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HAWAIIAN AND OTHER PACIFIC ECHINI.

THE CIDARIDÆ.

BY

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WITH FORTY-FOUR PLATES.

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* Hawaiian species.

NOTICE.

THE following account of the Cidaridæ of the Hawaiian Echini collected in the spring of 1902 by the United States Fish Commission Steamer "Albatross," Commander Chauncey Thomas, U. S. N., commanding, is the first part of the description of a large collection of Sea-urchins intrusted to us for examination by the Hon. George M. Bowers, United States Fish Commissioner. A few other Echini collected by the "Albatross" in different parts of the Pacific have been incorporated in our Report, and special reference has been made to some Deep Sea Panamic Cidaridæ collected by the "Albatross" in 1891, for the sake of having a connected account of the pedicellariæ of the Pacific Cidaridæ. This part of the Report has been prepared by Mr. Clark, and he has, as far as practicable, analyzed the statements of Mortensen, Döderlein, and de Meijere regarding their systematic value. Mr. Agassiz has in his Panamic Deep Sea Echini given his views of the new classification of Echinoids proposed by Mortensen and de Meijere. As regards the position taken by Döderlein regarding Mortensen's system, in his Echini of the "Valdivia," which has recently been published, it is difficult to follow him. His statements are often most guarded; next they may be enthusiastic in favor of a classification based upon pedicellariæ, and again are radically opposed to such a course. The numerous illustrations of pedicellariæ given by Döderlein are unfortunately somewhat indistinct, and it is often very difficult to distinguish their characteristic features.

The succeeding parts of this monograph on the Hawaiian Echini will be published as rapidly as the preparation of the plates will allow. In the meantime a preliminary list of the species included in the collection will shortly be printed. For the positions indicated in the Stations, see U. S. Hydrographic Chart, No. 1368.

ALEXANDER AGASSIZ.
HUBERT LYMAN CLARK.

MUSEUM OF COMPARATIVE ZOÖLOGY.
CAMBRIDGE, MASS., February, 1907.

HAWAIIAN AND OTHER PACIFIC ECHINI.

COLLECTED BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," COMMANDER CHAUNCEY THOMAS, U. S. N., COMMANDING.

CIDARIDÆ Müller.

PEDICELLARIÆ are present in considerable numbers among the secondary and miliary spines of the Cidaridæ and show the greatest diversity in their size, form, and relative abundance. We can distinguish in this family three sorts of pedicellariæ, differing from one another in structure, as well as in size, and for convenience these have been designated as "tridentate," "large globiferous," and "small globiferous." The three kinds are not, however, sharply distinct from one another, for intermediate forms are common, often on one and the same individual. Covered with their epidermal tissue the pedicellariæ are difficult to study, but when the organic matter has been cleaned off with caustic potash, or much better with hypochlorite of soda, their calcareous parts show many interesting features. In what follows, reference is made to these calcareous parts only.

The tridentate pedicellariæ have the valves elongated, and either flat or contracted rather abruptly into a slender blade, which may terminate in a rounded, more or less smooth end, or in a conspicuous hook or "end-tooth." Each valve is practically solid and does not contain any interior cavity, but it is often more or less perforated, near the base and along the sides, with small holes. A tridentate pedicellaria is usually made up of three valves, of equal size, connected with each other at the base by muscles, and freely movable on the end of a stalk of variable length. But similar pedicellariæ with only two valves occur regularly in *Porocidaris purpurata*, and rarely in *P. variabilis*, while in the latter species such pedicellariæ with four valves are also occasionally found. When closed, the valves may meet for their entire length (and this is always so in pedicellariæ having two or four valves) or, as in many of those with three valves, these meet only at the tip or for a fraction of their length, and are

more or less widely separated above their basal union. In size, the valves show a wide range, from less than half a millimeter to over half a centimeter long, the width being from .10 to .70 of the length. In small examples the stalk, which is a simple, straight rod, is often as long as the valves, but in large ones the valves are much the longer. Tridentate pedicellariæ occur mainly around the primary spines, especially on the actinal half of the test, but they may occur abactinally and are sometimes conspicuous on the abactinal system. They may be entirely wanting not merely in individual cases but in whole groups of species.

The large globiferous pedicellariæ are always three-valved. They take their name from the fact that when the valves, which are large and hollow, are closed in their normal position, the whole head appears more or less globular. The cavity of each valve opens on the inner side near the tip, or the opening may be terminal. The size of the opening is very variable, but the three valves of any one pedicellaria are all alike. When the opening is not at the end, the tip of the valve may be blunt and rounded or it may terminate in a more or less conspicuous "end-tooth." When the opening is large the edges are usually irregularly serrate, and more or less of the entire length of the margin of the valve may be provided with small teeth. The lower edge of the opening is usually sharply indicated by a horizontal, outwardly curved "lip," but this is frequently imperfect or entirely wanting. The lower part and back of the valve is more or less perforated with holes of variable size and shape. True large globiferous pedicellariæ show relatively little diversity in size, the valves ranging only from one-half to a little more than one millimeter in length. The stalk is usually about as long as the valves, but is often less, while on the other hand it may be twice as long. Usually it is a simple, straight, calcareous rod, but in some species there are frequently, if not always, projecting, slender spicules which form a circle near the distal end of the stalk; this is referred to as the "limb." Large globiferous pedicellariæ occur chiefly on the abactinal half of the test and most commonly between the primary spines, though they are often frequent on the abactinal system. They seldom occur on the ambulacra or near the actinostome and they are often entirely wanting, not merely in individual cases, but even in whole groups of species. In individuals on which they are abundant, there may not uncommonly be found large globiferous pedicellariæ in which the valves have become elongated and narrow, without a lip, and the opening

larger and longer than usual, and the transition into tridentate pedicellariæ can be traced step by step through a series of such intermediate forms. More commonly a series may be found in which, by a gradual reduction in size, the large globiferous intergrade with the small globiferous pedicellariæ.

The small globiferous pedicellariæ are very similar to the large ones in all essentials of structure, but the valves are more slender and the stalk is much longer, and rarely, if ever has a limb. Often the valves differ in some way very clearly from those of the large globiferous pedicellariæ of the same individual; thus, if the latter have an "end-tooth" most of the small ones may lack it, or vice versa. But they vary greatly, and in the same individual may be found small pedicellariæ the valves of which have no end-tooth, and others in which it is conspicuous. And in some species, moreover, the small globiferous pedicellariæ are just like the large ones and intergrade with them completely. The valves of the small ones range from .15 mm. upwards in length, while the stalk is often two or three times as much and in some cases is five or six times as long as the valves. Small globiferous pedicellariæ may occur anywhere on the test except within the areolæ and the poriferous zones. They are particularly abundant on the actinostome and on the actinal part of the ambulacra, but they may be equally common on the abactinal system. Those with the shortest stalks occur on the ambulacra, while those with the longest stalks are found among the secondary spines of the scrobicular circles. They are never entirely wanting except in the genus *Porocidaris*, where they are replaced by very small tridentates.

GONIOCIDARIDÆ Haeck.

CIDARIS Klein.

Cidaris tribuloides Agass.

Cidarites tribuloides Lamarck, 1816. Anim. s. Vert. III, p. 56.
Cidaris tribuloides Agassiz, 1835, Prodrome, p. 188.

Plate 2, figs. *1–4*.

All three kinds of pedicellariæ are present in most individuals, but occasionally the tridentate are wholly wanting, and now and then only two or three large globiferous ones will be found, even on large specimens.

The large globiferous pedicellariæ (Pl. 2, fig. *1*) have the opening large, terminal, with a well-developed lip and the margins conspicuously toothed.

The blade is somewhat curved, so that it has been described as "projecting in a snout-like way." This is the type of pedicellaria which Mortensen regards as characteristic of the genus *Cidaris;* as a matter of fact, however, it occurs in several other genera. The valves are .60–.70 mm. in length; the stalks (Pl. 2, fig. *2*) are .60–1.50 mm. long and have no limb. They occur chiefly on the interambulacra and most commonly on the abactinal surface.

The tridentate pedicellariæ (Pl. 2, fig. *4*) are not specially peculiar. The valves are narrow and somewhat compressed, usually .50 mm. long or less, often much less, but sometimes are nearly or quite 1 mm.; the stalks are shorter than the valves. They occur almost wholly on the actinal side of the test and are most abundant on the interambulacra.

The small globiferous pedicellariæ (Pl. 2. fig. *3*) have a conspicuous end-tooth on each valve; the opening is not terminal nor is the blade curved, so that the general appearance is quite different from the large ones. The valves are .20–.50 mm. in length, while the stalk is from one to three times as long. They occur everywhere on the actinostome, ambulacra, interambulacra and abactinal system.

Cidaris Thouarsii Val.

Cidaris Thouarsii Val. Agassiz et Desor. 1846, Cat. Rais. Ann. Sci. Nat. (3) VI, p. 326.

Plate 1, figs. *1*, *2*.

All three kinds of pedicellariæ are commonly present, but in specimens from the Galapagos Islands and occasionally in those from Panama, the tridentate are wholly wanting. The large globiferous are also often reduced in numbers so that only two or three are to be found.

The large globiferous pedicellariæ are like those of *C. tribuloides* in form, but are generally larger, often with valves nearly 1 mm. long. The stalk about equals the head and may have a well-developed limb, but this is more commonly lacking (Pl. 1, fig. *1*). These pedicellariæ occur mainly on the abactinal interambulacra.

The tridentate pedicellariæ are similar to those of *tribuloides*, but are somewhat larger. They occur mainly on the actinal surface.

The small globiferous pedicellariæ (Pl. 1, fig. *2*) are like those of *tribuloides*, but are larger, sometimes .75–.80 mm. in length of valves, though they are usually under .50 mm.; the stalk is one to three times as long as the valves. They occur abundantly everywhere.

In October and November of 1904, this species was collected by the "Albatross" at the following localities:

Perico Island Panama, one fathom; three specimens.

Toboquilla Island, Panama, shore; one specimen.

Chatham Island, Galapagos, shore; eight specimens.

Cidaris metularia Bl.

Cidarites metularia Lamarck, 1816, Anim. s. Vert. III, p. 56.
Cidaris metularia Blainville, 1830, Zoophytes: Dict. Sci. Nat., LX, p. 212.

Plate 1, figs. *3–7*.

All three kinds of pedicellariæ are present, usually in considerable numbers.

The large globiferous pedicellariæ (Pl. 1, fig. *6*) are like those of *C. tribuloides*, but are a trifle smaller. The stalks are one or two times as long as the valves and are provided with a conspicuous limb (Pl. 1, fig. *3*), which seems to be always present. They occur on the interambulacra, chiefly abactinally.

The tridentate pedicellariæ (Pl. 1, fig. *7*) are similar to those of *tribuloides*. The valves are about .80 mm. in length and the stalks are about equal to them. These pedicellariæ are common everywhere except on the abactinal system.

The small globiferous pedicellariæ (Pl. 1, figs. *4–5*) are like those of *tribuloides*, but a little smaller, the valves usually about .35 mm. long.; the stalks are one to three times as long as the valves. They occur everywhere on the test and are very common.

None of the two hundred and ninety-six specimens of this widely distributed Indo-Pacific species show any notable peculiarities, and they differ from Zanzibar examples only in their brighter color. They were taken by the "Albatross" at the following stations.

Station 3838. Off S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gy. br. s.

Station 3847. Off S. coast of Molokai. 23–24 fathoms. S. st.

Station 3849. Off S. coast of Molokai. Bott. temp. 67.6°. 43–73 fathoms. Crs. s. brk. sh. co.

Station 3861. Pailolo Channel, and N. E. approach. 30–52 fathoms. Fne. s. sm. p. co.

Station 3871. Auau Channel, between Maui and Lanai. 13–43 fathoms. Fne. wh. s.

Station 3872. Auau Channel, between Maui and Lanai. Bott. temp. 74.6°. 32–43 fathoms. Yl. s. p. co.

Station 3874. Auau Channel, between Maui and Lanai. Bott. temp. 75.3°. 21–28 fathoms. S. p. sh.

Station 3876. Auau Channel, between Maui and Lanai. Bott. temp. 74°. 28–43 fathoms. S. g.

Station 3955. Vicinity of Laysan. Bott. temp. 74°. 20–30 fathoms. Co. r. alg.

Station 3962. Vicinity of Laysan. 16 fathoms. Wh. s. co.

Station 3968. French Frigate Shoal. $14\frac{1}{2}$–$16\frac{1}{2}$ fathoms. Crs. s. co.

Station 3970. French Frigate Shoal. 17–$17\frac{1}{2}$ fathoms. Crs. s. sh. co.

Station 3971. French Frigate Shoal. 17 fathoms. Crs. s. sh. co.

Station 3978. Vicinity of Modu Manu. 32–46 fathoms. Co. s. for. r.

Station 4027. Vicinity of Kauai. Bott. temp. 42.8°. 319 fathoms. Fne. gy. s. r.

Station 4032. Penguin Bank, S. coast of Oahu. 27–29 fathoms. Fne. co. s. for.

Station 4033. Penguin Bank, S. coast of Oahu. 28–29 fathoms. Fne. co. s. for.

Station 4034. Penguin Bank, S. coast of Oahu. 14–28 fathoms. Fne. co. s. for.

Station 4046. Off W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4146. Vicinity of Modu Manu. Bott. temp. 78.7°. 23–26 fathoms. Crs. co. s. for.

Station 4147. Vicinity of Modu Manu. Bott. temp. 77.9°. 26 fathoms. Co. corln.

Station 4148. Vicinity of Modu Manu. Bott. temp. 77.9°. 26–33 fathoms. Co. s. for.

Station 4149. Vicinity of Modu Manu. Bott. temp. 77.7°. 33–71 fathoms. Co. corln.

Station 4150. Vicinity of Modu Manu. Bott. temp. 74°. 71–160 fathoms. Co.

Station 4158. Vicinity of Modu Manu. Bott. temp. 78.6°. 20–30 fathoms. Co. corln.

Station 4159. Vicinity of Modu Manu. Bott. temp. 78.3°. 30–31 fathoms. Crs. co. s. brk. sh. for.

Station 4160. Vicinity of Modu Manu. Bott. temp. 78°. 31–39 fathoms. Co. corln.

Station 4161. Vicinity of Modu Manu. Bott. temp. 77.9°. 39–183 fathoms. Co. corln.

Station 4162. Vicinity of Modu Manu. 21–24 fathoms. Co.

Station 4167. Vicinity of Modu Manu. 18–20 fathoms. Co. s.

Station 4169. Vicinity of Modu Manu. Bott. temp. 78.6°. 21–22 fathoms. Co.

Bathymetrical range, 13–319 fathoms. Extremes of temperature, 78.7°–67°.

Dorocidaris A. Ag.

Dorocidaris abyssicola A. Ag.

Dorocidaris abyssicola A. Ag., 1869. Bull. M. C. Z., I, 9, p. 253; Rev. Ech. Pl. I, figs. 1–4.

Plate 12ª, figs. *1–5*.

Further examination of a large series of Dorocidaris from the West Indies and Florida, comparisons being carefully made with a considerable number of European specimens of *D. papillata*, makes it evident that *abyssicola* can be constantly distinguished from that species. Mortensen's[1] suggestion that the small pedicellariæ might be a distinguishing character is however not a happy one, for the pedicellariæ in *abyssicola* are very variable. The large globiferous ones show remarkable diversity even in a single individual, as is well shown in the figures here given, so that it would be unwise to lay any stress on their form as a systematic character. In general it may be said that the pedicellariæ agree closely (as would naturally be supposed) with those of *papillata*. The smooth, white spines afford the most obvious character by which *abyssicola* may be recognized.

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, p. 34.

Dorocidaris affinis A. Ag.

Cidaris affinis Philippi, 1845. Arch. f. Naturg. Eilfter Jahrg. Bd. I, p. 351.
Dorocidaris affinis A. Ag., 1869. Bull. M. C. Z., I, pp. 17 and 254; Rev. Ech. Pl. I, fig. 5.

Plate 12[b], figs. *1–3*.

Mortensen[1] has pointed out the characteristics distinguishing this species from *papillata*, but he fails to realize the diversity which the pedicellariæ may show. It is true that the large globiferous pedicellariæ are ordinarily like those of *Cidaris* (Pl. 12[b], fig. *3*), but occasionally they are scarcely distinguishable from those of *Dorocidaris* (Pl. 12[b], fig. *1*), while not infrequently they are somewhat intermediate as the opening is not quite terminal (Pl. 12[b], fig. *2*.).

Dorocidaris Bartletti A. Ag.

Dorocidaris Bartletti A. Ag., 1880. Bull. M. C. Z., VIII, 2, p. 69.

Plate 12[a], figs. *6–13*.

Of all the Cidaridæ which we have examined, none exhibit more remarkable diversity in the form of the large globiferous pedicellariæ than does this interesting and handsome West Indian species. Although the most common form (Pl. 12[a], fig. *10*) is that which Mortensen[2] gives as the distinguishing feature of his proposed genus *Tretocidaris*, others (Pl. 12[a], fig. *7*) are quite frequent which ought to distinguish a true Cidaris, while others (Pl. 12[a], figs. *6* and *9*) are quite unlike either. The pedicellaria shown in Pl. 12[a], fig. *6*, may possibly be a stage of growth of the one shown in Pl. 12[a], fig. *7*, but this hardly seems probable. If one were to attempt to determine the generic position of this species by the pedicellariæ, it is obvious that serious difficulties would arise, nor would the presence of a "limb" on the stalk be of assistance, for it is also a very variable character (Pl. 12[a], figs. *12* and *13*). This great diversity in the pedicellariæ is of special interest because the primary spines of *Bartletti* show a greater variety of form than those of any other member of the genus, and according to Mortensen's view[3] the pedicellariæ ought to afford more constant characters.

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, pp. 35–37.
[2] Loc. cit., p. 16.
[3] Loc. cit., p. 15.

Dorocidaris Blakei A. Ag.

Dorocidaris Blakei A. Ag., 1878. Bull. M. C. Z., V, 9, p. 185. Pl. IV; "Blake" Ech. Pl. I.

Plate 12[b], figs. *4–6*

Although the large globiferous pedicellariæ of this species are much less variable than those of *Bartletti*, nevertheless they show sufficient diversity to prevent assigning them all to a single type. The opening at the tip may be broadly triangular with a well-defined lip (Pl. 12[b], fig. *4*), but it is commonly more elongated (Pl. 12[b], fig. *5*), and may be so narrow (Pl. 12[b], fig. *6*) as to approach the form which Mortensen[1] assigns to "*Schizocidaris*." The valves are, however, much broader than in that group, and none were found which would indicate any other genus than Dorocidaris.

Dorocidaris panamensis A. Ag.

Dorocidaris panamensis A. Ag., 1898. Bull. M. C. Z., XXXII, 5, p. 73. Pls. I and II, fig. 1; Pan. Deep Sea Ech. Pl. 1.

Plate 2, figs. *5–8*.

Only two kinds of pedicellariæ are present in the specimens of this species which are at hand, as the tridentate are entirely wanting.

The large globiferous pedicellariæ (Pl. 2, fig. *5*) are much like those in *Cidaris*. The valves are .90–.95 mm. in length and the stalk is about the same or a little shorter; it has no limb. These pedicellariæ are not very common, but occur between the primary spines on the interambulacra.

The small globiferous pedicellariæ (Pl. 2, figs. *6–8*) are quite different from the large ones and sometimes have a large end-tooth (Pl. 2, fig. *8*) as in *Cidaris*. The valves are only .30–.60 mm. in length, while the stalk varies from .30 to 2.50 mm. They are common on all parts of the test.

Dorocidaris bracteata A. Ag.

Dorocidaris bracteata A. Ag., 1879. Proc. Am. Acad., XIV, p. 197.

Plate 3, figs. *15–18*.

Three small specimens of a *Cidaris* were collected at Station 3746, May 19, 1900, off Suno Saki, Sagami Bay, Japan, in 49 fathoms, gy. s. p., the largest of which has a test 15 mm. in diameter, and the smallest only 8 mm. We take

[1] Ingolf Exped. Echinoidea, 1903, Pt. I, p. 25.

them to be the young of *Dorocidaris bracteata*, although the serrations of the radioles (Pl. 3, fig. *14*) are sharper and more prominent than the blunt ones forming the ridge of the fluting of larger specimens. The color of the bands of the radioles is light greenish brown; the small spines are of a lighter color, yellowish gray, while the older specimens of *D. bracteata* collected by the "Challenger" were of a reddish-brown tint. Coming from so near the spot, where the adults of *D. Reini* Döderlein (referred to beyond) were taken, it would be natural to regard these small specimens as the young of that species; but the form and coloration of the spines leave no doubt that they belong rather to *bracteata*. In these specimens, all three kinds of pedicellariæ are present. They resemble quite closely those of *D. Reini*, but are somewhat smaller.

The large globiferous pedicellariæ (Pl. 3, fig. *15*) are more common and the limb (Pl. 3, fig. *23*) curves outward more than in *Reini* and its branches are sometimes provided with additional projections. In addition to these, other large pedicellariæ (Pl. 3, fig. *16*) are found which have the opening of the valves on the inner surface, very large and with no lip, somewhat like those which Mortensen considers characteristic of *Stereocidaris*. There are also tridentate pedicellariæ with strongly curved valves (Pl. 3, figs. *19*, *20*), which are quite peculiar. The small globiferous pedicellariæ (Pl. 3, figs. *17*, *18*) often lack the end-tooth.

Mortensen, on the strength of a large pedicellaria like Pl. 3, fig. *17*, places this species in *Stephanocidaris*, while the presence of pedicellariæ like Pl. 3, fig. *15* surely fixes its place, according to his scheme, in *Cidaris!* On the other hand, Pl. 3, fig. *16* would seem to show that it is nearer to *Stereocidaris!* What are we to do in the face of such disorderly pedicellariæ?

Dorocidaris Reini Död.

Cidaris (Dorocidaris) Reini Doderlein, 1887. Jap. Seeigel., p. 7, Taf. IV, figs. 1–7 and Taf. VIII, fig. 4 a-d.

Plate 3, figs. *1–14*.

Five specimens of this species were collected off Honshu Island, Japan, which agree well with the specimen figured by Döderlein. They range in size from 22 mm. to 30 mm. in diam. The primary radioles (Pl. 3, fig. *9*) are very uniform in appearance and structure; in one of the specimens, however, the radioles are somewhat more slender and proportionally longer in comparison to the diameter of the test than in the specimen figured by Döderlein.

There seems to be some variation in the coloring of the secondary spines; in some specimens they are yellowish green and in other light reddish brown.

All three kinds of pedicellariæ occur in some specimens, but in others only the tridentate and small globiferous are present.

The large globiferous pedicellariæ (Pl. 3, fig. *1*) are of the form found in *Cidaris*, with valves .75–.80 mm. in length. The stalks have a well developed limb (Pl. 3, fig. *8*) and are from .80 to 1.50 mm. long. The few examples of this sort of pedicellaria which were found were between the primary spines on the interambulacra.

The tridentate pedicellariæ (Pl. 3, figs. *4–7*) show much variety of form, the valves in some being short and broad and in others long and narrow. Many were only partially developed. The valves measure from .65 to 1.25 mm. and the stalks vary greatly, sometimes shorter than, sometimes equal to, and sometimes twice as long as the valves. These pedicellariæ are common on the actinal portion of the interambulacra.

The small globiferous pedicellariæ (Pl. 3, figs. *2*, *3*) are remarkable for their great diversity of size, some of them being longer than the large globiferous form. The end-tooth on the valves is often wanting. The valves are .27–.87 mm. long and the stalk is 1–3 times that length. They are common everywhere.

This species was collected at the following stations:

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fms. Bk. s. sh. Three specimens.

Station 3751. Off Suno Saki, Sagami Bay, Japan. 140–148 fms. Gn. m. vol. s. Two specimens.

Bathymetrical range. 83–158 fathoms.

Dorocidaris calacantha A. Ag. and Clark.

Plates 4, figs. *1–12*; 13; 14; 34; 35.

The specimens collected of this species vary in diameter from 40 mm. (Pls. 34, 35) to 12 mm. (Pl. 14; figs. *5–8*). The primary radioles taper very gradually from the slight swelling above the milled ring.

The longest radioles of the largest specimen collected are 78 mm. in length (Pls. 34, 35); they are delicately fluted (Pl. 4, fig. *4*), the ridges formed of low serrations closely packed. The primary radioles are of a violet gray tint, often banded with rings of a darker color than the shaft. The small

primary radioles of the actinal side (Pl. 4, fig. 8) are somewhat club-shaped and fluted at the extremity.

The secondary interambulacral spines are spathiform, slightly grooved on the upper surface, and delicately fluted. They are of a yellowish gray tint, with a greenish stripe extending from the tip towards the base of the spine. The ambulacral spines are similar to the interambulacral, only much narrower, longer, and more slender.

In a specimen 34 mm. in diameter (Pls. 13, figs. 1, 2; 14, figs. 1, 2) there are five and six interambulacral plates. In the larger plates the scrobicular area is surrounded by a ring of large secondaries, which occupy the whole of the plate both in the median row and along the outer edge of the poriferous zone (Pl. 14, figs. 1, 2). In the smaller interambulacral plates towards the actinal system the median zone is formed of three or four rows of small secondaries, and larger secondaries flank the poriferous zone (Pl. 13, fig. 2). The median ambulacral zone is formed by two vertical rows of small secondaries. The abactinal system is 17 mm. in diameter. The anal system is pentagonal, with an outer row of larger plates inclosing two irregular rows of smaller plates (Pl. 13, fig. 2); when dry the anal system and the genital plates are of a light-green color. The ocular plates are heart-shaped, with few small secondaries; the genital plates are covered near the anal system by a cluster of small tubercles; these carry short, sharp, flattened, minute miliaries. The actinal system is 14 mm. in diameter, and shows twelve narrow ambulacral plates, with a small secondary on each side of the poriferous zone. There is only a single row of five interambulacral plates occupying the space between the actinal ambulacral plates; on the edge of the interambulacral plates are very minute miliaries. The central part of the madreporic genital is riddled with the madreporitic openings.

In a specimen 29 mm. in diameter (Pls. 13, figs. 3, 4; 14, figs. 3, 4) the abactinal system measures 15 mm., and the actinal 12 mm. in diameter. There are five and five primary interambulacral tubercles. There are no important differences in the test of this smaller specimen as compared with that of the larger one. The principal difference to be noticed is the absence of miliaries and secondaries on the abactinal system. The genital and ocular plates are nearly bare; a few miliaries only are scattered on the proximal part of the genital plates.

In the smallest specimen collected, measuring 12 mm. in diameter (Pl. 14, figs. 5–8), the abactinal system was 7 mm. and the actinal 6 mm. There

are no differences in the abactinal system, except those due to size, and there are four and five primary tubercles. The secondaries occupy nearly the whole of the interambulacral plates outside of the scrobicular area. There are only four actinal interambulacral plates.

In this smallest specimen the primary spines are stouter and less tapering in proportion to the diameter of the test (Pl. 14, figs. *1, 5, 6*) than in older specimens.

Only two kinds of pedicellariæ occur in this species, as the large globiferous seem to be wholly wanting.

The tridentate pedicellariæ (Pl. 4, fig. *3*) have the valves very long and slender, and quite abruptly expanded near the base, while the narrow portion is much compressed. The valves are about 1.20 mm. long, and the stalks are of about the same length. These pedicellariæ are found mainly on the actinal part of the test.

The small globiferous pedicellariæ (Pl. 4, figs. *1, 2*) are like those of *Reini* and *bracteata*; the end-tooth is usually very marked. The valves are from .20–.87 mm. long, while the stalks are one to three times as long. They occur everywhere, but the largest ones, on the longest stalks, occur in the scrobicular circles.

This species we have named *calacantha*, from the regular and graceful shape of the primary radioles. It was collected by the "Albatross" at the following localities.

Station 3859. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 60.2°. 138–140 fathoms. Fne. s. m.

Station 3863. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 60°. 127–154 fathoms. Brk. co. ers. g. r.

Station 3882. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 63.5°. 136 fathoms. S. co. r.

Station 3885. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 64.8°. 136–148 fathoms. S. p.

Station 3886. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 65°. 148 fathoms. P. r.

Station 4045. West coast of Hawaii. Bott. temp. 49°. 147–198 fathoms. Co. s. for.

Station 4100. Pailolo Channel, off Mokuhooniki Islet. Bott. temp. 61°. 130–151 fathoms. Co. s. sh. for.

Bathymetrical range, 127–198 fathoms. Extremes of temperature, 65°–49°.

Twenty-eight specimens.

Chondrocidaris A. Ag.

Chondrocidaris gigantea A. Ag.

Chondrocidaris gigantea, A. Ag. 1863. Bull. M. C. Z., I, 2, p. 18. Rev. Ech. Pl. I *a*.

Plate 4, figs. *13–19*.

At the time a specimen of this species was first obtained from the Hawaiian Islands, it was separated from the other Cidaridæ as a new genus; subsequently it was assigned to the genus Phyllacanthus. An examination of two additional specimens collected by the "Albatross" from Station 4050 off Kealakekua Light House, W. coast of Hawaii, as well as of other Cidaridæ, inclines us to revert to the first determination and to recognize again the genus Chondrocidaris, not merely upon the nature of the pedicellariæ as has been done by Mortensen,[1] but also owing to the uniform granulation of the test and of the abactinal system. This is composed of very small tubercles of nearly uniform size, carrying minute, triangular, miliary spinelets.

The abactinal system is circular. There is only a single ring of secondary tubercles round the scrobicular area.

In a specimen of 83 mm. diameter there are nine and nine primary interambulacral plates. The abactinal system is 31 mm. in diameter; the greatest width of the anal pentagon is 15 mm.; the actinal system is 19 mm. When dry the secondary spines are at the tip, of a dark chocolate color, and the primary radioles are of the same color from the milled ring to the base of the tip of the radiole. The rest of the spine is of a lighter color.

The mammary boss of the primaries is perforate, but not crenulated.

No large globiferous pedicellariæ are present in any available specimens, so that it has not been possible to determine the accuracy of Mortensen's figures.

The tridentate pedicellariæ (Pl. 4, figs. *14*, *17–19*) have the valves very slender and in contact for practically their entire length. They are about 1.65 mm. long, while the stalk is somewhat shorter. They are rather infrequent, occurring chiefly between the actinal primary spines.

The small globiferous pedicellariæ (Pl. 4, figs. *13*, *15*, *16*) are very characteristic. The valves are short and wide with a large opening, well-defined lip and prominent end-tooth. They are only .40 mm. in length, and

[1] Ingolf Echinoidea, 1903, Pt. I, p. 29.

the stalk on which they are borne is even less. These pedicellariæ are abundant everywhere among the numerous miliary spines so characteristic of this species.

Station 4050. Off Kealakekua Light, W. coast of Hawaii. 14–215 fathoms. Frag. cor. r. Two specimens.

Phyllacanthus Brandt.

Phyllacanthus annulifera A. Ag.

Cidarites annulifera Lamarck, 1816. Anim. s. Vert. III, p. 57.
Phyllacanthus annulifera A. Ag. 1872. Rev. Ech. Pt. I, p. 150. de Loriol's Trois Esp. Ech. Pl. IV.

Plate 12[b], figs. *14*, *15*.

It has seemed worth while to figure the actinal primary spines of this species to show the contrast between them and those of *Stephanocidaris bispinosa*, with which this species appears to have often been confused.

Phyllacanthus baculosa A. Ag.

Cidarites baculosa Lamarck, 1816. Anim. s. Vert. III, p. 55.
Phyllacanthus baculosa A. Ag. 1872. Rev. Ech. Pt. I, p. 150. Pl. I *f*, *4–5*.

Plate 12[b], figs. *16*, *17*.

The actinal primary spines of this species are also figured to emphasize the contrast between Stephanocidaris and Phyllacanthus in this particular.

Phyllacanthus Thomasii A. Ag. and Clark.

Plates 5, figs. *1–17*; 26, figs. *5–8*; 27–30.

The specimens collected of this species vary in size from 70 mm. to 30 mm. in diameter. In a specimen of 70 mm., with nine and nine primary interambulacral tubercles (Pls. 27–30), the abactinal system measures 33 mm., the anal system 18 mm., and the actinal 26 mm. in diameter. The longest primary radiole is 101 mm.

In a specimen 40 mm. in diameter (Pl. 26, figs. *5–8*), with six and seven primary interambulacral tubercles, the abactinal system measures 20 mm., the anal 11 mm., and the actinal 20 mm. in diameter, and the longest primary radioles, 70 mm.

In a specimen 35 mm. in diameter, with six and seven primary interambulacral plates, the abactinal system measures 16 mm., the anal 10 mm., the actinal 17 mm.

The longest primary radiole of a specimen 30 mm. in diameter, with six and six primary tubercles, measures 73 mm.

The primary radioles (Pl. 5, fig. 7) are somewhat swollen near the base, and taper very gradually toward the tip (Pls. 27–30). The radioles are of a grayish pink tint faintly banded transversely with darker, alternating with lighter, colored patches. The shaft is covered with longitudinal rows of low, blunt serrations. The base of the shaft above the milled ring is of a dark chocolate color. The same coloring extends to the secondary and miliary spines. There is but little difference in the shape and proportion of the primary radioles in the specimens collected. The radioles of the smaller specimens are proportionally more slender (Pl. 30). The small actinal primary radioles are fluted and somewhat club-shaped (Pls. 27, 30, fig. 1). In large specimens the general aspect of the regular secondary and miliary tuberculation of the test (Pls. 27–30) greatly resembles that of Chondrocidaris, though the contrast between the secondaries of the scrobicular area and of the rest of the interambulacral plates is not as marked as in that genus, and is perhaps more as we find it in the test of Stereocidaris. In smaller specimens (Pl. 26, figs. 5–8) the tubercles of the interambulacral plates outside of the scrobicular circles are less uniform in size and less regularly arranged and carry small miliary spinelets.

The median ambulacral space is filled by two irregular vertical rows of small secondaries (Pls. 27, 28, 29, fig. 1). In smaller specimens the median vertical rows are well separated and run close to the outer rows of secondaries (Pl. 26, fig. 8).

The abactinal system of large specimens (Pl. 28) is very uniformly covered with secondaries. These are less prominent in smaller specimens (Pl. 26, fig. 5).

The outer row of plates of the pentagonal anal system is made up of large, irregularly shaped plates, the next and following rows of which there are four or five, of smaller polygonal plates, which become smaller towards the anal opening.

In the actinal system there is but a single row of narrow interambulacral plates (Pl. 26, fig. 6). In larger specimens they are split into three or four rows (Pl. 27.)

Only the tridentate and small globiferous pedicellariæ are present in this species, no large globiferous ones occurring in any of the numerous specimens examined.

The tridentate pedicellariæ (Pl. 5, figs. *2, 5, 6*) have the valves very slender and generally about 1.5 mm. long; in some specimens, however, where these pedicellariæ are very abundant, they vary greatly in size and sometimes the valves are only .30 or .40 mm. in length. Usually the stalks are as long as the valves or a little longer, but often they are shorter. These pedicellariæ are generally fairly common around the primary spines; when very abundant they occur on the ambulacra also.

The small globiferous pedicellariæ (Pl. 5, figs. *1, 3, 4*) are not peculiar; they have rather narrow valves and a well-developed end-tooth. The valves are from .18 to .80 mm. long, and the stalks are from one to three times as long. These pedicellariæ are usually abundant everywhere, but in specimens with an exceptionally large number of tridentate pedicellariæ, they are much less frequent and occur chiefly among the secondaries of the scrobicular circles.

Station 3823. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 69°. 78–222 fathoms. Fne. s. p.

Station 3838. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gr. br. s.

Station 3863. Pailolo Channel, between Molokai and Maui. Bott. temp. 61°. 127–154 fathoms. Brk. co. crs. g. r.

Station 4046. Off Kawaihae Light, W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4062. Off Kauhola Light, N. E. coast of Hawaii. 83–113 fathoms. Co. vol. s. sh. for.

Station 4096. N. E. approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Bathymetrical range, 71–286 fathoms. Extremes of temperature, 69 – 45.3°. Nineteen specimens.

Stephanocidaris A. Ag.

The discovery of a cidarid among the Hawaiian Islands which shows clearly the characters of this genus emphasized by the senior author in 1873, is interesting, for specimens of *S. bispinosa* seem to be remarkably

rare, and recent writers have been disposed to ignore the genus altogether. This tendency has been increased by confusing *Phyllacanthus annulifera* with *S. bispinosa*, and as the former does not have a specially peculiar abactinal system, it is not strange that the characteristic feature of Stephanocidaris has been misunderstood. The Hawaiian specimens not only show clearly the remarkable abactinal system, but enable us to call attention to another feature of the genus, found in the peculiar "capping" of the actinal primary radioles (Pl. 12[b], figs. *10–13*), a character we have observed in no other cidarid except *Acanthocidaris hastigera* (q. v.).

Stephanocidaris bispinosa A. Ag.

Cidarites bispinosa Lamarck, 1816, Anim. s. Vert. III, p. 57.
Stephanocidaris bispinosa A. Ag. 1872, Rev. Ech., Pt. I, p. 160. Pl. I, *f*, *1*.

Plate 12[b], figs. *10*, *11*.

The peculiar "capping" of the actinal primary spines is a striking character of this handsome species, and is clearly shown in the figures given. It will also be noticed that the abactinal side of these spines is marked with roundish white spots, and it is interesting to see that the same feature is present to an even greater degree in the new species from Hawaii (Pl. 12[b], fig. *13*). We have been unable to find any large globiferous pedicellariæ in the single available specimen of this species, but it is safe to say that the figure given by Mortensen[1] is not that of a Stephanocidaris pedicellaria, if, indeed, it represents the valve of a *large* globiferous pedicellaria at all; it appears to be a large example of a *small* globiferous pedicellaria of a Phyllacanthus, and probably *P. annulifera*.

Stephanocidaris hawaiiensis A. Ag. and Clark.

Plates 4, figs. *30–33*; 12[b], figs. *12*, *13*; 24; 25; 26, figs. *1–4*.

A large series of this species was collected by the "Albatross," varying in size from 41 mm. to 6 mm. in diameter. In a specimen of 41 mm. diameter the abactinal system measures 20 mm., the anal 11 mm., and the actinal 18 mm., and the longest primary radioles are 87 mm. long; there are eight and eight large interambulacral tubercles. In a specimen 33 mm. in

[1] Ingolf Echinoidea, 1903, Pt. I, Pl. X, fig. 17.

diameter, the largest radioles are 83 mm. long, with six and six primary interambulacral tubercles. In a specimen 20 mm. in diameter with six and six primary tubercles, the longest radiole measures 56 mm. In a specimen 32 mm. in diameter with six and seven primary tubercles, the abactinal system is 15 mm., the anal system 10 mm., and the actinal 13 mm. in diameter. In a specimen 31 mm. in diameter, the longest radiole measures 73 mm. In a specimen 14 mm. in diameter with five and five primary tubercles, the longest radiole is 34 mm., and the abactinal as well as the actinal system, 6 mm.

In a small specimen 9 mm. in diameter, with five and four primary interambulacral plates, the abactinal system measures 4 mm., the anal system 2.5 mm., and the longest radiole 16 mm.

In this small specimen the genitals are in contact at the proximal angles; the ocular plates do not as yet separate them as they do in larger specimens (Pl. 26, fig. *1*) where the ocular and genital plates form a continuous ring in contact with the distal row of large anal plates. The anal plates form four or five irregular rows of large plates diminishing in size towards the anal opening. The primary radioles are flattened on the lower side (Pl. 24), rounded above (Pl. 25); they vary greatly in color. Most of them are transversely banded with brick-red and yellowish or white, from the tip of the radiole to the dark, chocolate-colored band above the milled ring. In some young specimens the prevailing shade is yellowish-green, in place of the red. In others again, the radioles are of a uniform brick-red color towards the base of the spine, and are only banded near the tip. Others are of a uniform dull brick-red, with serrations of darker color, while still others, usually those round the abactinal system, are of a uniform dark-violet color. Seen from the lower side the primaries, as well as the secondaries are of a uniform, dull, light-yellowish red, the latter being somewhat darker. The larger and longer serrations on the edge of the primary radioles are usually white; the serrations of the upper side are usually of a brick-red color, somewhat darker than the color of the transverse bands. In the smaller specimens the banding of the radioles towards the tip is very marked.

The interambulacral secondary spines are long, slender, flattened, and sharply pointed (Pls. 24, 25), of a dirty, greenish-brown color. The ambulacral are more slender and pointed than the interambulacral secondaries, but are of the same greenish-brown color as the median interambulacral

spines and are carried upon tubercles which might truly be called miliaries. The secondary tubercles form a ring of a single row round the scrobicular area; the rest of the interambulacral plates is occupied by miliaries both in the median interambulacral space and in the space adjoining the poriferous zone. This granulation resembles somewhat that of *Chondrocidaris gigantea*. The median ambulacral space carries only very small miliaries forming irregular, interrupted, vertical rows between the two vertical rows of larger ambulacral secondaries.

This arrangement is only well developed in the larger specimens; it is only apparent in specimens as large as those figured in Pl. 26, figs. *1–1*, and fully developed in larger specimens.

There is only a single vertical row of narrow, elongate actinal interambulacral plates.

Besides the radical differences in color, this species may be distinguished from *S. bispinosa* by the much longer and more slender primary radioles and the large actinal system, which is but little, if at all, smaller than the abactinal.

The large globiferous pedicellariæ seem to be entirely wanting, and in young individuals the tridentate are also quite infrequent.

The tridentate pedicellariæ (Pl. 4, figs. *22–23*) have valves long and slender, as much as 1.5 mm. in length, while the stalks are more or less nearly equal to them. They occur chiefly on the interambulacra about the primary spines, and are quite common in large individuals.

The small globiferous pedicellariæ (Pl. 4, figs. *20–21*) are not peculiar, but the valves have a prominent end-tooth. The valves are about .50 mm. in length and are borne on stalks from one to six times as long. These pedicellariæ are common, especially on the abactinal system of the young and the interambulacra of the adults.

This species was collected by the "Albatross" at the following localities.

Station 3845. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71°. 60–64 fathoms. Crs. s. p. sh.

Station 3846. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.5°. 60–64 fathoms. Crs. br. s. sh. g.

Station 3849. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67.6°. 43–73 fathoms. Crs. s. br. sh. co.

Station 3861. Pailolo Channel and N. E. approach. 30–52 fathoms. Fne. s. sm. p. co.

Station 3863. Pailolo Channel and N. E. approach. Bott. temp. 61.° 127–154 fathoms. Brk. co. crs. g. r.

Station 3872. Auau Channel between Maui and Lanai. Bott. temp. 74.6°. 32–43 fathoms. Yl. s. p. co.

Station 3876. Auau Channel between Maui and Lanai. Bott. temp. 74°. 28–43 fathoms. S. g.

Station 3906. Off Mokapu Islet, N. coast of Molokai. Bott. temp. 72°. 66–96 fathoms. Gy. s. sh. p.

Station 3936. Vicinity of Laysan. Bott. temp. 68°. 79–130 fathoms. Sml. brk. sh. corln.

Station 3955. Vicinity of Laysan. Bott. temp. 74°. 20–30 fathoms. Co. r. alg.

Station 3987. Vicinity of Kauai. Bott. temp. 73°. 50–55 fathoms. Crs. co. s. co. frag.

Station 3991. Vicinity of Kauai. Bott. temp. 43.7°. 272–296 fathoms. Fne. s. r.

Station 4027. Vicinity of Kauai. Bott. temp. 42.8°. 319 fathoms. Fne. gy. s. r.

Station 4046. W. coast of Hawaii. Bott. temp. 59°. 71–147 fathoms. Co. s. for.

Station 4054. N. E. coast of Hawaii. 26–50 fathoms. Crs. co. s. corln.

Station 4057. N. E. coast of Hawaii. 75–77 fathoms. Fne. gy. s. sh.

Station 4064. N. E. coast of Hawaii. Bott. temp. 69°. 63–107 fathoms. Vol. s. for. co.

Station 4066. Between Maui and Hawaii. Bott. temp. 52.5°. 49–176 fathoms. Rky.

Station 4073. N. E. and N. coast of Maui. Bott. temp. 71.9°. 69–78 fathoms. Crs. co. s. for.

Station 4077. N. E. and N. coast of Maui. Bott. temp. 70°. 99–106 fathoms. Fne. co. s. for.

Station 4128. Vicinity of Kauai. Bott. temp. 47.8°. 68–253 fathoms. Crs. br. co. s. for.

Station 4160. Vicinity of Modu Manu. Bott. temp. 78°. 31–39 fathoms. Co. corln.

Station 4161. Vicinity of Modu Manu. Bott. temp. 77.9°. 39–183 fathoms. Co. corln.

Bathymetrical range, 20–319 fms. Extremes of temperature, 78°–42.8°.

One hundred and five specimens.

STEREOCIDARIS Pomel.

Stereocidaris grandis Död.

Stereocidaris grandis Död., 1887. Jap. Seeigel, p. 3. Pls. I; II, figs. 1–11; VIII, fig. 2.

Plates 5, figs. *18–20*; 33 and 36.

The "Albatross" collected *Stereocidaris grandis* both in Japan and in the Hawaiian Islands. In the Japanese specimens the primary radioles are more slender and comparatively longer than in the Hawaiian specimens, and are slightly pointed. The lateral serrations of the flattened actinal primary radioles are also marked in some cases, while in the Hawaiian specimens the actinal radioles are cylindrical and blunt.

A note by the collector with the specimens from Station 4044 states that "the test is pale olive gray, the long spines a still paler muddy gray and the secondary spines at the base of the primary radioles pale green." The specimens collected vary from 8 mm. to 39 mm. in diameter. All of the different kinds of pedicellariæ are present in this species and quite common.

The large globiferous pedicellariæ (Pl. 5, fig. *18*) have the valves short and stout with a large opening and no end-tooth; they measure about .75 mm. in length, while the stalks are usually shorter and have no limb. These pedicellariæ are frequent on the interambulacra and are often found singly at the inner angles of the coronal plates.

The tridentate pedicellariæ (Pl. 5, fig. *20*) generally have the valves unusually broad and widely separated at the base, only meeting near the tip; sometimes, however, they are narrow and compressed and only slightly separated near the base. The valves are about 1.25 mm. in length, while the stalk is somewhat shorter. They are found almost wholly on the actinal side of the test.

The small globiferous pedicellariæ (Pl. 5, fig. *19*) are much like the large ones, but the margins are straighter. The valves are only about .40 mm. in length while the stalk is from one to three times as long. They are abundant everywhere.

This species was taken at the following localities.

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fathoms. Bk. s. sh.

Station 3831. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 45.1°. 178–261 fathoms. Br. m. co. s. r. co.

Station 3919. Off Diamond Head, Oahu. Bott. temp. 45.6°. 220–257 fathoms. Gy. s.

Station 4044. Off Kawaihae Light, W. coast of Hawaii. Bott. temp. 47°. 198–233 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Bathymetrical range, 83–286 fathoms. Extremes of temperature, 47°–45.1°. Fifteen specimens.

Stereocidaris leucacantha A. Ag. and Clark.

Plates 6; 15; 32.

The specimens collected vary in diameter from 52 mm. (Pl. 32, figs. *1–4*) to 26 mm. They are notable for their long, slender primary radioles. In a specimen measuring 28 mm. in diameter, the longest radioles are 67 mm. In a larger specimen, 37 mm. in diameter, the longest radioles measure 87 mm.; they vary in color from light violet-gray to white, with the band above the milled ring more or less distinctly purple. This species is closely allied to *S. grandis*, but the radioles (Pl. 6, fig. *8*) differ from those of that species in being more slender and more cylindrical (Pls. 15, figs. *1*, *2*; 32, figs. *5*, *6*). The fluted extremity often expands somewhat.

The serrations of the radioles of *leucacantha* are smaller and less distinct than those of *grandis*. The secondary spines both in the ambulacral and interambulacral areas are shorter and smaller than those of *grandis*. The granulation of the abactinal system and of the test is much closer and smaller in this species than in *grandis*. (Compare Pls. 15 and 32 with Pls. 33 and 36). The plates on the angles of the anal pentagon are much larger than the corresponding plates of *grandis*. With increasing size the ocular plates become more elongate (compare fig. *5*, Pl. 32, with fig. *1*, Pl. 32). The large specimen figured on Pl. 32, figs. *1–4* shows an extraordinary splitting of the upper interambulacral plate (Pl. 32, fig. *1*) so that the abactinal circle of interambulacral plates consists of fifteen plates instead of ten, a structure we have not noticed in any other Cidarid. In another specimen, from Station 3992, the abactinal edges of the plates which are split have been pushed out by the genital and ocular plates, forming a steep wall round the abactinal system, which thus bulges as much as 10 mm. well up

beyond the general outline of the test. This specimen measures 40 mm. in diameter, the abactinal system 27, showing a proportionally far larger abactinal system than in the smaller specimens measured.

The median ambulacral zone consists of two outer vertical series of large secondaries with irregularly arranged miliaries, forming two or three indistinct vertical rows. In *grandis*, there is only one irregular median vertical row of miliaries.

In a specimen measuring 52 mm. in diameter (Pl. 32, fig. *1*) there are six and six interambulacral plates; the abactinal system measures 25 mm.; the genital plates are more rectangular than those of *grandis;* the actinal system measures 18 mm.

In a specimen of 38 mm. there are five and five interambulacral plates; the abactinal system measures 19 mm. and the actinal system 18 mm.

In a smaller specimen, 31 mm. in diameter (Pl. 32, figs. *5*, *6*) the abactinal system measures 15 mm. and the actinal 12 mm. There are five and five interambulacral plates.

These measurements clearly show that the proportionate increase in height of the test is mainly due to the greater vertical height of the abactinal interambulacral plates in larger specimens than in the smaller ones.

All of the different kinds of pedicellariæ occur in considerable numbers and very closely resemble those of *grandis*.

The large globiferous pedicellariæ (Pl. 6, figs. *3* and *6*) are a trifle smaller than in *grandis* and usually have the stalk shorter, but these differences are not at all constant. These pedicellariæ occur on the abactinal surface, but usually not within the abactinal system.

The tridentate pedicellariæ (Pl. 6, figs. *1*, *2*, and *5*) are smaller than in *grandis*, the valves usually under a millimeter in length, and the stalks still less. They are almost wholly actinal.

The small globiferous pedicellariæ (Pl. 6, fig. *4*) are usually only about .25 mm. long, though the stalk may be three times that. They are abundant everywhere.

This species was collected by the "Albatross" at the following localities.

Station 3828. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 43.8°. 281–319 fathoms. Brk. sh. g.

Station 3835. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 55°. 169–182 fathoms. Fne. br. s. m.

Station 3839. Off Lae-o Ka Laau Light, Molokai. Bott. temp. 46.3°. 259–266 fathoms. Lt. br. m. s.

Station 3865. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 45°. 256–283 fathoms. Fne. vol. s. r.

Station 3866. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 43.8°. 283–284 fathoms. Gy. m. fne. s.

Station 3867. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 44°. 284–290 fathoms. Fne. s. m.

Station 3893. Off Lae-o Ka Laau Light, Kaiwi Channel. Bott. temp. 47°. 220–346 fathoms. Fne. wh. s. r.

Station 3909. Off Diamond Head, Oahu. Bott. temp. 43.5°. 308–322 fathoms. Fne. wh. s. m.

Station 3912. Off Diamond Head, Oahu. Bott. temp. 43°. 310–334 fathoms. Fne. gy. s. m.

Station 3917. Off Diamond Head, Oahu. Bott. temp. 44°. 294–330 fathoms. Gy. s. m.

Station 3918. Off Diamond Head, Oahu. Bott. temp. 44.5°. 257–294 fathoms. Wh. s. m.

Station 3992. Off Mokuaeae Islet, Kauai. Bott. temp. 39.6°. 528 fathoms. Fne. gy. s. m.

Station 4096. Off Mokuhooniki Islet, N. E. approach to Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4097. Off Mokuhooniki Islet, N. E. approach to Pailolo Channel. Bott. temp. 44.2°. 286 fathoms. Fne. gy. s.

Station 4116. Off Kahuku Pt., N. W. coast of Oahu. Bott. temp. 48.8°. 241–282 fathoms. Cor. s. for.

Station 4117. Off Kahuku Pt., N. W. coast of Oahu. Bott. temp. 45.6°. 253–282 fathoms. Cor. s. for.

Bathymetrical range, 169–528 fms. Extremes of temperature, 55°–39.6°.

Forty-one specimens.

Goniocidaris Des.

Goniocidaris biserialis Död.

Stephanocidaris biserialis Död., 1885. Arch. f. Naturg. 51 Jahrg. Bd. I, p. 79.
Goniocidaris biserialis Död., 1887. Jap. Seeigel, p. 10. Pls. V and VIII, fig. 8.

Plate 10, figs. *22–25.*

Specimens of *G. biserialis* Döderlein from 17 to 30 mm. in diameter were collected at the stations given below. They agree well with the figures given by Döderlein on Plate V of his Memoir. There are no tridentate pedicellariæ to be found, but both sorts of globiferous pedicellariæ occur.

The large globiferous pedicellariæ (Pl. 10, figs. *22, 23*) are short and broad, with a large terminal opening much as in Cidaris. The valves are somewhat curved and are about .55 mm. in length, while the stalk is even shorter. These pedicellariæ are found only on the interambulacra and are rather rare.

The small globiferous pedicellariæ (Pl. 10, figs. *24, 25*) have the valves straighter, narrower, and with an evident end-tooth, and only .27–.45 mm. in length. The stalk may be shorter or longer, sometimes twice as long. These pedicellariæ are abundant everywhere.

Station 3700. Off Seno Umi, Suruga Gulf, Japan. 63 fathoms. Vol. m. s.

Station 3707. Off Ose Zaki, Suruga Gulf, Japan. 63–75 fathoms. Vol. s. a. g.

Station 3718. Off Ose Zaki, Suruga Gulf, Japan. 65 fathoms. Vol. s. sh. r.

Bathymetrical range, 63–75 fathoms. Seven specimens.

Goniocidaris clypeata Dod.

Goniocidaris clypeata Dod., 1885. Arch. f. Naturg. 51 Jahrg. Bd. I, p. 82; 1887, Jap. Seeigel, p. 13. Pls. VI and VIII, fig. 7.

Plate 10, figs. *27–31.*

A number of specimens of this species were collected by the "Albatross" in Japan at the stations given below. They range in size from 6 mm. in diameter to 18 mm. Three of the larger specimens showed the large disks figured by Döderlein at the extremity of the primary abactinal spines. The test is much flattened in young specimens, gradually increasing in height with age. The number of primary interambulacral plates is proportionately

larger in young specimens than in other Goniocidaridæ. In a specimen 13 mm. in diameter there are seven and seven plates; in a specimen of 18 mm. there are only seven and eight plates. In a specimen only 8 mm. in diameter there are already five and five plates. With the exception of the variation in the radioles and the absence of the cup-bearing radioles, there are but slight differences to be noted in the structure of the test, the sunken median ambulacral and interambulacral areas, the shape of the abactinal system and of the anal system, between the smaller and larger specimens examined. The smaller specimens usually carry only the serrated radioles. Usually a specimen 12 mm. in diameter carries a few disk-bearing radioles; though in the largest specimens collected all the radioles, actinal as well as abactinal, belong to the serrated type.

The series of specimens before us leaves little doubt that Döderlein's *Porocidaris gracilis* [1] was based on a young specimen of this species, in which the expanded radioles were not developed.

There are only two kinds of pedicellariæ present in *clypeata*, as the tridentate seem to be wholly wanting.

The large globiferous pedicellariæ (Pl. 10, figs. *27–29*) show considerable diversity in the shape of the valves; normally (Pl. 10, fig. *29*) they are like those of *G. biserialis* but sometimes they are much longer and narrower, with a large terminal opening (Pl. 10, fig. *28*) or still narrower, slightly curved and with an end-tooth (Pl. 10, fig. *27*). They measure from .50 to .90 mm. with the stalk somewhat shorter. These pedicellariæ are somewhat rare and occur only on the interambulacra.

The small globiferous pedicellariæ have a strong end-tooth on the valves; sometimes (Pl. 10, fig. *30*) they are like those of *G. mikado*, while others (Pl. 10, fig. *31*) are like those of *biserialis*. The valves are .25–.50 mm. in length, while the stalks are shorter, longer, or twice as long. They are abundant everywhere.

Station 3748. Off Suno Saki, Sagami Bay, Japan. 73–200 fathoms. Yl. s. rot. co.

Station 3749. Off Suno Saki, Sagami Bay, Japan. 83–158 fathoms. Bl. s. sh.

Station 3751. Off Suno Saki, Sagami Bay, Japan. 140–148 fathoms. Gn. m. vol. s.

[1] Dorocidaris (?) gracilis, 1885. Arch. f. Naturg. 51 Jahrg. Bd. 1, p. 78.
Porocidaris gracilis, 1887. Jap. Seeigel, p. 8. Pls. IV, figs. 8–20; VIII, fig. 5.

Station 3752. Off Suno Saki, Sagami Bay, Japan. 54–100 fathoms. Gy. s. g.

Bathymetrical range, 54–200 fathoms. Fifteen specimens.

Goniocidaris mikado Död.

Discocidaris (Cidaris) mikado Död., 1885. Arch. f. Naturg., 51 Jahrg., Bd. I, p. 80.
Goniocidaris mikado Död., 1887. Jap. Seeigel, p. 15. Pls. VII and VIII, figs. 6 and 9–18.

Plate 10, fig. *26*.

Two specimens of this species were collected by the "Albatross" in Sagami Bay. As has been stated by Döderlein, it is one of the most beautiful and elegant of the Cidaridae, and the peculiar structure of its primary ambulacral spines is without parallel in the family. The remarkable cupuliform expansion of the shaft occurs immediately above the milled ring, while in *G. tubaria* the great expansion of the shaft takes place at its extremity; in *G. mikado*, moreover, there are rudimentary cupular expansions along the shaft, often merely flattened serrations. The distal part of the shaft carries smaller serrations. Döderlein has given a number of figures showing the great variation found among the primary radioles of this species in Pls. VII and VIII of his Memoir on Japanese Sea Urchins, though even the best lithographic figures can scarcely do justice to the great delicacy of the structure of the primary radioles.

This species is notable for the absence of both large globiferous and tridentate pedicellariæ. The small globiferous pedicellariæ (Pl. 10, fig. *26*) have a very large end-tooth with the opening some distance beneath it. The valves are very small, only .20–.30 mm. in length, while the stalk is even shorter. They occur abundantly everywhere on the test.

Station 3755. Off Suno Saki, Sagami Bay, Japan. 52–77 fathoms. Gy. s. co.

Station 3759. Off Suno Saki, Sagami Bay, Japan. 52–60 fathoms. Gy. s. fne. g. brk. sh. r.

Centrocidaris A. Ag.

Centrocidaris Doederleini A. Ag.

Goniocidaris Doederleini, A. Ag., 1898. Bull. M. C. Z., XXXII, 5, p. 73, Pl. III, fig. 1.
Centrocidaris Doederleini, A. Ag., 1904. Mem. M. C. Z., XXXI, p. 33, Pls. 5, 14, figs. 1–2.

Plates 10, figs. *1–9*; 12[b], figs. *7–9*.

In this species there are at least four very distinct sorts of pedicellariæ present, of which two may be regarded as large globiferous pedicellariæ.

The normal large globiferous pedicellariæ (Pl. 12[b], fig. *7*) are of great interest because they are intermediate in character between those which Mortensen considers characteristic of *Cidaris*, and those which he assigns to *Dorocidaris*; thus they are curved and have a large, nearly terminal opening as in the former, but have a powerful end-tooth as in the latter. The valves are about .70 mm. long, and the stalks are about the same length or a little longer. These pedicellariæ are found on the abactinal surface, but are not very common. In addition to them, peculiar large pedicellariæ (Pl. 12[b] fig. *8*) with flat, wide valves, having an inner cavity and a terminal opening, but no end-tooth and no lip, also occur: the valves are about .52 mm. long and nearly .20 wide; these pedicellariæ are found on the actinal surface, especially on the actinostome.

The trudentate pedicellariæ (Pl. 12[b], fig. *9*) have the valves long (1.15 mm.) and slender, considerably separated at the base. They are found mainly on the abactinal surface and appear to be very rare.

The small globiferous pedicellariæ (Pl. 10, figs. *1*, *2*) are not peculiar, but have an end-tooth as in Cidaris. The valves are from .19 to .75 mm. in length and their stalks, one or two times as long. They occur everywhere, but are not very common.

This handsome and very interesting species was collected by the "Albatross" during her trip to the Eastern Pacific, in 1904, at the following stations.

Station 4642. Off southern side of Hood Island, Galapagos. Lat. 1 30.5′ S.; Long. 89° 35′ W. Bott. temp. 48.6°. 300 fathoms. Brk. sh. glob.

Station 4643. Off southern side of Hood Island, Galapagos. Lat. 1° 28.7′ S.; Long. 89° 48.5′ W. Bott. temp. 67.2°. 100 fathoms. Brk. sh. glob.

Bathymetrical range, 100–300 fathoms. Extremes of temperature, 67.2°–47.6°. Twelve specimens.

Anomocidaris A. Ag. and Clark.

This genus is established for a specimen we take to be *Cidaris tenuispina* Yoshiwara[1] (Pl. 31, figs. 5–8). It can at once be distinguished from all other Cidaridæ by the sharp, deep sutures separating the plates of the abactinal system, and of the interambulacral areas, and the deep median vertical suture of the ambulacral area. Towards the actinal system the sutures tend to imitate, at the angles of both the ambulacral and interambulacral plates, those of some species of Goniocidaris. When seen from above the general aspect of the test resembles somewhat that of the Arbaciadæ, the upper interambulacral plates having no well developed primary tubercles, much as in Cœlopleurus, and among the Cidaridæ in Diplocidaris and to a lesser degree, in some species of Stereocidaris. The primary tubercles begin only at the equatorial zone and extend from there to the actinal system. The primary radioles (Plate 12, fig. *19*) resemble a combination of those of Dorocidaris and of Porocidaris. Anomocidaris is notable for its conical test and the presence of rudimentary abactinal primary tubercles.

Anomocidaris tenuispina A. Ag. and Clark.

Cidaris (Stereocidaris) tenuispina Yoshiwara, 1898. Annot. Zool. Jap., II, p. 57.

Plates 11, figs. *6–12*; 12, figs. *18–20*; 31, figs. *5–8*.

The only specimen of this species collected measures 29 mm. in diameter; the abactinal system is circular, 14 mm. in diameter, the actinal system is pentagonal and 10 mm. across.

The genital plates are large, irregularly heptagonal. The anal system is sharply pentagonal, included by the genital plates. The genital pores are large; the ocular plates are small, elongated triangular, deeply cut into by the ambulacral system; the ocular pores are prominent; the whole abactinal system is covered with irregularly arranged, distant, small secondaries and interspersed miliaries. A similar granulation extends over the interambulacral plates above the equatorial belt and surrounds an ill-defined scrobicular area with a rudimentary low, imperforate tubercle. Below the equatorial belt, there are five or six primary tubercles, usually two large ones at the ambitus, gradually diminishing in size. The scrobicular areas are well defined, somewhat sunken, edged by a large ring of

[1] Annot. Zool. Jap., 1898, Vol. II, p. 57.

secondaries; these with the scrobicular area occupy nearly the whole of each interambulacral plate; along the median interambulacral line, some of the larger scrobicular areas below the equatorial belt are flanked by half-circles of secondaries and irregular rows of minute miliaries. On the interambulacral plates below the equatorial belt, the mammary boss is high, the tubercles are small and perforate. On both sides of the sharply cut median line of suture of the ambulacral plates runs a vertical line of secondaries with an inner row of irregularly placed miliaries. Unfortunately the actinal system is wanting; it is pentagonal and 10 mm. in greatest width.

The primary radioles (Pl. 12, fig. *19*) are slender, gradually tapering, with lines of blunt serrations. The shorter primary radioles are slightly flattened at the extremity and indistinctly fluted. The longest equatorial radiole is 37 mm. in length. Others of the shorter radioles taper rapidly to a point above the equatorial belt. The secondary and miliary spines are slender and pointed; a few of the secondaries round the scrobicular areas are stouter at the base. The larger interambulacral spines round the scrobicular areas on the equatorial and actinal side are narrow and flattened, with rounded tips. The ambulacral spines are blunt, somewhat cylindrical or flattened. Only a single kind of pedicellaria is found, as the tridentate and large globiferous are both wanting. The small globiferous ones are very numerous everywhere and very variable in size and form. The valves are elongated and rather slender, and the lip and end-tooth may both be present, or either or both be wanting. In length they range from .28 to .91 mm., while the opening varies in size from .15 to .32 of the length. The stalk is shorter than the valves, or as long, or even twice as long.

Station 3709. Off Spithead, Shimizu Harbor, Honshu Island, Japan. 173–260 fathoms. Sft. bl. vol. m. r.

Porocidaris Desor.

Porocidaris Cobosi A. Ag.

Porocidaris Cobosi A. Ag. 1898. Bull. M. C. Z., XXXII, 5, p. 74. Pl. III, figs. 2–5.

Plate 7.

Only tridentate pedicellariæ are present in this beautiful species, even the small globiferous pedicellariæ being entirely wanting.

The tridentate pedicellariæ have the valves very broad, thick, and flat. They vary enormously in size, ranging from .50 to 5.5 mm. in length; the small ones have the stalk about equal to the valves, but in the large ones it is much less. The small ones are abundant everywhere; the larger ones are on the interambulacra, while the largest are mainly above the ambitus and often near the abactinal system. The largest are 20 to 30 in number, more or less, though they may be much fewer; their valves are always tapering and more or less distinctly pointed.

Porocidaris variabilis A. Ag. and Clark.

Plates 8, 16–22, and 23, figs. *1–4*.

An excellent series of specimens of this species was collected by the "Albatross" from thirteen localities, in 202 to 346 fathoms, varying in size from 77 mm. in diameter to 22 mm. (Pls. 16–22; 23, figs. *1–4*). In the smaller specimens the primary radioles are much longer in proportion to the diameter than in larger specimens. In the small specimen (Plate 22) of 22 mm. there are several of the primary radioles more than 76 mm. in length. In a specimen 35 mm. in diameter, the longest radioles are 122 mm. long (Pls. 20, 21). In a specimen 40 mm. in diameter (Pl. 23, figs. *1–4*) the longest radioles are only 74 mm. long. In the largest specimen examined (Pls. 16, 17) the longest radioles have a length of only 71 mm. The general appearance of the large primary radioles varies greatly (Pl. 8, figs. *13–20*); in the smaller specimens the majority are pointed, the shaft is very delicately striated with minute serrations. The shaft is a porcelain white, but towards the extremity it becomes yellowish-brown, slightly fluted. The base of the spine above the milled ring is a delicate salmon color. In older specimens there are but few white primary radioles. The shaft of the radioles is of a light-brown color with only a small part white; the base of the spine is of a darker color. The shaft of the radioles is also more deeply fluted, the serrations larger and more blunt than in smaller specimens. The fluting becomes very marked and quite deep towards the tip of the radioles, and many of the shorter and stouter primary radioles spread somewhat at the tip (Pls. 16, 17; 23, figs. *1–4*). The actinal primary radioles (Pl. 8, figs. *19* and *20*) are short, slightly curved, deeply fluted, with large blunt serrations; the smaller radioles are flattened; the lower part of the shaft of the larger radioles is porcelain

white, in marked contrast to the dark-brown color of the base of the radiole above the milled ring and with the brown of the heavily fluted tip of the radiole. The large radioles are frequently infested with numerous specimens of a small species of Scalpellum (Pls 16–21). The secondary spines (Pl. 8, figs. *21–24*) are slender, pointed, flattened or rounded or slightly dished, and finely fluted.

Seen from above (Pls. 17, 21) the test is a dark violet or chocolate-brown; the abactinal system is the darkest and towards the equatorial region of the test the color of the ambulacral and interambulacral spines becomes somewhat lighter, of a greenish tinge at the tip. From these stand out prominently the yellowish or brownish or whitish primary spines.

The specimens figured on Pl. 23, figs. *1–4* and on Pl. 22 are of a much lighter color. In the specimen of Pl. 22 the ambulacral and interambulacral spines are of a light yellowish-brown color, and those of the specimen figured on Pl. 23, figs. *1–4* are of a still lighter color. On the whole, judging from the specimens at our disposal, the color increases in depth with size.

In a specimen 72 mm. in diameter (Pls. 18, 19) and 50 mm. in height, there are eight and nine interambulacral plates. The primary tubercles are perforate, but irregularly crenulated (Pl. 19). The scrobicular area is surrounded with secondaries only slightly larger than those of the median interambulacral space and filling the angles of the interambulacral plates next to the poriferous zone (Pl. 19, fig. *2*). The scrobicular areas below the equatorial zone are slightly confluent. The median ambulacral zone is slightly broader than the poriferous zone. It is undulating, separated from the poriferous zone by an outer vertical row of secondaries, the median belt carrying miliaries forming irregular vertical rows. The inner row of pores is somewhat larger than the outer row (Pl. 19, fig. *1*). The abactinal system (Pl. 18, fig. *2*) is circular, 31 mm. in diameter. The madreporic genital is far larger than the others; they all are irregularly heptagonal; the ocular plates are small, heart-shaped, and are all excluded from the anal system. The anal system is sharply pentagonal, with a large outer row of anal plates; there is a second row of smaller plates adjoining the irregularly arranged minute plates which surround the anal opening. The miliaries on the genital plates are limited in their distribution: they are small, comparatively few in number, and irregularly arranged round the genital pores. On the oculars they occur on the median belt of the plate. The larger anal plates carry from one to three secondaries, with a few

miliaries on the plates forming the angles of the pentagonal anal system. The proximal part of the madreporic genital is riddled with pores. The genital openings are large (a female Pl. 18, fig. 1) and placed near the distal edge of the genital plates. The actinal system (Pl. 18, fig. 2) is pentagonal, 25 mm. in diameter, with eight rows of ambulacral plates, and not more than four or five small interambulacral plates. The latter are bare or carry one indistinct miliary. The ambulacral plates carry minute secondaries on the actinal edge of the plates.

In a specimen 36 mm. in diameter (Pl. 23, figs. 1–4) and 26 mm. in height, there are six and seven interambulacral plates. The abactinal system is circular, 16 mm. in diameter (Pl. 23, fig. 1); it differs only in size from the structure of the abactinal system of the larger specimen described (Pl. 18, fig. 1), and being that of a male it has small genital openings. A comparison of the interambulacral plates of the specimens figured on Plate 18 with those of Pl. 23, figs 3, 4, shows that the equatorial increase of the test takes place more rapidly than the increase in width of the median interambulacral zone covered by secondaries and miliaries. In the smaller specimen there is only one circle of secondaries round the scrobicular area, with a few irregularly arranged large miliaries filling the angles of the interambulacral plates along the median line. The actinal system is pentagonal (Pl. 23, fig. 2) 14 mm. in diameter. There are but five rows of ambulacral plates with three or four small elongated plates in the small interambulacral space, four of the rows of ambulacral plates being in contact along the interambulacral line, and leaving but a small angle for the interambulacral actinal plates.

In the specimen 22 mm. in diameter and 14 mm. in height, there are six interambulacral plates. In the smallest specimen, 4.5 mm. in diameter and 3 mm. in height, there are already four and five interambulacral plates. The longest primary radiole is 14 mm. The secondaries are few in number and are more or less cylindrical or club-shaped. The abactinal system is very large, 2.5 mm. in diameter, and each genital plate carries a conspicuous perforate tubercle. The actinostome is less than 2 mm. in diameter and is practically covered by the ten buccal plates, a pair in each ambulacrum. The pedicellariæ are already conspicuous, and, like the primary radioles, are strikingly similar to those of the adult. In specimens of *P. Cobosi* slightly larger, the structure of the abactinal system is very similar to that of this young individual.

The general aspect of *P. variabilis* (Pl. 17) is much like that of *P. Sharreri* (Pl. 3, "Blake" Echini, Mem. M. C. Z., X, No. 1). It differs from *P. Sharreri* in having the genital plates united as in *P. Cobosi* (Panamic Deep Sea Echini, Pl. 11, figs. *5, 6*), while they are separated by the anal plates in *P. Sharreri* (Pl. 4, fig. *2* "Blake" Echini). In the latter the secondary tubercles round the scrobicular circle are larger and the secondaries and miliaries are arranged in rows parallel to the horizontal suture of the median interambulacral zone (Pl. 4, fig. *1* "Blake" Echini), while they are of more uniform size and more irregularly arranged in *P. variabilis* (Pl. 19).

The general aspect of the smaller specimens of *P. variabilis* (Pl. 22) is more like that of *P. elegans* ("Challenger" Echini, Pl. 3, fig. *1*). It is difficult to determine to just how great an extent *variabilis* differs from Yoshiwara's *P. misakiensis*, but if we may rely on de Meijere's[1] figures of the latter, *variabilis* has a much smaller abactinal system, and smoother and more slender primaries.

Although this species resembles *Cobosi* in the entire absence of globiferous pedicellariæ, the tridentate show some peculiarities. They are very variable (Pl. 8, figs. *1-11*), occasionally having only two valves, sometimes four. The valves are broader and less tapering than in *Cobosi*, and the tip is rounded or little pointed. They vary in length from .50 up to 4.00 mm. and the stalk is always shorter, sometimes only half as long. The largest occur actinally as well as above the ambitus, but are often present in numbers on the abactinal system.

Specimens of *Porocidaris variabilis* were collected at the following stations:

Station 3865. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 44.8°–45°. 256–283 fathoms. Fne. vol. s. r.

Station 3866. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 43.8°. 283–284 fathoms. Gy. m. fne. s.

Station 3883. Off Mokuhooniki Islet, Pailolo Channel. Bott. temp. 45.2°. 277–284 fathoms. Glob. oz.

Station 3893. Off Lae-o Ka Laau Light, Kaiwi Channel. Bott. temp. 47°. 220–346 fathoms. Fne. wh. s. r.

Station 3918. Off Diamond Head, Oahu. Bott. temp. 41.5°. 257–294 fathoms. Wh. s. m.

Station 4081. Off Puniawa Point, Maui. Bott. temp. 51.7°. 202–220 fathoms. Gy. s. for.

[1] Die Echinoidea der Siboga-Expedition. 1904. Pl. II, figs. 15, 16.

Station 4083. Off Puniawa Point, Maui. 238–253 fathoms. Gy. s.

Station 4085. Off Puniawa Point, Maui. 267–283 fathoms. S. sh.

Station 4090. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 43.8°. 304–308 fathoms. Fne. gy. s.

Station 4096. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 45.3°. 272–286 fathoms. Fne. gy. s.

Station 4097. Off Mokuhooniki Islet, N. E. approach Pailolo Channel. Bott. temp. 44.2°. 286 fathoms. Fne. gy. s.

Station 4116. Off Kahuku Point, N. W. coast of Oahu. Bott. temp. 48.8°. 241–282 fathoms. Cor. s. for.

Station 4117. Off Kahuku Point, N. W. coast of Oahu. Bott. temp. 45.6°. 253–282 fathoms. Cor. s. for.

Bathymetrical range, 202–346 fathoms. Extremes of temperature, 51.7°–43.8°.

Twenty-seven specimens.

Aporocidaris A. Ag. and Clark.

The discovery of a cidaroid in deep water off Kamchatka very similar to *Porocidaris Milleri* A. Ag. calls attention with new emphasis to the peculiarities of that form, and makes it seem desirable to establish a genus for the reception of the two species, in order to make more clear the features in which they differ from Porocidaris. The extraordinary size of the abactinal system, which is from .60 to .70 of the horizontal diameter of the test; the small number of ambulacral plates, which are usually fewer than 30 and only in the largest specimens exceed that number; the fact that the poriferous zones are scarcely sunken at all; the very slender but rough primary radioles; the nearly cylindrical or even club-shaped secondaries and miliaries; and the absence of any sort of tridentate pedicellariæ, combine to make the line between these species and the other Cidaridæ remarkably distinct. They are small and rather delicate echinoids, apparently confined to very deep water.

Aporocidaris Milleri A. Ag. and Clark.

Porocidaris Milleri A. Ag. 1898. Bull. M. C. Z., XXXII, 5, p. 74. Pl. IV.

Plate 9.

Neither tridentate nor large globiferous pedicellariæ occur in this species, but small globiferous ones of very diverse sizes are abundant all over the test. They have the valves short and wide though the proportions vary, from those having the width .38 of the length to those in which it is .75. The opening is very irregular, either with or without a lip, and there may or may not be an end-tooth. The valves range in length from .32 to .87 mm. and the stalks are one or two times as long.

The great variability of the primary radioles referred to in the previously published description is remarkably illustrated by two specimens, each 10 mm. in diameter, one from St. 3399, off Cocos Id., the other from St. 4717. In the former, all the radioles are very slender and almost perfectly smooth, while in the latter many are much stouter and are provided with longitudinal series of stout, hooked prickles, as long as one-half the diameter of the spine.

This species was collected by the "Albatross," during her trip to the Eastern Pacific, in 1904, at the following stations.

Station 4647. 4°33′ S.–87°42.5′ W. Bott. temp. 35.5°. 2005 fathoms. Very lt. gy. glob. oz.

Station 4717. 5°10′ S.–98°56′ W. Bott. temp. 35.2°. 2153 fathoms. Red br. glob. oz. diat.

Aporocidaris fragilis A. Ag. and Clark.

Plates 10, figs. *10–21*; 23, figs. *5–8*.

Of this species two specimens were collected at Station 3783. It is closely allied to *P. Milleri*. It is more flattened (Pl. 23, figs. *7*, *8*) than that species, but like it in that the miliaries and secondaries are distant and the smaller spines are of uniform size, and very slender and elongate. In a specimen of 20 mm. diameter there are five and five interambulacral plates; the longest radioles (Pl. 10, fig. *14*) are 35 mm. and are comparatively stouter than in *P. Milleri*. They are of a whitish tint, and are covered with sharp, prominent serrations. The actinal primary radioles (Pl. 10, fig. *15*) are curved, flattened, with longer teeth on the edges. The color of the secondary spines and papillæ is light yellowish-brown.

In a specimen measuring 15 mm. in diameter and 9 mm. in height there are four and five interambulacral plates. The abactinal system measures 9 mm. across, the actinal system 8 mm. The median ambulacral zone consists of two vertical rows of secondary tubercles about equal in size to those surrounding the scrobicular area. In the younger specimens of *Milleri* and *fragilis* the genital pores are frequently not developed (Pl. 23, fig. 5), and the actinal interambulacral plates are limited to a very small area between the ambulacral plates (Pl. 23, fig. 6).

Neither tridentate nor large globiferous pedicellariæ are to be found. The small globiferous ones occur everywhere, but are not specially abundant. They are very variable, but the valves are somewhat more slender than in *Milleri;* the lip is generally present, but the end-tooth is usually wanting. The valves range in length from .40 to 1.00 mm., and the stalk is about equal to them, or may be as much as twice as long.

Station No. 3783. Off Kamchatka; S. E. Cape, Copper Id. 1567 fathoms. Gy. v. s. gn. m.

Acanthocidaris Mort.

It is not surprising that Mortensen[1] should have established this genus without any further examination than the superficial one he was able to make of the specimens in the British Museum and in the Jardin des Plantes and of the pedicellariæ he figured of *Cidaris curratispinis* Bell.[2] For this cidarid is indeed a most striking Echinoid and is remarkable for its huge curved primary spines resembling those of Cœlopleurus, though they are not smooth, and end in a shallow grooved socket and not in a point as in that genus. The base of the primary spines above the milled ring is smooth, with fine striation, and indistinct, undulating ribs or ridges extend to the base of the shoe, which is sharply fluted or longitudinally ribbed. The primaries are curved near the extremity and are also often flattened there. The shaft of the spine is not more than one third the length of the shoe. The longest radioles are on the abactinal interambulacral plates (Pls. 37, 38). The radioles of the actinal part of the test (Pls. 12[b], figs. *18, 19;* 37; 39, fig. *1*) are much flattened, slightly dished, and have the shaft tipped with a conspicuous, short, curved shoe or cap, as in Stephanocidaris. The larger primary spines are somewhat triangular in section, the curved abactinal side of the radiole being wider than the side

[1] Ingolf Exped. Echinoidea I, p. 21.

[2] Trans. Zool. Soc. London, XIII, 1893, p. 303. Pl. XXXVIII.

faces of the spines. The younger primary spines adjoining the abactinal system are not tipped with shoes. They are irregularly triangular, smooth, and pointed (Pls. 38; 39; 40; 41, fig. *2*; 42, fig. *5*). The abactinal system is pentagonal. The actinal system is smaller than the abactinal.

Acanthocidaris hastigera A. Ag. and Clark.

Plates 11, figs. *1–5*; 12, figs. *1–17*; 12[b], figs. *18*, *19*; 37–42.

In a specimen 50 mm. in diameter and 40 mm. in height, the longest abactinal spines measure three times the diameter of the test, the smooth part of the shaft being nearly one quarter the length of the radiole seen from above, and the spines taper very gradually towards the extremity (Pl. 38). The extent of the curvature is well shown on two of the longest spines of Pls. 37 and 38, and in Pl. 12, fig. *4*. The secondary spines (Pl. 12, figs. *11–14*) are slender, elongated, flattened, and striated; they hardly extend beyond the milled ring of the radioles. The miliary spines (Pl. 12, fig. *15*) resemble the secondaries in every point except in size, though they appear on the whole as more pointed. The pentagonal abactinal system measures 25 mm. in greatest diameter (Pl. 39, fig. *2*), while the actinal system does not measure more than 18 mm. (Pl. 39, fig. *1*). There are seven and eight primary tubercles in each vertical interambulacral row; these tubercles are perforate and crenulate. The scrobicular circle is surrounded by a single row of large secondaries. The small secondaries and miliaries in two or three irregular rows cover the sides of the interambulacral plates, forming a broad, median belt along the suture of the interambulacral plates (Pl. 40, figs. *1*, *2*). The scrobicular areas of the small interambulacral plates, near the actinal system, unite on the horizontal line of suture (Pl. 39, fig. *1*).

The poriferous zone of the ambulacral area is slightly undulating. The area itself is divided into three belts of equal width; the two poriferous zones and the median ambulacral belt which is defined by a vertical line of small secondaries flanking the poriferous zones (Pl. 40, fig. *1*), with a line of minute miliaries on the median angle of each ambulacral plate. The larger ambulacral tubercles carry comparatively long, slender, sharp-pointed spines. The miliary spines are slender and minute. The outer line of pores is composed of larger pores than the inner line; the pores are slightly confluent.

The genital plates are irregularly hexagonal with rounded angles, the

distal sides being the smallest (Pl. 39, fig. 2). The genital pores are near the distal edge; the specimen figured in Pl. 39, fig. 3, is probably a male. The genital plates are covered with well-separated secondary tubercles, all more or less comma-shaped, especially in the area adjoining the anal system. The madreporic genital is riddled with pores, and is covered with small globular tubercles closely packed together (Pl. 39, fig. 2). The ocular plates are heart-shaped, irregularly triangular, with rounded sides, and with the exception of the right anterior one, come in contact with a large intergenital anal plate. The anal system is pointedly pentagonal, with an outer ring of large, irregularly shaped plates, an inner ring of irregularly shaped smaller plates, and the smallest plates immediately round the anal opening. The plates of the anal system carry a few tubercles similar to those of the genital and ocular plates.

The ambulacral plates of the actinal system are very narrow; they are edged with three small miliaries on each side of the central line of pores. To the thirteen ambulacral plates in each vertical row only six interambulacral plates correspond.

In a smaller specimen measuring 24 mm. in diameter the ratio of the diameter of the test to the length of the longest primary spine is somewhat less than in the larger specimen. In this specimen the longest primary spines are 65 mm. only, and the basal part of the radiole is fully one third the length of the whole spine. Although the test is proportionately much flatter, only 12 mm. in height, there are already five and six interambulacral plates. With diminishing size the flattening of the test also rapidly increases. In a specimen 18 mm. in diameter, the height is 8 mm. (Pl. 42, figs. 1–4), the longest primary spine is 48 mm., and there are five and six primary tubercles. In a specimen 9 mm. in diameter, the height is 4 mm., the longest spine is 14 mm. (Pl. 42, figs. 7–10), and there are four and five primary tubercles. In the smallest specimen examined, with three and four primary tubercles, the diameter was 5 mm., and the height 2.25 mm. The longest spines measure 12 and 14 mm.; the basal part of the spine being nearly one-half the length of the radiole. In small specimens the abactinal system is smaller than the actinal. In the specimen figured in Pl. 42, figs. 1, 2, the abactinal system measures 6.5 mm. and the actinal 7 mm. across. In the specimen Pl. 42, figs. 7, 8, the abactinal system measures 3.5 mm., and the actinal 4 mm. In the smallest specimen, 5 mm. in diameter, the abactinal and actinal system each measure 3 mm.

When dried the secondary and miliary spines are of a uniform brown, chocolate color. The primary spines are of a lighter color with a pinkish tinge, the basal part of the spine yellowish, or sometimes porcelain white in smaller specimens.

Although the tridentate and small globiferous pedicellariæ are present always, the large globiferous may be wholly wanting in large specimens.

The large globiferous pedicellariæ (Pl. 11, fig. *1*) are not essentially different from the small ones, but often have the lip incomplete and the end-tooth is wanting. There are numerous calcareous ridges and elevations on the inner face of the valve, which measures about .80 mm. in length. The stalk (Pl. 12, fig. *1*) is about as long and has a well-developed limb. These pedicellariæ are infrequent and apparently most common in young specimens.

The tridentate pedicellariæ (Pl. 11, figs. *4, 5*) have long stout valves, with longitudinal ridges on the inner face. The valves are as much as 1.55 mm. in length and the stalk is about the same. They occur mainly on the actinal surface.

The small globiferous pedicellariæ (Pl. 11, figs. *2, 3*) have straight sides and a well-developed end-tooth, which is less conspicuous in large valves. They range in size from .20 mm. upwards, in length of valve, with stalks 1–3 times as long, and intergrade with the large globiferous ones, so that it is hard to draw any line between the two. They are abundant everywhere.

Although similar in its general appearance to Bell's species (*Cidaris curvatispinis*) from Mauritius, *hastigera* differs so strikingly in color, as well as in the form of the basal half of the primaries, that the two cannot be identical.

This species has been collected at the following stations in the Hawaiian Islands.

Station 3823. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 69°. 78–222 fathoms. Fne. s. p.

Station 3838. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 67°. 92–212 fathoms. Fne. gy. br. s.

Station 3845. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71°. 60–64 fathoms. Crs. s. p. sh.

Station 3846. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.5°. 60–64 fathoms. Crs. br. s. sh. g.

Station 3847. Off Lae-o Ka Laau Light, S. coast of Molokai. 23–24 fathoms. S. st.

Station 3848. Off Lae-o Ka Laau Light, S. coast of Molokai. Bott. temp. 71.1°. 44–73 fathoms. S. g.

Station 3861. Off Mokuhooniki Islet, Pailolo Channel. 30–52 fathoms. Fne. s. sm. p. co.

Station 3906. Off Mokapu Islet, N. coast of Molokai. Bott. temp. 72°. 66–96 fathoms. Gy. s. sh. p.

Station 4061. Off Kauhola Light, N. E. coast of Hawaii. 24–83 fathoms. Co. s. corln. nod. for.

Station 4062. Off Kauhola Light, N. E. coast of Hawaii. 83–113 fathoms. Co. vol. s. sh. for.

Station 4064. Off Kauhola Light, N. E. coast of Hawaii. Bott temp. 69°. 63–107 fathoms. Vol. s. for. co.

Station 4066. Off Ka Lae-o Ka Ilio Point, Maui. Bott. temp. 52.5°. 49–176 fathoms. Rky.

Station 4077. Off Puniawa Point, Maui. Bott. temp. 70°. 99–106 fathoms. Fne. co. s. for.

Bathymetrical range, 23–222 fathoms. Extremes of temperature, 72–52.5°. Fifty specimens.

EXPLANATION OF THE PLATES.

PLATE 1.

Plate 1.

1-2. **Cidaris Thouarsii** Val.

1. Upper end of stalk of globiferous pedicellaria, showing entire absence of limb. × 156.
2. Valve of small globiferous pedicellaria. × 156.

3-7. **Cidaris metularia** Bl.

3. Upper end of stalk of globiferous pedicellaria, showing presence of limb. × 156.
4. Valve of small globiferous pedicellaria. × 156.
5. Tip of valve of another small globiferous pedicellaria. × 156.
6. Valve of globiferous pedicellaria. × 156.
7. Valve of tridentate pedicellaria. × 156.

PLATE 2.

Plate 2.

1–4. **Cidaris tribuloides** Ag.

1. Valve of globiferous pedicellaria. × 156.
2. Upper end of stalk of globiferous pedicellaria, showing absence of limb. × 156.
3. Valve of small globiferous pedicellaria. × 156.
4. Interior view of base of valve of tridentate pedicellaria. × 156.

5–19. **Dorocidaris panamensis** A. Ag.

5. Tip of valve of globiferous pedicellaria. × 156.
6. Valve of small globiferous pedicellaria. × 156.
7. Tip of valve of another small globiferous pedicellaria, without end-tooth. × 617.
8. Tip of valve of another small globiferous pedicellaria, with end-tooth. × 617.
9. Ambital primary spine. Nat. size.
10. Base of same spine. × 5.
11. Tip of same spine. × 5.
12. End view of same tip. × 5.
13. Small actinal primary spine. × 11.
14. Abactinal interambulacral secondary spine. × 11.
15. Actinal ambulacral secondary spine. × 23.
16. Actinostomal miliary. × 23.
17. Same miliary from side. × 23.
18. Most common form of miliary. × 23.
19. Less common form of miliary. × 23.

PLATE 3.

Plate 3.

1–14. **Dorocidaris Reini** Desl.

1. Valve of globiferous pedicellaria. × 55.
2. Valve of small globiferous pedicellaria. × 55.
3. Valve of another small globiferous pedicellaria. × 55.
4. Developmental stage of valve of tridentate pedicellaria. × 55.
5. Later developmental stage of valve of tridentate pedicellaria. × 55.
6. Valve of tridentate pedicellaria. × 55.
7. Interior view of base of valve of tridentate pedicellaria. × 55.
8. Upper end of stalk of globiferous pedicellaria. × 55.
9. Ambital primary spine. × 3.
10. End view of tip of same spine. × 3.
11. Actinal primary spine. × 3.
12. Primary spine nearest actinostome. × 3.
13. Secondary spines. × 11.
14. Miliaries. × 11.

15–28. **Dorocidaris braeteata** A. Ag.

15. Valve of globiferous pedicellaria. × 55.
16. Valve of small globiferous pedicellaria. × 55.
17. Valve of another small globiferous pedicellaria. × 55.
18. Valve of another small globiferous pedicellaria. × 55
19. Developmental stage of valve of tridentate pedicellaria. × 55.
20. Later developmental stage of valve of tridentate pedicellaria. × 55.
21. Valve of tridentate pedicellaria. × 55.
22. Interior view of base of valve of tridentate pedicellaria. × 55.
23. Upper end of stalk of globiferous pedicellaria. × 55.
24. Ambital primary spine. × 3.
25. End view of tip of same spine. × 3.
26. Actinal primary spines. × 11.
27. Secondary spines. × 11.
28. Miliaries. × 11.

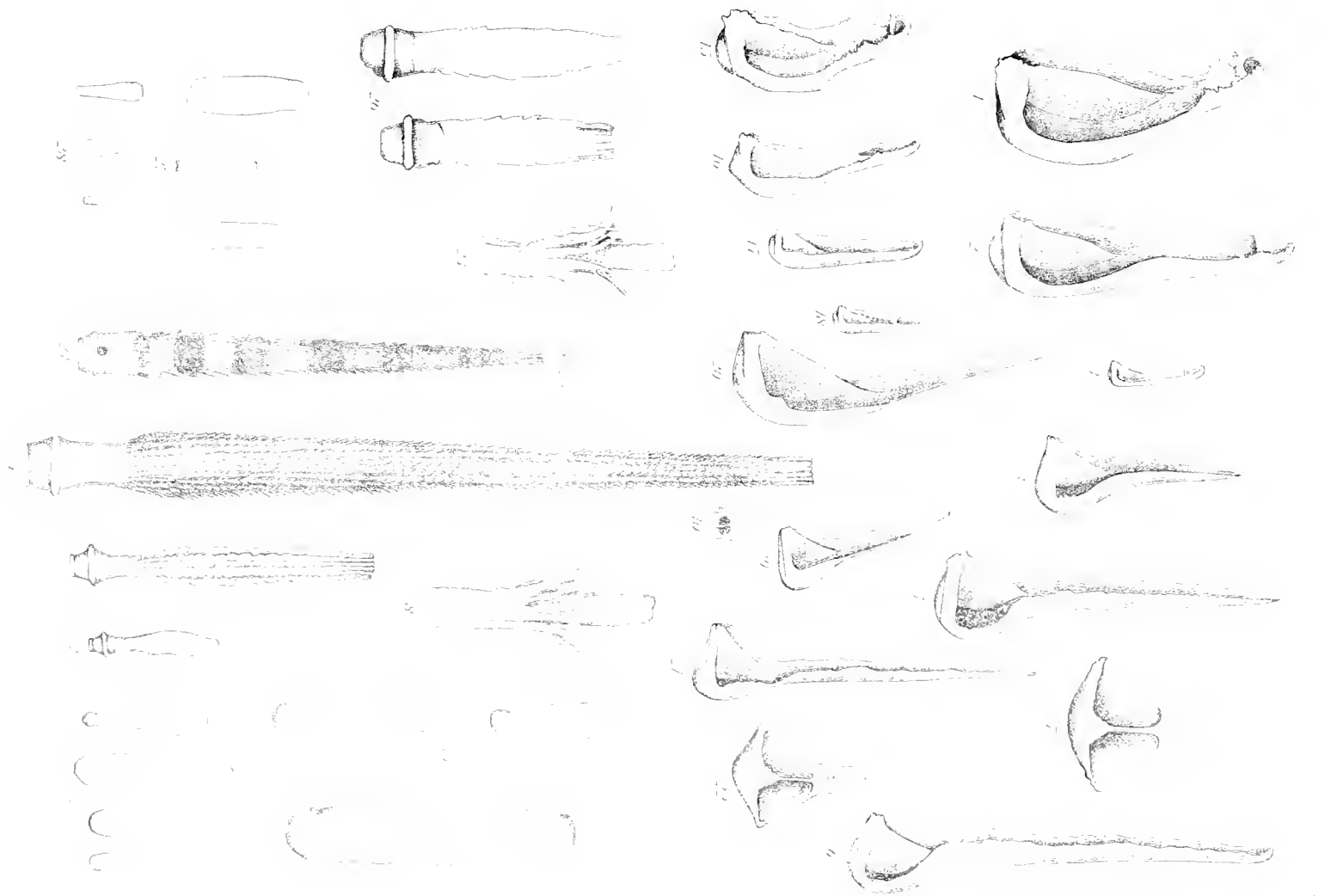


PLATE 4.

Plate 4.

1–12. **Dorocidaris calacantha** A. Ag. and Clark.

1. Valve of small globiferous pedicellaria. × 55.
2. Valve of another small globiferous pedicellaria. × 55
3. Valve of tridentate pedicellaria. × 55.
4. Ambital primary spine. Nat. size.
5. Tip of same spine seen from side. × 5.
6. End view of same tip. × 5.
7. Abactinal primary spine. Nat. size.
8. Actinal primary spine. × 11.
9. Interambulacral secondary spine. × 11.
10. Ambulacral secondary spine. × 11.
11. Actinostomal miliaries. × 11.
12. Other miliaries. × 11.

13–19. **Chondrocidaris gigantea** A. Ag.

13. Small globiferous pedicellaria. × 23.
14. Tridentate pedicellaria. × 23.
15. Valve of small globiferous pedicellaria. × 156.
16. Exterior view of same valve. × 156.
17. Valve of tridentate pedicellaria. × 55.
18. Interior view of base of valve of tridentate pedicellaria. × 55.
19. Side view of tip of valve of tridentate pedicellaria. × 156.

20–23. **Stephanocidaris hawaiiensis** A. Ag. and Clark.

20. Valve of small globiferous pedicellaria. × 156.
21. Tip of valve of small globiferous pedicellaria. × 156.
22. Valve of tridentate pedicellaria. × 55.
23. Interior view of base of valve of tridentate pedicellaria. × 55.

PLATE 5.

Plate 5.

1-17. **Phyllacanthus Thomasii** A. Ag. and Clark.

1. Small globiferous pedicellaria. × 23.
2. Tridentate pedicellaria. × 23.
3. Valve of small globiferous pedicellaria. × 156.
4. Small valve, from side. × 156.
5. Valve of tridentate pedicellaria. × 55.
6. Interior view of base of valve of tridentate pedicellaria. × 55.
7. Ambital primary spine. Nat. size.
8. Tip of same spine. × 5.
9. End view of same tip. × 5.
10. Actinal primary spine. Nat. size.
11. Primary spine nearest actinostome. Nat. size.

12, 13. Interambulacral secondary spines. × 11.

14. Ambulacral secondary spine. × 11.
15. Actinal secondary spine. × 11.
16. Side view of same spine. × 11.
17. Miliaries. × 11.

18-20. **Stereocidaris grandis** Död.

18. Valve of globiferous pedicellaria. × 55.
19. Valve of small globiferous pedicellaria. × 55.
20. Valve of tridentate pedicellaria. × 55.

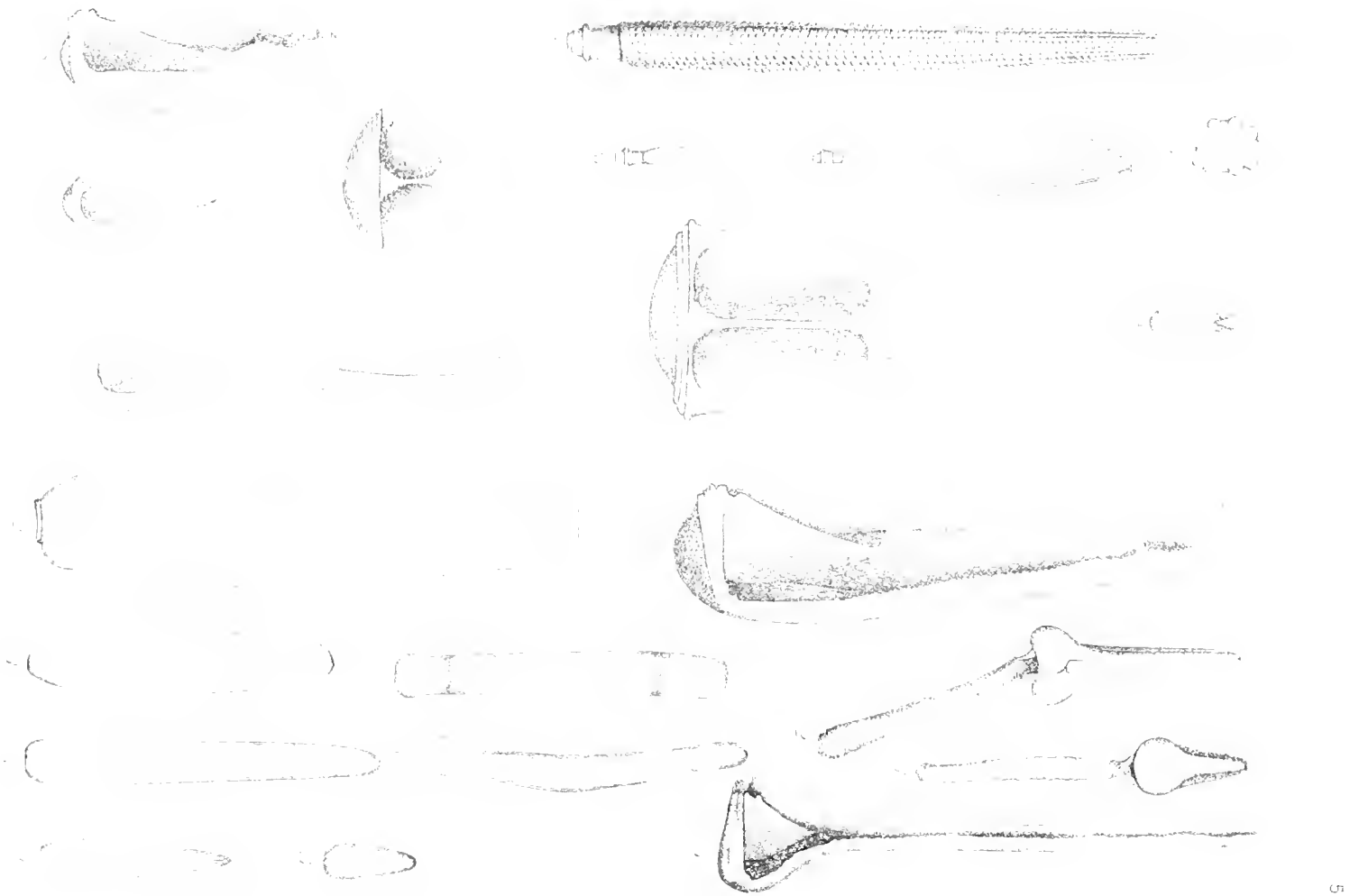


PLATE 6.

Plate 6.

1-17. **Stereocidaris leucacantha** A. Ag. and Clark.

1. Tridentate pedicellaria. × 55.
2. Smaller tridentate pedicellaria. × 55.
3. Globiferous pedicellaria. × 55.
4. Small globiferous pedicellaria. × 156.
5. Valve of tridentate pedicellaria. × 55.
6. Valve of globiferous pedicellaria. × 156.
7. Calcareous particles from pedicels. × 156.
8. Ambital primary spine. Nat. size.
9. Base of same spine. × 5.
10. Tip of same spine. × 5.
11. End view of same tip. × 5.
12. Actinal primary spine. × 5.
13. Smallest actinal primary spine. × 11.
14. Interambulacral secondary spine. × 11.
15. Ambulacral secondary spine. × 23.
16. Actinal secondaries. × 23.
17. Miliaries. × 23.

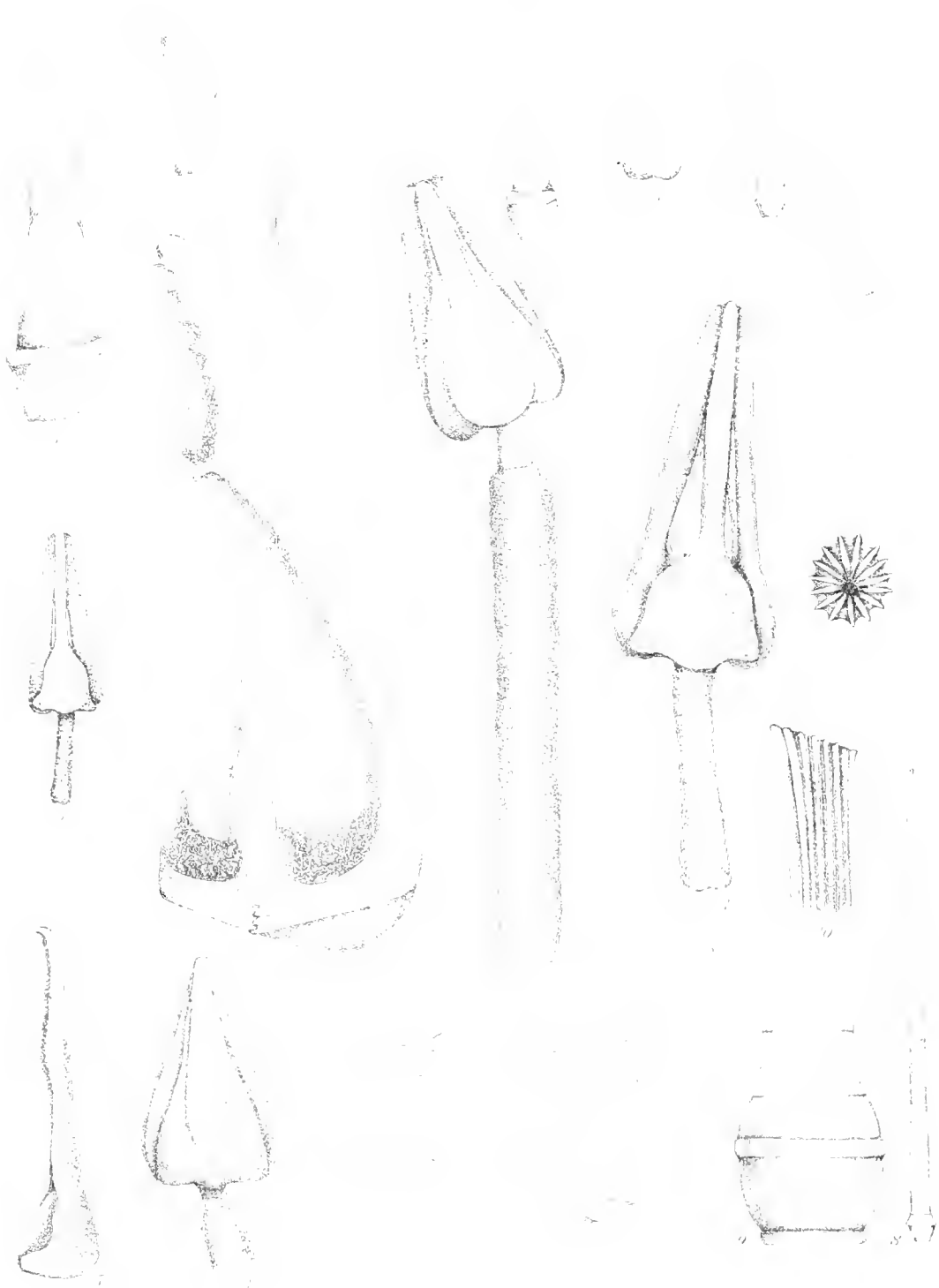


PLATE 7.

Plate 7.

1–24. **Porocidaris Cobosi** A. Ag.

1. Tridentate pedicellaria. × 11.
2. Smaller tridentate pedicellaria. × 11.
3. Developmental stage of tridentate pedicellaria. × 11.
4. Very small tridentate pedicellaria. × 55.
5. Valve of large tridentate pedicellaria. × 30.
6. Interior view of base of valve of small tridentate pedicellaria. × 55.
7. Calcareous particles from pedicels. × 156.
8. Abactinal primary spine. Nat. size.
9. Ambital primary spine. Nat. size.
10. Base of same spine. × 5.
11. Tip of same spine. × 5.
12. End view of same tip. × 5.
13. Ambital primary spine of small individual. × 3.
14. Actinal primary spine. × 5.
15. Side view of same spine. × 5.
16. Smaller actinal primary spine. × 5.
17. Smallest actinal primary spine. × 5.
18. Young abactinal primary spine. × 5.
19. Somewhat younger abactinal primary spine. × 5.
20. Youngest abactinal primary spine. × 5.
21. Interambulacral secondary spine. × 11.
22. Another interambulacral secondary spine. × 11.
23. Ambulacral secondary spine. × 11.
24. Actinal miliaries. × 11.

PLATE 8.

Plate 8.

1-27. **Porocidaris variabilis** A. Ag. and Clark

1. Large pedicellaria. × 23.
2. Another pedicellaria. × 23.
3. Another large pedicellaria. × 8.
4. Interior view of valve of pedicellaria. × 8.
5. Very small pedicellaria. × 23.
6. Side view of normal four-valved pedicellaria. × 23.
7. End view of same. × 23.
8. Abnormal four-valved pedicellaria. × 23.
9. Side view of two-valved pedicellaria. × 11.
10. End view of same. × 11.
11. Rear view of same. × 11.
12. Abactinal primary spine. Nat. size.
13. Ambital primary spine. Nat. size.
14. End view of same spine. Nat. size.
15. Small piece of primary spine, near middle. × 10.
16. Subambital primary spine. Nat. size.
17. Subambital primary spine. Nat. size.
18. End view of same spine. Nat. size.
19. Actinal primary spine. Nat. size.
20. Smallest actinal primary spine. Nat. size.
21, 22. Interambulacral secondary spines. × 11.
23. Ambulacral secondary spine. × 11.
24. Actinal secondary spine. × 11.
25. Actinostomal miliary. × 11.
26. Calcareous particles from pedicels. × 156.
27. Calcareous particles from pedicels of another individual. × 300.

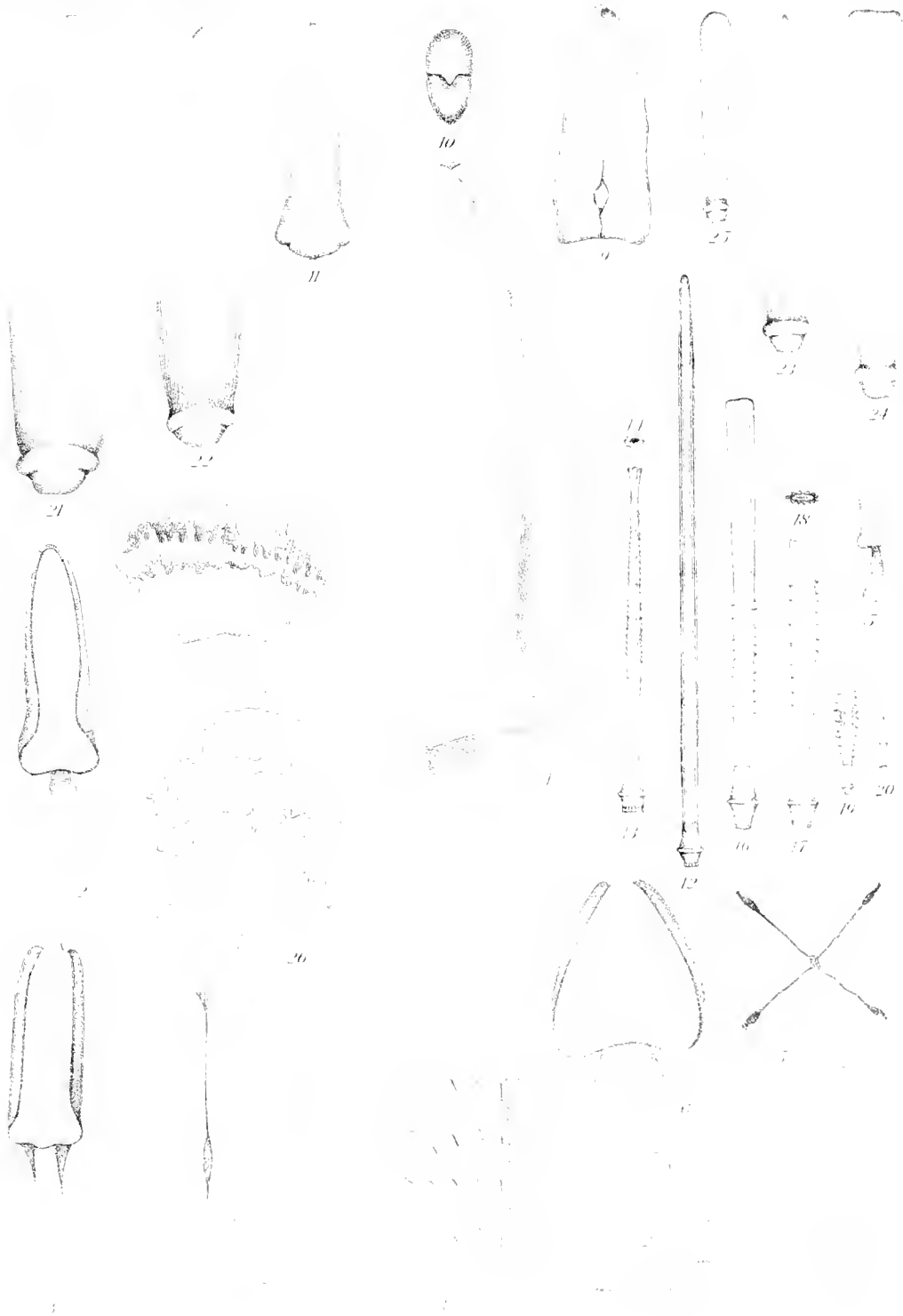


PLATE 9.

Plate 9.

1-26. **Aporocidaris Milleri** A. Ag and Clark.

1. Typical pedicellaria, with stalk. × 23.
2. Valve of broader pedicellaria. × 23.
3. Valve of narrower pedicellaria. × 23.
4. Interior view of valve of pedicellaria. × 156.
5. Tip of pedicellaria, showing well formed lip. × 156.
6. Tip of pedicellaria, showing absence of lip; same individual. × 156.
7. Tip of pedicellaria, showing presence of end-tooth and lip. × 156.
8. Tip of pedicellaria, showing absence of end-tooth and lip; same individual. × 156.
9. Upper end of pedicellaria-stalk, showing absence of limb. × 55.
10. Upper end of pedicellaria-stalk, showing indication of limb. × 55.
11. Upper end of pedicellaria-stalk, showing rudimentary limb. × 55.
12. Primary spine. Nat. size.
13. Base of same spine. × 5.
14. Tip of same spine. × 5.
15. End view of same tip. × 5.
16. Primary spine from another individual. Nat. size.
17. Subambital primary spine. Nat. size.
18. Actinal primary spine; abactinal surface. × 11.
19. Actinal primary spine; actinal surface. × 11.
20. Very small actinal primary spine. × 11.
21. Smallest actinal primary spine. × 11.
22. Interambulacral secondary spine. × 23.
23. Actinal secondary spine. × 23.
24, 25. Ambulacral secondary spines. × 23.
26. Calcareous particles from pedicels. × 156.

PLATE **10**.

Plate 10.

1–9. **Centrocidaris Doederleini** A. Ag.

1. Small globiferous pedicellaria. × 55.
2. Interior view of valve of same pedicellaria. × 120.
3. Primary spine. Nat. size.
4. Base of same spine. × 5.
5. Tip of same spine. × 5.
6. End view of same tip. × 5.
7. Actinal primary spine. × 16.
8. Interambulacral secondary spine. × 23.
9. Ambulacral secondary spine. × 23.

10–21. **Aporocidaris fragilis** A. Ag. and Clark.

10. Interior view of valve of pedicellaria. × 55.
11. Side view of similar valve. × 55.
12. Interior view of valve of pedicellaria. × 55.
13. Side view of similar valve. × 55.
14. Primary spine. × 5.
15. Actinal primary spine. × 5.
16. Side view of smallest actinal primary spine. × 11.
17. Abactinal view of same spine. × 11.
18. Secondary spine. × 11.
19. Actinostomal miliary. × 11.
20. Side view of actinostomal miliary. × 11.
21. Abactinal miliary. × 11.

22–25. **Goniocidaris biserialis** Död.

22. Interior view of valve of globiferous pedicellaria. × 55.
23. Side view of similar valve. × 55.
24, 25. Valves of small pedicellariæ. × 55.

26. **Goniocidaris mikado** Dod.

26. Valve of small pedicellaria. × 55.

27–31. **Goniocidaris clypeata** Död.

27. Valve of peculiar globiferous pedicellaria. × 55.
28. Valve of peculiar globiferous pedicellaria. × 55.
29. Valve of normal globiferous pedicellaria. × 55.
30, 31. Valves of small pedicellariæ. × 55.

PLATE **11.**

Plate 11.

1–5. **Acanthocidaris hastigera** A. Ag. and Clark.

1. Valve of globiferous pedicellaria. × 156.
2. Valve of small globiferous pedicellaria. × 156.
3. Valve of another small globiferous pedicellaria. × 156.
4. Valve of tridentate pedicellaria. × 55.
5. Exterior view of base of valve of tridentate pedicellaria. × 55.

6–12. **Anomocidaris tenuispina** A. Ag. and Clark.

6–10. Valves of small globiferous pedicellariæ, showing the great diversity in form and size. × 55.

11. Tip of valve of small globiferous pedicellaria, showing absence of end-tooth. × 156.
12. Tip of valve of small globiferous pedicellaria, showing presence of end-tooth. × 156.

PLATE **12**.

Plate 12.

1–17. **Acanthocidaris hastigera** A. Ag. and Clark.

1. Tip of stalk of globiferous pedicellaria, showing limb. × 156.
2. Most abactinal primary spine. Nat. size.
3. Abactinal primary spine. Nat. size.
4. Side view of ambital primary spine. Nat. size.
5. Ambital primary spine. Nat. size.
6. Subambital primary spine. Nat. size.
7. Actinal primary spine. Nat. size.
8. More actinal primary spine. Nat. size.
9. Still more actinal primary spine. Nat. size.
10. Most actinal primary spine. Nat. size.

11, 12. Interambulacral secondary spines. × 11.

13, 14. Ambulacral secondary spines. × 11.

15. Actinal view of actinal secondary spine. × 11.
16. Side view of same spine. × 11.
17. Miliary. × 11.

18–30. **Anomocidaris tenuispina** A. Ag. and Clark.

18. Valve of pedicellaria. × 156.
19. Ambital primary spine. × 3.
20. Actinal primary spine. × 3.
21. Most actinal primary spine. × 3.

22, 23. Interambulacral secondary spine. × 11.

24. Actinal secondary spine. × 11.

25–27. Ambulacral secondary spines. × 11.

28, 29. Actinal ambulacral secondary spines. × 11.

30. Miliary. × 11.

PLATE **12**[a].

Plate 12a.

Parts of large globiferous pedicellariae of Dorocidaris; only the tips of the valves have been drawn, as the bases are more or less alike and no claim has been made that they afford generic characters. × 70.

1–5. **Dorocidaris abyssicola** A. Ag.

All the figures are from a single individual, and show the great diversity in the large globiferous pedicellariæ.

6–13. **Dorocidaris Bartletti** A. Ag.

Figures 6–11 are from a single individual and show the extraordinary diversity which is exhibited by the large globiferous pedicellariae of this species. The usual form is that shown in fig. 10 but the kind shown in fig. 7 is quite common.

Figures 12 and 13 are from a second individual and show that the "limb" on the stalk may be either present or wanting.

PLATE 12 b.

Plate 12 b.

1–3. **Dorocidaris affinis** A. Ag.

All the figures are from a single individual. × 70.

1. Tip of valve of a large pedicellaria of exactly the same appearance as the small pedicellaria of the same individual.
2. Tip of valve of an ordinary large globiferous pedicellaria, but the opening is not quite terminal.
3. Tip of valve of a somewhat larger pedicellaria with the opening distinctly terminal.

4–6. **Dorocidaris Blakei** A. Ag.

All the figures are from a single individual, to show the diversity in the form of the opening. × 70.

7–9. **Centrocidaris Doederleini** A. Ag.

7. Valve of an ordinary large globiferous pedicellaria; side view. × 70.
8. Valve of peculiar large globiferous pedicellaria; inner view. × 70.
9. Valve of tridentate pedicellaria; side view. 70.

10–19. Actinal Primary Spines. × 5.

The even numbers show the abactinal side; the odd numbers, the actinal side.

10, 11. Stephanocidaris bispinosa A. Ag.

12, 13. Stephanocidaris hawaiiensis A. Ag. and Clark.

14, 15. Phyllacanthus annulifera A. Ag.

16, 17. Phyllacanthus baculosa A. Ag.

18, 19. Acanthocidaris hastigera A. Ag. and Clark.

PLATE **13**.

Plate 13.

Dorocidaris calacantha A. Ag. and Clark.

1. (7 on Plate.) Abactinal view of partly cleaned specimen.
2. Actinal view of same.
3. Abactinal view of cleaned test.
4. Actinal view of same.

All figures natural size.

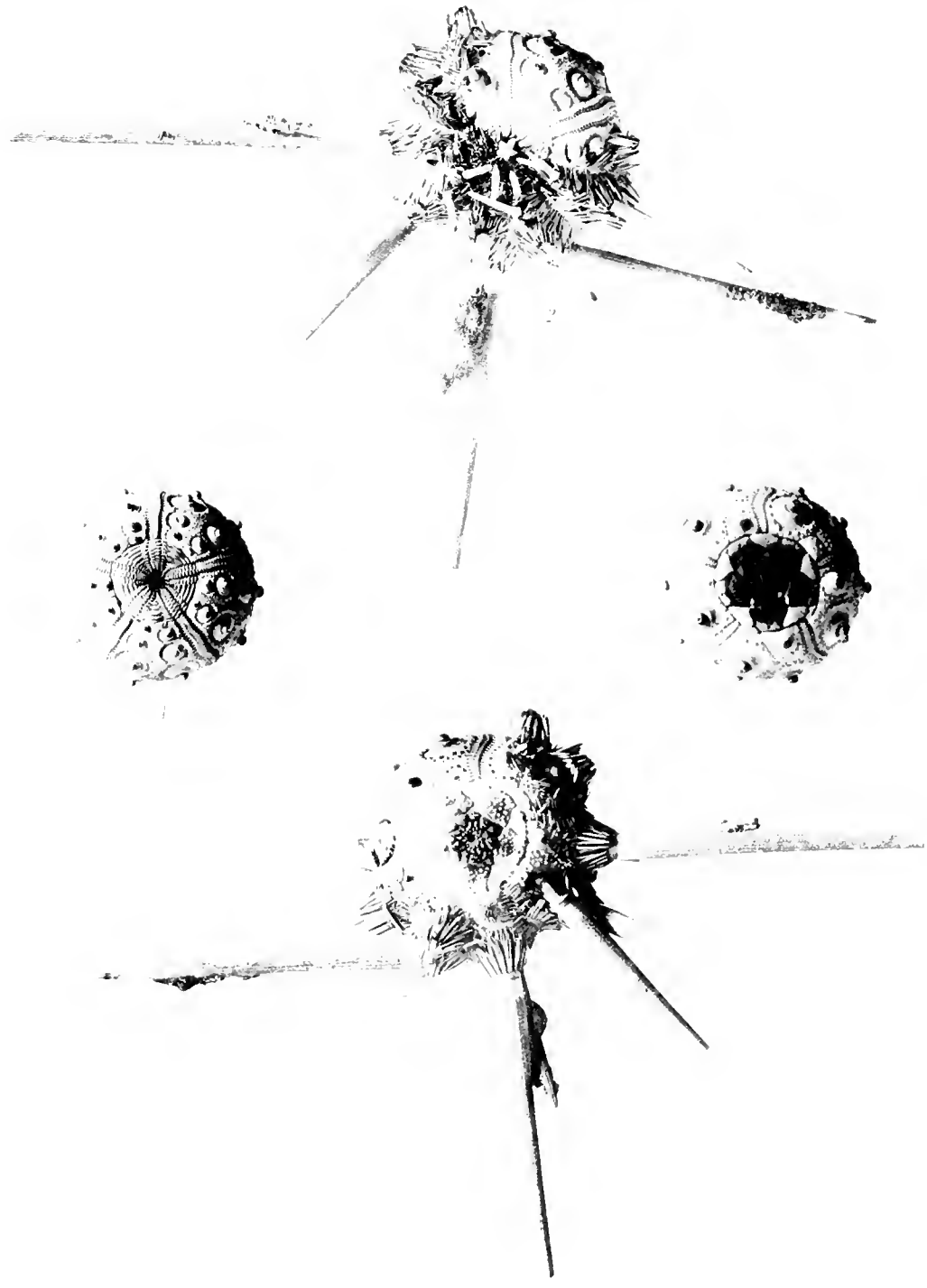


PLATE **14**.

Plate 14.

Dorocidaris calacantha A. Ag. and Clark.

1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.
3. Interambulacral view of cleaned test.
4. Ambulacral view of same.
5. Abactinal view of partly cleaned young specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

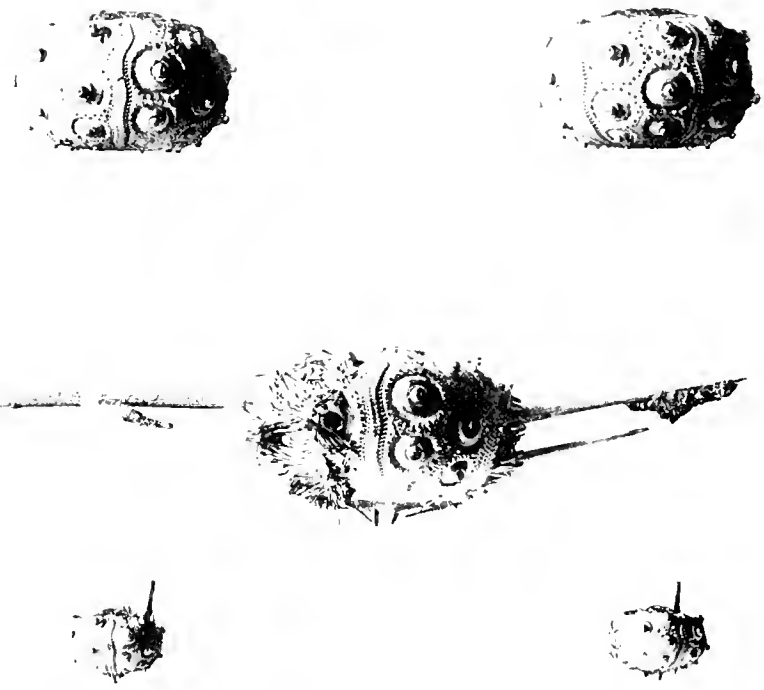


PLATE **15**.

Plate 15.

Stereocidaris leucacantha A. Ag. and Clark.

1. Abactinal view of medium-sized specimen.
2. Actinal view of same.
3. Ambulacral view of partly cleaned specimen.
4. Interambulacral view of same.

Other views of specimen shown in figs. 3 and 4 will be found on Plate 32, figs. 5 and 6.

All figures natural size.

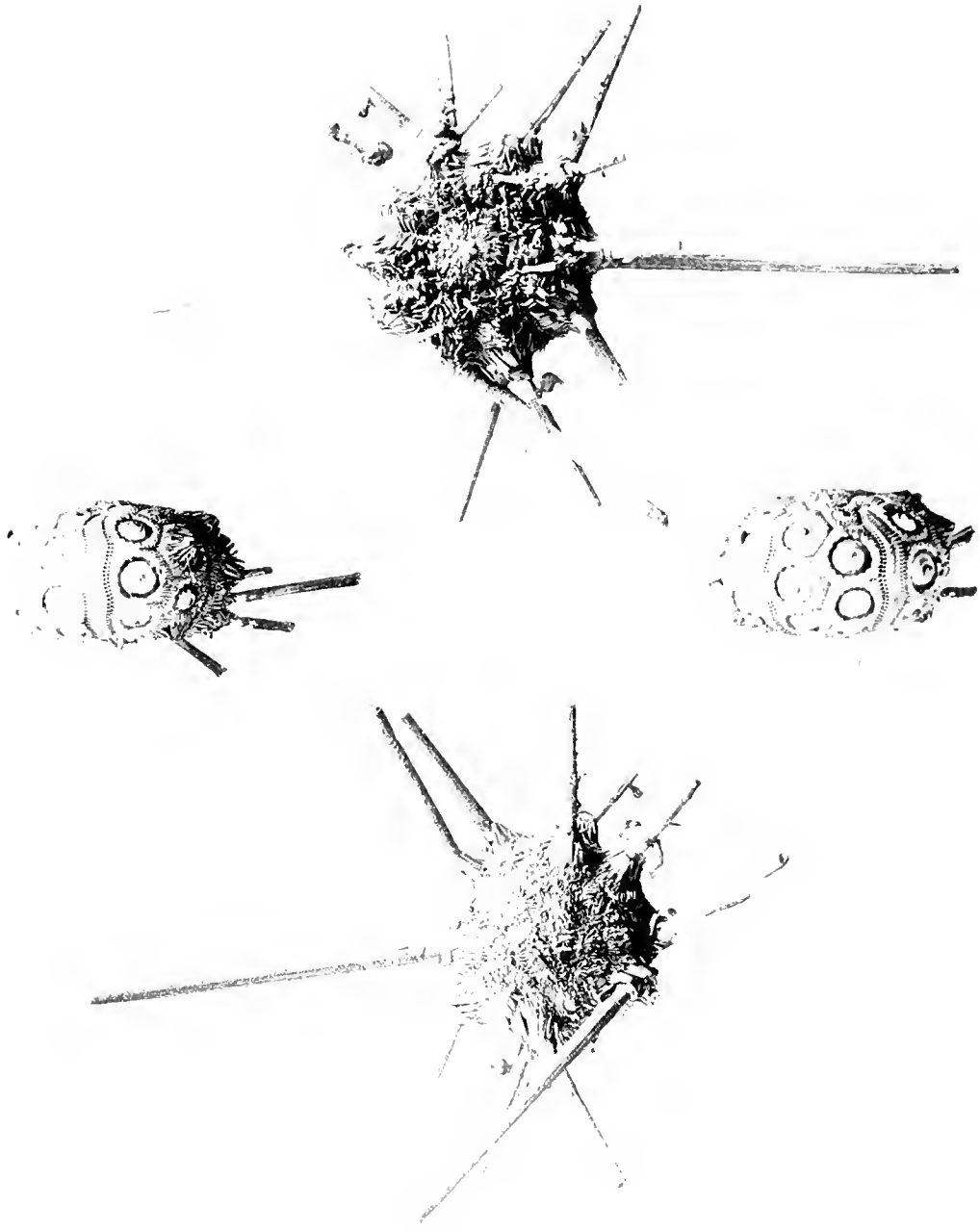


PLATE **16**.

PLATE 16.

Porocidaris variabilis A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 17.

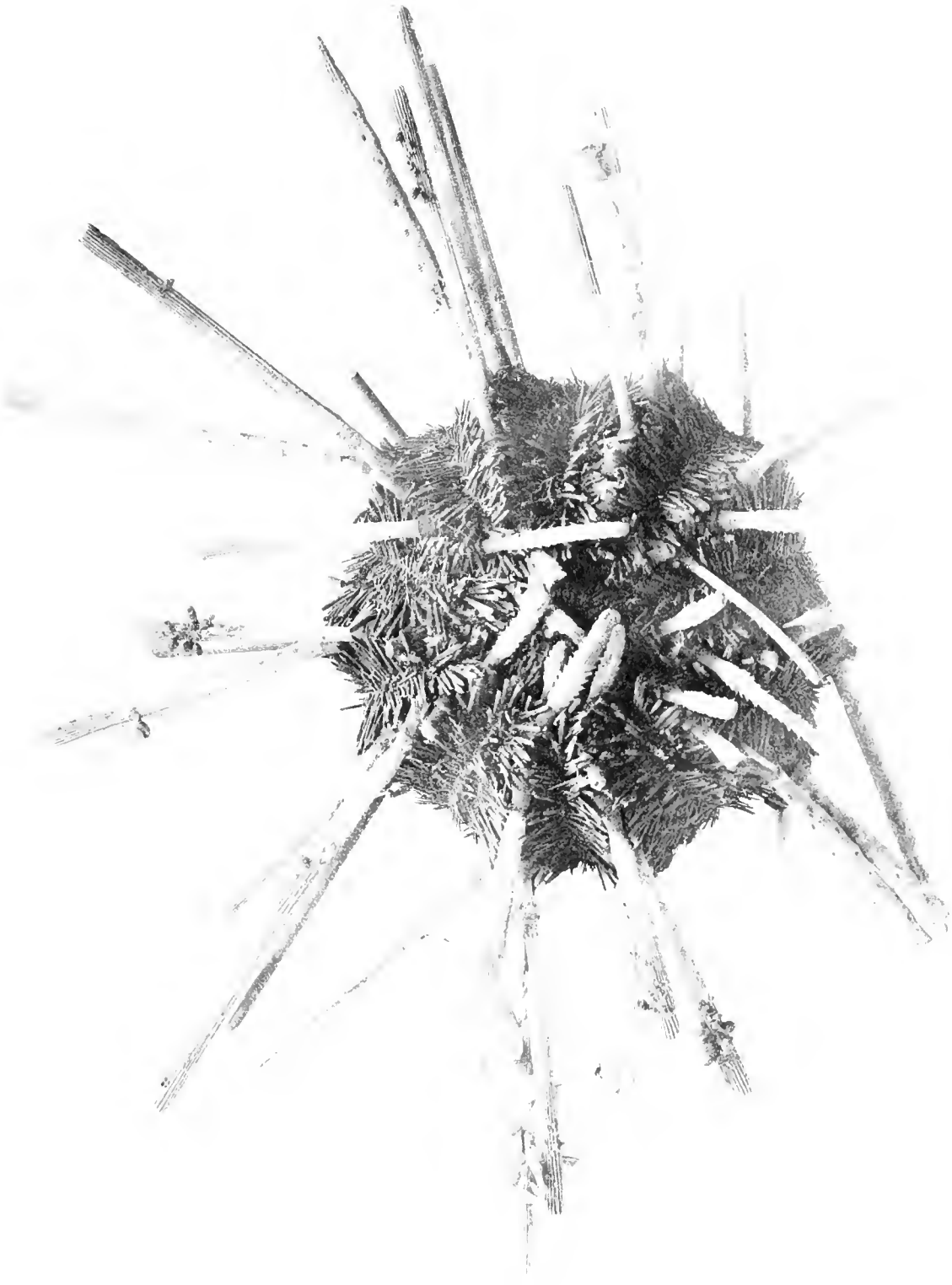


PLATE **17**.

Plate 17.

Porocidaris variabilis A. Ag. and Clark.

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 16.

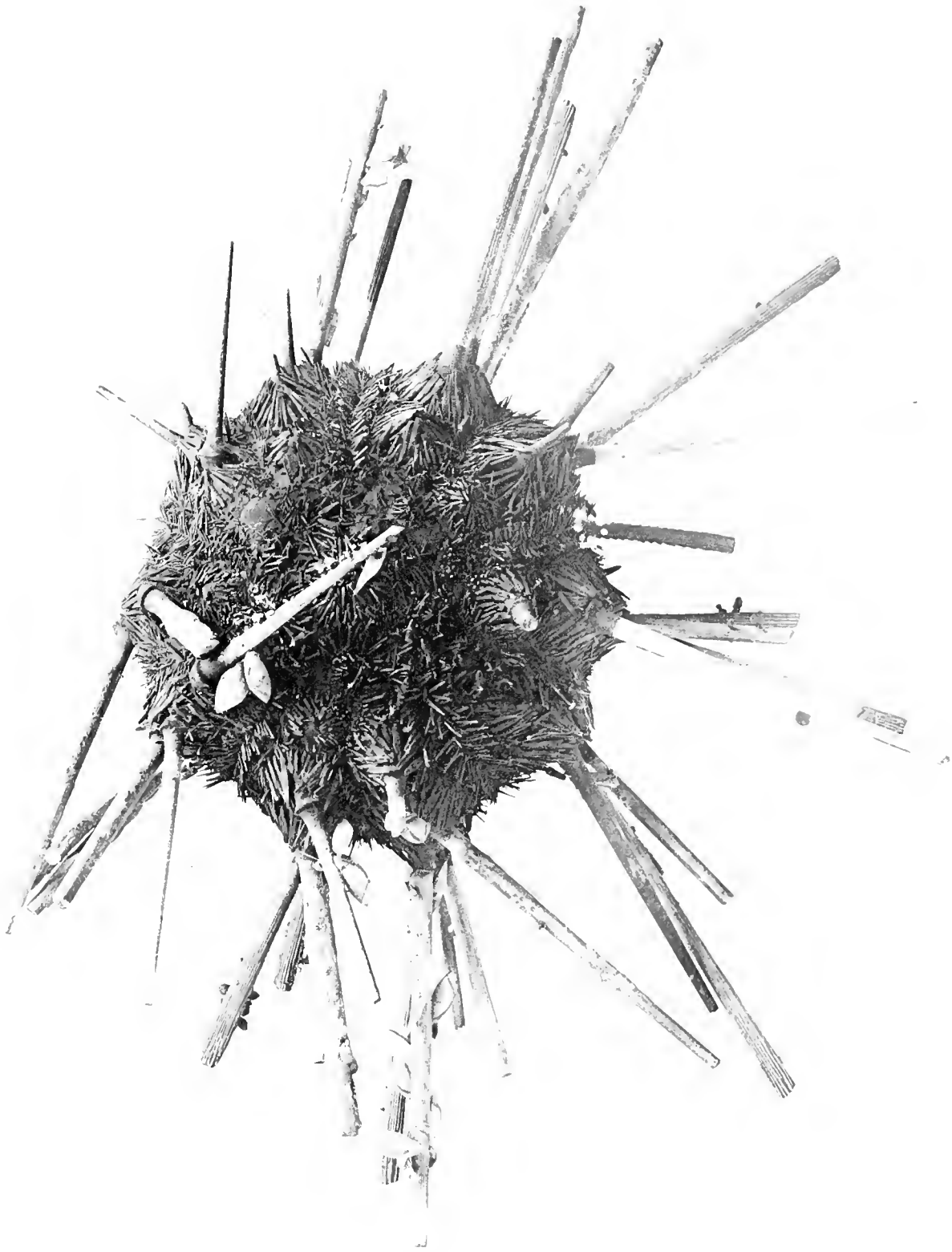


PLATE **18.**

Plate 18.

Porocidaris variabilis A. Ag. and Clark.

1. Abactinal view of partly cleaned specimen.
2. Actinal view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 19.

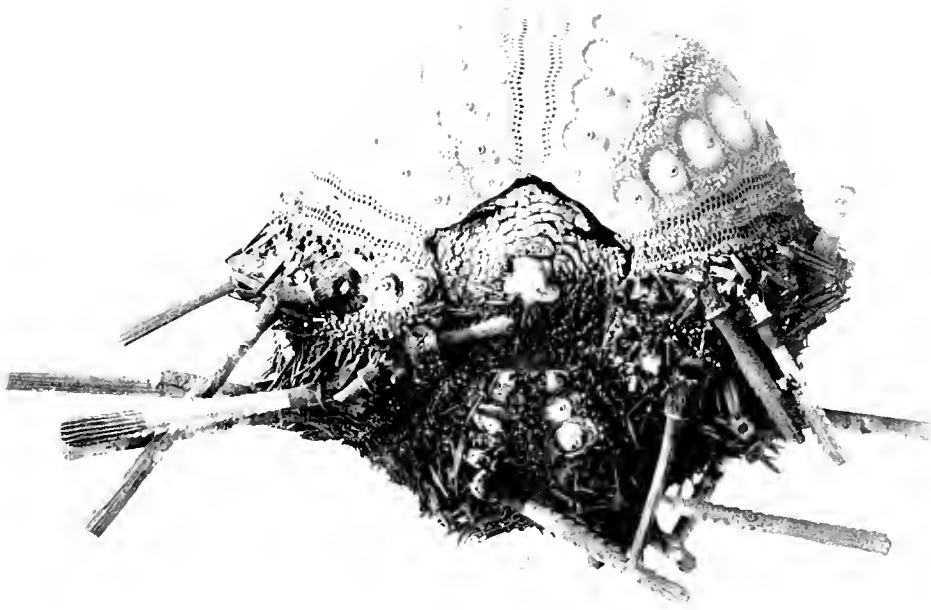


PLATE **19**.

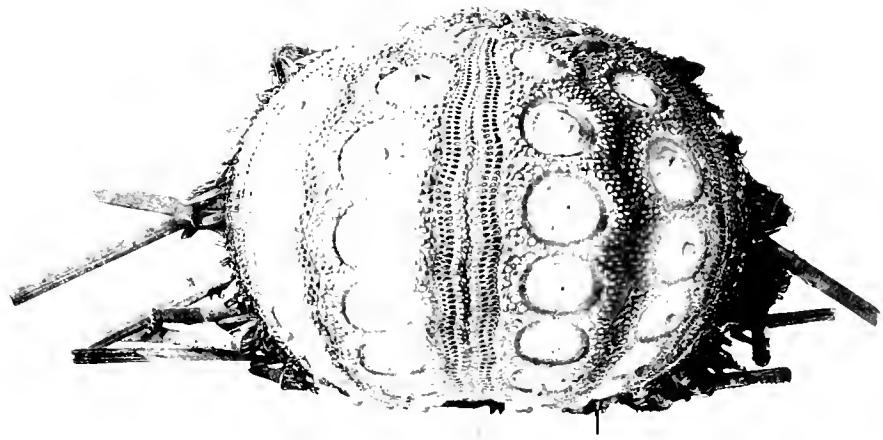
Plate 19.

Porocidaris variabilis A. Ag. and Clark.

1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 18.



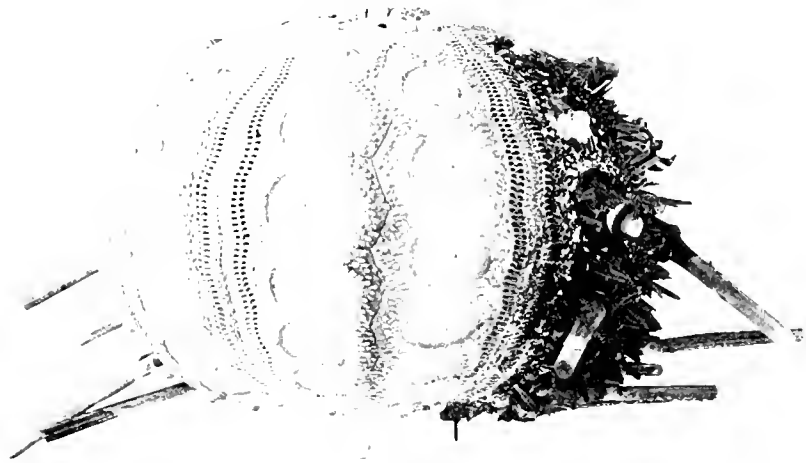


PLATE 20.

PLATE 20.

Porocidaris variabilis A. Ag. and Clark.

Actinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 21.

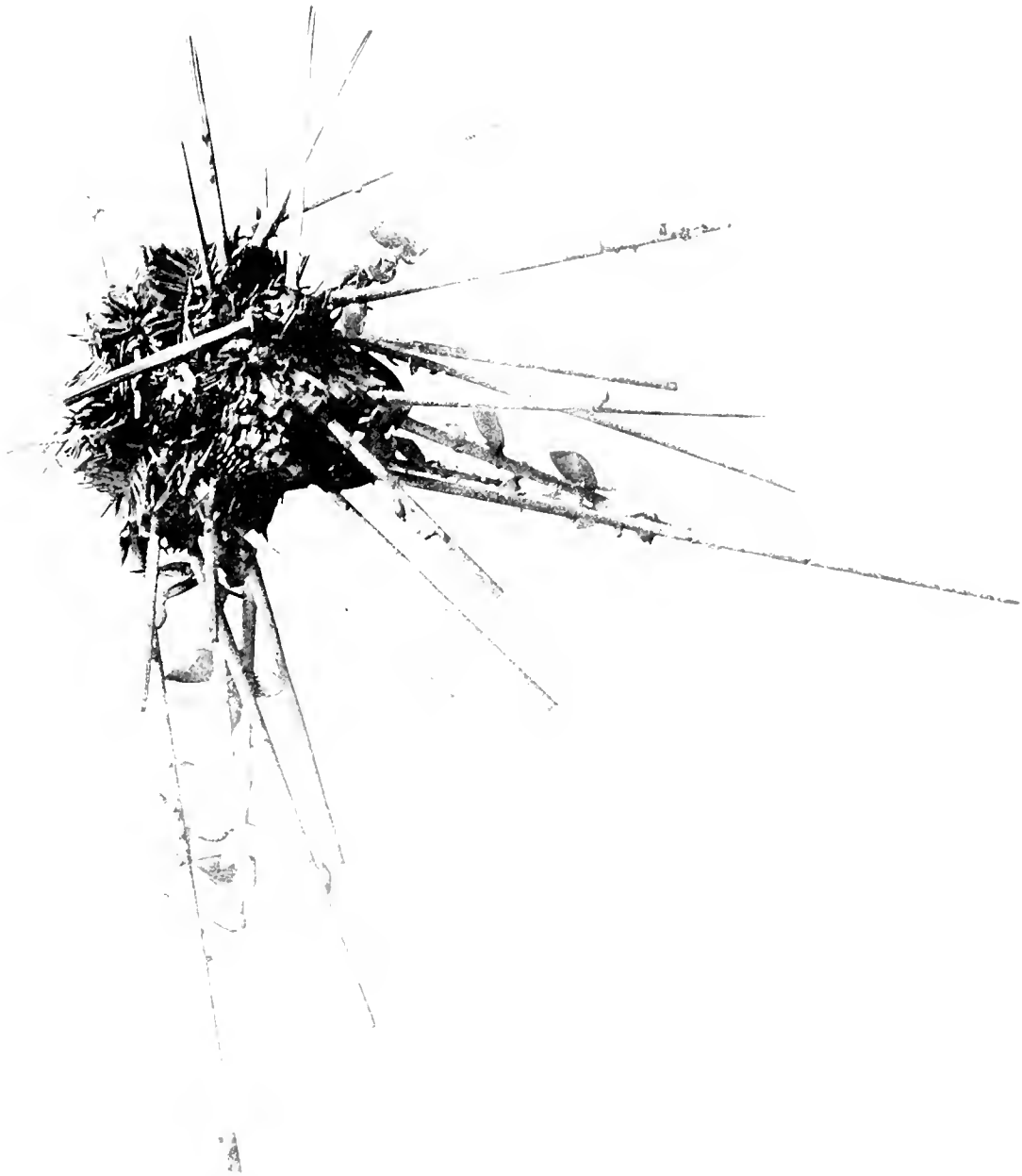


PLATE **21**.

PLATE **21**.

Porocidaris variabilis A. Ag. and Clark.

Abactinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 20.

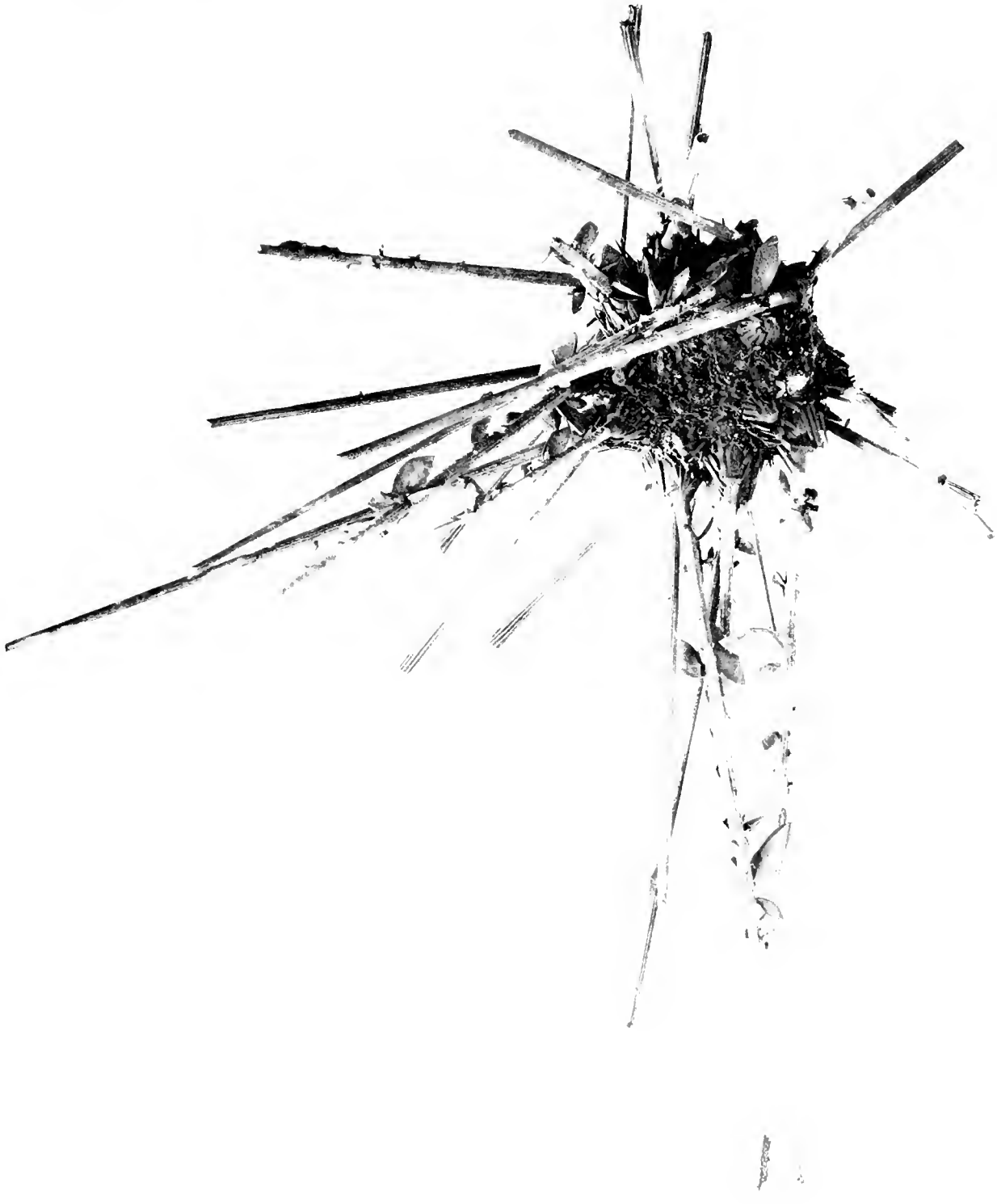


PLATE **22.**

Plate 22.

Porocidaris variabilis A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.

PLATE 23.

Plate 23.

1–4. **Porocidaris variabilis** A. Ag. and Clark.

1. Abactinal view of partly cleaned, light-colored specimen.
2. Actinal view of same.
3. Ambulacral view of same.
4. Interambulacral view of same.

5–8. **Aporocidaris fragilis** A. Ag. and Clark.

5. Abactinal view of cleaned test.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

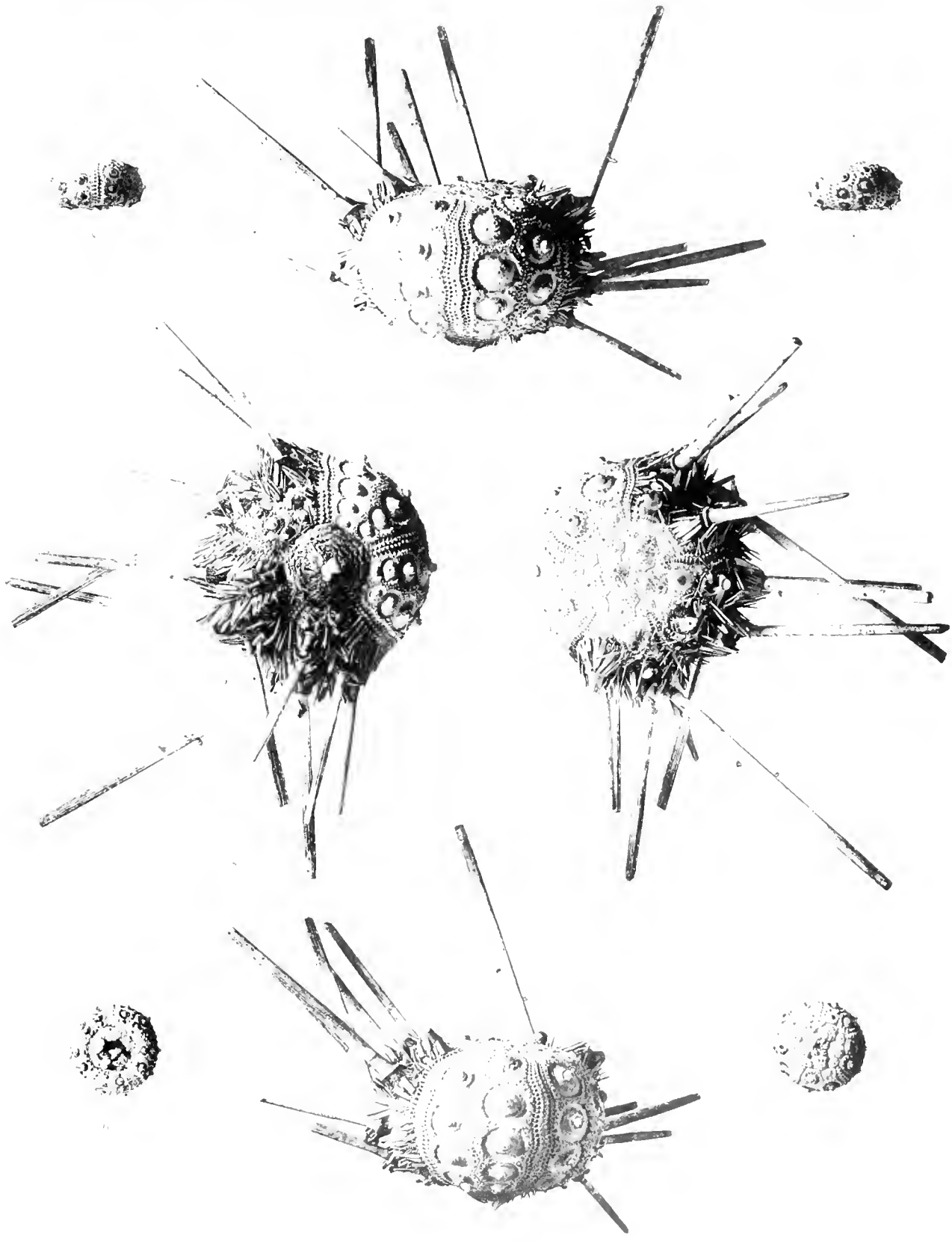


PLATE **24**.

PLATE 24.

Stephanocidaris hawaiiensis A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 25.

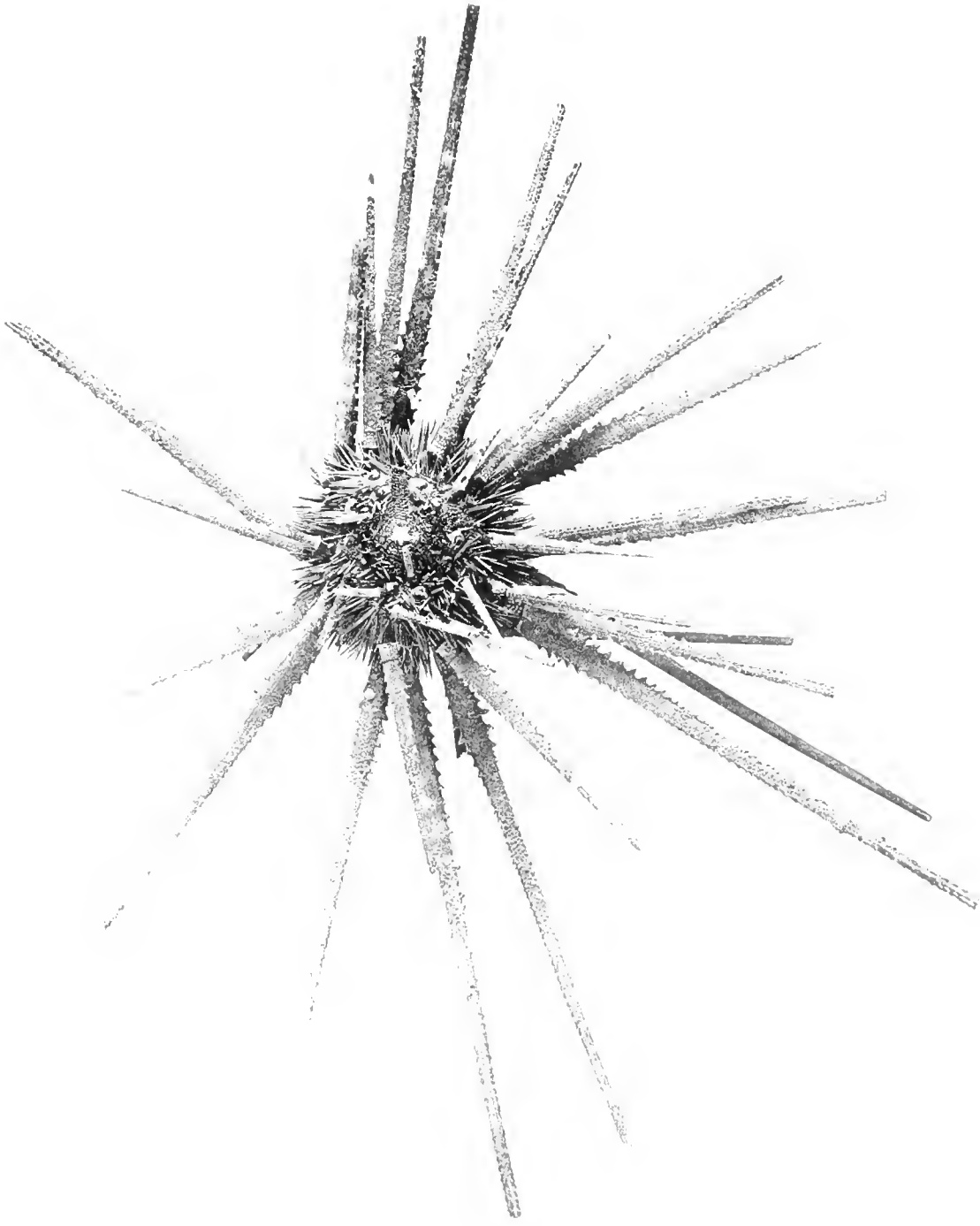


PLATE 25.

PLATE 25.

Stephanoeidaris hawaiiensis A. Ag. and Clark

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 24.

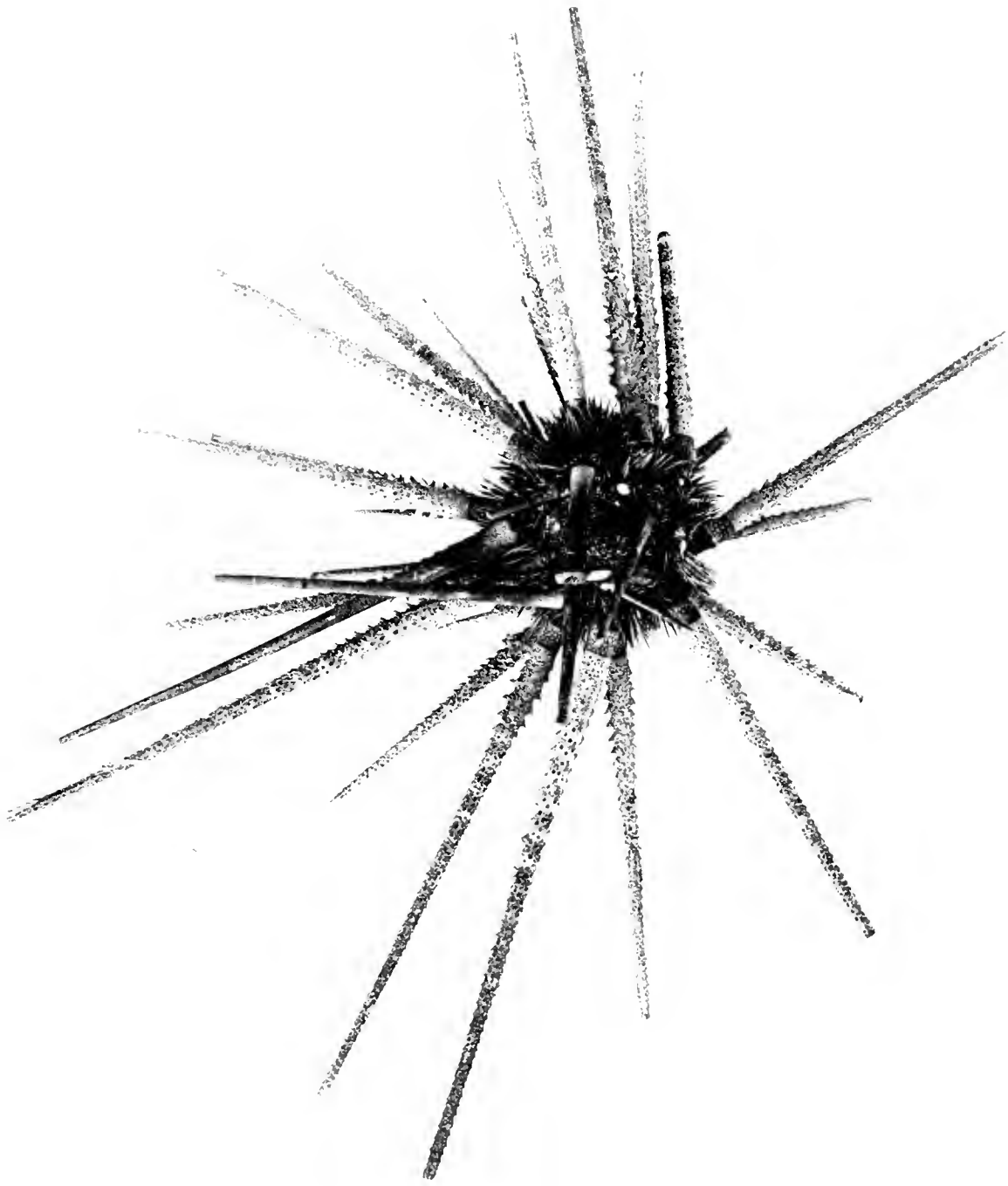


PLATE 26

Plate 26.

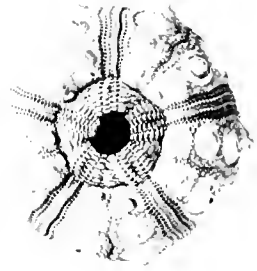
1–4. **Stephanocidaris hawaiiensis** A. Ag. and Clark.

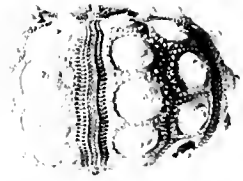
1. Abactinal view of cleaned test.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

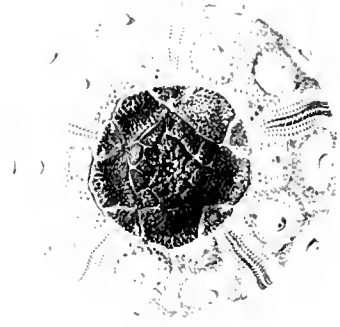
5–8. **Phyllacanthus Thomasii** A. Ag. and Clark.

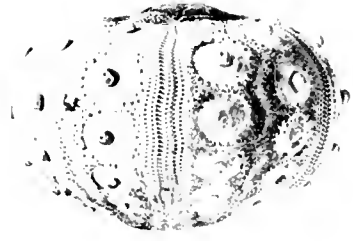
5. Abactinal view of cleaned test of medium-sized specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.









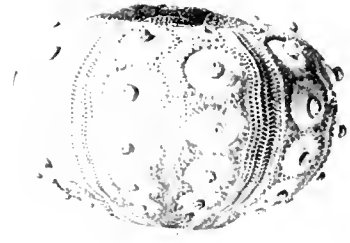


PLATE 27.

PLATE 27.

Phyllacanthus Thomasii A. Ag. and Clark.

Actinal view of partly cleaned specimen. Natural size.

Other views of same specimen are shown in Plates 28 and 29.

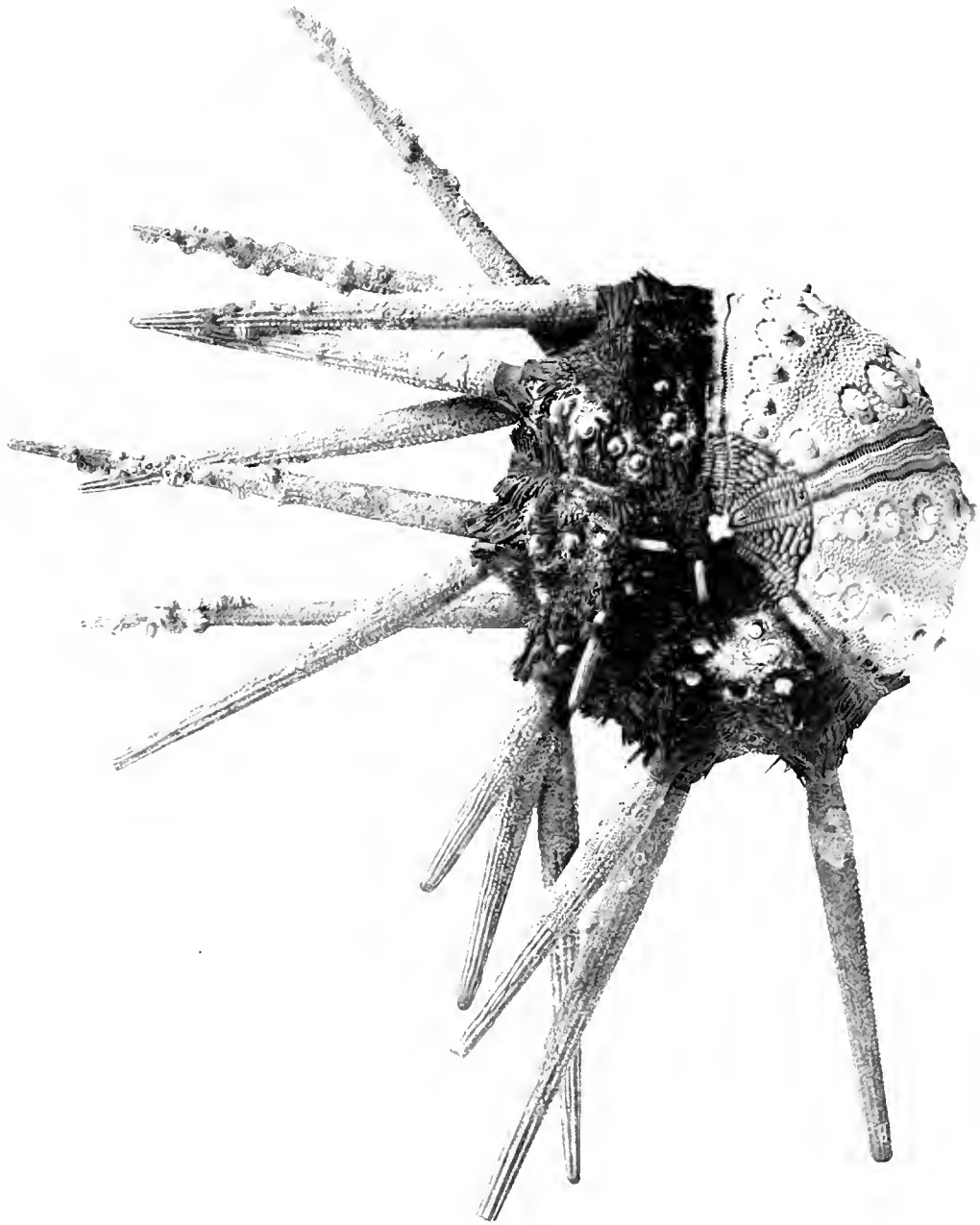


PLATE 28.

PLATE **28**.

Phyllacanthus Thomasii A. Ag. and Clark.

Abactinal view of partly cleaned specimen. Natural size.

Other views of same specimen are shown in Plates 27 and 29.

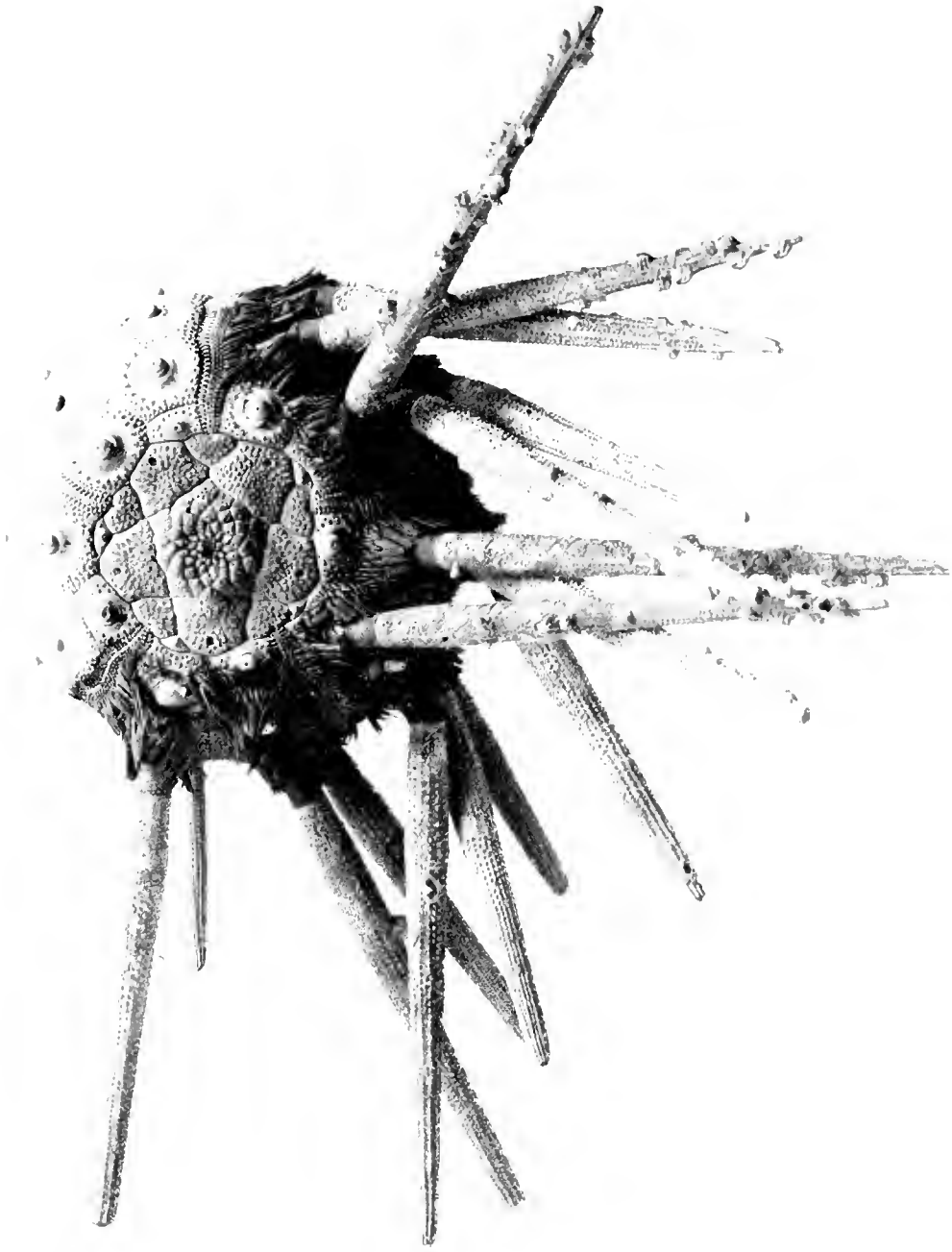


PLATE 29.

Plate 29.

Phyllacanthus Thomasii A. Ag. and Clark.

1. Ambulacral view of partly cleaned specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plates 27 and 28.

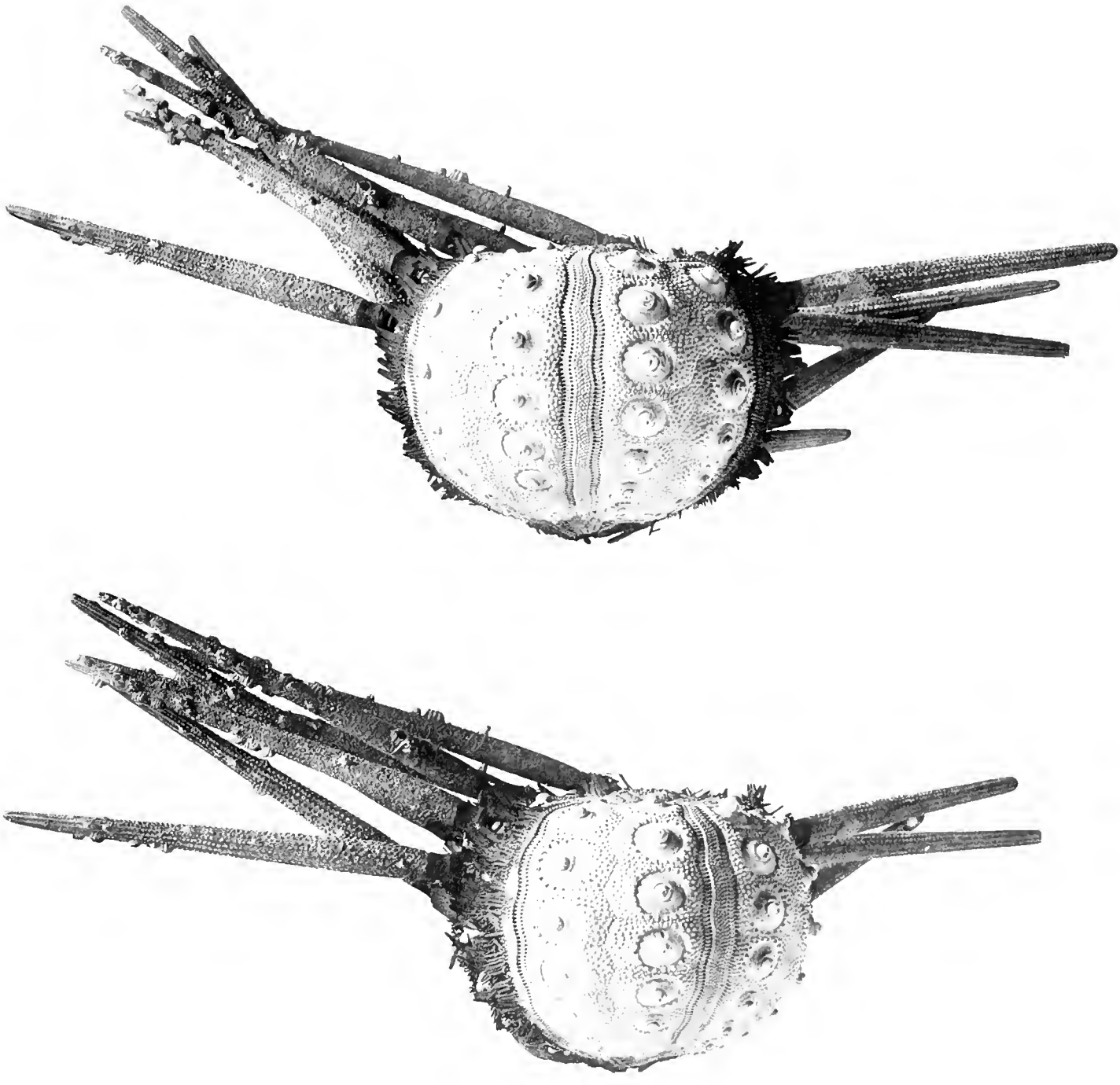


PLATE 30.

Plate 30.

Phyllacanthus Thomasii A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.

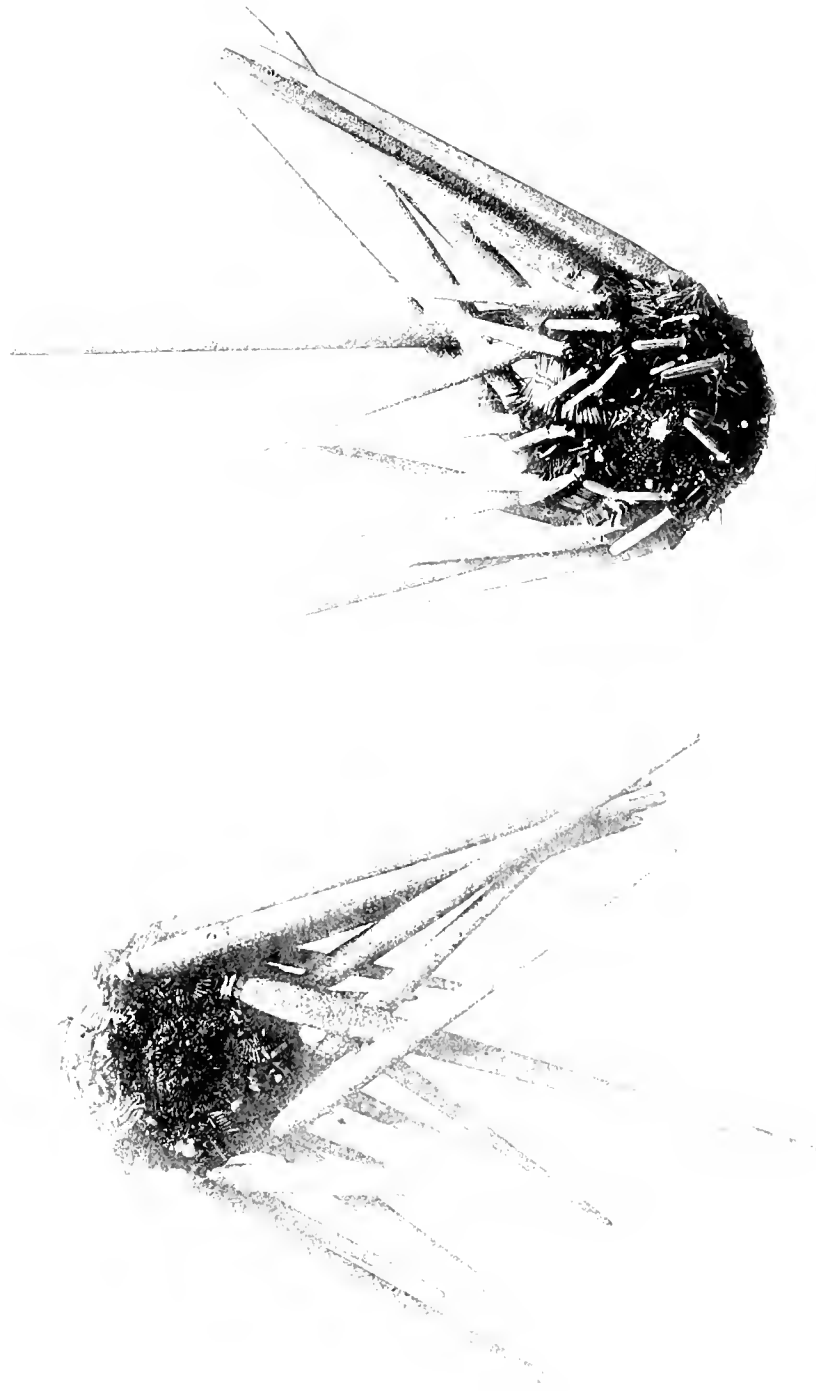


PLATE 31.

Plate 31.

1–4. **Phyllacanthus Thomasii** A. Ag. and Clark.

1. Abactinal view of cleaned test of small specimen.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

5–8. **Anomocidaris tenuispina** A. Ag. and Clark.

5. Abactinal view of partly cleaned specimen.
6. Actinal view of same.
7. Interambulacral view of same.
8. Ambulacral view of same.

All figures natural size.

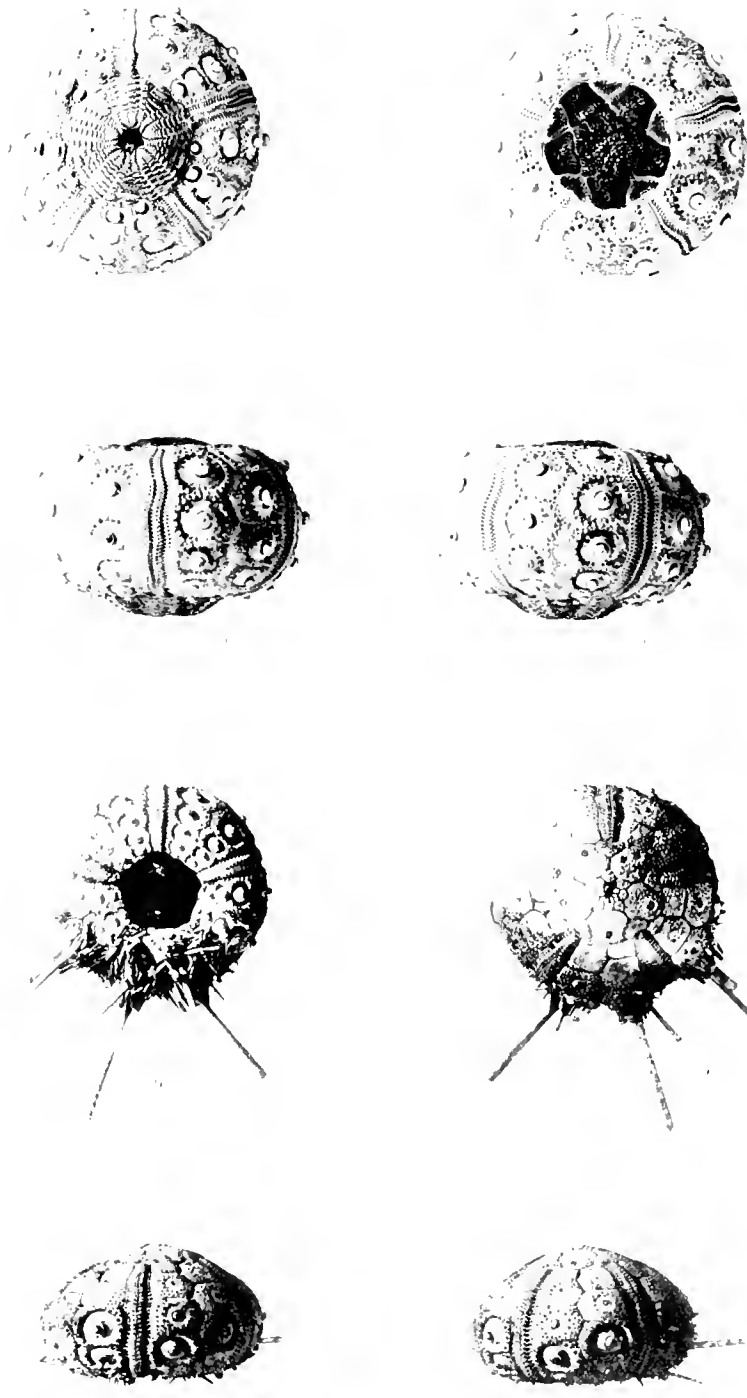


PLATE 32.

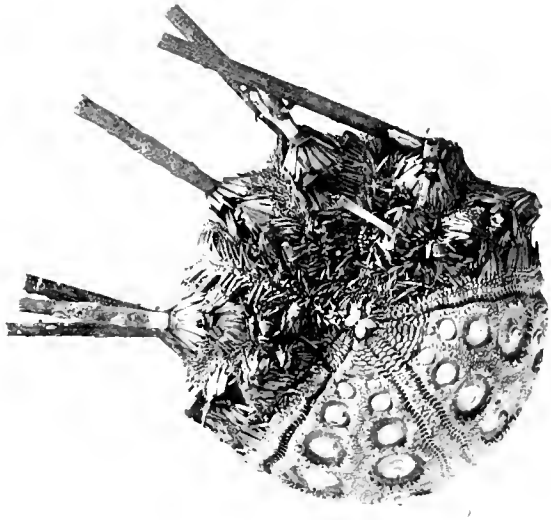
Plate 32.

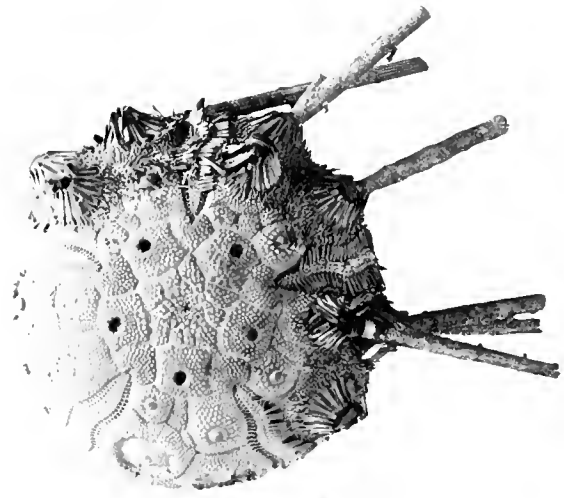
Stereocidaris leucacantha A. Ag. and Clark.

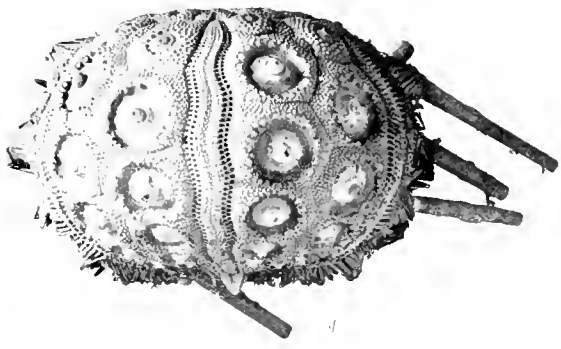
1. Abactinal view of partly cleaned, large specimen ; primaries all broken.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.
5. Abactinal view of partly cleaned, small specimen.
6. Actinal view of same.

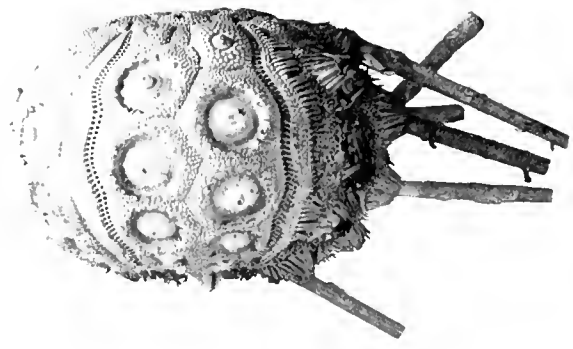
All figures natural size.

Other views of specimen shown in figs. 5 and 6 will be found in Plate 15, figs. 3 and 4.









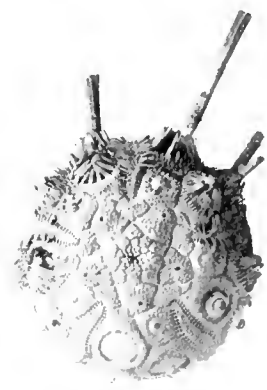


PLATE 33.

Plate 33.

Stereocidaris grandis Döderlein.

1. Ambulacral view of partly cleaned specimen from Hawaii.
2. Abactinal view of same.
3. Actinal view of same.
4. Interambulacral view of same.

All figures natural size.

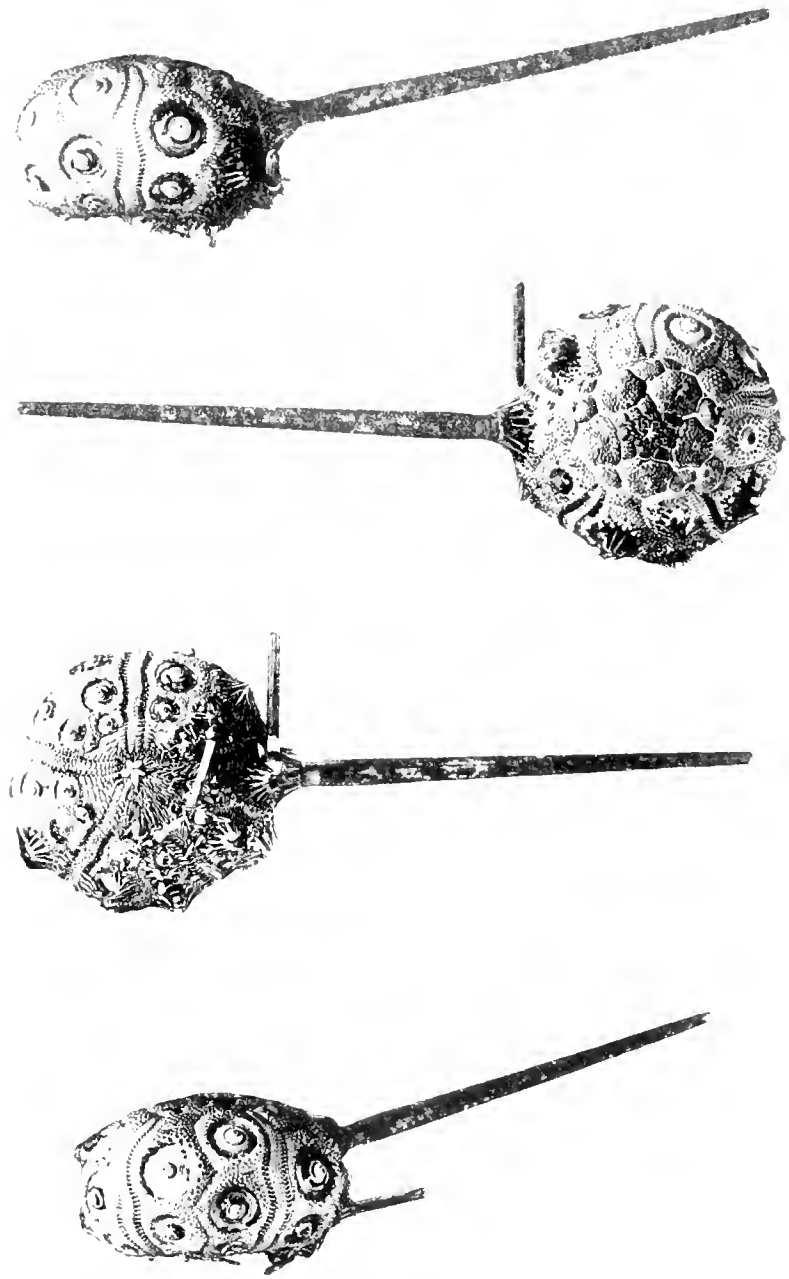


PLATE **34**.

PLATE **34**.

Dorocidaris calacantha A. Ag. and Clark.

Actinal view. Natural size.

Another view of same specimen is shown in Plate 35.

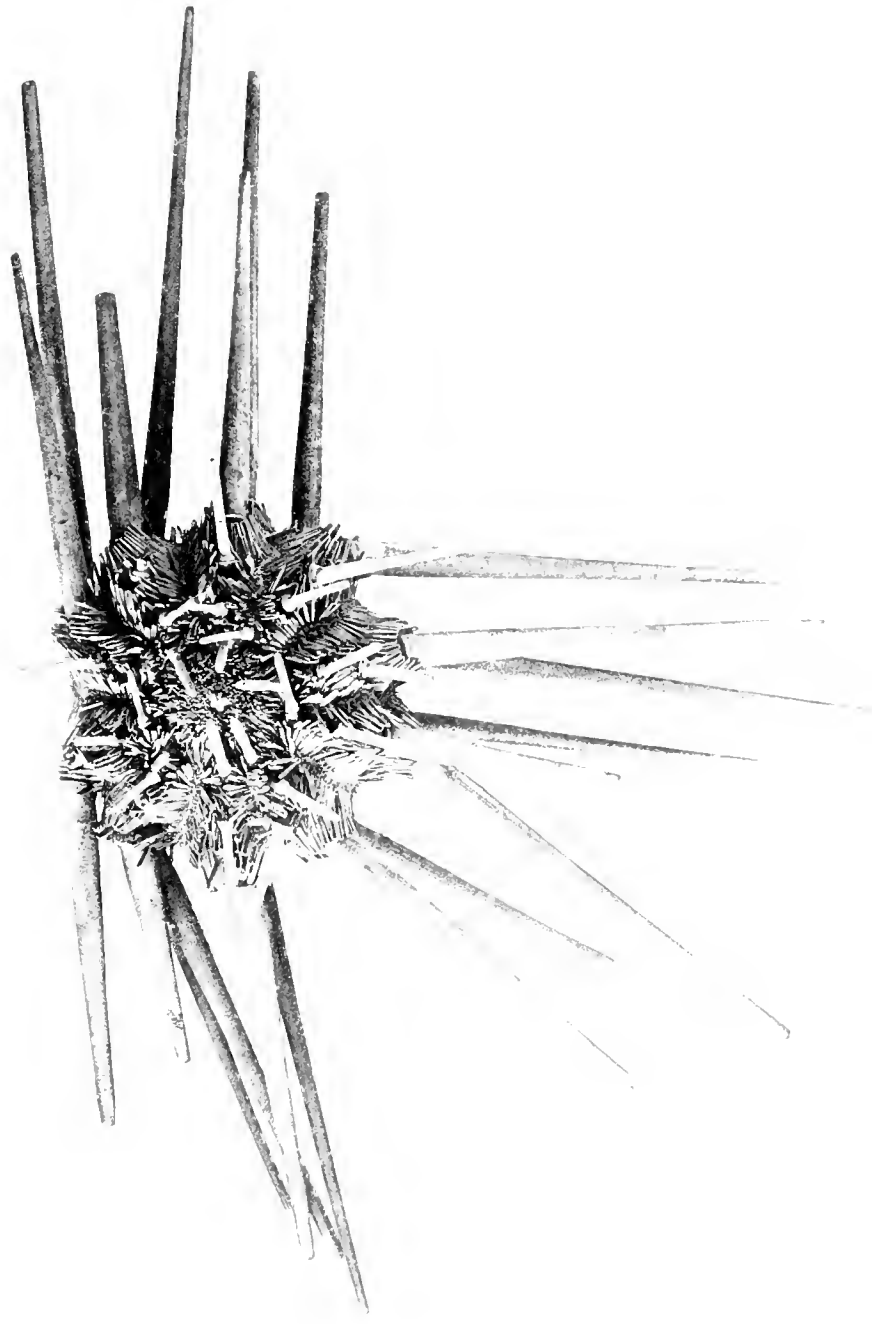


PLATE 35.

PLATE 35.

Dorocidaris calacantha A. Ag. and Clark.

Abactinal view. Natural size.

Another view of same specimen is shown in Plate 34.

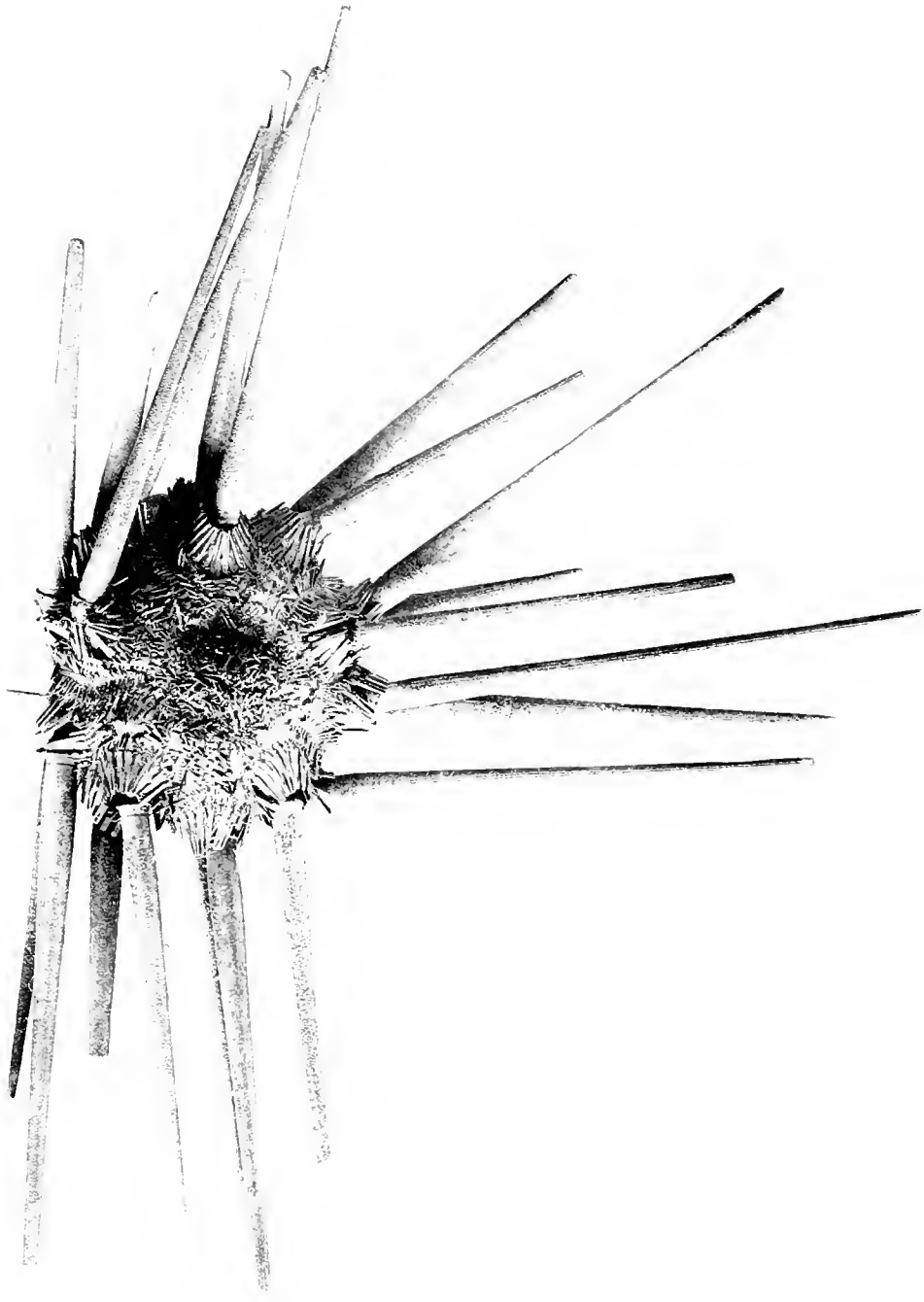


PLATE 36.

Plate 36.

Stereocidaris grandis Doderlein.

1. Abactinal view of partly cleaned specimen from Japan.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.

All figures natural size.

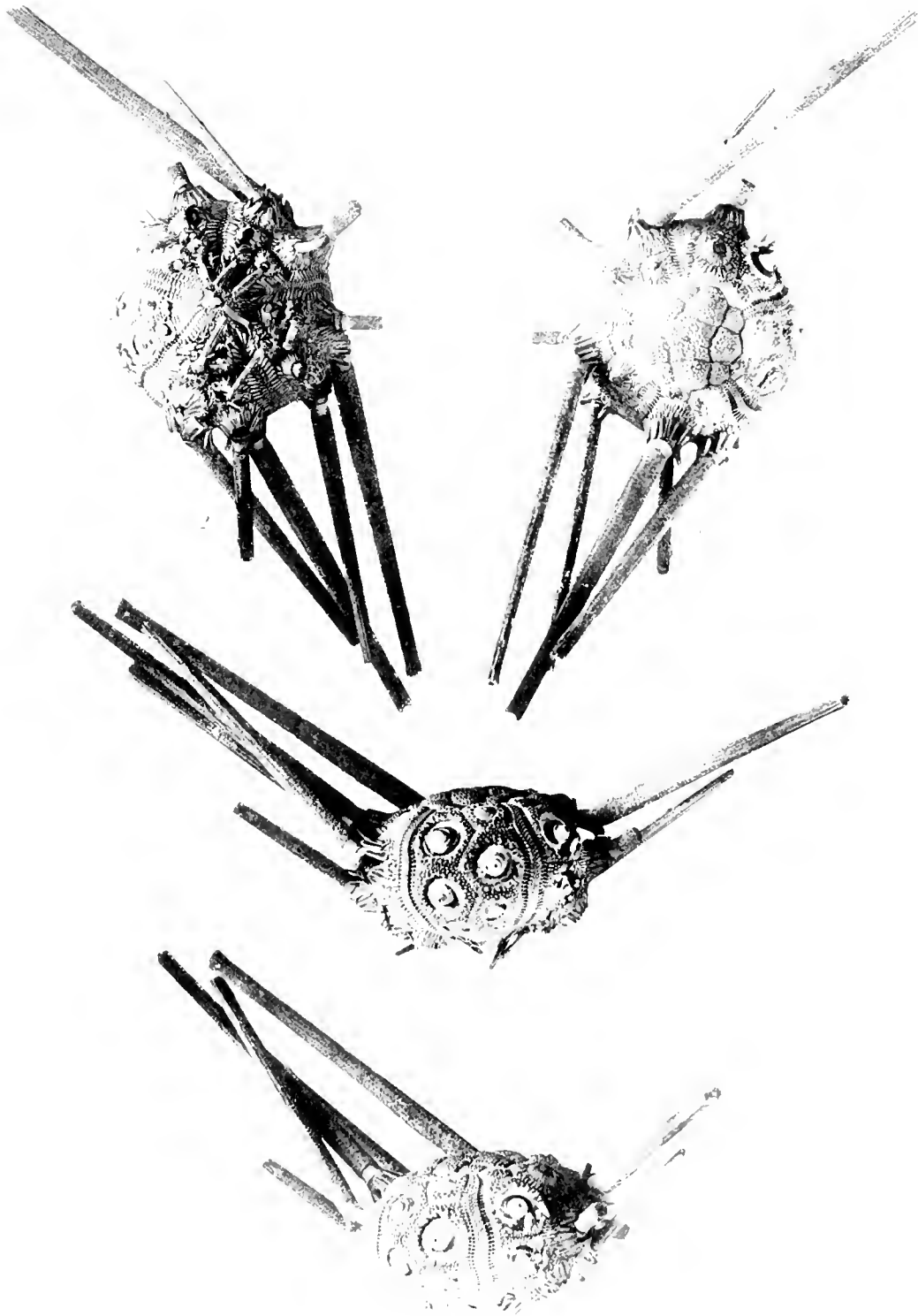


PLATE 37.

Plate 37.

Acanthocidaris hastigera A. Ag. and Clark.

Actinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 38.

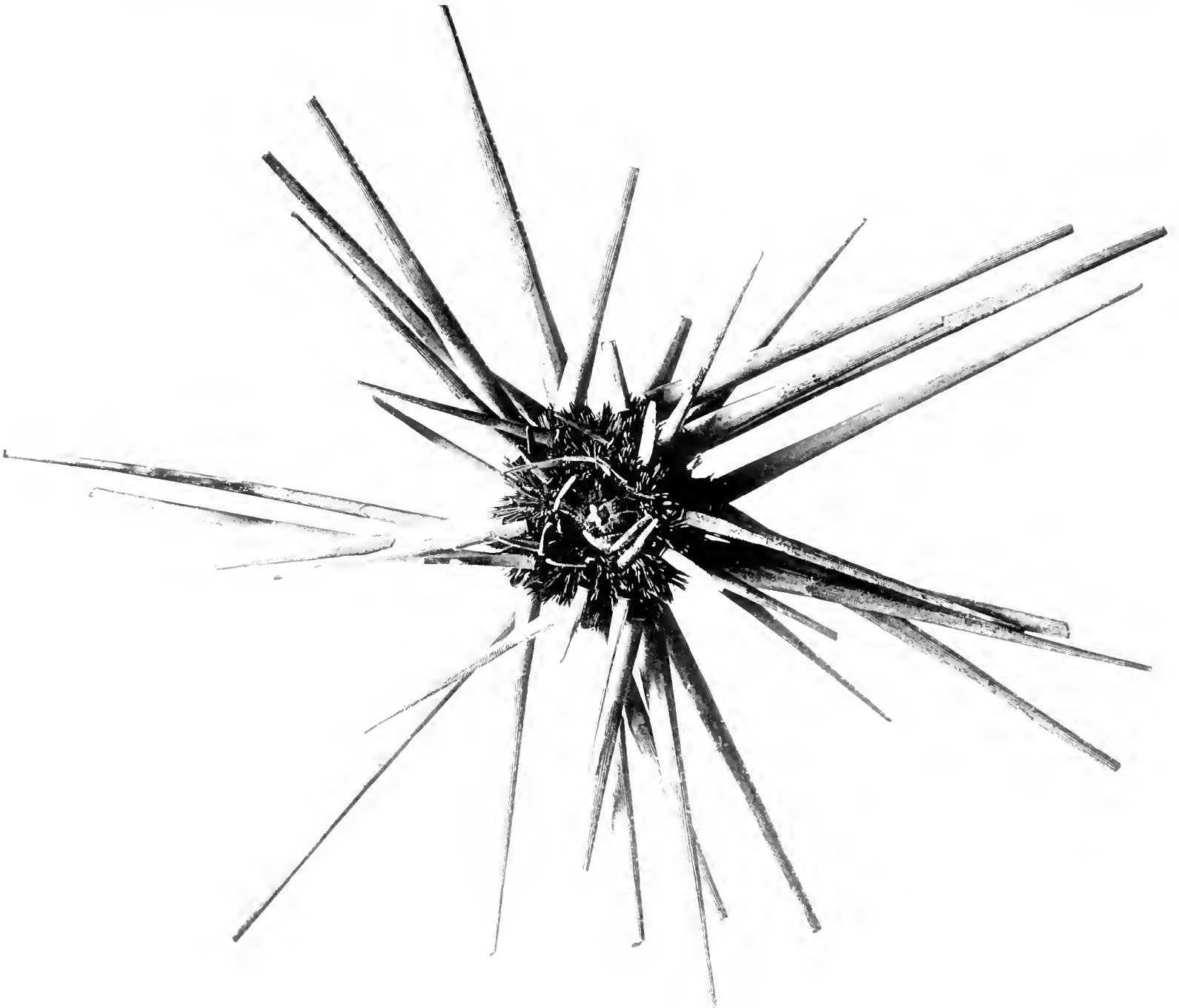


PLATE 38.

PLATE 38.

Acanthocidaris hastigera A. Ag. and Clark.

Abactinal view of medium-sized specimen. Natural size.

Another view of same specimen is shown in Plate 37.

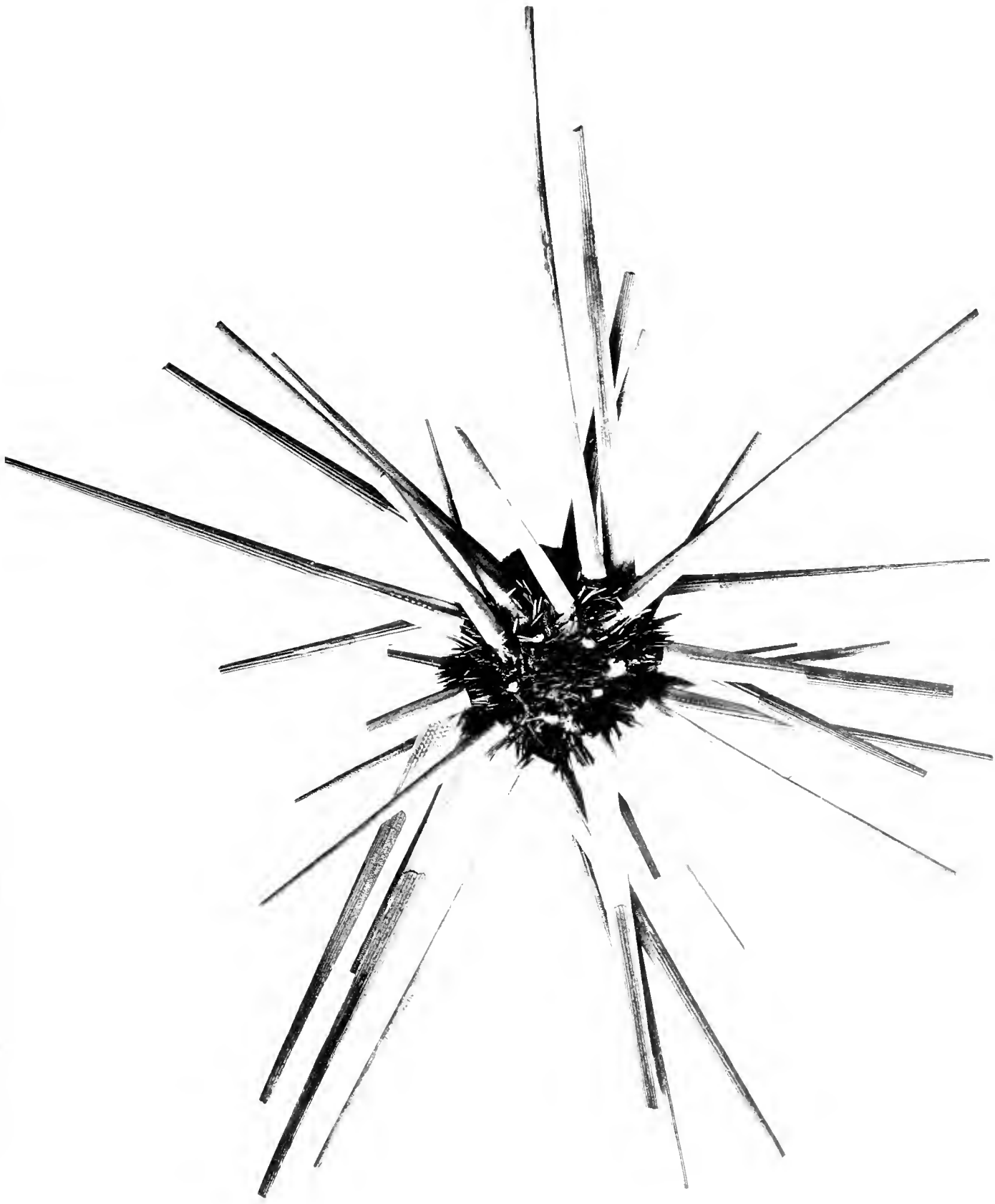


PLATE 39.

Plate 39.

Acanthocidaris hastigera A. Ag and Clark.

1. Actinal view of partly cleaned, large specimen.
2. Abactinal view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 40.

PLATE **40.**

Plate 40.

Acanthocidaris hastigera A. Ag. and Clark.

1. Ambulacral view of partly cleaned, large specimen.
2. Interambulacral view of same.

Both figures natural size.

Other views of same specimen are shown in Plate 39.

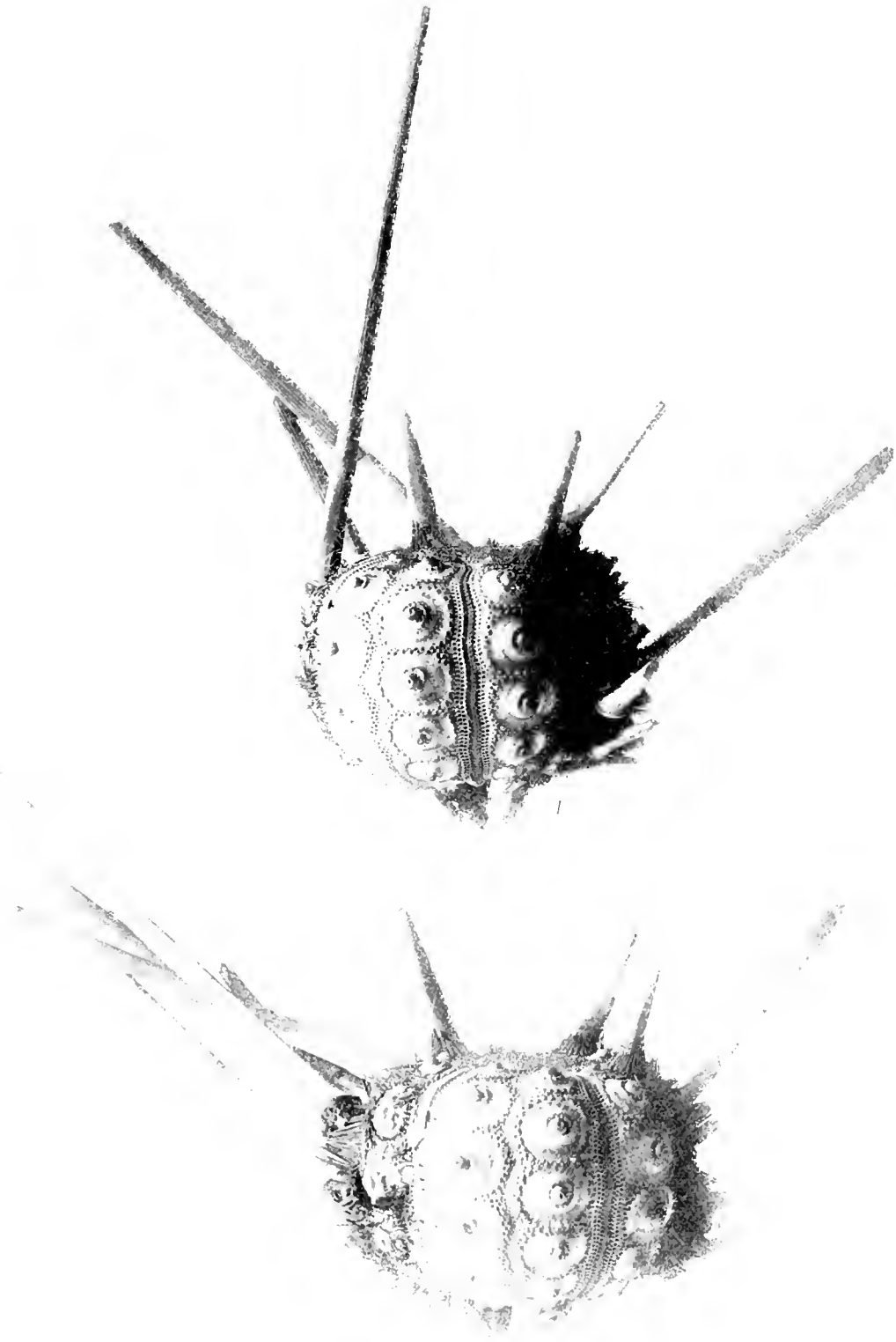


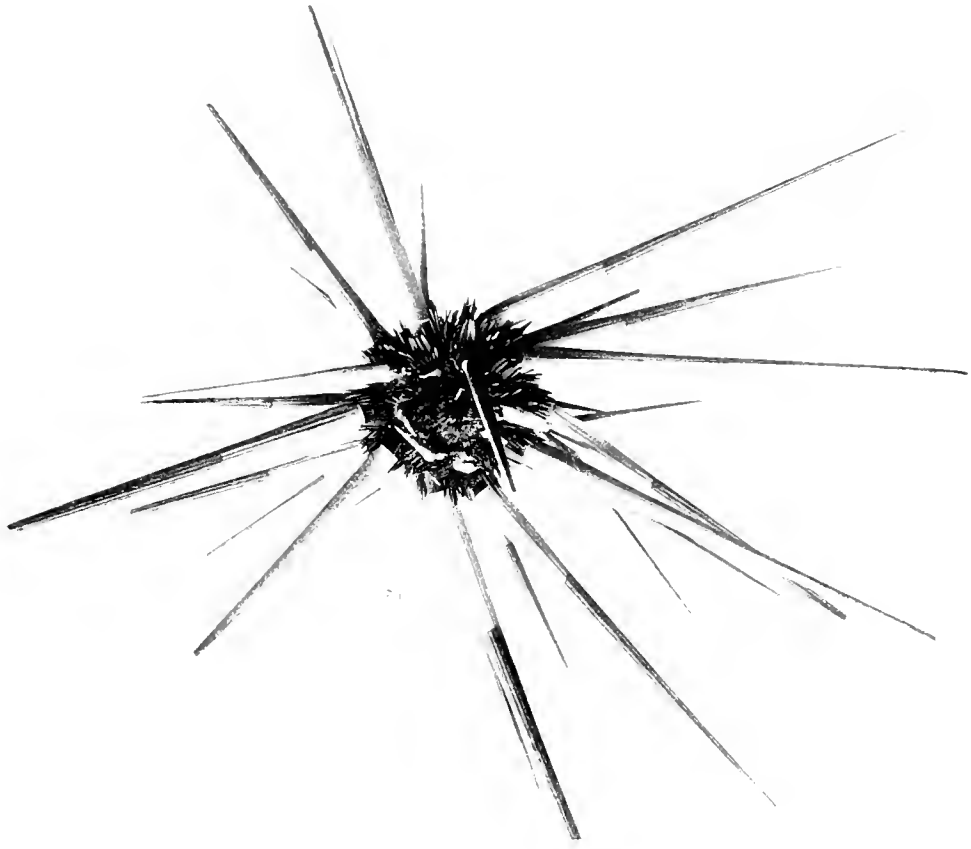
PLATE 41.

Plate 41.

Acanthocidaris hastigera A. Ag. and Clark.

1. Actinal view of small specimen.
2. Abactinal view of same.

Both figures natural size.



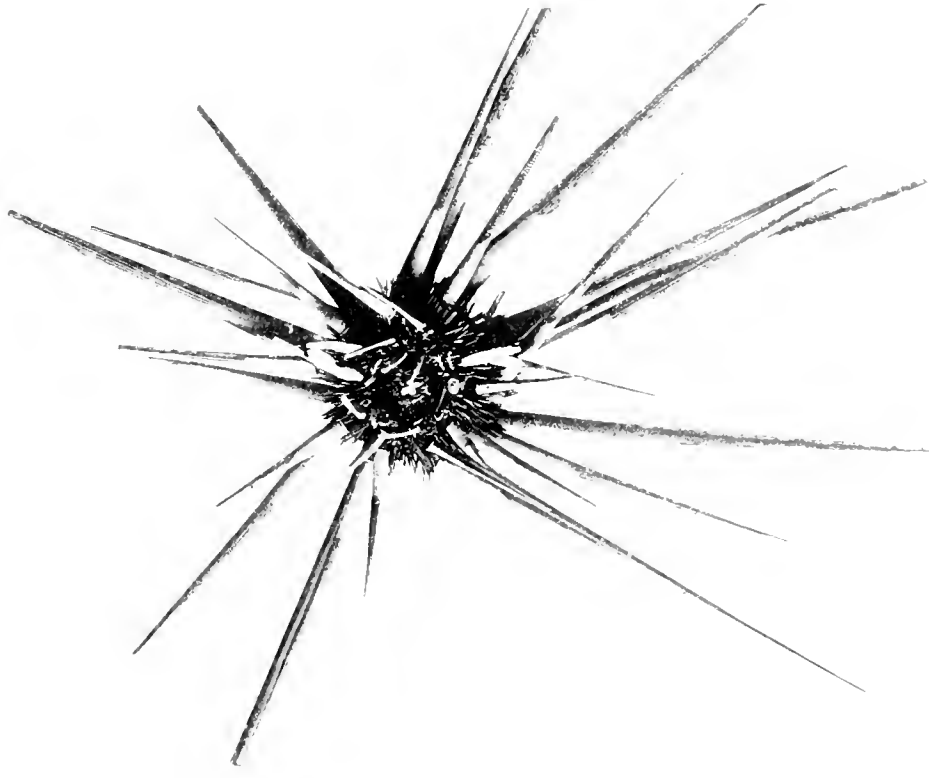


PLATE **42.**

Plate 42.

Acanthocidaris hastigera A. Ag. and Clark.

1. Abactinal view of partly cleaned, small specimen.
2. Actinal view of same.
3. Interambulacral view of same.
4. Ambulacral view of same.
5. Abactinal view of small specimen.
6. Actinal view of same.
7. Abactinal view of partly cleaned, very small specimen.
8. Actinal view of same.
9. Interambulacral view of same.
10. Ambulacral view of same.

All figures natural size.