

IV.—REVISION OF CERTAIN GENERA AND SPECIES OF STARFISHES
WITH DESCRIPTIONS OF NEW FORMS. BY A. E. VERRILL.

Family **GONIASTERIDÆ.**

Goniasteridæ Verrill, Trans. Conn. Acad. Sci., i. p. 343, 1867; Perrier, Revision, Arch. Zool. Exper. et Gen., iv. pp. 281, 283, 289, 291, 1875; op. cit., V., p. 1, 1876.

Goniasteridæ (pars) Forbes, 1840.

Pentacerotidæ (pars) Gray, p. 275, 1866.

Pentagonasteridæ Perrier, 1884; Sladen, p. 260, 1889.

THE generic nomenclature in this family has become very much confused for several reasons.

The genera themselves are difficult to limit and define, and scarcely any two investigators, in the past, have agreed as to their number or limits. Nor have they agreed as to what characters should be considered as of generic value. This was the case, in a very marked degree, and very unfortunately, when the ancient and comprehensive genus *Asterias* was first divided into numerous genera by J. E. Gray, in 1840, and by Müller and Troschel, in 1842. In these two works, issued within a brief period, there was very great diversity, both as to the number of genera and their names. In the genus *Astrogonium* of M. and Tr. four of Gray's genera were reunited into one. In *Goniodiscus* M. and Tr., five of his genera were also reunited. For about half a century most subsequent authors have tried to take an intermediate course, but gradually more and more of Gray's genera have been adopted, though often with their limits more or less modified. Fortunately Gray assigned definite types to his genera, and in his later works he described and figured many of the species, so that in most cases his groups can be readily understood. Moreover he followed, pretty closely, the generally accepted rules of zoological nomenclature, which has not always been done by later writers.

The failure of several writers to follow the ordinary and accepted rules of priority has led to much needless confusion of names. The failure to recognize the priority of Gray's generic names has been the cause of more confusion than any other one thing, throughout the group of starfishes.

The efforts that certain writers have made, from time to time, to restrict or apply certain generic names to species or groups to which they were not originally given, has repeatedly led to confusion and

uncertainty. This applies strikingly to *Goniaster*, *Astrogonium*, *Dorigona*, etc.

A few recent and prominent writers, especially Perrier and Sladen, have restored the ancient names given by Linck (1733) to certain genera and species of starfishes, thus displacing names well established under the binomial system. Linck was a very able naturalist, for his period, but he was not a binomial writer, and his names cannot properly be allowed priority over those established under the binomial system.

The name *Pentagonaster* is the only generic name in this family to which this remark applies.

Perrier himself, although he restores several of Linck's names of species, does not go so far as to try to restore others that have equal claims to priority, for to do this would overthrow the well known names of several common European species.* Nor has he proposed to restore the names of Seba, which have equal claims to recognition.

In the following pages I propose to briefly review the history of some of the earlier names and of the more important groups to which they have been applied by various writers, in order to show, if possible, to what particular groups certain of these names ought rightly to be applied, in accordance with the generally accepted rules of biological nomenclature.†

* Among the names adopted by Perrier, and also by Sladen, from Linck, are *oculata*, under *Cribrella*; *planus*, under *Hippasterias*; *corniculatus*, under *Ctenodiscus*. Neither of these can be justified.

† Among the recognized rules that I follow, and which need to be applied to this group, are the following:

A.—Strict priority to be applied to all names properly published in actual *binomial works*, in general dating only from Ed. X. of the *Syst. Nat.* of Linné.

B.—Exclusion from the rule of priority of names taken from earlier polynomial writers, unless adopted by later binomial writers. In that case they should date only from their introduction into binomial literature.

C.—When an old composite genus has been divided by a later writer, the original name must be kept for one of the component groups, and for one or more of the species originally included *by name*. If a definite generic *type* was given by the original author, the name must remain with that type. If *no type* was mentioned, the mere position on the page cannot fix the type. Nor does it follow that the *first* species named was the type, unless so stated originally, for many early writers arranged their species alphabetically, or in some other arbitrary way.

D.—A composite genus having been subdivided and the original name definitely applied to one of its parts (in accordance with rule C), it must ever after be kept for that group (or some part of it) just the same as if it had been originally so

This brief review is, however, by no means intended as a complete history of the subject. Generally only the works that seem essential to the object in view will be referred to here. A fuller discussion must be left to a much more extensive work on American starfishes, which is now well advanced towards completion and in which most of the genera and species will be well illustrated.

1. The first generic name applied by binomial writers to any subdivision of the old genus *Asterias* (Linné), and pertaining to the present family, was *Goniaster*. This name was proposed by L. Agassiz, in 1836, for the pentagonal starfishes, collectively, including representatives of more than one family.

This name was adopted by Forbes in 1841 (Brit. Starfishes), in the same sense, for he included in it such diverse forms as *Hippasteria* and *Asteropsis*, without assigning to it any definite type. Müller and Troschel used it in the same way, in 1840. Dr. J. E. Gray, in 1840, adopted the name for a very restricted group, with a definite diagnosis, and named as a type, *G. cuspidatus*, a well-known species and one of those given by Agassiz as examples of his genus. This species should, therefore, remain as the type of the restricted genus.

In 1842, Müller and Troschel reunited *Goniaster*, *Pentagonaster*, *Tosia*, and *Hippasteria* of Gray into a single genus, to which they applied the new name, *Astrogonium*. If these four groups really constitute only a single genus, it is evident that *Goniaster* (emended) should have been adopted as its name.

II. The name *Pentagonaster* was first used, under the binomial system, by Gray, in 1840. He applied it to a particular type (*P.*

applied. In other words, a generic name correctly applied to a restricted group has just as much claim to priority, *in the new sense*, as a *new name* would have.

E.—When a generic name is a *real synonym* of another earlier one it should be dropped from the system, unless it had a different type-species when first proposed. In case the two types belong to different subdivisions of a composite genus both names may be retained in a modified sense. In cases where two names are only *partially* synonymous, both may be used if they can be properly restricted to distinct subdivisions of the groups to which they may have been originally applied (in accordance with rule C).

F.—The application of an old or discarded name to a species or group not included in the group to which it was originally applied is to be avoided as leading to confusion and instability. A name once dropped from the system, for good cause, should fall into disuse in every other sense. To use a discarded generic name for a new genus in the same class or order (as if it were a new name), should never be thought of, for it is sure to cause confusion. (*Goniaster* and *Astrogonium* among starfishes afford examples of incorrect transposition of names.)

pulchellus) and gave it a definite diagnosis. His use of the name should, therefore, have priority, and the name should not be applied to any other group, unless *P. pulchellus* be included in a larger generic group, as was done by Perrier, in 1876, and by Sladen. But in the latter case, *Goniaster* should have had precedence over *Pentagonaster*, for such a comprehensive group, on the ground of priority.

In a later work (1894) Perrier separated Gray's *Pentagonaster* as a distinct genus, but he ignored the original application of the name by Gray, and adopted the later name, *Stephanaster* of Ayres, for Gray's genus.

At the same time he retained *Pentagonaster* for a large group of species closely allied to *P. australis*, which was the type of *Tosia* Gray, 1840. This arrangement was based on the fact that Linck, in 1733, had figured an indeterminable species, apparently of the latter group, under the name of *Pentagonaster*. But Linck, however great his merits may have been, was certainly not a *binomial* writer. Most of his names were trinomial or polynomial, and there is nothing to be gained, except increased confusion, by trying to give priority to the names used by such polynomial writers, in place of later binomial names that have been definitely defined and fixed in the binomial system.

Perrier, in 1876, restricted *Goniaster* to a genus containing only a single species, *Pentaceros obtusangula* (Lam.) Gray. This species was not mentioned by Agassiz in connection with the genus *Goniaster*. Its use by Perrier is, therefore, in a new sense and like that of an entirely new name, and was not justifiable.*

Sladen (1889) has also restricted *Goniaster* to the same type.

III. *Tosia* was also proposed by Gray, in 1840, for a definite group of this family, with *T. australis* as the type. Several other species were added to it by him in 1847. This name has been ignored by most later writers on starfishes, or else it has been placed as a partial synonym of *Pentagonaster* (Sladen, Perrier) or *Astrogoninum* (M. and Trosch.). If Gray's restricted genus *Pentagonaster* be deemed a valid one, as by Perrier (1894), then *Tosia* should be used for the large group of species, called *Pentagonaster* by Perrier and Sladen, agreeing well with Gray's diagnosis and type-species (*T. australis*).

IV. *Hippasteria* was proposed by Gray, in 1840, for the single type-species, *H. phrygiana* (as *H. Europæa*, etc.). This name has been so generally adopted by later writers that it needs no discussion here.

* The restriction of *Goniaster* to its correct type leaves this genus without a name. Therefore I would propose for it *Pseudoreaster*, with *P. obtusangulus* (Lam.) as its type and only known species.

V. *Calliaster* proposed by Gray, in 1840, for the single type-species, *C. Childreni*, is very distinct from the genera already named, not only on account of the spinose plates of both surfaces, but also by reason of its very different adambulacral spines.

VI. *Hosia*. When Gray established this genus, in 1840, he referred to it only *H. flavescens*. Perrier (1876) has redescribed the types of this species and refers them to two distinct species of true *Anthenea* (Gray, 1840). Therefore *Hosia* becomes a synonym of the latter. In 1847 and 1866, Gray added another species (*H. spinulosa*) to *Hosia*, but according to Perrier (1876), who reëxamined Gray's type, this species belongs to a different genus. He referred it to his section C of *Pentagonaster*. It has spinulose marginal plates, and also valvular pedicellariæ. It is probably an immature species of *Tosia*, or of some closely related genus.

VII. The names proposed by Müller and Troschel, in 1842 (Syst. Ast.), are next in order.

Astrogonium, as stated above (p. 145), was formed by uniting four of Gray's genera. It thus became a composite group without any definite type, and not very different from the original group called *Goniaster* (1st section) by Agassiz. In 1847 and 1866, Gray applied the name to a more limited group, including *A. granularis* (Retz.), which is nearly allied to *Tosia*, together with species now referred to *Odontaster*.

If it were to be used at all in the modern system, it should be restricted to the group containing *A. granularis*. But as it was an artificial group and should have had no real status originally, it should properly drop out of use except as a synonym of Gray's genera.

By Sladen (1889) *Astrogonium* was restricted to Gray's genus *Pentagonaster*=*Stephanaster* Ayres.

Perrier (1894) has used it improperly for a very different group, (= *Pseudarchaster* + *Aphroditaster* Sladen), including several deep-sea species, none of which were known to M. and Troschel, nor to Gray.

VIII. *Goniodiscus*. M. and Troschel (1842) constituted this genus by reuniting five of Gray's genera, together with forms unknown to Gray. Perrier (1894) has very judiciously restricted the name to those species that have stellate or 6-lobed abactinal plates, included in it by M. and Trosch., such as *G. cuspidatus* (Lam.), and in this sense it should be adopted.

The genera proposed subsequently to those already mentioned have given rise to no great confusion and therefore need not be discussed here.

Goniaster (Agassiz), Gray (restr.). Type *G. cuspidatus* Agassiz.

Goniaster (pars) Agassiz, Prod. Mem. Soc. Neufch., 1836.

Goniaster Gray, Ann. and Mag. Nat. Hist., vol. vi, p. 280, 1840. Type *G. cuspidatus*. Synopsis, p. 10, 1866 (*non* Perrier, 1876, *nee* Sladen, 1889).

Pentagonaster (pars) Perrier, Revis., Arch. de Zool., v, p. 24, 1876. Sladen, Voy. Chall., xxx, p. 264, 1889.

Astrogonium (pars) Müll. and Trosch., Syst., pp. 52, 56, 1842.

Phaneraster Perrier, Exp. Sci. Trav. and Talisman, pp. 334, 337, 387, 1894. (Type *G. semilunatus* = *cuspidatus*.)

As already explained, the genus *Goniaster* was restricted by Gray, in 1840, to a definite and well known type (*G. cuspidatus*). Perrier, in 1894, has, quite unnecessarily, applied a new name (*Phaneraster*) to exactly the same group, with the same type. Whether *Goniaster*, as here restricted, is worthy of generic separation from the great group called *Pentagonaster* by Perrier and by Sladen, must remain, for the present, a matter of personal opinion, but if they should be reunited under a single generic name, *Goniaster* would be the name that ought to be chosen for the whole group, if we are to follow the generally accepted rules of binomial nomenclature. (See above, p. 146.)

The principal character by which the present group has been distinguished is the presence of one or more large, stout conical tubercles or spines on more or less of the dorsal marginal and abactinal plates, in adult specimens; or of verruciform swellings in the same situations, in the young. In most adults these conical spines form a central group on the disk and five large radial groups, but the number of plates that may bear spines is variable; sometimes they occur on nearly all the dorsal plates.

The marginal plates are large, thick, convex, not numerous, and usually naked, except for one or two marginal series of granules, but they are more or less granulous over the surface in the very young. They are more numerous in the ventral series. Those in the dorsal series may not decrease regularly distally; the last one is sometimes as large as, or even larger than, the one that precedes it. The apical plate is small, conical. The actinal plates are large, polygonal, and crowded, mostly in series parallel with the adambulacral plates, and covered with coarse granules; the granules on the center of the plates are often larger and may be like small tubercles. Sometimes part or all of these plates bear high, slender, spatulate pedicellariæ. The adambulacral plates and spinules and the dentary plates are essentially the same as in *Pentagonaster* or *Tosia*. The adambulacral spinules are numerous and closely crowded in three or more rows; the row next to the furrow-series is largest.

The abactinal plates are rather large, polygonal or roundish, covered with crowded, short, angular granules, with a larger marginal series; sometimes they also bear pedicellariæ. Between these there are often, in adults, many small ossicles, usually bearing groups of few granules. Papular pores are present between most of the abactinal plates, except in the small interradial areas.

In adult specimens some of the distal, lower, marginal plates bear small conical spines or tubercles, in some species.

Pedicellariæ have been observed only in *G. Americanus*, where they are sometimes numerous, both on the actinal and abactinal plates, and they occur also on the sides of the dorsal spines and marginal plates. They are small, high, slender, pincer-shaped, with spatulate blades and corresponding sockets on the plates. (See below.)

Perrier erroneously states (1894) that pedicellariæ are not found in this genus. They were described by me in 1871.

When very young (up to 12 or 14^{mm} in diameter) there is no appearance of dorsal spines or tubercles and the marginal plates are few in number and granulated. In this stage there appears to be no obvious distinction between this genus and *Pentagonaster* or *Tosia*.

Such specimens were mistaken by Perrier for a distinct species (*Pent. parvus*). They will be more fully described on a later page.

Goniaster Americanus Verrill.

Goniaster Americanus Verrill, Amer. Journ. Sci., vol. ii, p. 230, 1871.

Pentagonaster semilunatus (pars) Perrier, Arch. de Zool. exper., v, p. 24, 1876.

Phaneraster semilunatus (pars) Perrier, Sci. Exp. Trav. and Talis., p. 388, 1894.

Pentagonaster parvus Perrier, Mem. Etoiles de mer, Nouv. Archives du Mus. d'Hist. Nat., vi, p. 231, pl. vii, figs. 7, 8, 1884. (Young.)

PLATE XXIVa. FIGURES 1, 2.

PLATE XXVI. FIGURES 1-6.

This species was originally described by me so minutely that it is not necessary to repeat the general description of the adult. The type was from rather shallow water, off the coast of South Carolina.

This type specimen, which is in the museum of Yale University, has a large number of high, pincer-like pedicellariæ, with two slender spatulate or spoon-shaped blades, and a slightly enlarged articulating base; the blades are sometimes straight, but often more or less strongly curved to the right or left. The blades, when fully expanded, rest in socket-like depressions of the plates, which correspond in shape and curvature with the blades, so that the two belonging to a pedicellaria with curved blades, form, when taken

together, a crescent-shaped or semicircular pit, with a round central pore and a wider rounded depression at each end. Sometimes one or two granules exist close to the pedicellariæ, and when rubbed off the pits that they leave make the markings on the plates still more complex.

Pedicellariæ of this peculiar form are present on a large proportion of the actinal plates; on some of the marginal plates; on the borders of the spinose abactinal plates, around the bases of the spines, 1 to 6 on a plate; on the basal part of the spine itself; and on those abactinal plates that do not bear spines, 1 to 4 or more.

On the actinal plates they are variously placed, and irregularly oriented; most of the plates have but one, which is most commonly near the center, but many have two; those plates in the row next to the adambulacral plates usually have two or three. The pedicellariæ on the abactinal plates and on the spines are smaller than those of the lower surface, but have the same form and similar sockets. Each pedicellaria of the actinal and abactinal plates occupies a small, slightly elevated, smooth, rounded or ovate area, surrounded by granules. A pedicellaria and a stout blunt tubercle co-exist on some of the actinal plates, near the jaws.

Between all the abactinal plates, except those of the small interradial areas, where there are no papular pores, there are small intermediate ossicles, the larger of which bear small circular or angular rosettes of about 5 to 9 prismatic, flat-topped granules, like those around the margins of the large plates. One to three of the granules occupy the center of these groups. Between these small rosettes there are many small irregular groups of two or three similar angular granules, intervening between the numerous and rather large papular pores, of which there may be ten or twelve around the larger plates.

The madreporic plate is very large, somewhat swollen, with fine gyri. The apical plate is small and conical, similar in size and form to the tubercles of the distal marginal plates.

The two distal pairs of dorsal marginal plates are in contact medially. On each of the distal adambulacral plates there is a single large, obtuse conical spine, outside the furrow-series of slender spinules. These spines are longer and larger than the more numerous corresponding spines of the more proximal plates. There are usually, in large specimens like the type, four stout, prismatic, blunt, crowded spinules on each plate, in the furrow-series, as in *G. Lamarckii*, instead of three, present in *G. cuspidatus*.

A fine series of specimens, of various ages, was dredged by the "Albatross," off Florida and in the West Indies.

Some of the variations noted among these are as follows :

A.—Station 2363. One large example.

Lesser radius, 35^{mm} ; greater, 65^{mm}.

Most of the dorsal marginal plates, except distally, bear a high, acute, conical spine. On each ray the last dorsal marginal plate is elongated, subconical, with a small terminal spine. It looks as if it might have been about to divide into two or more plates ; or as if two or more had abnormally consolidated. The distal lower marginal plates bear rudimentary conical spines. There is also a group of 2 to 4 small obtuse tubercles on each jaw, around the mouth. The abactinal plates bear a central group of 9 or 10 large, high, acute, conical spines and four or five rows of about 6 or 7 on each radial area, with shorter rows of 2 to 4 on each side of these.

B.—Station 2373. One large example.

Nearly normal, but 4 to 6 of the interradial plates have very large, stout, transversely compressed spines, bilobed at the tip.

C.—Station 2318. One very large.

Similar to A, with 18 or 19 pairs of marginal plates, the distal ones regularly decreasing. Three or four of the distal, dorsal marginal spines bear acute conical spines.

No tubercles around the mouth on the jaws.

D.—Station 2316. Six examples.

These vary in size from 40 to 54^{mm}, in larger radius. They have from 13 to 16 pairs of marginal plates on each side. All have tapered, acute rays, with a small conical apical plate. They agree pretty closely as to the lower surface. The more spinose examples have a central abactinal group of 6 or 7 conical spines and there are 4 to 6 (usually 5) spines in each radial row ; nearly all the upper marginal plates have a single stout, conical spine. In others there are but 3 to 5 spines in each radial row ; in some 8 to 10 spines are irregularly scattered over the abactinal surface. In some cases more or less of the spines have been broken off, leaving a smooth scar in their places. In some examples the dorsal marginal plates bear high, acute, conical spines ; in others low, blunt, cones or tubercles with broad bases.

The lower marginal plates bear a variable number of spines, toward the end of the rays ; most frequently there is a small group

of spines on the 4 or 5 distal plates; in others only one; in some none at all. These variations may occur on different rays of the same example.

E.—Station 2406. Three examples.

The two larger are much like those described above. The smallest has the smaller radius 15^{mm}; the larger radius, 23^{mm}. It has 12 pairs of marginal plates on each side. The dorsal ones are thick, convex or rounded, and some are beginning to swell up in the middle to form tubercles or spines. The distal lower marginal plates show sub-conical elevations, where the spines are beginning to grow. Some of the abactinal plates show an elevation in the center, where the spines are beginning to develop.

F.—Station 2315. One example.

Similar in size to the one last described. Ten pairs of marginal plates on each side. They are of the usual shape and many of the dorsal ones show a central, low, conical elevation or rudiment of a developing spine. The abactinal plates are without evident tubercles.

G.—Station 2374. Four examples.

Similar to the last in size. Three have 10 pairs of marginal plates on each sides; the other has 12. Most of the dorsal marginal plates have conical or subspineform elevations. The abactinal radial plates have 3 or 4 conical spines in a row, nearly like those of adult examples. There is also a central group of spines on the disk, sometimes as many as five.

H.—Station 2370. One, very young. (Specimen figured, Pl. xxv, fig. 6.)

The larger radius is 5^{mm}. Six pairs of marginal plates on each side. Apical plate broadly triangular. No marginal nor abactinal tubercles. Abactinal and actinal plates surrounded by a single series of granules.

I.—Station 2370. No. 18,457, specimen figured. One young example.

Radii 12 and 17^{mm}. Dorsal marginal plates 10 pairs on each side, all short, broad, strongly convex. Ventral marginal plates 14 on a side. Small, slender pedicellariæ with long spatulate blades occur on many of the actinal and abactinal plates. No trace of spines on the abactinal plates, which are finely granulated over the central area, with larger marginal granules; a few very small intermediate ossicles occur between them, each with 1 to 3 small granules. Papular pores are few and small, but scattered over most of the radial areas. The adambulacral spinules are in four longitudinal series; those next

to the furrow-series are distinctly larger than the others, two to a plate on the proximal half of the series; those of the furrow-series are slender, equal, obtuse, regularly placed in a row, four to each plate. One or two of the distal lower marginal plates of each series bears a small conical tubercle, but the dorsal plates are smooth, naked, without tubercles, though considerably elevated centrally.

I have also examined four young specimens of this species from the "Blake" Exp., preserved in the Museum of Comparative Zoölogy.

Three of these (*a, c, d*) were types of *Pentagonaster parvus* Perrier. They agree perfectly with those of similar size collected by the steamer "Albatross" in the West Indies. (See H and I above.) With the latter they form a complete series, connecting the smallest with the full grown examples from the same region.

The smallest of the specimens (*b*) from the "Blake" Exp. is from station 253. It is enumerated under *P. parvus* by Perrier, but is not marked as a type, but it agrees with the others. Its lesser radius is 7^{mm}; greater radius, 10^{mm}. In this there are, for the most part, four upper marginal plates, above and below, on each side; but in one case there is a small triangular plate interpolated between the first interradial and the next normal one, while there is a normal plate next the apical one, so that there are four marginal plates on one side of this ray and the adjacent semi-margin. On another interradial margin there is a small, triangular, odd interradial marginal plate of the upper series; similar to that in *Odontaster*.

The lower marginal plates are usually six to a side, but on one margin there are seven. The distal plate of some of the series is small and only recently developed. The marginal plates of both series are covered with granules. The papular pores are few in number, in small radial groups.

The specimens next in size are 25 to 35^{mm} in diameter (types of *P. parvus*) and usually have six marginal plates on each side, above and below. In the smaller of these the upper and lower marginal plates and the actinal interradial plates are nearly or quite covered with small granules, but in the somewhat larger specimens more or less of the central area of these plates is naked. Most of them show a distinct central swelling where the conical tubercles would have appeared later. In some the abactinal plates are entirely covered with granules, but in others the central area is naked, the amount of naked surface increasing with age, but not regularly so. The papular pores increase in number with age and cover more and more of the median radial areas and the central area of the disk, but these areas have no sharp boundaries.

List of Specimens of Goniaster Americanus taken by the Albatross, in the West Indies.

Station 2315,	37 fathoms,	No. 10071,	1, young.
"	2316, 50	"	10076, 6, young.
"	2318, 45	"	10821, 1, very large.
"	2318, 45	"	10876, 2, half-grown.
"	2363, 21	"	10618, 1, large.
"	2370, 25	"	----- 7, young.
"	2372, 27	"	----- 3, young.
"	2373, 25	"	10337, 1, large; 11, young.
"	2374, 26	"	10820, 6, young and half-grown.
"	2374, 26	"	10340, 5, young.
"	2406, 26	"	10459, 3, half-grown.
"	2407, 24	"	----- 6, young and old.

Specimens examined from the Blake Expedition.

a.	Station 32,	95 fathoms.
b.	" 253,	92 "
c.	" 276,	94 "
d.	" 296,	84-129 "

Goniaster Africanus Verrill.

Goniaster Africanus Verrill, Amer. Journ. Sci., vol. ii, p. 131, 1871.

PLATE XXV. FIGURES 1, 2.

Perrier (Revis. 1876, p. 24) united this species and *G. Americanus* with *G. cuspidatus* of the East Indies. He showed very well, by his comparison of a large series of specimens, that the number and precise form of the dorsal spines and marginal plates are variable in specimens from each region and cannot be depended upon to separate the species.

It has long been known that the number of marginal plates in all starfishes increases with age, and that their shape also varies with age, also that the spines increase with age.

Perrier, however, did not make careful comparisons of the much more important characters to be derived from the size and character of the granules, tubercles, and spines of the plates; presence or absence and shape of pedicellariæ; form and character of the ambulacral spines; size and form of the small ossicles and granules between the abactinal plates.

In all these characters *G. Africanus* differs decidedly from *G. Americanus*, if the numerous specimens of the latter that I have

been able to examine are to be depended upon. I have not had a sufficient series of the East Indian *G. cuspidatus* for examination to warrant me in making so positive a statement as to its distinctness from *G. Africanus*, but the published descriptions indicate important differences.

In addition to the marked differences between *G. Africanus* and *G. Americanus* in the number and character of the dorsal spines and marginal plates, I wish to call attention to the following points. *G. Africanus* (type) has no pedicellariæ, above or below. The actinal plates mostly have a central cluster of three to six or more unequal rounded tubercles, much larger than the granules. No specimens of *G. Americanus* that I have seen have this character, though some of the largest ones may have one or two central tubercles, on a few of the plates near the mouth. The granules of the abactinal plates are much smaller than in the latter and are more rounded, with less differentiation of the marginal series. The small, intermediate abactinal plates seldom bear distinct rosettes of granules, but usually appear as small, round or oval, smooth-topped ossicles, on a level with the other plates.

In having the distal pair of dorsal marginal plates larger and more swollen than those that precede it, and largely in contact medially, this species agrees with *Pentagonaster pulchellus* and allied species. I have seen no specimens of *G. Americanus* having this character, nor is it said to occur in *G. cuspidatus*.

It is my intention to fully illustrate these species in another article, now in course of preparation.

G. Africanus is native of the West Coast of Africa.

G. Lamarckii (*Astrogonium Lamarckii* Müll. and Trosch., p. 56, 1842; *Pentagonaster Lamarckii* Per. (Revis., p. 29, 1876) is from an unknown locality. It has rounded dorsal marginal plates and seems quite distinct from the other species.

Pentagonaster Gray, 1840, 1866. Type *P. pulchellus* Gray.

Stephanaster Ayres, Proc. Boston Soc. Nat. Hist., iv, p. 118, 1851. Type *S. elegans* Ayres=*pulchellus* Gray.

Pentagonaster (Sect. A, *a, pars*) Perrier, Revision, Arch. Zool., V., p. 12, 1876.

Astrogonium Sladen, Voy. Chall., xxx, pp. 263, 285, 1889.

Stephanaster Perrier, Exp. Trav. and Talisman, p. 402, 1894.

The name *Pentagonaster* was first introduced into binomial nomenclature by Gray in 1840. By him it was definitely defined, and a well-known species was given as the type (see p. 147, above). Therefore, the name should be used for the group thus limited by him.

The following species apparently belong to the genus as restricted by Gray (1840):

- P. pulchellus* Gray. New Zealand to China.
- P. abnormale* Gray. Unknown locality.
- P. Bourgeti* Perrier. Cape Verde Islands.
- P. Gunnii* Perrier. Tasmania and Australia.
- P. Dubeni* Gray. South and West Australia.

Tosia Gray, 1840. Type *T. australis* Gray.

Astrogonium (pars) Müll. and Troschel, Syst., Ast., 1842.

Tosia Gray, Synopsis, p. 11, plates iii and xvi, 1866.

Pentagonaster (Sec. A, b, *pars*) Perrier, Revision, p. 20, 1876.

Pentagonaster (pars) Sladen, Voy. Chall., xxx, p. 264, 1889. Perrier, Exp. Trav. et Talism., pp. 389, 390, 1894.

Under the ordinary rules of priority, in zoological nomenclature, there is no valid reason why *Tosia* should not be adopted for a large part of the species included by Perrier and by Sladen in the genus *Pentagonaster*, providing we are to consider this group generically distinct from *Pentagonaster* Gray. This question of the generic distinction must still be regarded as doubtful by many students of the group, though Perrier, in his later works, has definitely separated them, as shown above.

The only obvious difference, hitherto pointed out, that may be considered as of generic value, is the gradual decrease in size of the marginal plates distally, so that the rays are sub-acute, instead of the distal ones being larger and swollen, as in the true *Pentagonaster*.

But there are species of the latter in which the distal plates are only slightly larger than the others, while the amount of decrease in the plates of the species of this group is variable. Moreover in the restricted genus *Goniaster*, one species (*G. Africanus*, type) has the distal dorsal plates more swollen and larger than those that precede it.

Nevertheless, since the marked enlargement of the distal plates indicates a different law of growth in species so characterized, it seems desirable to keep the two groups separate, at least until truly intermediate forms become known.

In the typical species of *Tosia*, the marginal, abactinal, and usually some of the actinal plates have a naked central area, with one or more rows of granules around the margin. But the extent of the granulation varies more or less individually, and also according to the age of the specimen. Therefore we cannot regard this as a matter of much importance, generically.

The typical species appears to be destitute of pedicellariæ, but small, high, pincer-like pedicellariæ, with spatulate blades or chisel-shaped blades, occur in many of the allied species more recently described (e. g. *Perrieri*, *Vincenti*, *hesitans*).

In many of the species of this group all the dorsal marginal plates, except the last or two last pairs, are separated by one or more rows of abactinal plates. But in several deep-sea species (*Perrieri*, etc.) three to five distal pairs of marginal plates are in contact medially. In some species different individuals have been found to vary, in this respect, from those having only one pair joined, to those with three or four pairs joined.

Considerable variations also occur among the species, in respect to the character and arrangement of the adambulacral spinules, in the number and arrangement of the papular pores, and in the form of the abactinal plates.

Most of these characters are not sufficiently constant nor important for generic divisions, but may well afford grounds for dividing the group into convenient sections. (See p. 160.)

Sladen, in his great work on starfishes, included in his genus *Pentagonaster* not only those that are here separated as typical *Goniaster*, but also others that apparently belong to *Mediaster* and *Hoplaster*, besides some that belong perhaps to undescribed genera.

To *Mediaster* I refer three of his new species: viz. *P. Japonicus*, *P. Patagonicus*, and *P. arcuatus*. But as the existence of internal connecting ossicles between the abactinal plates has not been ascertained for either of these species, this reference is based on the general appearance and on the character of the plates, spinules, and pedicellariæ.

His *P. lepidus* appears to be a true *Hoplaster*. It has odd inter-radial marginal plates and all the plates are spinulose. *P. gibbosus* Perrier also appears to be generically distinct, as well as *P. intermedius* and *P. dentatus*. If these forms be eliminated, the genus becomes more homogeneous and better capable of definition, though it still remains an extensive group.

Perrier, in his later works, has generically separated numerous species that he formerly referred to *Pentagonaster*, such as *Rosaster*, *Odontaster*, and the forms that he refers to *Dorigona*. But some of the other species that he has described as belonging to this genus, especially *P. intermedius* and *P. dentatus*, also appear to be worthy of generic distinction.

In this article, I have constituted several new genera to include some of these peculiar forms, hitherto referred to *Pentagonaster*, together with some new species.

Tosia Gray, emended.

The genus *Tosia*, as here limited, will include not only the typical group of species named by Gray, in which more or less of the marginal and abactinal plates are naked in the middle, but also those that are granulated over the whole surface, as in *granularis* and its allies, the extent of the granulation having been found to be variable in many species. In each section there are species with pedicellariæ and others in which they appear to be lacking.

The marginal plates are regular and generally correspond pretty closely in the upper and lower series, except distally; an odd interradial plate sometimes occurs abnormally. Apical plate small.

The abactinal plates of the radial areas are polygonal, most often hexagonal, or roundish, crowded pretty closely together, without distinct, intervening, connecting ossicles and without secondary plates of small size.

The papular pores are usually rather numerous, generally placed singly in the angles between the plates of the basal radial areas, and sometimes on the central part of the disk, but not on the triangular interradial areas, where the plates are angular and closely in contact. The pedicellariæ when present are small, elevated, usually with two spatulate blades, higher than broad, and often set in special pits of corresponding shape. They may occur on any or all the kinds of plates, either above or below, or on both sides.

The adambulacral spinules are numerous and crowded, and grade into the actinal granulation; the furrow-series form a simple row, usually not much longer than those of the next series and not separated from them by a wide space. Distally some of the spines of the second series usually become much longer than the rest.

In the following table we give an arrangement of most of the figured species of *Tosia*, in sections and sub-sections.

Section A.—Typical. Distribution Indo-Pacific and Australian.

More or less of the marginal and abactinal plates are naked in the center, margined by one or two rows of granules. Adambulacral plates narrow, each with few spinules, usually only two or three in the furrow-series.

Pedicellariæ absent or not recorded in most species. Only one or two of the distal, dorsal, marginal plates are usually in contact medially.

b.—The actinal as well as abactinal and marginal plates are usually naked centrally.

T. australis Gray, Synop., p. 11, pl. 16, fig. 1. West Australia.

T. rubra Gray, Synop., p. 11, pl. 16, fig. 3. Australia.

T. tubercularis Gray, Synop., p. 11, pl. 16, fig. 4. Australia.

T. magnifica (M. & Tr.), Ast., p. 53, pl. iv, figs. 1, *a*, *b*, 1842. Tasmania.

T. astrologorum M. & Tr., Ast., p. 54, Australia. A variety has pedicellariæ (*t.* Perrier).

bb.—The actinal plates are usually entirely covered with granules.

T. aurata Gray, Synop., p. 11, pl. 16, fig. 2 (= *Astrogonium australis* M. & Tr., non Gray, *t.* Perrier). Australia.

Pedicellariæ size of granules on abactinal plates.

T. grandis Gray, Synop., p. 11, pl. 3, fig. 1. West Australia.

T. tuberculata (Gray). Port Natal.

Section B. *Plinthaster*.—Pedicellariæ with narrow blades are present, of small size, about equal to the granules, or but little larger. Adambulacral plates are wider, about as large as the actinal plates, and bear many crowded spinules; usually four to six in the furrow series. Marginal and abactinal plates usually naked in the middle and often areolated. Three to five of the dorsal marginal plates are usually in contact medially. Atlantic.

T. Perrieri (Sladen) = *P. Perrieri* Perrier, 1894, p. 391, pl. 25, figs. 1*a*, 1*b*.

Off Morocco, 930 to 1590 meters.

Pedicellariæ occur on the abactinal and on both series of marginal plates. They are set in special bilobed pits. Upper marginal and abactinal plates are granulated only around the edges.

T. compta Ver. West Indies, 683 fathoms.

T. nitida Ver. West Indies, 335 fathoms.

Section C. *Ceramaster*.—All the plates, above and below, are usually granulated nearly or quite all over, unless rubbed; in some species the marginal plates may often have a small, naked, central area. Adambulacral plates with four to six furrow spines. Atlantic.

c.—Pedicellariæ absent or not recorded. Only one or two dorsal marginal plates are usually in contact medially.

T. granularis (Retz.). Arctic Ocean and both coasts of the North Atlantic, 20 to 750 fathoms.

The variety *Deplasi* Per. (1894, p. 401) has some of the marginal plates naked in the middle; the same occurs in some of our examples.

T. simplex Ver., 1895, p. 135. Off Martha's Vineyard, 640 fathoms. The type of this species has a small naked spot in the middle of the marginal plates, above and below.

T. eximia Ver., 1894, p. 264. Off Nova Scotia, 80–122 fathoms.

T. Greenei (Bell, 1889); 1892, p. 74, fig. Off Ireland, 1000 fathoms.

T. placenta (M. & Tr.). Mediterranean, 40–50 fathoms.

T. mirabilis (Per.). Mediterranean.

T. mammillata (M. & Tr.). Locality unknown. Pedicellariæ absent on type (t. Perrier).

cc.—Pedicellariæ are present; their blades are higher than broad, usually spatulate or spoon-shaped. Only two to three pairs of dorsal marginal plates are in contact medially.

T. Vincenti (Per.), 1894, p. 396, pl. 26, fig. 2. East Atlantic, 946 to 1105 meters.

In this species there is a regular row of spatulate pedicellariæ on the row of plates next the adambulacral series.

T. hesitans (Per.), 1894, p. 397, pl. 23, fig. 7, pl. 25, fig. 2. East Atlantic, 2210 meters.

Pedicellariæ small, numerous; they occur on the actinal, adambulacral, abactinal, and on both series of marginal plates. In the type some of the marginal plates are naked in the middle, perhaps accidentally rubbed. Three of the dorsal marginal plates are in contact medially.

T. Grenadensis (Per.), 1881, 1884, p. 232, pl. viii, fig. 2. West Indies, 176 fathoms. Pedicellariæ few, small, abactinal.

T. Gosselini (Per.), 1894, p. 399, pl. 26, fig. 4.

East Atlantic, 946 to 1440 meters.

Small spatulate pedicellariæ, with special pits, occur on the abactinal and both series of marginal plates.

T. pulvinus (Alcock, 1893), India, 1200 fathoms.

Tosia granularis (Retzius).

Asterias granularis Retzius, K. Vet. Akad. Nya. Handl., vol. iv, p. 238, 1788. Abilg., in Zool. Dan., fas. 3, p. 19, pl. xcii, 1788. Bruzelius, Diss. Sys. Ast., p. 10, 1805.

Astrogonium granulare Müller and Trosch., Syst. Asteriden, p. 57, 1842. Gray, Synop., p. 10, pl. 1, fig. 4, 1866. Verrill, Expl. by the Albatross in 1883, p. 542, pl. 18, figs. 48, 48a, 1885.

Goniaster granularis Lütken, Vidensk. Medd. nat. Foren., p. 146, 1865.

Pentagonaster granularis Perrier, Revis. Stell. du Mus., p. 224, 1876. Sladen, Voy. Challenger, vol. xxx, p. 268, 1889. Bell, Catal. British Echinod. in British Museum, p. 73, pl. x, figs. 4, 5, 6, 1892. Verrill, Distrib. of Echinod., Amer. Journ. Sci., vol. xlix, p. 135, 1895. Danielssen and Koren, Asteroidea, Norske Nordhavs-Expd. Zool., xi, p. 58, 1884.

Pentagonaster balteatus Sladen, Proc. Royal Irish Acad., i, p. 688, pl. xxv, 1891 (t. Bell).

Pentagonaster concinnus Sladen, op. cit., i, p. 690, pl. xxvi, 1891 (t. Bell).

A large specimen, from off Halifax, N. S., has the following characters:

The inner adambulacral spinules form a simple marginal row, with three or four spines on each plate, of which the proximal is smaller

and sets farther back, so as to be partly overlapped by the distal one of the preceding plate; the others are rather short, stout, blunt, scarcely tapered, about as long as the breadth of the adambulacral plates. Outside the furrow-series, each plate bears an actinal group of about seven to eleven short, stout, polygonal spinules or granules, one of which occupies the center, and the others surround it; those on the side next the furrow-series are much larger and somewhat longer than the rest. Oral spinules numerous, short, stout, polygonal, seven or eight on the border of the dentary plate, and a median or sutural group consisting of a row of six or eight on each plate, with two shorter intermediate or central rows of three or four smaller ones.

The actinal interradial plates are crowded, polygonal and closely covered with small polygonal granule-like spinules with rounded tips, about thirty on the larger plates, their size decreasing toward the marginal plates, where they are very small.

The marginal plates, above and below, are closely covered with similar but smaller granules. The plates of the upper surface are hexagonal on the radial areas of the bases of the rays, and are mostly transversely elongated, and surrounded by six papular pores, corresponding to the angles. In the interradial areas they are transversely rhombic, often with the acute angles truncated, where pores intervene. All are closely covered with small angular granules.

Madreporic plate small, with conspicuously convoluted, deep grooves and high ridges. It is nearer to the center than to the margin.

Taken on the American Coast, by the "Albatross," at several stations between N. lat. $44^{\circ} 28' 30''$ and $41^{\circ} 47'$. Also taken by the Gloucester fisherman on the Banks off Nova Scotia. Occurs off the coasts of Norway and Great Britain.

Bathymetrical range, 50 to 471 fath. on the American coast. Rarely taken below 150 fathoms.

Tosia (Plinthaster) compta Ver., sp. nov.

PLATE XXVII. FIGURE 2.

Pentagonal with regularly incurved margins and short, tapering subacnte rays. Radii as 13 : 8.

Marginal spines large, mostly nearly square, slightly convex, the upper and lower ones nearly corresponding along the margins of the disk, but alternating on the distal part of the rays. There are usually, in the type, 16 upper and 18 lower plates on each side of

the body, but on one margin there are two ventral plates corresponding to one of the upper dorsals nearest the median line, so that there appears to be an odd, lower, interradial plate on this side.

The dorsal marginal plates are smooth, microscopically strigillate, and naked except for a single row of small, round marginal granules and a central irregular cluster of large, well spaced, round granules, each implanted in a pit and easily detached. They are lacking on the small distal plates. Three or four of the distal plates are in contact medially. The apical plate is of moderate size, wedge-shaped proximally and prominent at the tip.

The ventral marginal plates have most of the surface covered with implanted round granules, like those of the upper ones, and distinctly larger than those of the marginal row.

The abactinal plates are flat, even, closely crowded, regularly arranged, and mostly of about the same size, though the median radial rows are easily distinguished. They are mostly rounded or hexagonal with rounded angles. They are covered with small hemispherical bosses, but are not granulated, having only a single row of minute grains around the edges. A group of these grains, of somewhat larger size, surrounds each papular pore. The latter are few and small, but easily visible; they are confined to the basal radial areas. The madreporite is small, convex, prominent, with fine gyri.

The proximal adambulacral plates bear each a straight, regular row of five or six short, blunt, prismatic spinules in the furrow-series. The actinal side bears a second row of about four stouter conical spinules, of about the same diameter, but larger than the actinal granules; the outer margin bears four to six granules, like those of the actinal plates. Distally the plates have an angular inner edge, with fewer and more slender spinules in an oblique row, while one or two of those in the actinal row become much longer and larger.

The actinal plates are large, mostly rhombic, well defined, and covered with rather coarse, somewhat conical granules, which are not closely crowded.

Pedicellariæ, about like the granules in size, with narrow oblong blades, occur very sparingly on the adambulacral and some of the actinal plates. The dentary plates are large, covered with spaced, conical granules, similar to those of the actinal plates, but larger; those near the apex become stouter and prismatic, like the apical teeth; there are 7 or 8 in the furrow-series, similar to the adambulacral spinules.

Greater radius, 44^{mm}; lesser, 27^{mm}.

Taken by the U. S. Fish Com. steamer Albatross in the West Indies, at station 2117, in 683 fathoms, and by the Blake, station xi, in 555 fathoms, 1880.

This species is very similar to *T. Perrieri* of the East Atlantic. Without a direct comparison of specimens it is impossible to say whether our form may not be merely a variety of the latter. However, the American form differs from the photographic figures of *T. Perrieri* in having larger marginal plates and in the details of the actinal surface. Moreover its pedicellariæ are much fewer and apparently are different in form.

Tosia (Plinthaster) nitida Ver., sp. nov.

PLATE XXVII. FIGURES 1, 1a, 1b.

Pentagonal with regular incurved sides; 18 or 19 upper marginal plates on each side; 20 lower ones; 4 or 5 upper marginal plates are in contact medially.

Closely allied to the preceding species in form and most of the details of structure. It differs chiefly in the finer granulation and in having the abactinal plates more closely crowded and even, with less evident sutures between them and with the areolation of their surface much finer; the granules around their margins are also much smaller and lacking in many places, but a group of rather larger ones surrounds each of the very small, unequal papular pores, so that these appear quite distinctly over a limited basal radial area. They are lacking on the central part of the disk and on the large interradial areas.

The dorsal marginal plates are partially naked and smooth, but have a central group of well spaced, rounded, implanted granules, as in *T. compta*, but the granules are much smaller; the lower third of these plates is closely covered with small round granules, like those of the ventral plates. The adambulacral plates, on the proximal part of the groove, usually have five or six slender, compressed furrow spines, in a straight row; the actinal surface of each plate bears two rows of small, blunt, granule-like spinules, much like the granules of the actinal plates.

Pedicellariæ of small size, similar to the granules in appearance, occur sparingly on some of the distal adambulacral plates.

Greater radius, 27^{mm}; lesser, 15^{mm}.

Taken by the Albatross, in the West Indies, at station 2396, in 335 fathoms.

This species is so similar to the last, in most of its characters, that it might prove to be only a variety, if we had a large series for study. But although the type is not much more than half as large as that of *T. compta*, it has rather more marginal plates and more numerous adambulacral spinules and actinal granules. The reverse would usually occur in the young of this genus. Hence I am disposed to consider it a very closely related, but distinct, species.

Pyrenaster Ver., gen. nov. Type, *P. dentatus* Perrier.

Form flat, more or less pentagonal, or stellate with a broad disk. Rays tapered. Marginal plates rather large, those of the two series similar and generally paired; sometimes there is on one or more of the margins (rarely on all) an odd interradiial plate,—but this seems to be more or less abnormal.

In the type the upper marginal plates are partially naked, and the abactinal plates usually have a small naked central area, surrounded by marginal granules, but this is not constant. The upper marginal plates in the type species are sometimes all separated by a row of abactinal plates; in other specimens of the same species two to five pairs are in contact medially. Actinal and inferior marginal plates granulated.

Pedicellariæ occur sparingly on the adambulacral plates; they are similar to the granules in size and height and have short chisel-shaped blades.

The dentary plates are large, triangular, with numerous prominent granules on the actinal surface, and with somewhat enlarged prismatic spinules on the oral margin.

Adambulacral plates large, squarish, with 4 to 7 furrow spinules in a regular marginal series; these are decidedly more elongated than the granules of the actinal surface and are separated from them by a naked space, as in *Mediaster*. Distally these plates become small, with the furrow end prominent and bearing a convex group of spinules, while one or two of the spinules of the second row, on the actinal side, become much longer and larger than the rest, as in *Tosia* and most of the allied genera.

The actinal plates are flat, rather large, polygonal, crowded and arranged in series parallel with the furrows.

The abactinal plates of the radial areas are rounded, convex and of two kinds, smaller, secondary, rounded plates being interpolated between and around the larger or primary plates. The smaller plates are, however, of the same form as the others, and are granu-

lated in the same way, but their presence gives an appearance of irregularity to the arrangement of the plates.

Papular pores are of moderate size and not very numerous; they are confined to the median radial areas. In young specimens these areas are small and well defined and the pores few. Each pore seems to be surrounded by a special group of granules.

This genus is distinguished from *Tosia* and *Pentagonaster* especially by the existence of smaller secondary, rounded plates between the primary abactinal plates, and also by the greater specialization of the furrow-series of adambulacral spines, for these do not grade into the actinal granulation, as they do in the genera referred to. In this respect this genus is more nearly like *Mediaster*, but the latter does not have the secondary abactinal plates, but has concealed, radiating connecting ossicles between the distinctly separated abactinal plates. *Peltaster* also has secondary abactinal ossicles, but they are different in character, and it also differs in having broad valvular pedicellariæ and graded adambulacral spinules.

Pyrenaster dentatus (Perrier) Ver.

Pentagonaster dentatus Perrier, Nouv. Arch. du Mus., vi, p. 242, pl. viii, fig. 3, 1884. Sladen, op. cit., pp. 265, 744, 1887.

PLATE XXVII. FIGURES 3, 3a, 3b.

I have had an opportunity to examine Perrier's types of this species, in the Mus. of Comp. Zoölogy, and to compare them with those dredged by the "Albatross."

Among the latter there are both large and small specimens. They show remarkable variations in several respects.

Two large examples of the same size, Nos. 10,370 and 18,433, are of special interest. In the former, four or five distal pairs of dorsal marginal plates are in contact medially. In No. 18,433, which is closely similar in other respects, all the plates, or all but the last pair, are separated by abactinal plates. In this specimen, on one margin, two upper plates correspond to one lower, so that there is an odd median plate above. In some of the young specimens one or more odd, interradiial marginal plates may occur both above and below.

This species was taken by the Blake Exp., in 41 to 1500 fathoms. By the Albatross it was dredged in several localities, in the West Indies and off the Carolina coasts, in 478 to 1639 fathoms.

Pyrenaster affinis (Perrier) Ver.

Pentagonaster affinis Perrier, *Nouv. Arch. du Mus.*, p. 243, pl. viii, fig. 4. 1881. Sladen, *op. cit.*, pp. 265, 744, 1889.

This is, perhaps, only a variety of the last. The coarser granulation and the differentiation of the granules around the margins of the abactinal plates, in the papular areas, are the special characters cited by Perrier. I have not seen the type.

Some of the younger examples, which I refer to this species on account of the last peculiarity, are not in other respects distinguishable from *dentatus*.

It was dredged by the "Blake" in 1131 and 1323 fathoms, in the West Indies, and by the Albatross.

Peltaster Ver., gen. nov. Type, *P. hebes* Verrill.

Form nearly pentagonal, with very short, obtuse rays. Marginal plates rather large, regular, decreasing in size distally, covered like all the other plates, above and below, with fine nearly uniform granules. Apical plate small.

Abactinal plates numerous, not large, closely crowded, of two kinds. The primary plates are mostly hexagonal. Between, and often surrounding them, are smaller roundish or irregular plates granulated like the larger ones, but with fewer granules. Papular pores small, numerous, arranged singly around the primary plates and occupying large radial areas.

Pedicellariæ, in the type, large, bivalve, sessile, with broad, lamelliform jaws, as wide as half the diameter of a plate. They occur mostly on the actinal plates next the adambulacral series. In *P. planus* none have been observed, but only one specimen is known. Adambulacral plates large, with several series of spinules, which are short, crowded, prismatic and grade into the granulation of adjacent plates. The furrow-series form regular rows of four to six on each plate; they are smaller and not longer than those of the next series, and there is no naked space between the series.

Distally one or two of those in the second series gradually change to much longer and larger blunt or conical spines. Dentary plates not prominent, covered with numerous blunt prismatic spinules, like those of the adambulacral plates, but rather coarser.

Actinal plates numerous, squarish or rhombic, closely crowded, the outlines obscured by their close, uniform granulation. They run in series parallel with the adambulacral furrows.

This genus is separated from *Tosia* on account of the small, irregular, secondary plates or ossicles between the primary abactinal plates, and the large, broad bivalve pedicellariæ of the type.

The characters of the marginal plates, actinal plates, and of the adambulacral spinules are like those of *Tosia*, of the *granularis* group (section C).

The second species (*planus*), although, so far as known, without pedicellariæ, is placed in this genus because it agrees with the type in the characters of the skeleton.

Peltaster hebes Ver., sp. nov.

PLATE XXVIII. FIGURE 4.

Form broadly pentagonal, with very short rays and a rather thick, flat disk and large, slightly convex marginal plates, decidedly higher than long. Radii as 7:8. All the plates are closely and uniformly granulated, above and below, and many actinal plate shave, in the type, central, large, bivalve pedicellariæ with broad blades.

Upper marginal plates about 20 on each side of the body; lower ones about 24 in the type. Along the sides of the disk the upper and lower ones are pretty closely paired and nearly of the same size and shape, though the vertical sutures are not strictly coincident, except between the middle plates, owing to the slightly wider lower plates. In each series the plates are nearly twice as high as long, and this form holds good except for the last two upper and last four or five lower plates, which decrease in size and change form very rapidly, the last ones being very small. The apical plate is very small, obconic, not prominent.

The abactinal plates are closely crowded, and so closely granulated that the outlines are concealed, unless denuded. The primary plates are rounded or polygonal, with many rounded angles, and are surrounded, in the radial areas, by many smaller secondary plates, having the same form and granulation, but variable in size, and mostly less than half the diameter of the larger plates. All are closely covered with small round granules, the marginal series scarcely different from the rest. The larger plates may have 40 to 50 granules, of which 18 to 24 may form the marginal row.

The papular pores are very small and numerous, placed singly, and occupy wide radial areas.

The adambulacral plates bear a closely crowded group of graded spines on the actinal side; the furrow-series consists of five or six short, thick, blunt, prismatic or compressed spinules, in a nearly

straight row; next, and close to these, there is a row of three or four larger, angular blunt spinules of the same height; these are followed by another row of three or four similar but small spines, in a slightly curved row; then there is a group of five or six, sometimes forming rows, on the outer part of this plate, of the same form and size as the actinal granules.

The actinal plates are numerous and even, closely crowded, mostly rhombic or squarish, covered with granules that become angular where most crowded.

Large valvular pedicellariæ occupy the center of many of the plates in the series next the adambulacral; they are about as broad as half the diameter of the plate, or more.

The dentary plates are not prominent, but are covered with numerous prismatic granules and spinules, larger than those of the adambulacral plates.

The madreporic plate is large, round, with numerous fine gyri. The dorsal nephridial pore is surrounded with granules larger than those of the surrounding plates.

Greater radius, 56^{mm}; lesser, 50^{mm}.

Taken by the Albatross, in the West Indies, at station 2668, in 294 fathoms, gray sand.

***Peltaster planus* Verrill.**

Pentagonaster planus Verrill, Distr. Echinod., Amer. Journ. Sci., xlix, p. 135, 1885.

PLATE XXVIII. FIGURES 3, 3a.

Form pentagonal, with the sides only slightly incurved; rays very short, triangular, and obtuse, with the tip turned up and terminated by a small, conical plate.

Marginal plates large, median ones nearly square, higher than long, the upper and lower nearly corresponding, fourteen in the dorsal series and sixteen in the ventral series, all uniformly covered with rather coarse, rounded granules, standing a little apart; the margins of the plates with a regular row of granules of about the same size. The three distal dorsal plates are in contact medially. Apical plate small, obovate.

Abactinal plates nearly flat, the primary ones rather large, rounded or hexagonal with rounded angles, with many small, rounded, unequal secondary ones interspersed; all are uniformly covered with rather coarse, spaced granules, like those of the marginal plates, so that the whole of the upper surface has a remarkably uniform granular coat-

ing. The larger plates often bear fifty to seventy granules; the small intermediate plates frequently carry but nine to twelve, one or two being central. Actinal plates large, rhombic, uniformly covered with coarse, angular granules, distinctly larger than those of the marginal plates.

Adambulacral plates numerous and crowded, similar to the actinal plates, but slightly larger and longer; toward the ends of the rays the plates are smaller and one or two of the first actinal row of spinules become much larger and longer, round and blunt. Each plate usually bears three or four marginal spines in a simple row; outside of these there are usually nine to twelve thicker, obtuse, angular spines, forming four irregular longitudinal rows, the outer ones smallest and like the actinal granules.

Dentary plates not prominent, covered with numerous blunt, angular spinules, similar to the actinal spinules, but larger.

The papular pores are numerous, placed singly, and occupy large radial areas, extending nearly to the center of the disk.

No pedicellariæ could be found.

Greater radius of the type, 50^{mm}; lesser radius, 35^{mm}; thickness at margin, 8^{mm}.

N. lat. 39° 53', off Martha's Vineyard, in 156 fathoms, one specimen (No. 13,362).

Litonotaster Ver., gen. nov. Type, *P. intermedius* Per.

Stellate, with a rather broad, flat, flexible disk and tapered rays, becoming slender distally. The dorsal integument is so thin that it is wrinkled in the dried specimens. Marginal plates unusually small for this family. The dorsal ones encroach but little on the upper surface of the disk; distally they become irregular near the tip of the rays, in the type; two to four pairs are in contact medially (a single oblong plate, equal to two or three of the usual distal plates, may replace the latter on some of the rays).

Abactinal plates polygonal, flat, thin, closely united, finely granulated, with two or more rows of granules around the edges, but with a small, central, round, naked area, in the type.

Papular pores rudimentary, few, small, obscure, not visible except when the plates are denuded; they occur only between the three central rows of plates, in a very circumscribed basal radial area.

Actinal plates granulated, rather large, angular, of various forms, not forming regular rows.

Adambulacral plates are large, as wide as the adjacent actinal plates or wider. Each one bears seven or eight small, compressed furrow spines, in a regular row; the spinules of the actinal side are very small, on the proximal plates, and form an irregular group on the outer half or else stand more or less in three or four rows; most of them are scarcely larger than granules; distally one or two of the second row become much larger conical spines.

A small elongated pedicellaria, with two, three, or four spatulate blades, occurs on the center of many of the adambulacral plates and on some of the actinal plates.

The dentary plates are large, separated by an open suture; each one bears an actinal triangular group of numerous small granules and a furrow-series of about ten or twelve small, prismatic, blunt spinules, those toward the apex becoming larger.

This genus is separated from its allies mainly on account of the few and minute papular pores and the very limited area on which they occur; the thin and small marginal plates; flexible dorsal surface of the disk; and large number of adambulacral spines.

The type is the only species determined. Mr. Alcock has recorded this species from the East Indies. Possibly this may indicate a second species of the genus.

Litonotaster intermedius (Perrier).

Pentagonaster intermedius Perrier, *Etoiles de Mer.*, p. 243, pl. v, figs. 5, 6, 1884. Sladen, *Voy. Chall.*, xxx, p. 746, 1889.

PLATE XXVIII. FIGURES 5, 5a, 5b.

This species was taken by the Blake Expedition in the West Indies, in 1930 fathoms.

It was also taken by the Albatross at station 2379, in 1467 fathoms, yellow ooze (two examples, No. 18,424).

I have compared the type described by Perrier, from the Blake Expedition, now in the Museum of Comp. Zoöl., with those taken by the Albatross. They agree closely. The larger Albatross specimen has the radii 33^{mm} and 14^{mm}.

Eugoniaster, gen. nov. Type, *E. investigatoris* (Alcock).

Form broadly pentagonal, with short rays. Abactinal plates uniformly small and rounded, naked, except for a marginal series of granules; some of them bear broad, bivalve pedicellariæ. Papular pores numerous, placed singly, radial. Marginal plates mostly naked with a border of granules and also some in a central group.

Bivalve pedicellariæ, with wide blades, occur on some of them, as well as on the adambulacral and actinal plates.

Adambulacral plates are covered with actinal granules in longitudinal rows; there are six or more prismatic spinules in a regular furrow-series. Actinal plates are granulated and extend to near end of rays.

This genus is related to *Peltaster*, but differs in having the abactinal plates all small and similar, and also naked centrally, and in having the marginal plates mostly naked, except around the margin. The large bivalve pedicellariæ are similar in the two genera. The character of the pedicellariæ differentiates the genus from *Tosia* and its closer allies.

Eugoniaster investigatoris (Alcock).

Pentagonaster investigatoris Alcock, Ann. and Mag. Nat. Hist., xi, p. 88, 1893.

This large species has, on the abactinal surface, "uniformly small round tabular plates, which are distinctly isolated from one another and are fringed with a single row of flat squamous, membrane-clad granules flush with the general surface, but are otherwise naked, except that some of the plates (perhaps one-fourth) bear a very excentric or quite marginal, broadly bilobed pedicellaria."

The marginal plates are also bordered with squamous granules and bear bilobed pedicellariæ; some also have a central group of granules.

Bivalve pedicellariæ also occur on the adambulacral plates and broad ones on the actinal plates near the jaws.

Adambulacral plates bear crowded, graded actinal granules in two or three longitudinal rows, and a furrow-series of six or seven prism-shaped spinules.

Antheniaster, gen. nov. Type, *A. sarissa* (Alcock, sp.).

This genus resembles *Anthenoides* Per. in having a thin, finely granulous membrane over the abactinal surface of the plates, but it differs so much in other respects that it cannot properly be referred to the same genus. The pedicellariæ are papilliform or spoon-shaped; not large and bivalvular as in the latter.

It has two kinds of abactinal plates, which is not the case in *Anthenoides*. The larger plates are "stellate or somewhat polygonal," arranged in radial rows; the small secondary plates are "inlaid everywhere between the large plates." Papular pores exist on large radial areas. Marginal plates are large and partly granulated; the dorsal distal plates are in contact medially and mostly naked.

Pedicellariæ of a simple papilliform structure occur on some of the upper plates. The lower marginal plates have two or three spines in a horizontal row; one distally.

The adambulacral plates have a divergent or palmate-series of furrow spines and a larger spine on the outer actinal end; many have also a central pedicellaria with spoon-shaped blades.

The actinal plates are numerous, in chevrons, and extend to about the 13th or 14th adambulacral plates; they are covered with a granulose membrane, and some bear papilliform pedicellariæ. The dentary plates are very prominent and bear large granules actinally, but the oral spines are large. The ambulacral feet have a terminal sucker.

***Antheniaster sarissa* (Alcock).**

Atthenoides sarissa Alcock, Ann. Mag. Nat. Hist., xi, p. 99, 1893.

Andaman Sea, 139 to 250 fathoms.

Subfamily **HIPPASTERIINÆ**, nov.

This group is established for those Goniasteridæ that have large elongated, divergent, and differentiated adambulacral spines, one or two larger ones situated on the central part of the plate. The dorsal and marginal plates are bordered or covered with large granules and often have one or more central tubercles or stout spines. Bivalve pedicellariæ, often of large size, are usually present. The abactinal plates are thick, closely joined, and polygonal or roundish.

***Hippasteria Caribæa* Ver., sp. nov.**

PLATE XXVIII. FIGURES 1, 1a.

Form stellate with a rather broad disk and tapered acute rays; disk convex. Radii about as 2:1.

Marginal plates regularly paired, those of the interradial margin nearly square; all are bordered with coarse rounded granules, and some granules are scattered on the central parts; in some cases these form a central cluster on the lower plates. Most of the upper plates are naked centrally, and rise into a low conical tubercle, often surmounted by a small, round, ovate, blunt spine or large granule. Many of the lower plates have a central large bivalve pedicellaria with low, broad blades; their breadth is about half the width of the plates.

The abactinal plates are rounded, with a marginal row of coarse round granules; the center is occupied, in most cases, by a broad, low, bivalve pedicellaria, nearly as wide as the plate. Each plate of the radial areas and of the center of the disk has five or six papular pores around it. The apical plate is irregularly ovate, with a pair of small apical spines.

The actinal plates are not numerous, much crowded, and closely united, so that their outlines are obscure. They have marginal granules and a large central pedicellaria, like those of the actinal plates, but rather larger.

The adambulacral plates are narrower; each has two, or sometimes three, flattened, blunt or spatulate, often crooked furrow spines; a larger clavate spine in the next row, standing on the center of the plate; and three to five much smaller, unequal, conical or clavate spinules in a group on the actinal end.

The oral spinules are numerous, crowded, and much compressed.

Greater radius, 17.5^{mm}; lesser, 8.5 to 9.5^{mm}.

Taken by the Albatross at station 2668, N. lat. 30° 58' 30", W. long. 79° 38' 30", in 268 fathoms, gray sand (No. 18,425, one young).

The discovery of this tropical species is of special interest, for the genus was previously represented by only two species; one (*H. phrygiana*) found in the boreal parts of the North Atlantic, on both coasts, extending on the American coast to Cape Cod in moderately deep water; the other (*H. magellanica*) from the region of Patagonia. The occurrence of the genus in the intermediate tropical region is, therefore, significant.

Cladaster Ver., gen. nov.

Stellate, with a broad, flat disk; interradial margins regularly incurved; rays tapered.

Marginal plates of both series rather large, not numerous, encroaching upon both sides of the disk, regularly paired, except distally, decreasing regularly in size; about four pairs of the dorsal ones are in contact medially. No odd interradial plates. Apical plate and those adjacent, small.

The marginal plates and all the actinal and abactinal plates are normally granulated, but in the type many of the marginal and abactinal plates have irregular, partially naked central patches, covered with small pits where granules have fallen off.

Abactinal plates all polygonal with rounded angles, rather large, not numerous; the median row of the rays is distinct, and bordered

on each side by a regular row of about the same size and form, arranged alternately.

Papular pores are arranged singly around and between the three central radial rows of plates, except distally, usually six to a plate, but are absent from the small interradial areas.

Actinal plates are few, rather large, angular, rather irregular and do not extend beyond the second pair of marginal plates, in the type; they are covered with well spaced, coarse granules. Pedicellariae with two elevated spatulate blades occur on the middle of some of the actinal plates.

Adambulacral plates bear relatively large and long, prominent, interlocking, spatulate or club-shaped spinules. Two of these, on each plate, belong to the furrow-series and are much flattened. Outside of these, there is a stouter median spine, of the same length, usually not much flattened, clavate or blunt at the tip; outside of this there are usually two smaller, conical spinules, on the actinal margin. The larger spines of the first actinal row do not increase in size distally, as in *Tosia*, etc., but gradually decrease.

The dentary plates are rather large, flat, and bear marginal and sutural rows of elevated, flattened or spatulate spines, like those of the furrow-series.

This genus seems to be more nearly allied to *Hippasteria* than to any other.

Cladaster rudis Ver., sp. nov.

PLATE XXVIII. FIGURES 2, 2a, 2b, 2c.

Rays narrow distally with four dorsal marginal pairs of plates in contact medially; these distal plates are small and not regularly paired. Radii about as 2:1; greater radius, 25^{mm}; lesser, 12^{mm}.

Dorsal marginal plates vary from 13 to 15 on different sides of the body. Ventral plates 15. Those of both series are similar in form and size, thick, somewhat convex, rectangular, higher than long on the interradial margins, and encroach considerably upon both sides of the disk; they are separated by deep sutures. Four larger pairs form the margins of the disk; those on the rays become rapidly smaller and more square. Those of both series are sparsely covered with coarse, rounded, well-spaced granules, many of which have fallen off, leaving small, shallow, rounded pits on the central portions of some of the plates. The marginal granules are of the

same form, but rather smaller and more closely arranged. The granules are higher than broad with a rounded top.

Abactinal plates are covered with granules like those of the marginal plates. They are roundish and slightly convex, in contact by their angles, between which some of them are slightly notched or incurved, to make room for the papular pores.

The madreporic plate is rather small, with many fine gyri.

The granules of the actinal plates are well-spaced and rather larger and more conical than those of the upper side; they form a marginal series, mostly of six to ten, which are somewhat divergent, and surround one or two larger central ones, which are sometimes replaced by a central pedicellaria, having broadly spatulate blades, rather higher than the granules.

The two outer spinules or granules of the adambulacral plates are like those of the actinal plates; there is often a minute conical spinule on the proximal side of the larger central spine.

Taken by the Albatross, off Florida, at station 1415, N. lat. 30° 44', in 440 fathoms, coarse sand, shells and foraminifera (No. 18,426, one example).

Subfamily **MEDIASTERINÆ**, nov.

This subfamily is proposed for those Goniasteridæ that agree very closely with the typical Goniasterinæ in the structure of the actinal side and marginal plates, but have paxilliform abactinal radial plates in the papular areas. These plates may be in the form of protopaxillæ or parapaxillæ, but are usually covered by close granules and not by spinules, but sometimes they are spinulose. They stand a little apart, when denuded, and may appear stellate at base, *Mediaster* and *Nymphaster* are the leading genera. In these there are bivalve pedicellariæ.

In *Mediaster*, and probably other genera, these plates are united by small dermal radiating ossicles that do not show distinctly at the surface (see pl. xxvi, figure 8). In *Nymphaster* there are no connecting ossicles, but the columnar plates have enlarged and six-lobed bases. Some of the forms placed here show strong affinities to some Pseudarchasterinæ.

Mediaster Stimpson.

Mediaster Stimpson, Journ. Boston Soc. Nat. Hist., vol. vi, p. 490, pl. 23, figs. 7-11, 1857.

Mediaster Sladen, Voy. Challenger, Zool., vol. xxx, pp. 263, 752, 1889.

Isaster Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 257, 1894.

The original description and figure of this genus and of the type species by Stimpson were incomplete and rather imperfect, so that the genus has not been well understood by most subsequent writers who have referred to it. I have, therefore, thought it desirable to re-describe and figure the type species at this time.

Form stellate, with a broad flat disk and moderately long tapered rays. Marginal plates well developed, not swollen, granulated, rather numerous, higher than broad, paired, upper and lower series nearly equal in size and number and with their sutures more or less closely corresponding vertically; oblique in the type. No odd interradial plate. Abactinal plates or parapaxillæ are regularly longitudinally arranged, of moderate size, somewhat elevated, mostly roundish, covered with a rosette of short, obtuse spinules or granules. When these are removed the plates on the central part of the disk and along the median region of the arms appear as roundish or oval convex bosses. They are connected together by five or six internal radiating ossicles, between which are the pores for the papulæ.* The papulæ may be single, or (in the type) clustered. Thus the plates appear to be stellate at the base, though they are not actually of that shape. The median row of abactinal plates extends to the apical plate of the rays in the type, but not in some of the other species. Some of the abactinal plates bear a central, broad, sessile, valvular pedicellaria, which, in the type species, is nearly as wide as the plate. They are sometimes lacking.

The adambulacral plates bear a regular marginal row of three to seven slender spinules, and usually two exterior longitudinal groups or rows of shorter spinules, which may be angular and obtuse, and toward the tips of the rays, some of them, in the type, become larger and longer, as in *Pentagonaster* of authors. Some of these spinules may be replaced by spinuliform or clavate, two or three-bladed pedicellariæ. The actinal disk-plates are angular, often rhombic, closely arranged in rows parallel with the ambulacral grooves, covered with a rosette of granules, the central granules often replaced by a wide valvular pedicellaria. The dentary plates are not very prominent;

* I have found these ossicles in *M. equalis* and *M. Bairdii*. Other species have not been examined as to this feature.

each has an actinal row of larger spinules, similar to those of the oral margin.

This genus is closely allied to *Pentagonaster*, as limited by Sladen and some other recent writers. The principal differences consist in the somewhat more elevated and convex abactinal plates, especially in the papular areas, where they are more widely separated by the large papular pores and united by intervening small internal ossicles, which give them a stellate appearance. On other parts of the disk, as near the interradial margins, the plates are angular and closely joined in a mosaic, as in the former genus. The large valvular pedicellariæ are also, to some extent, characteristic, but the marginal, actinal, and dentary plates and their spinules are essentially the same in the two genera. The spinules on the adambulacral plates are, however, more definitely triseriate, and the furrow series is more differentiated in all the known species, though this is perhaps of no more than specific value.

The type inhabits the Pacific coast of North America, in rather shallow water. No other species seems to have been described until a second one, from deep water off our north-eastern coast, was described by me in 1882, under the name of *Isaster Bairdii*. Its close affinity to *Mediaster* was not recognized at that time, though I have referred it to that genus, for several years, in my MSS. lists and in the museum catalogues.

Mediaster æqualis Stimp.

Journ. Boston Soc. Nat. Hist., vol. vi, p. 490, pl. 23, figs. 7-11, 1857.

PLATE XXIV. FIGURES 10, 11, 12.

Rays five, in length about equal to the diameter of disk, regularly tapered, slender at the tip. Radii nearly as 1:3. Marginal plates on each side of a ray 22, above and below, in a specimen having the greater radius 36^{mm}. The plates on the margin of the disk are higher than wide with the intervening sutures somewhat oblique. The lower marginal plates are similar in size and shape. All are closely covered with small rounded granules. Abactinal areas of the rays are wide at the base, where they may consist of seven or nine rows of plates, but they rapidly decrease to three rows, and only the median row reaches the apical plate. The papular areas are large, covering nearly the whole width of the proximal half of the rays, as well as most of the central disk. In these areas the plates are rounded or elliptical, convex, somewhat elevated, and separated by

intervening spaces, in which there are usually five or six groups of papular pores, the individual pores being small and unequal, two or three or more forming each group.

Each of the larger abactinal radial plates is covered with a rosette consisting of about five to seven central, and twelve to fourteen marginal, short, blunt or clavate, granule-like spinules, rather longer than broad. Some of the disk-plates are larger with more spinules. A large valvular pedicellaria often replaces the central group of spinules on some of the plates. These occupy nearly the whole breadth of the central area of the plate, and are narrowly oblong, not much elevated, with a nearly even and straight margin. Similar pedicellariæ, as well as some much narrower ones, occupy the central area of some of the actinal disk-plates.

The madreporic plate is small, sunken, with narrow, acute gyri. The central nephridial pore is small but distinct.

The actinal disk-plates are crowded and closely united; those next the adambulacral plates are squarish or rhombic and form regular rows, but those in the angles are smaller, irregular, and more rounded. All are covered with rosettes of granules, or short, obtuse, often prismatic spinules, rather larger and less regular than those of the upper side. A central valvular pedicellaria occurs on some of the plates, as stated above.

The adambulacral plates are squarish, not very large. Each bears a marginal row of three or four, small, oblong, more or less prismatic or compressed, blunt spinules, the middle one usually a little larger than the others. External to these are two sets of shorter spinules, about three in each series; these sometimes form two rows, but in other cases are in a rosette-like group; those next the inner or groove-series are longer than the others; one or more of these, especially distally, may be replaced by a spinuliform pedicellaria with two or three blades. On the distal part of the ray one or two of the spinules on the central part of these plates becomes considerably longer and larger than the rest. The oral spinules are similar to the adambulacral, but those at the tip of the oral plates are rather larger and more angular. The apical plates are rather small, prominent, somewhat obovate.

Radius of disk, 13^{mm}; of rays, 36^{mm}.

Off Wilmington, Cal., 27 fathoms, U. S. Nat. Mus.

Mediaster Bairdii Verrill.

Archaster Bairdii Verrill, Amer. Journal Sci., vol. xxiii, p. 139, 1882.

Isaster Bairdii Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 258, 1894. Amer. Journal Sci., vol. xlix, p. 136, 1895.

Mediaster stellatus Perrier, Mem. Soc. Zool. de France, iv, p. 268, 1891. Results des Campag. Scient., fas. xi, p. 46, 1896, pl. iv, figs. 1-1^d.

PLATE XXIV. FIGURES 1-9. PLATE XXVI. FIGURES 8, 8a.

A comparison of this species with the type-species of Stimpson has convinced me that they are very closely allied and should be referred to the same genus, though the Atlantic species is often nearly or quite destitute of pedicellariæ. But when pedicellariæ do occur they have nearly the same valvular forms seen in those of *M. æqualis*, though they are narrower and more elevated.

Mediaster Agassizii, sp. nov.

Five-rayed; regularly stellate, with a large disk and rather long tapered rays. Radii nearly as 1 : 3. Interradial angles are broadly curved.

Marginal plates large, nearly square, slightly convex, but not swollen; 36 dorsal and 38 ventral ones in the type, on each of the five sides; the transverse sutures between those of the upper and lower series are narrow and shallow and usually do not coincide.

The upper plates are sparsely granulated centrally, having only a few rather distant, rounded granules; their margins are surrounded with a close row of angular granules, but these do not form distinct fascioles. Some of the upper marginal plates have also small valvular pedicellariæ.

The lower marginal plates are coarsely granulated over the whole surface, the granules being larger than those of the upper ones; most of them also have one to three or more, oblong, valvular pedicellariæ, larger than those of the upper plates.

The abactinal plates are regularly arranged in radial series, very unequal in size, mostly roundish in outline, naked in the middle, but with a marginal row of coarse angular granules.

Many of them have a central, large, oblong, valvular pedicellaria, sunken in a pit; on the larger plates the pedicellaria is about one-half the diameter of the plate, but on the smaller plates it often occupies nearly the entire breadth of the top. Some of the plates lack the pedicellaria and have a central granule in its place. The valves of these pedicellariæ are usually higher than broad, with the blade broadly spatulate distally.

The abactinal plates become suddenly reduced to three radial rows, about opposite the fourth or fifth pairs of marginal plates, and a little farther out only the median row remains; this disappears about opposite the ninth pair of plates, beyond which the nine distal pairs of marginal plates are in contact medially. The apical plate is rather small, subconical, prominent. The papular pores are small and scattered singly over large baso-radial areas.

The actinal interradial plates are angular and polygonal, rather large, closely crowded together, forming rows parallel with the ambulacra; they are covered with large, crowded, rounded granules; most of them have, also, a single, large, oblong or elliptical, valvular pedicellaria, usually occupying about one-half the width of the plate.

The adambulacral plates have each four or five, short, stout, blunt, angular or prismatic spines in the furrow-series, placed in a regular row; next to these, on the actinal surface, there is also a row of three similar, but shorter, compressed spinules; on the outer end there are one or two rows of smaller and shorter, thick spinules; a large valvular pedicellaria usually occupies the center of the plate, but when it is absent there is a central row of spinules, making four rows on the actinal surface.

The dentary plates are large; each one, of a pair, bears about five stout, blunt, prismatic or compressed spinules in the furrow series, and two rows of short, thick, obtuse spinules on the actinal surface, those next the mouth being largest; at the apex of the jaw there are two larger, thick, blunt, prismatic and compressed spines.

Lesser radius, 25^{mm}; greater radius, 75^{mm}. Taken by the Blake Expedition, in the West Indies.

This fine species appears to be closely allied to *M. pedicellaris*. It is referred to the genus *Mediaster* with some doubt, for the character of the abactinal skeletal plates could not be satisfactorily ascertained by an external study of the single alcoholic specimen.

***Mediaster* (?) *pedicellaris* Verrill.**

Goniodiscus pedicellaris Perrier, Nouv. Arch. du Mus., vi, p. 245, pl. iv, fig. 3, 1884. Sladen, op. cit., p. 756, 1889.

The following notes were made upon one of the original types of Perrier, in the Museum of Comp. Zoölogy.

Radii as 7:19. Dorsal or abactinal plates, large, roundish, the summit convex when naked, but flat when covered with the spinules; the largest have about sixteen marginal, tapered, acute spinules, and one to five or more somewhat larger acute central ones. Intervening

popular pores large, single, about six around each plate, except that there are none between those plates in the middle radial rows; a row on each outer border of the abactinal space extends nearly to the end of the rays, or to within about ten marginal plates of the end, and as far as the rows of lateral plates extend.

The median series of plates extends about four or five plates farther than the lateral, but ceases within four or five plates of the tip; from thence the marginal plates are in contact.

Upper marginal plates bevelled and covered with small, sharp, spaced spinules; the upper spinules are shorter than the lower ones, larger, stouter, acute, divergent; those around the margins are similar and do not form regular fascioles.

Lower marginal plates large, roundish, with one or two marginal series of sharp, divergent, stout spinules, and a central larger one. Sometimes there are three to five central spinules on the dorsal plates and on the row of plates next to the adoral plates. Pedicellariæ small, narrow, elevated, spatulate in form and rather numerous on the dorsal side. Lesser radius, 18^{mm}; greater, 59^{mm}.

Station 295, Blake Exped., 180 fathoms. This species was also taken by the *Albatross* in the West Indies.

Mediaster arcuatus (Sladen).

Pentagonaster arcuatus Sladen, Voy. Chall., Zool., vol. xxx, p. 277, pl. xviii, figs. 5, 6; pl. lii, figs. 1, 2, 1889.

This species has a few small pedicellariæ on the abactinal plates, similar in size to the granules.

South of Yeddo, Japan, 345 fathoms.

Mediaster Japonicus (Sladen).

Pentagonaster Japonicus Sladen, op. cit., p. 272, pl. xlvi, figs. 1, 2; pl. xlix, figs. 1, 2, 1889.

This species has rather large, sessile, bivalve pedicellariæ with broad valves, on the adambulacral plates; others of smaller size occur on many of the actinal plates. Some of the pedicellariæ have three valves.

South of Yeddo, Japan, with the last.

Mediaster Patagonicus (Sladen).

Pentagonaster Patagonicus Sladen, op. cit., p. 269, pl. xlvi, figs. 1, 2; pl. xlix, figs. 3, 4, 1889.

This species has rather small, sessile, somewhat elevated pedicellariæ, sparingly scattered on the abactinal and superior marginal plates; their blades are usually chisel-shaped or spatulate, and variable. Similar ones occur sparingly on the adambulacral plates. Larger ones, with broader valves, occur on the actinal plates; some of them have three or four blades. The dorsal marginal plates and some of the ventral ones have a small central naked area.

Near Atlantic entrance to Straits of Magellan, 55 fathoms; off entrance to Smyth Channel, 245 fathoms.

The *Mediaster roseus* (Alcock, 1893, p. 98), from India, 740 fathoms, is not a true *Mediaster*. It appears to belong to *Pseudarchaster* and resembles *P. granuliferus* V.

Nymphaster Sladen.

Nymphaster Sladen, Narrative Chall. Exp., i, p. 612, 1885. Voy. Chall., vol. xxx, p. 294, 1889.

Pentagonaster (pars) Perrier, Etoiles de Mer, p. 233, 1884.

Dorigona Perrier, Exp. Trav. et Talism., p. 365, 1894 (not of Gray, 1866, p. 7, nor of Perrier, 1876, p. 44.)

PLATE XXVI. FIGURE 7.

This genus is closely allied to *Mediaster*. It differs chiefly in having, in the typical species, the dorsal marginal plates in contact medially for the greater part of the length of the rays. The character of the pedicellariæ, adambulacral plates and spines, jaws, and marginal plates is essentially the same in both, though the pedicellariæ are usually higher and spatulate in this genus.

The abactinal radial paxillæ, in the papular areas, differ in structure from those of *Mediaster*. In *N. ternalis* these plates, when separated, have no basal connecting ossicles, so characteristic of the latter. They are short, thick, columnar, with the basal portion somewhat swollen and slightly six-lobed; they articulate by means of the lobes, while the papular pores are situated in the spaces corresponding to the emarginations. The lobes are so slight that they can hardly be called stellate. The stellate appearance, as seen from the exterior, is due to the radial connecting bands of soft tissues between the pores. These plates are less stellate at base than those of *Pseudarchaster*, and rather more so than those of *Plutonaster*.

The name *Dorigona*, used for this genus by Perrier, is untenable. The type of Gray (1866) was *D. Reevesii*=*Ogmaster capella*, and the only other species mentioned by him was *longimana* (Möbius). The genus, as understood by Gray, was synonymous with *Ogmaster* (Von Mart.) of earlier date, and therefore should be dropped. If it were desirable to retain it at all, it should have been restricted to *D. longimana*. For the latter, Sladen, 1889, established the genus *Iconaster*, thus excluding *Dorigona* from the system.

Perrier, 1876, p. 44, used *Dorigona* for a section or a subgenus of *Pentagonaster*, and included in it *P. longimanus* and *P. capella* (as *Mulleri*), thus closely following Gray. But in his later work (1894), he has restricted it to *Nymphaster* Sladen, a group totally unknown to Gray and to Perrier, himself, in 1876.

This total transposition of the name is not justifiable. Perrier, himself, has disapproved of such a course in other cases of the same kind.

Seven species of *Nymphaster* have been described from the Atlantic and others from the Indo-Pacific. Probably the number of Atlantic species may be hereafter reduced when direct comparisons of the types shall have been made. I have studied only the three American species, from the types of Perrier and a good series dredged by the Albatross.

Atlantic species of Nymphaster.

***Nymphaster ternalis* (Per.).**

Pentagonaster ternalis Per., 1881, p. 20; 1884, p. 233, pl. x, fig. 1.

Nymphaster (?) *ternalis* Sla., 1889, p. 752.

Dorigona ternalis Per., 1894, p. 371.

PLATE XXVI. FIGURE 7.

West Indies, in 416 and 734 fathoms (Blake Exped.). Also dredged by the Albatross, at nine stations in the Gulf of Mexico and West Indies in 196 to 1181 fathoms, muddy bottoms, and at two stations off Brazil.

***Nymphaster subspinosus* (Per.).**

Pentagonaster subspinosus Per., 1881, p. 21; 1884, p. 234, pl. vi, fig. 1.

Nymphaster (?) *subspinosus* Sla., 1889, p. 752.

Dorigona subspinosus Per., 1874, p. 375.

West Indies, 163 to 209 fathoms (Blake Exped.). Also dredged by the Albatross at two stations in the West Indies, in 338 to 388 fathoms, coral sand and gray sand.

Nymphaster arenatus (Per.).

Pentagonaster arenatus Per., 1881, p. 21; 1884, p. 236, pl. vii, figs. 3, 4.

Nymphaster (?) *arenatus* Sla., 1889, p. 752.

Dorigona arenata Per., 1894, p. 379, pl. xxii, fig. 6, pl. xxiv, figs. 5, 6.

Found on both sides of the Atlantic. It was taken by the Blake in the West Indies, in 164 to 874 fathoms, and by the Travailleur and Talisman, at many localities, in 157 to 1635 meters. It was also dredged in the West Indies by the Albatross.

Nymphaster Jacqueti (Per.).

Dorigona Jacqueti Per., 1894, p. 383, pl. xxi, fig. 4, pl. xxii, fig. 5.

Dorigona prehensilis Per., 1885; 1894, pp. 32, 33.

Nymphaster (?) *prehensilis* Sladen, 1889, p. 752.

East Atlantic, from N. lat. $44^{\circ} 5'$ to $28^{\circ} 35'$, in 540 to 1238 meters.

Perrier does not explain why he has changed the name of this species from *prehensilis* to *Jacqueti*, except that he states (1894, p. 426) that the former is a "variety" of the latter. If no other reason exists, the earlier name should be retained.

Nymphaster protentus Sladen.

Voy. Chall., xxx, p. 303, pl. 1, figs. 3, 4, pl. liii, figs. 9, 10, 1889.

Off Canary Islands, in 1525 fathoms.

Nymphaster albidus Sladen.

Voy. Chall., xxx, p. 306, pl. li, figs. 1, 2, pl. liii, figs. 5, 6, 1889.

Off Cape Verde Islands.

Nymphaster basilicus Sladen.

Voy. Chall., xxx, p. 308, pl. lvii, figs. 8, 9, 1889.

Off Brazil, 1200 fathoms.

Two Indo-Pacific species, described by Sladen, differ from all the others in having a single median row of abactinal radial plates between the dorsal marginal ones, nearly or quite to the tip of the rays. In this group the pedicellariæ are high and spatulate, as in *Goniaster*, and the adambulacral spines are in very regular parallel rows. This group may, therefore, well deserve a distinct generic or subgeneric name, and I would suggest *Nereidaster*, with *N. symbolicus* as the type. The two species are as follows:—

Nereidaster symbolicus (Sla.), op. cit., p. 297, pl. 1, figs. 1, 2, pl. liii, figs. 7, 8, 1889.

East Indies and Philippines, 28 to 140 fathoms.

Nereidaster bipunctus (Sla.), op. cit., p. 301, pl. lii, figs. 3, 4, pl. liii, figs. 11, 12, 1889.

Off Admiralty I., 150 fathoms.

Subfamily. **PSEUDARCHASTERINÆ** Sla. (emended).

Pseudarchasterinae Sladen, Voy. Chall., xxx, p. 109, 1889.

Astrogoniinae (pars) Per., Exp. Trav. et Talism., pp. 337, 338, 1894.

This subfamily is remarkable for combining, in various ways, the structures that are generally characteristic and distinctive of *Goniasteroidæ* and *Plutonasteridæ*. The intermediate character of the group is so marked that Perrier and Sladen have differed as to its place. Perrier placed it in his *Pentagonasteridæ*, while Sladen placed it in his *Archasteridæ*. In fact, its affinities appear to be nearly evenly balanced between the two groups. True pedicellariæ, which might throw light on the subject, are generally absent from all the known species of the typical genera.

The abactinal radial plates are arranged in radial rows, the medium ones larger. They are paxilliform, more or less columnar, with round or elliptical convex tops, and with an enlarged six-lobed or stellate basal portion, the projecting lobes articulating and leaving spaces between them for the papular pores, which occupy large radial areas. About six are arranged singly around each of the plates.

Marginal plates are thick, moderately large and paired; they have deep fasciolated sutural grooves between them. The dorsal plates are rarely in contact medially, unless close to the tip of the rays. They are covered with close granules or small, crowded, appressed spinules, and the lower ones often have several larger central spines of the same character, but in some species the plates are all evenly granulated.

The adambulacral plates are broad, and usually angular or convex on the furrow margin, so that the furrow is constricted opposite each pair, especially distally. The furrow spines are usually in a curved or divergent series; those of the actinal side may be in longitudinal rows or clustered.

The actinal plates are often numerous, angular, arranged in chevrons, with the rows parallel to the ambulacral furrows. More or less

of those in the rows next the adambulacral plates have their transverse edges bordered by specialized spinules, forming with those of the plates opposed to them, special fascioles (*pedicellaires fasciolaires* of Perrier). But they are not real pedicellariæ.

True papilliform pedicellariæ occur very rarely on the actinal and marginal plates in *Paragonaster*.

The jaws are rather large and prominent and bear numerous elongated spinules, both on the actinal surface and the margin. At the oval apex of the jaw there is usually a larger odd median spine, but this is not constantly present in all species, and in certain species it is generally, if not always, lacking. Some specimens may have the odd spine on some of the jaws and lack it on others, so that it cannot be considered of much morphological importance, though its presence is a useful indication of the affinities of certain doubtful species.

The ambulacral feet have well formed suckers, as in *Nymphaster* and *Mediaster*.

In the general appearance of the abactinal and marginal plates and the granulation of the dorsal surface this group agrees essentially with *Mediaster* and allied genera. It differs from that group mainly in the more prominent margins of the adambulacral plates, the lack of bivalve pedicellariæ, and the more divergent groups of furrow-spinules, together with the usually spinulose covering of the actinal and inferior marginal plates; but this last character is not constant.

The singular actinal fascioles are characteristic of many species, but are not constant. The same is true of the odd apical spine of the jaws.

If true bivalve pedicellariæ were present we should not hesitate to combine the group with *Mediaster* and *Nymphaster* in one sub-family.

On the other hand, the adambulacral plates and spines, the jaws, and the form and structure of the dorsal paxillæ are very much like those of *Plutonaster* and allied genera, though the latter does not have the regular serial arrangement of the radial abactinal plates. Nor is there in this group any distinct arrangement of the actinal plates in rows running from the adambulacral plates to the marginals, as in *Plutonaster* and allied genera.

The actinal plates have nearly the same form and are imbricated in the same way as in *Mediaster*. The adambulacral plates next the dentary plates are somewhat oblique and slightly modified, but much less so than in *Plutonaster*, and more so than in *Tosia* and *Mediaster*.

The jaws are also intermediate, in respect to size, form, and amount of elevation of the actinal ridges, between *Mediaster* and *Plutonaster*. The enlarged stellate bases of the abactinal radial paxillæ may be considered as a farther development of the slightly enlarged and lobate bases at the columnar paxillæ of *Plutonaster*. There are no separate, internal, radiating connecting ossicles between the plates, such as exist in *Mediaster*. At least, I have not found them in anatomical preparations of *Pseudarchaster intermedius* and *Paragonaster formosus*, both of which have enlarged six-lobed bases on the paxilliform plates.

But in *Nymphaster (ternalis)* the connecting ossicles are also lacking, and the plates are short-columnar, with the bases only slightly enlarged, thick, and but slightly six-lobed, the lobes being rounded and often indistinct. The same is true of the corresponding ossicles of *Rosaster*.

Considering all these points, the affinities of the group seem to me rather more with *Nymphaster* and *Mediaster* than with any other genera. This is also the view taken by Perrier (1894).

Pseudarchaster Sladen. Type, *P. discus* Sladen.

Pseudarchaster Sladen, 1885, p. 617. Voy. Chall., xxx, p. 109, 1889.

Astrogonium (pars) Perrier, Exp. Trav. et Talism., p. 338, 1894 (not of M. and Troschel, nor of Gray).

The principal characters of this genus have been mentioned in the above description of the subfamily.

The adambulacral plates have a divergent or palmate series of furrow spines and a group or radiant cluster of actinal spines. The actinal plates are generally closely covered with small appressed spinules, often somewhat squamiform, rarely elongated, but frequently a few larger spinules exist among the smaller ones. Lower marginal plates are usually spinulated like the actinals, rarely granulous, often with one or more central rows of larger appressed spinules.

Specialized fascioles usually (but not always) exist between more or less of the larger actinal plates, especially toward the jaws. The ambulacral feet have well formed suckers.

The abactinal plates and upper marginals are usually closely granulated. More than one series of abactinal plates usually extend nearly to the ends of the rays.

Perrier united *Aphroditaster* with this genus, but the type seems to me sufficiently distinct. However, the presence or absence of the

specialized actinal fascioles cannot be made a character by which to distinguish them, for they may be present or absent in the same species (e. g. *intermedius*). Their presence seems to be the normal condition.

Six species are known to me from off the American coast. Several other species have been described from the East Atlantic.

***Pseudarchaster intermedius* Sladen.**

Pseudarchaster intermedius Sladen, Voyage of the Challenger, vol. xxx, p. 115, pl. 19, figs. 3, 4; pl. 42, figs. 5, 6, 1889. Verrill, Proc. Nat. Mus., vol. xvii, p. 249, 1894. Amer. Jour. Sci., xlix, p. 131, 1895.

Archaster Parelîi (pars) Verrill, Amer. Journ. Sci., vol. vii, p. 500, 1874 (not of Düben and Koren); vol. xxiii, p. 140, 1882; Rep. U. S. Com'r Fish and Fisheries, vol. xi, p. 543, 1884.

PLATE XXX. FIGURES 1, 1a, 1b.

This is the most common species off the eastern coast of the United States and Canada.

It was taken at about 33 stations by the Albatross and Fishhawk, 1880 to 1887, in 85 to 1608 fathoms, from N. lat. $44^{\circ} 26'$ to $37^{\circ} 59' 30''$. It has also been brought from the fishing banks, off Nova Scotia, by the Gloucester fishermen.

The variety (*insignis*) named and described by me in 1895 (p. 132), is probably only the fully adult form of this species. The largest example has the larger radius, 75^{mm}; the lesser, 23^{mm}. It lacks distinct actinal fascioles. These exist, however, in variable numbers, on other similar specimens, of somewhat smaller size, as well as on quite young examples. Their presence does not depend upon age, for they may be absent or present in specimens of equal size. Most specimens have the odd apical oral spine somewhat larger and longer than those adjacent. The genital pores are opposite and close to the first pair of dorsal marginal plates.

***Pseudarchaster fallax* Perrier.**

Astrogonium fallax Per., 1885. Exp. Trav. et Talism., p. 347, pl. xiii, fig. 4, pl. xxv, fig. 4, 1894.

Archaster Parelîi (pars) Verrill, Rep. U. S. Comm. Fish and Fisheries for 1883, vol. xi, p. 543, pl. xiii, fig. 37, 1885.

PLATE XXX. FIGURES 2, 2a.

This was formerly considered by me a variety of the preceding with narrow dorsal radial areas.

More recently I have compared our specimens with one of the types of *P. fallax* Per., in the Mus. of Comp. Zoology. They agree with the latter in all respects.

The species can be distinguished by the larger and more massive marginal plates, which encroach farther upon the dorsal surface, and by the very narrow abactinal areas on the rays. The granulation of the actinal plates is also closer and the adambulacral spines are shorter than in *P. intermedius*, but the two are very closely related. There is an odd apical spine on the jaws. Actinal fascioles are generally present.

Pseudarchaster (?) *hispidus* Ver., sp. nov.

PLATE XXX. FIGURE 5.

Pentagonal with moderately long rays. Radii as 1 : 2.

About twenty-five marginal plates, above and below; these are rectangular, broader than long, not oblique. The upper ones extend only a short distance on the dorsal surface, and are only a little convex. They are covered with numerous very small, slender spinules; those on the middle are erect, but those on the margins form fascioles of very slender spinules.

Inferior marginal plates extend far within the margin; they are spinulated much like the upper ones, but the spinules are larger, longer, tapered, acute, arranged obliquely and divergently in four or five rows, not counting the marginal fascioles; usually none of the median ones are distinctly larger than the rest, but sometimes, on a few plates, one or two of the distal ones are somewhat larger and longer.

Abactinal paxillæ are relatively large, rounded, and nearly uniform in size. There is a somewhat distinct median row on the rays. About six rows occur opposite the third pair of marginal plates; they are reduced to three rows near to the end of the rays, and to one median row between the last three plates. They are uniformly covered with small, sharp, elongated, divergent spinules, often thirty or more in a group. Of these, twenty or more may be marginal and a little smaller than the others, the adjacent ones interlocking so as to conceal the papulæ. These appear to be small and few. The plates are round, elevated, convex or somewhat clavate, well separated.

Interradial actinal regions are of moderate size, triangular, with the outer plates extending out to about the seventh pair of interambulacral plates. They are in rows parallel with the adambulacrals and not separated by radiating grooves. They are rather large, roundish, covered with rather long, divergent, acute spinules, often nine to twelve on the larger ones.

Jaws a little prominent, bearing a large number of slender marginal spines and very numerous similar ventral ones, in about two crowded rows on each half. The apical spines are only a little larger than the marginal ones.

Adambulacral plates on the middle of the rays bear about four or five relatively very long and very slender, terete spinules on the convex marginal edge; one to three on the actinal surface, of similar size and form, and four or five divergent ones on the outer margin, that are shorter, but of the same form. No pedicellariæ were seen. The abactinal and ventral plates and paxillæ are much larger and fewer than in any species of *Plutonaster* or *Dytaster*, of similar size, and the appearance is decidedly hispid under a lens, owing to the elongated and acute spinules of the whole surface. Greater radius, 12^{mm}; lesser, 6^{mm}.

Taken by the Blake Expedition in the West Indies, in 600 fathoms, and by the U. S. Fish Commission Steamer *Albatross*.

The specimens of this species that I have examined are doubtless immature, but they differ decidedly from the young of the other known American species. It is not a typical *Pseudarchaster*.

The specimen from the Blake Expedition was mixed with specimens labelled as *Plutonaster intermedius* by Perrier.

***Pseudarchaster granuliferus* Ver., sp. nov.**

PLATE XXX. FIGURES 6, 6a.

Form stellate with a broad disk and deeply emarginate sides, the rays wide at base and tapering rapidly to acute tips.

Radii as 1:2.20. Greater radius, 22^{mm}; lesser, 10^{mm}.

The marginal plates are large and thick, encroaching considerably on both sides of the disk, producing a rather thick rounded margin. The upper ones are closely covered with polygonal granules; the lower ones are closely covered with small, uniform, closely appressed, ovate, subsquamiform granules or granule-like spinules, without any larger median ones.

The abactinal plates are small, rounded, elevated, and covered with a polygonal group of prismatic granules, about five to eight forming the central cluster. Papular pores are regularly arranged, and placed singly between the basal radial plates. The madreporic plate is small and irregular.

Actinal plates are crowded and covered with spaced polygonal granules, without any spinules. On each area there are three to five special pectinate fascioles of small size, one of which is opposite

the dentary suture. The adambulacral plates have a curved, pal-
mate, strongly projecting furrow-series of five or six unequal blunt
spinules; the two or three median ones are larger and more slender,
compressed; the two distal ones are shorter, stouter, flattened or
spatulate, but on the distal half of the rays they are all slender. The
actinal side is covered with shorter, obtuse or clavate spinules, either
clustered or in two or three irregular rows, but without any larger
central spines.

The jaws are not prominent; there is an odd apical spine on each
jaw, distinctly larger and longer than the rest; the furrow margin
bears ten to twelve small obtuse spinelets, like those of the adambu-
lacrals; the distal ones are rather larger than the others. On the
sutural margin there are about ten shorter blunt or clavate spinules,
a little larger than the actinal granules; another small intermediate
row of similar ones covers the actinal surface.

Taken by the Albatross at station 2751, in — fathoms. One
example (No. 18,448*a*).

Pseudarchaster concinnus Verrill.

Pseudarchaster concinnus Verrill, Proc. U. S. Nat. Mus., vol. xvii, p. 250, 1894.
Amer. Jour. Sci., xlix, p. 132, 1895.

PLATE XXX. FIGURES 3, 3*a*, 3*b*.

Taken at 3 stations between N. lat. $41^{\circ} 28' 30''$ and $41^{\circ} 07'$; in
1188 to 1791 fathoms.

In this species the genital pores are large and usually plainly
visible, without preparation. They are situated far apart on the
dorsal surface, about opposite the second pairs of dorsal marginal
plates; they are separated by about nine radial rows of abactinal
interradial plates; about six plates intervene between the pore and
the marginal plate.

The jaws often have an odd apical oral spine, only a little longer
and larger than those adjacent. In other cases no such spine is
found, the apical spines being all paired. This variation may occur
on the different jaws of the same specimen.

In this species there is less distinction between the smaller and
larger spines on the lower marginal plates, there being many inter-
mediate in size, and the largest not very large, in three or four
irregular rows. The adambulacral and dentary spines are shorter,
those of the actinal side of the jaws being much less conspicuous.
The larger central spine of the actinal plates is also less prominent.

Pseudarchaster ordinatus Ver., sp. nov.

PLATE XXX. FIGURES 4, 4a, 4b.

A large species, having a broad disk, with the sides regularly incurved, and rather long, tapered, subacute rays, closely resembling *P. concinnus* in form and in the character of the upper side, but more spinose below.

Radii about as 1:2.8. Greater radius, 47 to 50^{mm}; lesser, 17-18^{mm}.

The abactinal paxillæ are regularly arranged, and evenly granulated, with very small, crowded, slightly elongated, round granules, of which twenty to thirty may occupy the central part; those around the margin are longer and divergent.

Upper marginal plates about 64 on each side of the body, much higher than long, encroaching considerably on the disk, sloping upward so as to form a bevelled margin. They are rather closely and finely granulated, like the abactinal plates. They have the narrow sutural grooves fasciolated.

Lower marginals similar to the upper in size and shape, but covered with small, acute, unequal spinules, and with one or two median vertical rows of larger appressed spines, of which there may be 8 to 10 or more on the larger plates.

The actinal plates mostly have a long, rather slender, acute central spine, surrounded by several small acute, erect spines. Many of those of the principal series have pectinate fascioles between them. Sometimes as many as 16 of these special fascioles occur on each intraradial area.

The adambulacral plates bear a palmate furrow-series of seven or eight slender, divergent, nearly equal spines; one or two larger central spines on the actinal side; and an outer marginal curved row of several small acute spinules.

The jaws usually have an odd apical spine considerably larger than the rest, but it may be lacking on some jaws; there are about eight or nine spines in the furrow series, rather longer and larger than those farther out; and about seven to nine rather larger and longer actinal spines on each dentary plate, so that the jaws appear very spinose.

The genital pores are small but easily visible; they are situated opposite to the second pairs of dorsal marginal plates.

Taken by the Albatross in the Gulf of Mexico, at station 2396, in 335 fathoms (No. 18,438); also at station 2376, in 324 fathoms.

This species has a much thinner disk and more slender and more rapidly tapered rays with less massive plates than *P. intermedius*, or even *P. concinnus*.

The following additional species have been recorded from the East Atlantic :

Pseudarchaster annectens (Per.).

Astrogonium annectens Per., Exp. Trav. et Talism., p. 343, pl. xxiii, fig. 5, pl. xxiv, fig. 1, 1894.

Gulf of Gascony, 900 meters; station 213, 1888, 1384 meters.

This is very closely related to *P. intermedius* Sla.

Pseudarchaster hystrix (Per.).

Astrogonium hystrix Per., Exp. Trav. et Talism., p. 345, pl. xxiii, fig. 3, pl. xxiv, fig. 2, 1894.

Coast of Morocco, 840 meters, one example.

Very closely related to the preceding.

Pseudarchaster necator (Per.).

Astrogonium necator Per., Exp. Trav. et Talism., p. 350, pl. xxiii, figs. 1a, 1b, 1894.

Off the Azores, 1257 meters, one example.

Pseudarchaster Aphrodite (Per.).

Astrogonium Aphrodite Per., Exp. Trav. et Talism., pp. 342, 354, pl. xxi, fig. 2, pl. xiii, fig. 2, 1894.

Coast of Sahara, 1090 meters.

Aphroditaster gracilis Sla.

Aphroditaster gracilis Sla., Voy. Chall., xxx, p. 117, pl. xvii, figs. 1, 2, pl. xviii, figs. 7, 8, 1889.

Astrogonium gracile Per., Exp. Trav. et Talism., pp. 342, 354, 1894.

Off the Azores, 1000 fathoms.

Pseudarchaster tessellatus Sla. is from off the Cape of Good Hope.

P. Patagonicus (Per.) is from Patagonia, 283 meters.

P. discus Sla. is from Messier Channel, west coast South America, 147 fathoms.

A few species have been described from the Indo-Pacific region :

P. mosaicus Alcock and Wood Mason, is from the Andaman Sea, India, in 188 to 220 fathoms.

P. roseus (= *Mediaster roseus* Alcock, 1893, p. 98) is from the Laccadive Sea, in 740 fathoms.

Paragonaster subtilis Perrier.

Goniopecten subtilis Perrier, Bull. Mus. Comp. Zoöl., ix, p. 26, 1881. Mém.

Etoiles de Mer, p. 253, pl. v, figs. 3, 4, 1884.

Goniopecten subtilis Sladen, Voy. Chall., xxx, p. 726, 1889.

Paragonaster subtilis Perrier, Exp. Trav. et Talism., p. 358, 1894.

The type of this species, from station 31, Blake Expedition, I have compared with specimens of *P. formosus* Ver., of similar size.

The two are very closely related, but in *P. subtilis* the adambulacral plates usually have, on the actinal surface, a rather long and stoutish acute central spinule; and the outer marginal spinules are also larger than those of *formosus*. On the proximal plates there are usually 6 or 7 furrow spinules and 8 or 9 on the actinal surface, all of which are stouter than in *formosus*. The spinules on the actinal surface of the dentary plates are also more numerous, larger and more divergent than in *formosus*; they form four rather irregular rows. The larger actinal paxillæ have 14 to 16 marginal granules, with 4 to 6 larger central ones.

Possibly a large series of specimens would compel us to unite the two, as only varietal forms of one species.

Four other Atlantic species of this genus have been described. They are as follows:

P. formosus (Ver.) 1884, p. 383; 1894, p. 257; 1895, p. 137.

Off East Coast of United States, 1396 to 2021 fathoms.

P. strictus Per., 1894, p. 363, pl. xxv, fig. 3.

East Atlantic, 3665 meters.

P. elongatus (Per.), 1885. 1894, p. 362, pl. xxi, fig. 3, pl. xxiv, fig. 4.

Off the Azores, 2115 to 4060 meters.

Perrier suggests that this may be only a variety of *P. subtilis* and that *P. strictus* may be the young of the same species.

P. cylindratus Sladen, Voy. Chall., xxx, p. 314, pl. li, figs. 3, 4, pl. liii, figs. 3, 4, 1889.

Off Cape Verde Islands, in 1850 fathoms. Closely related to *P. formosus*.

Rosaster Alexandri Perrier.

Pentagonaster Alexandri Perrier, Bull. Mus. Comp. Zoöl., ix, p. 22, 1881.

Nouv. Arch. du Mus., vi, p. 238, pl. vi, figs. 3-8, 1884.

Rosaster Alexandri Per., Exp. Sci. Trav. et Talism., Echinod., p. 387, 1894.

This species has rounded, columnar, paxilliform abactinal plates, covered, like the marginal and actinal plates, with small spinules. Most of the upper marginal plates of the rays are in contact medially.

The genus *Rosaster* is evidently very distinct from *Paragonaster*. Perrier states that it has no pedicellariæ of any kind, but some of the larger specimens that I have examined have had a small number of simple pedicellariæ on the actinal plates.

The larger examples have two long, slender spines on the actinal side of the adambulacral plates.

It was taken at several stations by the Blake, in 84 to 1930 fathoms, and by the Albatross at a number of stations in the West Indies and Gulf of Mexico, in 182 to 980 fathoms.

INCERTA SEDES.

Hoplaster Perrier. Type, *H. spinosus* Per.

Hoplaster Perrier, 1882, Rapport, p. 32. Exped. Trav. et Talism., p. 323, 1894.

Form pentagonal with short rays. Marginal plates well-developed, not numerous, spinulated. An odd marginal interradial above and below. Abactinal and actinal plates angular, crowded, closely united, covered with a group of elongated spinules. No pedicellariæ observed. Adambulacral plates with three or four spinules in the furrow-series and an irregular group of spinules on the actinal surface. Jaws without a recurved spine.

The relations of this genus are doubtful. Perrier placed it next to *Gnathaster*, on account of the odd marginal plate, etc. (See p. 202). It may, perhaps, belong to Goniasteridæ, or be allied to *Lasiaster*. The details of its skeleton are not known.

Hoplaster spinosus Perrier, 1882, Rapport, p. 32. Exped. Trav. et Talism., p. 324, pl. xiv, figs. 2a, 2b, 1894.

Off the Azores, etc., 2995 to 3307 meters.

Only small examples are known.

Hoplaster lepidus (Sladen).

Pentagonaster lepidus Sladen, Voy. Chall., xxx, p. 275, pl. lvii, figs. 1-4, 1889.

This species agrees so closely, in all structural characters, with the type of the genus, that there can be little doubt that they belong to one genus. In fact, the present species might even prove to be an older state of the former, to judge from the descriptions. They both came from the same region and similar depths.

Off the Azores, 1000 fathoms.

Lasiaster Sladen. Type, *L. villosus* Sladen.

General form as in *Tosia* and *Goniaster*. Marginal plates well-developed, in both series, paired. No odd interradial. Marginal, actinal, and abactinal plates covered with groups of small, acute spinules.

The general appearance of this genus is similar to *Hoplaster*, with which it may, possibly, be related, though no odd interradials are present. M. Sladen refers the genus to the *Gymnasteridæ*.

Lasiaster hispidus (Sars) Sladen.

Goniaster hispidus M. Sars, Fauna litt. Norveg., iii, p. 72, pl. 8, figs. 24, 25, 1877.

Pentagonaster hispidus Perrier, Nouv. Arch. du Mus. d'hist. Nat., Ser. 2, vol. i, p. 84, 1878. Danielssen and Koren, Asteroidea, Norske Nordhavs-Exped. Zoöl., xi, p. 58, pl. xv, fig. 6, 1884.

Lasiaster hispidus Sladen, op. cit., p. 372, 1889.

Arctic coasts of Europe, especially in the Drontheim Fjord, in deep water.

The larger specimens are 72^{mm} in diameter.

Revision of the Classification of the orders Valvata and Paxillosa of Perrier, and especially of the Archasteridæ.

Archasteridæ Sladen, Voy. Chall., xxx, pp. 1-4, 1889. Perrier, Exp. Trav. et Talism., pp. 237-252, 1894.

In a former article (1894, pp. 266-269) I endeavored to show that this extensive group is probably not a natural family.

This opinion has been confirmed to some extent by the subsequent publication of Perrier's report, quoted above, in which he discussed, at considerable length, the characters of this "family," as contrasted with *Pentagonasteridæ*. He enumerated seven principal characters by which the two families are distinguished. It is sufficient to state

here that every one of these seven characters fails in certain cases, and that nearly all of them may occur in each family, so that there is no certain means of deciding in which family certain genera should be placed. Perrier, himself, admits something of the kind, but holds that the preponderance of the characters ought to determine the family in each case.

The recent discovery of new genera has so increased the exceptional cases, by revealing forms that are more or less completely intermediate between the two groups, that it has become difficult to define them in any satisfactory manner.

The two principal writers who have recently discussed the classification of these starfishes, Sladen and Perrier, have differed considerably as to the limits and characters of each group. Thus Sladen included the Odontasteridæ (as *Gnathaster*) and the genera *Mimaster* and *Leptogonaster* in the Pentagonasteridæ, but Perrier put all these in the Archasteridæ. On the other hand, Sladen puts *Pseudarchaster* and *Aphroditaster* in the Archasteridæ, but Perrier transfers them to the Pentagonasteridæ.

These are well-known genera that have been thoroughly studied by both writers, therefore we must conclude that the two so-called families are not really well defined, natural groups, otherwise such able investigators could hardly disagree to such an extent.

This question would be of less importance were it not for the fact that in the more general classification of Perrier, these two "families" belong to two distinct orders. The Archasteridæ he places in the order Paxillosa (op. cit., pp. 28, 29); the Pentagonasteridæ in the order Valvata.

The fact that the two so-called families run together, without definite limitations, would necessarily imply that these two "orders" are also badly limited or unnatural groups.

Almost the only special character by which the two groups can be distinguished, as limited by Perrier, will be the character of the pedicellariæ, which, however, are often lacking in both groups.

But the papilliform pedicellariæ of the Paxillosa, with two to four or more valves, apparently formed from modified spinules or granules, are also found in the *Valvata*. Sometimes such pedicellariæ are found associated with larger valvular pedicellariæ on the same specimen, in the genus *Nymphaster* and other genera, while well-formed, though small, bivalve pedicellariæ often occur on certain of the antarctic *Gnathasterinæ*, and on other species referred to *Paxillosa*.

Therefore, if this feature is to be the criterion, the Paxillosa should only include such groups as never have true bivalve pedicellariæ. The existence of paxilliform plates on the dorsal surface cannot be made an important character, for they occur in typical forms of Valvata. The development of terminal suckers on the ambulacral feet varies much in both groups, and depends mainly on the nature of the bottom inhabited.

The Paxillosa would be a more natural group if limited to the Porcellanasteridæ, Astropectinidæ, and the genus *Archaster*, while the rest of the Archasteridæ (Sla.) might go into the Valvata (sens ext.) However, it seems to me a more natural arrangement to consider these groups as the two suborders of one order, equivalent in rank to the three others proposed by Perrier. For this order Sladen's name, *Phanerozonia*, might well be used, in a slightly restricted sense, the Asterinidæ and Gymnasteridæ being excluded.

The classification of the order as now proposed would be as follows:

Order **PHANEROZONA** Sladen (rest.).

Suborder I.—**Valvata** Perrier (sens ext.).

Family I.—**LINCKIIDÆ** Perrier.

Family II.—**PENTACEROTIDÆ** Gray (restr.).

Family III.—**ANTHENEIDÆ** Per. (restr.).

Family IV.—**GONIASTERIDÆ** Forbes (restr.).

Subfamily I.—Goniasterinæ V., nov. = Pentagonasterinæ Sla. (*pars*).

Subfamily II.—Goniodiscinæ Sla.

Subfamily III.—Mediasterinæ V., nov.

Subfamily IV.—Pseudarchasterinæ Sla.

Subfamily V.—Hippasteriinæ V., nov.

Family V.—**ODONTASTERIDÆ** Ver. nov. = Gnathasterinæ Per. (*pars*).

Family VI.—**PLUTONASTERIDÆ** Ver.

Subfamily I.—Mimasterinæ Sla.

Subfamily II.—Plutonasterinæ Sla.

Subfamily III.—Pontasterinæ Ver., 1894.

Family VII.—**GONIOPECTINIDÆ** V., nov.

Family VIII.—**BENTHOPECTINIDÆ** V. = Benthoplectininæ Ver., 1894.

Suborder II.—**Paxillosa** Per. (sens. restr.).

Family IX.—**PORCELLANASTERIDÆ** Sla.

Family X.—**ARCHASTERIDÆ** Vig. (restr. to *Archaster*).

Family XI.—**ASTROPECTINIDÆ** Gray (restr.).

Family XII.—**LUDIIDÆ** V., nov. = *Ludiinæ* Sla.

It will be noticed than in the above arrangement the Archasteridæ of Perrier, 1894, has been divided into five distinct families (Families V, VI, VII, VIII and X). The larger number of genera are placed in the Plutonasteridæ, which includes three groups that appear to be of subfamily rank.

The synonymy given will sufficiently indicate the limits of the groups in most cases.

The new family, Gonioplectinidæ, is proposed to include *Goniopecten* Per. (restr.), type *G. demonstrans*, together with an allied new deep sea genus *Prionaster* Ver., type *P. elegans*, with odd interradial marginal plates and a corresponding odd row of actinal plates. It is from the West Indies. The genus *Craspidaster* Sla., which I have not seen, probably belongs to the same family. In this group the adambulacral, actinal, and marginal plates are surrounded by special spinules united together by a web, so as to form very specialized fasciolated grooves. It is related to the Astropectinidæ, as well as to Pontasterinæ.

The family Benthoplectinidæ includes, so far determined, only the genus *Benthopecten* Ver. = *Pararchaster* Sladen.

The family Odontasteridæ is proposed for *Odontaster*, *Gnathaster*, and allied forms, having one or two large recurved spines on the jaws, and also odd interradial marginal plates. It is equivalent to *Gnathasterinæ* Per., minus *Hoplaster*.

Archasteridæ is restricted to the typical genus *Archaster*, which is believed to be closely allied to the Astropectinidæ.

Family **ODONTASTERIDÆ** Ver., nov.

Gnathasterinæ (pars) Perrier, Exp. Trav. et Talism., pp. 244, 251, 1894.

Form either pentagonal or stellate with a broad disk. Marginal plates well-developed.

Jaws, each with a single, recurved, more or less hyaline median spine, or with two such spines, side by side. In the latter case one

of these spines arises from near the apex of each dentary plate. Both conditions sometimes occur, abnormally, on the same specimen.

An odd interradial marginal plate, above and below, on each side.

Abactinal surface covered with more or less paxilliform plates, parapaxillæ or protopaxillæ, with intervening large papular pores on the radial areas. The abactinal plates may bear clusters of more or less elongated spines, or a group of small granules. They usually form obliquely transverse lines on the rays, not always regular.

Actinal plates angular, covered either with spines or granules. Small simple pedicellariæ sometimes occur on the actinal or abactinal plates. They may have two, three, or four papilliform blades.

Adambulacral plates usually bear elongated spinules arranged in three or four pairs of small transverse rows, generally only two or three of the furrow-series are on each plate; sometimes only one. Dentary plates usually have elongated, acute marginal and apical spines. They are sometimes closely united along the median suture; in other cases (*Odontaster*), they are separated by a space covered only by membrane.

The marginal plates are covered either with spinules or granules; sometimes the upper ones are granulated and the lower spinulose, like the corresponding disk-plates; they usually have deep fasciolated sutures.

Perrier, 1894, instituted a sub-family under the name *Gnathasterine* to include the present group, together with some other forms (*Hoplaster*) in which no recurved jaw-spines occur. He based the group more particularly on the odd interradial marginal plate. But the latter character seems to me to be of less importance, for I have found it abnormally present in various species of *Tosia* and allied genera. (See under *Pyrenaster dentatus*, p. 167, above). Moreover in *Benthopecten*, which normally has an odd interradial plate, I have found it replaced by two plates, on some of the margins (see p. 218 below and pl. xxx, figs. 7, 7a).

Therefore, I have taken the presence of the recurved dentary spines as the special feature of the group.*

As the name *Gnathaster* is nearly a synonym of *Odontaster*, and may, therefore, be dropped from the system by future authors, it seems desirable to change the name of the group to *Odontasteridæ*.

Perrier has divided the group into three genera: *Gnathaster*, *Asterodon*, and *Goniodon*.

* A similar recurved tooth is found in certain species of *Pterasteridæ*.

Asterodon Per. has a pair of dentary spines on each jaw.* Type, *A. singularis* (M. and T.). Peru and Chili.

Goniodon Per. has some of the distal marginal plates enlarged. A pair of recurved spines on each jaw. Type, *G. dilatatus* Per., New Zealand.

Gnathaster Sladen (restr.) has the marginal plates regularly decreasing. One recurved spine on each jaw. Type, *G. pedicellaris* Per. = *G. meridionalis* (t. Leip.), Cape Horn.

As thus limited and defined *Gnathodon* is identical with *Odontaster* Ver., of earlier date. The type cited, however, is not a typical *Odontaster*.

When Sladen established his genus *Gnathodon* he included in it all the known forms belonging to the three divisions proposed by Perrier. He did not designate any particular species as the type. His personal studies and detailed descriptions and figures were devoted to three Antarctic species, all of which would go in the genus, as restricted by Perrier.

Bell, 1893, combined all the known forms under the name *Odontaster* Ver., which is the earliest generic name in the group. The latter was based by me on a single species (*O. hispidus*), which is one of a group of species having very spinulose paxillæ and plates, and is apparently not strictly congeneric with *O. meridionalis* Smith (= *O. pedicellaris* Per.), which Perrier cites as the type of *Gnathodon*, 1894.

It seems to me unnecessary, therefore, to consider *Gnathodon* (Perrier, restr.) a synonym of *Odontaster*.

Since *Odontaster* was originally established for a more restricted group, Sladen's name was not originally truly synonymous with it. Therefore it may well be restricted to one of the other subdivisions included in it by him, as Perrier has done imperfectly.

Another division may be established for *G. elongatus* Sl., and *G. miliaris* Gray, in which the abactinal skeleton consists of pseudo-paxillæ, or low rounded plates covered with granules, while granules also cover the actinal and marginal plates, thus giving them nearly the same appearance as species of *Tosia* and allied genera, for which, indeed, some of them were formerly mistaken and described (under *Astrogonium* by Gray, and others; and under *Pentagonaster* by Perrier).

* Leipoldt, 1895, figures an abnormal specimen of *A. singularis* in which two jaws have each but one median tooth (pl. xxi, fig. 7c).

Acodontaster Ver., gen. nov. Type, *G. elongatus* Sladen.

Gnathaster (pars) Sladen, Voy. Chall., xxx, p. 285, 1889. Perrier (*pars*), p. 244 (1894).

Odontaster (pars) Bell, Proc. Zoöl. Soc. London, p. 261, 1893. Leipoldt, Zeit. wissenschaft. Zoöl., lix, p. 614, 1895.

One odd median, recurved, hyaline spine* on each jaw, or angle of the mouth-frame. The two dentary plates are closely united along the suture.

Actinal, marginal and abactinal plates are covered with granules or short granule-like spinules.

Abactinal plates have the character of pseudopaxillæ, or are not truly paxilliform, nor much elevated. They form obliquely transverse rows on the rays. Papular pores are large in the radial areas.

The marginal plates decrease regularly in size distally. The adambulacral spines are arranged in several series; two of each series usually are situated on each plate.

Actinal plates form series in two directions. Adambulacral plates usually bear only two spines in the furrow-series. Pedicellariæ are not found in the type. The distribution is Antarctic.

The following species belong to this group.

Acodontaster elongatus (Sladen, 1889). Off Marion I.; off Heard I.; off Kerguelen I., etc., 50–150 fathoms.

Acodontaster miliaris (Gray, 1847). New Zealand.

Gnathaster Sladen (restr.). Type, *G. meridionalis*.

Gnathaster (pars) Sladen, Voy. Chall., xxx, p. 285, 1889. Perrier (*pars*), Exp. Trav. et Talism., p. 244, 1874.

Odontaster (pars) Bell, Proc. Zoöl. Soc. London, p. 261, 1893. Leipoldt, Arch. wiss. Zoöl., lix, p. 614, 1895.

A single hyaline recurved spine (movable?) on each jaw. The two dentary plates consolidated at the suture.

Abactinal plates are elevated, convex or capitate, and with radial basal processes. They are covered with a group of short spinules or with prismatic granules. They extend to the apical plate.

Dorsal marginal plates not very large, covered with granules or with small short spinules, like the disk. Ventral marginal plates and actinal plates covered with granules or minute spinules.

* According to Sladen's description these spines, in his species, are more closely united to the jaw than in *Odontaster*, and would hardly be movable. In the latter they are only attached by their bases, at the apex of the jaw, and are movable.

Adambulacral plates are narrow and usually have only two furrow spines; several other pairs are borne on the actinal side of each plate.

G. pilulatus Sladen also belongs to this restricted group.

G. pedicellaris Per., from Cape Horn, is placed as a synonym of *meridionalis* Smith by Leipoldt, as are, also, *G. Grayi* (Bell) and *G. pilulatus* Sladen. All the species are Antarctic.

Odontaster Verrill.

Odontaster Verrill, Amer. Journ. Science, xx, p. 402, 1880. Proc. U. S. Nat.

Mus., xvii, p. 262, 1894. Amer. Journ. Sci., xlix, p. 136, 1897.

Gnathaster Sladen (*pars*), Voy. Challenger, vol. xxx, Asteroidea, p. 285, 1889.

Perrier (*pars*), Exp. Trav. et Talism., p. 244, 1894.

Odontaster Bell (*pars*), Proc. Zoöl. Soc. London, p. 260, 1893.

A single, odd, hyaline, recurved movable spine on the apex of each jaw. Dentary plates large, separated by an open, fusiform space covered by membrane. Abactinal surface covered with elevated, convex or clavate paxilliform plates, or parapaxillæ, which usually bear clusters of elongated spinules, like true paxillæ; their bases are stellate; upper marginal plates are usually finely spinulated.

Lower marginal plates and actinal plates are covered with acute, more or less elongated spinules.

Papular pores are generally large and placed singly in the angles around the radial paxillæ. The radial abactinal plates form more or less evident obliquely transverse rows and extend nearly or quite to the apical plate.

The odd interradial marginal plate is usually triangular or wedge-shaped. Simple pedicellariæ occur rarely.

The adambulacral plates usually bear several rows of spines; usually three or four in the furrow-series, rarely but two.

The species, so far as known, are from the North Atlantic.

The open suture between the dentary plates of the jaws; the movable hyaline spine, attached only by its base, at the apex of the jaw, together with the very spinose character of the abactinal paxillæ and marginal plates, separate this genus from its allies. The marginal plates are also larger than in most of the other groups, and the adambulacral plates bear usually three or four spines in the furrow-series.

A reexamination of the numerous specimens of this genus formerly collected by the U. S. Fish Commission Steamer Albatross, off our coast, convinced me, several years ago, that two species were comprised under the name of *O. hispidus* in our earlier lists, and

probably in the collections sent to various museums by the U. S. Fish Commission and National Museum. Two examples of another new species was also discovered in the same collections. I have, therefore, thought it desirable to prepare comparative descriptions of these two new species, and to give morphological figures of the three forms, for comparison.

***Odontaster hispidus* Verrill.**

Odontaster hispidus Verrill, Amer. Journ. Sci., vol. xx, p. 402, 1880. Proc. U. S. Nat. Mus., vol. xvii, p. 263, 1894. Amer. Journ. Sci., vol. xlix, p. 136, 1895.

PLATE XXIX. FIGURES 3, 3a.

Form depressed, stellate, with a rather broad disk. Radii vary in proportion from 1:2 to 1:3. The rays taper regularly and are subacute.

The marginal plates are only moderately developed and do not encroach much on the disk, either above or below. In large examples there are about 37 to 39 on a side, in each series. They are convex and separated by wide and rather deep sutural grooves. The upper and lower nearly coincide. The upper ones are squarish, with rounded angles; the lower ones, along the disk margin, are higher than long. The odd interradial one is somewhat wedge-shaped, and only a little smaller than those adjacent to it.

The marginal plates of both series are densely covered with small elongated, divergent spinules which over-arch and partly conceal the sutural furrows. The spinules on the upper plates are slender and acute. Those on the lower plates, especially those on the actinal side, are longer and much stouter, terete and tapered, subacute or acute. When the spinules are removed the marginal plates are covered with small hemispherical elevations, where the spinules were attached. Those of the upper plates are smaller and more crowded.

The abactinal plates are round at top, convex, well separated; those of the radial areas and center of the disk are elevated, with a somewhat capitate round top, which is covered by a dense cluster of slender, elongated, acute divergent spinules.

Between most of the radial plates, over a large area, there are moderately large papular pores, about six around each plate, placed singly in most cases.

Smaller pores are scattered over the center of the disk, but they are absent from the small interradial areas and from the distal part of the rays.

The actinal plates, when denuded of spines, are numerous, decidedly convex, with deep sutural grooves between them; their surfaces are covered with uneven irregular elevations, where the spines were attached. They are arranged in about five rows parallel to each ambulacral furrow. The first row extends nearly to the tip of the ray; its plates are larger and rather more square than those of the next row. The interradial plates become small, rounded and crowded. The actinal plates all bear dense groups of rather stout, elongated, tapered, mostly acute or subacute spinules, essentially like those of the lower marginal plates.

The adambulacral plates are transversely oblong, rather narrower than the adjacent actinal plates, and have, like the latter, a tuberculated surface. Each one, proximally, bears two, or more often three, unequal spinules of the furrow-series, but more distally they bear only two, nearly equal ones. On the actinal side each plate bears about four or five quite similar spines, which sometimes seem to stand, more or less distinctly, in pairs. These spines, like those of the furrow-series, are essentially like those of the actinal plates, in size and form.

The jaws are rather large, rhombic; the two dentary plates are separated by a rather wide sutural furrow covered with membrane; they are covered with spines on the margin and actinal side, like those of the adambulacral plates. The median recurved spine is large, somewhat compressed; the distal part is hyaline and very acute.

A large example has the greater radius 55^{mm}; lesser, 16^{mm}. Another has the greater radius 42^{mm}; lesser, 14^{mm}.

This species has been taken by the U. S. Fish Commission at many localities, from off Martha's Vineyard to Florida, in 43 to 480 fathoms and more.

It is easily distinguished by the small marginal plates and stout actinal spinules.

Regularly 4-rayed and 6-rayed specimens have been taken.

Odontaster setosus Ver., sp. nov.

PLATE XXIX. FIGURES 1—1c, 2.

Form depressed, stellate, with a broad disk. Sides regularly incurved. Radii about as 1:2, somewhat variable. The marginal plates are pretty well-developed and encroach considerably upon the disk, above and below. They are transversely oblong, distinctly higher

than broad, and separated by deep sutural grooves. They are decidedly larger than in *O. hispidus* and not so square. The upper and lower ones correspond closely in size and position, so that the sutural grooves are continuous. Large examples have about 35 in each series on each side of the body.

In some specimens as many as five or six of the distal dorsal marginal plates are in contact medially; in others all are separated, the abactinal plates reaching even the apical plate.

The marginal plates, above and below, are thickly covered with large numbers of small, slender, acute spinules, those near the margins divergent and forming fascioles. The spinules of the upper plates are rather smaller and more numerous than those of the lower ones, but there is no such difference in character as in *O. hispidus*. When the spinules are removed the plates are thickly covered with minute tubercles.

The abactinal radial plates are well separated, small, paxilliform with a rounded, convex or capitate top, covered with a cluster of slender, acute, setiform, divergent spinules.

The papular pores are large and conspicuous and occupy large areas; they are placed singly. The actinal plates are rather numerous, rhombic, finely tuberculated, arranged in three or four rows parallel with the ambulacra; the first series extends to about the seventh marginal plate. They are covered with dense clusters of slender, acute, setiform spinules, like those of the upper surface but longer.

The adambulacral plates are transversely oblong, narrower than the adjacent actinal ones. They bear each three or four slender furrow spinules in a nearly regular row, and a dense group of 10 to 12 or more, somewhat longer, slender spinules on the actinal side. The latter are similar to the actinal spinules, but rather larger and less acute.

The dentary plates bear marginal and actinal spines, similar to those of the adambulacral plates, but those at the apex are shorter, prismatic and blunt, while there are usually two or three near the sides that are larger than the rest and somewhat curved. The plates are separated by wide sutural grooves.

The recurved spines are compressed and often somewhat curved; the distal end is hyaline, suddenly narrowed or acuminate, and usually very acute.

One of the larger specimens has the greater radius 37^{mm}; lesser, 18^{mm}. Another has the greater radius 32^{mm}; lesser, 17^{mm}.

This species was taken by the U. S. Fish Commission Steamer Albatross, at many stations, from off Martha's Vineyard to the Carolina coasts, in 56 to 400 fathoms or more. It was often associated with *O. hispidus*.

In form and general appearance it resembles *O. hispidus*, but is easily distinguished by the higher marginal plates, and especially by the slender setiform spinules of all the plates on the under side.

Odontaster robustus Ver., sp. nov.

PLATE XXIX. FIGURES 4, 4a.

Form broadly stellate, with short, rapidly tapered rays and thick margins. The sides are regularly incurved. Radii about 1:1½.

The marginal plates are larger and thicker than in the two preceding species. Those of the two series correspond closely in size and position. There are 27 of each series on each side of the body, in the type. They encroach considerably upon the disk, both above and below, and rise distinctly above the abactinal plates, thus forming a conspicuous margin. They are transversely oblong, about twice as high as broad. About four pairs of the distal dorsal plates are in contact medially.

The odd interradial plates are small and wedge-shaped, and do not reach the marginal sutural groove, but in this groove, opposite the odd interradials, there may be a small, odd, ovate plate. This is lacking, or very small, on two of the margins of the type. The sutural grooves are narrow and deep, with marginal fascioles of small slender spinules. Both series of marginal plates are thickly covered with small, slender, setiform spinules, those of the lower series somewhat larger and longer than those of the upper ones.

The abactinal plates are small, round, well separated, paxilliform. Those of the radial areas have a rather high column, somewhat capitate, with the top somewhat convex and covered with a divergent cluster of small, slender, acute, setiform spinules.

The papular pores are conspicuous and occupy five large radial and a disconnected central area; those in the central parts of each area are much larger than those at the edges; about six surround each plate.

The actinal plates are squarish and form about four rows parallel with the ambulacra; they are separated by rather wide grooves, and each bears a thick group of elongated, slender, setiform spinules.

The adambulacral plates are rather narrower than the adjacent actinals. Each bears four or five slender spinules in the furrow series; these are terete and rather larger than the actinal spinules; on the actinal side there is a group of 12 to 16 slender spinules, those next the furrow series about the same as the latter in size and form; the outer ones are rather smaller.

The dentary plates are separated by wide open sutures; their marginal and surface spinules are like those of the actinal plates.

The recurved spines are conspicuous and not much compressed, with regularly tapered, very acute, hyaline tips.

The type specimen has the greater radii 33 to 35^{mm}; lesser, about 20^{mm}.

The type (No. 9758) was taken in 1881, by the Albatross, off Martha's Vineyard, at station 994, in 368 fathoms, mud. A smaller specimen (No. 18423) was taken in 1885, at station 2586, in 328 fathoms, in the same region.

This species is easily distinguished from the two preceding by the thicker margin and disk, shorter rays, larger and fewer marginal plates, more numerous adambulacral spinules, etc.

Family **PLUTONASTERIDÆ.**

Plutonasterine (sub-family) Sladen, op. cit., pp. 2, 60, 1889. Perrier, Exp. Trav. et Talism., p. 251, 1894.

This group appears to be sufficiently distinct to be regarded as a family. The great group called the family *Archasteridae* by Sladen and by Perrier is so heterogeneous that it cannot be definitely defined, as already explained by me. (See p. 199.)

In the present group the form is stellate, the rays often long and tapered. The abactinal plates are usually very numerous, in the form of columnar parapaxillæ or protopaxillæ, covered with small divergent spinules. They generally have no very definite arrangement and the median radial series is often not distinguishable.

The marginal plates are generally well developed and paired, but are sometimes small. They often bear one or more acute spines.

The actinal plates are imbricated and generally form rows running from the ambulacral to the marginal plates.

The pedicellariæ, when present, are usually of simple structure, with two to four papilliform blades. See pl. xxvii, fig. 6. They seem to be lacking in many species. Supra-ambulacral plates are present.

Nearly all the species of this group are from the deep sea. None are littoral. For the subdivisions see p. 200.

Plutonaster Agassizii Verrill.

Archaster Agassizii Verrill, Amer. Journal Sci., vol. xx, p. 403, 1880.

Plutonaster rigidus Sladen, op. cit., p. 91, pl. xiv, figs. 3, 4; pl. xv, figs. 3, 4, 1889; also var. *semiarmatus*, op. cit., p. 94.

Plutonaster bifrons (pars) Sladen, op. cit., p. 88, 1889 (very young example).

Plutonaster Agassizii Verrill, Proc. Nat. Mus., vol. xvii, p. 248, 1894. Amer. Journ. Sci., xlix, p. 131, 1895.

PLATE XXVII. FIGURE 6.

This species is intimately related to *P. bifrons* and other forms that have been described from the East Atlantic. Probably several of these species will have to be united eventually. It is also very closely allied to *P. intermedius* (Per.) of the West Indies, with which I have compared it. From the latter it appears, however, to be distinct.

Our specimens occasionally have one or two small pedicellariæ on the actinal side near the jaws (see pl. xxvii, fig. 6). They have three or four simple papilliform blades, and are very similar to the ordinary form found on *Dytaster*.

Perrier and Sladen both state that no pedicellariæ are found in this genus.

Four-rayed and six-rayed specimens occasionally occur.

Taken at 103 stations between N. lat. $41^{\circ} 53'$ and $35^{\circ} 45' 23''$; in 182 to 1700 fathoms. Most common in 300 to 1200 fathoms.

Plutonaster efflorescens Perrier.

Archaster efflorescens Perrier, Etoiles de Mer, p. 255, 1887.

Plutonaster efflorescens Perrier, Trav. et Talism., p. 322, 1894.

The type of this species from station 29, 955 fathoms, Blake Expedition, when examined by me in 1896, was in a very poor state of preservation; all the rays but one were broken off and the granules of the disk were largely rubbed off.

It is a young specimen. The radii are only 17^{mm} and 5.5^{mm} , so that the adult specific characters are not developed.

The rays are relatively large for so young a specimen, slender, tapered, and narrow distally, being more like those of *Dytaster* than *Plutonaster*.

Marginal plates are 34 to 36 on each side of the body, small, squarish, not oblique; the upper ones extend a little on the actinal side of the disk. They are covered with minute raised spinules, which are not crowded; along the interradial margins each usually bears a slender tapered, conical spine, about as long as the breadth of the plate. The marginal plates are convex with a distinct groove between them.

The lower marginal plates extend much farther back from the margin than the dorsal ones, but they have the same fine spinulation; there are distinct marginal fascioles between them; most of the distal and some of the proximal plates also have a central spine, like those of the dorsal series, but rather longer.

The apical plate is relatively large, elongated, ovate, with a large proximal notch.

The abactinal paxillæ are numerous, very small, round, nearly uniform in size; when rubbed the plates are convex and elevated, well separated; three or four rows continue even to the apical plate. There is no distinct median dorsal series; each plate bears a group of four to eight (usually six) very small, slightly elongated, divergent spinules, forming regular stellate clusters, without any evident larger central spine.

The actinal plates are rather numerous, forming triangular areas; they are similar to the abactinal plates, but rather larger; each usually bears six to eight small, rough, divergent spinules, in a stellate group. They extend to about opposite the fourth or fifth adambulacral plates, and do not form evident radial rows.

The adambulacral plates are relatively large; the inner or furrow margin is convex and along the middle portion of the groove of each plate four or five slender, elongated, rough, terete furrow-spines on its convex edge, and six to eight shorter and smaller, divergent spinules on its actinal surface, forming two or three irregular transverse rows, or else an irregular roundish cluster.

The dentary plates are rather prominent, sub-carinate, and are covered with numerous small, slender spinules on the actinal surface; on the furrow margin there are numerous small slender spinules and about six larger, convergent, apical ones. No pedicellariæ could be found.

Although this is evidently the young of some large species, it differs decidedly from the young of *Dytaster insignis* and *D. grandis*, of the same size, with which I have compared it directly. It has shorter rays; single marginal spines; much smaller and more finely spinulose dorsal paxillæ; more numerous actinal plates, with finer and more numerous spinules; more numerous spinules on the dentary plates; more nearly equal and regular and more slender furrow spines on the adambulacral plates; the edge of the latter is less prominent, so that the furrow-series is less broken. In these characters it agrees better with *Plutonaster* than with *Dytaster*.

It should probably be referred to *Plutonaster*, as has been done by Perrier (1894), but it does not agree with the young of either of the adult forms known from the American coasts.

Perrier (1894) seems inclined to unite this with *pulcher* (Per.), though he points out a number of differences. The latter is also quite young. Their identity seems to me very doubtful, after a comparison of the types.

Family GONIOPECTINIDÆ Ver., nov.

Stellate with elongated rays; marginal, adambulacral and actinal plates bordered with peculiar pectinate spinules united by a web-like membrane, and thus forming specialized, continuous fascioles. Surface of the marginal plates usually smooth or with a few scattered granules, sometimes entirely granulated, usually covered with a thin membrane.

Marginal plates large, regularly paired; the sutures corresponding above and below; sometimes they are spinose. There may be an odd interradial marginal plate in each series (*Prionaster*).

Abactinal plates are paxilliform or columnar and covered with small spinules. They are arranged in oblique transverse rows on the rays. Actinal plates form radial series, usually double (single in *Craspidaster*), running from the adambulacral to the marginal plates, with deep fasciolated grooves between them, continuous with the fasciolated grooves between the marginal plates.

The adambulacral plates project over the ambulacral furrows, forming constrictions; they bear a curved or angular series of furrow spinules united by a basal web.

The jaws are rather large and very prominent, with an open suture. They bear two or more enlarged apical spines, and more or less numerous smaller spinules on the actinal side.

Craspidaster Sladen appears to belong to this family.

Goniopecten demonstrans Perrier.

Goniopecten demonstrans Per., 1881, p. 24. Etoiles de Mer, p. 249, pl. iv, fig. 5, 1884. Exp. Trav. et Talism., p. 295, 1894.

PLATE XXVII. FIGURE 5.

The genus *Goniopecten*, as originally defined by Perrier, included *Plutonaster* and other forms now regarded as very distinct genera.

But later (1894, p. 294) he restricted the genus to the single type, *G. demonstrans*. This was also done by me independently, in 1894 (p. 249).

The genus is very peculiar in appearance, owing to the smooth plates and curiously fasciolated sutural grooves.

It is, however, very much like the new genus *Prionaster* in appearance, but it has a fasciolated sutural furrow running from the suture of the jaws to the suture between the first pair of marginal plates.

It has no odd interradial marginal plates, which are present in *Prionaster*. The dorsal marginal plates do not bear spines as in the latter. It has a large madreporic plate with fine radial gyri.

The dorsal nephridial pore is surrounded by a large number of very small paxillæ, which form a low central prominence (probably much more elevated in the young). The papular pores are numerous, small, arranged regularly, about six around each paxilla, over most of the disk and on wide basal radial areas, but even in the basal regions they are lacking along the three or four median radial rows of paxillæ and do not reach the ends of the rays.

The paxillæ are very numerous on the disk, smaller centrally; they are high, with rounded or elliptical tops, and covered with a group of very small, short, blunt spinules, of which one to three are central. Distally the paxillæ become narrow-elliptical and very small. On base of the rays they form obliquely transverse rows.

The marginal plates are mostly smooth except around the margins, and covered with thin membrane; distally on the rays they bear minute scattered granules. Around their margins there is a regular rim, formed by the regular row of webbed spinules, which project over the edges of the sutural grooves. In these grooves there are several rows of much finer slender spinules. The apical plate is rather large, obconic, unarmed.

The actinal plates are large, angular, of various forms, not numerous; they extend out to about the 12th adambulacral plate, there being but a single row of small ones beyond the 7th. They form, proximally, double series, the two united rows corresponding to each marginal plate, but with from $1\frac{1}{2}$ to $2\frac{1}{2}$ adambulacrals. The actinal plates are flat and most of them bear from 1 to 3 minute scattered spinules, besides the marginal fasciolated row.

The adambulacral plates proximally have an oblique, angular furrow-series of 9 or 10 slender, divergent spines, webbed together at base. Farther out, about the middle of the ray, the series becomes more regularly convex and more prominent, with 10 to 12 smaller and more slender spinules, which sometimes, in dry specimens, nearly meet across the furrow, leaving large roundish or elliptical spaces for the passage of the adambulacral feet, which are very large and tapered, but without any sucker. The actinal margin of the adambulacral plates has one or more series of small, stout, divergent spinules, webbed together and fasciolated.

The jaws are very prominent, elliptical in outline. There are two or four tapered apical spines, much larger than the rest; the furrow-series is convex and contains 9 or 10 small spinules, like those of the adambulacrals. The elevated actinal surface is covered with many small, acute, spaced spinules, in three or four irregular rows.

No pedicellariæ could be found.

A large specimen has the larger radius, 115^{mm}; lesser, 21^{mm}.

Taken by the Blake Exped. in 358 fathoms, off Santa Cruz, etc., and by the Albatross in the West Indies and Gulf of Mexico, at several localities, in 335 to 347 fathoms.

I have compared the Albatross specimens with the types of Perrier from the Blake Expedition.

Prionaster Ver., gen. nov.

Stellate with long, tapered, squarish rays, high at base.

Abactinal paxillæ are arranged on the rays, in obliquely transverse rows, about four rows to each marginal plate; they are small, high, rounded or elliptical, with a terminal cluster of small spinules.

Marginal plates large, high, not encroaching much on the disk, those on the interradial regions much higher than those of the rays. There is an *odd interradial plate* above and below, similar to the others in size and shape. The upper and lower plates correspond accurately even to the end of the ray. The proximal upper ones mostly have a central, acute, movable spine near the upper end. The lower ones may also bear a small spine. All are margined by a very regular series of small pectinate spinules, webbed together. Some of them may bear groups of minute granules.

The actinal plates are not numerous, flat, covered with thin membrane and with a few small scattered spinules, and a marginal series webbed together, so as to form fascioles. They are arranged in double series; the series are separated by the fascioles, but the two rows of a series are not. An *odd interradial series*, with two rows of plates, runs from the jaw and first adambulacrals plates to the odd interradial marginal plate. (See Plate xxvii, figure 4a.) The other series correspond each to a marginal plate, but have no regular relation to the adambulacrals.

The jaws are very prominent, with a large sutural groove. They have each two large apical spines and a row of sutural spinules. The adambulacrals plates are large and project far over the furrow, so that the spines meet across it. They have a furrow series of numerous small spinules, webbed together; their lateral and outer margins have smaller webbed spinules.

Prionaster elegans Ver., sp. nov.

PLATE XXVII. FIGURES 4, 4a, 4b, 4c.

Disk small; sides high and vertical, evenly incurved; rays high and nearly square at base, tapering regularly to the slender tips.

Radii as 1 : 5. Greater radius, 70^{mm}; lesser, 14^{mm}.

The marginal plates are oblong and much higher than long on the disk, but gradually become squarish on the rays. The upper and lower are exactly coincident, so that the vertical sutures are continuous. Their sides are nearly perpendicular and they encroach only a short distance on the disk, but at the middle of the rays each series is about as wide as the actinal area; distally, near the tips of the rays, they are separated only by a single row of very small paxillæ. The distal plates bear groups of small spaced granules near the upper end. Each of the upper ones, except on the distal third of the rays, bears a small, movable, tapered, acute spine at the upper angle; those at the base of the rays are longer than the rest. Some of the lower marginal plates of the rays have a similar, but smaller, spine at the lower angle and near the distal edge of the plate; most of the interradials have also a small cluster of minute granules near the lower end. All the marginal plates are bordered by a very regular and even series of small spinules webbed together to their tips. Those of the upper plates are much more numerous, finer and closer, and evenly pectinate; they nearly touch across the grooves. Those of the lower plates stand a little apart and are more divergent, about half as many in the same space as on the upper plates, and very similar to those between the actinal plates. The apical plate is large, prominent, oblong, with the inner end acute-angled.

The actinal plates are irregular in size and form, but mostly have curved outlines; they are partially concealed by a thin membrane, and many of them bear a very small subcentral spinule. All are bordered on that side next the fasciolated grooves by a row of appressed, slender, webbed spinules, which nearly or quite meet across the grooves; the latter are continuous with the grooves between the marginal plates and with those between and back of the adambulacrals. The actinal areas are not large and extend to about the eighth adambulacral. The median odd series consists of two closely united rows of about six each, the distal ones becoming very small. The next series contains a row of five plates and one of three similar plates; this series corresponds to the second and third adambulacrals. The next series, corresponding nearly with the

fourth adambulacral, has three plates in one series and two in the other. Beyond this the plates are few and irregular.

The adambulacral plates are broad and roundish, the proximal ones quite oblique; their furrow edge projects over the furrow and bears a row of 10 to 12 small, slender, acute spinules, which are somewhat divergent and are webbed together for about half their length; they meet or interlock across the furrow, leaving rounded or ovate open spaces between them for the passage of the large and tapered ambulacral feet. These spinules become very small and slender distally, but still meet across the furrow. On the outer and lateral margins of the plates there is also a series of divergent, webbed, fasciolated spinules like those of the actinal plates.

The jaws are oblong and very prominent on the actinal side; each half has an actinal sutural row of very small spinules, and some additional ones on the surface. The furrow-series contains about ten spinules, increasing in length toward the apex of the jaw, where there are two much larger and longer, acute oral spines.

The madreporic plate is rather large, with fine gyri. The dorsal nephridial pore is situated in the center of a low elevation composed of very small, round paxillæ.

Taken by the Albatross at station 2401, in the Gulf of Mexico, in 142 fathoms. (No. 18,428.)

Family **BENTHOPECTINIDÆ** Ver., nov.

Benthopectininae Ver., Proc. Nat. Mus., xvii, p. 245, 1894.

Benthopecten spinosus Verrill.

Benthopecten spinosus Verrill, Amer. Journal Sci., vol. xxviii, p. 218, 1884;

Explorations made by the Albatross in 1883, in Annual Report, U. S. Comm. of Fish and Fisheries, pp. 519 [47], 543 [41], 1885. Proc. Nat. Mus., vol. xvii, p. 245, 1894. Amer. Journ. Sci., xlix, p. 129, 1895.

Pararchaster semisquamatus var. *occidentalis* Sladen, Voyage of the Challenger, vol. xxx, p. 10, 1889.

Pararchaser armatus Sladen, op. cit., p. 19, pl. 1, figs. 5, 6; pl. 4, figs. 5, 6, 1889.

PLATE XXX. FIGURES 7, 7a.

This species was taken north of Cape Hatteras, at 62 stations, between N. lat. 42° 47' and 35° 10', in 721 to 2021 fathoms, by the U. S. Fish Commission. Most common in 1200 to 1600 fathoms.

It was also taken in the Gulf of Mexico, station 2380 and station 2381, in 1430 and 1330 fathoms, and off Jamaica, station 2127, 1639 fathoms.

One specimen of this species (No. 15,570) is remarkable for having, on one of the interradial margins, a pair of plates in place of the usual odd median plate.

Figure 7, plate xxx, represents the abnormal segment of this specimen, with the jaw and corresponding pair of marginal plates (*m, m*), and figure 7*a* represents a normal segment and jaw of the same specimen, with the odd marginal plate (*m*).

Family **ASTROPECTINIDÆ** Gray.

Blakiaster conicus Perrier.

Blakiaster conicus Per., 1881, p. 28. Etoiles de Mer, p. 265, pl. ix, fig. 2, 1884.

Leptoptychaster conicus Per., Exp. Trav. et Talism., pp. 242, 243. 1894.

PLATE XXVII. FIGURE 7.

Perrier, in his later report, has united this genus with *Leptoptychaster*, but it seems to me sufficiently distinct, though doubtless they are closely allied. In this genus the actinal plates are not arranged in distinct radial series, nor do they have such well developed fascioles between them. On the contrary, they have a rather irregular, crowded, tessellated arrangement, the plates being roundish or polygonal, pretty closely united, without deep, sutural, fasciolated furrows. The marginal plates, also, have only rudimentary fascioles. The jaws are stout and evenly convex, instead of thin and carinate. The dorsal paxillæ are larger, rounded, and more regular.

There is a distinct dorsal nephridial pore or "anus." The dorsal papulæ are large, five or six around each plate, except on the distal half of the ray and on the small interradial areas.

The lower marginal plates have three or four larger and longer spines on the border.

There are also, on some of our specimens from off Havana, a number of pedicellariæ. Those on the actinal and adambulacral plates have four to six convergent papilliform blades, similar to the surrounding spinules, but rather stouter and blunter (see pl. xxvii, fig. 7). Similar ones, but smaller, with three or four blades, occur on the marginal and abactinal plates.

West Indies and Gulf of Mexico, 92 to 175 fathoms.

Sideriaster Ver., gen. nov.

Form broadly stellate with a very large disk ; dorsal surface convex, and capable of inflation, closely covered with uniform, stellate paxillæ. Upper marginal plates small, entirely lateral.

Interradial actinal areas are large, with numerous plates, the distal ones extending to the distal third of the rays. They are arranged in single radial series, each series usually corresponding to an adambulacral plate and most of them to a marginal plate, but some of the series are short and do not reach the margin, there being more adambulacral than marginal plates proximally, but distally they generally correspond in number, though there are sometimes, locally, two marginals to one adambulacral. These plates are covered with granules, and have divergent, fasciolated spinules along their radial margins, thus forming fasciolated grooves that are coincident with those between the marginal plates.

The abactinal paxillæ are large, closely arranged, and nearly uniform in size and shape, regularly stellate, with short, even spinules.

The madreporic plate is *very large*, round, flat, fully exposed, and has very numerous, thin, radiating gyri.

Papular pores are very numerous and are arranged singly, about six around each plate over the whole of the disk and rays, even close to the ends.

There is no distinct dorsal nephridial pore visible, nor do the central plates differ in size from those of the disk in general.

Marginal plates are small and not prominent. The upper ones are entirely confined to the margin, and are granulated, without spines. The lower ones form the lower part of the margin, but extend also on the disk below ; they are spinules with a median row of larger spines.

The adambulacral plates have a prominent furrow angle, on which there is a large, median, odd compressed spine ; at each side of this there are, in the furrow-series, two or three erect flattened spines ; a stout spine occurs on the center of the actinal side, with a single or double row of shorter flat spines back of it.

The jaws are large, not very prominent, covered with numerous short, blunt spinules and having furrow spinules like those of the adambulacral plates.

This remarkable genus seems to be very distinct from all known forms, but clearly belongs to the Astropectinidæ. Its very broad convex disk and large actinal interradial areas and small marginal plates are exceptional ; and so is the very large madreporic plate.

Sideriaster grandis Ver., sp. nov.

PLATE XXX. FIGURES 8, *Sa*, *Sb*.

Large, regularly five-rayed, with a broad, somewhat inflated disk, regularly and broadly incurved at the sides. The rays are rather long and rapidly tapered. Radii as 1:3.4. Greater radii, 133–138^{mm}; lesser, 40^{mm}.

The margin is formed mostly by the upper plates, which do not extend at all upon the upper side. They are small and short, those on the interradial margins shortest and highest, at least four times as high as long. They are covered with coarse rounded granules, and bordered with fascioles of slender spinules. The lower marginals are of the same length and extend on the under side considerably. They are covered closely with small appressed, flattened spinules, largest centrally, grading laterally to the marginal fasciolated spinules. On the middle of each plate there is a vertical row of about four stout, tapered, more or less flattened, acute spines.

The abactinal paxillæ are round and high, remarkably uniform in size, arranged on the rays in imperfect, transverse, oblique rows. They bear a round, rosette-like cluster of rather coarse, short, clavate or capitate, divergent spinules, of which one is usually central, with 6 or 7 in a circle around it, while about 15 to 18 form the marginal row, interlocking with those of the adjacent plates, so as to conceal the papular pores. The latter are rather large and regularly arranged over the whole disk and nearly to the ends of the rays, usually six around each paxilla. The bases of the paxillæ appear stellate.

The madreporic plate is remarkably large and flat or slightly concave, with very numerous and thin radiating gyri.

The actinal plates are granulated nearly like the upper marginal plates. Other under parts have been described above under the generic description.

Pedicellariæ occur in small numbers on the adambulacral plates and on the first row of actinals. They have two or three short, stout, flattened, spinuliform blades, similar in size to the adjacent spinules.

One specimen (No. 10,877) was taken by the Albatross at station 2378, in Gulf of Mexico, in 68 fathoms.

Family **PTERASTERIDÆ** Per.

Hexaster obscurus Perrier.

Hexaster obscurus Per., Mem. Soc. Zool. France, iv, p. 267, 1891. Res. Camp. Sci., xi, p. 41, pl. iii, figs. 1, 1a, 1896.

Pteraster (Temnaster) hexactis Verrill, Proc. Nat. Mus., vol. xvii, p. 175, 1894. *Temnaster hexactis* Verrill, Amer. Journ. Sci., xlix, p. 202, 1895.

There can be no doubt that the genus and species described by Perrier is the same as that described by me. Both were from the same region and nearly the same depth.

The original description by Perrier (1891) was overlooked by me when I described the species in 1894.

Only one specimen was taken by the Albatross, in 57 fathoms, at station 2433, N. lat. $43^{\circ} 05'$; W. long. $50^{\circ} 43'$, off Newfoundland.

It was taken by the Hironnelle, off Newfoundland, in 155 meters.

Hymenaster regalis Ver., 1894; var. **Agassizii** nov.

Large, swollen, polygonal, with short rays, and with concave interradial areas. The interradial margins are prolonged into a broad, soft web. Abactinal pore small, regular, five-angled.

Adambulacral spines three in a series, appearing rather stout and club-shaped at the tip, in the alcoholic preparation. The whole under side of the body is covered with a thick fleshy membrane.

The dorsal surface is covered with prominent, regularly arranged, well spaced, slender, acute spines.

Color, in alcohol: under side deep pink or rose-color; upper side somewhat paler pink. This species was taken by the Blake Expedition, off Martha's Vineyard, N. lat. $41^{\circ} 24' 45''$, in 1242 fathoms, 1880.

Family **ASTERINIDÆ** Gray.

Marginaster austerus Ver., sp. nov.

Pentagonal with five short, triangular, subacute rays; interradial margin incurved. Dorsal surface thickly covered with small and short, rough spinules, on crowded indistinct plates.

Papulae rather large, solitary between the plates, generally diffused, even down to the margin; a regular row between the upper and lower marginal plates and just above the lower ones. Ten primary calicinal plates of the disk are larger than the rest and distinct from them; the interradial most so. Dorsal nephridial pore distinct, surrounded by spinules.

Upper marginal plates small, irregular in form and arrangement, scarcely distinct from the abactinal plates, except close to the end of the rays, and without marginal clusters of spinules. Lower marginal plates prominent, transversely oblong, depressed, the sharp outer edge bearing a regular horizontal row of four to six rough, blunt spinules, usually four or five on the proximal and five or six on the distal ones; on the upper side of the same plates there is a secondary row of the same number of much smaller and shorter spinules.

Actinal plates evident, irregular in size and form, the smaller distal ones roundish; the more central ones elliptical, transversely elongated, and bearing about three crescentic rows of spinules; one to three bear a single, small, central spine in each area. In one specimen there are two of these spines. The adambulacral plates, near the mouth, bear a single slender inner spine, on the edge of the groove, and two stouter ones, side by side, on the actinal surface; in the middle part of the groove the spines are placed obliquely, and distally the three spines gradually come to stand nearly in a single transverse row, and they also become longer and more crowded.

Taken in the West Indies by the Blake Expedition and by the Albatross, in — fathoms.

Family **STICHAsterIDÆ** Perrier, 1885.

Stichasteridae Sladen, 1889, p. 430. Perrier 1894, p. 128. 1896, pp. 25-27. Verrill, 1895, p. 206.

Stephanasterias Verrill, 1871. Type, *S. albula*.¹

Stephanasterias Ver., Bull. Essex Inst., iii, p. 5, 1871. Expl. of Casco Bay, Proc. Am. Assoc. Adv. Sci. for 1873, pp. 356, 359, 364, 1874. Check List Invert., 1879. Expl. Albatross, 1883, p. 540, 1885.

Nanaster Perrier, Exp. Trav. et Talism., pp. 129, 131, 133, 1894. Camp. Scientif. l'Hirondelle, p. 27, 1896.

Stichaster (pars) Verrill, 1866, p. 351. Perrier, p. 347, 1875. Sladen, p. 432, 1889.

Perrier, in adopting this generic division, proposed by me in 1871, changed the name to *Nanaster*, on the ground that *Stephanasterias* was preoccupied by *Stephanaster* Ayres. The latter name was well known to me when I used the former, but I regard the two names as perfectly distinct: the one being based on *Asterias*; the other on *Aster*. The genus, if adopted, should therefore be called *Stephanasterias*. It is certainly very closely related to typical *Stichaster*.

The type species, *S. albula*, is common in moderately deep water (1-229 fathoms) from Greenland to Cape Hatteras. It has once been taken by the Albatross, in 1253 fathoms (station 2726, N. lat. $36^{\circ} 34'$), unless some mistake was made in the labelling. It has also been dredged by the U. S. Fish Commission off the coast of South Carolina and apparently in the West Indies. At least I have not yet been able to find any satisfactory characters for distinguishing the West Indian form *S. gracilis* (Per. as *Asterias*, 1884) from the northern one. It also has a wide range on the European coasts.

NOTE.

The specimens above described and discussed belong to several collections :

- I. The general collection of the Peabody Museum, Yale University, of which I have had personal charge for many years.
- II. The Museum of Comparative Zoology of Harvard University, where I have had opportunities to examine especially the collections made in the West Indies by the U. S. Coast Survey steamer "Blake," during several expeditions under the supervision of Mr. Alexander Agassiz. This collection is of particular importance for it contains the types described by Perrier, from these expeditions. My thanks are due to Mr. Waiter Faxon for his kindness in affording me facilities for this study.
- III. The very extensive collections made by the U. S. Fish Commission, under my supervision, from 1871 to 1887, off the north-eastern coasts of North America. A large part of this collection is now in the U. S. National Museum, but a duplicate series is in the Yale Museum.
- IV. A very interesting collection of deep-sea species dredged in the West Indies and Gulf of Mexico by the U. S. Fish Comm. steamer "Albatross" in 1884-1886, and sent to me from the U. S. Nat. Museum for identification and study. This collection contains most of the new species described by Perrier, and some additional new forms.
- V. A small but interesting collection made in the Bahamas and off Cuba by an expedition from the University of Iowa, and sent to me for study.

The two last named collections will be reported upon by me in detail in subsequent articles.

Much of the value of this article will be due to the unusually accurate enlarged drawings of the structural details of many of the genera and species discussed. These have all been made by my son, Mr. A. H. Verrill, and reproduced in facsimile by photolithography.

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The following partial list of works is intended to include, especially, those that are of importance in connection with the generic synonymy and those that relate to the deep-sea species of the Atlantic, though others are included for various reasons. Most of the older descriptive works are omitted. For convenience, a special list of papers by the writer, relating to starfishes, has been added.

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EXPLANATION OF PLATES.

All the figures have been drawn from nature by Mr. A. H. Verrill except Plates xxiv^a and xxv, which are from photographs.

PLATE XXIV.

- Figure 1.—*Mediaster Bairdii* Ver. Type. Dorsal side of the distal part of one of the rays with the granules removed. $\times 8$.
Figure 2.—The same specimen. Group of abactinal paxillæ from the base of a ray with the spinules removed, showing the papular pores. $\times 8$.
Figure 3.—The same. Actinal side of a ray. $\times 4$.
Figure 4.—The same. Abactinal side of the middle portion of a ray. $\times 3$.
Figure 5.—The same. Group of adambulacral and adjacent actinal plates. $\times 5$.
Figure 6.—The same. Group of paxillæ and papular pores from the abactinal side of the disk. Some of the paxillæ have pedicellariæ. $\times 12$.
Figure 7.—The same from the ray, without pedicellariæ. $\times 8$.
Figures 8, 9.—The same. Smaller abactinal paxillæ.
Figure 10.—*Mediaster equalis* Stimp. Actinal side of the basal part of a ray. $\times 6$.
Figure 11.—The same specimen. Abactinal side of the basal part of a ray. $\times 6$.
Figure 12.—The same specimen. Group of abactinal paxillæ and papular pores from the base of a ray, with granules partly removed. $\times 8$.

PLATE XXIV^a.

- Figure 1.—*Goniaster Americanus* Ver. Original type, dorsal side. From a photograph. Somewhat reduced.
Figure 2.—The same specimen. Ventral side. Somewhat reduced.

PLATE XXV.

- Figure 1.—*Goniaster Africanus* Ver. Original type. From a photograph. About natural size.
Figure 2.—The same specimen. Ventral side. About natural size.

PLATE XXVI.

- Figure 1.—*Goniaster Americanus* Ver. Original type. Group of plates of the abactinal radial areas at the base of a ray, showing the two kinds of plates, covered with granules, and the papular pores. The central plate has three spatulate pedicellariæ. Much enlarged.
Figure 2.—The same specimen. A single actinal plate having a pedicellaria (*p*) with curved blades. The blades have been removed to show the pits into which they fold when fully opened. Much enlarged.

- Figure 3.—The same species. Group of abactinal plates from the central part of the disk of a smaller specimen, showing several pedicellariæ (*p*) in different positions. \times about 24.
- Figure 4.—The same specimen. Dorsal side of the distal part of a ray. $+5\frac{1}{2}$.
- Figure 5.—The same specimen. Actinal side of one of the jaws and adjacent parts. $\times 5\frac{1}{2}$.
- Figure 6.—The same species. A young specimen (No. 18,459), like that described as *P. parvus* by Perrier. Dorsal surface. $\times 7$.
- Figure 7.—*Nymphaster ternalis* (Per.). Dorsal side of a part of the disk and base of a ray. The granules have been partly removed from some of the marginal plates, and entirely from some of the abactinal ones. $\times 5\frac{1}{2}$.
- Figure 8.—*Mediaster Bairdii* Ver. Part of the abactinal system of plates from the base of a ray and a part of the disk, seen from the inner side, showing the bases of the paxillæ with the radiating ossicles that connect them together, and the intervening papular pores. On the right are some of the interradial plates without papular pores between them. $\times 9\frac{1}{2}$.
- Figure 8a.—The same. Abactinal paxillæ from the papular region.

PLATE XXVII.

- Figure 1.—*Tosia (Plinthaster) nitida* Ver. Type. Dorsal view of a part of the disk and a ray. $\times 5\frac{1}{2}$.
- Figure 1a.—The same specimen. Actinal side. $\times 6$.
- Figure 1b.—The same specimen. Abactinal plates of a papular radial area. $\times 6$.
- Figure 2.—*Tosia (Plinthaster) compta* Ver. Type. Actinal side of the base of a ray. $\times 5\frac{1}{2}$.
- Figure 3.—*Pyrenaster dentatus* (Per.). Oral region of specimen No. 18,433. $\times 5\frac{1}{2}$.
- Figure 3a.—The same. Dorsal surface of one of the rays of No. 18,433. Variety with wider abactinal radial areas. $\times 5\frac{1}{2}$.
- Figure 3b.—The same species. A younger specimen (No. 7079). Under side of a part of the disk showing the actinal and adambulacral plates. Two of the actinal plates have a bivalve pedicellaria. $\times 9\frac{1}{2}$.
- Figure 4.—*Prionaster elegans* Ver. Type. Under side of basal part of a ray. $\times 5\frac{1}{2}$.
- Figure 4a.—The same specimen. One of the jaws and adjacent actinal and adambulacral plates, showing the odd interradial series of actinal plates (*m*) and the first of the paired series on each side. $\times 5\frac{1}{2}$.
- Figure 4b.—The same specimen. Distal part of the upper side of a ray, with the apical plate. $\times 7$.
- Figure 4c.—The same. One of the dorsal paxillæ. Much enlarged.
- Figure 5.—*Goniopecten demonstrans* Per. Under side of part of a ray, middle portion, showing adambulacral and marginal plates in contact. $\times 5\frac{1}{2}$.
- Figure 6.—*Plutonaster Agassizii* Ver. One of the jaws and adjacent parts of a specimen having pedicellariæ. One of these, with four blades, is situated on the first actinal plate in line with the dentary suture. $\times 7$.
- Figure 7.—*Blakiaaster conicus* Per. Part of the actinal surface, showing two of the pedicellariæ (*p*) with spiniform blades. $\times 14$.

PLATE XXVIII.

- Figure 1.—*Hippasteria Caribæa* Ver. Type. Actinal side of a part of the disk and base of a ray. $\times 6$.
- Figure 1a.—The same. One of the adambulacral plates, more enlarged.
- Figure 2.—*Cladaster rudis* Ver. Type. Dorsal side of a part of the disk and one of the rays. $\times 6$.
- Figure 2a.—The same. Actinal side. $\times 6$.
- Figure 2b, 2c.—The same. Profile views of one of the spatulate pedicellariæ, much enlarged.
- Figure 3.—*Peltaster planus* Ver. Original type. Dorsal side of the distal part of a ray. $\times 5\frac{1}{2}$.
- Figure 3a.—The same specimen. A group of plates from the basal part of the ray; *c, c*, median plates. $\times 5\frac{1}{2}$.
- Figure 4.—*Peltaster hebes* Ver. Type. Actinal side of the basal part of a ray. $\times 5\frac{1}{2}$.
- Figure 5.—*Litonotaster intermedius* (Per.) Ver. Dorsal side of a ray. $\times 6$.
- Figure 5a.—The same. Denuded group of plates from the small papular area; *c, c*, median row.
- Figure 5b.—The same. Actinal side of the base of the ray and part of disk. $\times 8$.

PLATE XXIX.

- Figure 1.—*Odontaster setosus* Ver. Under side of the base of a ray and part of the disk. $\times 9\frac{1}{2}$.
- Figure 1a.—The same. Under side of a portion of the disk with the spinules removed to show the plates; (*m*) lower marginal plates; *b, b*, actinal; *a, a*, adambulacral plates. $\times 7$.
- Figure 1b.—The same. One of the jaws and adjacent parts, showing the recurved odd apical spine (*s*) of the jaw. $\times 9\frac{1}{2}$.
- Figure 1c.—The same. A few paxillæ from one of the basal radial areas of the upper side. \times about 5.
- Figure 2.—*Odontaster setosus* Ver. Part of the interradial area of the disk with three adjacent upper marginal plates. The middle plate (*m*) is the odd interradial. $\times 7$.
- Figure 3.—*Odontaster hispidus* Ver. Part of the abactinal and upper marginal plates (*m*) at the base of a ray. The larger spines (*c*) of the lower marginal plates are also visible. $\times 7$.
- Figure 3a.—The same. Adambulacral plates (*a, a*) and spines, and first row of actinal plates (*b, b*). The spines have been removed from most of the plates; *f*, ambulacral furrow. $\times 7$.
- Figure 4.—*Odontaster robustus* Ver. Type. Actinal side of the base of a ray. $\times 9\frac{1}{2}$.
- Figure 4a.—The same. Abactinal side of a ray. $\times 6$.

PLATE XXX.

- Figure 1.—*Pseudarchaster intermedius* Sla. Actinal side of a part of the disk and a ray. $\times 5\frac{1}{2}$.
- Figure 1a.—The same. One of the adambulacral plates more enlarged.
- Figure 1b.—The same. Abactinal side of the basal part of a ray with most of the granules removed. $\times 5\frac{1}{2}$.
- Figure 2.—*Pseudarchaster fallax* (Per.). Abactinal side of a part of the disk and a ray, from which most of the granules have been removed. $\times 5\frac{1}{2}$.
- Figure 2a.—The same. One of the jaws and adjacent plates. $\times 5\frac{1}{2}$.
- Figure 2b.—The same. One of the abactinal paxillæ. Much enlarged.
- Figure 3.—*Pseudarchaster concinnus* Ver. Type. Actinal side of the basal part of a ray, showing three pectinate fascioles (*p*). $\times 5\frac{1}{2}$.
- Figure 3a.—The same specimen. One of the jaws and the adjacent plates showing three pairs of pectinate fascioles. $\times 5\frac{1}{2}$.
- Figure 3b.—The same specimen. A group of abactinal paxillæ and papular pores from the basal radial region of a ray, including the median row (*c*, *c*). \times about 6.
- Figure 4.—*Pseudarchaster ordinatus* Ver. Type. Actinal side of part of the basal area of a ray and disk, showing four fascioles. $\times 5\frac{1}{2}$.
- Figure 4a.—The same specimen. A jaw and the adjacent parts, showing seven pectinate fascioles (*p*).
- Figure 4b.—The same specimen. A group of abactinal plates and papular pores from the base of a ray, including the median row of plates (*c*, *c*).
- Figure 5.—*Pseudarchaster hispidus* Ver. Actinal side of the basal part of a ray. $\times 7$.
- Figure 6.—*Pseudarchaster granuliferus* Ver. Type. Actinal side of a part of the disk and basal part of a ray, showing a single pectinate fasciole (*p*).
- Figure 6a.—The same specimen. A group of abactinal paxillæ with granules removed. $\times 6$.
- Figure 7.—*Benthopecten spinosus* Ver. Abnormal specimen. One of the jaws (*j*) and interradial area, with lower marginal plates, showing a pair (*m*, *m*) in place of a single odd interradial plate. $\times 7$.
- Figure 7a.—The same specimen. A similar view of another jaw, having the normal odd interradial plate (*m*). $\times 7$.
- Figure 8.—*Sideriaster grandis* Ver. Type. Actinal side of a part of the middle of a ray. $\times 4$.
- Figure 8a.—The same. One of the adambulacral plates more enlarged. $\times 7$.
- Figure 8b.—The same specimen. One of the abactinal paxillæ. $\times 5\frac{1}{2}$.

ERRATA.

- Page 146, foot note, for *planus*, read *plana*.
- Page 148, line 24, for *obtusangula*, read *obtusangulus*.
- Page 149, line 21, for *granularis* read *granulare*.
- Page 158, line 4, for *abnormale*, read *abnormalis*.
- Page 161, line 7, for *australis*, read *australe*.