No. 4. — *Reports on the Results of Dredging, under the Supervision of* Alexander Agassiz, *in the Gulf of Mexico, and in the Caribbean Sea*, 1877–79, *and along the Atlantic Coast of the United States during the Summer of* 1880, *by the United States Coast Survey Steamer "Blake,"* Lieutenant-Commander C. D. Sigsbee, U. S. N., *and* Commander J. R. Bartlett, U. S. N., Commanding.

XVI.

Preliminary Report on the Comatulæ, by* P. Herbert Carpenter.

The *Comatula* collection of the Museum of Comparative Zoölogy, which has been intrusted to me for examination and description, contains a very large number of specimens from widely different localities. The majority of these were dredged in the Florida Straits and in the Caribbean Sea, under the auspices of the U. S. Coast Survey. There is also a foreign collection, which mainly consists of specimens obtained by the U. S. and N. P. Exploring Expeditions. Many of them are from localities that I had not previously known as the homes of *Comatulæ*, while others are merely additions to *Comatula* faunas already known to me at particular localities. Except in these respects the foreign collection presents no features of special interest.

The case is very different, however, with the collection obtained by the "Blake" in the Caribbean Sea. In one respect, indeed, — the number of duplicates, — it is superior to that made by the "Challenger." A few species occur not only in great numbers, but also at several localities; so that I have been able to study their range of variation in a more satisfactory manner than it has hitherto been possible for me to do in the case of any *Comatulæ* but the common *Antedon rosacea* and *Ant. Eschrichtii*. This opportunity has proved of immense value to me in every way; and I am convinced that continued investigation will reveal the existence of so many intermediate forms, that many types which now appear quite distinct will prove to be specifically identical. This has, in fact, been the case with two of the species described by the late

* A few species obtained by the U. S. Coast Survey steamers "Corwin," "Bibb," and "Hassler" are also considered in this Report.

Mr. Pourtalès, which I have been compelled to unite under one name, together with three other forms that seemed at first sight quite distinct both from one another and from the two species of Mr. Pourtalès.

The importance of the collection made by the "Blake" in the season 1878–79 may be gathered from the fact that it contains nearly three times the number of species previously known as inhabiting the Caribbean Sea. Under the general name of *Antedon* Mr. Pourtalès had described five species of *Antedon* and four of *Actinometra*, which were obtained by the U. S. Coast Survey steamers "Corwin," "Bibb," and "Hassler," in 1867–72, and by the "Blake" in 1877–78. During a visit to the principal European museums, in the autumn of last year, I examined nine West Indian *Comatulæ*, including six species of *Actinometra* and three of *Antedon*. I believe a few of them to be identical with some of the species of Mr. Pourtalès.

Hence, before I commenced work on the "Blake" collection from the Caribbean Sea, I was acquainted with less than twenty species of *Comatulæ* from that area. Pending the completion of my memoir on the *Comatulæ* of the "Challenger" Expedition, I am unable to give the "Blake" collection the critical attention which is more than ever necessary on account of the number of duplicates which it contains. But so far as I can judge at present, it includes nearly forty new species, besides most of those from the same region which were already known to me. Altogether, therefore, I should estimate that the number of *Comatula* species now known to inhabit the Caribbean Sea is about fifty-five, nearly three quarters of which were first obtained by the "Blake" Expedition of 1878–79.

Comatulæ were dredged at fifty-seven out of the two hundred stations occupied during this season's work. Nearly all of them were in comparatively shallow water, i. e. in depths less than 200 fathoms. On three occasions only did the depth exceed 300 fathoms; viz. Nos. 150, 151, and 222, the depths being 373½, 356, and 422 fathoms respectively; and the *Comatulæ* obtained at these stations represent new and very singular types. The remarkable form *Atelecrinus* (nov. gen., Figs. 1–7) was met with at each station; and at No. 222 the unique specimen of *Antedon columnaris* (n. sp.), which is represented in Fig. 8, was also obtained.

These facts agree very well with the results of the "Challenger" dredgings,* which only yielded *Comatulæ* at twenty stations where the

* Preliminary Report upon the *Comatulæ* of the "Challenger" Expedition. Proceedings of the Royal Society, No. 194, 1879, pp. 383–386.

depth exceeded 200 fathoms. One may fairly conclude, therefore, that these animals are essentially inhabitants of shallow water. There is, however, in one respect a considerable difference between the results of the "Blake" and "Challenger" Expeditions.

The "Challenger" species of *Actinometra* were nearly all obtained at depths of less than 20 fathoms, the genus occurring at only one station where the depth exceeded 100 fathoms. In 1878–79, however, the "Blake" dredged *Actinometra* 3 times at 7 to 50 fathoms, 10 times at 50 to 100 fathoms, 25 times at 100 to 200 fathoms, and 4 times at 200 to 300 fathoms, making in all 42 stations; while *Antedon* was only met with at 34 stations, at all but four of which the depth was less than 200 fathoms.

As might be expected from the above facts, *Actinometra* is not only represented by a larger number of species than *Antedon*, but it is also individually more abundant. *Comatulæ* were especially plentiful at four stations, viz. Nos. 155, 203, 262, and 269; and at all but the last *Actinometræ* were the most numerous, both specifically and individually. In fact at Station 203 no *Antedon* was obtained at all, though at least six species of *Actinometra* were met with.

There are several points of difference between the general *facies* of the "Blake" and of the "Challenger" collections respectively, which supplement one another in a very interesting manner. The great peculiarity of the Caribbean fauna is the abundance of ten-armed *Comatulæ* representing both the principal genera. About two thirds of the *Antedon* species and three fourths of the *Actinometræ* belong to this simple type; while in the remaining species the rays rarely divide more than twice, and in two species only is there a fourth division. In this respect the contrast with the *Comatula* fauna of the Eastern seas is very marked. Ten-armed forms of both genera are there decidedly in the minority, especially of *Actinometra*, in which genus the rays may divide as often as seven times, so that the number of arms falls very little short of two hundred.

The "Blake" collection from the Caribbean Sea may be fairly compared with that made by the "Challenger" in cruising from Cape York through the Banda and Arafura Seas to the Philippine Islands, and thence southwards to the Admiralty Islands. About seventy species were collected from this area, nearly all from depths less than 150 fathoms. The numbers of *Antedon* and *Actinometra* species are about equal, but while half of the former are ten-armed, only three *Actinometræ* are equally simple. These three species all agree in having the second

and third radials united by syzygy, and also a syzygy in each of the first two brachials, as in *Act. solaris.*

This area averages about 10° farther south than that of the "Blake" dredgings, and it is possible that the greater vegetative development of its *Comatulæ* may be due to the higher temperature of the shallower water from which they were obtained.

Although three fourths of the *Actinometra* species from the Caribbean Sea are ten-armed, there is not one among them that recalls the *Act. solaris* of the Eastern seas, in which the second and third radials are united by syzygy, and each of the first two brachials is a syzygial or double joint. All the ten-armed *Actinometræ* of the West Indies belong to a type which is but slightly represented in the Eastern hemisphere, viz. that of *Act. meridionalis.* In this type, as in every *Antedon* that I have yet examined, the second and third radials are articulated together by a vertical ridge on each of their apposed faces, at the sides of which are large masses of ligament, but no muscular bundles. The first syzygy in the arms is on the third brachial, while the first and second brachials are articulated together in the same manner as the second and third radials, instead of forming a syzygial or double joint, as in *Act. solaris.* Nearly all the ten-armed *Actinometræ* in the Eastern hemisphere belong to the *solaris* type. The only exceptions known to me are *Act. Cumingii* Müll. sp., from Malacca, and two or three undescribed species from China, Japan, and Sumatra. Even among the "Blake" *Comatulæ*, in which the rays divide more than once, there is very little variety of type. Either there are two distichals united by ligament, or three, of which the axillary has a syzygy, the former case being the more frequent; and in six out of the nine species in which the rays divide a third time, there is only one joint between the distichal and palmar axillaries, to the latter of which it is united by ligament.

On the other hand the Eastern *Comatulæ*, with about the same number of arms (11–40), present several well-marked varieties of type, according to the number of joints in the primary and secondary ray-divisions and their modes of union.

Of all the *Antedon* species dredged by the U. S. Coast Survey, that with the widest range within the Caribbean Sea is the little ten-armed *Ant. Hagenii*, Pourt.* It was obtained by the "Blake" on the Yucatan Bank, and also at various stations between Dominica and Grenada, at different depths between 75 and 291 fathoms; while Mr. Pourtalès dredged it in great abundance at several localities in the Florida

* Bull. Mus. Comp. Zoöl., Vol. I. Nos. 6, 11; Vol. V. No. 9, p. 214.

Straits. The original type specimens were obtained off Sand Key, and several individuals from Barbados and Grenada differ so much both from them and from one another, that I was at first inclined to regard them as representing two new species; but a more careful examination did not confirm this impression. There are, however, three distinct species besides the type, to which the name *Ant. Hagenii* has been given. The specimens sent to the Museums at Edinburgh and Copenhagen under this specific name do not belong to the genus *Antedon* at all, but are varietal forms of *Actinometra meridionalis* A. Agass. sp.; and among the large number of individuals of *Ant. Hagenii* from the Florida Straits I found a few examples of two entirely new *Antedon* species. One of them is distinguished by having enormous lancet-like processes on the lower joints of its oral pinnules; while the other is a very exceptional type, with no pinnules at all upon the second and third brachials, though those of the other arm-joints are developed as usual. This is a singular condition, which occurs but rarely among the *Comatulæ*. The "Challenger" dredged a specimen near the Philippine Islands which presents the same peculiarity, and another in which the large pinnule on the second brachial is present as usual, but that on the third brachial is undeveloped, though those of the fourth and succeeding arm-joints are perfectly normal. Except in the remarkable type *Atelecrinus* (Figs. 1, 2, 7), which has no pinnules at all upon the ten or twelve lower arm-joints, these are the only *Comatulæ* I have ever met with in an examination of several hundred individuals that present any departure from the ordinary pinnule arrangement.

At Station cccxi. of the "Blake" dredgings in 1880, on the Atlantic coasts of the United States, a small ten-armed *Antedon* was found to be very abundant. It was doubtfully referred by Mr. Agassiz* to *Ant. Sarsii*, which species was obtained by Mr. Verrill, somewhat later in the season, at several localities off the northern coasts of New England.† I have carefully compared the "Blake" specimens with a Norwegian example of *Ant. Sarsii*, which I owe to the kindness of Prof. G. O. Sars, and also with the two specimens obtained by H. M. S. "Porcupine" in 1869, at two stations in the "cold area" of the North Atlantic.

All the specimens agree in their general characters, and must certainly be united under one specific name; but they differ considerably among themselves while corresponding fairly well with Müller's description of

* Bull. Mus. Comp. Zoöl., Vol. VI. No. 8, p. 150.

† Notice of the Remarkable Marine Fauna occuping the Outer Banks off the Southern Coast of New England. American Journal of Science, Vol. XX. p. 401.

Ant. Sarsii. Both the American and the "Porcupine" specimens are larger and more stoutly built than any Scandinavian ones that I have ever seen. This is especially the case with the American specimens, which have a considerable resemblance to some forms of *Ant. Hagenii.* But the characters of the oral pinnules are entirely different in the two species. Although the number of their component joints may be the same, about 25, their dimensions are very different. In *Ant. Sarsii* the lower joints of the oral pinnules are clear and glassy, and remarkably long, their length being four or five times their width; while in *Ant. Hagenii* the joints are more opaque, and also shorter and thicker, their length rarely exceeding twice their width. Both species agree with *Ant. rosacea* and *Ant. celtica* Barrett, sp., which is identical with *Ant. phalangium* Müll. sp., in the absence of any basal star in connection with the rosette, such as is found in every other species of *Antedon* or *Actinometra* the calyx of which I have been able to dissect.*

I have pointed out above that four distinct types of *Comatulæ* have hitherto passed under the name *Ant. Hagenii.* In like manner the specific designation *meridionalis*, given by Mr. Agassiz † to a ten-armed *Comatula* which has long been known from the coast of South Carolina, has been applied to almost every specimen with ten arms and an eccentric mouth, and even in two cases to forms with more than ten arms, owing to some of the rays forking twice. All of these are true *Actinometræ* with combed oral pinnules,‡ and the name *Antedon meridionalis* must therefore be exchanged for *Actinometra meridionalis* A. Agass. sp.

Among the many individuals sent to me under this specific name, there are at least four distinct types. Mr. Pourtalès § seemed to think that the species varied considerably with age, "older and larger specimens looking so much more massive than the young, that they at first sight appear like different species, although the usual specific characters agree." But almost all the characters given by him in his specific description ‖ apply equally well to every ten-armed *Actinometra* which has no syzygy in the radials or lowest brachials, including those of the Eastern seas, such as Müller's species *Act. Cumingii* and also *Act. echinoptera* (loc. ?), which are nevertheless perfectly distinct from *Act. meridionalis* and from one another. Under these circumstances the

* On the Genus *Actinometra* Müll. Trans. Linn. Soc., Sec. Series, Zoölogy, Vol. II. pp. 96–100.

† Seaside Studies in Natural History, p. 121.

‡ *Actinometra*, loc. cit., pp. 20, 28.

§ Bull. Mus. Comp. Zoöl., Vol. V. No. 9, p. 214.

‖ Ibid., Vol. I. No. 11, p. 355.

specific name *meridionalis* must be restricted to the type from South Carolina, on which it was originally conferred. The only example of this type which has reached me is too imperfect for a satisfactory specific diagnosis to be framed upon it. It is valuable, however, for having two Pentacrinoids entangled in its cirrhi, to which I shall refer immediately. I am inclined to agree with Mr. Pourtalès in thinking that the specimens from French Reef (1869) belong to the same type, and also those obtained by the "Hassler" off Cape Frio. The latter certainly constitute a strongly marked variety (as indicated by him on his labels), which differs from the French Reef specimens in the characters of the cirrhi, and especially in the relative proportions of the lower pinnules. I have dissected the calices of both, and find them to be so very similar that the differences between them can hardly be regarded as due to anything more than local variation. The radials of the French Reef specimens are relatively higher and slightly more sloping than those of the Cape Frio variety; but were these calices fossil specimens I should have much hesitation in referring them to different species. There is another structural character that I shall mention later on as common to certain examples from both localities. It is therefore of some importance as tending to indicate their specific identity.

Lütken has given the MS. name *Antedon brasiliensis* to a ten-armed *Comatula* which is abundant on the coast of Brazil. It was described by Mr. Pourtalès* as answering "to the description of the *Comatula carinata* Lamk. (Leach. sp.)" from Mauritius, and as differing only in some minor details from Zanzibar specimens of *Ant. carinata*. Rathbun has spoken to the same effect,† and though I was at first inclined to follow Lütken in separating the two types, further study has led me to believe in their specific identity. By the kindness of Prof. Möbius, of Kiel, I have been enabled to examine specimens of *Ant. carinata* from Mauritius. This is the original locality of Müller's type specimens, which Prof. E. von Martens courteously permitted me to study in the University Museum at Berlin. I have also seen specimens from Chili, Madagascar, St. Helena, the Seychelles, the Red Sea, and Aden, and find it impossible to separate them specifically. This conclusion is confirmed by the resemblance between the dissected calices of specimens from Bahia and Zanzibar. They are so very similar that, if they were fossils, I should unhesitatingly refer them to the same species. In fact, the Bahia specimens vary considerably *inter se*, and there is less like-

* Bull. Mus. Comp. Zoöl., Vol. V. No. 9, p. 214.

† A List of the Brazilian Echinoderms. Trans. Connect. Acad., Vol. V. p. 156.

ness between two calices from this locality than between one of them and a calyx from Zanzibar. *Ant. carinata* is described by Rathbun as probably ranging along the Brazilian coast from Rio Janeiro to Pernambuco. It was not obtained by the "Blake" at all; but it was found in abundance by Captain Cole, of the "Investigator," in 278 fathoms, off St. Lucia, so that it may fairly be considered as belonging to the Caribbean fauna.

The two *Comatulæ* which appear from their abundance to be especially characteristic of the neighborhood of the Caribbean Islands, ranging from Santa Cruz to Grenada, are an *Antedon* and an *Actinometra*, both of which had been obtained previously to the "Blake" Expedition of 1878–79. In the year 1870, M. Duchassaing brought from Guadeloupe to the Paris Museum a fine specimen of *Antedon*, with thirty very spiny arms. Prof. Perrier having kindly permitted me to examine this type and to make a note of its characters, I readily recognized it in the "Blake" collection, and propose to name it *Ant. spinifera*. It was obtained by the "Blake" (1878–79) at ten stations, in depths of from 80½ to 297 fathoms. It was most abundant at No. 269, in 124 fathoms, off St. Vincent, and was also dredged in 278 fathoms, off St. Lucia, by the "Investigator." Its more striking distinctive characters are as follows: —

Antedon spinifera n. sp.

Cirrhi 12–20, long and slender, composed of 40–60 joints, the later ones of which bear dorsal spines. The rays may fork four times, each subdivision consisting of two joints not united by a syzygy. Usually, however, there are not more than two axillaries, the distichal and the palmar, above the radials; and palmars are frequently only developed upon the inner pair of the four secondary arms, so that there are thirty arms in all (as in the Paris specimen), viz. six on each ray, in the following order: 1, 2, 2, 1. Tolerably large sharp spines are scattered irregularly over the calyx and arm-bases. The arm-joints are triangular in outline, alternating with one another from side to side; and from near the base of each triangular surface there rises a strong curved spine, which projects forwards and slightly outwards. On the lower parts of the arms, therefore, there is a double row of these spines alternating right and left of the median dorsal line; but farther out, as the joints become more and more compressed laterally, the two rows gradually coalesce into a single median one, the spines at the same time becoming less and less prominent. The disk bears a fairly complete anambulacral plating, and there is a double row of plates along each edge of the pinnule ambulacra, viz. side plates resting on the pinnule joints and supporting the covering plates which overlap one another alternately from opposite sides. The color varies from almost white through pale straw-

color to a light yellowish brown. The diameter of the disk is 6 or 7 millimeters, and the spread of the arms about 20 centimeters.

The common *Actinometra* of the Caribbean Sea is a singularly protean species, which was obtained at twenty-nine stations during the "Blake" Expedition of 1878–79, and once in the previous season. The "Hassler" dredged it off Barbados; and it was found by the "Investigator" at the station already mentioned off St. Lucia, and also on the Martinique and Dominica cable. It ranges from 73 to 278, and possibly to 380 fathoms. Not only is it everywhere very abundant, but it presents a most remarkable series of minor variations on one fairly distinct type, to which I must refer the two forms named *Antedon alata* and *Ant. pulchella* respectively by the late Mr. Pourtalès.* These two forms seemed to me at first sight to represent entirely distinct species; but I have felt obliged to unite them both with one another, and with four others also apparently distinct at first sight. In naming this type I prefer to use the second of the two specific designations employed by Mr. Pourtalès, viz. *pulchella;* for the other, *alata*, refers to a character which, though very marked in some individuals, is barely traceable in others. Generally, the type is a true *Actinometra*, with eccentric mouth and combed oral pinnules; though Mr. Pourtalès gave the name *Antedon* to both his species, the two genera not being so distinctly differentiated at the time he wrote as they are now. Most of the specimens have 20 arms, or perhaps one or two less; some, however, have as few as 12–15, and there is so little difference between them and a few ten-armed individuals occurring at the same localities that I do not think the latter can be regarded as a separate species. A small *Antedon* which is tolerably abundant at five stations exhibits the same variability, and I have met with a few similar cases in the "Challenger" collection. As a rule, however, ten-armed *Comatulæ* are sharply distinguished from those in which the rays divide more than once. *Act. pulchella* is also interesting as furnishing the third instance which I have met with of a variation from the ordinary type of five rays.† One specimen, like one dredged by the "Challenger," has six rays; while another "Challenger" specimen has but four, though in other individuals of each species there is the usual number of five rays. It is curious that this variation, which is common in *Rhizocrinus*, should be so rare among the *Comatulæ*.

The special characters of this species are as follows: —

* Bull. Mus. Comp. Zoöl., Vol. V. No. 9, pp. 215, 216.

† Proc. R. S., 1879, p. 385.

Actinometra pulchella Pourtalès sp.

Cirrhi 15–20, of 15–18 joints; the fourth or fifth is the longest, and the following ones gradually develop a blunt spine on the dorsal side. Two radials only visible; the axillary short, wide, and almost triangular. 10–20 arms, most of the rays usually dividing twice, the first division (distichals) consisting of two joints which are not united by syzygy. When the arms spring directly from the radial axillary, the two lowest brachials are united by ligament, as in most *Comatulæ*, and the third is a syzygial or double joint. But in all the arms which spring from a distichal axillary, the two lowest brachials are united by syzygy to form a double joint; and the true third brachial, which is also a syzygial joint, as in all *Comatulæ*, thus becomes the second arm-joint, as in *Act. solaris*.* The position of the next syzygy may be anywhere between the 12th and 20th joints, after which there are usually intervals of three or four joints between the successive syzygia. The lower arm joints are sharply wedge-shaped, alternating from side to side, the later ones gradually becoming blunter. In some specimens the dorsal surface of the arms is unusually smooth, the joints not overlapping in the slightest degree; but in others the lower parts of the arms, about as far as the 25th joint, are exceedingly rough. The distal edge of each joint is raised on the side next the pinnule into a high, somewhat recurved plate, with more or less serrated edges. This is largest about the 15th joint and gradually decreases in prominence, the joints after the middle of the arm being quite smooth.† The arms of most individuals, whether rough or smooth, are bordered throughout their whole length by a lateral expansion of the ventral perisome, which embraces the lowest joints of the pinnules.‡ The first pinnules of the arms are rather long, with well-marked terminal combs. The length gradually decreases till about the 10th brachial, and then begins to increase, but there is no specially small pinnule. The terminal comb may continue as far as the 10th brachial, or cease four or five joints sooner. The pinnule joints may be almost smooth, or they may have strong projections towards the dorsal side, even to far out on the arms.

* This peculiarity is a very marked one. In no case have I found a syzygy in the first joint of any arm springing from a radial axillary. The ten-armed forms thus belong to the type of *Act. meridionalis*. But individuals with 12, 13, 15, etc. arms are by no means rare, and furnish a complete transition to the large examples with 20 arms to which the specific designation (*pulchella*) by Pourtalès is strikingly applicable.

† This character is especially distinct in the *Ant. alata* of Pourtalès from Barbados, and in several specimens, both ten- and twenty-armed, from Station 269 (St. Vincent). In other individuals from this station, as in those named *Ant. pulchella* (Pourtalès), the arms are perfectly smooth throughout their whole length.

‡ This is the character which led Pourtalès to give the specific name *alata* to certain individuals dredged by the "Hassler" at Barbados, in which it is especially marked. It occurs also, though less distinctly, in the original specimens of *Ant. pulchella*. I find it to be a very variable one, even among the different arms of the same individual, some of which are webbed and others not.

The mouth is radial, and the disk either bare or more or less covered with irregular calcareous concretions. Its diameter, in large specimens, is 12 or 15 millimeters, and the spread of the arms is about 25 centimeters. The color (in alcohol) varies greatly, — white, straw-color, and brown, either alone or more or less mixed with a dirty lilac.

The results of my examination of the "Challenger" and "Blake" collections, and of the numerous *Comatulæ* to which I had access in the various European museums last autumn, entirely confirm and extend the conclusions to which I had been previously led respecting the separation of *Antedon* and *Actinometra* as distinct generic types.* A glance at the skeleton is sufficient to enable me to distinguish the genus; and it is even possible to determine the genus of a mere arm fragment, or in fact of a single pinnule. For the problematical red spots (sacculi) at the sides of the ambulacra which have puzzled all the workers on *Antedon* are entirely absent in *Actinometra*. They are much more abundant in some *Antedon* species than in others, but they are always to be found by careful examination. They are also present in *Ophiocrinus*, *Promachocrinus*, *Pentacrinus*, *Rhizocrinus*, *Bathycrinus*, and *Atelecrinus*, all of which are types with a subcentral mouth. But I have never yet met with them in *Actinometra*, though some specimens of *Act. pulchella* seemed at first sight to be exceptions to this rule. Microscopic examination showed, however, that the appearances are due to irregular aggregations of brown pigment at the sides of the ambulacra, which are altogether different from the vesicular sacculi that are so puzzling in *Antedon* and in the other genera mentioned above.

On the other hand, there are certain structures which are peculiar to *Actinometra*, though far from being as universal in their occurrence as the sacculi are in *Antedon*. I allude to the brown cellular bodies which I have supposed to be sense-organs. I found them first in some specimens of *Act. polymorpha* from the Philippines,† and have since detected them in two of the "Challenger" species, also from the Eastern seas. They are confined almost exclusively to the middle and later pinnules of the ungrooved hinder arms, each one occupying the dorsal half of a pinnule segment just beneath its calcareous axis. There are several individuals in a very large collection of *Act. meridionalis* obtained at French Reef in 1869, which exhibit this peculiarity in a very marked degree. It also occurs in a few individuals of the Cape Frio variety of this species, and

* *Actinometra*. Trans. Linn. Soc., Sec. Ser., Zoöl., Vol. II. pp. 17–20, 81, 82. — Quart. Journ. Geol. Soc., Vol. XXXVI. pp. 41–43. — Proc. R. S., 1879, p. 394.

† *Actinometra*. Trans. Linn. Soc., Sec. Ser., Zoöl., Vol. II. p. 40, Pl. II. Fig. 6.

is therefore of some importance as tending to indicate the specific identity of the examples from these two localities. In most specimens the spots are confined to the pinnules of the hinder arms, sometimes to one or two arms only; but in one case I found them on all the arms except the two immediately adjoining the mouth. As a general rule, the arms distinguished by their presence are of the ungrooved type, to which I have already called attention.* In some specimens the dimorphism of the arms is exceedingly marked, just as in *Act. polymorpha*. The anterior arms are long, slender, and composed of many joints bearing similar long and slender pinnules; while the hinder arms are shorter, fewer-jointed, and much more fleshy, with stouter pinnules, in which the genital glands are better developed than in the pinnules of the anterior arms. These are grooved and tentaculiferous, while the hinder arms have no ambulacral groove nor tentacles, and the pinnules are usually spotted with the "sense-organs." These may occur in *Act. meridionalis* as early as the 10th pinnule of the arm, while in *Act. polymorpha* I have rarely found them lower than the 25th pinnule.

In *Act. meridionalis*, as in all species of which I have been able to examine any considerable number of individuals, the presence of ungrooved arms and of "sense-organs" is altogether inconstant and irregular. But though it is in this way merely a potential character, it is one which is peculiar to *Actinometra*, and is therefore of some systematic value. On the other hand, there is a similar potential character, which so far as I have yet seen is peculiar to *Antedon*, though it appears to be constant in *Pentacrinus*. This is the existence of a complete calcareous plating at the sides of the ambulacra on the arms and pinnules. Many of the *Antedon* species dredged by the "Challenger" in the Pacific resemble *Pentacrinus* in having a very complete anambulacral plating on the disk;† while there is a double row of plates along each side of the ambulacra of the arms and pinnules, especially of the latter. The side plates rest on the pinnule joints and support the covering plates, which can be made to overlap one another from opposite sides so as to close in the groove completely.‡ Several of the "Blake" *Antedons*, including *Ant. spinifera*, exhibit these peculiarities better than some *Pentacrinus* species do. But I have never yet found them in any *Actinometra*. There are many species, such as *Act. pulchella* and *Act. granulifera* Pourt. sp.,

* *Actinometra*. Trans. Linn. Soc., Sec. Ser., Zöol., Vol. II. pp. 31–41, Pl. II. Figs. 3–6. — Popular Science Review, N. S., Vol. IV. pp. 195, 199, Pl. VI. Figs. 1, 2.

† Proc. R. S., 1879, pp. 388, 389.

‡ Popular Science Review, N. S., Vol. IV. pp. 195, 196, Pl. VI. Figs. 10, 12.

in which there is a considerable amount of anambulacral plating in the anal area; but it is usually rather of the nature of an aggregation of tubercles than of a regular pavement of plates, and I have never met with it so completely covering the disk and extending out on to the arm bases and lower pinnules as it does in *Antedon*. The species in which I have found it to reach its greatest development is a large one which is common at Cape York, and is probably identical with *Act. robusta* Lütken, MS. The plating supports the sides of the ambulacra on the disk and occupies the intervals between them, the plates immediately adjacent to the grooves being extensively pierced by the water-pores. The plating ceases, however, just within the circumference of the disk, so that the perisome of the arms and pinnules is perfectly bare, just as in the common *Antedon* species which inhabit the North Atlantic. This entire absence of side plates and covering plates on the arms and pinnules of *Actinometra*, even in species which have a strongly plated disk, is a very singular peculiarity, and one which I am quite unable to explain.

The principal differences between *Antedon* and *Actinometra* are conveniently summarized in the subjoined table.

Antedon.	*Actinometra*.
Disk with central or subcentral mouth and five equal ambulacra.	Disk with eccentric mouth and a variable number of unequal ambulacra, at least two of which enclose the anal area in a horseshoe-shaped curve.
Oral pinnules not specially distinguished.	Oral pinnules have terminal combs.
All the arms equal in length, grooved, and tentaculiferous.	Some of the hinder arms may be much shorter than the rest, ungrooved, and non-tentaculiferous.
Red spots (sacculi) always present at sides of the ambulacra.	Sacculi wanting.
"Sense organs" wanting.	Brown spots (sense organs?) may be present on the dorsal side of the pinnule segments, mostly in the ungrooved hinder arms.
Pinnule ambulacra may be protected by side plates and covering plates.	Pinnule ambulacra (when present) unprotected by plates.
Cirrhi many, sometimes very numerous, and more or less covering the under surface of the hemispherical, conical, or columnar centrodorsal.	Cirrhi few in number, and almost entirely limited to the margin of the discoidal centrodorsal.
Outer faces of radials relatively high, with large muscle plates, and much inclined to the vertical axis of the calyx.	Outer faces of radials relatively wide, with small muscle plates, and nearly or quite parallel to the vertical axis of the calyx.

I have mentioned above that two Pentacrinoids were entangled in the cirrhi of the type specimen of *Act. meridionalis* from Charleston. They presumably belong to that species, and are therefore interesting as being the first *Actinometra* Pentacrinoids that I have seen. The smaller one is at about the stage represented at Fig. 1. B on Plate XXXIX. of Dr. Carpenter's memoir on *Ant. rosacea;* * while Fig. 1. C on the same plate, and Fig. V. on Tab. V. of Sars's "Crinoïdes Vivants," † correspond to the condition of the larger specimen, which has seven arm-joints beyond the radial axillaries. The oral plates of the former are plainly visible, but in the latter it is difficult to make out the condition of the disk. The radials, however, are broader and more closely united than in the corresponding stage of *Ant. rosacea*, and their superolateral angles are much less truncated. The basals form a closed ring, and the centrodorsal is scarcely larger than the stem-joints immediately below it. Five of these are short and discoidal, and the next joint much elongated. In both these respects the Charleston Pentacrinoids resemble *Ant. Sarsii* rather than *Ant. rosacea*. As in both these species the lower arm-joints do not bear pinnules at first, but, with the exception of the second brachial, do not acquire them until a much later developmental stage. Both in *Ant. Sarsii* and in *Ant. rosacea* the first pinnule appears on or about the twelfth joint of the growing arm; and it is not until some time later, after several pinnules have been formed towards the end of the arm, that any appear, even on the second brachial. In fact, the basal portions of the arms of *Ant. rosacea* remain without pinnules until after the development of ten cirrhi on the centrodorsal and its separation from the stem. But in *Ant. Sarsii*, which retains its stem until twenty or thirty cirrhi have appeared, all the lower arm-joints acquire pinnules before the close of the Pentacrinoid stage. So far as can be judged at present, this appears to be a somewhat exceptional condition; for I have found five other species besides *Ant. rosacea* in which the third and the following arm-joints do not develop their pinnules until some time after the loss of the stem. Thus a very young *Act. meridionalis* has a relatively large well-combed pinnule on the second brachial, and another fairly large one on the eighth brachial. The intervening joints have small or poorly developed pinnules, that of the fifth brachial being either a mere stump or absent altogether. In a young *Antedon* from Station 231 the 7th to the 9th arm-joints have no pinnules. A young example of another species of the same genus (locality unknown) has a large pinnule on the

* Philosophical Transactions, CLVI., 1866.

† Mémoires pour servir à la Connaissance des Crinoïdes Vivants. Christiania, 1868.

second brachial, and a small stump on the third. Neither the 4th nor the 5th joint has a pinnule at all, but there are small ones on the 6th and 7th joints, and a larger one on the 8th, which was probably the first pinnule to appear at all.

I have sometimes found that the different arms of the same young individual have reached different stages of development. Thus, in a young *Antedon* from station 232, one arm has large pinnules on the 2d and 16th joints, smaller ones on the 3d to the 6th, and mere stumps on the rest of the intervening joints. On other arms, however, there are no pinnules at all between the 4th and the 15th joints. Again, in a young *Ant. phalangium* from the Mediterranean, some arms have no pinnules at all between the 2d and 10th joints; while in one arm there are pinnules on 2, 4, 6, and 10, but none on 3, 5, 7, 8, or 9. This would seem to show that, when the basal pinnules of this species do begin to appear, the first-comers are those borne by the even-numbered joints on the outer side of the arm.

Hence, whatever be the order of succession of these basal pinnules *inter se*, there is good reason to believe that their late appearance as a whole is a marked developmental character among the *Comatulæ*. This is a point of some importance, as will be seen immediately.

During the Gulf Stream Expedition of 1869, Mr. Pourtalès dredged two small ten-armed *Comatulæ* in 450 fathoms, off Cojima, on the coast of Cuba. They were described by him under the name of *Antedon cubensis*;* but the description given by him only applies to the larger and more perfect specimen, which differs considerably from the smaller and much mutilated one. Mr. Pourtalès seems to have recognized that the two were different, for in his description † of the Crinoids obtained by the "Blake" Expedition of 1877–78, he wrote as follows: — "To this species (i. e. *Ant. cubensis*) I refer provisionally two specimens very much mutilated, having lost the cirrhi and the arms, differing somewhat from my type specimen, but possibly the differences may be due to age." He then described a specimen dredged at Station 43, in 339 fathoms (to which I shall refer directly), and added that a smaller, equally mutilated one had been previously dredged by himself in 450 fathoms, near Havana (Fig. 7).

These two specimens are quite different from the type of *Ant. cubensis*. Not only are the first radials visible and the second but little shorter than broad, as was mentioned by Mr. Pourtalès, but the first radials are

* Bull. Mus. Comp. Zoöl., Vol. I. No. 11, p. 356.

† Ibid., Vol. V. No. 9, pp. 214, 215.

separated from the centrodorsal by a complete circlet of basals, and there are no pinnules upon any of the first six arm-joints, which are the only ones preserved. An equally mutilated specimen was dredged by the "Challenger" in 350 fathoms, near Pernambuco, and more perfect ones were obtained off Nevis, St. Lucia, and Grenada during the cruise of the "Blake" in 1878–79 (Stations 150, 151, 222, and 260, depths 291–375 fathoms). In most individuals the first pinnule is borne by the 12th arm-joint (Figs. 1, 2), but in one arm of one individual it occurs as early as the 10th joint. In no case, however, is there any pinnule on the second brachial.

This type is one of singular interest. With the exception of the doubtful genus *Comaster*,* no recent *Comatula* yet known retains its embryonic basals on the exterior of the calyx after the latter part of its existence as a "Pentacrinoid"; while there is no known *Comatula*, either recent or fossil, in which the basal circlet is complete, as it is in some *Pentacrini*,† and in the earlier stages of the Pentacrinoid larva.

As regards the characters of its calyx, therefore, this new *Comatula* may be considered as a permanent larval form. The absence of pinnules from the lower portions of the arms points to the same conclusion; and it is not a little singular to find these two larval characters (viz. a closed basal circlet and pinnule-less arm-bases) persisting in recent *Comatulæ*. The combination seems to me sufficiently remarkable to justify the establishment of a new genus, which I propose to call *Atelecrinus*.‡

The original specimen from Cuba (Fig. 7) is so different from those obtained later (Figs. 1, 3), that it should, I think, be regarded as a distinct species, and may retain the name *cubensis*, originally conferred upon it by Mr. Pourtalès. The other species I propose to name *balanoides*, in allusion to the peculiar form of its centrodorsal (Figs. 1, 3), which was well described as acorn-shaped by Mr. Pourtalès. It may be as much as 5 mm. long by $3\frac{1}{2}$ mm. in diameter, and bears five double rows of cirrhus-sockets, which are separated near its upper end by slight interradial ridges and do not quite reach the dorsal pole. Each socket has a horseshoe-shaped rim which is much more strongly marked in some specimens than in others. The arch of the horseshoe is directed upwards, and the two ends are frequently turned somewhat upwards and outwards, so that the surface of the centrodorsal has a very rough appearance. This is more marked, however, in *Atelecrinus cubensis* (Fig. 7).

* Journ. Linn. Soc. Zoöl., Vol. XIII. pp. 454–456.

† Ibid., Vol. XV. pp. 210, 213–215.

‡ ἀτελής, incomplete.

In none of the specimens are the cirrhi preserved entire. They are long and slender, consisting of 30+ joints, the lowest of which are quite short; but from the fifth or sixth onwards they are very long ($2\frac{1}{2}$ mm.) and tolerably equal (Fig. 1).

The extent of development of the basals varies with the size of the individual, apparently diminishing with age as in ordinary *Comatulæ*. In the smallest specimen they are wide but low pentagons, which fall away very rapidly from their interradial apices to the points where they meet one another beneath the radials. The middle of each basal rests on the top of one of the interradial ridges at the upper end of the centrodorsal (Figs. 4, 5), just as the basals of *Pentacrinus* rest on the upper ends of the interradial ridges of the stem. The pentagonal shape of the basals is still traceable in the slightly older specimens which are the originals of Figs. 1 and 3; but in still older ones, just as in the Pentacrinoid of *Antedon rosacea*, the amount of the first radials which is visible on the exterior of the calyx, becomes relatively less and less, and the same is the case with the basals. These are best described as triangular, with their lower angles extended so as just to meet those of their fellows and separate the radials from the centrodorsal by what is practically little more than a line, only visible at all under specially favorable conditions of light. In fact, I believe that even this is absent in parts of some of the specimens, the radials coming into partial contact with the centrodorsal just as in *Pent. asteria*.

The acorn-shaped centrodorsal of *Atelecrinus balanoides* is nearly as deep as it is high. The opening of its cavity has a narrow pentagonal rim, from the interradial angles of which strong ridges descend the sloping walls, diminishing in size as they approach the apex, where they die away without meeting one another (Fig. 5). The large openings of the cirrhus sockets are visible between them. Owing to the manner in which they project inwards, the centrodorsal cavity has a five-lobed shape, the re-entering angles between the broad but short lobes corresponding to the interradial ridges. The large upper ends of these ridges are somewhat hollowed, as are the lower surfaces of the basal plates which rest upon them (Fig. 4). When seen edgeways each of these plates has the form of a short triangular prism, with a flattened plate-like extension on each side (Figs. 6 *a*, 6 *b*). They are in complete contact laterally, so as to form an unbroken ring around the central opening of the calyx, which is not quite so large as is shown in Fig. 4; for it is encroached upon by excessively delicate processes that project inwards from near the lateral margin of each basal. Owing to their extreme

fragility, — the "rosette" of a small *Antedon* being massive in comparison, — I found it impossible to preserve them intact; but their position is indicated in Fig. 6 *b*.

There is nothing specially remarkable about the radials and the lowest arm-joints of *Atelecrinus*, but the arm-joints generally are somewhat peculiar in their characters. They are rather longer than in most *Comatulæ*, and have shallower bodies, while the muscle plates which rise from about the middle of each joint are unusually thin. There is, in consequence, a series of large gaps between the muscle plates of successive joints, which are occupied by correspondingly large muscular bundles (Figs. 1, 2, 7). These are not concealed from view by superficial perisome as they are in ordinary *Comatulæ;* but the food-groove lies close down upon and between the muscles, all the structures connected with it being very much reduced and contracted together, as I have sometimes found to be the case in *Ant. rosacea*. At the sides of the groove are a few scattered "sacculi" (Fig. 2). The pinnules which are borne by the twelfth and following joints are comparatively short and styliform, and are composed of ten or twelve elongated joints. Their ambulacra are more spotted with "sacculi" than those of the arms, and are fringed with tentacles, of which I have as yet found no traces on the arms.

The following are the chief points of difference between *Atelecrinus cubensis* and *A. balanoides*. In the former species (Fig. 7) the base of the centrodorsal is much wider relatively to its height than in the latter (Figs. 1, 3); the cirrhus sockets are more closely packed, and the points of their horseshoe-shaped rims more prominent; while the five processes at the ventral rim which support the basals are more strongly marked than in any specimen, large or small, of *Atelecrinus balanoides*. In correspondence with this feature, the shape of the basals is very different in the two species. In the little *A. cubensis* they form a kind of belt of tolerably uniform height with its interradial angles somewhat produced, which everywhere separates the first radials from the centrodorsal. The second radials are squarer, and the axillaries project rather more into them than is the case in *A. balanoides;* while the first brachials are relatively shorter, the second longer and projecting more into the first, and the three following joints also relatively longer than in the larger species.

Taking all these facts into consideration, I think it very probable that we are dealing with two distinct species. Although Pourtalès's original specimen (*A. cubensis*) is very considerably smaller than those obtained

more recently, its centrodorsal bears quite as many cirrhus sockets as theirs do, or even more. This rather indicates that it is not merely a premature form, as one might be inclined to regard it, owing to the relatively greater length of its arm-joints.

The peculiarities of *Antedon columnaris* are almost sufficiently obvious in Fig. 8. I can find no traces on its columnar centrodorsal of any sutures which would indicate its composition out of two or more anchylosed joints. In fact the alternating arrangement of its cirrhus sockets indicates the improbability of such an anchylosis. They are disposed in five double rows separated by interradial ridges, at the tops of which minute basals are visible, just as in *Pentacrinus asteria*. The lower end of the column is somewhat concave, but appears to be completely closed and devoid of any central perforation. The loose arms obtained with the calyx are rather large and massive, and resemble those of *Atelecrinus* in having the ambulacrum close down upon the top of the large muscular bundles.

In conclusion I may mention that many of the *Comatulæ* I have examined were the hosts of *Myzostomidæ*. The Gulf Stream dredgings of 1867–69 yielded these curious parasites at five stations. They were also obtained on the Yucatan Bank, and at two other localities during the "Blake" expedition of 1877–78, and at fourteen stations between Montserrat and Grenada in 1878–79. Twenty specimens were dredged at No. 269 (off St. Vincent), where *Comatulæ* were very abundant. Captain Cole's haul off St. Lucia also yielded one specimen, and I found another on the *Actinometra* sent to the Copenhagen Museum as *Antedon Hagenii*. The *Actinometra* brought from Yeddo by Prof. E. S. Morse also furnished an example. All the *Myzostomidæ* have been sent, together with those from the "Challenger" dredgings, to my friend, Prof. L. Graff, of Aschaffenburg, who has added so much to our knowledge of the European species.

Published October 1, 1881.

EXPLANATION OF THE PLATE.

Figs. 1–6. *Atelecrinus balanoides* nov. gen. & sp.

Fig. 1. The best specimen obtained (No. 151, off Nevis). The first pinnule visible is on the 13th brachial, that borne by the 12th brachial being on the opposite side of the arm, and therefore out of sight. × 4.

Fig. 2. Portion of an arm between the 10th and 18th joints, showing the absence of pinnules as far as the 11th joint (inclusive). × 4.

Fig. 3. Side view of the calyx of another specimen. × 8.

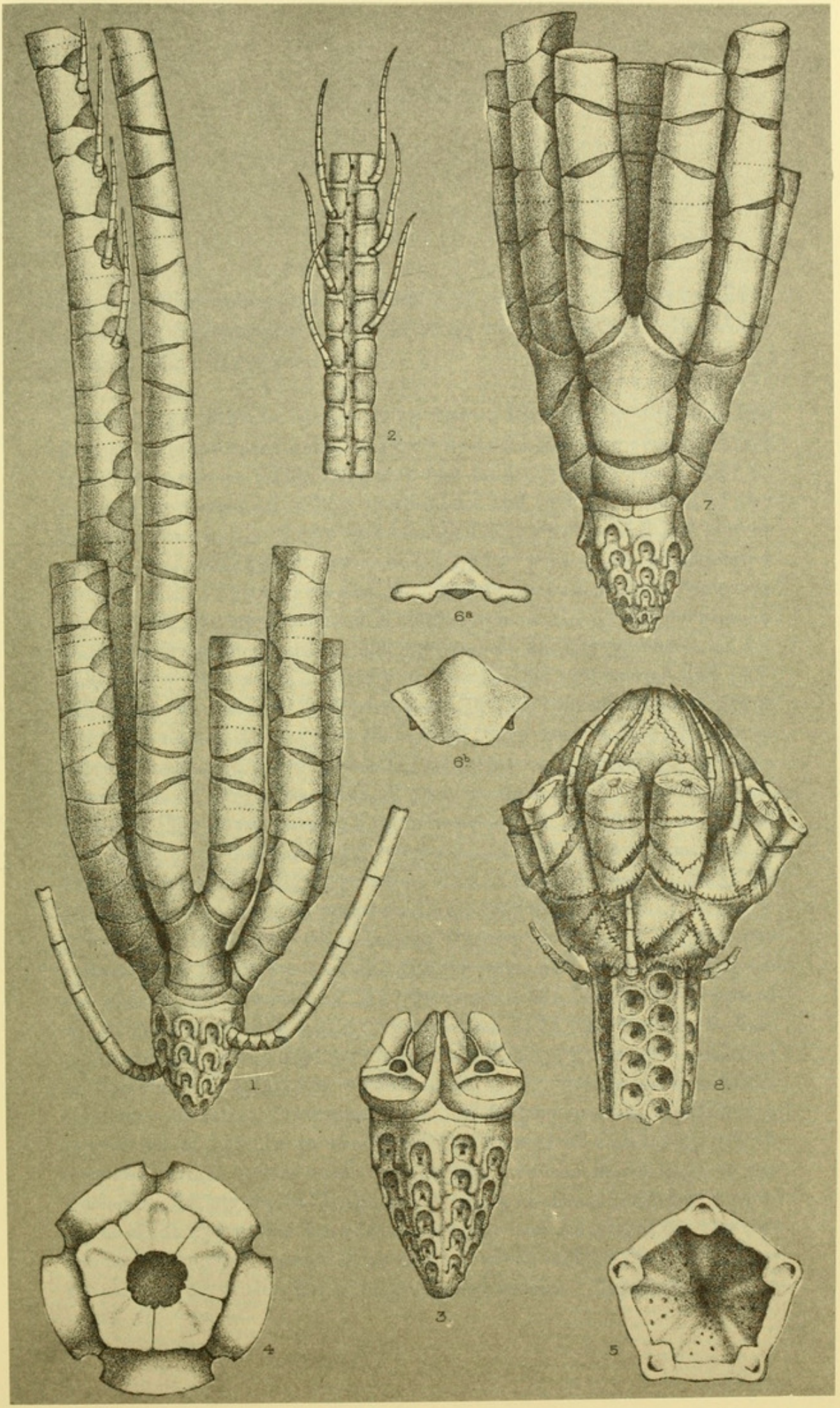
Fig. 4. Radials and basals from beneath. The minute processes at the central ends of the basals are omitted. × 10.

Fig. 5. The centrodorsal from above. × 10.

Fig. 6. A single basal (without its central processes). *a*. From the outer side. *b*. From above. × 14.

Fig. 7. *Atelecrinus cubensis*. Pourt. sp. A single specimen dredged by Mr. Pourtalès, in 1869, off Cojima, near Havana, in 450 fathoms. × 8.

Fig. 8. *Antedon columnaris* n. sp. No. 222, off St. Lucia. × 4.



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NEW CARIBBEAN COMATULAE

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