ECHINI. Pl. XVIII

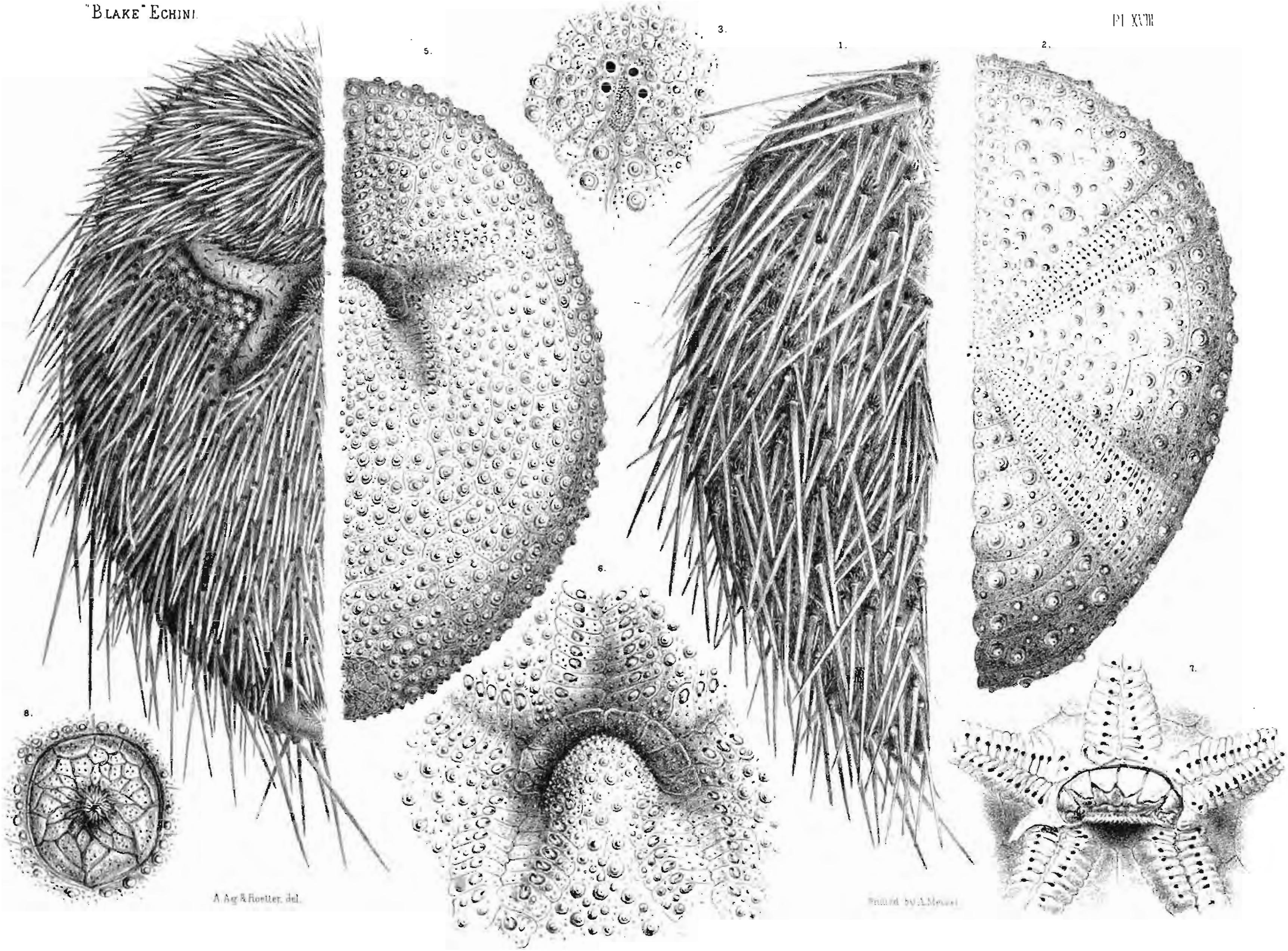

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PLATE XIX.

Linopneustes longispinus A. Ag.

Fig. 1. Seen in profile (upper figure). Natural size.

Paleopneustes hystrix A. Ag.

Fig. 2. Seen in profile (lower figure). Natural size.

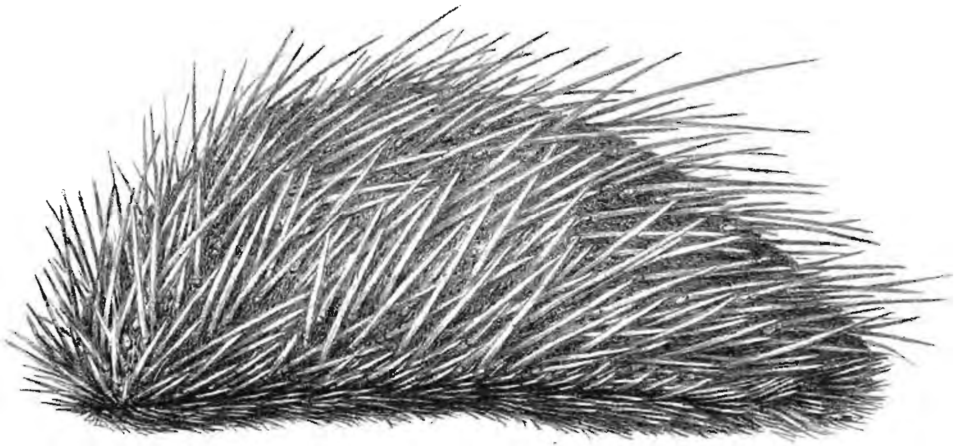

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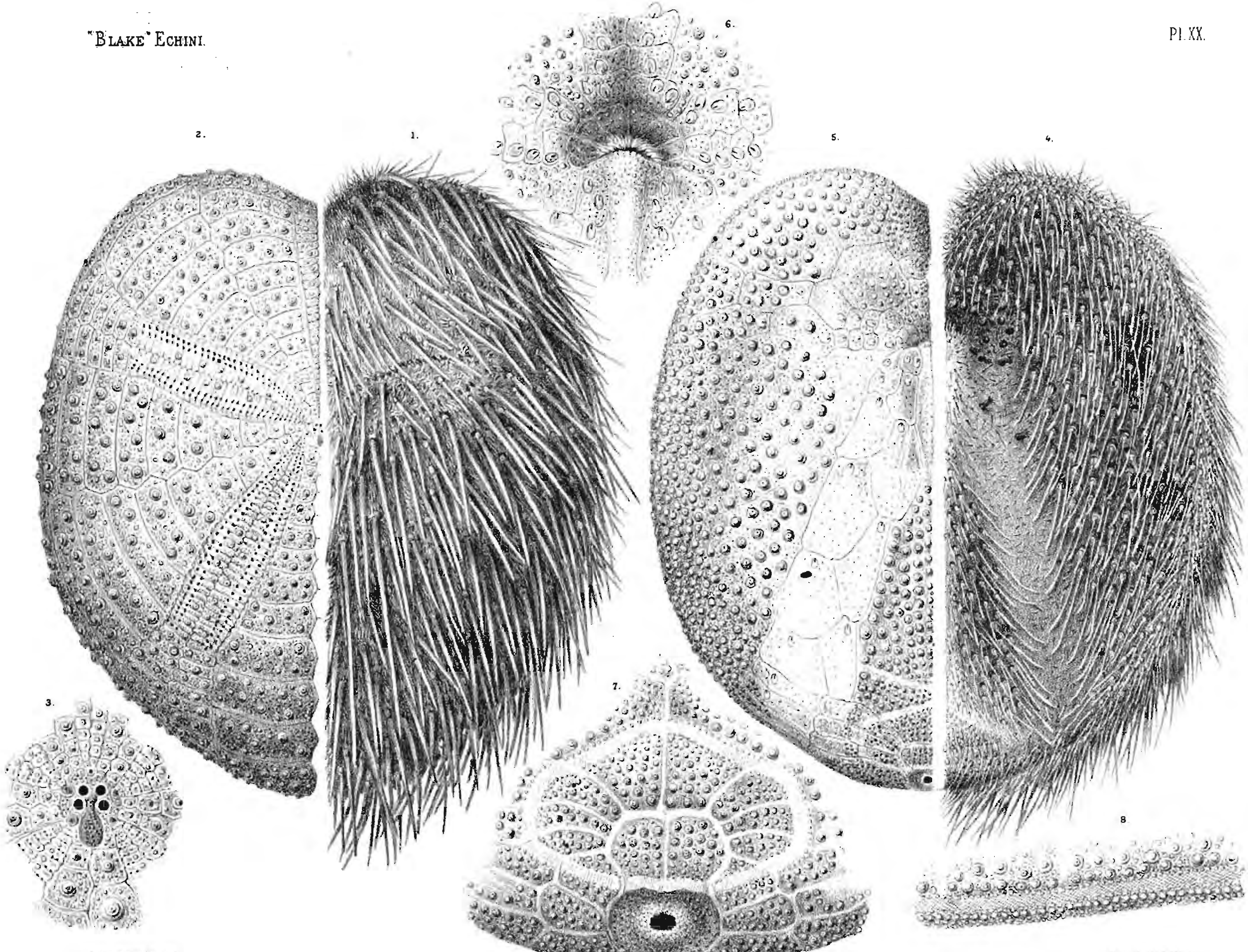
PLATE XX.

Linopneustes longispinus A. AG.

Fig. 1. Right half of test covered with spines from above, natural size.
Fig. 2. Left half, denuded.
Fig. 3. Abactinal system ($\frac{8}{1}$).
Fig. 4. Same as Fig. 2, seen from the actinal side, covered with spines.
Fig. 5. Same as Fig. 1, seen from the actinal side, denuded.
Fig. 6. Actinal system ($\frac{2}{1}$).
Fig. 7. Anal system with subanal fasciole ($\frac{2}{1}$).
Fig. 8. Marginal fasciole on the edge of the ambitus.

"BLAKE" ECHINI.

Pl. XX.



A. Ag & Roetter, del.

PLATE XXI.

Paleopneustes cristatus A. Ag.

Fig. 1. Lower extremity of the right anterior lateral ambulacrum of a specimen 150 mm. in length and 85 mm. in height ($\frac{1}{1}$).

Fig. 2. Part of test across the posterior part of the same ambulacrum at the ambitus ($\frac{1}{1}$).

Fig. 3. Apical system of same ($\frac{3}{1}$).

Fig. 4. Anal system of same ($\frac{1}{1}$).

Fig. 5. Actinostome of same ($\frac{1}{1}$).

Fig. 6. Part of test across the ambital region of the right anterior ambulacrum, to show part of the marginal fasciole of a specimen 85 mm. in length.

Fig. 7. Young *Paleopneustes cristatus*, seen in profile ($\frac{1}{1}$).

Fig. 8. Part of test (corresponding to Fig. 6) of same, magnified.

Fig. 9. Young *Paleopneustes cristatus* 16 mm. in length, seen from the abactinal side.

Fig. 10. The same as Fig. 9, seen in profile.

Fig. 11. The same, seen from the actinal side.

Fig. 12. Apical system of same, greatly magnified.

Fig. 13. Actinostome of same, greatly magnified.

Fig. 14. Anal system of same, greatly magnified.

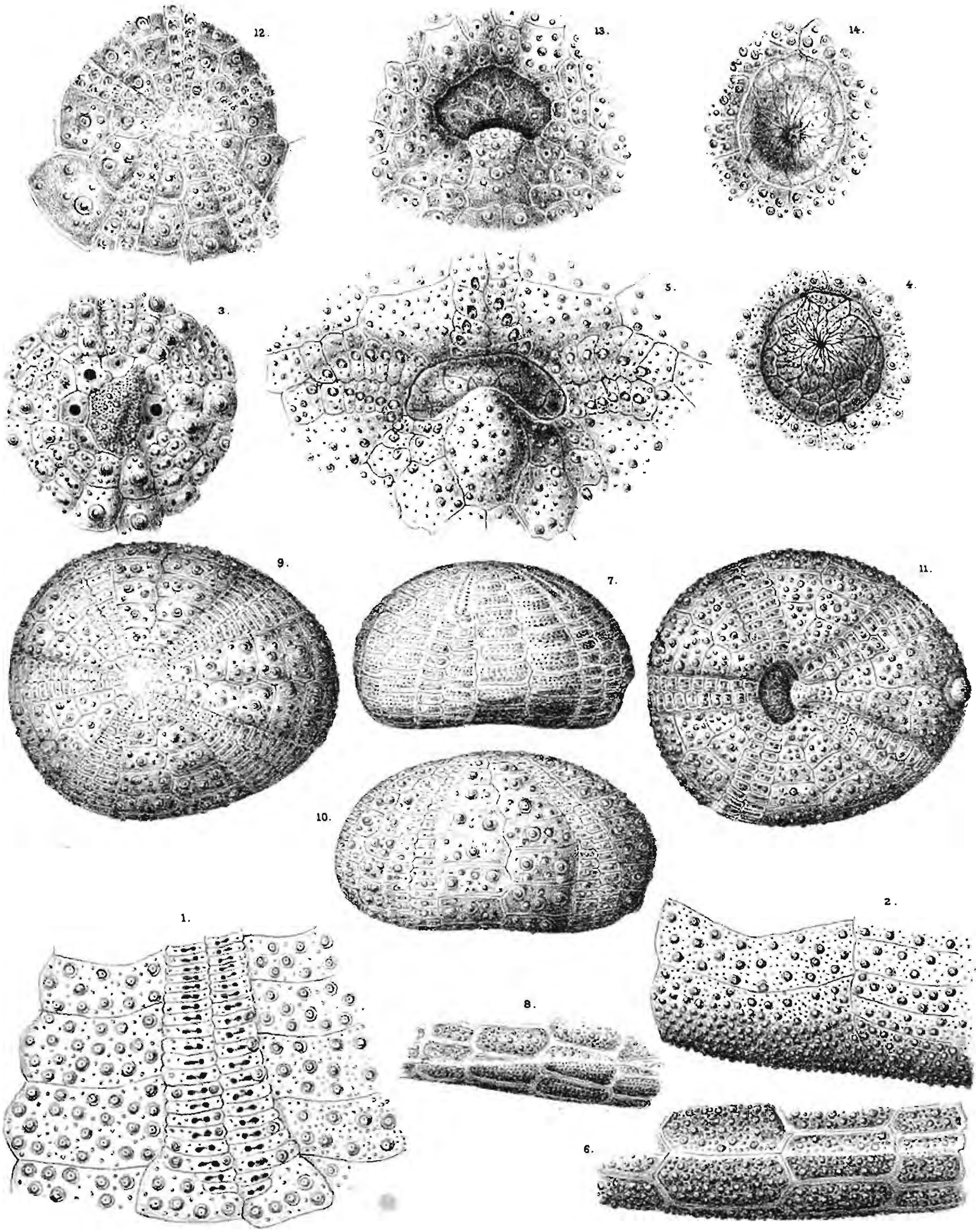


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PLATE XXII.

Neolampas rostellata A. Ag.

Fig. 1. Specimen 11 mm. long. diameter, denuded, seen from the abactinal pole (female).

Fig. 2. The same as Fig. 1, seen from the actinal side.

Fig. 3. The same, seen in profile.

Fig. 4. The same, seen facing the anal extremity.

Fig. 5. The same, seen facing the odd anterior ambulacrum.

Fig. 6. Primary granulation of test of young specimen, 4 mm. long. diameter, arranged in indistinct irregular lozenge-shaped figures.

Fig. 7. Actinal termination of one of the lateral ambulacra, showing the five large, short-stemmed globular sphæridia placed in the median ambulacral space of a specimen 12 mm. long. diameter.

Fig. 8. Magnified view of denuded actinostome of a specimen 11 mm. long. diameter.

Fig. 9. Magnified view of actinal part of test, showing the suckers, sphæridia, and primary spines and tubercles of a specimen 6 mm. long. diameter.

Fig. 10. Abactinal part of test of a female, showing the manner in which the genital openings are protected by spines, of a specimen 12 mm. long. diameter.

Fig. 11. The same, denuded, showing the large genital openings and the pores of the madreporic body.

Fig. 12. General view of the abactinal system and adjoining part of the test of a female about 11 mm. long. diameter.

Fig. 13. Denuded specimen, seen from above (male), 9 mm. long. diameter.

Fig. 14. The same, seen in profile.

Fig. 15. The same, seen facing the (anal system) posterior extremity.

Fig. 16. The same, seen facing the odd anterior ambulacrum.

Fig. 17. Greatly enlarged view of the abactinal system and adjoining part of the test of the same specimen as Fig. 13.

Fig. 18. Greatly enlarged view of actinostome of same.

Fig. 19. Young male specimen, denuded, seen from the abactinal side, 4.5 mm. long. diameter.

Fig. 20. The same, seen in profile.

Fig. 21. The same, seen facing the posterior (anal) extremity.

Fig. 22. Enlarged view of anal groove of a specimen about 12 mm. long. diameter.

Fig. 23. Young specimen (measuring 2.5 mm. long. diam.) covered with spines, seen from the actinal side.

Fig. 24. The same, seen from the abactinal side.

Fig. 25. Plates of anal system.

Fig. 26. Head of short-stemmed trifid actinal ambulacral pedicellaria.

Fig. 27. Long-stemmed, long-headed trifid coronal pedicellaria.

Fig. 28. Young miliary spine, with spiny cupuliform extremity.

Fig. 29. Minute short-stemmed ellipsoidal sphæridia.

Fig. 30. Anal pyramid, composed of eight large triangular plates, of a young specimen 4 mm. long. diameter.

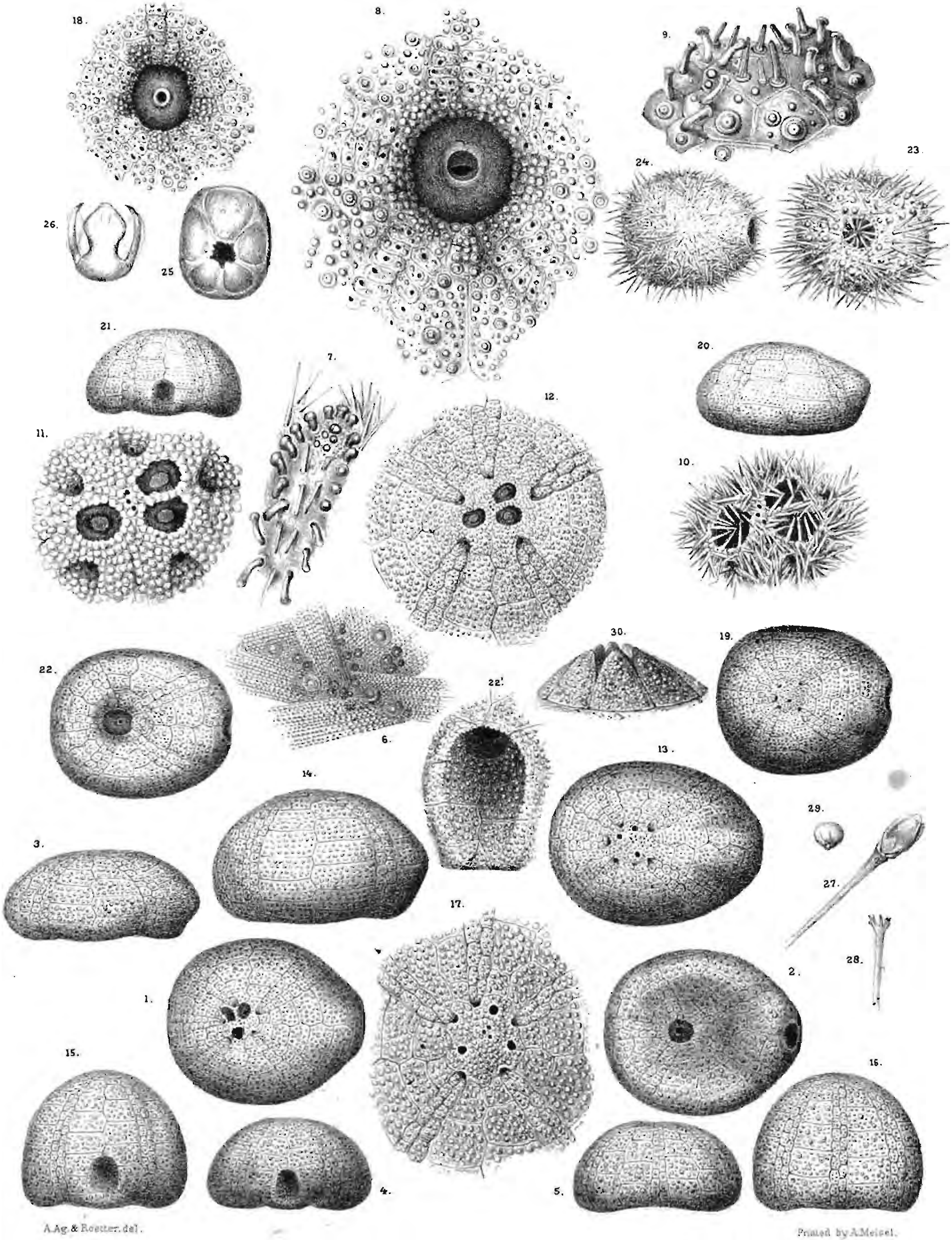

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PLATE XXIII.

1–4. **Rhinobrissus micrasteroides** A. Ag.

Fig. 1. Seen in profile, covered with spines.
Fig. 2. Same, seen from the actinal side.
Fig. 3. Seen from above, denuded.
Fig. 4. Seen facing the posterior extremity.
Figs. 1–4 from a specimen 23 mm. in long. diameter.

5–14. **Palæotropus Josephinæ** Lovén.

Fig. 5. Seen from above, covered with spines.
Fig. 6. Same, seen from the actinal side.
Fig. 7. Denuded specimen, about the same size, seen from the abactinal side.
Fig. 8. Same, seen from the actinal side.
Fig. 9. Same, seen in profile.
Fig. 10. Same, seen from the anterior extremity.
Fig. 11. Same, seen from the anal extremity.
Fig. 12. Magnified view of abactinal system of same.
Fig. 13. Magnified view of anal system.
Fig. 14. Magnified view of actinal system.

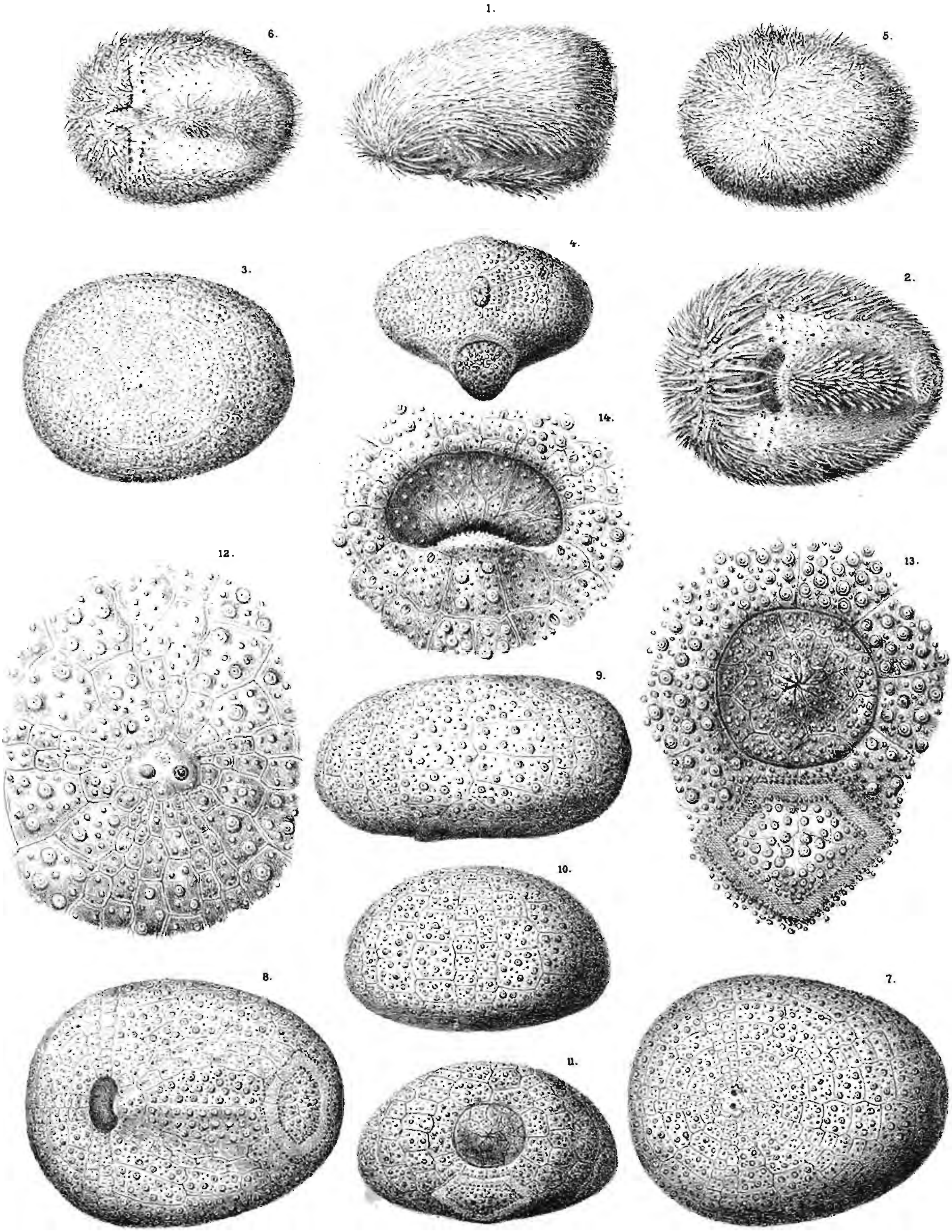

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PLATE XXIV.

1–5. **Echinolampas depressa** Gray.

Fig. 1. Young specimen, seen from above, 5 mm. long. diameter.
Fig. 2. The same, seen in profile.
Fig. 3. The same, seen from the actinal side.
Fig. 4. The actinostome of same.
Fig. 5. The anal system of same.

6–15. **Palæobrissus Hilgardi** A. Ag.

Fig. 6. Seen from above, covered with spines.
Fig. 7. The same, from the actinal side.
Fig. 8. The same, in profile.
Fig. 9. Same as Fig. 7, denuded.
Fig. 10. Same as Fig. 6, denuded.
Fig. 11. Same as Fig. 8, denuded.
Fig. 12. Same, seen facing the anal extremity. Figs. 6–12, natural size.
Fig. 13. Actinostome of Fig. 9, enlarged.
Fig. 14. Anal system, enlarged.
Fig. 15. Apical system, enlarged.

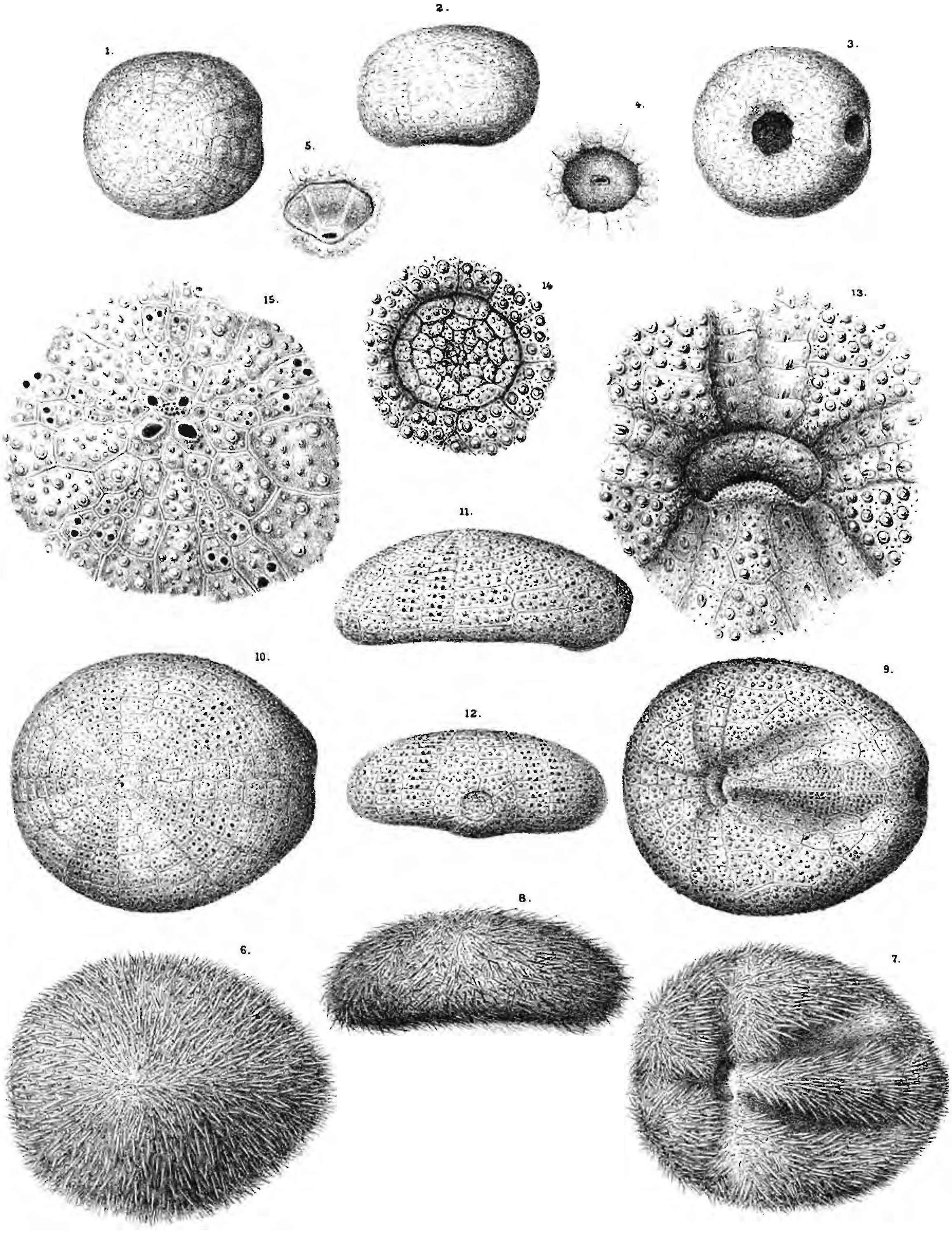

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PLATE XXV.

Agassizia excentrica A. Ag.

Fig. 1. Seen in profile, covered with spines, 20 mm. long. diameter.

Fig. 2. A specimen of the same size, seen in profile, denuded.

Fig. 3. The same, seen from the actinal side.

Fig. 4. The same, seen from the abactinal side.

Fig. 5. The same, seen facing the odd anterior ambulacrum.

Fig. 6. The same, seen facing the anal system (posterior extremity).

Fig. 7. Young Agassizia, 7 mm. long. diameter, seen in profile.

Fig. 8. The same, seen facing the anal system.

Fig. 9. The same, from the abactinal pole.

Fig. 10. The same, seen from the actinal side.

Fig. 11. Enlarged abactinal system, with adjacent part of test of a small specimen 6.5 mm. long. diameter.

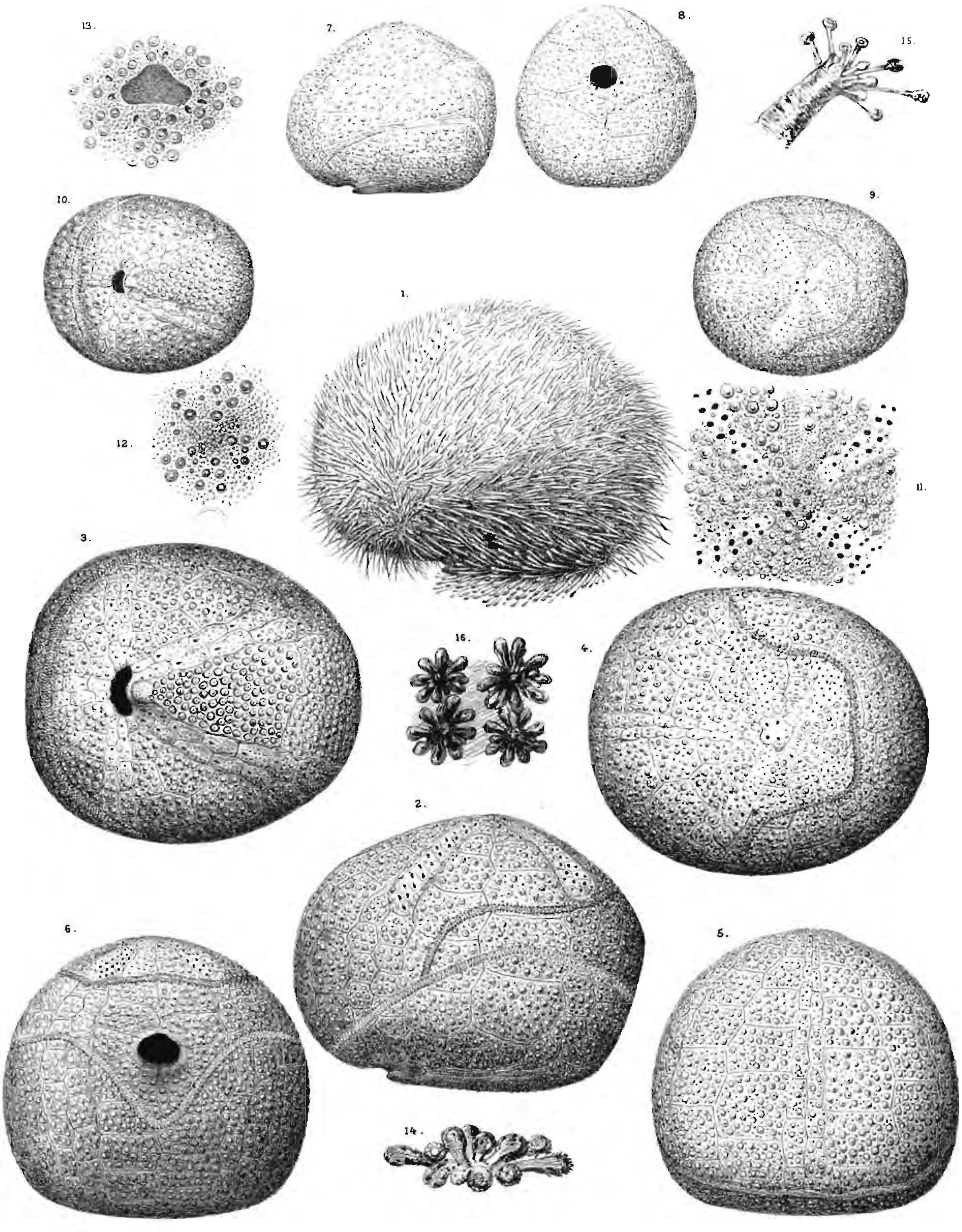
Fig. 12. Abactinal system of a young Agassizia, 3 mm. long. diameter.

Fig. 13. Actinal system of same.

Fig. 14. Magnified miliary spines of the lateral fasciole.

Fig. 15. One of the large ambulacral suckers of the odd anterior petaloid ambulacrum, expanded, from a specimen 11 mm. long. diameter.

Fig. 16. Four ambulacral suckers from same, of the outer petaloid part of the odd anterior ambulacrum, somewhat contracted.



A.Ag. & Roetter. del

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PLATE XXVI.

1–3. **Urechinus naresianus** A. Ag.

Fig. 1. Actinostome of specimen 33 mm. long. diameter.
Fig. 2. Abactinal system and adjoining part of test of same.
Fig. 3. Anal system and adjoining part of test of same

4. **Rhinobrissus micrasteroides** A. Ag.

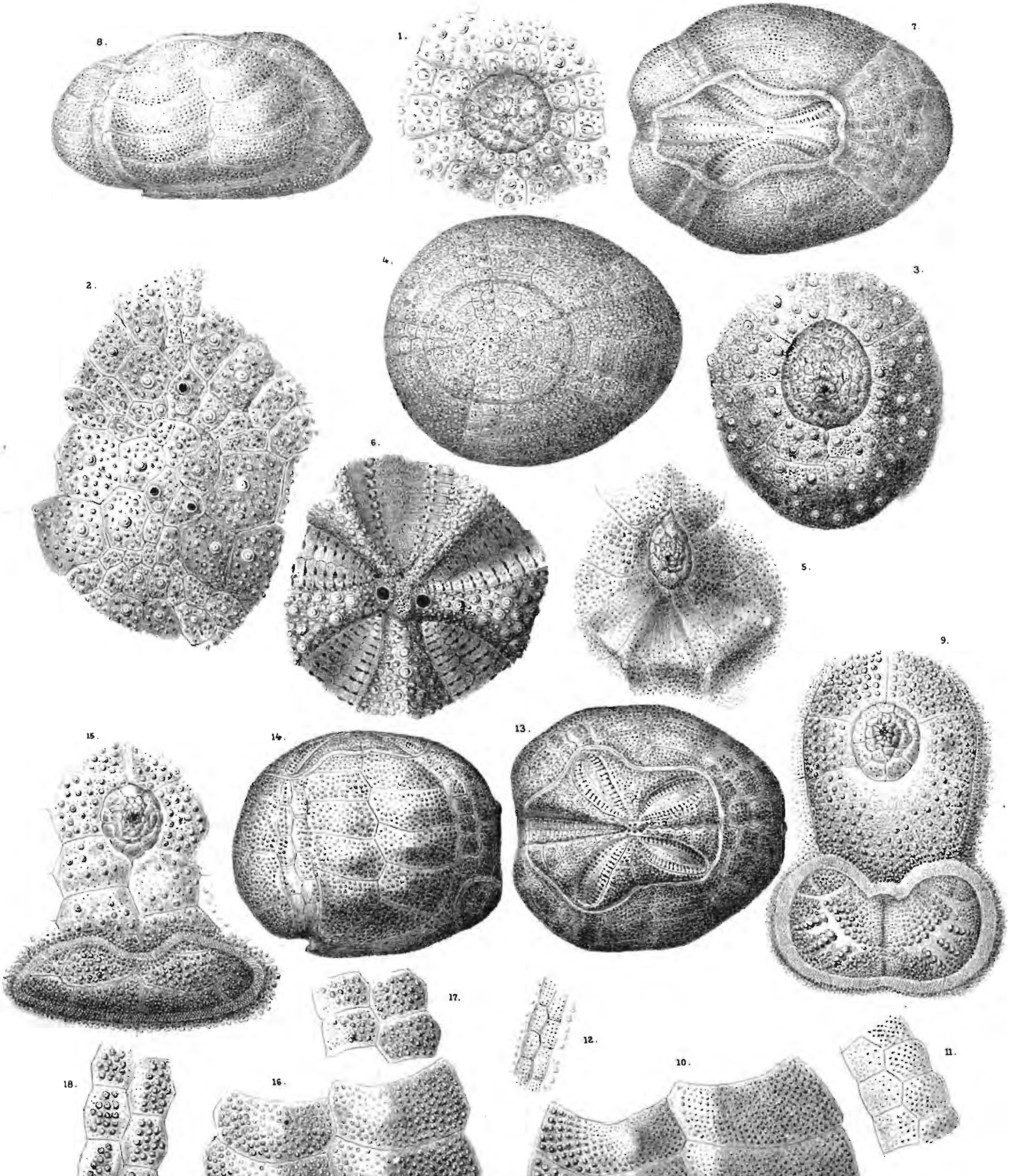
Fig. 4. Specimen 32 mm. long. diameter, seen from the abactinal side.

5, 6. **Schizaster (Periaster) limicola** A. Ag.

Fig. 5. Anal system of specimen 68 mm. long. diameter.
Fig. 6. Apical system, with surrounding part of test of same.

7–18. **Brissopsis lyrifera** Agass.

Fig. 7. Elongated type, seen from the abactinal side, natural size.
Fig. 8. The same, seen in profile.
Fig. 9. Enlarged view of posterior extremity of test, showing the anal system and fasciole, with the subanal fasciole.
Fig. 10. Portion of lateral interambulacral part of test near the ambitus.
Fig. 11. Portion of posterior lateral ambulacral zone.
Fig. 12. Portion of anterior lateral ambulacral zone.
Fig. 13. Globular type of the species, seen from the abactinal pole, natural size.
Fig. 14. The same, seen in profile.
Fig. 15. Posterior part of test of same, enlarged, corresponding to Fig. 9 in the elongated type.
Fig. 16. Corresponds to Fig. 10 of the elongated type.
Fig. 17. Corresponds to Fig. 11 of the elongated type.
Fig. 18. Corresponds to Fig. 12 of the elongated type.



A. Ag. del. Roetter, lith.

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PLATE XXVII.

Macropneustes spatangoides A. Ag.

Fig. 1. Seen in profile, natural size.

Fig. 2. Another specimen, seen from the abactinal side, natural size.

Fig. 3. Enlarged view of actinostome of same.

Fig. 4. Enlarged view of the reticular peripetalous fasciole of the specimen of Fig. 2.

Fig. 5. Enlarged view of anal system and subanal fasciole of the same.

Fig. 6. Profile outline of a large specimen, with high posterior extremity, natural size.

Fig. 7. The same, seen from the abactinal pole ; the apical part of the petaloid ambulacra has become atrophied, as is so frequently the case in allied genera.

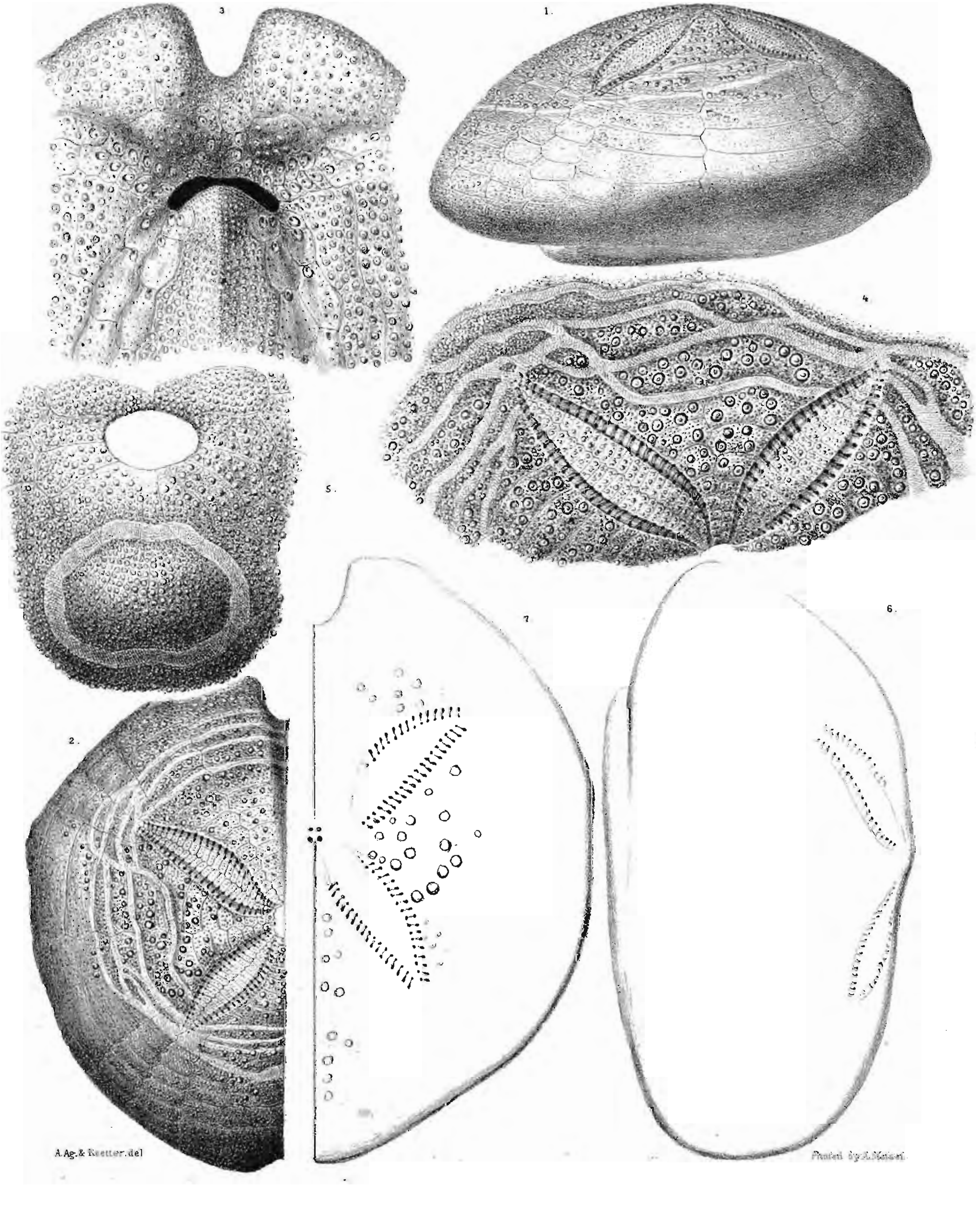

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PLATE XXVIII.

1–7. **Schizaster orbignyanus** A. Ag.

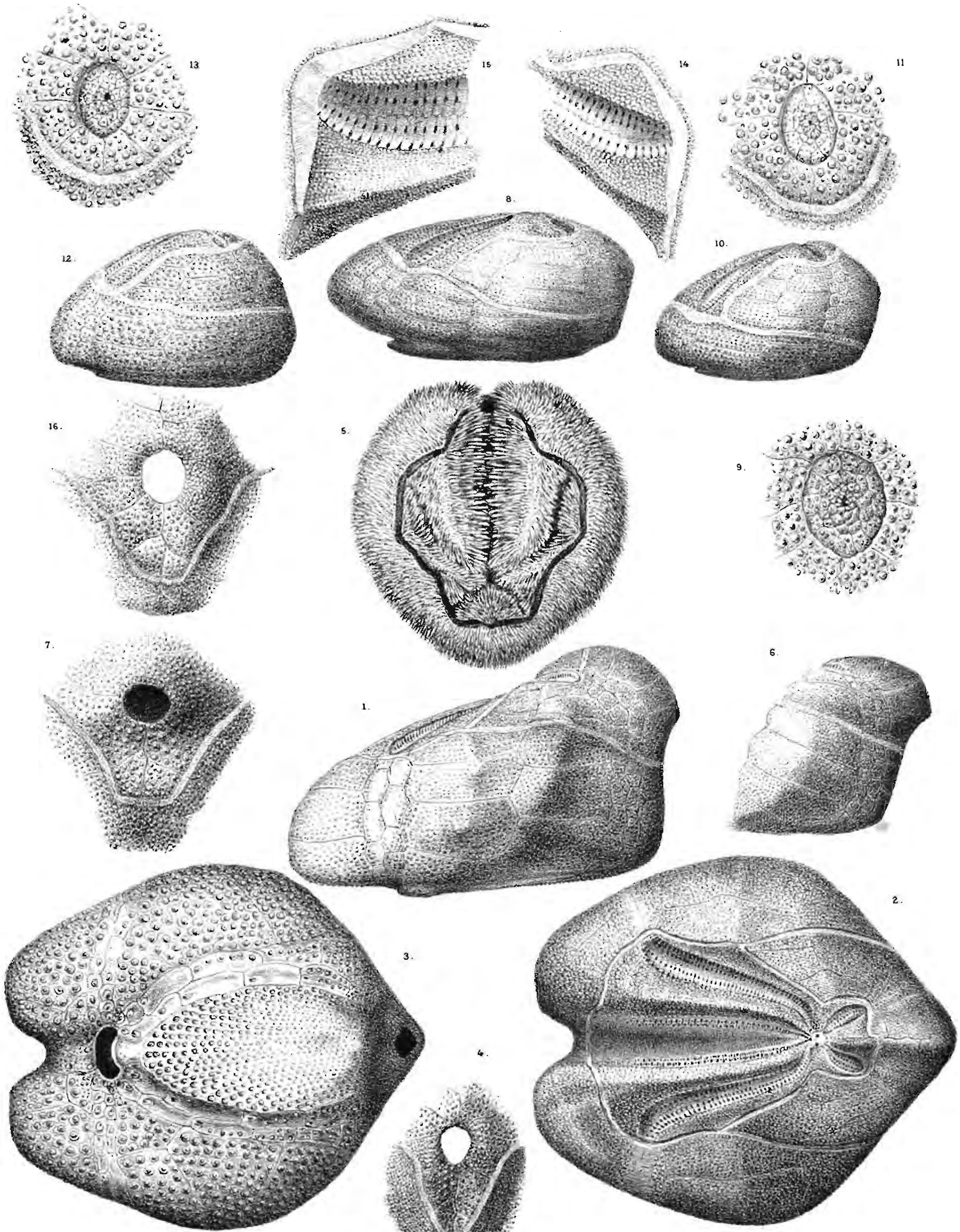
Fig. 1. Denuded specimen, natural size, seen in profile.
Fig. 2. The same, seen from the abactinal pole.
Fig. 3. The same, seen from the actinal side.
Fig. 4. Anal system of subanal fasciole of same.
Fig. 5. Specimen covered with spines, natural size, seen from the abactinal side.
Fig. 6. Profile (natural size) of posterior extremity of a specimen intermediate between Figs. 1 and 5.
Fig. 7. Anal system of same, with subanal fasciole, somewhat enlarged.

8–14. **Schizaster fragilis** Agass.

Fig. 8. Young Schizaster, seen in profile, 23 mm. long. diameter.
Fig. 9. Anal system of same, enlarged.
Fig. 10. Somewhat younger Schizaster than Fig. 8, 10 mm. long. diameter, seen in profile.
Fig. 11. Anal system of same, with its subanal fasciole.
Fig. 12. Still younger specimen, only 6 mm. long. diameter, seen in profile.
Fig. 13. Anal system and adjoining part of test of same.
Fig. 14. Extremity of the petaloid right anterior ambulacral petal, with its adjoining fasciole, of a specimen about 55 mm. long. diameter.

15, 16. **Schizaster canaliferus** Agass.

Fig. 15. The extremity of the left petaloid ambulacrum of a specimen measuring 70 mm. long. diameter.
Fig. 16. The anal system and fasciole of same.



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