XXI. *On the Echinoidea of the 'Porcupine' Deep-sea Dredging-Expeditions.*

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I.

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The deep-sea dredging-cruises of H.M. Ships 'Lightning' and 'Porcupine' during the summers of 1868, 1869, and 1870, in the North Atlantic, were comprehended within a belt 1500 miles in length by from 100 to 150 miles in width, extending from the Færöe Islands along the northern and western coasts of Scotland and Ireland and the coasts of Portugal and Spain to the Strait of Gibraltar. In this area fifty-seven successful hauls of the dredge were made during the three summers in water exceeding 500 fathoms in depth, sixteen beyond 1000 fathoms, and two beyond 2000 fathoms.

Even at the latter extreme depths Echinodermata appeared to be abundant. At 2435 and at 2090 fathoms all the Echinoderm orders were represented—the Echinoidea by a small variety of *Echinus norvegicus*, v. Düben and Koren, and a young example of *Brissopsis lyrifera*, Forbes; the Asteridea by an undescribed species of the genus *Archaster*; the Ophiuridea by *Ophiocten sericeum*, Forbes, and *Ophiacantha spinulosa*, Müller and Troschel; the Holothuridea by *Echinocucumis typica*, Sars; and the Crinoidea by a very remarkable new form of the Apiocrinidæ, which has been noticed under the name of *Bathycrinus gracilis*, Wyville Thomson. From 2000 fathoms upwards the number of Echinoderms seems to increase rapidly; but this apparent increase may possibly be due to our greater knowledge of the fauna of shallower water; at from 300 to 800 fathoms along the coast of Britain many species of all the orders are enormously abundant, so much so as to give a very marked character to the fauna of that special zone. Several of these species (such as *Cidaris papillata*, Leske, *Toxopneustes dröbachiensis*, Müller, *Echinus norvegicus*, D. & K., *Astropecten tenuispinus*, D. & K., *Archaster Parellii*, D. & K., *A. Andromeda*, M. & T., *Euryale Linkii*, M. & T., and *Antedon celticus*, Barrett) have long been known to inhabit the deep water of the British area, and form part of a fauna which will be probably found to have a very wide lateral extension at temperatures whose minimum ranges from 0° C. to +2° C.—a fauna which crops up, as it were, within the ordinary limits of observation in the seas of Scandinavia, and which has consequently been carefully studied by the Scandinavian naturalists.

Another group of species (including *Tripylus fragilis*, D. & K., *Ctenodiscus crispatus*, Retzius, *Pteraster militaris*, M. & T., *Amphiura abyssicola*, Sars, *Antedon Eschrichtii*,

O. F. Müller, and several others) are members of the same fauna described from the seas of Scandinavia and Greenland, but not hitherto known as British. A third section, consisting of a number of undescribed Echinoideans, Asterideans, and Ophiurideans, may probably also belong to this fauna; while a fourth group, likewise undescribed, and including such forms as *Porocidaris*, *Phormosoma*, *Calveria*, *Pourtalesia*, *Neolampas*, *Zoroaster*, *Ophiomusium*, *Pentacrinus*, *Rhizocrinus*, and *Bathycrinus*, would rather appear to be referable to a special deep-sea fauna of which we as yet know only a few examples, and with whose conditions and extension we are unacquainted. This abyssal fauna is of great interest, inasmuch as nearly all the hitherto discovered forms referred to it show close relations to family types of Cretaceous or Tertiary age, and hitherto supposed to have become extinct.

Twenty-seven species of Echinoidea were procured during the cruises of 1868, 1869, and 1870, off the coasts of Britain and Portugal, at depths varying from 100 to 2435 fathoms.

Class ECHINOIDEA.

Order I. DESMOSTICHA (E. Häckel).

Family 1. CIDARIDÆ.

Test globular. The plates of the test are thick and abut against one another in vertical surfaces, showing no tendency to overlap. The ambulacral areas are very narrow, usually slightly undulating; they are composed of numerous plates which bear miliary granules only, and these usually in not more than six rows. The poriferous zones are narrow: the pores of a pair are usually contiguous; sometimes they are a little remote from one another, and are united by a shallow groove. The interambulacral areas are very wide, from three to five times the width of the ambulacral; they consist of two rows of large plates, each plate bearing one large scrobicular areola more or less depressed and encircled by a raised rim: in the centre of the areola a prominent boss, sometimes crenulate and sometimes smooth, bears a large smooth perforated mamelon.

The oral and apical openings are very large. The peristome is round or slightly pentagonal without notches. The peristomial membrane is closely mailed with twenty rows of thick calcareous scales, five double rows ambulacral and five interambulacral, imbricating towards the mouth. The ambulacral scales are perforated for the passage of tube feet, which are continued from the pore-areas of the corona in double series up to the edge of the mouth. The free edges of the scales bear granules, to which are attached small flattened spines and pedicellariæ.

The apical disk is large and rounded, and consists of five large genital plates (one of them modified to include the madreporic tubercle) and five ocular plates. The anus is central, directly opposite the mouth; and the membrane of the periproct is clothed with a varying number of irregularly formed thick plates and calcareous granules, which form a continuous pavement round the anal aperture.

The dental pyramid is strong and well developed. The outer angles of the two divi-

sions of the tooth-sockets bear short epiphyses; but these are not united into an arch, as in the *Echinidæ*. The teeth are powerful, but they are simply grooved without a median longitudinal ridge. The primary spines are remarkably large, sometimes three times the diameter of the test in length: they are cylindrical, or prismatic, or tapering, or flattened, or club-shaped; smooth or finely striated, or ornamented with longitudinal spiny ridges, or regularly or irregularly tuberculated. The secondary and smaller spines are flattened and striated. The pedicellariæ differ in form in different genera.

Thus defined, the Cidaridæ form a very natural group.

They are at once distinguished from all the other families of the "regular" Urchins, with the exception of the Saleniadæ, by the extreme narrowness of the ambulacra. They resemble the Saleniadæ in general appearance, but they differ from them in the structure of the peristome and in that of the apical disk, which, in the Saleniadæ, includes a large plate in addition to the normal double range of five "ocular" and five ovarial plates.

They approach the Echinothuridæ in the important character of the continuity of the rows of ambulacral tube feet through imbricated scales over the buccal membrane and up to the edge of the mouth, in the condition of the epiphyses of the tooth-sockets, and in the form and structure of the teeth; but they differ from them widely in the homogeneity of the tube feet, in the remarkably solid inflexible nature of the test, and in the form of the spines and pedicellariæ.

They resemble the Diadematidæ in the structure of the tooth-sockets and teeth, but they differ from them in the continuation of the ambulacral over the buccal membrane, in the absence of notches in the peristomial rim, which in the Diadematidæ are particularly deep, and in the structure of the spines and pedicellariæ.

From the Echinidæ they are distinguished by the absence of the calcareous arches uniting the halves of the tooth-sockets, by the absence of the median ridge in the concavity of the teeth, and by the absence of notches in the peristome and of branchiæ.

Genus *Cidaris*, Klein.

Test globular, slightly and equally flattened at the oral and apical poles. Ambulacral areæ very narrow, bearing miliary tubercles only, in from four to six rows. Pore-areæ simple: the pores of each pair are contiguous, or, when slightly separated, they are united by a groove. The interambulacral plates are seven to ten in a row; the areolæ are large, circular, or transversely elliptical; the bosses supporting the primary tubercles are crenulated or smooth. The ovarial plates are large, more or less rectangular or shield-shaped, with a large defined perforation for the duct of the ovary passing through the plate about one third of its width from the outer margin. The primary spines are large and variously formed in different species. The pedicellariæ are variously formed, but they are all 3-valved. The ovaries are compact and lobed, and their outer wall is supported by irregularly shaped fenestrated calcareous plates. Fenestrated plates likewise occur in the walls of the intestine.

Hitherto the attempts to subdivide the family of the Cidaridæ into genera has not

been very satisfactory. So very large a proportion of the species are extinct that the group comes rather within the domain of palæontology than that of recent zoology; and, as the two branches of the subject have not always gone hand in hand, some confusion has occurred. Among the fossil Cidaridæ, palæontologists have never regarded the smoothness or crenulation of the bosses of the primary tubercles as a character of generic value; and I believe they are entirely justified in disregarding it, for crenulation occurs in every possible degree, and we frequently find in a single specimen that some of the bosses are crenulated and others smooth. The contiguous or remote arrangement of the pores is also a very critical character.

In the fossil genus *Rhabdocidaris*, Desor, in which the remote arrangement with the connecting-groove is most marked, it is always associated with very strongly crenulated bosses, and usually with elliptical areolæ; still, although the group thus distinguished has a certain characteristic *facies* and a definite distribution in geological time, I do not think it can be regarded as of more than subgeneric value. The genus or subgenus *Phyllacanthus*, Brandt, founded upon the form of the radioles chiefly, has no sufficient basis. The genus *Leiocidaris*, established by M. Desor for the reception of certain living species with remote pores and smooth bosses, seems to me to be valueless. In these the character derived from the arrangement of the pores is so obscure that several species (as, for example, the common *Cidaris tribuloides*) occupy an uncertain intermediate place, while certain subordinate characters (such as the comparatively large size of the areolæ and the great length and the cylindrical form of the spines) are not constantly associated with it, and are shared by many fossils which still retain a place in the type genus. In his valuable 'Revision of the *Echini*,' now progressing towards completion, Mr. Alexander Agassiz sets aside the genus *Leiocidaris*; but he proposes, apparently for *Cidaris papillata* alone, the subgenus *Dorocidaris*, founded upon a number of somewhat vague characters, all of them to be found singly and in different combinations in various fossil species of the genus *Cidaris*.

This multiplication of names seems unnecessary; I would therefore propose, at all events provisionally until it is in our power to revise the whole of the fossil series from a zoological point of view (an issue which, through the excellent work of Dr. Wright, M. Cotteau, and others, may not be far distant), to restore *Leiocidaris* and *Phyllacanthus* to the genus *Cidaris*, and likewise to relegate to the type genus the species now constituting the genus *Rhabdocidaris*, retaining *Rhabdocidaris*, however, as a subgenus under *Cidaris*. *Diplocidaris* seems to have some claim to generic rank on account of its tendency to a bigeminal arrangement of the pores; and possibly the same may be accorded to *Goinocidaris* from the singular sculpture of the test. *Porocidaris* is distinguished by a remarkable character, which is evidently of some physiological import, and also differs from *Cidaris* in other less important particulars.

1. *Cidaris papillata*, Leske. (Plate LIX. figs. 1–13.)

Principal synonyms:—*Cidaris papillata*, Leske *apud* Klein, 1778; *Cidarites hystrix*,

Lamarck, An. s. Vert. 1816; *Cidaris papillata*, Fleming, Brit. Animals, 1828; *Cidaris hystrix*, Blainville, Actinologie, 1834; *Cidaris papillata*, Forbes, Brit. Starfishes, 1841; *Cidaris hystrix* and *Cidaris papillata*, Agassiz, Catalogue raisonnée, 1846; *Phyllacanthus hystrix*, Brandt, Prod. 1835; *Leiocidaris hystrix*, Dujardin et Hupé, Echinoderms, 1862; *Dorocidaris abyssicola*, A. Agassiz, Bull. M. C. Z. 1869.

The test in a mature full-sized example, from a depth of 200 fathoms off the south coast of Ireland (Plate LIX. fig. 1), is of a spheroidal form, gently depressed at the oral and apical poles. It measures 65 millims. in diameter from the centre of an ambulacral area to the centre of the opposite interambulacral area measured at the ambitus, and 50 millims. in height from the edge of the mouth to the centre of the apical disk. The ambulacra are very narrow, 7 millims. in width between the outer edges of the pore-areæ, and slightly sinuous; and they present the same character and arrangement and are nearly of uniform width from the peristome to the ocular plates. The ambulacral plates form a narrow raised sinuous band along the centre of each ambulacral area, with a row of small tubercles along either side towards the pore-areæ, and two rows of principal granules towards the centre of the band, with two or more imperfect rows of minute granules somewhat irregularly interspersed among them. The pore-areæ are depressed, forming decided grooves. The pairs of pores are ranged in single series: there are from twelve to fourteen pairs opposite each of the large interambulacral plates of the ambitus. The pores of a pair are close together but not contiguous. It can scarcely be said that they are connected together by a groove, but rather that a slight ridge runs out between the pairs of pores from the marginal tubercles of the ambulacral plates, and abuts against the edge of the adjoining interambulacral plate.

The interambulacral spaces are very wide, about 35 millims. in their widest diameter. They consist of two rows of large plates, in full-sized examples seven in each row, diminishing to either end; and the smallest plate at either end of the area belongs to the right or left row alternately. On each plate there is a large, smooth areola, greatly depressed, and occupying nearly the whole area of the plate. The areolæ round the ambitus are 12 millims. in diameter, round or slightly elliptical; they are bounded by an abruptly elevated border, and show no tendency to coalesce, except occasionally in the case of some of the smaller plates round the peristome. A very definite row of from twenty to thirty small tubercles with distinct smooth articulating surfaces border each areola; and the spaces between the areolæ are closely crowded with miliary granules, which decrease in size towards the line of junction between the two rows of plates. A boss with a smooth uncrenulated edge rises in the centre of the areola, and is surmounted by a smooth tubercle of moderate size with a large deep central perforation. The apical opening in the corona is large and nearly round. The ovarial plates are large, irregularly rectangular or shield-shaped, somewhat narrower towards the edge of the disk, where they abut against the inner halves of two terminal interambulacral plates of an area, and expanding inwards where they come in contact with the small plates of the periproct. One ovarial plate is much larger than the others, and shows the usual

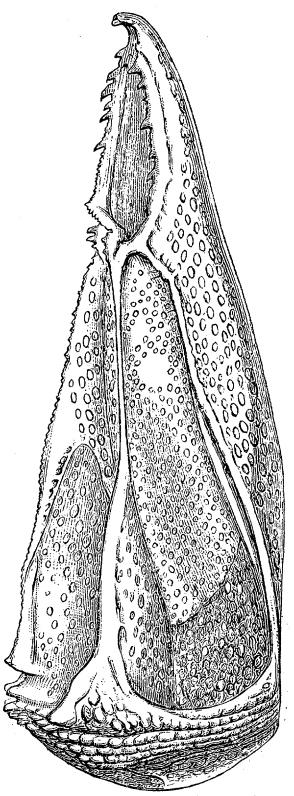
fenestrated structure, indicating its modification into the madreporic tubercle. A large definite round aperture, about one third of the width of the plate from its outer edge, is in connexion with the duct of the ovary. The "ocular plates" are heart-shaped, with a well-marked opening for the lodgment of the sense-organ. The plates of the periproct are irregular in form, diminishing in size towards the central anal opening; five of the outer row, however, are somewhat spear- or lancet-shaped, and pass outwards between the inner angles of the ovarial plates, giving the periproct a stellate form. The central portions of the ovarial, the ocular, and the larger anal plates bear close-set granules, but round the edge the plates are smooth and bare. This smooth border round the individual plates of the apical disk is a style of ornament very characteristic of this species, although not special to it.

The oral opening of the corona is 25 millims. in diameter. The peristome is markedly pentagonal. The buccal membrane is closely covered with thick and strong imbricated scales, their free edges beset with granules for the articulation of spines and pedicellariæ. The pairs of pores which traverse the ambulacral scales are smaller, and have the pores more closely set than those of the pore-areæ of the corona. The jaw-pyramid is of the ordinary form. The epiphyses of the jaw-sockets are rather longer and more developed than those of the more typical species, such as *C. tribuloides*, and the rotulæ are longer and rather more slender. The teeth are strong and sharp, formed of a simple deeply grooved band of semitransparent, very dense calcified areolar tissue. The auriculæ are large and spade-shaped; they arise entirely from the interambulacral plates; they lean slightly over the ambulacra, but they form no approach to an arch. The plates supporting the walls of the ovaries are large and closely set (Plate LIX. figs. 12, 13); they appear to originate from calcareous spicules with three rays spreading in one plane, the open angles between the branches becoming gradually filled up with thin cribriform calcareous expansions. The plates imbedding the wall of the intestine (fig. 11) and those in the suspending folds of the mesentery (fig. 10) are small and irregular in shape. The external tube feet, which are similar in character throughout the entire length of the ambulacra, have their walls supported by long curved spicules, rough with small conical projections; they terminate in sucking-disks, whose skeleton consists of a very irregular rosette of four, five, or six wedge-shaped pieces (Plate LIX. fig. 8).

The primary spines or radioles articulated to the primary tubercles on the interambulacral plates are large; those round the ambitus of large spines are sometimes 150 millims. in length by 6 or 7 millims. in greatest diameter. They are slightly enlarged just beyond the neck, and taper very gradually, rarely in full-grown spines coming to a point, but usually ending abruptly with a kind of cicatrix, which sometimes takes the form of an irregular cup. The surface of the spine is finely granular, and usually from twelve to fourteen rows of small pointed tubercles rather than spines, pointing slightly outwards, traverse its entire length at equal distances; sometimes these tubercles become regularly spine-like, and project from a continuous raised crest; and sometimes, as in a very marked variety dredged by Count Pourtales in the Gulf-stream

region, they become entirely obsolete and the spine is perfectly smooth. The radioles of the second size are about 8 millims. in length and 2 millims. in width, very much compressed and flattened, rounded at the end and finely striated longitudinally. They are articulated in a single row to the small tubercles round the edge of the areola, and in their natural attitude they lean over the naked part of the areola and cover the muscles and the head of the large radiole like a frill. A series of very much smaller spines are attached to the rows of larger granules which border the raised ambulacral band, and these are laid over to either side, covering and protecting the pore-areæ. These small pointed spines have a deep depression running down the centre, almost giving the idea of a tendency to divide into two. The miliary granules over all parts of the shell bear small flat-pointed spines. Only very minute granules bear pedicellariæ, which are of three forms. The most conspicuous of these are remarkably large, about 1·5 millim. in length and nearly a millimetre in width. The valves are greatly inflated, the central chamber large, and the ridges prominent (woodcut, fig. 1). These pedicellariæ are abundant and developed to a large size on the apical disk, particularly in northern examples (Plate LIX. fig. 5). Pedicellariæ of another form, with the valves long and slender, are ranged among the secondary spines along the borders of the ambulacral areæ and round the bases of the primary radioles (Plate LIX. fig. 6); and smaller tridactyle pedicellariæ, closely resembling a form very common in the Echinidæ, are scattered apparently irregularly all over the test.

Fig. 1.



Valve of a pedicellaria from the apical disk of *Cidaris papillata*. × 80.

Cidaris papillata has a very wide distribution. We dredged it in from 100 to 400 fathoms wherever there was a gravelly or sandy or in any way a hard bottom, in one continuous belt from the Færöe Islands to Gibraltar. Though not so abundant, it was frequent to 600 and 800 fathoms; and on one or two occasions small specimens were brought up from upwards of 1000 fathoms. In some localities the number of individuals was quite surprising. In the Shetland sea and at some stations off the south and west of Ireland, the dredge-bag was almost choked with them. *Cidaris papillata* is common off the coast of Norway. Specimens from Norway and the north of Scotland have the test usually thick and strong, the spines stout and comparatively smooth, and the large inflated pedicellariæ very numerous on the apical disk. Specimens from the Mediterranean, where the species is abundant, passing in some places into much more shallow water, are named in our Museums *Cidaris hystrix*, and are usually regarded as having the spines longer, more slender, and more markedly echinated, and the pedicellariæ less numerous than in the northern form. After examining a very large number of specimens from all

localities, I am quite satisfied that no characters of specific value distinguish the two forms. The one passes through every intermediate gradation into the other, and frequently a single locality yields a complete series, including characteristic examples of both extremes.

2. *Cidaris affinis*, Philippi. (Plate LX.)

Principal synonyms:—*Cidaris affinis*, Philippi, Wieg. Archiv, vol. i. 1845; *Cidaris Stokesii*, Agassiz, Cat. raisonnée, 1846; *Cidaris affinis*, Sars, Middelhavets Litt.-Fauna, 1857; *Leiocidaris affinis*, Dujardin and Hupé, 1862; *Cidaris* (*Dorocidaris*) *papillata*, A. Agassiz, Revision of the *Echini*, 1872.

The test of a full-grown specimen of this species is about 25 millims. in diameter. It is slightly more depressed than in *C. papillata*. The general arrangement of the plates of the test is the same, but the ambulacra are somewhat wider in proportion to the width of the ambulacral areæ. The pore-areæ are also relatively somewhat wider. There are nine or ten pairs of pores opposite the edge of one of the large interambulacral plates of the ambitus. The interambulacral plates have usually two rows of large-sized tubercles surrounding the areola, so that, instead of there being only a single row of the larger flattened spines converging over the areola, there is a double series of such spines. The radioles are long and rather delicate, ornamented as in *C. papillata*, only the pointed tubercles are much more pronounced. The spines from the larger areolæ taper to a fine point: those round the mouth are shorter, stouter, and more cylindrical; and immediately round the mouth some of them are slightly flattened. The general colour of the animal is a very brilliant cinnabar shaded with dark brown. The large spines are usually banded cinnabar and brown.

This is a very beautiful and well-marked little urchin, but I admit that its claim to specific rank is doubtful. Some varieties approach very closely to stunted, shallow-water forms of *C. papillata*, and particularly that special to the Mediterranean; and many (some of them very vivid in colour) were dredged in Tangier Bay.

Genus *Porocidaris*, Desor.

The ambulacra are narrow and strap-shaped, and slightly sinuous. The ambulacral areæ are narrow and bear miliary granules only. The pore-areæ are simple, the pores of each pair closely approximated. The interambulacral plates are large, eight to ten in a row. The areolæ are large and elliptical, and show a tendency to become confluent. The bosses of the primary tubercles are smooth or crenulated. The tubercles are of moderate size, smooth and perforated. The ovarial plates are large, halbert-shaped. A deep arch-like cleft passes inwards through about one third of the width of the plate, and a corresponding cleft separates through part of their length the two last interambulacral plates of each double series, so that the two clefts together form a large diamond-shaped opening through the test. This opening is filled up by a strong chitinous membrane, and a large pore penetrates the centre of the membrane, affording an exit to the duct of the ovary. The primary radioles are large and long, cylindrical or pointed round

the ambitus, but in the neighbourhood of the peristome becoming flattened, curved, longitudinally striated, and strongly toothed round the edge; in fact assuming a very peculiar and characteristic form. The pedicellariæ are numerous and two-valved, a structure as yet unique, so far as I am aware, among Echinoideans. The auricles are fused together through the greater part of their height in the middle of the interambulacral areæ, sending off short wing-like processes which arch over towards the ambulacra, but scarcely extend beyond their edges. The peristomial opening, the buccal membrane, and the dental pyramid and teeth have much the same character as in *Cidaris*.

I feel very little hesitation in referring the following very remarkable form to the genus *Porocidaris* of DESOR, even although it is wanting in the very character upon which that genus was founded, and although the characters upon which its claims to generic distinctness are based are not shown in any of the fragments which alone have been met with in a fossil state. M. DESOR gives the following characters of the genus. The areolæ, which have the form and general character of those of *Cidaris*, are pierced round the edge by a series of apertures; these pores are placed in the course of little grooves which radiate from the boss. The alveoli have a tendency to become confluent. The tubercles are perforated and crenulated. The radioles are compressed into the form of plates, and are curved, deeply grooved longitudinally, and strongly toothed along the edges. From their very remarkable form several species have been founded upon these radioles alone.

Some separate plates have been found associated with the radioles of one species only, *Porocidaris verronensis*, Schmidel, from the Nummulitic Tertiaries of Verona and of the neighbourhood of Nice; the other species (*P. serrata*, D'Archiac, from beds of the same age near Biarritz; *P. serraria*, Broun, from the Miocenes of Castel Arguato; and *P. Schmidelii*, Münster, from the Lower Oolite of the valley of the Frick) rest upon the evidence of the spines only. The last species M. DESOR quotes with some hesitation, as it would be somewhat remarkable to meet with the same type at such distant periods, while they do not seem to occur in intervening beds. The recent species dredged off the north of Scotland has the spines, the perforated and crenulated bosses, and the coalescing areolæ of *Porocidaris*, which genus is known to come down as far as the Miocene Tertiaries; and it must be remarked that many animal forms hitherto known only as Miocene fossils are met with living at great depths in the present sea.

M. DESOR attached much significance to the ring of perforations in the scrobicular area. In this I cannot concur. Several species of *Cidaris*, and even more markedly the species of *Porocidaris* under discussion, have radiating muscular impressions for the insertion of the muscles which move the large spines. It is perfectly conceivable that these depressions may sometimes actually go through the test, or at all events leave it so thin that the action of water and attrition during the process of fossilization may be well supposed to have completed the perforation.

Porocidaris purpurata, Wy. T. (Plate LXI. & Plate LIX. figs. 14 & 15.)

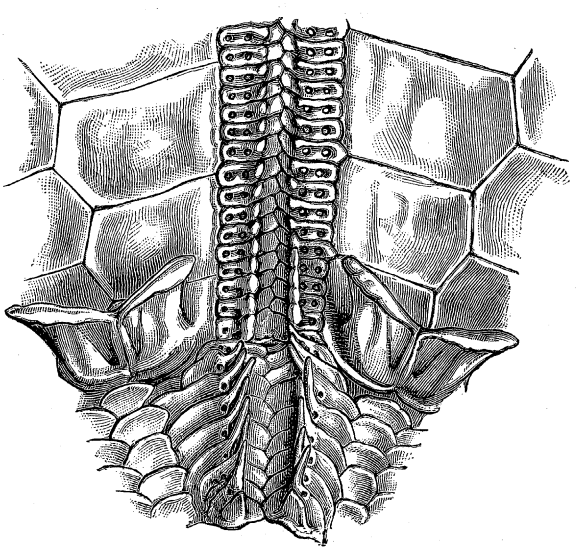
Synonyms:—*Porocidaris purpurata*, Wyville Thomson, Proc. R. S. 1869, 1872; The Depths of the Sea, 1873; *Porocidaris purpurata*, Alexander Agassiz, Revision of the *Echini*, 1872.

The test (Plate LXI. figs. 2, 3), in what appears to be a full-sized example of this species, from a depth of 542 fathoms about 100 miles to the north of the Butt of the Lews, is generally globular, but decidedly pentagonal in outline, owing to the central portions of the interambulacral areæ projecting considerably beyond the lateral portions and the ambulacra. It is 50 millims. in diameter at the ambitus, and greatly depressed, its polar axis not being more than 35 millims. in length. The ambulacra are narrow and band-like, 4 millims. in width between the outer edges of the pore-areæ, which occupy the greater part of the space, seeing that the central miliary strap of the ambulacra bears only two marginal rows of larger miliary tubercles with a few minute granules irregularly scattered between them.

The interambulacral areæ are wide, about 22 millims. in width at the ambitus. The plates are large, eight or nine in longitudinal series. The areolæ, which are transversely elliptical, slightly depressed, and surrounded by a raised border, occupy the greater part of the surface of the plates, the interspaces being crowded with miliary granules. A single row of large granules occupies the raised border of the areola. The bosses for the primary tubercles are rather prominent, those on the oral aspect of the test smooth, those on the apical aspect strongly crenulated, the change taking place quite suddenly at the ambitus. The tubercles are of moderate size, smooth, and perforated.

The peristomial opening in the test is proportionally rather small, in the specimen described 7 millims. in diameter. The peristome is subpentagonal, not notched. The buccal membrane is paved with imbricated scales, ten double rows ambulacral, and perforated up to the edge of the mouth with double pores in continuation of the pore-areas of the corona. The interambulacral spaces are filled up by a single row, or an imperfect double row, of imperforate scales, which alternate in imbrication with the neighbouring ambulacral scales. The free edges of all the scales are crowded with granules for the articulation of small spines of a special form. On the inner surface the ambulacral scales of the buccal membrane rise up into a series of curved spines on each side of the ambulacral vessel, so as to form a kind of channel for the passage of the

Fig. 2.



Auricles and buccal membrane of *Porocidaris purpurata*. ×5.

vessel continuous with the channel formed by processes of the ambulacral plates towards the oral end of the ambulacral areæ of the corona. The apical disk is very wide, 23 millims. in diameter. The ovarial plates are halbert-shaped; the cleft in their outer border is 3 millims. in depth and 3 millims. in width at the base, where it meets the corresponding cleft between the interambulacral plates. One of the ovarial plates is modified, as in *Cidaris*, to include the madreporic tubercle. The ocular plates are very regularly heart-shaped. The pore for the sense-organ is very distinct, about one fourth of the width of the plate from its outer edge. The peri-proct is pentagonal, the outer row of plates large and somewhat irregular in form, the inner plates becoming smaller towards the central anal orifice, round which the final two or three rows converge almost in the form of spines.

The primary radioles are longest round the ambitus, from 100 to 120 millims. in length (Plate LXI. figs. 4, 5), cylindrical or pointed, finely striated longitudinally, with some of the ridges prominent and rising into irregular lines of strong spines. The radioles on the apical aspect of the test become gradually somewhat shorter and are more pointed (Plate LXI. figs. 6, 7); on the oral surface they diminish in size towards the mouth, and assume the flattened, curved, grooved, toothed, paddle-like shape characteristic of the genus (Plate LXI. figs. 8, 9, 10). The spines of the second series form single rows converging towards the base of the principal spines over the alveolæ; they are flattened and striated, and about 10 millims. in length. The spines of the third series are narrower and more pointed, about 8 millims. in length, and diverge from the outer edges of the central band of the ambulacra over the pore-areæ. Smaller pointed spines are articulated to the smaller miliary granules over the surface of the test. The pedicellariæ are very remarkable. They consist of two long pointed valves, which, when closed, resemble very closely the smaller forms of the flattened spines (Plate LIX. fig. 14). Their structure, however, is in every way the same as that of the ordinary three-valved pedicellariæ, except in the number of the valves. All the usual chambers and ridges are developed, and the different muscles are very evident through the transparent walls; they are congregated chiefly on the apical disk and along the edges of the pore-areæ.

The basal portions of most of the large spines for about one third of the length of the spines are of a rich deep purple, and the remainder of the spines pale pink. Some of the large spines are of a uniform purplish brown, and all the smaller spines and the pedicellariæ are of a rich purple-brown.

The dental pyramid is lower and a little wider in proportion than in *Cidaris*; but it is constructed on the same plan, the epiphyses of the tooth-sockets forming ear-like appendages, but not uniting into an arch. The teeth are simply channelled, as in *Cidaris*. The auricles start from the interambulacral areæ, in the centre of which the two adjacent buttresses of two auricles are soldered together through nearly their whole height (woodcut, fig. 2), and only send out a small curved expansion which projects slightly towards the ambulacral groove. The tube feet are provided with suckers, which are supported by small and irregularly formed calcareous rosettes, and very small calca-

reous styles are scattered in the walls of the vessel. The ovaries are botryoidal, loosely lobed, and of rather small size. The ovarial ducts are very wide, and the ova are remarkably large. No calcareous framework could be detected in the investing membrane of the ovaries, but small irregular fenestrated plates are imbedded in the wall of the intestine.

With the general facies of *Cidaris*, *Porocidaris purpurata* differs in many remarkable details. Probably the character of the highest physiological import is the structure and great size of the ovarial openings, particularly when taken in connexion with the unusual size of the ova. The form of the pedicellariæ and the form and arrangement of the scales of the buccal membrane are likewise highly characteristic.

Four specimens were taken with the dredge at one station about 100 miles to the north of the Hebrides. One or two spines of apparently the same species were dredged by Mr. Gwyn Jeffreys off Cape Espichel. As I have already said, I have no doubt that this species must be associated, at all events generically, with the tertiary species of *Porocidaris*, and that it is one of the many examples, which are now forcing themselves upon our notice daily, of the persistence of tertiary, and even of older, types in deep water to the present day.

No representatives of the Saleniadæ or or the Diadematidæ were procured in these dredgings.

II.

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Family 2. Echinothuridæ, fam. nov.

Regular Echinoideans with the plates of the test imbricated and the test flexible. The plates of the interambulacral areas overlap from the mouth towards the apex, and the ambulacral plates in the opposite direction. The plates of the ambulacral areas are within those of the interambulacral areas, and their ends are overlapped by the ends of the adjacent interambulacral plates. The peristome is covered by ten double rows of imbricated calcareous scales, and five alternate double rows of these are perforated for the passage of tube feet in continuous series with those of the ambulacral areas of the corona, as in the Cidaridæ. The edge of the peristome is entire, as in the Cidaridæ. The spines are hollow, as in the Diadematidæ. The ambulacral tubes on the oral surface of the test are provided with a sucking-disk supported by a rosette of fenestrated calcareous plates, while those on the apical surface are long, conical, and pointed, without either sucking-disks or terminal pits. On both aspects of the body the walls of the tubes contain fenestrated calcareous spicules.

The dental pyramid is large and strong. Epiphyses are developed on the upper and outer angles of the pairs of tooth-sockets, but there is no arch formed. The teeth are deeply and symmetrically channelled within. The auriculæ are large and strong, forming closed arches, and their bases are united across the interambulacral spaces by strong

calcareous ridges. The auriculæ have the effect of springing from the edges of the ambulacral plates; but this character seems to have but little value, as the ring of calcified elements forming the auriculæ and their uniting ridges appears to be entirely distinct, merely forming adhesions with the ambulacral and interambulacral elements of the perisom in its course.

The peristome and the periproct are unusually large; the peristome entire in outline, and the peristomial membrane mailed, as in the Cidaridæ; and the periproct somewhat irregular in form, owing to the large size of the ovarial plates. The pores of the ambulacral areas are trigeminal; but the two pairs of each arc nearest the central line of the area are approximate to one another, and each pair penetrates an accessory plate, the two accessory pore-plates being intercalated between two of the ambulacral plates, while the third pair of pores of the arc is remote from the others, and penetrates the substance of the ambulacral plate near its outer edge. The ambulacral areas are rather wide, usually more than one half the width of the interambulacral areas.

The Echinothuridæ occupy an intermediate position between the Cidaridæ and the Diadematidæ, certain very important anatomical characters associating them with the former family, while in general facies and habit they more nearly resemble the latter. As in *Cidaris* the edge of the peristomial opening is entire, and the oral branchiæ are absent; the peristomial membrane is covered with imbricated calcareous scales, with their free edges studded with tubercles for spines and pedicellariæ, and perforated for lines of tube-feet which carry the ambulacra up to the edge of the mouth. As in *Cidaris*, *Diadema*, and *Echinocidaris*, the tube feet on the apical surface of the test are conical, with neither sucking-disks nor terminal pits; and as in *Cidaris*, *Diadema*, and *Echinocidaris*, the epiphyses of the tooth-sockets do not unite into an arch over the roots of the teeth. As in *Cidaris* and *Diadema*, there is no central ridge dividing the inner tooth-groove, and, as in many species of the Diadematidæ, the spines are hollow.

From the Cidaridæ, the Echinothuridæ differ in the arrangement and in the delicacy of the calcareous structures of the perisom, in the relations of the auriculæ (which start from the edges of the ambulacral areas, and not from the interambulacral plates), and in the structure of the spines. From the Diadematidæ, they differ in the absence of external oral branchiæ and branchial notches, and in the continuity of the ranges of pores up to the edge of the mouth; and they differ from the Echinidæ in the absence of longitudinal ridges dividing the concavity of the teeth.

The flexibility of the shell, the continuity of the ambulacra over the membrane of the peristome, the hollow spines, the peculiar arrangement of the pairs of pores, the singularly large ovarial openings, the absence of calcified arches uniting the elements of the tooth-sockets, the simply grooved teeth, the duck-billed pedicellariæ, and the singular arrangement of the walls of fenestrated fascia bounding the ambulacral spaces, form together an assemblage of characters which altogether preclude the fusion of the group with any family hitherto defined. It is very possible that *Asthenosoma varium*, Grube (45ter Jahres-Bericht d. schles. Gesell. f. vat. Cult. Breslau, 1868), may belong to this

family; but, if so, all the important anatomical characters, the overlapping of the plates of the perisom, the absence of branchial notches, the heterogeneous tube feet and their occurrence on the peristomial membrane up to the edge of the mouth, are omitted in the description.

The genus *Astropyga*, rightly placed among the Diadematidæ, certainly approaches the Echinothuridæ in many respects, and resembles them closely in general appearance. The plates of the perisom in *Astropyga* overlap slightly, but they all overlap in one direction, towards the apical pole; so that the arrangement in the two forms, though presenting a certain resemblance, is essentially different. The peristomial membrane in *Astropyga* is studded with irregular calcareous granules, with ten perforated bosses for the five pairs of large mouth-tentacles; and the edge of the peristome is deeply notched for the external branchiæ. The groove on the inner surface of the teeth becomes gradually filled up towards the tip. The spines are solid. The pairs of pores are trigeminate, arranged in symmetrical arcs as in the typical Diadematidæ. There is a marked difference in character between the apical and the oral surfaces of the test, which recalls this peculiarity in *Phormosoma*; and the structure of the small pedicellariæ is somewhat similar to that of the pedicellariæ in the Echinothuridæ. It appears, therefore, that while some characters would seem to indicate a tendency to a passage from the Diadematidæ to the Echinothuridæ through such forms as *Astropyga*, the resemblances are for the most part superficial, and very important anatomical characters maintain, according to our present knowledge, a broad line of distinction between the families.

Phormosoma, gen. nov.

Plates of the corona only slightly overlapping, and forming a continuous shell without membranous interspaces. Ambulacral and interambulacral areas of the apical surface of the test with irregular rows of primary tubercles with small areolæ. Oral surface of the test different in character from the apical, with the areolæ of the primary spines large and deep, occupying a large portion of the surface both of the interambulacral and of the ambulacral plates.

Phormosoma placenta, sp. nov. (Plate LXII. and Plate LXIII. figs. 1–8.)

The test is extremely thin, round, and much depressed. The only example which was procured in a condition sufficiently perfect for measurement is 80 millims. in diameter by about 18 millims. in height. The interambulacral areas are 32 millims. in width at the edge of the disk-like body, and the ambulacral areas 16 millims., exactly half. The peristome is 30 millims. in diameter, nearly circular, without notches, and the periproct 30 millims. from the outer edge of an ovarial group of granules to the outer edge of the opposite ocular plate.

The apical surface of the corona (Plate LXII. fig. 2) is slightly arched, not much more so apparently than is necessary for the accommodation of the masticatory pyramid. At the circumference the test is angular, almost carinated, and the ventral surface of the

body is nearly flat. The interambulacral plates of the apical surface are transversely oblong, the alternating double row meeting in the central line of the interambulacral area in a serrated suture; thus the plates of the opposite sides of the area slightly overlap, and all the plates of the interambulacral area slightly overlap one another from the circumference of the test towards the apex. The outer edges of the interambulacral plates are truncated, and form together nearly a straight line, the whole series overlapping the outer edges of the plates of the adjacent ambulacral areas (Plate LXIII. figs. 6 & 7). The plates of the ambulacral areas are thus essentially *within* those of the interambulacral areas. The first four or five interambulacral plates of each area towards the apex are separated—in four of the areas to accommodate the outer angle of the groups of tubercles which represent the genital plates in this genus, and in the fifth to admit the madreporic tubercle (Plate LXIII. fig. 4).

The surface of the interambulacral plates is smooth, with sparsely scattered primary tubercles, a few secondary tubercles, and a few minute miliary grains (Plate LXIII. fig. 5). The primary tubercles are one or two on each plate towards the apical end of the area; but they become more numerous, two at least, and often three, on each plate towards the circumference. The primary tubercles are perforated. The mamelon is surmounted by a distinct porcellanous ring, but is not crenulated. The areola is well marked, slightly excavated, and about 1·5 millim. in diameter. The number of interambulacral plates in series, from the circumference of the test to the edge of the periproct, is about ten.

The ambulacral plates of the apical surface are likewise oblong, in double series; meeting in the centre of the ambulacral area in a serrated suture. The outer edges of the plates are slightly rounded. The plates overlap from the apex towards the circumference. The outer edges of the ambulacral plates are entirely covered by the outer ends of the plates of the adjacent interambulacral series. Nearly midway between the central line of the ambulacral area and the outer edge, two small accessory plates, each perforated with a double pore, are intercalated between each contiguous pair of ambulacral plates; and another pair of pores, forming the lowest pair of an arc, penetrates the substance of the ambulacral plate a little nearer the outer edge. The pores are therefore trigeminal (Plate LXIII. figs. 5 & 6). Each ambulacral plate usually bears towards the centre a single primary tubercle or two smaller-sized tubercles, or, in some cases, only miliary granules. The number of ambulacral plates in series from the edge of the periproct to the circumference is about fifteen.

At the circumference there is an abrupt change of character. Just above the edge there is a nearly continuous band, running through all the plates, of large miliary tubercles bearing five spines, which form a kind of marginal fringe; and beneath that, towards the lower surface, an interrupted smooth band with neither tubercles nor granules; and the ambulacral and interambulacral areas then proceed towards the edge of the peristome. Each interambulacral plate is deeply excavated or impressed with two or three disproportionately large and deep areolæ, which appear on the outside like deep cups

upwards of 4 millims. in diameter, surrounded by a distinct areolar ridge with miliary tubercles, the areolæ sometimes tending to become confluent. On the inside of the test, owing to the thinness of the shell, the areolæ have the appearance of raised bullæ (Plate LXII. fig. 1, Plate LXIII. figs. 1, 2, 3). The mamelon is large and hollow, with an entire porcellanous ring; the tubercle is rather small and perforated. The general arrangement of the plates is the same on the lower as on the upper surface, but it is difficult to make out the sutures from the extraordinary size of the scrobiculæ. The pairs of pores are jostled into single file, and find their way to the edge of the peristome as best they can.

The apical opening (Plate LXIII. fig. 5) is very large and star-shaped, owing to the passing down into the interambulacral areas of a triangular prolongation of the membrane of the periproct, in the centre of which the ovarial duct opens. Over each ovarial aperture there is a small crescentic calcareous plate; and this, with a set of small calcareous granules imbedded in the membrane round the opening, represents the large ovarial plate, which is usually developed in this position. The madreporic tubercle, which is reniform and of large size, is in the position of the crescentic plate above one of the ovarial openings. The ocular plates are quadrate, with the angles rounded. The anal aperture is central, and the membrane of the periproct is thickly studded with small round plates, most of them bearing a miliary granule and a spine, the interstices between them filled up with calcareous granules thickly set. The plates decrease in size towards the anus, and immediately round the opening they become lengthened, and have almost the character of spicules converging towards it.

The peristome is mailed with ten double rows of thick calcareous imbricated scales, five double rows ambulacral and five interambulacral, all overlapping towards the mouth. The ambulacral scales are perforated for the passage of processes from the ambulacral canals which pass right up to the edge of the mouth-opening (Plate LXII. fig. 1).

There are two kinds of spines, one articulated to the primary tubercles, and the other to the minute miliary tubercles. The larger spines (Plate LXII. fig. 3) are from 10 to 15 millims. in length, with the shaft 5 millims. in diameter; they are hollow, consisting of a fenestrated calcareous tube with eight to ten projecting ridges, which are here and there raised into obliquely ascending spines. Sometimes a spiral arrangement may be detected in their projections, as we see in the very small spines of *Diadema*. The proximal end of the spine is enlarged, with a marked ring, and a space for the insertion of the large muscular mass which fills the deep alveola. The acetabulum is shallow, with a smooth margin and a central pit for the "round ligament." The distal end of the spine is drawn to a transparent point, like the drawn-out and sealed end of a glass tube (Plate LXII. fig. 3). The smaller spines are excessively fine hair-like fenestrated calcareous tubes. The spines are most numerous towards the edge and on the oral surface of the body, the small spines, mixed with pedicellariæ, clothing the scales of the peristomial membrane close up to the mouth. It is difficult to imagine the object of the peculiar arrangement on the oral portion of the corona; the size of the areolæ and of the masses

of muscle which fill them seem disproportionate to the rather small and very delicate and fragile spines.

There are two forms of pedicellariæ: one (Plate LXII. fig. 5), which occurs in small number in rows obscurely parallel with those of the larger spines, approaches in form the ordinary tridactyle pedicellariæ of the Echinidæ, though presenting some special characters; the second is a peculiar form of the so-called "ophiocephalous" pedicellariæ, peculiar, so far as I am aware, to the Echinothuridæ and the Diadematidæ (Plate LXII. fig. 6). The head of this pedicellaria is three-valved and very minute—in the present species not more than ·5 millim. in length. The distal end of the valve is broad and thin, and the three valves when closed meet only at the edges, and leave a small triangular space in the centre. The proximal end of each valve is truncated, ending in a triangular fluted plate. These three plates, meeting in the centre, form the base of the head of the pedicellaria, and are attached beneath to a gelatinous column about equal in length to the valve of the pedicellaria, which intervenes between the head and the end of the delicate stem. About the middle of each valve the fenestrated calcareous plate of which it is formed appears to curl inwards on each side, and the valve becomes double, forming a small conical chamber. A triangular keel runs from the inner angle of the basal plate up the face of this chamber in the middle line nearly to the point where the chamber ceases and the plate becomes single. The calcareous rod supporting the pedicellaria is of considerable length, from 3 to 5 millims. Pedicellariæ of this description are excessively numerous, scattered apparently irregularly all over the test; they are particularly abundant on the lower surface towards the edge of the peristome.

The tube feet on the lower surface of the test have their walls supported by large, broad, fenestrated plates (Plate LXIII. fig. 8), and are provided with a sucker with a well-developed calcareous rosette of four or five pieces. The tube feet on the apical surface of the test are much longer, conical, and come to a point: these are probably subservient to the function of respiration only.

The auriculæ are well developed and strong, though not very heavy. The two sides meet in a complete arch. Each pair of adjacent auriculæ are connected together by a raised calcareous ridge, which passes across, soldered to the interambulacral plates (Plate LXIII. fig. 1). The jaws are short and very wide, forming together a wide depressed pyramid. The two sides of each jaw-pair are broad and wing-like, and their outer angles present scarcely a trace even of epiphyses. The teeth are simply channelled, and come to a fine sharp point, as in some species of *Diadema*.

The specimen from which the above description was taken, the only one procured with the exception of some fragments, was torn open and the soft parts were greatly injured. The ovaries were long and narrow, running, closely attached to the test, from the ovarial opening to the periphery, along the middle line of the interambulacral space. The colour of the test is a pale grey flecked with purple. The tube feet are purple, and the spines are nearly colourless.

Locality. One imperfect specimen from a depth of about 500 fathoms, lat. 59° 43′ N.,

long. 7° 40′ W., about 100 miles to the north of the Butt of the Lews. Numerous fragments and spines from depths from 500 to 800 fathoms off the west coasts of Scotland and Ireland.

This form derives a special interest from its evident relation to the fossil *Echinothuria floris* from the White Chalk, described by the late Dr. S. P. Woodward.

Two imperfect specimens of this singular fossil had been obtained—the first, many years ago, by Mr. Wickham Flower, of Park Hill, Croydon, from the Upper Chalk of Higham, near Rochester, and the second by the Rev. Norman Glass, from Charlton, in Kent.

Mr. Flower's specimen consisted of several series of imbricated plates converging towards a point, and some of them showing the characteristic double pores and spine-tubercles of the Echinoderms, which at once set aside the first idea that it might be part of a large cirriped allied to *Loricula*. Edward Forbes examined the Higham specimen, but was unable to come to a decision. Afterwards Dr. Woodward examined it, and felt in a like dilemma. The general impression was that it might be a group of the scales of the peristome or the periproct of some large Echinoid allied to *Diadema* or *Cyphosoma*.

While Dr. Woodward was hesitating about publishing Mr. Flower's specimen, the second example was procured by the Rev. Mr. Glass, and it seemed to solve the problem; for it consisted of a well-developed dental apparatus with portions of several series of imbricating plates radiating from it, thus apparently supplying the peristome and lantern of the same great *Diadema* or *Cyphosoma* of which Mr. Flower's specimen might be the apex or periproct.

Still there were difficulties in the way of accepting this explanation. Dr. Woodward writes:—"In Mr. Flower's specimen the imperforate plates imbricate towards the centre, where the smaller ends of the several series converge. In Mr. Glass's specimen they slope away from the centre or mouth, that is also towards the apex. The perforated or ambulacral plates which overlap one another outwardly in fig. 1 are seen in fig. 2 sloping towards the dental cone and reclining upon it. The portion of an ambulacral area (*a*, fig. 2) consists of seven plates, diminishing in size in a line not accurately directed towards the centre. This portion exhibits the interior surface of the plates, known by their curved surfaces destitute of ornamental granules; it is not, however, the oral end of one of the segments turned over (a thing scarcely possible to happen), for in that case the dip of the plates would be reversed; but it must be the opposite (or apical) extremity of a series folded back upon its origin and exposed to view by the damage which the surface of the specimen has sustained. From this circumstance it seems probable that the whole fossil when complete was not elongated nor even spherical, but somewhat depressed in a vertical direction, though doubtless admitting of a moderate degree of flexure. At the last hour, after making this drawing, I ventured to clear away the chalk from the side of Mr. Glass's fossil, where the ambulacral segment is seen to curve as if it might be continued round to the other surface. The attempt was successful; for the ambulacrum and also the adjacent interambulacral segment were found conti-

nuous, though crowded and displaced at the turns, falling again into regular order and diminishing in size, though not nearly so complete as in Mr. FLOWER'S specimen.

"After this apparently conclusive demonstration it appears desirable to give a name to this fossil, and to attempt a short description, although its rank and affinities are to us still a matter of conjecture. At present it is one of those anomalous organizations which MILNE-EDWARDS compares to solitary stars belonging to no constellation in particular. The disciples of VON BAER may regard it as 'a generalized form' of Echinoderm, coming, however, rather late in the geological day. The publication of it should be acceptable to those who base their hopes on the 'imperfection of the geological record,' as it seems to indicate the former existence of a family or tribe whose full history must ever remain unknown.

"Order ECHINIDÆ.

"Genus *Echinothuria*.

"*Echinothuria floris*, n. sp. Test globular ?, diameter of compressed specimen 4 inches, thickness $\frac{1}{2}$ an inch, lantern projecting $\frac{1}{2}$ an inch; composed of ten segments or double series of imbricating plates, ornamented with obscure miliary granules and small spine-bearing tubercles, a few larger than the rest; *interambulacral* plates narrow, slightly curved, with the convex edge upwards and overlapping; the alternate plates bearing one large extero-lateral tubercle, perforated and surrounded by a raised ring and smooth areola; largest plates measuring 6 lines in length, the smallest 3 lines or less (the longest in second specimen equalling 7 lines); *ambulacral* plates 7 lines long, equalling the breadth of the exposed portions of eight plates, similar to the former, but curving and imbricating downwards towards the dental orifice, and having two small plates, each perforated by a pair of pores, intercalated in a notch of the middle of the lower margin; a third pair of pores perforating the plate itself a little external to the centre; primary tubercles few, irregularly distributed.

"*Spines* of three kinds, those adhering to the plates minute and striated; fragments of larger spines (not certainly belonging to the species) striated, annulated, and furnished with a prominent collar to the articular end (fig. C); the third kind minute, clavate, and truncate, articulated (?) to a slender stalk (fig. E *d*)"*.

Calveria, gen. nov.

Plates of the corona greatly expanded towards the middle line of the interambulacral and ambulacral areas, the wide expanded portions overlapping. The plates curve abruptly about one third of their length from the middle line in the interambulacral spaces towards the mouth, and in the ambulacral areas towards the apex (the direction opposite to that in which they overlap). The outer portions of the plate in each area are so narrow as to leave spaces between the plates covered by membrane only. There is no special difference in character between the apical and the oral surfaces of the test.

* "On *Echinothuria floris*, a new and anomalous Echinoderm from the Chalk of Kent," by S. P. WOODWARD, Geologist, vol. vi. (1863) p. 330.

1. *Calveria hystrix*, sp. nov. (Plates LXIV. & LXV.)

The test is circular and depressed. The calcareous plates are very thin, but they are imbedded in a firm leathery perisom, so that the body-wall is tough and resistant. The only perfect specimen of the species procured is 130 millims. in diameter and about 25 millims. in height. The interambulacral areas are about one third wider than the ambulacral. The peristome is 35 millims. in diameter, and the periproct 20 millims. from the outer edge of an ocular plate to the outer edge of the ovarial plate opposite. Both the apical and the oral surfaces are nearly flat. The edge is round and full, with no tendency to become angular; and the plates, both ambulacral and interambulacral, retain, in passing round the edge, the same character, both as to form and position and as to the distribution of primary and secondary tubercles, which they have on other parts of the test. The number of interambulacral plates in a row extending from the edge of the peristome to that of the periproct is about forty-four, and that of the ambulacral plates considerably greater, as very frequently two ambulacral plates terminate under one interambulacral plate. Near the circumference, on the oral surface, the interambulacral plates are 25 millims. in length, and the narrowest part of the plate is 2·5 millims. in width, expanding at the middle line to 4 millims. The narrow strap-shaped portion of the plate occupying the outer part of the interambulacral area is 20 millims. in length, and the wide expansion which over- or underlaps the like expansion of the corresponding plate on the other side of the area in the middle line is about 5 millims.; so that although the total length of each interambulacral plate is 25 millims., the total width of the area is not much more than 40 millims. Each plate is rounded and somewhat expanded towards the outer edge, where it covers the end of one or of two ambulacral plates; and at this point it bears a primary tubercle with a large smooth scrobicular area. It then continues for about two thirds of its length narrow and strap-shaped, bearing a few secondary tubercles and miliary grains. It then expands again and bears another primary tubercle not quite so large as the former, and then abruptly curves towards the oral pole, passing in that direction under the expanded end of its fellow on the opposite side. The outer surface of the expanded portions of the plate, in the centre of the area, is also studded with miliary granules (Plate LXV. figs. 1 & 2).

The strap-shaped portions of the plate between the two primary tubercles is so much narrowed that the plates of a series are not in contact at this point, a narrow linear space being left between them, closed only by the soft perisom and the membrane in which the calcareous plates are formed.

The ambulacral plates are much narrower than the interambulacral. They likewise have narrow fenestræ between them towards their outer ends, and they overlap, though not to so great an extent, in the centre of the ambulacral area. Each ambulacral plate is studded with secondary tubercles and miliary granules, and at about two thirds of its length from the outer edge it bears a small primary tubercle. As in *Phormosoma*, the double pores are arranged in arcs of three, and, as in that genus, the two inner pairs of pores pass through special pore-plates intercalated between the ambulacral plates, while

the third pair, remote from the others, penetrates the ambulacral plate near its outer end.

About two thirds of their length from the outer edge, the ambulacral plates bend strongly towards the apical pole, as in the case of the interambulacral plates, in the direction contrary to that in which they overlap. The outer edges of the series of ambulacral plates are covered by the ends of the plates of the interambulacral series. Frequently only one ambulacral plate slips under the end of one interambulacral plate; but perhaps once out of thrice the outer ends of two ambulacral plates approach one another, and together are covered by the end of one interambulacral plate. The ambulacral plates are thus considerably more numerous than the interambulacral. As already stated, the interambulacral and ambulacral plates do not differ materially either in their individual form or in their arrangement in combination on the opposing surfaces of the flattened corona.

The primary tubercles are perforated. The mamelon is surrounded by a slightly marked ring, but is not crenulated. The areola is large and is not depressed, or very slightly so. The tubercle, mamelon, and scrobicule seem to be formed of a separate calcareous piece, cemented, as it were, to the surface of the plate which passes behind it, leaving the mamelon hollow, and a small conical space between the tubercle and the inner calcified layer of the plate.

The larger spines (those which are articulated to the primary tubercles) are from 15 to 20 millims. in length and ·8 millim. in diameter. They are hollow as in *Phormosoma*, the fenestrated calcareous tube rising into from sixteen to twenty ridges, between which are uniform rows of fenestræ. As in the former genus, the ridges rise here and there into processes which have a distinctly spiral arrangement in the larger spines. Near the proximal end the spine is markedly enlarged, running out a kind of collar; and from this point it diminishes, forming a regular cone down to the acetabulum, which is shallow, with a puncture in the centre for the insertion of the ligament of the spine (Plate LXIV. fig. 2). The fine spines articulated to the miliary tubercles are extremely delicate fenestrated calcareous tubes running to a fine point.

The pedicellariæ are very numerous and of three forms. The largest are the least numerous; they occur in irregular rows parallel with and near the rows of large spines, and are also sparsely scattered, apparently irregularly, over the surface of the test. The head (Plate LXIV. fig. 4) is not less than 1·2 millim. in length; and as these pedicellariæ are attached to stalks as long as medium-sized spines, they can be seen quite distinctly with the naked eye (Plate LXIV. fig. 1). They have the general character of the tridactyle pedicellariæ of the Echinoideans, only the basal triangular portion of each valve is unusually broad; the middle part is arched outwards and narrow, and the terminal expanded part is shorter and more regularly spoon-shaped than in most species. The second form (Plate LXIV. fig. 5), which is a modification of the first more or less reduced in size and lengthened in its proportions, is like some of the common varieties in the Cidaridæ. The third (Plate LXIV. fig. 6) resembles in all essential respects the

small pedicellariæ in *Phormosoma*. The valves are somewhat thicker and stronger and wider at the distal end in proportion to the width of the base, therefore widening out more. The head of the pedicellaria has thus more the form of an inverted cone.

The tube feet on the oral surface of the test are cylindrical, expanding distally into a sucker, which is supported by a fenestrated calcareous disk in four, five, or six pieces, with the edge produced into an irregular spiny border. Irregular cribriform plates (Plate LXIV. fig. 3) are imbedded in the walls of the tubes on both surfaces of the body. The tube feet on the apical surface are conical and pointed, with neither sucking-disk nor terminal pit.

The ovarial plates are complete and triangular in form; the aperture is very large, and filled in with a membrane of a dark purplish colour. As has been already said, the interambulacral plates, while overlapping towards the apical pole, bend strongly near the middle line of the area towards the mouth. The triangular space thus left between the first pair of plates of the series is occupied in four of the areas by the large ovarial plates, and in the fifth by the still larger ovarial plate, which is partly modified into the madreporiform tubercle. The membrane of the periproct is thickly set with discoid plates, becoming gradually smaller towards the circumference of the anus, and studded with small spines and small pedicellariæ. The ocular plates are club-shaped, and touch the outer angles of the ovarial plates on either side. A strong calcareous ridge runs across each ambulacral area at the border of the peristomial opening of the test, soldering its plates together, and rising up at the edge of the ambulacral area into a rod which forms one half of the auricle, which arches over the ambulacral space by uniting by a small anchylosed suture with the corresponding rod on the other side.

The peristomial membrane is covered by twenty rows of densely imbricated scales in ten double rows, corresponding with the ambulacral and interambulacral areas of the test. The plates of the peristome are all imbricated towards the mouth. The scales of the five double rows, corresponding with the ambulacra, are perforated towards their outer angles with double pores, which carry the tube feet up to the edge of the oral opening. The peristomial scales are studded with small tubercles bearing small spines and many pedicellariæ. The edge of the peristomial aperture is entire, as in *Cidaris*, without branchial notches.

The dentary pyramid is broad and low. The pairs of jaws are broadly triangular; the epiphyses are small, and show no tendency to form an arch. The rotulæ are wide and strong. The teeth have much the character of those of *Diadema*, being narrow and coming to a long point, and being simply grooved without the characteristic inner ridge of the Echinidæ.

The colour of the perisom is a brilliant deep rose inclining to claret-colour; twenty bands of deeper shade run in pairs, alternately closer and more remote from one another, along the ambulacral and interambulacral spaces. The ends of the spines are pale pink, and the tube feet are nearly white.

The specimen of *Calveria hystrix* from which the above description was taken, the

only one of its species which we met with, was dredged about 100 miles off the Butt of the Lews in 445 fathoms water on the edge of the warm area, with a temperature of 7°·5 C. It came up perfect and living. The spines were moving freely; and after the animal had rolled out of the dredge upon the deck, and assumed what appeared to be its normal form and attitude, curious vermicular movements passed through its test. When handled the test moved and shrank from the touch, and had much the feel of the disk of a *Polaster* or other large starfish.

As this specimen was exceptionally good it was reserved nearly intact to show the general characters of the group, a small segment of the ventral surface only having been removed to allow the description of the structure of the test and pyramid. The disposition of the plates and the structure and arrangement of the soft parts will be more fully detailed in the description of the next species, for which there were fuller materials. Fragments of plates and spines apparently belonging to *Calveria hystrix* occurred in several of the dredgings on the west coasts of Scotland and Ireland.

2. *Calveria fenestrata*, sp. nov. (Plate LXIII. figs. 9 & 10 and Plates LXVI. & LXVII.)

The test is rounded, slightly pentagonal in outline; in the largest specimen procured 110 millims. in diameter. It is greatly depressed, being little more than 20 millims. in extreme height in the centre, from which the upper surface droops uniformly to the edge, which is sharper than in *C. hystrix*, although it does not form any thing like the keel of *Phormosoma*. The form and general arrangement of the plates is the same on the apical and oral surfaces of the test. The structure of the ambulacral and interambulacral areas is the same as in *C. hystrix*; the overlapping portion of the plates is, however, much larger and wider, and the strap-shaped portion of the plate is much narrower, narrowed in some cases almost to a rod, and thus leaving wide membranous fenestræ between the plates. The ambulacral areas are nearly equal to the interambulacral in width, while in *C. hystrix* they are at least one third narrower, and the plates of the perisom generally are lighter and more delicate (Plate LXVII. figs. 1, 2, 3).

As in *C. hystrix* the outer surface of each plate bears tubercles of three kinds:—primary tubercles with a large smooth areola, a smooth conical mammillary eminence, and a perforated mamelon; smaller tubercles of a similar character; and miliary granules. The arrangement of the primary and larger tubercles is nearly the same as in *C. hystrix*, but they are fewer and more remote.

The spines are, as in the species previously described, of two kinds. The large spines articulated to the primary tubercle are like those of *C. hystrix*, only they are somewhat more delicate; the ridges on the shaft of the spine are more numerous, and the projecting processes are irregular and less strongly marked (Plate LXVII. fig. 4); and the collar at the tip of the conical portion of the spine to which the muscle is attached is more irregular in outline. The smaller spines are extremely delicate transparent fenestrated tubes.

The pedicellariæ are of three kinds. The largest of these are arranged, both on the

interambulacral and the ambulacral plates, in irregular rows parallel to the rows of the larger spines. A long style (Plate LXVII. figs. 5 & 6) is articulated to one of the miliary granules. This style enlarges somewhat at the distal end; and from the enlargement there spring four delicate rods which gradually widen and become tubular, their walls being at length perforated by wide fenestræ (Plate LXVII. fig. 6). Each rod is surmounted by a hollow disk very gracefully twisted, reminding one somewhat of a frustule of *Campylodiscus*. The walls of the disk are fenestrated, and from the margin a delicate calcareous border is thrown backwards and downwards, edged with a fringe of singularly elegant design. A large mass of red muscle, covering the end of the main stem and the bases of the four branches, no doubt for the purpose of imparting motion to the latter, renders these pedicellariæ very conspicuous. They are strikingly beautiful objects, and differ entirely from any pedicellariæ which have hitherto been described.

The pedicellariæ next in size are of the ordinary tridactyle type, with a special modification in form, the bases of the valves being very broad, and the spoon-shaped extremities unusually long and close-fitting (Plate LXVII. fig. 7). The third set resemble closely the minute pedicellariæ of *C. hystrix*; but they are more delicate in their proportions, corresponding in this with the test and its other appendages.

The apical disk (Plate LXVI. figs. 1, 2) is 18 millims. in diameter from the outer angle of an ovarial plate to the outer edge of the ocular plate opposite. The ovarial plates are large, and have nearly the form of an equilateral triangle; the outer angle, which is produced somewhat more than the others, is wedged between the first pair of interambulacral plates in the space formed by their common inclination towards the oral pole. The ovarial openings are remarkably large, 2·5 millims. in diameter, so large as to occupy the whole of the central part of the ovarial plate, leaving a narrow rim only. Even this rim is sometimes encroached upon and the side of the plate separated into two parts. The ocular plates are large and mallet-shaped. A transversely oval portion continues the line of the upper edges of the ovarial plates, coming into contact with one of these on either side, while a narrower process, perforated in the centre by the minute ocular pore, meets the two upper plates of the ambulacral series. On the inside of the test a raised calcareous ridge runs continuously along the free edge of the ovarial plates through the ocular plates, with a suture at the points of junction, forming a kind of ring supporting the edge of the apical space. The madreporic tubercle is large, formed of the modified upper portion of one of the ovarial plates. The membrane of the periproct is supported by irregularly shaped scattered plates bearing small tubercles and miliary grains and small spines and pedicellariæ. These plates are of considerable size, and are lenticular in form towards the circumference, but they become smaller and finally almost linear as they approach the anus.

As in *C. hystrix*, a calcareous keel runs across the interambulacral spaces at the edge of the oral opening, and complete auriculæ span the ambulacra; but these auriculæ, like the other part of the shell, are very light. The oral aperture is 25 millims. in diameter with an entire margin. As in the other members of the family, the peristomial

membrane is mailed with densely imbricated plates, those which continue the ambulacral series of the test being perforated by double pores up to the edge of the mouth; and the whole are studded, on their outer exposed edges, with tubercles for short spines and for pedicellariæ of the two smaller forms.

The dental pyramid is rather higher in proportion to its width than in *C. hystrix*, and much higher than in *Phormosoma placenta*. The epiphyses of the jaws are much larger, and form curved ascending processes almost as in *Diadema*, but they do not unite into an arch. The teeth are broad and simply and uniformly grooved; they come somewhat rapidly to a point at the extremity.

The arrangement of the internal organs is remarkable. It is probably the same, or nearly the same, in all the members of the family which have been described; but the largest specimen of the present species which we procured was torn open and a good deal injured, which gave an opportunity of working out the general arrangement of its parts without sacrificing a unique specimen. A strong fibrous fascia (Plate LXVI. fig. 3) rises from the inner surface of the ambulacral plates near their outer ends, and forms a kind of diaphragm nearly dividing the cavity of the test perpendicularly on each side of the ambulacral area, and thus inclosing the ambulacral organs (nerves, vessel, and vesicles) and cutting them off from the rest of the body-cavity. This diaphragm does not run up as a complete wall to the edge of the peristome and periproct, but a kind of notch is left towards the centre of the body-cavity to allow the passage of the intestine. At this point the fascia rises up from each side of the ambulacral area as elsewhere; but instead of joining the fascia from the opposite wall of the test, its fibres unite with those on the opposite side of the same ambulacral area, and take the form of a cribriform membrane, which thus closely arches over the ambulacral organs. The intestine, in passing round the body-cavity, is thus restricted, as it passes the ambulacral areas, to these notches, while in the interambulacral spaces it forms wide loops suspended from the interior of the test by delicate mesenteric membranes and filaments (Plate LXVI. fig. 4). This arrangement of fibrous fasciæ reminds one strongly of the arrangement of the calcareous plates and trabeculæ in the Clypeasters. The fascia is continued at the apical pole into a broad band which passes round the margin of the periproct, including in a common sheath the circular ambulacral vessel and the genital ducts (Plate LXVI. fig. 3). The ovaries are very long and narrow (Plate LXVI. fig. 3), and occupy the centre of the interambulacral areas to the circumference.

The ambulacral vessels send off a straight simple branch to each pair of pores, the branch dilating as it approaches the pores into a pyriform vesicle (Plate LXVI. fig. 5). The tube feet on the ventral surface are cylindrical; their walls are supported by irregularly shaped cribriform plates (Plate LXVII. fig. 9), and are provided with a terminal sucker with a calcareous rosette. The tube feet on the apical surface are long and conical, and taper to a point, without a terminal sucker.

The colour of the test generally is greyish, but ten wide bands of purplish brown radiate from the apical pole, shading off into the grey of the test, and giving a rich effect

of colour to the upper surface. The spines are whitish, and the ambulacral part grey tinged with purple. A large mutilated specimen of this species, and a smaller one nearly perfect, were dredged by Mr. GWYN JEFFREYS off the coast of Portugal. There was a fragment of the test taken by the dredge off Rockall, and some spines which must be referred to it were sifted out of the mud brought up by the dredge in the Bay of Biscay.

III.

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Family 3. ECHINIDÆ.

Genus *Echinus*, Link.

1. *Echinus melo*, Lamarck.

Two specimens were dredged off the coast of Portugal in shallow water.

2. *Echinus Flemingii*, Ball. (Plate LXVIII. fig. 14.)

The large typical form of this species was met with in deep water off the Shetlands, but not in large numbers.

3. *Echinus rarispina*, G. O. Sars.

4. *Echinus elegans*, Von Düben and Koren. (Plate LXVIII. figs. 11–13.)

5. *Echinus norvegicus*, Von Düben and Koren.

The last four are critical species; and although the extreme forms are very dissimilar, in a large series there are so many intermediate links that it is difficult to tell where the one begins and the other ends. It is possible that when our information is more complete all these may come to be regarded as varieties, and may be grouped together under LAMARCK'S name, *Echinus acutus*.

6. *Echinus microstoma*, nov. sp. (Plate LXVIII. figs. 1–10.)

Although I have great hesitation in proposing an addition to the genus *Echinus*, I feel compelled to separate, in the meantime, this very distinct form with a thin depressed test, a remarkably large apical system and periproct, a small peristome with the margin curved inwards and a uniform salmon-colour. *Echinus microstoma* is very abundant at depths between 150 and 400 fathoms off the western coasts of Scotland and Ireland.

7. *Echinus esculentus*, L.

A marked variety with a tall narrow test occurred in deep water off the Færöes.

Genus *Toxopneustes*, Agassiz.

1. *Toxopneustes dröbachiensis*, Müller.

Of this species *T. pictus*, Norman, and *T. pallidus*, G. O. Sars, can only be regarded as varieties. It is generally distributed at depths beyond 100 fathoms in the northern seas.

2. *Toxopneustes brevispinosus*, Reiss, sp.

In shallow water off the coast of Spain.

Genus *Psammechinus*, Agassiz.

1. *Psammechinus miliaris*, Lamarck, sp.

Abundant in the British area at depths less than 50 fathoms.

2. *Psammechinus microtuberculatus*, Agassiz.

A few examples were dredged in shallow water off the coast of Portugal.

Order II. PETALOSTICHA (E. Häckel).

Family 1. CASSIDULIDÆ.

Genus *Neolampas*, A. Agassiz.

Outline of the test pyriform from above, prolonged posteriorly into a short blunt rostrum and truncated. The test arches nearly uniformly from the anterior margin to the posterior rostrum. The oral surface is slightly concave. The ambulacra are flush with the surface of the test; they are reduced to the greatest simplicity, showing no rosette or other indication of a petaloid arrangement, but running from the apex to the peristome as a uniform double row of simple pores passing between the ambulacral plates and giving exit to minute conical tube feet. The mouth is pentagonal, nearly in the centre of the oral surface of the test, a little nearer the anterior border. It is surrounded by a well-marked floscelle and distinct bourrelets. The apical disk is on the upper surface of the test, nearly directly vertically over the mouth; it is compact, with three large ovarial openings, five very distinct pores for the sense-organs, and a rather small madreporic tubercle in the middle. The anal opening in the test is large, occupying a deep depression in the truncated posterior extremity of the shell.

Neolampas rostellata, A. Agassiz. (Plate LXIX.)

Synonym:—*Neolampas rostellata*, A. Agassiz, Bulletin of the Museum of Comparative Zoology, 1869.

The single specimen procured in the 'Porcupine' Expedition, which was dredged living in 690 fathoms at the mouth of the English Channel, is 20 millims. in length, 16 millims. in extreme width across the ambitus, and 7 millims. in height. The outline from above is not quite symmetrically oval or pyriform, the shell bulging on either side somewhat irregularly towards the posterior extremity. In profile, the anterior end of

the test is the thinnest (Plate LXIX. fig. 3); the outline rises to the apex and then sinks gradually to the truncated posterior rostrum, along the top of which it coincides with a slight longitudinal ridge. The oral surface of the test also rises slightly from the anterior border to produce the depression in which the mouth is placed, and from the mouth it sinks towards the truncated extremity forming the floor of the rostrum. This truncated end is occupied by a deep inversion (Plate LXIX. fig. 4), deepest above, at the bottom of which the anal orifice opens. The periproct is oval, large, and plated with small scales. In one specimen there is no trace of the exserted anal tube described by Prof. A. Agassiz as occurring in the specimens dredged by Count Pourtales in the Strait of Florida.

The ambulacra have all precisely the same character. Those of the bivium are apparently in slight depressions. This is, however, only an effect produced by the slight projection of the sides of the posterior rostrum (Plate LXIX. fig. 4). The ambulacra are not very easily seen, the pores are so minute; by holding the shell up to the light, however, they become sufficiently apparent as rows of simple pores passing between irregularly hexagonal plates, in double series, from the apex to the mouth. The ambulacral areæ widen somewhat from the apex to the ambitus, and become slightly narrower from the ambitus towards the mouth; they are about 4 millims. in width at the widest point, the lateral interambulacral spaces being 12 millims. At the mouth the ambulacra expand into a very distinct floscelle (Plate LXIX. fig. 6), and the interambulacral areæ end in bourrelets crowded with tubercles and bearing combs of long spatulate spines. The plates of the apical disk are so compacted and fused together that it is difficult to trace their outline. Eight holes, nearly of equal size, surround a central madreporic tubercle (Plate LXIX. fig. 5); of these, five terminate the ambulacra and are the pits for the sense-organs, the other three are ovarial. The posterior and the right anterior ovaries and ducts are undeveloped.

The surface of the test is crowded with minute tubercles for the articulation of the larger spines and many small granules (Plate LXIX. fig. 5). The tubercles are imperforate, with a smooth mammillary boss; they are placed in circular scrobicular depressions, but they project somewhat above these and above the surface of the test. The larger spines, articulated to the tubercles, are cylindrical, fenestrated, with slight asperities on the longitudinal calcareous shafts (Plate LXIX. figs. 7, 8, 10).

The small spines, which, attached to the minute granules, form a close underfelting all over the test, are fenestrated and slightly roughened, and expand at the end into a rosette of pointed tubercles (Plate LXIX. fig. 9). The pedicellariæ, articulated to some of the granules, are three-valved; they are very small and of a somewhat peculiar form, though resembling generally the smallest pedicellariæ in *Echinus*. The bases of the valves are wider, the valves themselves are rounder and more arched and toothed round the edge (Plate LXIX. fig. 11). Round the mouth there are groups of three and four very small pedicellariæ, differing in form somewhat from the others, and with the bases of the valves apparently fused together (Plate LXIX. fig. 12).

Family 2. CLYPEASTRIDÆ, Agassiz.

Genus *Echinocyamus*, Van Phelsum.

Echinocyamus angulatus, Leske.

Generally distributed, but not found living beyond 150 fathoms.

Family 3. SPATANGIDÆ, Agassiz.

Genus *Pourtalesia*, A. Agassiz.

The body is flask-shaped, the anterior extremity abruptly truncated; the test is then almost cylindrical for half its length, contracting gradually from the middle to the posterior extremity, where it is produced into a long rostrum. A narrow flattened plastron occupies the ventral surface, while on the dorsal surface a well-marked ridge runs along the middle line from the apex to a point a little way in front of the posterior rostrum, where it forms an arched projection protecting a deep pit, at the bottom of which the anal opening lies.

The apical system is produced or disjunct. The three ambulacra of the trivium, after passing up from the oral ring, the odd one along the centre and the two others along the outer sides of the truncated anterior face, meet directly above the mouth at a point where are also four large ovarial openings and a central madreporic tubercle. The ambulacra of the bivium, starting from beneath the mouth, diverge and pass one along either side of the ventral (interambulacral) plastron until they come opposite the anal opening, where they form loops, and return along either side of the dorsal ridge, and unite at a point about one fourth of the length of the test behind the point of junction of the ambulacra of the trivium.

The mouth is at the bottom of a deep inversion of the truncated anterior end of the test; it is elliptical, the peristome simple, not bilabiate. Teeth are entirely wanting, and there is no trace of either phyllodes or bourrelets. The anal opening is quadrate, the membrane of the periproct plated with irregular calcareous scales.

1. *Pourtalesia Jeffreysi*, n. sp. (Plate LXX. figs. 1–10 and Plate LXXI.)

One apparently mature example of this very remarkable urchin was dredged in 640 fathoms, halfway between Færöe and Shetland, at a bottom temperature of $-1°{\cdot}1$ C. The total length of the test is 45 millims., and its extreme width 18 millims.; the height of the test from the ventral plastron to the dorsal ridge at its highest point is 20 millims.

The groove at the bottom of which the mouth lies is very deep—a tunnel-like inversion of the test in the centre of the lower part of the truncated anterior end. The mouth-opening is elliptical, the peristome simple. The buccal membrane is bare towards the centre, and covered towards the outer edge with scales, the larger of which are granulated and give attachment to small spines and pedicellariæ. The odd ambulacrum of the trivium starts from the upper end of the mouth, forms, with a double row of somewhat irregularly shaped plates, the roof of the mouth-inversion (Plate LXXI. figs. 4, 5),

then passes up the centre of the anterior end of the test to the apex (Plate LXXI. fig. 3). The two lateral ambulacra of the trivium pass from the sides of the peristome upwards over the sides of the shell, just behind the lateral borders of the anterior end, to meet at the same point (Plate LXXI. fig. 3). The ambulacra of the bivium start very close together from this lower end of the mouth (Plate LXXI. fig. 4); they pass along on either side of the ventral plastron to a little beyond the anus, nearly to the end of the shell; then they turn upwards and, still separated by the interambulacrum of the bivium, run forwards on the dorsal aspect of the test to the secondary or posterior pole of the apical system (Plate LXXI. figs. 6, 8). The tube feet in connexion with the odd ambulacral vessel of the trivium are conical and of considerable size; those springing from the other four ambulacral vessels are uniform throughout, very small and pointed.

The interambulacral areas of the trivium are comparatively narrow, and form the lateral portions of the anterior truncated extremity running up to the principal apical pole. The lateral interambulacra are wide, and correspond with the space between the primary and secondary apical poles. The odd interambulacrum of the bivium is most remarkably developed, and chiefly contributes to the peculiar form of the shell. Starting from below the mouth, it forms a narrow plastron along the middle line of the ventral surface of the test; it then widens out to form the posterior rostrum, arching upwards to the edge of the periproct; it forms the projecting arch over the anal opening, whence it continues along the median ridge of the back to end with the bivial ambulacra in the secondary apical pole (Plate LXXI. figs. 1, 2, & 3).

The apical system is disjunct, as in *Dysaster*. The anterior portion consists of a series of coalesced ovarial plates, with four large and distinct apertures, the two anterior closer to one another than the two posterior, all of them inclining markedly forwards in passing through the test (Plate LXX. fig. 4). The ocular plates are undistinguishable, and there are no evident ocular pores. The posterior pole of the apical system consists of two odd plates terminating the ambulacra of the bivium, and therefore representing ocular plates. These plates show no pores, and they are so small and indistinct that this "secondary pole" is chiefly indicated by the junction of the bivial ambulacra.

The anal opening is small; the periproct is oblong, transverse, and plated with irregular unequal calcareous scales (Plate LXXI. fig. 7).

The surface of the test is somewhat sparsely and irregularly sprinkled with primary tubercles; the scrobicular area is rounded or slightly angular, roughened and slightly depressed; the mammillary boss is low, and peculiarly crenulated by a chain of minute rounded elevations. The tubercle is perforated, and likewise slightly crenulated (Plate LXX. figs. 6, 7). Between the primary tubercles there are numerous minute tubercles for the articulation of the small spines and the pedicellariæ. The larger tubercles are specially crowded near the apex and round the border of the anterior flattened surface (Plate LXX. figs. 1, 2).

The primary spines are cylindrical, fenestrated, with about twelve smooth ribs; the milled ring is very prominent, and gives attachment to a circle of very strong and

elastic muscular fibres (Plate LXX. fig. 7); some smaller spines have small pointed elevations on the ridges (Plate LXXI. fig. 9); the secondary spines are very minute, paddle-shaped, and ornamented with crenated ribs (Plate LXX. fig. 8). The pedicellariæ are of two kinds; the larger (Plate LXX. figs. 9, 9*a*) are very peculiar in form. Three thick stems are articulated to a short stalk, and from each of these curves inwards a calcareous disk, bordered by an extremely elegant fringe of spines. The stems and the disks which represent the valves of pedicellariæ of the ordinary form contain cavities which occupy the usual positions. The smaller pedicellariæ resemble generally the smaller forms in the Echinidæ.

The general colour of *Pourtalesia Jeffreysi* is purple, rather light over the greater part of the test, but dark and rich from the accumulation of large pigment-spots round the raised border of the anterior surface, and especially about the posterior rostrum. The test of *Pourtalesia* is so remarkably thin that it will scarcely bear its own weight.

Pourtalesia Jeffreysi differs from *P. miranda*, the species described by Prof. ALEXANDER AGASSIZ, in having the test more uniformly cylindrical, and particularly in the form of the rostrum, which is much smaller than in *P. miranda*, with the usual depression much less marked. Another character which, in these aberrant forms having a tendency to the extreme modification of various parts, may have less importance than we should at first sight be inclined to assign to it, might be supposed to separate the two species widely: Prof. AGASSIZ states that in *P. miranda* the apical system is elongate, but not disconnected. In *P. Jeffreysi* the apical system is certainly disjunct, several extra plates which cannot be referred to the apical system being intercalated between its parts (Plate LXXI. fig. 3).

A single specimen only of *Pourtalesia Jeffreysi* was dredged during the 'Porcupine' cruises. On one or two occasions, however, fragments of a thin purple test and fragments of spines, which we referred to this species, were sifted out of the mud. The shell is so excessively fragile that it may be regarded as a fortunate incident to have recovered any thing like a complete example.

2. *Pourtalesia phyale*, n. sp. (Plate LXX. fig. 11.)

Test very much prolonged, almost tubular; posterior rostrum more produced than in *P. Jeffreysi*; anterior surface oblique to the axis of the test; mouth-depression nearly central in the anterior end of the shell, surrounded by an oval raised rim or border.

The specimen of *P. miranda* described by Prof. A. AGASSIZ is very small, but it already approaches *P. Jeffreysi* closely in form, and gives no indication of having undergone any very great change during the later stages of the process of growth. I therefore cannot imagine that the singular little urchin to which I have given provisionally the name *Pourtalesia phyale* is the young of the species previously described. Both of the two specimens procured by Mr. GWYN JEFFREYS at a depth of 1215 fathoms in the Rockall Channel are immature, and their characters are too undefined for satisfactory description.

Genus *Brissopsis*, Agassiz.

Brissopsis lyrifera, Forbes.

Large specimens of this species are abundant at from 50 to 250 fathoms. Beyond this latter depth the specimens decrease in size, and at extreme depths only examples which have all the appearance of being very young are met with. These small delicate specimens are found at all depths, even down to 2090 fathoms.

Genus *Tripylus*, Philippi.

Tripylus fragilis, Von Düben and Koren.

At from 400 to 500 fathoms, between Scotland and Færöe. Hitherto known from the Scandinavian seas.

Genus *Schizaster*, Agassiz.

Schizaster canaliferus, Lamarck.

A single small specimen from the coast of Spain.

Genus *Amphidetus*, Agassiz.

Amphidetus ovatus, Leske, sp.

Abundant at moderate depths.

Genus *Spatangus*, Klein.

1. *Spatangus purpureus*, O. F. Müller.
2. *Spatangus Raschi*, Lovén.

This species is apparently gregarious, and is enormously abundant, in patches here and there, from the Færöes to the Strait of Gibraltar, at depths of from 100 to 300 fathoms.

Of the twenty-six species observed, six (namely, *Echinus Flemingii*, *E. esculentus*, *Psammechinus miliaris*, *Echinocyamus angulatus*, *Amphidetus ovatus*, and *Spatangus purpureus*) may be regarded as denizens of moderate depths in the "Celtic province," recent observations having merely shown that they have a somewhat greater range in depth than was previously supposed. *Spatangus Raschi* may probably be an essentially deeper-water form having its headquarters in the same region. Eight species (*Cidaris papillata*, *Echinus elegans*, *E. norvegicus*, *E. rarispina*, *E. microstoma*, *Toxopneustes dröbachiensis*, *Brissopsis lyrifera*, and *Tripylus fragilis*) are members of a fauna of intermediate depth; and all, with the doubtful exception of *Echinus microstoma*, have been observed in comparatively shallow water off the coasts of Scandinavia. Five species (*Cidaris affinis*, *Echinus melo*, *Toxopneustes brevispinosus*, *Psammechinus microtuberculatus*, and *Schizaster canaliferus*) are recognized members of the Lusitanian and Mediterranean faunæ, and seven (*Porocidaris purpurata*, *Phormosoma placenta*, *Calveria hystrix*,

C. fenestrata, *Neolampas rostellata*, *Pourtalesia Jeffreysi*, and *P. phyale*) are forms which have been for the first time brought to light during the late deep-sea dredging-operations, whether on this or on the other side of the Atlantic: there seems little doubt that these must be referred to the abyssal fauna, upon whose confines we are only now beginning to encroach. Three of the most remarkable generic forms, *Calveria*, *Neolampas*, and *Pourtalesia*, have been described by Prof. ALEXANDER AGASSIZ among the results of the deep-dredging operations of Count POURTALES in the Strait of Florida, showing a wide lateral distribution; and even a deeper interest attaches to the fact that while one family type, the ECHINOTHURIDÆ, has been hitherto known only in a fossil state, the entire group find nearer allies in the extinct faunæ of the Chalk, or of the earlier Tertiaries, than in that of the present day.

DESCRIPTION OF THE PLATES.

PLATE LIX.

Cidaris papillata.

Fig. 1. Test of a full-sized specimen, showing the arrangement of the apical disk. Natural size.

Fig. 2. Portion of the test, showing the arrangement of the scales of the buccal membrane. × 2.

Fig. 3. Radials from the region of the ambitus. Natural size, and fig. 3 *a* × 2.

Fig. 4. Small spine from the ambulacral area. × 20.

Fig. 5. One of the inflated pedicellariæ from the apical disk. × 25.

Fig. 6. Tridactyle pedicellaria from the edge of the pore-area. × 25.

Fig. 7. Tridactyle pedicellariæ from the miliary area of the test.

Fig. 8. One of the ambulacral tube feet, showing the calcareous spicules of the wall and the rosette of the sucker. × 50.

Fig. 9. Spicules from the ambulacral tube feet. × 100.

Fig. 10. Portion of the mesenteric membrane, showing the fenestrated supporting plates. × 15.

Fig. 11. The wall of the intestine, showing the calcareous plates.

Fig. 12. One of the ultimate branches of the ovary, showing the fenestrated plates. × 25.

Fig. 13. Plates from the wall of the ovary. × 50.

Porocidaris purpurata.

Fig. 14. Didactyle pedicellaria from the edge of the pore-area. × 50.

Fig. 15. Fenestrated plates in the wall of the intestine.

PLATE LX.

Cidaris affinis.

Fig. 1. Full-sized specimen from off Cape Spartel. Natural size.
Fig. 2. Apical aspect of test. × 2.
Fig. 3. Portion of the test, showing the pore-areæ. × 4.
Fig. 4. One of the radials from the region of the ambitus. × 3.
Fig. 4*a*. A portion of a primary radiole, showing the sculpture. × 5.
Fig. 5. Smaller spine from the neighbourhood of the mouth. × 2.
Fig. 6. Spine from the border of an areola. × 6.
Fig. 7. Dental pyramid. × 3.

PLATE LXI.

Porocidaris purpurata.

Fig. 1. A mature specimen. Natural size.
Fig. 2. The apical aspect of the denuded test. Natural size.
Fig. 3. A portion of the oral aspect of the test. × 2.
Fig. 4. Radiole from the region of the ambitus. Natural size.
Figs. 5–7. Smaller radioles from different parts of the corona.
Figs. 8–10. Paddle-shaped radioles from the neighbourhood of the mouth. Natural size.
Fig. 11. Spine from the margin of an areola. × 3.

PLATE LXII.

Phormosoma placenta, Wy. T.

Fig. 1. Oral surface of the test. Natural size.
Fig. 2. Apical surface of the test. Natural size.
Fig. 3. One of the smaller spines. × 50.
Fig. 4. Portion of one of the larger spines. × 25.
Fig. 5. Tridactyle pedicellaria. × 50.
Fig. 6. Ophiocephalous pedicellaria. × 150.

PLATE LXIII.

Phormosoma placenta.

Fig. 1. Interior of the oral portion of the test, showing the peculiar character of that part of the test, the auriculæ, the arrangement of the scales of the peristome, and the dental pyramid. × 2.
Fig. 2. A portion of the ventral surface of the test, seen from without. × 2.

Fig. 3. A portion of the ventral part of the test, seen from within. × 2.
Fig. 4. The apical plates and the periproct, seen from within. × 2.
Fig. 5. The outer aspect of a portion of the apical surface of the test. × 2.
Fig. 6. Inner aspect of the same. × 2.
Fig. 7. A cribriform plate from the wall of one of the tube feet. × 60.
Fig. 8. Appearance of a thin slice of one of the plates of the perisom under a low power.

Calveria fenestrata, Wy. T.

Fig. 9. A pair of tooth-sockets, showing the form of the epiphyses.
Fig. 10. Lateral view of the same.

PLATE LXIV.

Calveria hystrix, Wy. T.

Fig. 1. Natural size.
Fig. 2. Portion of one of the large spines. × 30.
Fig. 3. One of the tube feet from the ventral surface of the test. × 30.
Fig. 4. A large tridactyle pedicellaria. × 30.
Fig. 5. One of the smaller tridactyle pedicellariæ. × 50.
Fig. 6. An ophiocephalous pedicellaria. × 50.

PLATE LXV.

Calveria hystrix.

Fig. 1. Outer aspect of a portion of the test of the ventral surface. × 2.
Fig. 2. The same, seen from within. × 2.

PLATE LXVI.

Calveria fenestrata, Wy. T.

Fig. 1. Plates of the apical disk, from within. × 2.
Fig. 2. The external surface of the same. × 2.
Fig. 3. The test opened to show the arrangement of the fasciæ which enclose the ambulacral organs and the position of the ovaries. × 2.
Fig. 4. The test thrown back to show the mesenteric membranes and fibres which suspend and retain in position the coils of the intestine. × 2.
Fig. 5. A portion of a series of ambulacral plates, showing the arrangement of the ampullæ and the distribution of the branches of the ambulacral vessel to the pores.

PLATE LXVII.

Calveria fenestrata.

Fig. 1. A portion of an ambulacral area from the oral surface of the test. × 2.
Fig. 2. A portion of an interambulacral series from the same part of the test. × 2.
Fig. 3. A part of an interambulacral series from the apical surface of the test near the edge of the periproct. × 2.
Fig. 4. A portion of the base of one of the larger spines. × 20.
Fig. 5. One of the tetradactyle pedicellariæ. × 35.
Fig. 6. A like pedicellaria. × 60.
Fig. 7. A tridactyle pedicellaria. × 40.
Figs. 8, 8 *a*. An ophiocephalous pedicellaria. × 60.
Fig. 9. One of the tube feet from the oral surface of the test.

PLATE LXVIII.

Echinus microstoma.

Fig. 1. General view of the test from above.
Fig. 2. A portion of the test removed to show the form of the auricles and the position of the dental pyramid.
Fig. 3. Dental pyramid. × 2.
Fig. 4. One of the small flattened spines from the neighbourhood of the mouth. × 6.
Fig. 5. A pedicellaria. × 25.
Fig. 6. A pedicellaria, the valves provided with large external fleshy lobes containing curved calcareous spicules. × 40.
Fig. 7. The separated valves of a pedicellaria of this form. × 50.
Fig. 8. Stems of pedicellariæ with curved calcareous spicules imbedded in their investing membrane. × 80; the separate spicule × 100.
Fig. 9. A portion of one of the tube feet, showing the curved spicules imbedded in the wall. × 60.
Fig. 10. A portion of the wall of the intestine. × 100.

Echinus elegans.

Fig. 11. View of the test from above. × 2.
Fig. 12. One of the primary spines. × 5.
Fig. 13. The dental pyramid. × 4.
Fig. 14. The dental pyramid of *Echinus Flemingii*, introduced for comparison. × 2.

PLATE LXIX.

Neolampas rostellata.

Fig. 1. Oral aspect of the test. × 4.
Fig. 2. Apical aspect of the test. × 4.
Fig. 3. The test seen in profile. × 2.
Fig. 4. The posterior aspect of the test, showing the deep anal inversion. × 2.
Fig. 5. A portion of the test, showing the terminations of the ambulacra and the apical system. × 8.
Fig. 6. The mouth, the floscelle, and the bourrelets. × 8.
Figs. 7, 8. The larger spines. × 50.
Fig. 9. One of the smaller spines, showing the terminal rosette of pointed tubercles. × 90.
Figs. 10, 11, 12. Pedicellariæ with their stalks. × 90.

PLATE LXX.

Pourtalesia Jeffreysi.

Fig. 1. Lateral view of the test. × 2.
Fig. 2. View of the truncated anterior extremity of the test, showing the position of the oral inversion. × 2.
Fig. 3. Dorsal aspect of the posterior extremity of the test, showing the anal depression and the rostrum. × 2.
Fig. 4. Portion of the test, showing the arrangement of the apical system. × 8.
Fig. 5. An interambulacral plate, showing the distribution of the primary tubercles and of the granules.
Fig. 6. One of the primary tubercles. × 20.
Fig. 7. The base of one of the primary spines. × 40.
Fig. 8. One of the small spatulate spines. × 150.
Figs. 9, 9 *a*. One of the larger pedicellariæ. × 90.
Fig. 10. A small pedicellaria. × 100.

Pourtalesia phyale.

Fig. 11. Lateral view of the test.

PLATE LXXI.

Pourtalesia Jeffreysi.

Fig. 1. Test denuded to show the arrangement of the plates. × 2.
Fig. 2. Oblique view of the test. Natural size.

Fig. 3. Inner aspect of the anterior portion of the test, showing the mouth, the oral ring of the ambulacral vascular system, the ambulacral vessels of the trivium, and the disjunct apical system. × 2.

Fig. 4. The mouth from within, showing the ring of the ambulacral vascular system and the mode of origin of the five ambulacral vessels. × 4.

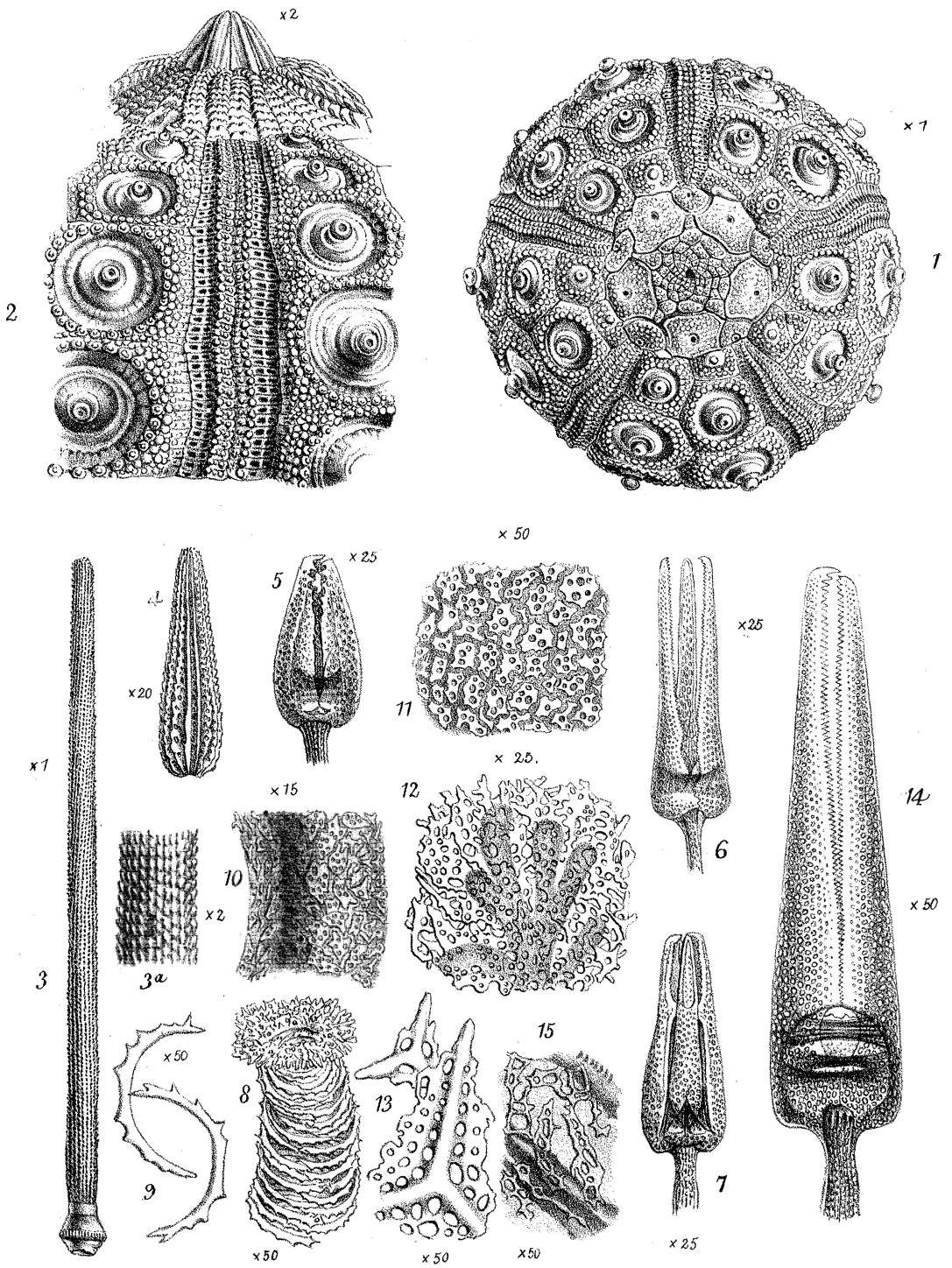
Fig. 5. Lateral view of the oral inversion of the test, seen from within. × 4.

Fig. 6. Inner aspect of the posterior portion of the test, seen from below. × 2.

Fig. 7. Anal opening, and the arrangement of the plates and scales of the periproct, from within. × 4.

Fig. 8. The looping of the vessels of the bivium opposite the anal opening.

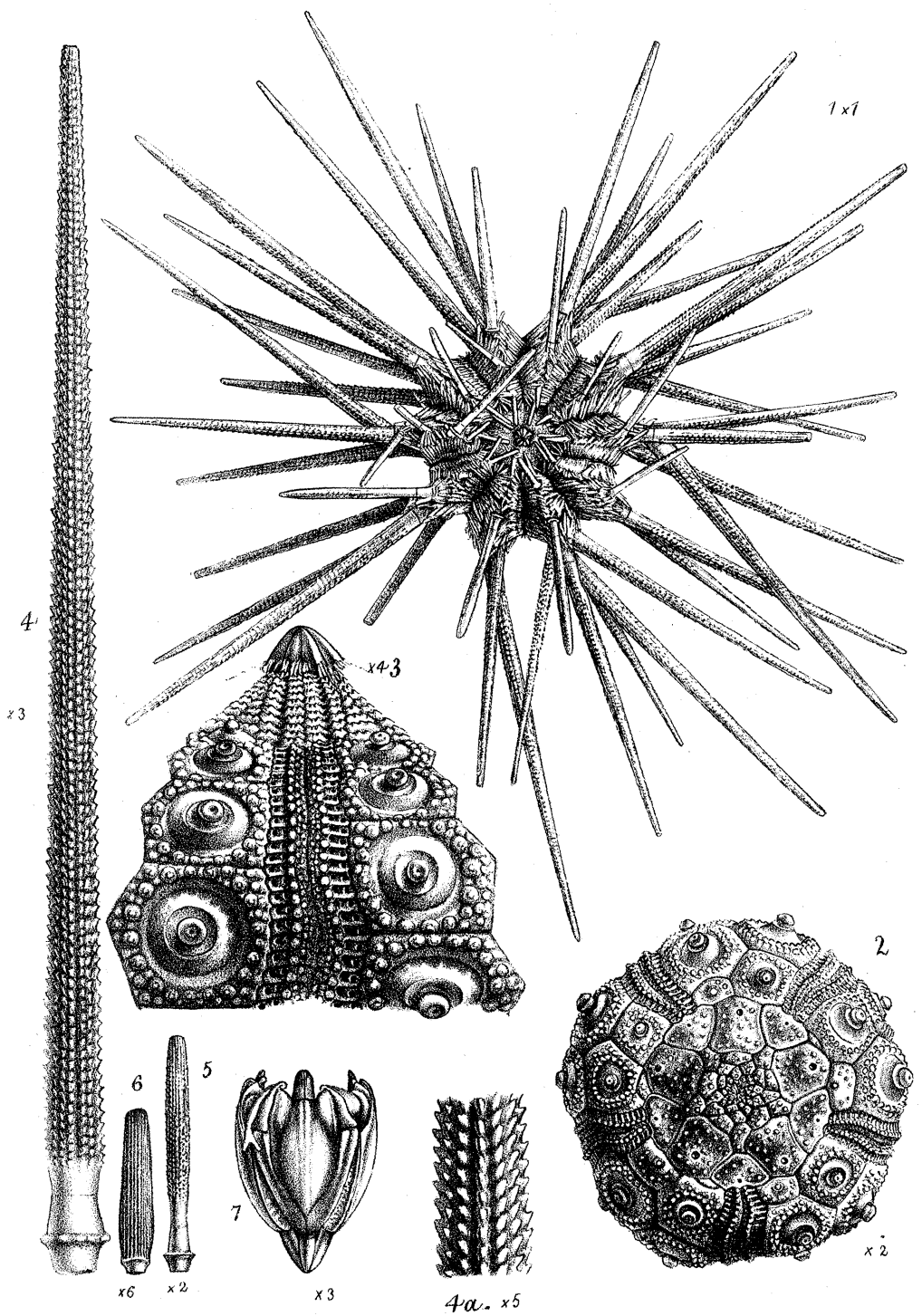
Fig. 9. A portion of a spine.



J.J.Wild lith.

M & N.Hanhart imp.

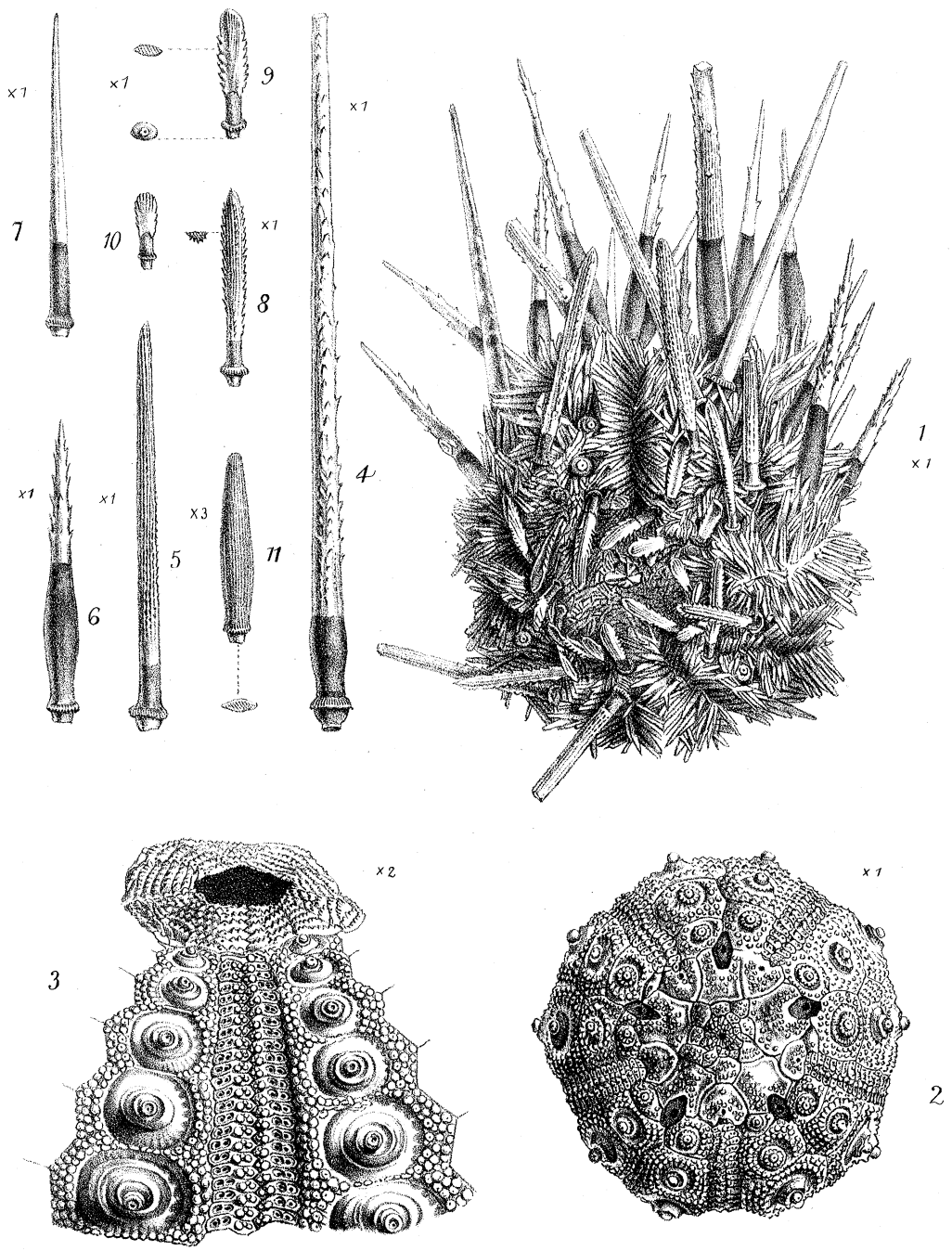
Fig 1. 13. CIDARIS PUPILLATA. *Leske.*
14.15. POROCIDARIS PURPURATA. *Wy.T.*



J. J. Wild lith.

M&N Hanhart imp.

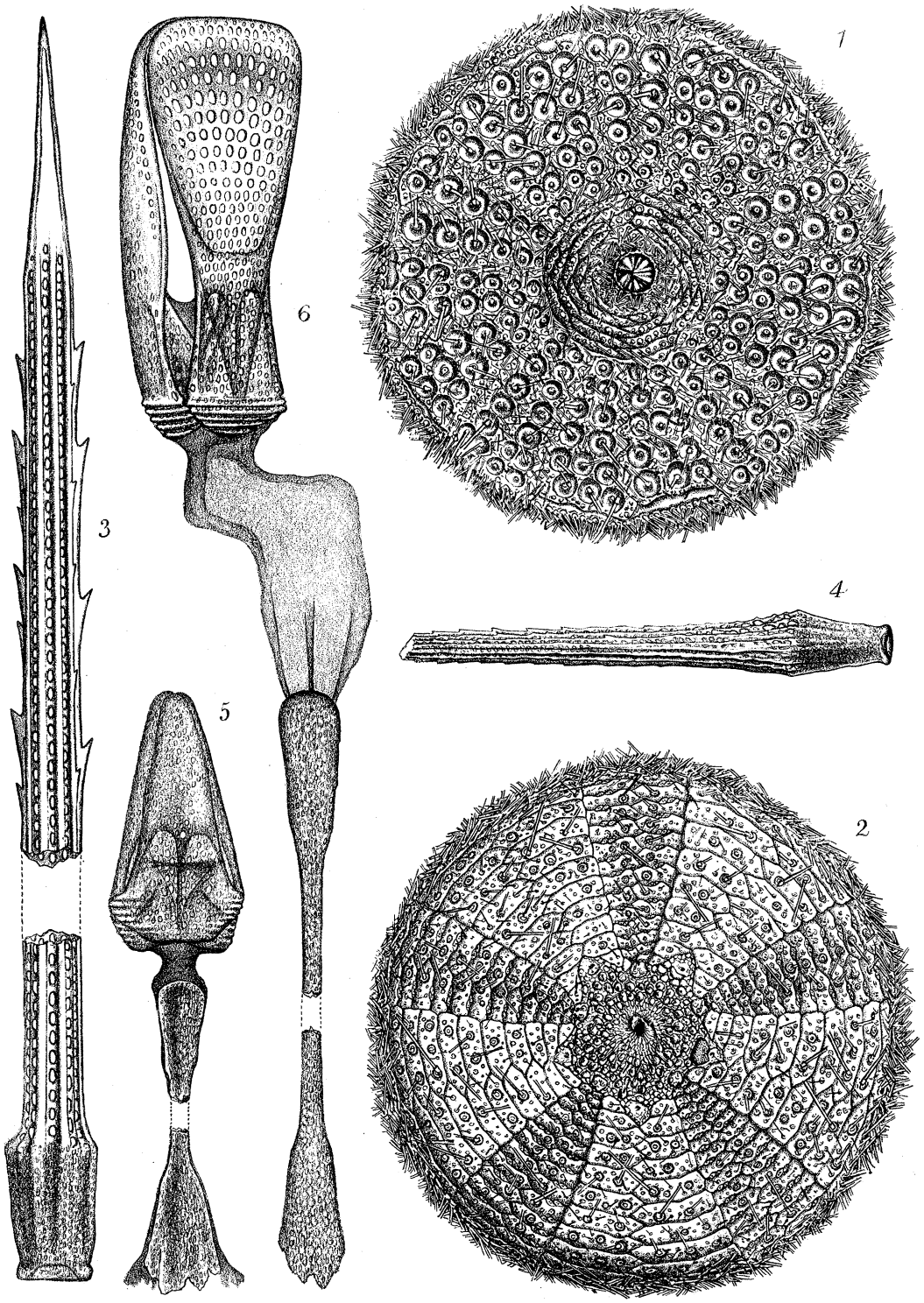
CIDARIS AFFINIS. *Philippi.*



J.J.Wild, lith.

M & N.Hanhart. imp.

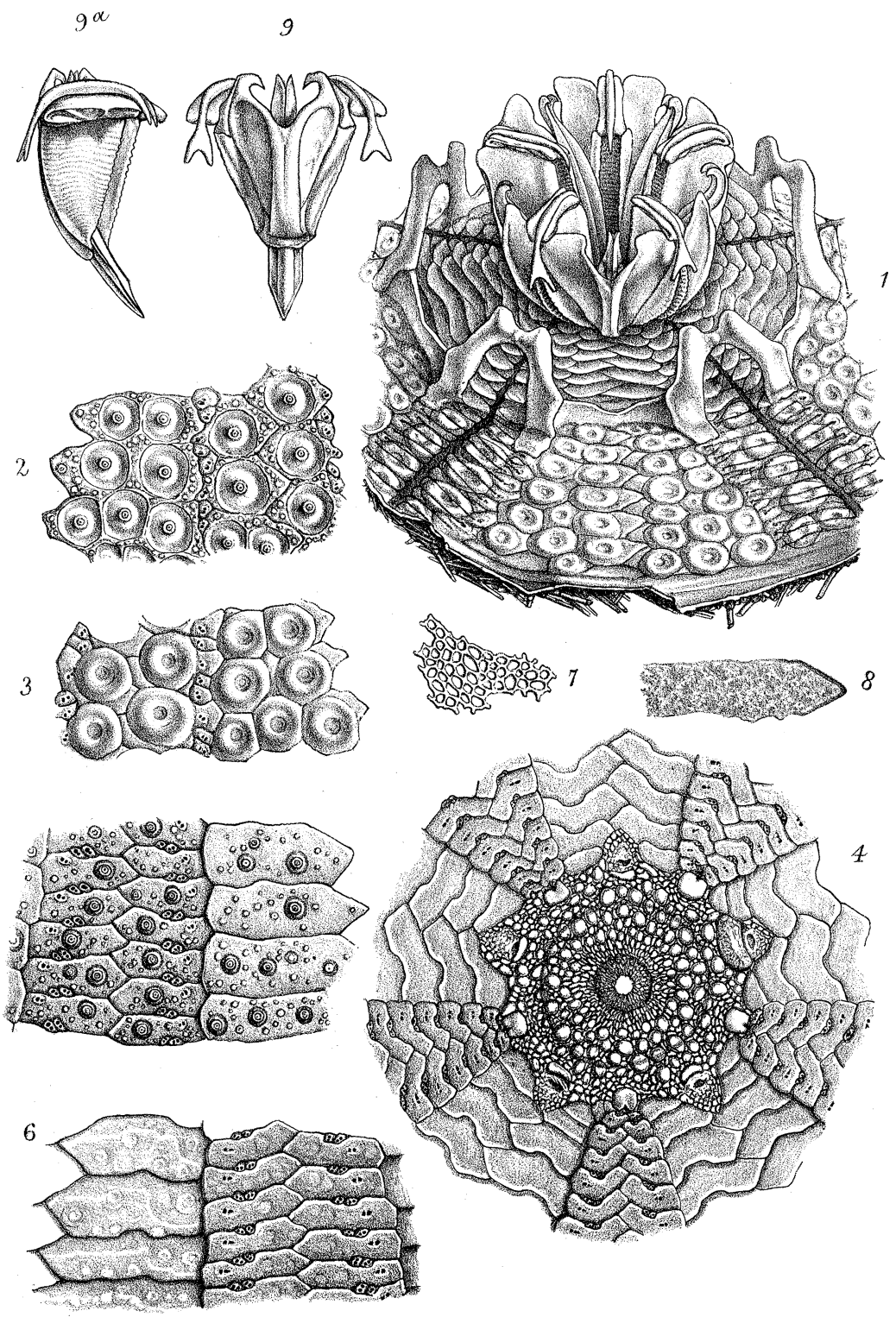
POROCIDARIS PURPURATA. *Wy. T.*



J.J.Wild, lith.

M&N.Hanhart imp.

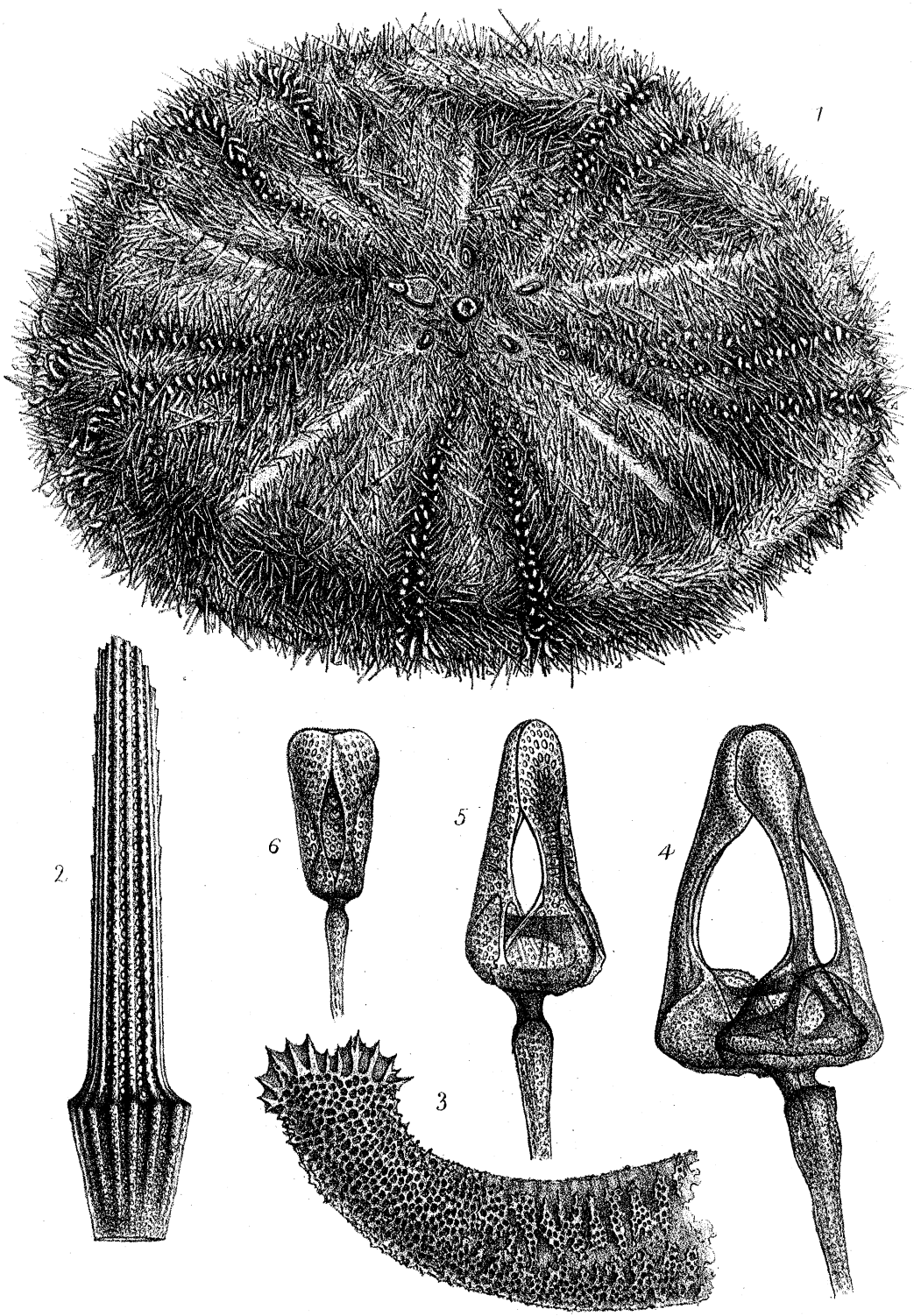
PHORMOSOMA PLACENTA. *Wy. T.*



J.J. Wild lith.

M&N Hanhart imp.

PHORMOSOMA PLACENTA. *Wy T.*

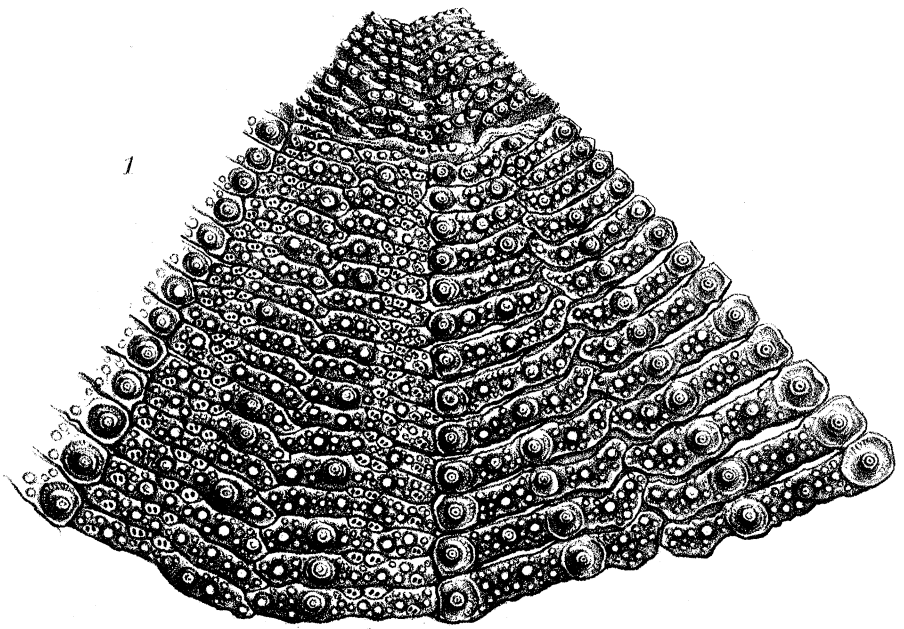


J. J. Wild lith.

M&N Hanhart imp

CALVERIA HYSTRIX. *Wy. T.*

1



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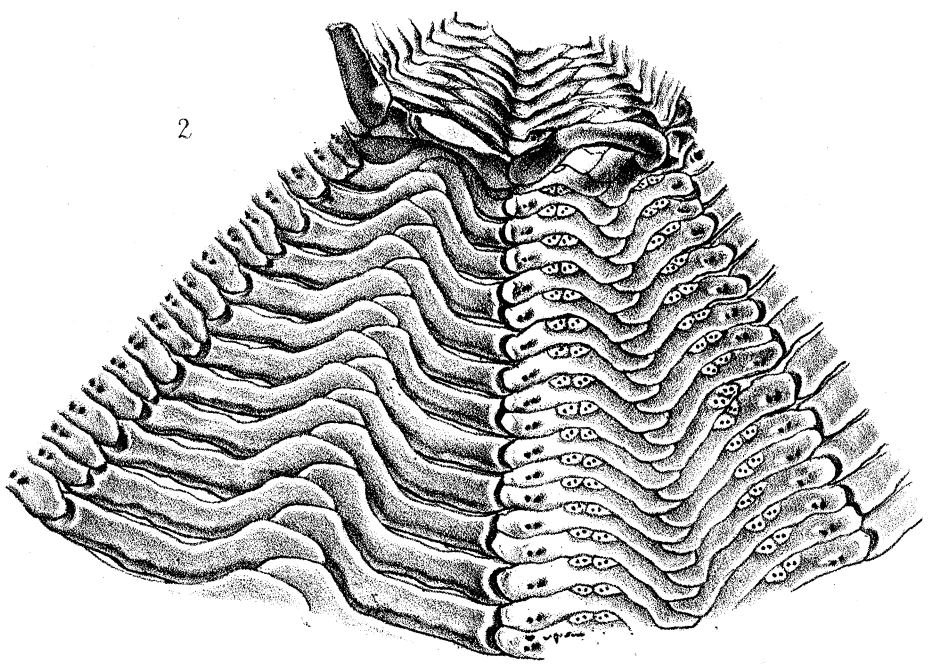
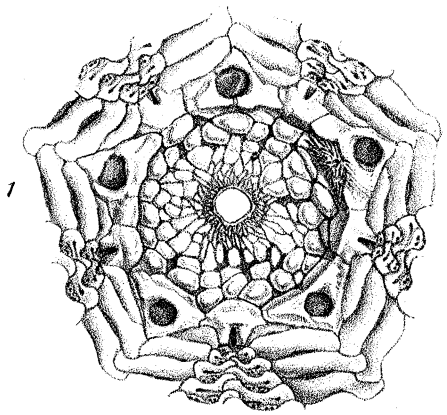


J. J. Wild lith.

M&N Hanhart imp

CALVERIA HYSTRIX *Wy. T.*



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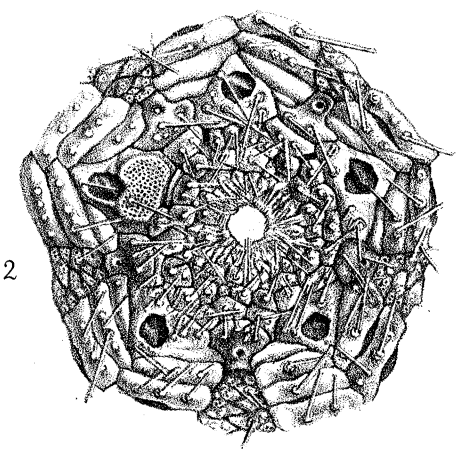

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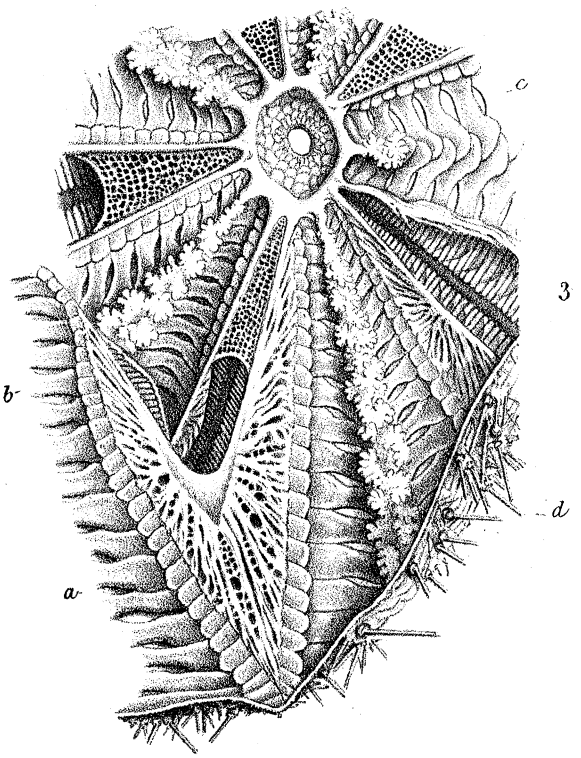
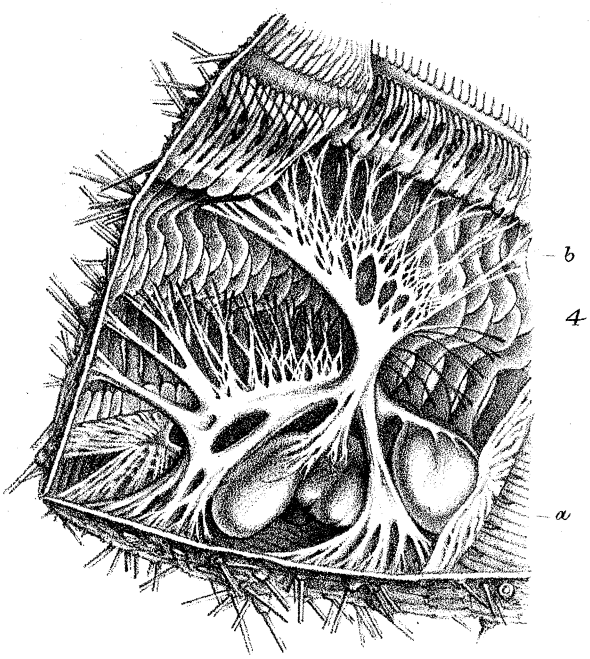
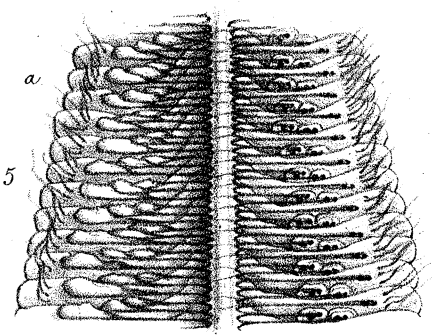


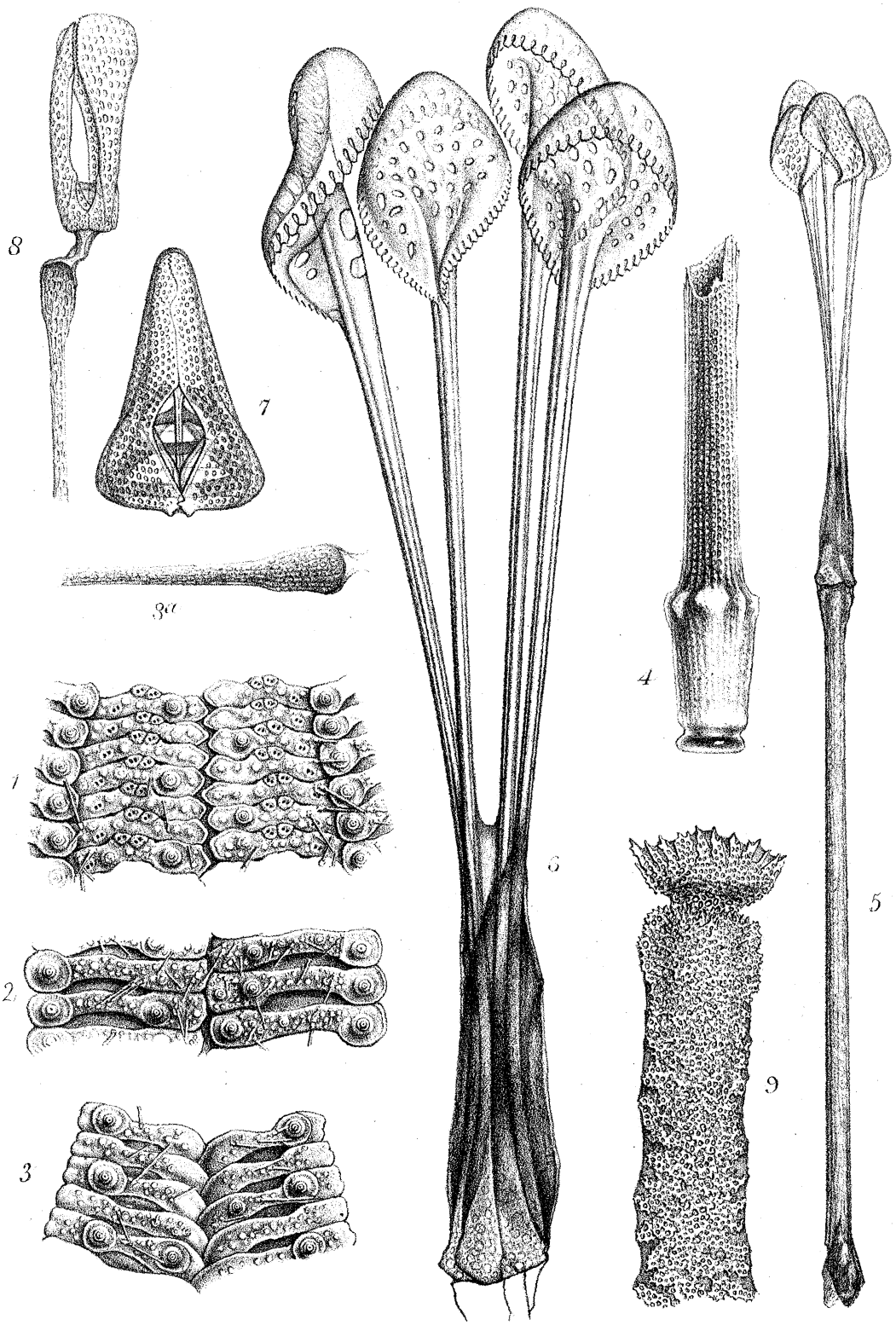




J.J. Wild lith.

M & N. Hanhart imp.

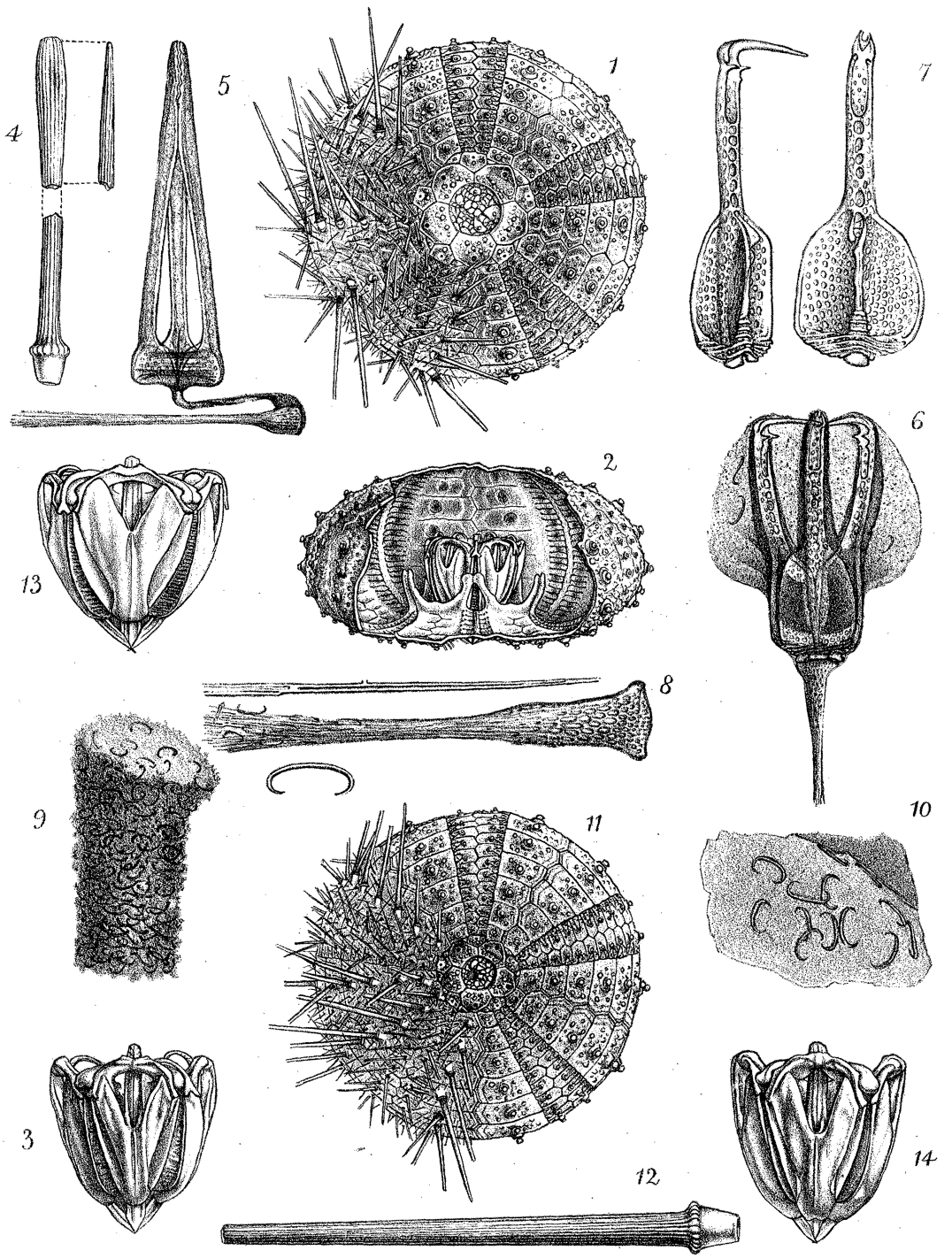
CALVERIA FENESTRATA. *Wy. T.*



J. Wild. lith.

M & N Hanhart imp.

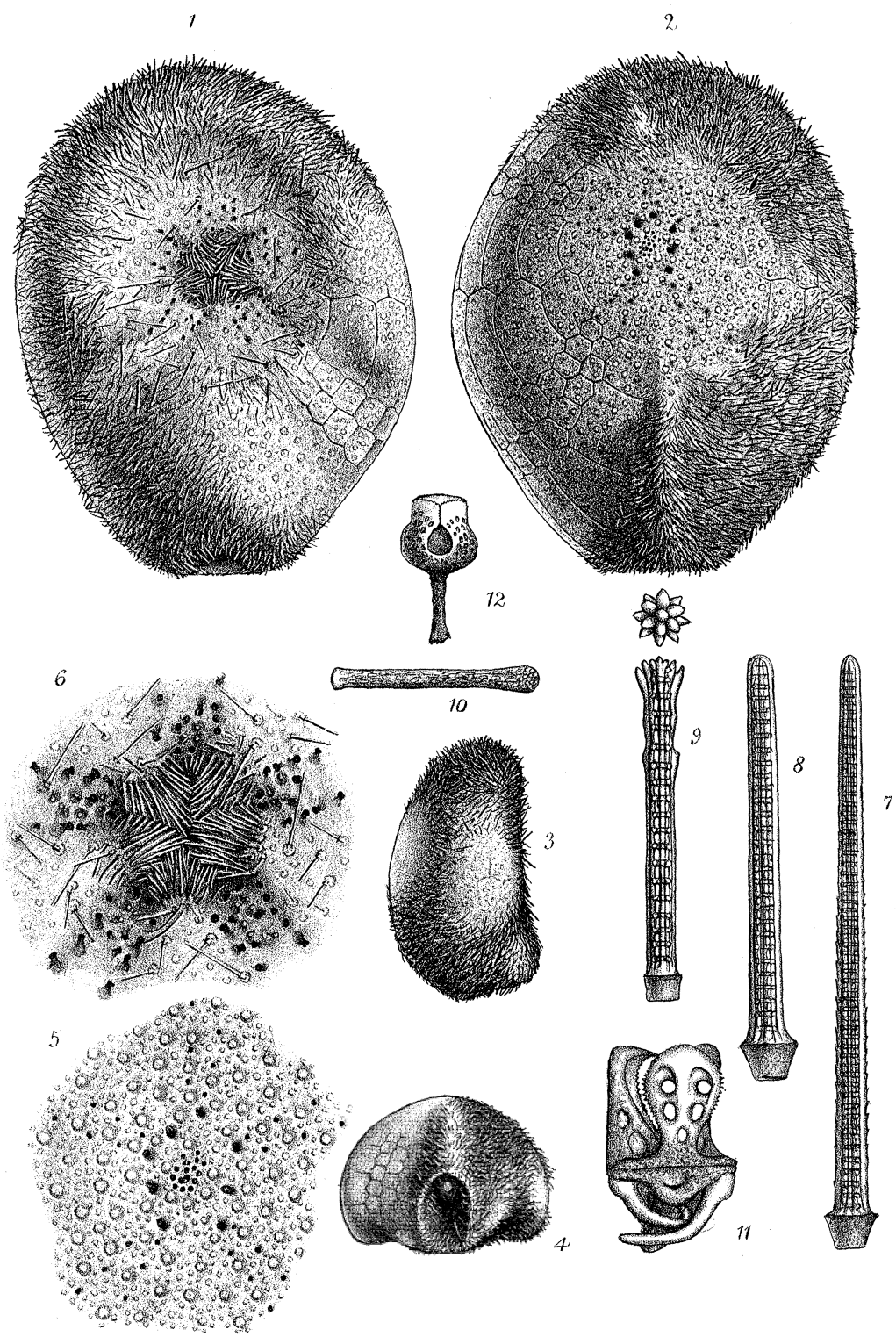
CALVERIA FENESTRATA. *Wy. T.*



J.J.Wild lith.

M&N.Hanhart imp.

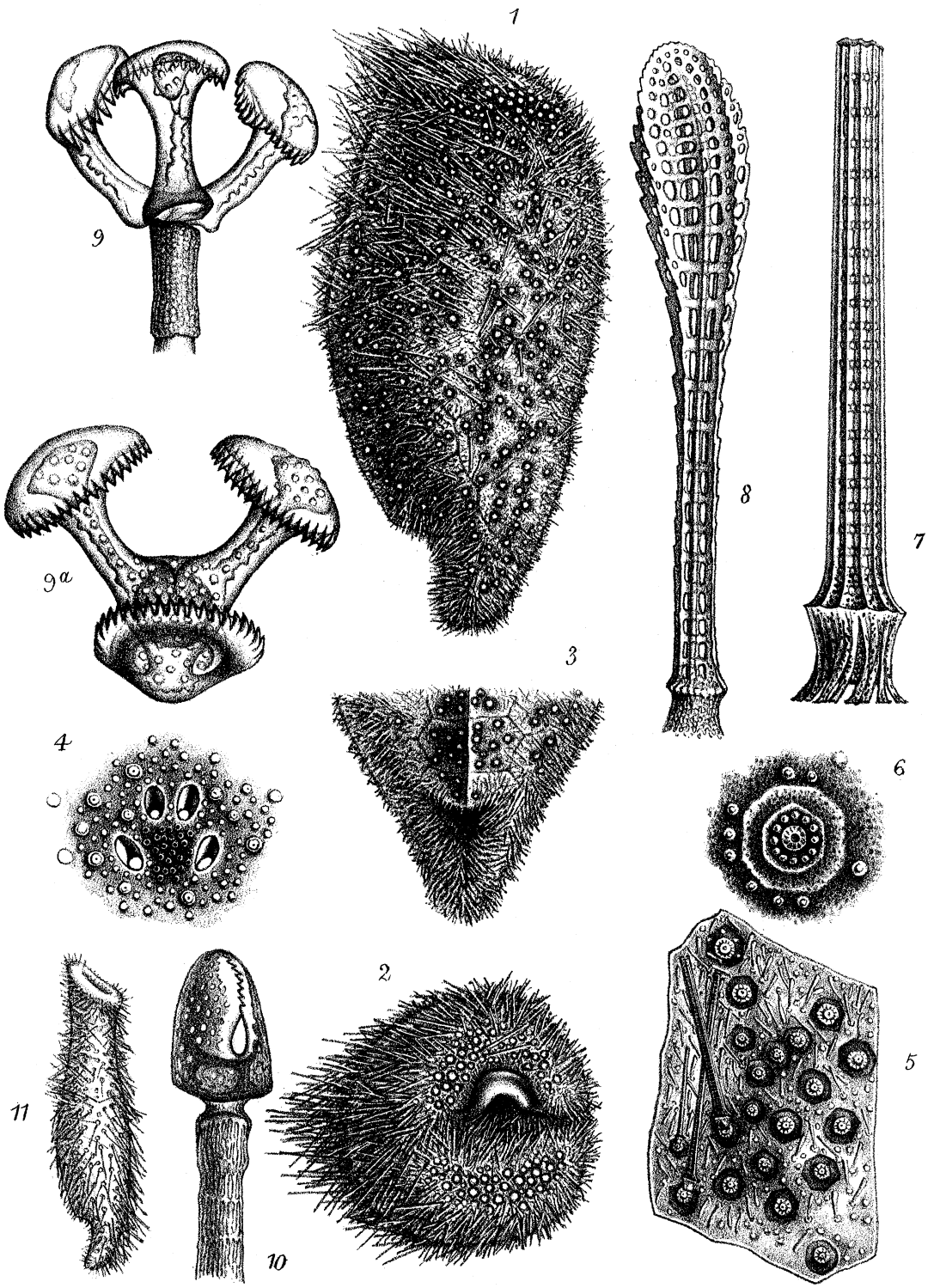
Fig 1 10. ECHINUS MICROSTOMA. *Wy. T.*
11 13. ECHINUS ELEGANS *von Duben and Koren.*
14. ECHINUS FLEMINGII. *Ball.*



J J. Wild lith.

M&N Hanhart imp.

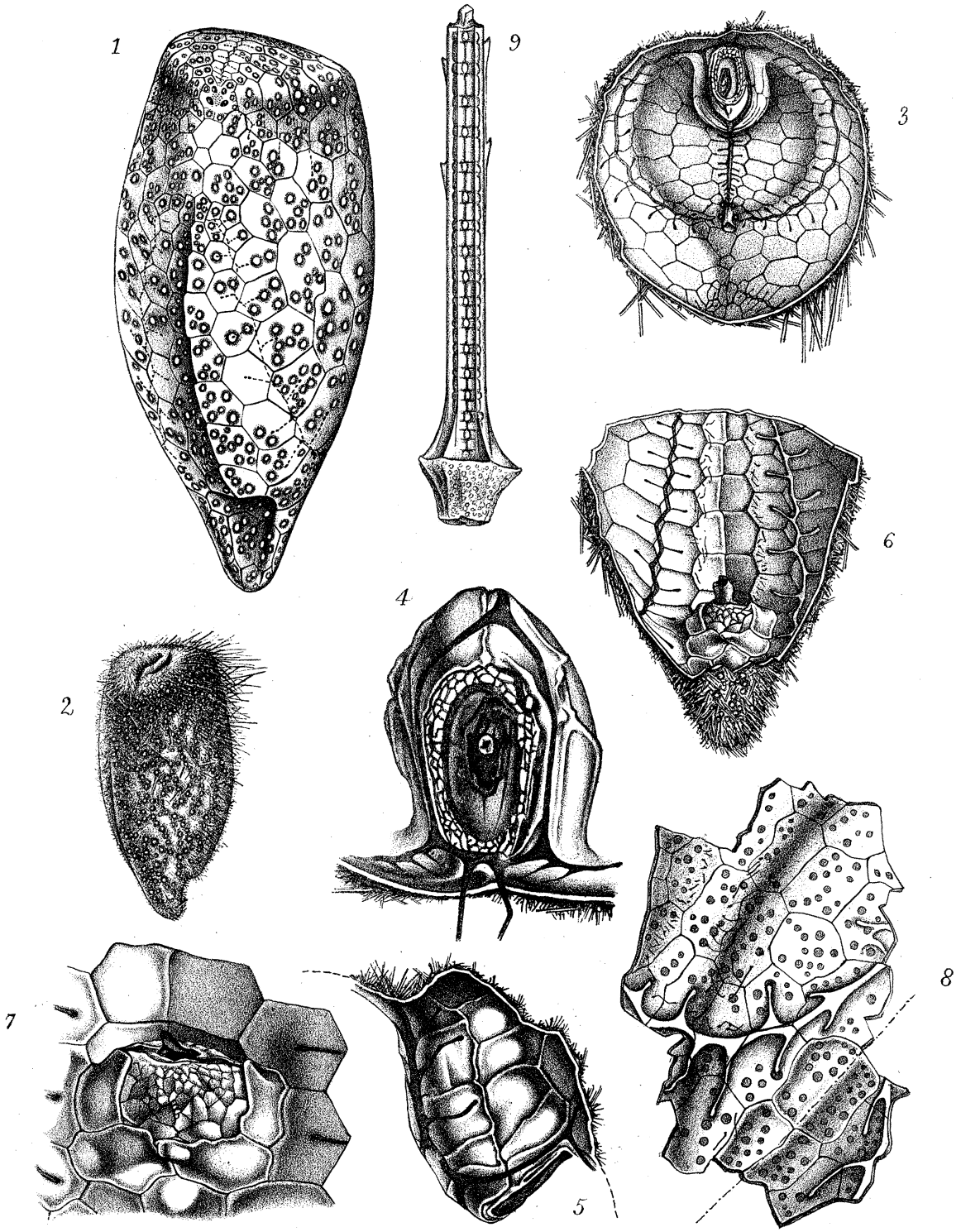
NEOLAMPAS ROSTELLATA, *A Agassiz*



J.J.Wild, lith.

M&N.Hanhart, imp.

Fig 1 10. POURTALESIA JEFFREYSI, *Wy. T.*
11. POURTALESIA PHIALE, *Wy. T.*



J.J.Wild, lith.

M&N.Hanhart, imp.

POURTALESIA JEFFREYSI. *Wy. T.*