REPORT ON THE ACTINIANS OF PORTO RICO.

BY

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The collection of Actiniaria secured by the United States Fish Commission steamer *Fish Hawk* from around Porto Rico supplements in many ways the results of several recent writers on the West Indian Actinian fauna. Within the past few years Prof. J. P. McMurrich (1889, 1889*a*, 1896, 1898) has studied the Actinians of the more northern Bahamas and Bermudas, and also a few specimens from Cuba; Prof. A. E. Verrill (1898, 1899, 1900) has added several species to the Bermudan list and introduced certain changes in nomenclature and synonymy; I have recorded nearly 40 species from around Jamaica (1898, 1898*a*, 1900) and described the *Zoantheæ* and *Stichodactylinæ* more fully. Among older writers Lesueur (1817) described a number of species found mainly around the Lesser Antilles, but Duchassaing & Michelotti, in their "Mémoire sur les Coralliaires des Antilles" and "Supplement" (1860, 1866), first made known to any degree of completeness the peculiarities and richness of the Actinian fauna of this region. Dr. O. Carlgren (1900*a*) has recently had the opportunity of examining in Turin the Actiniarian collections of Duchassaing & Michelotti, and gives the relationship of several whose identity has been somewhat doubtful. The West Indian Actiniaria, including also those of the Bermudas, are now probably as well known as those of most areas, although owing to the incompleteness of the description of many of the earlier species, and the difficulties involved in the specific study of genera such as *Palythoa* and *Zoanthus*, many synonymic difficulties have been introduced.

With two exceptions the species represented in the *Fish Hawk* collections are such as occur in abundance in the shallow waters around Jamaica, and the majority are also recorded from the Bahamas and the Bermudas. One species, which I have named *Bunodosoma spherulata*, seems to be new, and such will probably be the case with a single specimen of *Cerianthus*. Already most of the others have been fully described and figured among the writings of the authors above mentioned, but in order to make the report more complete brief descriptions are again given, the details obtainable from the preserved material being supplemented by observations made on the living polyps elsewhere.

Before proceeding with the description of the species some remarks are necessary upon the great changes which the classification of the *Actiniaria* is at present undergoing. All the most recent researches on their anatomy and development indicate that the Actinians are divisible into three main groups—*Ceriantheæ*, *Zoantheæ*, and *Hexactiniæ*, and representatives of all these occur in the present collection. The subdivision is based upon the method of increase of the mesenteries beyond the primary pairs, the order being fundamentally different in the three groups, and leading to adult conditions of the highest significance in Actinozoan morphology.

Although the developmental evidence is not altogether complete, all the facts we possess point to the conclusion that the primary six pairs of mesenteries (Protocnemes) arise practically in the same manner throughout the *Hexactiniæ* and *Zoantheæ*, that is, as bilateral pairs (a corresponding mesentery on each side of the principal axis), first toward one aspect of the polyp, then toward the other. In the *Ceriantheæ* only four of the six pairs of protocnemes seem to be developed; the fifth and sixth pairs, which often remain incomplete in other *Actiniæ*, perhaps never appear. According to van Beneden (1897), however, the development of the primary mesenteries in the *Ceriantheæ* does not admit of comparison with that in the two other groups.

In the three divisions the later mesenteries (Metacnemes) are added in a manner differing altogether from that followed by the primary mesenteries, the method varying in each of the three groups. In the *Ceriantheæ* they continue to arise as bilateral pairs at what has been regarded as the dorsal aspect of the polyp; in the *Zoantheæ* they are added as unilateral pairs (that is, the two mesenteries of a pair are adjacent on one side of the axis) at two regions, one on each side of the sulcar directives, each pair consisting of a small and a large mesentery; in the *Hexactiniæ* new mesenteries beyond the protocnemes appear in unilateral pairs, within the primary exocœles of the protocnemes. In the last group they arise either simultaneously or in successive pairs on each side, the succession being either from the dorsal to the ventral aspect of the polyp or vice versa. The mesenteries and other organs of the *Ceriantheæ* and *Zoantheæ* preserve in the adult a strong bilaterality, while in most *Hexactiniæ* they usually ultimately attain a biradial symmetry. The separation of the three groups is accentuated by other characters given in their definitions, but the order of appearance of the metacnemes and their disposition in the adult are the characteristics of primary importance. The bilateral mesenterial arrangement occurring in the *Ceriantheæ* and *Zoantheæ* is representative of a much more ancient type of Actinozoan development than is the cyclic plan followed by the *Hexactiniæ*. The characteristics of the three types are diagrammatically represented in fig. 1, on the text plate opposite.

The *Edwardsiæ*, *Halcampeæ*, *Protactiniæ*, and others have been proposed as Actiniarian tribes of equivalent value to the three above mentioned, but as regards their mesenteries they merely exhibit one or other of the developmental stages of the *Hexactiniæ*, without introducing any new type of mesenterial sequence. Any other characters possessed by them are only of subtribal or less importance.

Formerly regarded as only tribal subdivisions of the *Actiniaria*, the *Ceriantheæ*, *Zoantheæ*, and *Hexactiniæ* have now been raised to the rank of Actinozoan groups of equivalent value to those of the *Alcyonaria* and *Antipatharia*. Carlgren (1898, 1900*a*) has proposed that the terms *Ceriantharia*, *Zoantharia*, and *Actiniaria*, respectively, should replace the tribal names above given. Much objection is to be taken against using the old familiar and more comprehensive names *Zoantharia* and *Actiniaria* in such a restricted manner, but rather than introduce any synonymous terms at this critical stage of growth of our knowledge of the relationships of the Actinozoa I have adopted them in the present paper, though convinced that they should not be ultimately accepted.

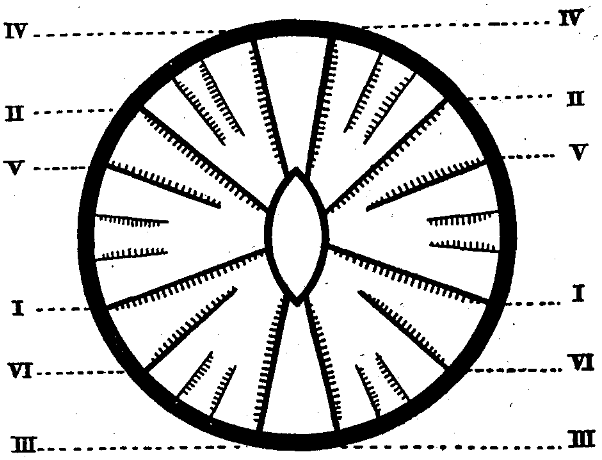

FIG. 1.—Diagrammatic representation of a stage in the development of a Hexactinian polyp. The six bilateral pairs of mesenteries numbered I to VI, and indicated by thicker lines, are the protocnemes, the fifth and sixth pairs being as yet incomplete; pairs III, III and IV, IV, respectively, represent the ventral and dorsal directives. In each of the six primary exocœles a unilateral pair of metacnemes has appeared, the sequence being bilateral, and from the dorsal to the ventral aspect of the polyp. At a later stage all the primary mesenteries become complete, and form a first cycle; the six pairs within the primary exocœles attain practically a uniform size, and constitute a second alternating cycle. Other unilateral pairs may arise in the exocœles between the members of the first and second cycles, and give rise to third, fourth, or fifth alternating cycles. Owing to the presence of directives the polyps attain only a biradial symmetry.

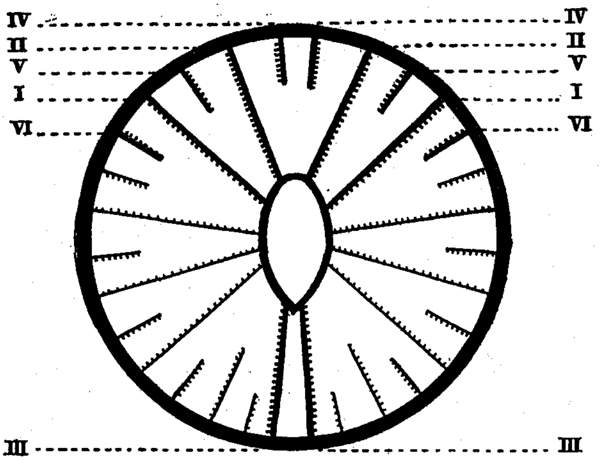

FIG. 2.—Diagrammatic representation of mesenteries in a brachytypic Zoanthid. As in previous figure the thicker mesenteries numbered I to VI are the protocnemes. The fourth (dorsal directives), fifth, and sixth pairs are permanently incomplete, except in the Macrocneminæ, where the sixth pair becomes complete. The metacnemes are all developed within the exocœle on each side of the ventral directives, and are arranged in unilateral pairs consisting of a brachycneme and a macrocneme. The mesenteries remain acyclic and the polyps exhibit bilateral symmetry.

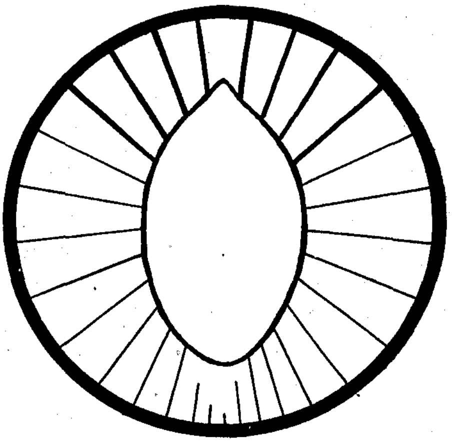

FIG. 3.—Diagrammatic arrangement of the mesenteries in *Cerianthus*. The four bilateral pairs represented by thicker lines have generally been considered to correspond with the Edwardsian mesenteries (I to IV) of Hexactinian and Zoanthid polyps, but according to van Beneden no such comparison can be maintained. New mesenteries are added as bilateral pairs at only one axial region of the polyp. According to Carlgren, this is the ventral or posterior aspect. The mesenteries remain acyclic and the polyps possess bilateral symmetry.

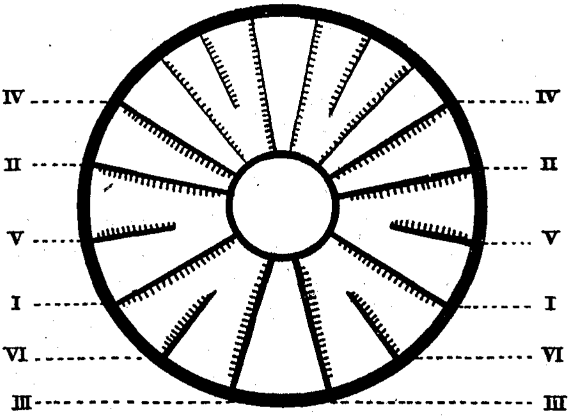

FIG. 4.—Diagrammatic arrangement of the mesenteries in a polyp of the coral *Porites*. Usually only the six protocnemes are developed in adult polyps, the Edwardsian pairs alone complete Additional mesenteries sometimes arise as bilateral pairs within the entocœle of either the dorsal or ventral pairs of directives; in the figure three new pairs have appeared within the dorsal directive entocœle. The mesenteries remain acyclic and the polyps exhibit bilateral symmetry.

E. van Beneden (1897) in his great work, "Les Anthozoaires de la Plankton-Expedition," has come to the conclusion that the *Ceriantharia* should be entirely removed from among the Actinians, as generally understood, and united with the *Antipatharia* to form a single group, *Ceriantipatharia.* In a similar manner he unites the *Actiniaria* (restr.) with the *Madreporaria* under the term *Hexactiniaria.* The evidence for the relationship of the *Ceriantharia* and *Antipatharia* is mainly embryological, and concerns the mode of origin of the first pairs of mesenteries and their associated chambers.

The character of greatest importance among the *Ceriantharia* is the appearance of the metacnemes in bilateral pairs at only one region of the polyp. Since the publication of van Beneden's work I have found that a somewhat similar method of mesenterial increase is followed by the coral *Porites* (1900), the other characters of which undoubtedly mark it out as a Hexactiniarian. The mesenteries beyond the primary six pairs appear in bilateral pairs within the entocœle of either the dorsal or ventral pair of directives (fig. 4, plate A). This discovery must be considered as modifying in some degree the strong separation from the *Actiniaria* which van Beneden has tried to establish for the *Ceriantharia.*

The arrangement proposed by van Beneden (p. 182) is as follows:

- Cnidaria..
  - Anthozoa=Scyphozoa.
    - Zoanthactiniaria ..
      - Zoanthiniaria [=Zoantheæ.]
      - Hexactiniaria.....
        - Madreporaria.
        - Actiniaria.
    - Octactiniaria.
    - Scyphactiniaria ...
      - Ceriantipatharia ..
        - Ceriantharia.
        - Antipatharia.
      - Scyphomedusa.
      - Rugosa.
  - Hydrozoa.

As the report was approaching completion I received the valuable paper "Ostafrikanische Actinien," 1900*a*, by Dr. Oskar Carlgren. As a contribution to the systematic study of the *Actiniæ* the work is of great importance, and calls for lengthy notice, especially as many of the present West Indian species are therein referred to. The author introduces a classification of the *Actiniaria* (*Hexactiniæ*) toward which he has been working for some time, the fundamental features of which are different from those hitherto accepted. In their systematic studies the earlier actinologists had to content themselves mainly with external characters. Gosse's "British Sea-Anemones" and Andres' "Le Attinie" are classic examples of this type. After the introduction by the brothers Hertwig (1879, 1882), about twenty years ago, of anatomical and histological methods of study, in which they were followed by Haddon, McMurrich, and others, the classification of the *Actiniaria* was founded upon the combination of external and anatomical characters. Among the former were included the arrangement and number of the tentacles, the nature of the column-wall, etc., and among the anatomical characters the arrangement of the mesenteries, the musculature, and the gonads. Carlgren now goes still deeper and, for the primary subdivisions, subordinates these more obvious features to histological details, the principal of which is the presence or absence of a longitudinal ectodermal musculature on the column-wall. With this appears to be often associated the presence of a columnar ectodermal nerve layer, the absence of a basilar muscle, and a weak parieto-basilar; likewise the absence of the Flimmerstreifen or ciliated streaks from the mesenterial filament, and the gonidial grooves from the stomodæum. Taxonomic studies of the *Actiniæ* may thus be said to have passed through three phases in the endeavor to secure a morphological and phylogenetic system.

Undoubtedly the best arrangement would be one in which the results from all three sources were combined, but it is doubtful if more than an approximation to this is possible, divergences having taken place along many different lines, often in the same species. Hence the great difference of results according as one or another feature is accorded special prominence in systematic studies.

Carlgren commences with the supposition that the earliest *Actiniæ* were free and possessed of a well-developed ectodermal musculature and ganglion layer[1] throughout the body-wall and stomodæum, and the column-wall, tentacles, and disk were much alike in structure. The internal musculature was very weak or absent, and the mesenterial filaments possessed only a single median lobe. The Flimmerstreifen or ciliated streaks and gonidial grooves were absent. With the assumption of a sedentary habit the external musculature diminished in importance, the internal basilar, sphincter, and mesenterial muscles increasing, while the ciliated bands and gonidial grooves appeared to strengthen the internal circulation. In some polyps the original ectodermal columnar musculature persists, while in others it has become altogether lost, though it remains in the tentacles and disk. Wherever the ectodermal musculature is persistent in the column-wall Carlgren would consider its possessor as a primitive type and, however divergent the species may have become in other directions, would classify it along with polyps in which the same structure occurs.

The classification followed by Carlgren in his "Ostafrikanische Actinien," with the principal characters in each subdivision of the *Actiniaria*, is as follows:

I. CERIANTHARIA.

II. ACTINIARIA.

A. Tribe *Protantheæ*. Actiniaria with a longitudinal musculature and ganglion layer in the column-wall and usually in the stomodæum; basilar muscle absent; filaments usually without ciliated streak; without acontia, marginal spherules, and cinclides; sphincter muscle either absent or very weak, and always endodermal.

  1. Subtribe *Protactininæ*. Protantheæ with only one tentacle in each radial chamber.
  2. Subtribe *Protostichodactylinæ*. Protantheæ with more than one tentacle in some of the radial chambers.

B. Tribe *Nynantheæ*. Actiniaria in which the column-wall and usually the stomodæum are devoid of a longitudinal musculature and ganglion layer. Basilar muscle and ciliated streaks usually present.

  1. Subtribe *Actininæ*. Nynantheæ with the tentacles arranged in alternating cycles, not in radial series. Each radial chamber with only one tentacle.
  2. Subtribe *Stichodactylinæ*. Nynantheæ in which all or part of the tentacles are arranged in radial rows or groups; all or part of the radial chambers bear more than one tentacle.

III. ZOANTHARIA.

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[1] Attention may be drawn to the strong development of the nervous layer which occurs at the aboral region in the larval, free-swimming stage of many anemones and corals. McMurrich (1891, p. 317) has described such in the larva of *Rhodactis sancti-thomæ*, and I have found a somewhat similar condition in the larva of *Lebrunia coralligens* (1899). Also in the larvæ of the Madreporarians *Favia fragum*, *Isophyllia dipsacea*, and *Agaricia agaricites* I have discovered a well-developed aboral nervous layer. Probably the formation represents part of an aboral sense-organ and disappears on fixation, the larvæ settling by that extremity. I am not prepared to say if it has any phylogenetic significance. No ectodermal muscle fibers have been distinguished in the larvæ, though on Carlgren's assumption they may be expected to occur.

The *Protantheæ* will thus include Actinians which have retained their primitive histological and anatomical structure, wholly irrespective of modification along other directions, while the *Nynantheæ* will embrace forms more highly developed as to their histology, anatomy, and external characteristics. Included under the former are representatives from each of the two great divisions, *Actininæ* and *Stichodactylinæ*.[1]

With the great progress which has been made in the morphological study of the *Zoantharia* (using the term in its usually accepted sense) within the last two decades, students of the group are in a better position than they formerly were for estimating which of the polypal characters are really of phylogenetic importance and should therefore be seized upon for the purpose of erecting a classification which will show their true relationships. Writers such as McMurrich (1898, page 229), Haddon (1898, page 411), and van Beneden (1897, page 153) are disposed to regard the ectodermal columnar musculature as ancestral, and the forms in which it occurs as the lowest members of their own particular group, but they are not prepared to accord to it the importance of making it the one character upon which the grouping should be determined, to the exclusion of later divergences. It is rather regarded as a character which, sporadically, as it were, may appear in any group, the various species possessing it not necessarily representing a homogeneous or natural assemblage.

No one doubts that the forms in which the columnar ectodermal muscle and nerve layers are associated with the absence of the basilar muscle, a weak parieto-basilar muscle, absence of the ciliated streak and gonidial grooves are more primitive than forms in which the muscle and nerve layers are absent, but it is doubtful as to how far their possessors represent a homogeneous group to be separated from others. To my mind they represent the most primitive members of various divergent groups, rather than a group to themselves. To separate them as a whole from others would be to neglect the facts of their subsequent development from the primitive type.

At the outset we are confronted with the fact that Actinians have evolved in complexity of structure along many different directions. In addition to that of the mesenterial plan there are divergences in the tentacular system, the musculature, the column-wall, as well as in many minor characters. Following Carlgren's proposals, Actinians which retain certain primary characteristics will be grouped together, however divergent they may have otherwise become. Carlgren replies that structures

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[1] In connection with the structural variation exhibited by the *Actiniaria* a comparison with the polyps of the closely allied *Madreporaria* is instructive. So far as I have observed in the course of an examination of the soft tissues of over twenty species of West Indian corals there are no certain indications of a columnar ectodermal musculature and ganglion layer, though such occur in the tentacles and disk. True gonidial grooves are always absent from the stomodæum. The mesenterial filaments are invariably formed of only a single median lobe, no lateral lobes with ciliated bands being developed. The internal musculature is everywhere very weak, and the sphincter remains endodermal; mesoglœal plaitings are rarely formed for the support of the parieto-basilar muscles, and basilar muscles are absent. Marginal spherules and cinclides *have not been met with; mesenterial filaments are freely extruded through any part of the column*-wall and disk, but at no part of their course are they independent of mesenterial attachment, and hence are not true acontia. The *Madreporaria* are therefore at practically the same phylogenetic level as the *Actiniaria* which Carlgren includes within the *Protantheæ*, except as regards the apparent absence of the columnar ectodermal musculature and ganglion layer.

such as evaginations of the column-wall (*Aliciidæ*,[1] *Bunodosoma*, 1900*a*, pp. 13, 28), and a strong constricted sphincter muscle (e. g., *Stoichactis*, *Actinoporus*, p. 118) may appear in any group, and that their occurrence does not necessarily imply any relationship in the forms possessing them. Undoubtedly this is in the main correct when isolated structures only are considered, but the classifications hitherto have been founded more upon a combination of features, and the greater the number which can be shown to agree the more likely are the forms to be closely related. Just as isolated characteristics may denote no natural relationships between their possessors, so certain primary characteristics may be retained by different species whose other features show them to be widely separated. It is really a question of determining which characters are homoplastic and which are homogenetic.

By adopting the course proposed by Carlgren it is evident that a duplication of groups within the two sections, *Protantheæ* and *Nynantheæ*. must arise. Within the *Protantheæ* may be species which have evolved in practically all directions known to actinologists, and also in the section in which the ectodermal musculature is lost will be forms modified along exactly similar lines. This is at once evident in the necessity for the subdivision of the hitherto sharply defined *Stichodactylinæ*. Tentacular disposition becomes subordinated to histological details. Though most students would probably admit that the old tribe *Stichodactylinæ* includes polyphyletic groups, yet to remove its simplest members seems to render impossible any natural arrangement.

I am also of opinion that once its importance is fully recognized, the ectodermal columnar musculature will be found in forms in which it has hitherto been overlooked. Except where maceration of fresh material can be resorted to it will be difficult to determine with certainty its presence or absence. Thus in sections of the column-wall of *Corynactis*, *Actinotryx*, *Actinoporus*, and *Phymanthus*, I have described appearances which would generally be assumed to indicate a weak muscle layer, but which, according to Carlgren, may be only the swollen ends of the supporting cells. I have not since had the opportunity of proving by means of maceration of fresh tissues whether the appearances described are actually referable to the presence of muscle fibrils or not, but considering the importance which is now attached to the question, and the possibility of the appearances being otherwise explained, I have in the present paper refrained from further reference to the genera in this connection.

Until the extent of the occurrence of the columnar ectodermal musculature and its association with other features have been more fully ascertained, it seems to me hazardous to break up, on its account, long-established systems of classification. Where forms have developed along similar lines from some ancestor it is more logical that they should be associated than that species should be kept together merely because they retain one or more ancestral characters. The combination of characters, both primitive and evolved, should be taken into account; the selection of only one would give an artificial character to any group.

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[1] The family *Aliciidæ* is characterized by a weak musculature and the column possessing simple or complex hollow evaginations. The genus *Bunodeopsis*, in which I first ascertained (1897) the presence of an ectodermal columnar musculature, will, according to Carlgren, have to be removed to the *Protantheæ* along with another representative, *Thaumactis*. In my description of the two species of the genus *Bunodeopsis* I had not realized the importance which this character has now assumed, nor of the other features associated with it, and therefore the account is incomplete in several essential details. The columnar ectodermal musculature in *Bunodeopsis* is strongly developed on delicate mesoglœal plaitings, and the nerve layer is also very clearly indicated. The stomodæal ectoderm likewise displays a muscular and nervous layer. No gonidial grooves occur and the internal musculature is very weak, the sphincter being of the diffuse endodermal type. The parieto-basilar is very feeble, and basilar muscles are absent, but a well-developed tentacular sphincter is present. Associated with these, however, are ciliated streaks on trilobed mesenterial filaments.

Thus the genus agrees in the main with Carlgren's definition of the tribe *Protantheæ*.

LIST OF SPECIES.

- Ceriantharia.
  - Family *Cerianthidæ*.
    - *Cerianthus*, sp.?
- Zoantharia.
  - Family *Zoanthidæ*.
  - Subfamily *Brachycneminæ*.
    - *Zoanthus pulchellus* (Duchassaing & Michelotti).
    - *Zoanthus sociatus* Lesueur.
    - *Isaurus duchassaingi* (Andres).
    - *Protopalythoa variabilis* (Duerden).
    - *Palythoa caribæa* (Duchassaing & Michelotti).
- Actiniaria.
  - Order Actininæ.
    - Family *Phyllactidæ*.
      - *Asteractis expansa* Duerden.
- Actiniaria—Continued.
  - Order Actininæ—Continued.
    - Family *Bunodactidæ*.
      - *Bunodosoma granulifera* (Lesueur).
      - *Bunodosoma spherulata*, n. sp.
    - Family *Sagartidæ*.
    - Subfamily *Aiptasinæ*.
      - *Aiptasia annulata* (Lesueur).
    - Subfamily *Metridinæ*.
      - *Calliactis tricolor* (Lesueur).
  - Order Stichodactylinæ.
  - Suborder Homodactylinæ.
    - Family *Stoichactidæ*.
      - *Stoichactis helianthus* (Ellis).
  - Suborder Heterodactylinæ.
    - Family *Phymanthidæ*.
      - *Phymanthus crucifer* (Lesueur).

LIST OF SPECIES ARRANGED ACCORDING TO LOCALITIES.

Mayagüez Harbor.—*Calliactis tricolor* (Les.); *Zoanthus sociatus* (Les.); *Zoanthus pulchellus* (Duch. & Mich.).

Aguadilla.—*Bunodosoma granulifera* (Les.); *Zoanthus pulchellus* (Duch. & Mich.).

San Juan Harbor.—*Bunodosoma granulifera* (Les.).

Puerto Real.—*Asteractis expansa* (Duerd.).

Guanica Bay.—*Aiptasia annulata* (Les.); *Stoichactis helianthus* (Ell.); *Zoanthus sociatus* (Les.); *Cerianthus*, sp.?

Arroyo.—*Stoichactis helianthus* (Ell.); *Bunodosoma spherulata*, n. sp.

Anoyo.—*Stoichactis helianthus* (Ell.).

Playa de Ponce Reef.—*Aiptasia annulata* (Les.); *Bunodosoma granulifera* (Les.); *Asteractis expansa* (Duerd.); *Phymanthus crucifer* (Les.); *Zoanthus pulchellus* (Duch. & Mich.); *Palythoa caribæa* Duch. & Mich.

Ensenada Honda, Culebra.—*Aiptasia annulata* (Les.); *Asteractis expansa* Duerd.; *Stoichactis helianthus* (Ell.); *Zoanthus sociatus* Les.

Fajardo.—*Stoichactis helianthus* (Ell.)

Hucares.—*Bunodosoma granulifera* (Les.); *Protopalythoa variabilis* (Duerd.); *Isaurus duchassaingi* (Andres).

CERIANTHARIA.

Family CERIANTHIDÆ Milne Edwards & Haime.

Genus CERIANTHUS Delle Chiaje.

Cerianthus sp. ?

Among the Porto Rican collections is a single specimen of a *Cerianthus*. The lower extremity is torn and the column is slit open for the greater part of its length. The length is now 6.5 cm. and the diameter 1 cm.; 38 tentacles occur in the outermost cycle and 35 in the inner. From the external characters alone I considered that the form might be the well-known *Cerianthus americanus* L. Agassiz, of the Carolina coasts. A comparison of its histology, however, with that briefly given by McMurrich

(1890) of *C. americanus* shows certain divergences, which make me hesitate in regarding it as this species. Without a thorough comparison of the two side by side it would be hazardous to establish the Porto Rican representative as a new species. I have since been endeavoring to secure specimens of the Carolina species for comparison, but so far without success. I therefore defer the description of the present specimen until its distinctness or otherwise can be established. Both McMurrich and H. V. Wilson have obtained at Nassau, Bahama Islands, larvæ of a *Cerianthus*, which may perhaps have been derived from polyps of the same species as the Porto Rican examples. I have never met with a *Cerianthus* around Jamaica.

ZOANTHARIA (restr.).

Zoantheæ, R. Hertwig, 1882; Haddon, 1891; etc.
Zoanthiniaria, van Beneden, 1897.
Zoantharia (restr.), Carlgren, 1900.

Actinozoa in which six primary mesenteries (protocnemes) arise bilaterally. The ventral or sulcar directives become complete, the dorsal or sulcular directives and the sulcar moiety of the protocnemic dorso-lateral pairs remain incomplete, while the sulcar moiety of the ventro-lateral pair is incomplete in one group (*Brachycneminæ*) and complete in another (*Macrocneminæ*). Additional mesenteries (metacnemes) arise independently (i. e. neither in pairs nor symmetrically on each side) within the exocœle on each side of the sulcar directives, and become arranged in unilateral pairs, constituted of an incomplete and a complete moiety.

Only the perfect mesenteries are fertile and bear mesenterial filaments with both glandular streaks and ciliated bands. A single sulcar gonidial groove is present. The ectoderm of the column-wall is devoid of a muscle and ganglion layer, and the mesogloea is traversed by irregularly branching ectodermal canals or by scattered groups of cells. The body-wall is usually incrusted with foreign particles. The polyps are generally grouped in colonies connected by a cœnenchyme, the cœlenteron of each polyp communicating with that of the other members of the colony by means of basal endodermal canals.

I have already given the reasons for which the tribe *Zoantheæ* has been erected into an Anthozoan division equivalent to the Ceriantharia, Actiniaria, Alcyonaria, etc. It includes only one family, which therefore carries with it the definition of the order. It is of interest to note that though filaments do not occur on the imperfect mesenteries of adult Zoanthids yet McMurrich (1899) has found the glandular streak to be present on the V and VI developmental pairs in egg embryos, as well as indications of the filament in the micro-directives, all of which never reach the stomodæum.

The mesenterial arrangement characteristic of the *Zoantharia* (restr.) suggests in many ways the mesenterial sequence which must have been followed by the polyps which produced certain types of Palæozoic corals. The formation of the calcareous septa in corals is found to conform very closely with that of the mesenteries, both as to order of appearance and adult arrangement, just as do the tentacles. In the Palæozoic family *Zaphrentidæ* the septa are disposed pinnately with regard to two primary axial septa, the "main" and "counter" septa of palæontologists, and two other primary septa, the lateral or "alar" septa, can also be distinguished. If the mesenterial plan of the Zoanthid represented in fig. 2, plate A, be compared with the septal plan of a Zaphrentoid coral, such as *Streptelasma*, it will be seen how very closely the mesenterial spaces of the former correspond with the septal scheme in the latter. From the known relationships of the soft parts of a coral to the hard parts there is the greatest suggestiveness in the primary mesenterial plan of a Zoanthid to "main," "counter," and "alar" septa, while a pinnate addition of the later mesenteries is characteristic of the ventral aspect, which would correspond with the pinnate septa in the counter quadrant of the Zaphrentoid.

The septal plan of *Streptelasma* as given by Kunth, and in the palæontological text-books of Zittel and Nicholson, indicates that the mesenteries were added in the primary exocœlic chamber on each side of one of the pairs of directives, just as in the *Zoanthidæ*; but in the fossil coral another similar series of mesenteries appeared in the next primary exocœle on each side. In modern Zoanthids only two exocœlic regions of active growth persist beyond the protocnemic stage, but in the extinct Zaphrentoids there were four. The main, counter, and alar septa are the septa formed within the primary entocœlic chambers. Where mesenterial increase is simply bilateral at one region within an axial entocœle, as in *Porites* and *Cerianthus*, no principal axial septum would be produced, but such is provided for in polyps built upon the Zoanthid type.[1]

Family ZOANTHIDÆ Dana.

With definition of order.

Subfamily BRACHYCNEMINÆ Hadd. & Shackl.

Zoantharia in which the sulcar element of the protocnemic sulco-lateral pair of mesenteries is imperfect.

The above definition with regard to the sulcar element of the sulco-lateral pair being imperfect is not invariably true for all the individuals of a species. For in all the genera, except *Sphenopus*, included within the subfamily, polyps have been met with in which the mesentery referred to is perfect. In the paper on the Jamaican *Zoantheæ* I have recorded that a specimen of *Gemmaria variablis* Duerden presented the normal brachycnemic arrangement on one side and the macrocnemic on the other. In a colony of *Palythoa mammillosa* Ellis & Solander, one polyp was brachycnemic on the right and macrocnemic on the left side; and in another polyp from the same colony the brachycnemic condition was on the left side and the macrocnemic on the right. Similar combinations of the microtype were found in *Palythoa caribæa* Duchassaing & Michelotti, but one polyp was altogether macrotypic on both sides, in place of the normal brachytype. In the course of the present investigations a polyp of *Zoanthus sociatus* was found which was brachycnemic on the left side and macrocnemic on the right (fig. 16); and Carlgren (1896, pl. VIII, fig. 6*a*) among other irregularities in a species of *Isaurus* found a polyp which was macrocnemic on the same side. Various other irregularities in the mesenterial arrangement of different species of Zoanthids have been given by other workers; but apparently very rarely is there an actual replacement of one type by the other, as in the cases above mentioned.

The numerous instances just cited are sufficient to indicate that the macrocnemic or brachycnemic type of mesenterial arrangement in the *Zoanthidæ* is not so fixed as has been supposed, that in the same polyp both types may occur on different sides, or even the entire macrocnemic arrangement may appear in place of the brachycnemic. Still, by far the majority of polyps of any species exhibit the normal order established by Hertwig, Erdmann, and others for the particular genus, and the exceptions now and again met with should not be allowed to diminish the taxonomic value of the two subfamilies. Of six polyps of the Porto Rican *Z. sociatus* examined, only the one represented by the transverse section in fig. 16 showed any departure from the established order, and the many Jamaican polyps examined were all normal.

Roule (1900) has recently suggested that the macrotypic genera *Epizoanthus* and *Parazoanthus* should disappear, and their representatives, along with those of *Gemmaria*, become united in the genus *Palythoa*. He goes so far as to place the *Gemmaria swiftii* of Duchassaing & Michelotti under the genus *Palythoa*, though I have shown (1898, p. 372) that its polyps, like those of all the species of *Parazoanthus*, are macrocnemic and possess a diffuse endodermal sphincter muscle.

Such associations as those proposed by Roule have reference mainly to the external appearance and habit of the colonies, and are wholly adverse to the principles of classification which hitherto have been found of the greatest value in Actinian studies.

Genus ZOANTHUS Lamarck.

Brachycnemic *Zoanthidæ*, with a double mesogloeal sphincter muscle. The body-wall is incrusted; the ectoderm is usually discontinuous; well-developed ectodermal canal system in the mesoglœa; monœcious or diœcious. Polyps connected by a thin lamellar cœnenchyme, stolons, or more rarely free.

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[1] Since this was written I have been able to show (Johns Hopkins University Circulars, vol. XXI, No. 155, January, 1902) from an examination of numerous serial sections that the primary septa of the Rugose coral, *Lophophyllum proliferum* (McChesney), are hexameral as in modern corals. Also that the later septa are added in such a manner as to leave no doubt that the mesenterial sequence bore the closest resemblance to that characteristic of living Zoanthids, except that in *Lophophyllum* new mesenteries and septa were added within four primary exocœlic chambers, whereas in Zoanthids new mesenteries arise in only two exocœlic chambers. Recent Zoanthids bear much the same relationship to the Palæozoic Rugose corals which living Actinians do to modern corals.

About a dozen different colonies belonging to the genus *Zoanthus* are contained in the Porto Rican collection. Externally they are divisible into two well-marked groups: (1) Colonies possessed of a continuous incrusting cœnosarc, from which small polyps rise as mammiform or cylindrical upgrowths, and are practically of the same diameter throughout. (2) Colonies without a continuous incrusting cœnosarc, the polyps forming irregular clusters, connected with one another and with foreign débris by narrow stolons, flattened cœnosarcal expansions, or growing directly from one another. In these the individual polyps are mostly club-shaped and pedunculated, but they may be cylindrical.

The representatives of the genus *Zoanthus* are very variable in form, dimensions, number of tentacles, and color, according to the conditions under which they are living, so that where an abundance of material is available it becomes very difficult to secure constant and specific characters, and thus to identify the different types with the descriptions of other workers.

Verrill in a recent paper (1900) recognizes ten West Indian species, including those from the Bahamas and Bermudas. Already many synonymic difficulties have been introduced. In my account of the Jamaican Actiniaria I have placed the colonies with a continuous incrusting cœnosarc under Duchassaing & Michelotti's term, *Mammillifera pulchellus*, a form which these authors believed to be but a variety of the *M. nympheæ* of Lesueur. Externally they exhibit no differences from the Bahaman specimens which McMurrich has determined as *M. nympheæ*, but the sphincter muscle of the two apparently differs to such a degree as to warrant their separation as distinct species. Transverse and longitudinal sections of the Porto Rican specimens of the Mammillifera type exhibit all the characteristics of the Jamaican specimens, and I have therefore determined them as *Zoanthus pulchellus*.

Verrill (1900, p. 566) in a footnote points out that Lesueur (1817, p. 178) was evidently in error in stating that the tentacles in *M. auricula* are 26 to 30; Lesueur's transverse section of the same species represents 61 mesenteries, and as the number of tentacles corresponds with the number of mesenteries it may be assumed that the former are about 52 to 60. As McMurrich distinguished his *M. nympheæ* from *M. auricula* mainly on the tentacular differences it is clear that the determinations of McMurrich and myself become very difficult of comparison with the original types of *Z. auricula*, *Z. nympheæ*, and *Z. pulchellus*, especially considering that the external characters upon which alone the three are founded are so very variable. I do not at present see that any advantage is to be gained by attempting to modify the synonymy already adopted, and therefore retain *Z. pulchellus* for the forms above mentioned. The characters as exhibited by the Jamaican and Porto Rican representatives seem clearly enough defined to enable them to be recognized at any time.

The Jamaica colonies with mostly clavate, pedunculated polyps, irregularly united by stolons, etc., I previously identified as the *Z. flos-marinus* of Duchassaing & Michelotti, mainly from the description which McMurrich gave of Bermudan specimens identified by him as this species. Verrill, however, has placed the *Z. flos-marinus* of McMurrich under his new species, *Z. proteus*, and the Jamaican *Z. flos-marinus* as a doubtful synonym of *Z. sociatus*. Judging from the figure of the sphincter of *Z. sociatus* which McMurrich (1898) has recently given I am inclined to think that Verrill's suggestion is the best solution of the present difficulty. There is nothing in Lesueur's description of *Z. sociatus*, nor in the more detailed study given by McMurrich, which does not occur in the specimens I have had under examination. I have therefore in the present paper placed the Jamaican *Z. flos-marinus* as a synonym of *Z. sociatus*, and identify the Porto Rican specimens as this species. The form possessing about 36 tentacles, which Duchassaing & Michelotti describe as *Z. flos-marinus*, has therefore yet to be rediscovered.

It is regrettable that Verrill has not given a figure of the sphincter muscle of his new species, *Z. proteus*; for among the external characters which he gives there are none which may not occur in the species already recognized. To my mind the validity of the new species can only be established by showing that the sphincter possesses a characteristic form, or that some other constant anatomical feature occurs.

Zoanthus pulchellus (Duchassaing & Michelotti). Pls. II, IV, Figs. 2, 3, 14.

Mamillifera pulchella, Duchassaing et Michelotti, 1866, p. 137, pl. VI, fig. 4 (an varietas *M. nymphææ?*).
Zoanthus puchellus, Duerden, 1898, p. 341, pl. VIIa, fig. 3; pl. XVIIIa, figs. 3, 4.

External characters.—The polyps are erect, cylindrical, short or elongated, thin-walled, smooth, usually closely arranged, and rise from a thin, tough, incrusting cœnenchyme. Where widely separated they generally appear on retraction as low mammiform prominences. On retraction they may be a little swollen above or remain of the same diameter throughout, and terminate distally in a rounded or slightly conical manner; a central aperture remains, from which radiate delicate capitular ridges. On partial retraction a deep groove is often seen dividing the capitulum into an inner and an outer part, but this becomes inturned when the column-wall is completely infolded.

The tentacles are short, digitiform, overhang during extension, and are arranged in two alternating rows of about thirty in each. The naked portion of the disk is depressed below the tentacular margin, smooth, thin-walled, and exhibits radiating lines. During expansion the oral cone is much elevated, and the mouth is slit-like. The stomodæal groove is not clearly seen in living polyps. The disk and capitulum become greatly enlarged during full expansion, so that when all the polyps in a colony are in this state their margins are in contact, and the mutual pressure produces a polygonal outline.

The cœnenchyme is smooth, continuous, lamellar, and adheres closely to the rocks and stones, following the various irregularities of their surface. Occasionally it becomes ribbon-shaped, when the polyps are more widely separated.

The color of the lower part of the elongated polyps is pale buff, the white mesenterial lines showing through the partly transparent walls; the upper part is olive blue, the capitulum being a little lighter and usually exhibiting green radiating lines. The tentacles are nearly always dark brown, but may be green or olive. The disk is generally a bright green, with lighter radiating lines; sometimes it is a pale green or yellow. A darker triangular area often extends from the two axial extremities of the mouth, and sometimes one is more pronounced than the other. The peristome in many is a bright pink, in others a bright green, more rarely yellow. The stomodæum sometimes appears green, with white radiating lines showing through. An olive-brown color is first extracted on immersing the colonies in alcohol, and the polyps become a uniform green, due to the presence of numerous zooxanthellæ within the endodermal cells.

The average diameter of the column in living specimens is 6 mm.; the diameter of the capitulum on full expansion varies from 8 to 10 mm. The length of the column is variable, depending mostly upon the position of the polyp in the colony. An average length is 5 mm.; some may attain a length of nearly three times this, while the mammiform polyps may extend only 3 to 4 mm. above the level of the cœnenchyme. The tentacles are from 2 to 3 mm. in length. Colonies are often met with from 20 to 30 cm. across.

Anatomy and Histology.—The column-wall is protected on the outside by a subcuticle, which is partly coated with a layer of foreign matter, mostly diatom frustules and fine mud. This is best seen in the lower part of the polyp, but may extend nearly the whole length. The ectoderm is very narrow, and its cells have lost their columnar character except in the distal region. Below, the layer is largely vacuolated, numerous nuclei occur, and the protoplasm is arranged in strands, and is granular and stains deeply. Connecting mesoglœal strands pass from the subcuticle to the middle layer, the ectoderm appearing as if embedded in irregular mesoglœal chambers. Toward the base the subcuticle is better developed and the ectoderm becomes thinner.

The mesoglœa is thickest in the region of the capitulum and also toward the cœnenchyme. It contains isolated connective-tissue cells, and fine processes are seen extending from the ectoderm to the endoderm. Cell-islets also occur, some of which contain dark, granular pigment matter. They are largest and most numerous toward the endodermal border, where they sometimes appear as forming an interrupted encircling sinus. Often a canal occurs opposite the insertion of each mesentery. Vacuoles, or circular spaces with only a single nucleus, are not infrequent in the mesoglœa toward its ectodermal border, and the margin is not always well defined.

The endoderm is a very narrow layer and is crowded with zooxanthellæ and small oval nematocysts. On its mesoglœal border it gives rise to a weak musculature.

The cœnenchyme contains numerous irregularly distributed canals connecting the cœlenteron of one polyp with that of others. These are lined with a strongly cilated endoderm, and possess a weak musculature.

The mesoglœal sphincter muscle is strongly developed and consists of a small upper or distal portion and a larger lower or proximal portion, the two separated by a deep groove in retracted polyps (fig. 14). The upper part consists of a number of small, closely arranged, rather elongated, irregular cavities, lined by muscle fibers. The mesoglœal spaces in the lower part of the sphincter are also very closely arranged, narrow, and at the broadest part extend nearly across the middle layer. Below, the muscle passes toward the ectodermal border and then turns inward, terminating in a number of small chambers toward the endodermal border of the mesoglœa.

Rather more chambers occur in the sphincter here represented than in the sphincter already figured in the account of the Jamaican polyps, and they are more closely arranged. Still the same general arrangement is presented in both; a certain amount of individual variation is to be expected.

The ectoderm of the tentacles is an ordinary columnar epithelium, and unlike that of the column-wall is devoid of any cuticle and subcuticle. Very small nematocysts occur in a peripheral zone, and a weak longitudinal musculature on its inner border. The mesoglœa is devoid of cell-islets, and the endoderm is greatly thickened in retracted examples, leaving scarcely any lumen and being crowded with zooxanthellæ. A weak circular endodermal muscle occurs.

The wall of the disk is much like that of the tentacles, but nematocysts are not so numerous in the ectoderm, and the endoderm is never so broad a layer. Numerous cells with granular protoplasm occur in the mesoglœa, especially toward its ectodermal border. Both the endodermal and ectodermal musculatures are very weak.

The stomodæum is usually greatly elongated in transverse sections, and the ectoderm forms about eight deep longitudinal folds on each side. The sulcar groove is smooth and elongated. Ciliated supporting cells are the principal constituents of the stomodæal ectoderm, but granular gland cells which stain deeply in methyl blue also occur, as well as a few nematocysts. The mesoglœa is rather broad, and contains a few isolated cells. The endoderm is very narrow, as is the case with the lining of the cœlenteron generally.

The mesenteries are microtypic in all the polyps examined, the number of pairs varying from 25 to 30. At their insertion in the column-wall they are narrow, but enlarge beyond, where the single basal canal occurs, the layer becoming very thin again. The basal canal is circular or oval in section in the upper region, but becomes more elongated below. A very weak parieto-basilar muscle occurs; the retractor muscle is clearly seen supported upon rounded folds of the mesoglœa and enables the paired character of the mesenteries to be established.

At the inner termination of the stomodæum the reflected ectoderm is very clearly seen, passing for a short distance up the face of the complete mesenteries and then downward along the free edge, giving rise to trifoliate mesenterial filaments. The character of the Zoanthid mesenterial filament has been fully described by McMurrich (1899), and it is unnecessary to repeat it here. Shortly below the stomodæal termination the mesenterial endoderm becomes greatly swollen, the mesentery appearing clavate in transverse section. The epithelium is densely crowded with granules of various kinds, many of them yellow. McMurrich has surmised that the granules are in some way products of digestion.

Many polyps from different colonies contained ova distributed about midway along the length of the macrocnemes.

Localities.—St. Thomas (Duchassaing & Michelotti); Jamaica (Duerden); Porto Rico (U. S. Fish Commission).

Zoanthus sociatus (Ellis). Pls. II, IV, V; Figs. 4, 15–22.

Actinia sociata, Ellis, 1767, p. 436, pl. XIX, figs. 1, 2; Ellis & Solander, 1786, p. 5, pl. I, figs. 1, 2.

Zoanthus sociatus, Lesueur, 1817, p. 176; McMurrich, 1889, p. 62, pl. II, fig. 3; pl. IV, figs. 15–18; 1898, p. 242, pl. III, fig. 1; Verrill, 1900, p. 561.

Zoanthus flos-marinus, Duerden, 1898, p. 339, pl. XVII *a*, fig. 2; XVIII *a*, fig. 2.

External characters.—The polyps are erect, clavate or cylindrical in form, and rise directly from a thin band-like incrusting cœnenchyme, or from a free irregular stolon, or directly from one another, either at the base or a short distance up the column. Usually the column is smooth, thin-walled, and pellucid, but sometimes a membranous cuticle occurs, more obvious toward the base, and foreign particles adhere to it. On complete retraction the column is usually swollen above, and on partial retraction a deep groove is seen separating the capitulum into an inner narrow zone and an outer region which passes insensibly into the column. Twenty-four to thirty minute rounded denticulations or capitular ridges, alternating with the outer row of tentacles, occur on the inner capitulum and are continued for some distance down the column.

The tentacles are dicyclic, slightly entacmæous, smooth, acuminate or rounded at the tip, and overhanging in full expansion. They vary in number from 48 to 60.

The disk is smooth, thin-walled, and shows radiating divisions. The peripheral area is more deeply grooved, and overhangs on full expansion; the middle region is elevated, and the mouth slit-like.

The cœnenchyme is very rarely band-like and incrusting; more often it is represented by stolons, variable in form and length, and constituting an irregular connection between the polyps. Sometimes the base of a polyp may be flattened or irregularly lobulated on one or more sides, as if forming cœnenchyme. Polyps all about the same size are often closely associated, incrusting some rock or stone. More often they are in practically free clusters, loosely attached to coral and shore débris, the polyps connected with one another in an irregular fashion by free, stolon-like cœnenchyme. Polyps living on the upper surface of stones are usually short and cylindrical, while those on the sides and underneath, or in crevices, become more elongated, with a distinct peduncle. In any large group of polyps the individuals on expansion rise to practically the same level however they are disposed with regard to one another basally.

The lower part of the column is usually sand-colored, the upper dark green or bluish; the tentacles are yellowish green, blue green, or brown. The disk presents various light and dark shades of blue and green, often mixed with yellow and black; the oral cone is bright yellow or green; a darker triangular area may be present at each angle of the mouth or at only one. McMurrich gives the column of the Bahaman specimens as usually flesh-colored, with the upper part purplish brown; the tentacles are the same in color as the upper part of the column.

The height of the polyps is very variable; an average may be about 17 mm.; the greatest diameter of the living retracted polyp is 5 mm., of preserved polyps 3 mm. The diameter of the disk in expansion varies from 5 to 8 mm.; the inner tentacles are 2.5 mm. long.

Anatomy and Histology.—The cuticle, subcuticle, and ectoderm are of the same character as in the previous species. The ectoderm is strongly vacuolated below, but less so above, and contains oval nematocysts; its mesoglœal boundary is often not well defined on account of the connecting mesoglœal strands, mesoglœal vacuoles, and cell-inclosures.

The mesoglœa is broad in the region of the lower sphincter muscle and thence narrows in both directions, becoming greatly constricted at the capitular groove. Large and small cell-inclosures occur, many of them containing fine pigment granules. Circular and oval vacuoles also occur, with but few cell contents. An interrupted encircling sinus is present, connected in places with the ectoderm. The endoderm is a very thin layer, loaded with zooxanthellæ, and forms a delicate circular musculature.

The sphincter muscle is double and mesoglœal; the smaller part consists of but a few distinct cavities, while the larger is very elongate and is represented by an enormous number of chambers variable in size and outline and becoming smaller below.

The ectoderm of the tentacles is devoid of cuticle and subcuticle, and contains numerous small oval nematocysts in its lower parts. Internally, fine pigment granules may occur and a weak ectodermal muscle on fine mesoglœal plaitings.

The mesoglœa is thin and finely plaited on its endodermal border for the support of the musculature. The endoderm is very broad in the retracted tentacles, leaving only a small lumen, and is crowded with zooxanthellæ.

The ectoderm of the disk is much narrower than that of the tentacles, and nematocysts are few. Between the ectoderm and mesoglœa appears a kind of intermediate layer in which are numerous oval granular cells with their long axis at right angles to that of the ectodermal columnar cells, some are partly free and partly embedded in the mesoglœa. The ectodermal and endodermal musculatures are weakly developed.

The stomodæum is usually oval in transverse section, with about six deep ridges on each side, less in number than the perfect mesenteries. The gonidial groove is rather wide, its ectodermal lining smooth, with few gland cells, and more strongly ciliated than the stomodæal ectoderm elsewhere. The rest of the ectoderm is broad and contains many small nematocysts in its deeper regions. A delicate nerve layer can be detected in favorable sections. The mesoglœa is also comparatively broad, more so than in the disk and mesenteries.

The mesenteries are normally brachytypic, but the macrotypic arrangement may occur on one side or another. The number of mesenteries is usually about 60.

The endoderm contains many zooxanthellæ and medium-sized oval nematocysts. The mesoglœa is finely plaited for the support of the retractor muscle. In most cases a basal canal occurs some little distance from the insertion of the mesenteries in the column-wall, but is not present in all. The canals contain many small oval nematocysts.

The reflected ectoderm and mesenterial filaments are of the usual Zoanthean character, and for this species have been fully described by McMurrich in his paper "The Mesenterial Filaments in *Zoanthus sociatus* (Ellis)," 1899. The endoderm becomes greatly swollen below, where it contains an enormous quantity of pigment and nutritive granules of various kinds. Before receiving Professor McMurrich's paper I had made numerous sections and drawings of the mesenterial filaments in this species, with a view to their study along somewhat similar lines to those followed in the above paper. My results as to the relationships of the intermediate tissues and ciliated bands, and also as to the very different character of the median part of the filament in its upper and lower regions, agree with those of McMurrich. I therefore merely give the figures and refer the reader to the latter's more detailed account. My studies on this and other species lead me to regard the uppermost part of the median filament as a downgrowth of the stomodæal ectoderm and the remaining part as endodermal, and, contrary to McMurrich, I am inclined to regard the intermediate streak as endoderm.

No fertile polyps have been met with.

Localities: Dominica (Ellis), Guadeloupe (Lesueur), Bahamas (McMurrich), Bermuda (Verrill), Jamaica (Duerden), Porto Rico (U. S. Fish Commission).

Genus ISAURUS Gray.

Large brachycnemic *Zoanthidæ*, with a single mesoglœal sphincter muscle. The body-wall is unincrusted; the ectoderm discontinuous; ectodermal and endodermal bays and small canals in the mesoglœa. Monœcious or diœcious. Polyps in small clusters or solitary.

Carlgren (1896) has carried out investigations upon several examples of an undescribed species of *Isaurus* in order to determine the relationship of the external smooth and tuberculated areas, occurring in all the species of the genus, with the internal bilaterality exhibited by the mesenteries and stomodæum. One would naturally expect that the external symmetry would correspond with the internal. Carlgren finds that, as a rule, the smooth concave part of the column corresponds with the dorsal side of the polyp, or side on which the pair of microdirective mesenteries is inserted (sulcular), and the convex part of the column, bearing the tubercles, corresponds with the ventral aspect of the polyp which bears the macrodirectives and the gonidial groove (sulcar). Although the tubercles may appear on both the right and left sides, it never happens that the smooth side is ventral; this belongs to the dorsal part of the body-wall.

The relationships met with in *I. duchassaingi* scarcely conform with Carlgren's results. In the specimen from which fig. 23 was taken a very large tubercle occurs a little distance from the middle of the dorsal side, and in varying sizes they extend nearly all round. A section of this kind, however, is unsatisfactory for showing the actual relationships of the smooth and tuberculated area. Very thick sections of two other polyps of the Porto Rican *Isaurus* were therefore taken and are represented in figs. 24, 25. Fig. 24 gives the appearance in one of the polyps, the mesenteries appearing much broader than in thin sections. The lightly shaded area represents the surface of the section, while the dark area beyond indicates the projections on the lower part of the segment. Fig. 25 represents the same details in the second polyp. In both, the narrow, smooth region of the polyp is wholly to the right side of the directive axis, but nearer the dorsal than the ventral border. The relationships were also checked on the entire polyp. It is clear from the figures that in none of the three polyps can the external bilaterality be said to correspond with the internal, as Carlgren found to be mostly the case with his specimens.

Isaurus duchassaingi (Andres). Pls. II, VI, VII, Fig. 5, 23-26.

Zoanthus tuberculatus, Duchassaing, 1850, p. 11; Duchassaing et Michelotti, 1860, p. 327, pl. VIII, fig. 5.
Antinedia tuberculata, Duchassaing et Michelotti, 1866, p. 136, pl. VI, figs. 2, 3.
Antinedia duchassaingi, Andres, 1883, p. 544.
Isaurus duchassaingi, McMurrich, 1896, p. 190, pl. XVII, figs. 6-8; Duerden, 1898, p. 346, pl. XVIIa, fig. 4, pl. XVIIIa, fig. 5.

Eight specimens of this peculiar Zoanthid were secured from Hucares, having evidently formed an isolated group in the same way that the species is found to occur around Jamaica and the Bahamas. In general the polyps, which are preserved in alcohol, are shorter and the transverse wrinklings and tubercles more pronounced than in forms obtained around Jamaica and preserved in formol. Still the same essential external characters are displayed; the constancy with which the overhanging bilateral form of the column, the vertical bilateral arrangement of the tubercles, and the peculiarities of the capitulum are repeated is a little remarkable. The polyps are rarely seen in an expanded condition.

One of the specimens sectionized longitudinally displayed the same histological and anatomical characters, including the form of the sphincter muscle, as have been already given by McMurrich and myself. Tangential sections through the ectoderm revealed very clearly the manner in which the layer is broken upon into distinct cubical blocks by mesoglœal partitions, extending from the subcuticula to the middle layer (fig. 26). The ectoderm cells in each block have lost their usual columnar form and become rounded, and are charged with zooxanthellæ and nematocysts; the endodermal bays are strongly developed, but not the ectodermal.

A polyp sectionized transversely revealed the normal microtypic arrangement of the mesenteries, with ten complete mesenteries on one side and nine on the other (fig. 23). The sulcar groove was not strongly defined, but the ectoderm was smooth, while along each side the stomodæal ridges were well pronounced. The mesenteries on the sulcar aspect were the first to become free. The section represented in figs. 23 passes through two of the tubercles of the wall; the one on the upper right hand is long and narrow, and the cœlenteron is prolonged into it. The ventral tubercle, though smaller, has a distinct bay-like character. The polyps represented in transverse section in figs. 24, 25 each possessed ten complete mesenteries on each side.

External characters.—The polyps are firmly adherent to rocks and stones by means of an expanded, irregular base. Although associated in groups they are only rarely found actually united with one another, the slight basal expansion representing all there is of a cœnenchyme. The column is cylindrical or clavate, greatly swollen toward the base, and overhangs, so as to present a concave and a convex border. The proximal part is smooth, with narrow, incomplete annuli, but the distal region bears rows of large, rounded or conical tubercles on the convex aspect, while the concave aspect is smooth, thus producing a marked external bilaterality. Four principal rows of from five to eight tubercles alternate with other rows which possess only two or three smaller protuberances. The column of young specimens may be wholly smooth. The disk is entirely hidden in retracted specimens, but the capitulum is flattened and simulates a disk. It forms the terminal truncated part of the retracted polyp, and is placed obliquely, a small central aperture remaining in the middle, from which radiate numerous ridges and furrows. Around the margin of the apparent disk occurs an incomplete ring of eight or nine tubercles, separated by deep depressions, and diminishing in size toward each extremity of the partial circle. In the living condition the column-wall is firm, tough, and partly transparent.

The basal cœnenchyme is colorless or irregularly greenish brown, apparently due to adhering algæ. The column may be dark granular brown, mottled with green and black.

The diameter of the column varies from about 2 cm. at the base to 0.6 cm. in the middle, where it is narrowest. Different polyps vary in height from 2.2 cm. to 4.2 cm. The retracted tentacles are 0.3 cm. long in section.

Anatomy and Histology.—The column-wall is provided nearly throughout with a thick subcuticle connected with the mesoglœa by strands across the ectoderm. The outside cuticle is practically devoid of adhering foreign matter. The ectodermal layer is broad, and its cells have lost their columnar character, the mesoglœal strands dividing it into cubical or spheroidal blocks, in which large thick-walled zooxanthellæ and nematocysts occur (fig. 26). The subcuticle disappears toward the upper extremity of the column, and the ectoderm then becomes continuous and columnar in character. The boundary between the ectoderm and mesoglœa is not clearly defined, portions of the former being, as it were, cut off and isolated within the mesoglœa as cell-inclosures or islets and becoming farther and farther removed inwardly.

The mesoglœa is very broad, and contains numerous cell-inclosures and uniformly distributed isolated cells with granular protoplasm. In the lower part of the column the cell-inclosures take the form of small communicating canals.

The endoderm is narrow and contains numerous zooxanthellæ and small nematocysts. A circular endodermal muscle occurs, and endodermal bays are met with at different levels, extending nearly as far as the ectoderm and evidently corresponding with the thin annuli noticed among the external characters. The tubercular projections on the upper part of the column are seen in sections to be formed mainly as thickenings of the mesoglœa, but the larger are hollow, their cavity communicating with the cœlenteron. Inturnings of the ectoderm may also occur, forming the ectodermal bays.

The sphincter is single, mesoglœal, and strong, extending nearly across the mesoglœa. Proximally the mesoglœal cavities are small and circular; distally they are oval and elongated.

The tentacles possess a peripheral zone of narrow nematocysts, among which are many gland cells. The mesoglœa is thin, but on its ectodermal border presents long, delicate, branching plaits for the support of the longitudinal muscle. The endoderm is narrow and contains zooxanthellæ of two kinds, large and small. The disk closely resembles the tentacles in structure, and also exhibits the peculiar ectodermal musculature.

The stomodæum may be strongly oval or nearly circular in outline, and the ectoderm is thrown into eight or nine folds on each side, corresponding with the mesenteries (figs. 23). The tube is but slightly truncated opposite the gonidial groove, the sulcar directive mesenteries extending from each corner.

The mesenteries are brachytypic; about ten pairs usually occur on each side. The perfect members are very narrow and arranged at equal distances apart all round the stomodæal wall. The mesenterial mesoglœa and endoderm are very thin, the latter crowded with zooxanthellæ and small oval nematocysts. The parieto-basilar and retractor muscles are clearly recognizable. Toward the insertion of the mesentery in the column-wall the mesoglœa is swollen and thrown into small, irregular plaits for additional support to the musculature. A basal canal and numerous other vertical canals and cell-inclosures occupy nearly the whole length of the mesentery. The reflected ectoderm is but feebly developed, and the mesenterial filaments are of the usual Zoanthean type. Toward the base of the polyp the mesenteries unite with one another and form a reticular structure, filling the whole of the cœlenteron.

No gonads have been met with in numerous specimens sectionized.

Localities.—Guadeloupe and St. Thomas (Duchassaing & Michelotti), Bahamas (McMurrich), Jamaica (Duerden), Porto Rico (U. S. Fish Commission).

Genus PROTOPALYTHOA Verrill.

Gemmaria, Duchassaing et Michelotti, 1860, p. 55; McMurrich, 1889, p. 131, etc.; Haddon, 1898, p. 639, etc.; Duerden, 1898, p. 350; Carlgren, 1900, p. 106.
Protopalythoa, Verrill, 1900, p. 562.

Brachycnemic *Zoantheæ*, with a single mesoglœal sphincter muscle. Solitary or connected by cœnosarc. The body-wall is incrusted. The ectoderm discontinuous or continuous. Lacunæ and cell-islets are found in the mesoglœa. Polyps diœcious or monœcious.

We owe to Professor Verrill (1900, p. 562) the recognition that Duchassaing & Michelotti's familiar name *Gemmaria* was preoccupied by McCready in 1859 in the Hydrozoa, and also to Verrill the substitution for *Gemmaria* of the term *Protopalythoa*. In doing this he has assigned as the type of the genus *Gemmaria variabilis*, a species described by me in 1898, and again referred to below. None of Duchassaing & Michelotti's species was regarded as sufficiently well known or recognizable to occupy this position.

Verrill (p. 563) comments upon the close relationship between the genera *Palythoa* and *Protopalythoa*, but wisely decides to keep them apart, a course which, for the time being, will tend to facilitate the study of their different representatives.

Under the name *Gemmaria* the genus has been defined in practically the same terms by all recent students of the *Zoantheæ*.

Protopalythoa variabilis (Duerden). Pls. II, VII, Figs. 6, 27.

Gemmaria variabilis, Duerden, 1898, p. 350, pl. XVIIa, fig. 5; pl. XVIIIa, figs. 7-9; von Heider, 1899, p. 130, pl. XVII, figs. 22-29.
Protopalythoa variabilis, Verrill, 1900, p. 562.

This species was first described from specimens obtained from Port Henderson, Jamaica, and von Heider (1899) has since provisionally identified as the same a form from the distant locality of Singapore. In the *Fish Hawk* collections from Hucares are fourteen specimens which are undoubtedly this species, and agree with the Jamaican representatives in the character suggested by the specific term, namely, the variability in size and outline of the polyps. Some are short and thickset, while others are long and slender. Mature polyps vary in length from 1 cm. to 2.5 cm.

Preserved in alcohol the polyps are now a dirty gray, due to the presence of dark incrusting particles. They are mostly free, as if torn from some other object, while a few are adherent to pebbles and shells, with a very limited development of cœnenchyme. Two or three small specimens rise directly from a broad base, as if grown from larvæ, but more likely from a separate fragment of cœnenchyme. All are in the retracted condition; the capitular region is swollen, and the capitular ridges, about thirty in number, are very distinct. On adding a few drops of acid to the liquid in which the polyps are placed a slight effervescence is set up, showing that some of the incrusting particles are calcareous; but in sections a large quantity of siliceous sand grains and a few sponge spicules and radiolarian tests remain, mainly limited to the outer half of body-wall. Not only is the greater part of the column-wall impregnated with foreign particles, but many are also found within the endoderm of the disk, although the two outer layers—ectoderm and mesoglœa—are here quite devoid of them.

Although charged to such a degree with sand grains and sponge spicules, it was possible to cut moderately thin sections from specimens embedded in paraffin. In vertical sections the sphincter muscle was found to be more strongly developed than in the polyp from which its form was originally represented (1889, pl. XVIII *a*, fig. 7), more nearly corresponding with that of *Gemmaria fusca* on the same plate. The sphincter muscle of the Porto Rican polyps is represented in fig. 27 to show the possible variation within the species. Transverse sections through a polyp displayed the microtypal arrangement of the mesenteries; seventeen complete mesenteries occur on one side of the dorso-ventral axis and fifteen on the other, while on each side of the sulcar directives three incomplete mesenteries are present in the region of active growth at the ventral aspect. Below are the more detailed characters of the species.

External characters.—The polyps are erect, firm, smooth, and rise independently from a lamellar cœnenchyme, or from around the base of one another, or rarely are solitary. They may be cylindrical in retraction, swollen a little above, or more usually are clavate. Preserved specimens are often transversely wrinkled. The capitulum usually presents about thirty capitular ridges and furrows. The tentacles are acuminate, arranged in two alternating rows of about thirty in each. The peristome may be considerably raised, and the mouth is elongated and slit-like. The disk and upper part of the column are greatly enlarged on expansion, and the margins of contiguous polyps come into contact and by mutual pressure produce a polygonal outline.

The cœnenchyme is thin and very sparingly developed. As a flattened band or ribbon it connects the different members of a colony, but individuals can be seen in process of separation, the cœnenchyme becoming constricted and ultimately breaking down.

The lower part of the column is light buff in color, while the upper part is dark brown. The tentacles are usually dark brown, but may be olive or green. The outer part of the disk may be dark brown with green radiating lines, and the peristome a bright green; or the disk may be green and the peristome brown; in others the whole of the disk is bright green. The stomodæum is colorless. In alcohol the brown color is first extracted, leaving the colony a uniform dark green; later, this gives place to a dirty buff color, due to the incrusting foreign particles.

The dimensions of the polyps vary greatly, even in the same colony. The length of the column of one of the largest polyps was 5 cm., diameter 1.2 cm; an average height is 1.5 cm. and diameter 0.7 cm. The diameter of the fully expanded disk is 2.3 cm.; the tentacles are about 0.3 cm. in length.

Anatomy and Histology.—The cuticle of the column-wall is thickly coated below with a layer of foreign material, principally diatoms. The ectoderm is continuous and presents irregular internal limitations, partly due to the occurrence of incrustations, but also as a result of the ectoderm passing insensibly into the cell-inclosures of the mesoglœa. Zooxanthellæ and large oval nematocysts occur. The incrustations consist mostly of sand grains, sponge spicules, and radiolarian tests, and extend from the inner border of the ectoderm beyond the middle of the mesoglœa. Sponge spicules are specially aggregated at the most distal part of the column (fig. 27). Von Heider (1899, pl. XVII, fig. 28) also represents a similar accumulation of spicules in the Singapore specimens.

The mesoglœa is thicker above and below than in the middle; numerous isolated cells and cell-inclosures occur, and among the cells of the latter are zooxanthellæ and oval nematocysts as in the ectodermal layer. Many small rounded or oval vacuolated spaces are present containing only a single nucleus.

The endoderm is of medium height and contains symbiotic algæ and pigment granules; the circular endodermal muscle is clearly recognizable.

The cœnenchyme contains numerous inclosures similar to those of the column-wall. Cœlenteric canals occur with a regular epithelial lining and a weak musculature.

The sphincter muscle is single and mesoglœal. It extends for a considerable distance down the column, situated a little nearer the endodermal border. The upper mesoglœal chambers toward its distal extremity are large, and a gradual diminution takes place toward the proximal end.

The tentacular ectoderm is broad, the periphery being crowded with small narrow nematocysts. The mesoglœa is thick in retracted tentacles, and contains isolated cells and foreign incrusting matter. Ectodermal and endodermal musculatures occur.

The discal ectoderm is also very broad and includes zooxanthellæ and glandular cells. The mesoglœa is nearly as broad as that of the tentacles, and contains cells with elongated processes and cell-inclosures, but no foreign matter. The endoderm is low and the cells contain zooxanthellæ. The layer may also be impregnated with foreign matter of the same character as that occurring in the column-wall.

The stomodæum is oval-shaped in transverse section, with a well-marked truncated gonidial groove, the sulcar directives extending from the corners. The ectoderm is thrown into vertical folds, 12 to 18 on each side. Large nematocysts and pigment granules are also present, and indications of a nerve layer. The cells are longer at the groove, and the mesoglœa thickens toward the same place.

The mesenteries are normally brachytypic, but occasionally the macrocnemic condition may occur on one side or the other. About thirty pairs of mesenteries are present, but the number may be either greater or less. Each mesentery contains a basal canal a little beyond the origin, and in the upper part other canals extend almost across the mesentery. In the complete mesenteries the canal is compressed, and more circular in the incomplete mesenteries. The cellular tissue in the canals contains zooxanthellæ and large oval nematocysts. Beyond the basal portion the mesenteries are very thin and the endoderm is provided with zooxanthellæ. The imperfect mesenteries are very short radially, appearing in transverse sections as goblet-shaped projections of the column-wall. The parieto-basilar muscle is well developed on both the perfect and imperfect mesenteries.

The reflected ectoderm and mesenterial filaments are of the usual Zoanthean type.

Both male and female gonads may occur within the same polyp, either separately or on the same mesentery.

Localities.—Jamaica (Duerden), Singapore (von Heider), Porto Rico (U. S. Fish Commission).

Genus PALYTHOA Lamouroux.

Brachycnemic *Zoanthidæ* with a single mesoglœal sphincter muscle. The body-wall is incrusted. The ectoderm is continuous. The mesoglœa contains numerous lacunæ, and occasionally canals. Diœcious, rarely hermaphrodite. Polyps immersed in a thick cœnenchyme, which forms a massive expansion.

Contrary to all other species previously examined a Javan *Palythoa* has been found by Carlgren (1900*a*, p. 110) to be hermaphrodite.

In the paper on the Jamaican *Zoantheæ* I have already discussed the practical absence of reliable taxonomic characters for the species of this genus. The external features available—color, number of tentacles and capitular ridges, form of the colonies and individual polyps, extent of immersion within the cœnenchyme, and dimensions—seem of little assistance; while, judging from the number of species already described, not much help is likely to be forthcoming from the characteristics of their internal anatomy and histology, including the nature and distribution of the incrusting particles, the form of the sphincter muscle, the arrangement of the mesoglœal canal system, thickness of the cœnenchyme, and presence or absence of pigment granules. In none of these features has specific differentiation proceeded very far, and I consider it very doubtful whether the best course would not be to regard all the forms as but one species. Such a conclusion has been forced upon Professor Hickson (1898) as a result of his extensive studies of the Hydrozoan coral *Millepora*. He believes that all the numerous species of this well-defined genus already described are but variations in the manner of growth, and that no reliable specific differences are forthcoming when the colonies with their zooidal tissues are compared in detail. A similar study of the recognized species of the genus *Palythoa* will be only possible where colonies from widely separated regions are available for comparison.

Among the abundance of Jamaica material which has passed under my examination I have only determined what seem to be two distinct species, the differences being based mainly upon the number of capitular ridges, which corresponds with the number of tentacles and mesenteries. In one series of colonies practically all the polyps possessed from 14 to 16 capitular ridges, and in another series 18 to 20. Scarcely any other constant differences, however, were forthcoming.

Palythoa caribæa Duchassaing & Michelotti. Pls. II, VIII; Figs. 7, 28.

Palythoa caribæorum, Duchassaing et Michelotti, 1860, p. 329.
Palythoa caribæa, Duchassaing et Michelotti, 1866, p. 141, pl. VI, fig. 11; Duerden, 1898, p. 365, pl. XVII *a*, fig. 9, pl. XIX, figs. 5–7.

A single *Palythoa* colony of about thirty strongly retracted polyps was found in the Porto Rican collections from the light-house reef at Playa de Ponce. The external characters avail but little toward its determination, but a careful comparison of sections with the Jamaican specimens which I identify as *Palythoa caribæa* reveals no important distinctions, and as the mesenteries are seventeen I identify it with this species rather than with *P. mammillosa*.

External characters.—The polyps are smooth, rigid, cylindrical, closely associated, and arranged within the cœnenchyme in an irregular manner. Distally they are free from the cœnenchyme for a short distance, the free portion being rounded or conical in retraction. On very strong retraction the upper surface of a colony may be nearly flat. At the periphery of the colonies the outlines of the marginal polyps are clearly indicated, and new individuals arise both at the margin and between the previously existing polyps. The capitular ridges and furrows vary from 14 to 17.

The tentacles are dicyclic, smooth, pellucid, very short, acuminate, and slightly entacmæous, the inner row opposite the capitular ridges. They vary in number from 28 to 34.

The disk is circular, depressed during partial expansion and overhanging on full expansion, being cup-shaped or saucer-shaped according to degree of expansion. Peripherally it is thin, transparent and non-incrusted, with rounded ridges and furrows; the central part is dome-shaped, contains a few small incrusting particles, and bears the slit-like mouth at apex. The gonidial groove is not clearly seen.

In the living condition the polyps are a nearly uniform cream color, or sometimes brown; they appear white when the ectoderm is rubbed off. The stomodæal walls are white.

The length of the polyp, as also the thickness of the cœnenchyme, varies much, and may be anywhere from 0.3 to 1.8 cm., but is usually about 0.7 cm.; the diameter of the polyp in section is 0.35 cm. The diameter of the disk on full expansion is about 1 cm. and on retraction 0.4 cm.; the distance of the centers of contiguous polyps is 0.5 cm.; the tentacles are about 0.2 cm. long. Colonies vary in size from a few centimeters across to several hundred.

Anatomy and Histology.—The lower part of the column-wall is indistinguishable from the general cœnenchyme in which the polyps are embedded, but except in the most strongly retracted polyps a free columnar region occurs above. The ectoderm spreads as a uniform layer over the whole external surface and is readily rubbed off in living colonies. The layer is continuous, but is not distinctly limited on its mesoglœal aspect, appearing to pass insensibly into the cell-inclosures of the latter. It contains zooxanthellæ and narrow, elongated nematocysts, as well as a large oval form. The foreign incrusting material is limited to the deeper part of the ectoderm.

The mesoglœa is thick and densely crowded with calcareous sand grains; a few siliceous sponge spicules, radiolarians, and an occasional test of a foraminifera also occur. Isolated cells and large and small cell-islets are scattered throughout, the latter containing nematocysts and pigment granules.

The endoderm is uniformly narrow, except in the upper region where the mesenteries are closer, when it becomes broader. It contains much granular pigment matter and many zooxanthellæ, and a weak endodermal muscle is present.

The single sphincter muscle is contained within an elongated series of small mesoglœal cavities; proximally, they are situated close to the endodermal border, but become more central above, where the cavities are a little larger (*fig.* 28).

The tentacles possess a broad ectoderm crowded with long narrow nematocysts, zooxanthellæ, and pigment granules; the mesoglœa and endoderm are both thin. The ectodermal musculature is well developed on mesoglœal plaitings, but the endodermal is weak.

The discal wall is much like that of the tentacles, but incrustations occur toward the middle where the mesoglœa thickens.

In its transverse outline the stomodæum varies in different regions and in different polyps. In most examples it is pyriform, truncated toward the groove, and the ectoderm forms seven or eight vertical folds on each side, the gonidial groove occupying nearly one-third of the diameter. In other polyps the stomodæum may be nearly circular and devoid of folds. The ectoderm is strongly ciliated and loaded internally with yellow pigment granules.

The mesenteries present the normal brachycnemic arrangement in most cases, but irregularities may occur, as where a polyp may be macrocnemic on one side and brachycnemic on the other, while one polyp has been met with in which the former arrangement occurred on both sides. The number of pairs varies from about 14 to 17. The mesenterial mesoglœa is very narrow except toward the column-wall, where it enlarges and contains the basal canal and sinuses. These occupy almost the whole transverse width in the upper region of the mesenteries, but are more restricted below. The basal canals are well developed in both the perfect and imperfect mesenteries and, in addition to cells with granular protoplasm, contain many oval nematocysts and pigment particles; below they are connected with the sinuses in the cœnenchyme. The endoderm on the lower part of the mesenteries is enormously thickened and loaded with nutrient granules.

The reflected ectoderm and mesenterial filaments are of the typical Zoanthean character.

Spermaria occurred on the complete mesenteries of some of the polyps examined.

Localities.—St. Thomas (Duchassaing & Michelotti), Jamaica (Duerden), Cuba (U. S. Fish Commission).

ACTINIARIA (restr.).

Actinozoa in which six pairs of primary mesenteries (protocnemes) arise bilaterally, and usually all become complete. The two axial pairs constitute the directives, in which the retractor muscles are on the faces turned away from one another; the remaining four constitute unilateral pairs, two on each side of the polyp, in which the retractor muscles are on the faces turned toward each other. Additional mesenteries (metacnemes) arise as unilateral pairs within the six primary exocœles, either simultaneously or successively in a bilateral manner from one aspect of the polyp to the other, and usually constitute one or more alternating hexameral cycles beyond the primary; sometimes the hexameral plan is departed from. One or more tentacles may arise from each mesenterial chamber. The column-wall occasionally possesses an ectodermal muscle and ganglion layer. Two gonidial grooves usually occur. Parieto-basilar and basilar muscles are generally developed, and usually ciliated bands on trilobed mesenterial filaments. The polyps are solitary, never forming colonies, and no incrusting or continuous skeleton is produced.

Order ACTININÆ Milne-Edwards.

Actiniaria in which the tentacles are simple, and arranged in alternating cycles at the periphery of the disk. Only one tentacle communicates with each mesenterial chamber.

The orders *Actininæ* and *Stichodactylinæ* are here employed with their older significance, not in the manner adopted by Carlgren (1900*a*).

Family PHYLLACTIDÆ Andres.

Actiniaria with a smooth or partly verrucose column; tentacles simple, subulate, situated at some distance from the apparent discal margin; between the tentacles and margin are low tentacular structures or foliose areas. Sphincter muscle endodermal, more or less circumscribed, lying in the interval between the tentacles and the frondose or tentacular structures. Two or more orders of mesenteries perfect.

The family *Phyllactidæ* has been studied anatomically mainly by Professor McMurrich (1889, 1893). It embraces at least the following genera: *Phyllactis* M. Edw., *Oulactis* M. Edw., *Diplactis* McMur., *Cradactis* McMur., and *Asteractis* Verr. Haddon (1898, p. 437) includes the genus *Hoplophoria* of H. V. Wilson (1890), but I have shown (1899) that Wilson's species, *H. coralligens*, is a *Lebrunia* and must therefore be placed with this genus under the family *Dendromelidæ*. The West Indian *Hoplophoria* never exhibits anything corresponding with the extensile and variable capitulum which Haddon describes for his *H. cincta*.

Genus ASTERACTIS Verrill.

Asteractis, Verrill, 1869, p. 464; 1899, p. 45; Andres, 1883, p. 506; Haddon, 1898, p. 439.

Phyllactidæ in which the column is provided in its upper part with vertical rows of adhesive verrucæ; outside the tentacles the acrorhagi are enormously developed, appearing as a flat, ruffled collar, and each bears numerous small hollow papillæ or finger-like simple or complex outgrowths. Sphincter muscle circumscribed. Twelve or more pairs of perfect mesenteries.

Asteractis expansa Duerden. Pls. II, VIII, IX, Figs. 8, 29–33.

Asteractis, n. sp., Duerden, 1898 *a*, p. 455.
Asteractis expansa, McMurrich, 1898, p. 232.

This species is one of the most plentiful in the collections from Porto Rico, but all the specimens received are strongly retracted and infolded. It is undoubtedly the form which is to be obtained in such abundance all around the Jamaica coasts, and which has been discussed and partly described by McMurrich (1898, p. 232) from twenty-six specimens obtained by him from Cuba. On account of the uncertainty involved in its identification with others already described it is desirable that a full account of its characters should be given. I have therefore supplemented the study on the Porto Rican examples with other details obtainable from living Jamaica specimens. A discussion of its relationship with other species is given at the end of the description.

The usual living condition of the polyps is that of an exposed circular disk at the level of the sea-floor in very shallow water, the remainder of the animal being completely buried. The base may be fixed to rocks or stones, or merely adherent to loose fragments. When the polyp is only embedded in gravel and sand it can readily be secured by passing the fingers downward and around it and then lifting up the entire mass. When thus collected the whole of the upper part of the column is thickly coated with sand, fragments of shells, and small pebbles, held there by means of verrucæ. The foreign matter is slowly dropped if the column remains exposed in the laboratory for some time. Placed in a tumbler or vessel, the upper part of the column, along with the acrorhagi, overhangs gracefully, its form and the delicacy of the colors rendering the polyp a very attractive object. It was from such a specimen that fig. 8, pl. II, was taken.

In the laboratory the polyps exercise some selection in their food, anything objectionable being dropped over the edge as a result of the contractions of the latter. Should the water become stale the stomodæum is everted, and if no change is made in its surroundings the eversion of the polyp may become complete, enabling all the internal organs to be observed. The exposed colors vary with the nature of the sea-floor, the general impression being dark olive on a black muddy floor, and gray in coral mud or sandy surroundings.

External characters.—When the polyps are expanded in the laboratory, free from foreign material, the base is larger in diameter than the column and pellucid, the mesenterial lines showing through. The margin is crenate.

The column is erect and cylindrical, narrow in the middle, and broad below and above. It is thin-walled and divided by the mesenterial lines into well-marked rounded ridges and furrows, especially toward each extremity. Distally the column is caliciform and considerably overhangs the lower part. The verrucæ are circular and extend in longitudinal rows down the intermesenterial ridges for about one-third of the length of the column, each ridge possessing about a dozen. The members of any row are usually irregularly arranged with reference to the contiguous rows, but sometimes they are disposed in transverse cycles. The middle of the verruca is usually depressed, giving a sucker-like character to the whole organ.

The oral disk, regarding as such all the flat exposed part of the polyp, consists of three areas: (*a*) A peripheral zone, constituted of radiating, frondose bodies—the acrorhagi, in diameter occupying from one-half to two-thirds of the whole disk, and corresponding in number with the tentacles. (*b*) The tentaculate zone, containing four cycles of subulate tentacles. (*c*) The usual smooth naked area of the disk or peristome, with the mouth in the center.

The frondose areas are broad radiating bands, closely arranged, but sharply separated from one another by deep, naked grooves, mesenterial in position, and only seen on actually separating the ridges. They are raised a little above the general level of the disk, and are partly distinct from one another at the outer margin, where they overhang. They bear tubercles and irregular short outgrowths, some of which become minutely dendriform, and are provided with rounded tubercles and short finger-shaped processes. The outgrowths are a little closer and more numerous at and toward the sides and ends of the acrorhagi, and are sometimes almost absent along the middle. The complete zone consists of three cycles: (*a*) A primary series, twelve in number, extending practically as far as the base of the outermost cycle of tentacles, and occupying the same radii as the first and second cycles of tentacles; centrally, as well as at the margin, they may be produced so as to be partly free from the rest of the disk. (*b*) A secondary series, also twelve in number, extending centripetally a little more than half the length of the first, and corresponding with the third cycle of tentacles. (*c*) A tertiary series of twenty-four, opposite the fourth cycle of tentacles, generally narrower and shorter than the last, with the tubercular and frondose outgrowths not as well developed. In the living condition the individual outgrowths at the centripetal end of the second cycle occasionally become much enlarged, inflated, and lighter in color, adding a peculiar character to the disk. The number may vary at times, an arrangement in fourteen instead of twelve being counted in one polyp. In preserved polyps the disposition of the frondose areas in cycles is by no means so readily recognized as in the living condition.

Comparing the acrorhagi of *Asteractis* with those of a typical Bunodid, such as *B. granulifera*, it is found that the papillæ, tubercles, etc., occur on the upper aspect of the organs in the former, while in the latter they are restricted to the lower aspect, the upper surface being quite smooth. The acrorhagi of most Bunodids bear stinging cells, while these are absent from *Asteractis*.

The tentacles are short, entacmæous, acuminate, broad at the base and thence narrow rapidly, smooth, generally forty-eight in number, and arranged in four cycles according to the formula 6 6 12 24. The disk and tentacles may be completely infolded. The naked portion of the disk is flat, smooth, and occupies but a small proportion of the total apparent disk. The mouth is oval and the gonidial grooves are strongly marked. The stomodæum is capable of complete eversion, and under uncongenial circumstances the animal may even turn itself inside out.

The coloration varies much in different parts of the same polyp, and also in individual polyps. The base is pellucid and white. The column is generally cream-colored below, becoming a lighter or darker olive above; sometimes the lower part displays irregular thin patches of crimson or orange; the verrucæ usually exhibit white centers. The colors on the disk vary somewhat according to the nature of the ground. The most usual condition is a pale olive, with the frond tubercles opaque white or grayish. The fronds may also be a dark olive, green, brown, or blackish brown. The tentacles are usually lighter or darker shades of olive or brown, with a green or crimson iridescence; several oval patches of opaque white, each with a clear center, occur on the inner surface. The disk may be flecked in various ways with opaque white or cream, often with irregular patches of crimson or green, especially around the mouth.

The height of the column varies from 4 to 6 cm.; it may even reach as much as 8.2 cm. The diameter is likewise inconstant; on full expansion it is about 3 cm. in the middle. The length of the inner tentacles is 1.5 cm. The diameter of the whole disk is usually 6 or 7 cm.

Anatomy and Histology.—The column-wall is of only moderate thickness. The ectoderm is much folded in contracted specimens, and no ectodermal musculature is recognizable. The mesoglœa is narrow, and exhibits a fibrous appearance; abundant connective-tissue cells are scattered throughout. The endoderm is very deep, and where the mesenteries are closely arranged becomes triangular in transverse sections. Zooxanthellæ are abundant. The endodermal muscle is well developed on fine branching mesoglœal plaitings, which in retracted polyps are arranged somewhat in groups. A section through a verruca reveals that the mesoglœa is elevated on each side (fig. 33).

The acrorhagi with their dendriform and tubercular outgrowths are extremely thin-walled structures, without any peculiar histological modifications. The mesoglœa is scarcely distinguishable as a distinct layer, and the ectoderm is much thinner than elsewhere and devoid of nematoblasts. A slight endodermal muscle occurs.

The sphincter (pl. VIII, fig. 30) is a small but typical circumscribed endodermal muscle, such as is characteristic of the *Bunodactidæ*. As in that family, it occurs between the acrorhagi and the origin of the outer row of tentacles. It is oval in shape and subpedunculated, and the mesoglœal plaitings are narrow and much branched.

The ectoderm of the tentacles is a broad layer, usually much folded in preserved specimens; the nematocysts are small and arranged in a peripheral zone. The longitudinal ectodermal muscle is strongly developed, and a thin nerve layer can be distinguished toward the proximal extremity. The mesoglœa is narrow and thrown into long, narrow, slightly branching plaits on its ectodermal border, following the foldings of the ectoderm. The endoderm is loaded with zooxanthellæ and presents very irregular internal limitations.

The naked portion of the disk shows both the ectodermal and endodermal muscles strongly developed on mesoglœal processes. Stinging cells do not appear to be present in the ectoderm.

The ectoderm of the stomodæum is strongly ciliated throughout, and displays a broad zone of deeply staining, elongated nuclei, among which occur abundant glandular cells and long nematocysts. The two gonidial grooves, though clearly distinguished in the living animal, are not strongly marked off from the rest of the stomodæum histologically. They are prolonged as languettes for some distance below the lower boundary of the tube. The mesoglœa is not appreciably thickened at the grooves, and is very thin throughout.

Forty-eight pairs of mesenteries are present, two pairs of which are directives. All are perfect for the greater part of the length of the stomodæum, but all except the primary cycle become free before the termination of the stomodæum is reached, the third cycle becoming free in advance of the second (fig. 32). In a small polyp only twenty-four mesenteries were present, all of which were complete in the upper region. Below the stomodæum the mesenteries are arranged in well-defined cycles, with the formula 6 6 12 24. The retractor muscle is circumscribed, and strongly developed on long, narrow, branching mesoglœal plaitings. A well-developed pennon, bearing the parieto-basilar muscle, occurs on the other face; in the upper region it is situated near the origin of the mesentery, but its internal free edge becomes further removed from the periphery as the lower region is approached. The retractor muscle is equally developed on the twelve pairs of mesenteries constituting the first and second cycles, but is weaker on the members of the third and fourth cycles.

Mesenterial filaments occur on all the mesenteries below the stomodæal region, both the ciliated and glandular streaks being well developed.

In the half section of a polyp, represented in fig. 29, the mesentery is viewed on its ectocœlic face, and the parieto-basilar muscle is indicated, extending practically the whole length of the polyp. The mesoglœa supporting it presents a very distinct free edge. The basilar muscle is clearly seen, and is also represented in section in fig. 31. Both inner and outer stomata occur, the former large and the latter exceptionally small and situated some distance from the periphery. In some mesenteries the outer stoma was not represented, while in others a thinning of the mesentery was recognizable where the aperture should occur, but the actual perforation had not taken place. Appellöf (1900, p. 77) has recently shown that, contrary to the generally accepted opinion, the mesenterial stomata originate in the embryo by resorption of the mesenterial tissue. It was maintained by the Hertwigs that they represent interruptions in the growth of the mesentery which had never been completed. Appellöf found in *Urticina* that at first the mesenteries are entire, and that it is only later that the perforations appear, first by resorption of the mesoglœa and then of the endoderm, the outer stomata appearing somewhat earlier than the inner.

In *Asteractis* it would seem that the outer stomata are in process of disappearing, or rather of ceasing to appear. Whenever present they are exceptionally small, while the large size of the mesenteries has enabled me to satisfy myself that in some cases they are altogether wanting. Where a thin, non-perforated spot occurs it is evident that the absorption of the mesenterial tissue is only partial. The incomplete development of the apertures may perhaps be associated with the exceptional width of the mesentery in this region, dependent upon the extraordinary development of the acrorhagi.

In one polyp sectionized male gonads were met with in great abundance, occupying a large proportion of the cœlenteron. The spermaria were arranged in roughly parallel rows, but on account of their crowded condition the cycle or cycles of mesenteries on which they were borne could not be determined.

Asteractis expansa is apparently one of the most plentiful of the Actinians within the West Indian area. This is certainly the case as regards Jamaica. Its abundance in the U. S. Fish Commission's collections would indicate the same for Porto Rico, while, according to McMurrich (1898, p. 233), it would seem to be fairly common on the Cuban coast. Like Professor McMurrich, in the paper just referred to, I have always considered this fact as strongly suggestive of its identity with one or other of the species established by the earlier actinologists. It can scarcely be expected that a form so abundantly represented around three of the islands of the Greater Antilles would be absent from the Lesser Antilles, whence Lesueur and Duchassaing & Michelotti obtained their types.

But uncertainties arise when it is attempted to compare it step by step with the descriptions of these writers and with the determinations of them made by subsequent students. Of the species to be considered are *Asteractis flosculifera* (Lesueur), *A. conquilega* (Duchassaing & Michelotti), *A. formosa* (Duchassaing & Michelotti), and *A. bradleyi* (Verrill). McMurrich (1889, p. 108) has described from the Bermudas, under the term *Oulactis fasciculata*, a Phyllactid which Verrill (1899, p. 45) regards as the *Actinia flosculifera* of Lesueur, and of which Verrill later gives a figure (1900, pl. LXVIII, fig. 1) under the title *Actinactis flosculifera*, the generic term being evidently a typographical error for *Asteractis*. Both Verrill and McMurrich have seen specimens of the Jamaica *Asteractis* and agree (*in litt.*) that it is quite different from the species referred to above.

The form which Duchassaing & Michelotti (1860, p. 46, pl. VII, figs. 7, 11) have described and figured as *Oulactis flosculifera* may perhaps be taken as referable to the present one, though their fig. 7 but indifferently represents the species when seen alive. A. Andres (1883) does not accept Duchassaing & Michelotti's identification of their form with the *A. flosculifera* of Lesueur, and separates *O. flosculifera* as a distinct species, *Oulactis foliosa*. McMurrich (1889, p. 56) described and figured as the *Oulactis flosculifera* of both Lesueur and of Duchassaing & Michelotti, and the *O. foliosa* of Andres, a single specimen which he found buried in the sand up to the tentacles on the shore of the island of New Providence, Bahamas. He described it thus: "The fronds, situated on the periphery of the disc, are in a single cycle, one surmounting each longitudinal row of verrucæ, there being altogether apparently 24." McMurrich (1898, p. 232) has since had the advantage of studying numerous specimens from Cuba which he regards as without question representatives of the present species. His opinion therefore of the identity of the present form with the older species of *Phyllactidæ* is of special value. He remarks as follows:

"With none, however, does it seem to agree very closely, though it seems to come nearest to *O. flosculifera* of Duchassaing & Michelotti ('60). In my original description of *O. flosculifera* ('89) I took it for granted that Duchassaing & Michelotti's identification was correct. Andres ('83) thinks otherwise and has separated the form described by these authors from Lesueur's *O. flosculifera* and named it *O. foliosa*. Perhaps after all Andres may have been right; the form which I described from the Bahamas agrees fairly well as to coloration with Lesueur's form, while the present form seems to agree more closely with that of Duchassaing & Michelotti. However, the earlier descriptions are all too indefinite to make the identification certain and it will perhaps lessen the chances of confusion in the future to accept Mr. Duerden's separation of the present species under the specific name he has chosen."

The occurrence of only 24 frondose areas at once separates the species from *A. expansa*, for in this 48 are invariably present, except in cases of irregularity.

The description given by Duchassaing & Michelotti (1860, p. 47) of their *Oulactis formosa* is very incomplete, but the accompanying figures (pl. VII, figs. 4, 5), showing only 20 tentacles in a single cycle, suffice to show that it is widely separated from *A. expansa.*

The species seems to bear some resemblance to *Asteractis bradleyi* Verrill, from Panama, the type species of the genus (1899, p. 46), though evidently this is a smaller form. Verrill in his original description (1869, p. 465) refers to "twelve conspicuous, dark spots, about midway between the tentacles and margin, and corresponding with the primary tentacles," in the drawing accompanying the specimens transmitted to him, but is unable to account for them. In Jamaican examples I have occasionally met with a similar appearance and found it to be due to a local distension of the papillæ. It is not a constant feature of the individual. The papillæ may afterwards return to their normal condition, and no distinction between them and the others is then apparent.

In his original account Verrill notes that the frondose areas are of different radial extent, exactly as found in the Jamaican species, but in his later description (1899, p. 46) he makes no reference to this, and his figure does not suggest an ordinal disposition. Further, the papillæ appear to increase in size from within outward in *A. bradleyi*, though such is not the case in *A. expansa.*

So far, then, the species seems distinctly separated from any previously described, and it seems preferable to retain the position assumed in McMurrich's paper.

Family BUNODACTIDÆ Verrill.

Bunodidæ, Gosse, 1858, 1860; et al.
Bunodactidæ, Verrill, 1899, p. 42.

Actiniaria with a flat contractile base; column usually provided over the whole or greater part of its extent with vertical rows of adhesive verrucæ or vesicular outgrowths, often with a capitular cycle modified as acrorhagi, no cinclides and acontia. Sphincter muscle endodermal and circumscribed. Perfect mesenteries usually numerous and strongly muscular: all may be gonophoric.

The family *Bunodactidæ* corresponds with the family *Bunodidæ* of Gosse and subsequent authors. The change of name is due to the recognition by Verrill that Gosse's generic term *Bunodes* was already preoccupied (see below).

The family includes Actiniaria which are readily recognized by the verrucose or vesicular character of the column and the very pronounced circumscribed sphincter. The genus *Leiotealia* alone has a smooth column. Both the *Phyllactidæ* and *Aliciidæ* are closely related with the *Bunodactidæ*, and as intermediate forms are studied the three may have to be united. The *Phyllactidæ* are separated mainly by the enormous development of the acrorhagi, which become strongly tubercular or lobed on their upper aspect, and constitute a large proportion of the exposed disk of the polyp. The *Aliciidæ* bear vesicular, often pedunculated, columnar outgrowths, but the muscular development throughout is much less, the sphincter being either absent or diffuse in character, while acrorhagi are usually absent.

Genus BUNODOSOMA Verrill.

Bunodes (pars), Gosse, 1855, 1860.
Bunodosoma, Verrill, 1899, p. 44.

Bunodactidæ in which the column is provided with vertical rows of vesicular outgrowths, which may be all of the same size or alternately larger and smaller, and with a cycle of simple or complex acrorhagi. Tentacles polycyclic. Twelve or more pairs of perfect mesenteries.

In 1899 Professor Verrill, having discovered that Gosse's generic term *Bunodes* (1855) had been employed a year previously by Eichwald for a genus of Eurypteroids, proceeded to subdivide into different genera the species which had been included under the long-established name. For forms the verrucæ of which serve as adhesive suckers, and of which the British *Bunodes verrucosa* (*B. gemmacea*) is the type, he gives the name *Bunodactis*. Attaching supreme importance to the presence of only six pairs of perfect mesenteries, he erected the genus *Bunodella* for the *Aulactinia stelloides* of McMurrich (1889, p. 28), but in a later paper of the same series (1899, p. 146) he withdrew the genus, having found that in large Jamaican specimens the number of perfect mesenteries in the type species may reach twenty-four. For the *Actinia granulifera* of Lesueur, Verrill proposed the genus *Bunodosoma*, distinguishing it from *Bunodactis* by the fact that the verrucæ do not form adhesive suckers, but are vesicular, and that the upper or submarginal verrucæ are larger, and in mature specimens more or less lobulated. The two forms of verrucæ appear to me well worthy of generic separation; they differ both histologically and physiologically. The alteration in the typical generic name made it necessary to effect a corresponding change in the family name, and Verrill therefore altered this from *Bunodidæ* to *Bunodactidæ*.[1]

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[1] Professor McMurrich, in his report on certain Puget Sound Actinians (Annals N. Y. Acad. Sci., vol. XIV, pt. 1, July, 1901), received while the present paper was going through the press, discusses at some length the synonymy of the genera now under consideration. Following the strict laws of priority, McMurrich employs Ehrenberg's (1834) subgenus *Cribrina* for the genus *Bunodes* of Gosse. It is only possible here to tabulate his conclusions, which are as follows:

Cribrina, Ehr.=*Bunodes* Gosse, *Evactis* Verrill, *Bunodactis* Verrill, *Bunodella* Verrill.
Urticina, Ehr.=*Tealia* Gosse, possibly *Epigonactis* Verrill.
Anthopleura, Duch. & Mich.=*Aulactinia* Verrill, *Ægeon* Gosse, *Bunodosoma* Verrill.

Bunodosoma granulifera (Lesueur). Pls. II, IX, X, Figs. 9, 34, 35.

Actinia granulifera, Lesueur, 1817, p. 173.
Urticina lessoni, Duchassaing, 1850, p. 9.
Oulactis granulifera, Milne-Edwards, 1857, p. 293; Duchassaing et Michelotti, 1860, p. 46.
Cereus lessoni (*Urticina*), Duchassaing et Michelotti, 1860, p. 42, pl. VI, figs. 13, 14.
Anthopleura granulifera, Duchassaing et Michelotti, 1866, p. 126, pl. III, fig. 8.
Aulactinia granulifera, Andres, 1883, p. 438.
Bunodes tæniatus, McMurrich, 1889, p. 23, pl. I, fig. 4; pl. III, fig. 7.
Bunodes granulifera, Duerden, 1898, p. 454.
Bunodosoma granulifera, Verrill, 1899, p. 45.

This common West Indian Actinian is represented by numerous specimens in the Porto Rican collection, sometimes with the light and dark longitudinal columnar bands still recognizable. In most cases the upper part of the polyps has become infolded, due to the action of the strong sphincter muscle; in one instance the reverse process of eversion has partly taken place, displaying the tuberculate or papillose acrorhagi to great advantage.

External characters.—The base is flat, circular, adherent to rocks and stones, and is a little larger in diameter than the column. It is radiately grooved in correspondence with the internal mesenteries, and preserved specimens also show deep concentric grooves.

The column is cylindrical, usually a little higher than broad, and very distensible. The entire surface of the column is crowded with subspheroidal vesicles, so that the actual body-wall can be seen only during full distension, in which condition the upper part of the column becomes very thin and transparent. The vesicular outgrowths vary much in size, arrangement, and form under the different conditions of expansion and retraction of the polyp. They are approximately equal in size and thin-walled; on large polyps they are bifid or even trifid toward the apex, and the wall is there denser. Their regular disposition in vertical rows is usually only evident during full expansion; at other times they press closely one upon another, and so disturb the regularity. They constitute twenty-four alternate lighter and darker vertical bands or zones, the color distinction being usually apparent for the whole length of the column. In large examples these color bands are not always recognizable. The darker zones have usually five rows of verrucæ, and the lighter zones three, making 96 rows in all, the former being nearly double the width of the latter. On partial expansion of the polyp each row may appear as if double, and in large polyps 192 rows are actually present. The number of verrucal rows is less in very young specimens. The outgrowths are incapable of attaching foreign particles to the column.

The column is deeply crenate at the apex, the depressions corresponding with the internal mesenterial attachments. A large acrorhagus, alternating with the outermost row of tentacles, occurs at the top of each entocœlic mesenterial division, and corresponds with two vertical rows of verrucæ; a smaller acrorhagus alternates with each of the larger, and is exocœlic in position, the series corresponding with the outermost cycle of tentacles. The acrorhagi are thus 96 in all, but in young polyps the smaller series may not be obvious. The outer or lower aspect of each acrorhagus bears numerous small papillæ; the inner or upper surface is smooth; the apex of each is thick-walled, and in certain states of preservation stands out prominently as a rounded, opaque white spheroid. A deep fossa occurs between the inner base of the acrorhagi and the outermost cycle of tentacles. Lesueur (p. 176) mentions that the margin is "furnished with tubercles, which are surmounted with small white pedunculated warts."

The tentacles are entacmæous, shortly conical, and generally 96 in number, arranged according to the formula 6 6 12 24 48.

The disk is large, smooth, flat, and often overhangs on full expansion. The two gonidial grooves are strongly marked by their thickened lips, and the stomodæum is smooth and readily everted. The tentacles and disk can be completely hidden by the overfolding of the column-wall.

The base is yellowish gray in color, with thin, radiating red bands; the column-wall is more usually a brick red, becoming dark reddish brown above. The verrucæ are mostly of the same color, but the tips are opaque white, especially in the distal region. The twenty-four alternate lighter and darker vertical rows are not well marked in some polyps, but are very persistent in others, even after preservation for a long time in alcohol. The acrorhagi are nearly colorless toward the tips, while the tubercles are opaque white; the fossa between the acrorhagi and the base of the outermost cycle of the tentacles is often scarlet. The tentacles are yellowish gray, and nearly transparent on the outer surface; several opaque, yellow oval patches occur on the inner aspect, and also a vertical, elongated spindle-shaped patch of crimson. The disk exhibits thin, radiating scarlet lines; and yellowish bands, passing from around the mouth, surround the base of the tentacles. The peristome and upper part of the stomodæum are a bright scarlet.

The above is the coloration generally met with, but different examples of the species vary much, and some may be here noted. Usually the column is a bright red, but may be crimson, orange, brown, chocolate brown, or a grayish olive. This latter color, and the verrucæ in light and dark bands, most nearly corresponds with McMurrich's Bahaman specimen. In the larger examples the alternate larger and smaller acrorhagi are well distinguished by the contrast of their opaque white tubercles with the rest of the column. The verrucæ toward the top of the column are usually more opaque white than those below; toward the base they become more transparent, with one or two dark centers. The column-wall in any individual specimen appears to be of practically the same color throughout, the lighter and darker vertical zones depending mainly upon the intensity of the pigmentation of the apex of the verrucæ.

Twelve series of radiating colored bands, each made up of three parts, the middle one much the broadest, may extend from around the mouth to the first and second cycles of tentacles, then each passing between the tentacular bases forms a cream-colored area on the antero-lateral portion of the base of the alternating tentacles in the outermost cycles. Often a narrow band of crimson passes up the anterior face of the tentacles.

The length of the column is usually about 4.5 cm., but a polyp may elongate as much as 7 or 8 cm. The diameter is from 4 to 5 cm., or may be even 7.5 cm.; the length of the largest tentacles is 1.3 cm., the diameter 0.4 cm. The acrorhagi may extend 0.3 cm. beyond the margin.

Anatomy and Histology.—In vertical sections the base is folded to an extraordinary degree; the foldings usually include all the three layers, long processes of the mesoglœa accompanying the ectodermal folds. The ectoderm of the base is very deep, being constituted of long narrow cells—mainly gland cells, with fine granular contents. The mesoglœa and endoderm are very thin; a weak, circular endodermal muscle is present, and fine black pigment granules occur in the inner layer.

The column-wall seems also much folded in sections, the appearance being due mainly to the presence of the vesicular evaginations (fig. 34). These are all hollow, and arise from both the entocœlic and exocœlic chambers. The wall of the vesicles is thinner than that of the column generally, and a short canal connects the cavity of the vesicle with the cœlenteron, while the endodermal muscle is specially developed around the aperture (cp. Dixon's figure of *Bunodes thallia*, 1889, pl. IV, fig. 4). The ectoderm of the vesicles is high, and medium-sized nematocysts are abundant, mainly limited to the outer apical region; numerous unicellular gland cells are present laterally. The granular secretion is seen partially extruded from many of the cells. The mesoglœa of the column-wall is very variable in thickness.

Small dark-colored pigment granules occur abundantly in the endoderm of the vesicles, as well as in the other parts of the column-wall, and, indeed, throughout the endoderm of the polyp. I have not been able to distinguish any yellow cells in the endoderm of any part of the polyps, but McMurrich states that numbers are contained throughout the layer in his Bahaman specimen. The endodermal muscle is very strongly developed along the column-wall, arranged on branching outgrowths of the mesoglœa.

The acrorhagi are much like the verrucæ in structure; nematocysts are abundant only at the tips of the tubercles, and the ectoderm is comparatively thin. No endodermal musculature can be recognized.

The sphincter muscle (pl. IX, fig. 34) is a typical circumscribed endodermal representative, situated within the fossa, and attached by only a very short pedicle. The appearance usually presented by transverse sections differs a little from that in the figure given by McMurrich, which is drawn associated with a mesentery.

In partial contraction the tentacles are fluted externally, and in transverse sections present a sinuous appearance similar to that described and figured by the brothers Dixon (1889, fig. 1) for *B. thallia*. The ectoderm is very broad, but the two other layers are narrow; the nematocysts in the former are small and slightly curved. The ectodermal muscle is arranged on dendriform mesoglœal plaitings, and is associated with a well-defined nerve layer (fig. 35). The endoderm contains many small pigment granules and forms a weak muscle.

The ectoderm of the disk contains few nematocysts, but numerous gland cells; both the endodermal and the ectodermal muscles are well developed, arranged on low mesoglœal plaitings. Large connective-tissue cells are distributed throughout the mesoglœa. The endodermal muscle is strong for some distance toward the mouth, but shows no marked concentration around the aperture, such as the Dixons found in *B. thallia*, and which they regarded as a second sphincter muscle, circumoral in position (1889, p. 322, pl. v, fig. 2).

The ectoderm of the stomodæum is thrown into numerous ridges and grooves, the former being followed by long delicate processes of the mesoglœa. The two gonidial grooves are not strongly distinguished histologically; attached to the directives, they extend for some distance below the rest of the stomodæum. Nematocysts are not plentiful in the stomodæal ectoderm, while large, deeply-staining gland cells are numerous. The nerve layer, separated from the mesoglœa, is clearly seen in places. The endoderm contains much granular matter.

Twenty-four pairs of mesenteries are present in small polyps, and forty-eight in larger. In the uppermost region they are all perfect; lower, only twelve pairs reach the stomodæum, and still lower only six pairs remain, of which two pairs are directives and are much shorter in transverse section than the laterals. The members of the three or four cycles alternate in the usual manner, and all bear mesenterial filaments as they become free from the stomodæum. The longitudinal retractor muscles are well developed, and circumscribed in character. The main portion of the muscle is in the middle of the width of the mesentery, but extends more than half-way across the face of the mesentery. It is very broad and arranged on fine branching mesoglœal plaitings. The transverse muscle on the opposite face is weak. Toward the insertion of the mesentery a slight enlargement of the mesoglœa occurs, and a pennon is often formed on the face opposite the retractor for the support of the moderately developed parieto-basilar muscle. The mesenterial endoderm is much vacuolated, and contains an abundance of fine black pigment particles.

Dissections and vertical sections through the pedal disk show a well-developed basilar muscle. The inner and outer stomata are both very small, especially the latter, which is represented by only a minute circular aperture some distance inward and below the upper extremity of the mesentery.

Both the ciliated and glandular streaks of the mesenterial filaments are well developed; the middle lobe bearing the glandular streak is often very narrow and greatly elongated.

Only one specimen, sectionized longitudinally, bore gonads. In his specimen McMurrich found all the mesenteries, with the exception of the directives, to be gonophoric.

This large and variously colored Bunodid has a wide distribution in the West Indies. Primarily described by Lesueur in clear terms, it was confused by Milne-Edwards with his genus *Oulactis*. Duchassaing & Michelotti first doubtfully accepted it as distinct from the *Urticina lessoni* described by the first of these two authors. Later they united the two as *Anthopleura granulifera*. Their figure in the second paper bears much more resemblance to the animal than the two given earlier. McMurrich found a single specimen of a Bunodid at Nassau, which, while noting that there seemed a good deal of probability that it might be simply a color variety of Lesueur's, *A. granulifera*, he preferred to regard as a distinct species, naming it *Bunodes tæniatus*. I have since forwarded examples and sections of the Jamaican representatives to Professor McMurrich, and he has concluded with me that they represent the same species as his Bahaman form, and therefore *B. tæniatus* becomes a synonym of *B. granulifera*.

The species is now known from the following localities: Martinique (Lesueur), Guadeloupe and St. Thomas (Duchassaing & Michelotti), in the bay westward of Nassau (McMurrich), Jamaica (Duerden), Porto Rico (U. S. Fish Commission).

Bunodosoma spherulata, n. sp. Pls. III, X, XI, Figs. 10, 36–40.

Among the collections from Porto Rico were two anemones which from the somewhat delicate character of their tissues and the presence of spheroidal outgrowths over nearly the whole of the column-wall suggested some species of *Cystiactis*, the most likely being the *Cystiactis eugenia* of Duchassaing & Michelotti (1866, p. 129, pl. vi, fig. 1). This surmise was strengthened by the fact that one of the specimens was attached to a free portion of a leaf of the marine phanerogam, *Thalassia* *marina*, and therefore might be capable of floating. *Bunodeopsis antilliensis*, with a similar habit, frees itself at times and floats with its basal disk upwards, and Duchassaing & Michelotti record the floating habit for *C. eugenia.*

Anatomical examination revealed a small, though very definite circumscribed endodermal muscle, and therefore the form could not be regarded as a *Cystiactis*, as that genus is now understood from an investigation of *C. tuberculosa* Quoy & Gaimard. Though strong, the sphincter in this latter has been found by Professor Haddon and myself (1896) to be endodermal and diffuse, and the genus has been placed in the family *Aliciidæ.* The possession of a circumscribed endodermal sphincter and of columnar evaginations marks the Porto Rican form as a member of the family *Bunodactidæ.*

Duchassaing & Michelotti give only the following description of *C. eugenia:* "Sp. parva, corpore tuberculis apice vesiculosis clavatis adoperto; tentaculis circiter 20 subaequalibus, translucidis, cylindricis, acutis, disco duplo et ultra longioribus ore conico exserto." Their figure (pl. VI, fig. 1) shows the vesicles to be somewhat cylindrical and spirally disposed. In the end I have concluded that the safest course will be to regard the present species as distinct from *C. eugenia.*

Viatrix globulifera is another long-looked-for West Indian species which has suggested itself, but it would undoubtedly be hazardous to compare this species possessing but a few spheroidal evaginations and tentacles with one in which the column is nearly covered with outgrowths and the tentacles are forty-eight in number.

In essential characters the new form differs very little from the genus *Bunodosoma* of Verrill, of which *B. granulifera* is the type, and may well be included under it. Verrill (p. 44) defines the genus as follows: "General form and appearance as in *Bunodactis*, but the hollow verrucae, arranged in vertical rows, are rounded or subconical and do not form adhesive suckers. Upper or submarginal ones are larger in the mature specimens, more or less lobulated, but have nearly the same structure as those below, though they are described as perforated when living. Tentacles numerous; many mesenteries, 12, 24, or more pairs being perfect. Sphincter muscle well developed, endodermal, and circumscribed." The only difference between the characteristics here given and those presented by the species now under investigation is in connection with the marginal evaginations. In the Porto Rican species they are simple, while in *Bunodosoma*, as understood by Verrill, they become more or less lobulated. In the present state of our knowledge of this group, such a detail does not seem worthy of generic recognition, and I have therefore modified the definition of the genus to this extent. Perhaps the uniformity in size of the columnar evaginations in *B. granulifera* and the alternations of large and small rows in the new species may, as further representatives are added, call for generic distinction.

External characters.—The base is flat and circular; preserved examples show radiating furrows, and the diameter is less than that of the column. In one specimen the base was adherent to a leaf of *Thalassia marina.*

The column is erect, cylindrical, thin-walled, and covered for the most part with vertical rows of nearly globular vesicles, which increase in size from below upward. At the apex of the column they terminate in a cycle of larger conical outgrowths—the acrorhagi. Both specimens are deeply constricted a short distance above the base, hence there is some uncertainty as to the character of the verrucæ in this region, but they appear to cease a little before the proximal termination of the column is reached. The vesicles are arranged in forty-eight rows, alternately large and small, a row corresponding with each mesenterial space, whether entocœle or exocœle. The twenty-four rows of smaller vesicles are opposite the twenty-four tentacles constituting the outermost cycle, while the rows of larger outgrowths, surmounted by the acrorhagi, alternate with the outermost tentacles. For the most part, the smaller vesicles alternate transversely with the larger, and all are so closely arranged that very little of the actual surface of the column remains exposed. The vesicles are simple, subspheroidal, sessile, hollow, and perfectly smooth, without any thickened areas which may represent special batteries of nematocysts. They are incapable of holding foreign particles to the column-wall. The acrorhagi are also simple and smooth, without any tubercular outgrowths or thickenings. A smooth, narrow fossa intervenes between the cycle of acrorhagi and the outermost cycle of tentacles.

The tentacles in preserved specimens are smooth, short, broad below and narrowing above, entacmæous, and closely arranged. They are forty-eight in number, twenty-four constituting the outermost cycle; the cyclic arrangement is therefore, 6 6 12 24.

The mouth is circular and widely open in the two specimens studied. The stomodæal walls are closely ridged and furrowed, and gonidial grooves are but weakly developed.

The specimens preserved in alcohol are now practically colorless; the tentacles, however, are slightly brown, due to the presence of brown pigment granules within the endodermal cells.

The height of the larger specimen is 1 cm., and of the shorter 0.4 cm. The diameter of the column of the former is 0.8 cm., and of the basal disk 0.5 cm. In all probability the dimensions of living specimens would be much larger.

Anatomy and Histology.—The basal disk possesses a very broad ectodermal layer, constituted of long narrow cells, many of which are peripherally charged with a yellowish granular secretion.

The column-wall is moderately thin throughout. The ectoderm is a broad epithelial layer; the mesoglœa nowhere becomes greatly thickened, while the endoderm everywhere is exceptionally low. The ectoderm consists mainly of glandular cells of two kinds—clear mucous gland cells and granular gland cells. The granular gland cells are so plentiful that it is very likely they give a certain degree of opacity to the tissues of the living polyp. Histologically the vesicular verrucæ differ in no important respect from the remainder of the column-wall, except that the ectoderm contains numbers of small nematocysts. The verrucæ are outgrowths from all the mesenterial chambers, the twenty-four rows of large vesicles being entocœlic and the smaller rows exocœlic in position. The acrorhagi are practically the same in structure as the other columnar outgrowths, but the ectoderm is a little higher than elsewhere and is abundantly charged with nematocysts, not, however, to such a degree as in the tentacles. The comparative fewness and small size of the nematocysts indicate that neither the vesicles nor the acrorhagi can be regarded as special batteries of nematocysts. In such organs the nematocysts are usually very large, thick-walled, and closely arranged.

The mesoglœa of the column-wall presents a slightly fibrous appearance and contains small, isolated, connective-tissue cells; its external and internal surfaces are smooth.

The endoderm throughout the polyp is remarkable for the shortness of its cells, these being scarcely half as long as the cells of the ectoderm, so that the layer everywhere is very narrow in section. Further, the cells are charged with brown or black pigment granules, which tend to obscure the other constituents. The granules evidently take the place of the symbiotic zooxanthellæ of other *Actiniæ*, for these are everywhere absent in the present species. In other examples of the *Bunodactidæ* a similar substitution seems to take place. Pigment granules occur in *Bunodosoma granulifera*, but zooxanthellæ are absent; in *Aulactinia stelloides* the conditions are reversed. Similar relations occur also among the *Sagartidæ*, but in some *Zoanthidæ*, such as *Palythoa*, both granules and zooxanthellæ occur in the same polyp.

The circular endodermal musculature is everywhere very feebly developed, except in the region between the outermost tentacles and acrorhagi, where it forms a characteristic circumscribed endodermal sphincter (fig. 36). Compared with that in many other *Bunodactidæ*, the sphincter muscle is rather feeble, but is remarkable on account of the very distinct peduncle which it possesses. In truly radial sections, away from the insertion of a mesentery, the muscle is, as it were, suspended from the inner surface of the wall of the polyp, but near the mesenteries it is displayed as a thickened ridge of the wall, and the mesentery may appear as if attached to it. The mesoglœal plaitings of the muscle are very numerous, and are disposed almost wholly on one side of the axis—not, as is usually the case, more or less pinnately on each side of the median axis.

The tentacles are of practically the same structure throughout their length. A uniform peripheral zone of long, narrow nematocysts extends from the origin to the apex. An ectodermal nerve layer is clearly shown, while the longitudinal muscle fibers are strongly developed on fine, subdendroid, mesoglœal plaitings, which are best seen in transverse sections. The tentacles being in the retracted condition, the mesoglœal layer is probably much thicker than would be the case in extended polyps. Here, as elsewhere in the polyp, the endoderm is a narrow layer with many pigment granules. In the tentacles the granules are often restricted to limited areas, other areas being wholly free from them; non-pigmented endoderm patches occur more plentifully toward the proximal extremity. Longitudinal sections of the tentacles display the ends of a weak, circular, endodermal muscle.

The stomodæum is wide and nearly circular in section, the ciliation being well preserved all round. The walls are thrown into numerous vertical ridges, which correspond somewhat with the internal attachment of the mesenteries, and are due to an increase in the thickness of the mesoglœa. The number of ridges, however, slightly exceeds that of the complete mesenteries, being from fourteen to sixteen on each side, while the mesenteries are only twelve on each side. The ridges become stronger in the lower region of the stomodæum, where many of the mesenteries have become free.

Gonidial grooves are only feebly indicated above, but are more strongly developed below. The walls at the opposite extremities are slightly depressed between the pairs of directives, the ciliation is a little stronger, and gland cells and nematoblasts are less numerous than elsewhere. The nuclei of the ectodermal supporting cells form a broad zone which stains very deeply; a nerve layer is also displayed, but no muscle fibrils. Many nematocysts and granular gland cells with yellowish contents occur, in addition to the supporting cells.

In serial transverse sections the stomodæum is seen to terminate first along its lateral walls, the two ends, with the directive mesenteries attached, being prolonged for some distance farther, independently of one another.

Twenty-four pairs of mesenteries, including two pairs of directives, are present in the polyp sectionized transversely. Twelve pairs, representing the first and second orders, are united with the stomodæum in the upper part of their course, and twelve alternating pairs, representing the third order, are free throughout and extend but a short distance from the column-wall. Of the twelve complete pairs, six alternating pairs—the second order—become free some distance before the lower termination of the stomodæum is reached; the remaining six pairs—the first order—extend practically all the way. Thus in the upper stomodæal region two cycles of mesenteries occur, twelve pairs in each, while in the lower region are three cycles, with the formula 6 6 12. The directives have the shortest transverse course of all the complete mesenteries.

The mesenteries are narrow and wide apart in the upper half of their course, but they become broader below, their free edge is greatly folded, and they more nearly fill the gastro-cœlomic cavity. The musculature is feebly developed above, but below the mesoglœal plaitings become stronger and mainly circumscribed in their arrangement (fig. 39). As the lower region of the polyp is approached a strong mesoglœal pennon, supporting the parieto-basilar muscle, is present on the face opposite the retractor muscle. The mesenterial mesoglœa increases much in thickness from above downward, and bears small stellate cells. Everywhere the endoderm is a very narrow layer, its cells being more or less charged with blackish pigment granules. The serial transverse sections indicate the presence of the inner mesenterial stomata on all the twelve pairs of perfect mesenteries, but I have not been able to establish an outer or parietal series. Basilar muscles occur, represented in fig. 37.

As already remarked, the six pairs of second-cycle mesenteries cease their connection with the stomodæum in advance of the first-cycle mesenteries, and some of the members of the latter cycle also become free slightly in advance of the others, while the directives continue their attachment over the greatest distance. The separation of the mesenteries from the stomodæum, as revealed by serial transverse sections, takes place in such an order as to suggest certain morphological considerations. The six pairs of second-cycle mesenteries do not become free simultaneously, but the pair on each side of what may be regarded as the ventral directives of the polyp are free in advance of the middle lateral second-cycle pairs; then the middle pair on each side become free, and finally the dorso-lateral pairs. The relationships are represented in fig. 40, taken from one of the sections. The ventro-lateral pairs are altogether free; the medio-lateral pairs are just becoming free, starting at the middle of the concave margin, and the dorso-lateral pairs as yet show no signs of separation. Thus, in the order of separation of the mesenterial pairs from the stomodæum, a regular succession from the ventral to the dorsal aspect of the polyp occurs, the process taking place simultaneously in the corresponding pairs on each side. Such a relationship may be taken to indicate that the mesenteries are older and further developed dorsally than ventrally.

The studies which have been carried out upon the development of the second cycle of mesenteries of the Actiniaria indicate that the order of appearance is paralleled by the above results obtained from serial transverse sections of probably a mature polyp. For, in general, it may be assumed that where a mesentery possesses diminished importance it represents a more recent development.

It is usually found, both in Actiniarian and Madreporarian polyps, that the second-cycle mesenteries are developed in unilateral pairs on each side of the polyp in a progressive manner, which may be either from the dorsal to the ventral aspect of the polyp, or vice versa. The fact that the dorsal mesenteries of the second cycle in *Bunodosoma* retain their connection with the stomodæum longer than the middle pairs, and these again than the ventral pairs, would indicate a progressive development of these pairs from the dorsal to the ventral aspect. The successive development of the pairs of second-cycle mesenteries from the ventral to the dorsal aspect of the polyp I have found to be characteristic of the buds of the coral *Cladocora arbuscula*, while in the development of larval polyps of *Siderastræa radians* the succession is from the dorsal to the ventral side.

The brothers G. F. and A. F. Dixon (1889, p. 322) first obtained evidence of the successive development followed by the members of the second cycle of mesenteries from freshly extruded larvæ of *Bunodes verrucosa*. Their series of sections from above downward first showed the dorso-lateral pairs on each side, then the middle pairs, and lastly the ventro-lateral pairs. The succession in growth was therefore from the dorsal to the ventral side.

At one region or another mesenterial filaments are present on all the mesenteries. On the members of the third cycle, which throughout their course are free from the stomodæum, the middle lobe first appears as a simple, more deeply-staining enlargement of the epithelium at the free end of the mesentery. But the lateral lobes make their appearance a little below, and the typical trilobed Actinian filament is then presented, the three lobes being very distinctly separated from one another (fig. 38). The four areas, which elsewhere (1900, p. 145) I have spoken of as the *glandular*, *ciliated*, *intermediate*, and *reticular streaks*, are well defined by their differences in histological detail, and do not require full description.

As the mesenteries of the second and first cycles cease their connection with the stomodæum they are tipped with filaments which, both in longitudinal and transverse sections, are shown to be continuous with the stomodæal ectoderm, the middle or glandular streak most nearly corresponding in histological detail. The strongly ciliated lateral lobes are limited to the region at which the mesenteries become free; below the stomodæum only the simple median lobe is retained (fig. 39), and this is the case also with the filaments of the third-cycle mesenteries. Where the filament is simple the mesenterial epithelium immediately behind becomes much swollen, as shown in fig. 39. The species is somewhat exceptional in the short course through which the lateral or ciliated streaks persist. In the lower region of the polyp the mesenteries are greatly contorted at their free edge, which is provided with the simple filament all the way.

No gonads were present in either of the specimens.

Family SAGARTIDÆ Gosse.

Actiniaria with a contractile pedal disk; body-wall smooth, or provided with verrucæ or tubercles, and usually perforated by cinclides, with or without a cuticle. Tentacles usually numerous and retractile, usually not very long, simple, and generally entacmæous. Sphincter muscle usually well developed and mesoglœal, occasionally diffuse endodermal, or even absent; at least six pairs of perfect mesenteries; the first cycle of six pairs of mesenteries may be fertile or sterile. Acontia present.

The above definition is mostly taken from Haddon (1898, p. 446), who in 1889 made one of the first anatomical studies of the group. In his latest paper he recognizes five subfamilies, as also does Carlgren: *Aiptasinæ*, *Sagartinæ*, *Phellinæ*, *Metridinæ*, *Chondractininæ*. The first and fourth have each a representative in the Porto Rican collection.

Subfamily AIPTASINÆ Simon.

Sagartidæ in which the sphincter muscle is either absent, or very feebly developed and mesoglœal, or diffuse and endodermal.

Genus AIPTASIA Gosse.

Aiptasia, Gosse, 1860, p. 151; Andres, 1883, p. 373; McMurrich, 1889, p. 6; Haddon, 1898, p. 447.
Bartholomea, Duchassaing et Michelotti, 1866, p. 133.

Aiptasinæ with an extensile soft body; column smooth, with cinclides arranged in from one to several horizontal rows around the middle of the column; no verrucæ or tubercles; tentacles numerous, long, smooth, or with thickened bands or tubercles, strongly entacmæous; sphincter muscle either absent or very feebly developed and mesoglœal, or diffuse and endodermal.

McMurrich (1889, p. 6) gives a full history of the genus, which is exceptional in the family *Sagartidæ* in that some of its members are entirely wanting a mesoglœal sphincter muscle, in consequence of which the disk and tentacles are never infolded. I have added the character of the tentacular wall to Haddon's definition of the genus.

McMurrich in 1896 (p. 182) described the *Heteractis lucida* of Duchassaing & Michelotti from specimens obtained from the Bahama Islands. The chief characteristic of the genus is the presence of tubercles upon the tentacles, and these are strongly marked in the West Indian representative. *H. lucida* is not uncommon in Jamaican waters, living under exactly similar conditions as *Aiptasia annulata.* When fully expanded the two are easily mistaken for one another, unless one is close enough to distinguish the character of the tentacular wall. The living polyps are found to be closely allied in such details as the peculiarities of coloration, the delicacy of the tissues, and inability to overfold on irritation. Internally the mesenterial musculature of *H. lucida* bears the closest resemblance to that of *A. tagetes* and *A. annulata*, and the other general characters of the three are found to agree. It is evidently best regarded as an *Aiptasia*, in which case the three Antillean species, *A. tagetes*, *A. annulata*, and *A. lucida*, present an interesting gradation in connection with their tentacles. The wall is smooth in the first mentioned, and nematocysts are distributed throughout; in the second the tentacles bear incomplete annuli, which are really thickenings due to the aggregation of large nematocysts; and in the third species the annuli have, as it were, become shortened up and form spheroidal tubercles. McMurrich found a feeble mesoglœal sphincter muscle in his specimens of *A. lucida*, but I can not discover such in the Jamaican polyps.

Aiptasia annulata (Lesueur). Pls. III, XI, XII, Figs. 11, 41–44.

Actinia annulata, Lesueur, 1817, p. 172.
Dysactis annulata, Milne-Edwards, 1857, p. 262.
Aiptasia annulata, Andres, 1883, p. 392; McMurrich, 1889, p. 7, pl. I, fig. 1; pl. III, fig. 1; Duerden, 1898*a*, p. 457; Verrill, 1900, p. 556; pl. XVIII, fig. 3.
Actinia solifera, Lesueur, 1817, p. 173.
Paractis ? solifera, Milne-Edwards, 1857, p. 249.
Paractis solifera (*Actinia*), Duchassaing et Michelotti, 1860, p. 39.
Bartholomea solifera, Duchassaing et Michelotti, 1866, p. 133, pl. VI, fig. 14.
Aiptasia solifera, Andres, 1883, p. 386.

Many specimens of this species were collected from Porto Rico, thirty or forty coming from Guanica Bay, so that it must be very abundant around the island. It is also common around Jamaica, and occurs in the more northern Bahamas and Bermudas. McMurrich has already given a full description of the Bahaman representative, but the specimens from Porto Rico and Jamaica present an important difference in the arrangement of the tentacles and mesenteries, to be referred to later. The description of the Porto Rican specimens given below is supplemented by notes on the living polyps as met with around Jamaica.

External characters.—In the living condition the base is flat and very firmly attached to various objects on the sea-floor. It is slightly larger in diameter than the column, and thin-walled, the lines of attachment of the mesenteries showing through. The column is erect, smooth, cylindrical, and capable of much extension and retraction. The internal mesenterial attachments show through as distinct white lines on the darker ground, and divide the column-wall into alternations of three narrow areas and a broader one; above, the mesenterial spaces are seen to be double those below. In preserved specimens, and this applies to all the Porto Rican examples, the column is deeply constricted a little below the apex, as in the figure of the species given by Duchassaing & Michelotti (1866, pl. VI, fig. 14), and as is recorded by McMurrich for *Aiptasia* sp. (1889*a*, p. 102). Verrill figures a specimen of the closely allied *A. tagetes* in this condition. The upper part of the column is altogether incapable of becoming overfolded on retraction of the polyp, so that the disk and tentacles are always visible.

Four or more horizontal cycles of oval cinclidal apertures, at the apex of white tubercles, occur about the middle of the column. The cycles are usually incomplete or broken, pores being missing here and there. The number of apertures in a vertical row, corresponding with one mesenterial chamber, usually ranges from one to five or six, but in a Bahaman example McMurrich found twelve. White acontia are emitted in abundance through the cinclides and also through the mouth. Distally the column becomes somewhat enlarged and passes directly into the tentacles, so that no definite columnar margin or fossa exists.

The tentacles are marginate, very numerous, and arranged in many hexamerous cycles; as many as 192, or even more, may be present. They are non-retractile and strongly entacmæous, the inner being usually long, as much as 5 or 6 cm. On full extension the walls are thin and nearly transparent, with numerous incomplete thickened spirals or rings, usually along the whole length. In some of the larger specimens the annuli on the inner cycles are few in number, the proximal portion of the tentacles being quite smooth. In preserved polyps the tentacular rings remain very evident as thickened bands. Microscopic examination proves that they represent special urticating areas. In all the examples of this species which McMurrich obtained at the Bahamas, the tentacles were arranged octamerously, the mesenteries likewise corresponding. In Jamaican specimens a hexamerous arrangement prevailed, both in the tentacles and mesenteries. There is no doubt, therefore, that the species varies in this important character, and an explanation is thus given to Lesueur's statement (1817, p. 172) that "the centre *tentacula* are about six or eight in number."

The naked portion of the disk is small; the peristome and lips are slightly crenulate, six ridges and grooves occurring on each side, corresponding with insertion of the mesenteries. The two stomodæal grooves are not distinctly shown. The lips often approach laterally, leaving an aperture at each end.

The base is white; the column is white or cream colored below, flecked with opaque white; above it is pale or dark brown and more strongly flecked. The tentacles are a granular brown; the numerous incomplete spirals or rings are gray or white with the internal brown granules showing through. The color of the innermost tentacles, when the annuli are almost absent, is a pale blue. The surface of the disk is dark brown; opaque white or brownish patches occur near the base of the innermost tentacles, and another series, corresponding with the tentacles, may be present around the mouth; the disk may also be flecked in other places with opaque bluish white.

At Port Antonio, Jamaica, a specimen was obtained nearly devoid of any brown color, the walls being perfectly transparent, or with only opaque white or cream flecks. The tentacular annulations in this example were not very perfect, the urticating areas being more in patches. Verrill describes the color of the Bermudan specimens as light green. The brown or green color is altogether endodermal in origin, and is due to the presence of numbers of zooxanthellæ within the cells of the endoderm. The white or cream opaque flecks are wholly superficial.

The column of large living specimens is 4 to 5 cm. in height; the diameter across the middle from 2 to 3 cm.; the inner tentacles are usually 4 to 5 cm. long; the outer 1 to 2 cm. Some polyps when fully expanded may be nearly double these amounts.

Anatomy and Histology.—The base is very thin-walled, the ectoderm being the broadest of the three layers. The latter is formed of long columnar cells, most of which have clear contents. The nuclei are mostly in a subperipheral zone, and the nerve layer is occasionally displayed. The mesoglœa is extremely narrow, and the endoderm is but a little thicker; many of the cells of the latter contain zooxanthellæ. A very weak basal endodermal musculature occurs.

The ectoderm of the column-wall in sections is thrown into deep folds as a result of contraction, the foldings being followed by long processes of the mesoglœa. Like those of the base, the ectoderm cells are largely glandular, and small nematocysts occur in places. A weak endodermal muscle, on slight mesoglœal plaitings, extends all the way from the base to the apex (fig. 42). It becomes a little stronger in the upper region, being best developed in the region corresponding with the external constrictions, that is, a short distance below the apex. In this position McMurrich found in *Aiptasia* sp.? (1889, p. 103) what he regarded as a second sphincter. Distally the endodermal musculature undergoes no increased development, such as can be regarded as a sphincter muscle.

Zooxanthellæ are abundant in the endoderm of the upper region, but less so below; hence the light color of the living polyp proximally, and the brown distally. McMurrich records a total absence of "yellow cells" in one of his specimens, and, as already mentioned, a colorless variety has been found around Jamaica.

A great difference is apparent in the walls of the tentacles according as the organs are retracted or fully extended. In the former state all the three layers are rather broad, the mesoglœa least so, and ectodermal and endodermal muscles are very evident on long processes of the mesoglœa. In the extended condition the wall is so thin that the three layers can scarcely be distinguished individually, except where the section passes through urticating areas. Here the ectoderm and endoderm are swollen, and nematocysts occur in the former, while the endoderm is crowded with zooxanthellæ (fig. 41). The nematocysts are of two kinds, large and small; the latter are arranged peripherally, and occur also in the intervening areas; the elongated examples extend wholly across the ectoderm and are restricted to the swellings. The zooxanthellæ present a curious distribution. Instead of being arranged uniformly throughout the endodermal layer, they are aggregated within restricted areas, and project some distance beyond the ordinary level of the endoderm (fig. 41). No doubt it is this aggregation which produces the granular character of the brown coloration observed in the living tentacles. McMurrich makes no mention of the peculiarity in his specimens of *A. annulata,* but records and figures a very similar condition in *Heteractis lucida* (1896).

The walls of the stomodæum are thrown into numerous small folds, except at the gonidial grooves, which are clearly indicated in sections. Cilia are present all around the stomodæum, but are longer at the grooves. Deeply-staining granular gland cells and long nematocysts are present in the stomodæal ectoderm, and the nerve layer is very evident in places. Muscle fibrillæ occur on the endodermal face of the mesoglœa.

In three Jamaica specimens dissected transversely only the eight Edwardsian mesenteries extend the whole length of the stomodæum; the ventral moities of each of the four lateral pairs, or what are known as the fifth and sixth developmental pairs, are complete in the uppermost region, but for the greater part of the stomodæal extent they are free (fig. 43). Three of the Porto Rican specimens dissected exhibited the same condition of the primary mesenteries, so that it may be assumed to be a general characteristic of the species. Six pairs of mesenteries form a second cycle and are never complete; twelve pairs constitute a third cycle, and twenty-four a fourth cycle. The last project but a little way beyond the column-wall, and do not bear retractor muscles. In one specimen only the second and third cycles bear the gonads in the lower stomodæal region; in another the four free mesenteries belonging to the primary cycle also bear gonads. The directives extending from the angle of the gonidial grooves are shorter than the other complete mesenteries. The large inner mesenterial stomata are easily seen in dissections, and the outer are large marginal apertures some distance from the upper extremity.

The retractor muscles on the three first cycles of mesenteries are strong and form a thickened band along the greater part of the face of each mesentery. The muscle commences a little beyond the origin of the mesentery at the column-wall and, slowly enlarging in thickness, ends centripetally in a rather abrupt manner. The parieto-basilar muscle is well developed, and also the basilar muscle.

The mesenterial endoderm in the lower region exhibits cells with clear contents; granular gland cells and zooxanthellæ also occur. The mesenterial filaments are provided with ciliated and glandular streaks. They are remarkable for the thickness of the endoderm on their outer aspect, which gives them a very exceptional appearance (fig. 44). The middle lobe is somewhat digitiform in transverse section and greatly prolonged beyond the lateral lobes.

Acontia are abundant and contain large thick-walled nematocysts, closely arranged. One example sectionized contained ova arranged in long, narrow, single rows on the mesenteries of the second and third cycles in the upper part of the stomodæum. They were more plentiful around one pair of directives than around the other. In another specimen both ova and spermaria occurred together on the second and third cycle mesenteries, and also on the free fifth and sixth pairs of the primary cycle, so that the species is hermaphrodite. McMurrich's specimens bore immature ova only on the mesenteries of the second and third cycles.

This large and handsome *Aiptasia* is found plentifully all around Jamaica, firmly attached to various objects, such as stones, rocks, and old shells, often to their under surface, the disk with the long tentacles showing above the sea-floor. Sometimes it attains considerable dimensions, having quite an impressive appearance when seen *in situ* with all its long, snake-like tentacles waving gracefully. A variety is occasionally met with in which the diameter of the whole disk and tentacles is 18 or 20 centimeters. In these the outer tentacles are of the usual granular brown color, with white, incomplete rings, but the inner tentacles are a very pale blue, with only a few urticating areas toward the apex, and when fully extended they are extremely delicate objects. The Porto Rican specimens are on the whole smaller than similarly preserved Jamaican examples. The large size which the species occasionally attains places it more in agreement with Lesueur's *A. solifera,* the body of which is stated to be about 4 inches in length (1817, p. 173). McMurrich has already discussed (1889, p. 10) the reasons for uniting the two forms, *A. solifera* and *A. annulata,* regarded by Lesueur as distinct species, and the large Jamaican specimens serve to confirm his conclusions.

The polyps appear very sensitive to light, contracting when exposed to full sunlight in the laboratory, but expanding again if placed in the shade. The long tentacles are usually in constant and graceful motion and are incapable of being much retracted. Acontia are emitted both through the cinclides and the mouth.

The species is now known from the following localities: Barbados (*A. annulata*), "in the hollows formed in madrepore rocks" (Lesueur); Guadeloupe (*A. solifera*), "in old shells, particularly in those of *Turbo versicolor*" (Lesueur); St. Thomas (*B. solifera*), Duchassaing & Michelotti; Bahamas, "attached to the lower surface of the blocks of coral rock, or in cavities in these" (McMurrich); Bermudas, "The largest examples were 8 inches or more in diameter when fully expanded, and had several hundreds of tentacles. The color is generally light green" (Verrill); Jamaica (Duerden); Porto Rico (U. S. Fish Commission).

The fact that the specimens of this species obtained by McMurrich at the Bahamas are octamerous, while the Porto Rican and Jamaican representatives are hexamerous, is of some interest. Eight specimens which I have examined all possessed the mesenterial plan represented in fig. 43, and McMurrich is quite emphatic as to the arrangement in the forms studied by him. Such variability is not unknown in other Actinians. Verrill (1899, p. 216) mentions that he has found specimens of *Urticina crassicornis* which are hexamerous, both as to tentacles and mesenteries, many others decamerous, some octamerous, and a few irregular or unequally developed on opposite sides.

The freedom of the ventral moieties of the four lateral pairs of mesenteries is a retention in the adult polyp of a characteristic met with in larvæ and young polyps. In most Actinian and Madreporarian young polyps the fifth and sixth bilateral pairs of mesenteries, which correspond with those mentioned, remain free from the stomodæum much longer than the other four primary pairs. In most instances they continue thus until the pairs of the second-cycle mesenteries are fully established. In this connection, also, attention may be drawn to the eight free-swimming larvæ, possessed of 24 mesenteries, described by van Beneden in his beautiful work, "Les Anthozoaires de la Plankton Expedition" (1897, pp. 189–194). Although the second cycle of six pairs of mesenteries is fully developed in each case, yet in no instance have the fifth and sixth developmental pairs become complete; only the eight Edwardsian mesenteries extend as far as the stomodæum. I have reared the young polyps of the coral *Siderastræa radians* for a period of seventeen weeks, until the six pairs of second-cycle mesenteries were established, and yet the fifth and sixth pairs of primary mesenteries remained free from the stomodæum.

Subfamily METRIDINÆ Carlgren.

Sagartidæ with column of medium height or low, without papillæ, verrucæ, or marginal spherules. Sphincter mesoglœal, well developed. Cinclides (chiefly endoderm evaginations) present. Complete mesenteries usually six; rarely, especially when only one pair of directive mesenteries is present, more than six. Mesenteries of the first order always sterile. Acontia emitted through the cinclides and mouth. One or two pairs of directive mesenteries.

This subfamily includes the four genera, *Metridium*, *Mitactis*, *Adamsia*, and *Calliactis*. Scarcely any differences exist between the last two genera, but they are strongly marked off from the other two. Both Haddon and Carlgren state that a cuticle is absent, but in *Calliactis tricolor* such a formation occurs, especially obvious in freshly collected specimens. The scapus is covered with a fairly thick, coarse, membranous cuticle, to which foreign particles adhere, and distally it is often found partly detached and hanging loosely. The capitulum is entirely smooth. When polyps are brought into the laboratory the cuticle is sloughed off within two or three days, and the scapus then presents a much clearer appearance.

I have also modified the definition with regard to the extrusion of the acontia. In the West Indian *Calliactis* they are thrown out quite as freely through the mouth as through the cinclides.

Where, as in *Metridium*, only one gonidial groove may occur, with only one pair of directives, and the hexameral plan of the mesenteries generally is disturbed, there is every likelihood that the polyps are the products of fission. In researches which I have recently conducted upon fission in coral polyps I find that in the process the stomodæum is usually divided into two equal or nearly equal parts, usually at right angles to the directive plane. The mesenteries connected with each half, including one pair of directives, go to the formation of a new polyp, or new stomodæal system where fission is incomplete. In the new or daughter polyps, however, a new pair of directives appears to be never formed, and generally the polyps lose all their hexameral regularity. Hence corals reproducing by fissiparity are usually devoid of directive mesenteries, except the two primary pairs which appear in the larva. No doubt similar relationships hold for Actinian polyps. In the Madreporaria gonidial grooves seem never to occur, so that the fate of these structures can not be compared.

Genus CALLIACTIS Verrill.

Calliactis, Verrill, 1869, p. 481; Hertwig, 1882, p. 73; Haddon, 1898, p. 456; Carlgren, 1900, p. 55.
Adamsia, McMurrich, 1893, p. 182.

Metridinæ with prominent cinclides, arranged in from one to several horizontal rows toward the base of the column; no verrucæ. Column usually divided into scapus and capitulum; scapus secretes a membranous cuticle which is shed from time to time; very changeable in form, in full expansion elevated, subcyclindrical, with a broadly expanded base, in retraction forming a low, flattened cone or convex disk. Pedal disk with a tough cuticle. Tentacles numerous, slender, subulate, highly contractile. Acontia highly developed, emitted through the cinclides and oral aperture.

The above definition is altered somewhat from Haddon's, which was founded upon that of Verrill, so as to include the cuticular formation. Carlgren does not mention if *C. polypus* is possessed of a capitulum.

Verrill (1869) erected the genus *Calliactis* with *C. decorata* (Drayton) as the type, and included the *Actinia tricolor* of Lesueur to be here described. He distinguishes it from the genus *Adamsia* of Forbes, which exhibits a peculiar low-spreading method of growth involving a union of the polypal base around the shells of mollusks. All the other characters agree so closely that it is very doubtful whether the mere peculiarity of growth should be considered sufficient to constitute a generic distinction.

Hertwig in the *Challenger* Report (1882, p. 74) retained Verrill's genus for *C. polypus*, but in the Supplement (1888, p. 3), following Andres, he states that it must be termed *Adamsia polypus*. Haddon (1898) in his latest paper retains the two genera, and Carlgren (1900) also admits *Calliactis*. McMurrich, however, employs *Adamsia* as the generic term for the present species.

Calliactis tricolor (Lesueur). Pls. III, XII, Figs. 12, 45, 46.

Actinia tricolor, Lesueur, 1817, p. 171.
Adamsia tricolor, Milne-Edwards, 1857, p. 281; Duchassaing et Michelotti, 1886, p. 134; McMurrich, 1898, p. 234, pl. I, figs. 6, 7; pl. II, figs. 1, 2.
Calliactis tricolor, Verrill, 1869, p. 481.
Actinia bicolor, Lesueur, 1817, p. 171.
Calliactis bicolor, Verrill, 1869, p. 481.
Adamsia egcletes, Duchassaing et Michelotti, 1866, p. 134, pl. VI, fig. 17.
Calliactis egletes, Verrill, 1869, p. 481.
Cereus sol, Verrill, 1864, p. 214 (*Actinia sol*, Agassiz, MS., 1849).
Adamsia sol, McMurrich, 1893, p. 183.

Fifteen specimens of an *Adamsia*, associated with fragments of an old *Cassis* shell, were obtained from Mayaguez Harbor. Polyps of very different sizes are represented, the basal diameter of some measuring only 1.2 cm., while others are 3.5 cm. They are rarely more than 1 cm. in height, complete retraction having taken place in every case. In all the base is very irregular in outline, the polyps having adapted themselves to the spiral convexities of the incrusted shell. Patches of a dark-brown cuticular membrane in some instances persist between the incrusted surface and the basal ectoderm.

The upper part of the column is infolded to such a degree that the disk and tentacles are completely hidden, only a small aperture remaining toward the middle of the flattened apex. The columnar surface is strongly ridged both vertically and transversely, being divided into small, square, or rhomboidal areas, which give a coarse tuberculated appearance to the polyps. For the most part the column is devoid of any cuticular investment, and toward the base the wall is so thin as to permit of the mesenteries being seen. In most specimens the cinclides can be made out as two or three more or less complete circular rows of darker spots, disposed a short distance above the base.

The above are practically all the external characters which can be made out on the Porto Rican specimens in their present retracted bleached condition, and from these alone it would be practically impossible to establish their specific identity among an admixture of species of the genus *Adamsia*. But the specimens differ in no respect from similarly preserved Jamaican polyps whose identity as *Adamsia tricolor* is beyond dispute, being founded upon the living characters, while, as shown below, only one widely distributed species of *Adamsia* is known to occur in the West Indies.

The species has never been fully described in its living condition. An account is therefore given below in some detail, as presented by the Jamaica representatives. McMurrich (1893, p. 234) has already partly described its anatomy.

Adamsia tricolor occurs plentifully in Kingston Harbor, attached to the shells of the living mollusks, *Pyrula melongena* and *Fasciolaria tulipa*, on dead *Pyrula* shells inhabited by the hermit crab, *Petrochirus* *bahamensis* Oliv., and often on the carapace of other crabs, such as *Pericera cornuta* Latreille. The latter relationship seems of very constant occurrence. The spinous crab is rarely found without many specimens of different sizes of the sea anemone adhering to its carapace and limbs. *Pyrula* shells inhabited by a *Petrochirus* are at times almost completely hidden by the anemones. As many as fourteen polyps have been found on a single shell, occupying almost every position, some even within the mouth, where they must come into close association with the hermit crab.

The polyps usually remain in an expanded condition when alive and appear very hardy, living well in aquaria. They retract quickly upon irritation, the disk, tentacles, and upper part of the column being infolded, but open again almost as readily. The lower part of the body is capable of considerable distention. The column may elongate and then be deeply constricted across the middle.

After two or three days' confinement in an aquarium the thick cuticle loosens and peels off, and the scapus then appears smoother. Should the water become impure the polyps are able to detach themselves and forsake the surface of the shells, move away and remain free, or they may again fix themselves by their expanded base to the smooth surface of the vessel. On irritation of the polyps acontia are emitted freely through the mouth, and apparently less freely through the cinclides. The threads are capable of independent movement after being shot out and can be again indrawn.

External characters.—The base of the polyps is usually spreading and much broader than the column. Generally a horny cuticular secretion intervenes between the ectoderm and the surface of attachment. The base is circular in small specimens, but in larger examples becomes very irregular in outline, adapting itself to the spiral convexities of the shell to which it adheres. The wall is so thin that the lines of attachment of the mesenteries show through, and is highly distensible when the polyp happens to leave its attachment.

The column is short, erect, broad below, narrowing above the middle and enlarging again toward the apex. The proximal part is very irregular in outline, while the middle and upper are circular in section. The wall appears thick and coriaceous, especially after preservation. The division into scapus and capitulum is readily observed in expanded polyps, the surface of the scapus being usually coarse and wrinkled, while that of the capitulum is smooth and more delicate. The coarseness of the former is largely due to the presence of an outer, loose, cuticular investment to which foreign particles adhere, and which is continually being shed in confinement. Often the column presents longitudinal and transverse furrows which give rise to approximately square or rhomboidal areas, more or less regularly arranged, or sometimes it presents distinct tubercles irregularly scattered. The lines or furrows are usually much less marked in living than in contracted preserved specimens.

Two or three alternating cycles of slightly elevated cinclides occur a short distance from the base. In the lower cycle they are smaller, and generally twice as many as in the next cycle. Only two or three members occur in the third uppermost cycle, but these are the largest of the series. They are easily distinguished in the living polyp by their darker color, and project above the general level of the surface. The apertures vary much in number and regularity of arrangement; sometimes certain members may be missing from the cycles, or additions may be intercalated at almost any part of the cinclidal zone. On irritation white or salmon-colored acontia may be extruded through the cinclides, and also through the mouth, as well as through accidental perforations in the disk.

The capitulum appears as a narrow, circular, smooth band at the apex of the column, and is more diaphanous than the scapus.

The tentacles are short, smooth, subulate, entacmæous, closely arranged, and overhanging. In mature polyps they number 192, or even more, arranged according to the formula 6 6 12 48 96. *Irregularities or variations from the hexameral plan sometimes occur.*

In expanded polyps the periphery of the peristome is slightly depressed, thin-walled, circular, and grooved in correspondence with the radiating, internal attachment of the mesenteries. The central area surrounding the mouth is usually elevated. The mouth is very small, and circular or oval in outline; the lips project but little, and the two gonidial grooves are not readily seen. When much expanded the mouth becomes larger and slit-like, or the stomodæum may be partly protruded. The gonidial groove is then clearly indicated at each end, and the stomodæal walls are seen thrown into six very strong folds on each side. When alive the lateral walls of the stomodæum sometimes meet along the middle, leaving open the grooves at each end, through which currents of water may be established.

The coloration is very complex in character, oftentimes somewhat brilliant, and varying much in different polyps. The base is dark gray. The column is occasionally bright orange, but more often brown and orange, tinged with purple. The cinclides are dark-brown elevated spots, often with yellow margins; two or three white, light yellow, or orange triangular bands extend to them from the margin of the base, or may go beyond. Narrower light bands of variable length occur in the interspaces all round, commencing at the base of the column; irregular light-colored patches may also occur toward the top of the column. When the cuticle is thick the column becomes dirty brown or purplish, due to adhering foreign particles.

The tentacles are gray, usually with faint purplish brown transverse bands or patches on their oral aspect; five or six of these are present on the larger tentacles, but only two or three on the smaller. Often a row of small opaque white or yellow spots extends nearly the whole length of the inner face of each tentacle; larger opaque white patches may also be present. In one specimen the tentacles throughout were a very delicate purple. The disk is yellowish gray. A wavy, disconnected circle of opaque white radiating patches occurs near the base of the tentacles of the four inner cycles, and outside this an irregular dark purple or black cycle extends nearly to the outer margin of the disk. A circle of twelve, opaque white, V-shaped markings is also present about midway between the tentacles and the mouth, the markings corresponding with the third cycle of twelve tentacles, and another cycle of six may be present nearer the mouth, opposite the second cycle of six tentacles. The middle of the peristome is grayish, the lips bright orange, the stomodæum yellowish brown. When fully extended, six dark purple areas within the tentacular and capitular region are seen to alternate with larger colorless patches. The acontia may be either opaque white or salmon colored.*

The diameter of the base of an average-sized specimen is 3 cm.; the height of the column about 2.8 cm.; the diameter of the disk, 1.5 cm. The length of the inner tentacles when expanded is 0.9 cm.; of the outer, 0.25 cm. A large specimen measured 4.5 cm. across the base and was 3.5 cm. in height.

Anatomy and Histology.—The basal wall is very thin compared with that of the column, the difference being determined by the relative development of the mesoglœa. The columnar cells of the ectoderm are long and narrow. Gland cells are numerous, the peripheral portion of which contains granular matter not staining with borax carmine; large clear gland cells are practically absent. The cuticular membrane secreted by the ectoderm of the base, and regarded by McMurrich (1893, p. 182) as characteristic of the genus, is present in some sections, but is readily separable from the ectoderm. The mesoglœa, though moderately developed, is much thinner than in the column-wall; small isolated cells are sparsely scattered throughout. The endoderm is a very narrow layer, and a weak endodermal muscle is developed.

The column-wall in the retracted condition is often very thick, mainly due to the increased development of the middle layer. A thick cuticle, with foreign particles attached, is present in specimens from which it has not recently been sloughed off. In sections the ectoderm is very narrow, and may be much folded in preserved specimens. By contrast with the base, clear or slightly granular gland cells are conspicuous, and form an outer, non-staining zone; a nuclear zone is displayed about the middle of the layer, while scattered nuclei occur more internally. The mesoglœa is greatly thickened and appears fibrous in character, containing many minute connective-tissue cells. Sometimes the fibrous character assumes a reticular appearance, and often the layer incloses minute pigment granules. Toward the apex it narrows abruptly, the capitulum being very thin-walled. Internally the mesoglœa is finely plaited for the support of the endodermal muscle. This latter is best developed below and about the middle of the column, and at the insertion of the mesenteries becomes mesoglœal. The endoderm displays the nerve layer very distinctly.

The sphincter muscle is a strong mesoglœal representative (fig. 45). Above it is very broad, extending nearly across the thick mesoglœa, while below it gradually tapers to its extremity, which is near the endodermal border. In the first part the mesoglœal muscle-containing cavities are so close that the sphincter region, as a whole, appears finely reticular in character, but the chambers soon become distinctly separated from one another. They are then arranged in regular rows, the different

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*The species of *Calliactis* and *Adamsia* are usually gaily and variously colored, even to the acontia. Prof. H. N. Moseley (Q. J. M. Sc., vol. XVII, 1877, p. 4) has investigated the coloring matter of an *Adamsia* obtained off the Philippines. The polyp was a mottled yellow and brown color with pink stripes. The pink coloring matter in the fresh condition yielded a single well-marked absorption band. The acontia, as in *C. tricolor*, were of a light red color, which gave two absorption bands in the green. Carlgren (1900*a*, p. 55) also mentions that the acontia of *Calliactis polypus* (Forsk.) are rose colored, and Haddon (1898, p. 457) describes those of *C. miriam* (H. & S.) as salmon colored.

cavities varying somewhat in size and outline in transverse section. Toward the lower extremity the linear character is almost lost, the chambers becoming irregularly arranged.

The form of the sphincter here represented should be compared with that which McMurrich gives of the same species (1898, pl. I, fig. 6; pl. II, figs. 1, 2). It will be seen that they present certain differences as regards the arrangement of the muscle-bearing cavities. Neither McMurrich's description nor figures give any indication that the cavities are arranged in transverse rows, though he speaks of an appearance of two or three longitudinal bands of mesoglœa. The reticular region occurs in both instances, but occupies a much larger proportion in the Cuban polyp; in the latter the remaining cavities are irregularly arranged, while they form very distinct rows in the polyps now under examination.

The differences between the two are so great that one would be inclined to doubt their specific identity. In other polyps which I have sectionized, however, intermediate conditions are met with. Sometimes only a slight indication of the linear arrangement of the rows is exhibited, and the reticular portion also varies much in extent. I am inclined to regard the differences in the character of the sphincter as in some measure dependent upon the age of the polyp. The specimen from which fig. 45 was taken was a young polyp only about two-thirds of a centimeter in diameter. McMurrich's single specimen (2.7 cm. in height, the diameter near the base about 2 cm.) was a medium-sized individual. Other examples which I have studied, and in which the appearance more nearly resembles that of the Cuban polyp, are also mature. It may be that with age the regularity of the chambers characteristic of young polyps becomes broken up. Were it merely an individual variation the possibility of a sphincter muscle of any species exhibiting such marked differences would greatly lessen the value which has been placed upon it for taxonomic purposes.

The tentacles display a very broad ectoderm, loaded peripherally with narrow nematocysts. The longitudinal muscle fibers are moderately well developed on deep, narrow mesoglœal plaitings; the endoderm presents irregular internal boundaries, the cells being much vacuolated. A strong endodermal muscle occurs and pigment matter is present in some abundance, but no zooxanthellæ occur within the endoderm of this or any part of the polyp. Professor McMurrich (1893, p. 182) also found a bright reddish orange pigment everywhere in the endoderm of *Adamsia involvens*, without mention of any zooxanthellæ.

The three layers of the disk much resemble those of the tentacles, but the ectoderm is nearly devoid of nematocysts and contains many gland cells. Both the endodermal and ectodermal discal muscles are strongly developed toward the tentacular region, but do not become mesoglœal.

The stomodæum is much folded in sections, and the gonidial grooves are only feebly indicated. The ectoderm is richly ciliated all round; narrow nematocysts and glandular cells with granular contents are observable toward the periphery of the layer, while the broad, deeply staining nuclear zone occurs below. The mesoglœa and endoderm are very thin; an ectodermal nerve layer and endodermal musculature occur.

Six pairs of perfect mesenteries occur, two pairs of which, the directives, are radially shorter than the others. Six pairs of secondaries alternate, and are never complete; four pairs of these bear mesenterial filaments more abundantly coiled than on the other two. Twelve pairs of mesenteries form a third cycle, and the mesenterial filaments on these are but slightly developed; twenty-four pairs of very short mesenteries form a fourth cycle. Representatives of a fifth cycle are present in large polyps, but the full number, forty-eight, appears to be rarely reached. The second, third, and fourth cycles bear the gonads in three examples sectionized transversely. Hints of a dorso-ventrality in the polyps are indicated in that the reproductive organs may not be present on a few of the mesenteries around one of the pairs of directives, while they are fully developed at the opposite aspect. In two young polyps only the first, second, and third mesenterial cycles were present. The third cycle of twelve was very fully developed, though no trace of the members of the fourth cycle could be found.

The mesenteries are usually thin at their origin from the body-wall and broader beyond. The retractor muscles occur on branching mesoglœal plaitings, extending over the greater part of the width of the mesenteries. In the second cycle the retractor muscle may be somewhat circumscribed in character. The endoderm becomes much thickened below the stomodæum, and contains many granular particles and a little brown pigment matter. The parieto-basilar muscles appear to be absent, or, at any rate, no mesoglœal pennons are formed for their support. McMurrich was unable to find any basilar muscle, but a very feeble pair occurs, as represented in fig. 46.

The mesenterial filaments occur on all the mesenteries except the members of the last cycle, and possess both ciliated and glandular streaks. The ciliated streak has only a very short course, disappearing from all the mesenteries a little below the level of the stomodæum. The acontia are crowded with narrow elongated nematocysts.

The male and female reproductive cells occur in different individuals. Both are developed in enormous quantities on the second, third, and fourth mesenterial cycles.

Lesueur (1817, p. 171) has described from the West Indies the two species *Actinia tricolor* and *A. bicolor* as distinct, and Duchassaing & Michelotti (1866, p. 234) have added a third, *A. egletes*. McMurrich (1898, p. 234), however, has discussed the validity of these three species, and finds that it is impossible to maintain their separation, a conclusion with which I agree. McMurrich has further decided that the *Actinia sol*, Agass. MS. (Verrill, 1874, p. 24), of the Carolina coast is indistinguishable from the West Indian species. Therefore the West Indies appear to possess but one species of *Calliactis*, with a range extending northward as far as the eastern coasts of the United States.

In addition to Jamaica and Porto Rico, the species is now known from the following islands: Barbados (*A. tricolor*), attached to shells tenanted by hermit crabs (Lesueur); St. Vincent (*A. bicolor*), adherent to shells (Lesueur); St. Thomas (*A. egletes*), upon shells and the carapace of the living *Pericera cornuta* (Duchassaing & Michelotti); Bahia, Cuba (McMurrich); also near Charleston, S. C. (Agassiz, Verrill).

Order STICHODACTYLINÆ Andres.

Actiniaria in which more than one tentacle may communicate with a mesenterial chamber. Usually a peripheral series of one or more cycles can be distinguished from an inner or accessory series, the members of which are radially arranged or in groups, and are often of different form. Sphincter muscle either endodermal or absent.

Next to the arrangement of the mesenteries, the disposition and character of the tentacles has been found of great service for classificatory purposes in the Actiniaria. The proposal of Andres to separate the *Hexactiniæ* into two groups, *Actininæ* and *Stichodactylinæ*, according as only one tentacle or more than one may arise from a mesenterial chamber, has in the past met with universal acceptance. Beyond the mesenterial plan it is recognized that within different groups different characteristics may assume particular importance, especially for the minor subdivisions. No mesenterial distinction avails to separate the *Actininæ* from the *Stichodactylinæ*, and within the various families of the former no very great difference in the tentacular plan is presented, while great diversity occurs in the latter. Therefore in the *Actininæ* the tentacles have not assumed that taxonomic importance which has been assigned them in the *Stichodactylinæ*. In the former the character of the musculature has been found to be of greater utility in determining what may be considered natural relationships.

In my paper on the Jamaica *Stichodactylinæ* I refer to the great variation presented by the tentacular systems of the different genera there studied, and consider it very doubtful if there is much homologous connection among them; more likely they are polyphyletic. To my mind, however, one great distinction is recognizable, according as the tentacles are all of one form or of two forms; and for these I suggested the two suborders *Homodactylinæ* and *Heterodactylinæ*.

The conception underlying the separation is altogether at variance with that which Carlgren is endeavoring to introduce, and in the "Nachschrift" to his "Ostafrikanische Actinien" (p. 116) he somewhat petulantly characterizes the division as "nicht viel besser, als wenn man die Actiniarien nach der verschiedenen Zahl der Tentakelcyklen einteilen wollte." Carlgren naturally regards every proposal in the light of its relationship with his own scheme, according to which he is seeking to combine all the forms with primary characteristics to the neglect of their later modifications. The division referred to above is based wholly upon these latter, and regards the species retaining the primary characters as the lowest of their own particular group. For example, within the *Stichodactylinæ* it is probably impossible to mention two species more widely divergent in their tentacular plan than *Ricordea florida* and *Actinotryx sancti-thomæ*. In the former the marginal and inner tentacles are all of the same form, arranged in regular radial rows; in the latter the marginal tentacles are simple, and two or three orders are represented in a single cycle; the inner tentacles are dendroid, separated by a naked space from the marginal, and are arranged in a middle discal and a circumoral group. Morphologically the two tentacular series—marginal and accessory—seem wholly unconnected with one another in *Actinotryx*, while they probably form a consecutive series in *Ricordea*. The two species are alike, however, in the absence of a basilar muscle, ciliated streak, and gonidial grooves, and each possesses only a weak musculature. On account of these characteristics, to the neglect of the tentacular divergences, they are classed together by Carlgren in the one family *Discosomidæ*.

Recognizing them as forms which retain the ancestral attributes just mentioned, but in other respects have become widely divergent, I see nothing illogical in considering *Ricorda* and *Actinotryx*, respectively, as among the lowest members of the two suborders *Homodactylinæ* and *Heterodactylinæ*, and for the present I propose to retain the two subdivisions.

Suborder HOMODACTYLINÆ.

Stichodactylinæ in which the tentacles are all of one kind, simple or complex, and usually follow one another in continuous radial rows.

Family STOICHACTIDÆ Carlgren.

Stoichactidæ, Carlgren, 1900, p. 278; 1900*a*, p. 72 (also p. 119).

Stichodactylinæ with a basilar muscle and well-developed basal disk. Sphincter always present, shortly diffuse or circumscribed, usually not strongly developed, with well-marked gonidial grooves and ciliated streaks. Column usually provided with a distinct fossa and adhesive verrucæ. Longitudinal musculature of the mesenteries well developed. The separation of the tentacles into a marginal and a discal series not pronounced; only one tentacle arises from each exocœle; tentacles simple or branched, sometimes swollen at the apex, never arranged in groups, nor as arm-like prolongations of the disk.

Reviewing the family *Discosomidæ* (1900, p. 155) I state: "As the Actiniaria of tropical regions are more studied, the genera embraced under this family become more and more numerous . . . it will be seen that the family includes a very heterogeneous assemblage of forms, corresponding in this respect with the *Sargartidæ* among the *Actininæ*. The only constant feature appears to be that the tentacles are all of the same form in any one species, and cover the greater portion of the disk; but apparently in no two genera are the peripheral and the inner tentacles similarly related. It will probably be found advisable later to separate as subfamilies forms in which only one row of tentacles communicates with a mesenterial chamber from those in which, as in *Actinoporus*, two or more rows may originate from the same mesenterial chamber."

At this time Carlgren was working upon a large assemblage of *Stichodactylinæ*, including specimens of the Jamaica representatives which I was able to send him. The papers of Haddon (1898) and Kwietniewski (1897, 1898), describing many new forms, had also appeared. Carlgren was therefore in a most favorable position for carrying forward the classification of the group, and this he has accomplished in a very elaborate manner. His first suggestions are contained in a short paper, "Zur Kenntnis der Stichodactylinen Actiniarien" (1890), followed the same year by that on the "Ostafrikanische Actinien." In these the value assigned the family distinction is very diverse. In some instances Carlgren chooses to attach supreme importance to the characters of anatomy and histology alone, and thus brings together many forms (e. g., *Ricorda*, *Actinotryx*) allied in anatomical and histological details, but outwardly most diverse, while in other cases—*Stoichactis*, *Homostichanthus*, and *Actinoporus*—new families, almost alike in their anatomy and histology, are constituted mainly upon tentacular differences.

In the first paper he defines the families *Discosomidæ*, *Stoichactidæ*, and *Aurelianidæ*. The first includes forms without basilar muscle, ciliated streak, and gonidial grooves, and with weak mesenterial musculature, and embraces the genera *Discosoma* (*D. nummiforme*, type), *Orinia*, *Ricordea*, *Actinotryx*, and *Rhodactis*, thus including the most heterogeneous tentacular plans. The *Stoichactidæ* and *Aurelianidæ* include forms in which all the organs just mentioned occur and in which the mesenterial musculature is better developed. Along with these, and mainly distinguished by their tentacular arrangement and form, are the *Phymanthidæ*, *Heteranthidæ*, *Thalassianthidæ*, and *Actinodendridæ*.

The family *Stoichactidæ* is defined above. It includes the genera *Stoichactis*, *Radianthus*, *Helianthopsis*, and *Antheopsis*. Carlgren has been able to compare the form I identify as the West Indian *Actinoporus elegans* with the European *Aureliania*, and, contrary to what I formerly expected from Gosse's description and figure, shows that they agree very closely. The two genera constitute the family *Aurelianidæ*.

In the "Nachschrift" (p. 118) to his last paper Carlgren erects another new family, *Homostichanthidæ*, for the species I have described as *Homostichanthus anemone*, but which he names *H. duerdeni*. Its chief distinction from the family *Stoichactidæ* lies in the origin of many tentacles from each exocœle, as well as from the entocœles, a character in which it agrees with the *Aurelianidæ*.

Genus STOICHACTIS Haddon.

Stoichactidæ usually of large size, column smooth below, with or without verrucæ above. Tentacles short, simple, subulate, rounded or capitate, covering nearly the whole of the disc. A single tentacle from each exocœle constitutes the most peripheral cycle; usually many tentacles, arranged in a single radial row, arise from each entocœle. Sphincter muscle strong and circumscribed, or circumscribed-diffuse. Usually two gonidial grooves.

Stoichactis helianthus (Ellis). Pl. I, Figs. 1*a*, 1*b*.

Actinia helianthus, Ellis, 1767, p. 436, pl. XIX, figs. 6, 7.
Discosoma helianthus, Milne-Edwards, 1857, p. 256; Duchassaing et Michelotti, 1866, p. 122; Andres, 1883, p. 493.
Discosoma anemone, McMurrich, 1889, p. 37, pl. I, fig. 8; pl. III, figs. 15, 16; pl. IV, fig. 1.
Stoichactis helianthus, Duerden, 1900, p. 162, pl. XI, fig. 7; pl. XIV, fig. 1.

This is a prominent Discosomid around Jamaica and other West Indian islands, including also the Bahamas (McMurrich), and the same must be the case in Porto Rican waters, for in the collection it is represented from most localities, often by numerous large specimens. It is met with on the coral reefs and sandy sea-floor at depths of two or more fathoms, and when alive different polyps vary much in color. Sometimes a number occur together in close contiguity, forming extensive patches. The variety of form which the polyps may assume on preservation is well illustrated by the many Porto Rican examples available for comparison. The tentacles especially differ in their appearance in the preserved examples, and, being very numerous, determine the general appearance of the polyps. Sometimes they are shrunk and widely apart; at other times they are more distended, and clothe the disk more completely. Two somewhat extreme cases, obtained from Fajardo, are represented by the photographic reproductions on pl. I. The essential characters of the species have already been described by McMurrich (1889) and myself (1900).

External characters.—The base is flat, usually adherent to the surface of rocks, and is a little larger in diameter than the lower part of the column. Preserved examples show strong concentric and radiating ridges and furrows.

The column is short and salver-shaped, narrowing a little above the base, and then expanding enormously in a crateriform manner; usually the column is partly embedded in sand and the distal region overhangs. The walls are smooth, thin, slightly transparent, and grooved. Distally, vertical rows of flat, oval, green verrucæ occur, but are incapable of holding foreign particles to the column. The apex of the column is rounded, devoid of acrorhagi, but with a very distinct fossa. The column is incapable of being infolded completely so as to cover the disk.

The disk is flat and greatly expanded. By far the greater part is covered with radiating rows of tentacles, more crowded toward the periphery. In young polyps a cyclic order in the radial extent of the different rows of tentacles can be established, but is mostly lost in large specimens. A single outermost cycle of exocœlic tentacles alternates with all the radial rows; the latter are entocœlic. The tentacles are short and digitiform, but vary a little in shape and size, according to the degree of distension. In the preserved condition they may become vesicle-like, or remain conical or digitiform, the surface finely fluted from apex to base. Small tentacles are seen in process of growth around the margin, but within the exocœlic cycle.

The central naked area of the disk is smooth, and the peristome is somewhat elevated. The mouth is large and oval. Two gonidial grooves are usually present, readily distinguished by their thickened margins; rarely three may be present.

The base is white or cream colored; the column white or cream below, and a little darker above. Large, irregular green patches may occur on the column, and distally vertical rows of small, oval, green areas represent the verrucæ, their number and closeness varying much in different rows. The disk may be a light or dark olive brown, and the tentacles the same, but irregular patches of varying intensity are exhibited. The peristome is a brownish yellow, the lips a deep rich yellow, and the stomodæal wall white. Color varieties are frequently met with. In one the column and disk are almost entirely colorless, and the tentacles a clear sulphur yellow.

The diameter of the base is about 5 cm., and the height of the column 4 cm. The diameter of the disk usually varies from 10 to 12 cm., or may be more in fully expanded specimens. The tentacles are about 0.6 cm. in length, and are often largest in diameter toward the tip, where they may measure 0.2 cm. across. The diameter of the naked part of the disk is about 2.5 cm.

Anatomy and Histology.—The basal disk is of considerable thickness. The ectoderm is an exceptionally broad layer and contains many narrow, elongated gland cells with granular contents; the mesoglœa presents delicate plaitings on its endodermal border for the support of a well-developed circular endodermal musculature.

The column-wall is of only moderate thickness; the ectoderm is deeply folded, the mesoglœa partly following. Numerous long granular cells are included among the supporting cells, and the mesoglœa presents a delicate fibrous structure with many connective-tissue cells. On the endodermal surface the latter forms narrow branching plaits for the support of the circular musculature. The endoderm is much thinner than the other two layers and contains many zooxanthellæ and granular gland cells. At the verrucæ the ectoderm consists almost wholly of supporting cells, gland cells are absent, and the ciliation is more obvious. Histologically, therefore, the organs most closely resemble the sucker-like verrucæ of other Actinians.

The sphincter muscle is strong and circumscribed, and made up of several lobes, so that its outline varies in different transverse sections. The pedicle is broad and short, and a narrow mesoglœal axis extends nearly the whole length.

Both the entocœlic and exocœlic tentacles are simple outgrowths of the disk, with the three constituent layers of about equal thickness. Long, narrow nematocysts occur in a peripheral zone toward the apex. The endoderm is crowded with zooxanthellæ and coarsely granular gland cells. The endodermal and ectodermal musculatures are developed, the latter being the stronger and associated with a nerve layer.

The discal ectoderm is nearly devoid of nematocysts and contains granular gland cells. The mesoglœa is deeply plaited on its endodermal border for the support of the circular muscle, while the radial ectodermal muscle is weak.

In young polyps the mesenteries are arranged in hexameral orders, but the regularity is lost in older specimens. One young example possessed twelve pairs of perfect mesenteries, an alternating cycle of twelve pairs stretched about halfway across the disk, and another cycle of twenty-four pairs extended just beyond the column-wall. In another polyp thirty-six pairs of mesenteries reached the stomodæum. Older polyps seem to possess merely an alternation of complete and incomplete pairs.

At the insertion in the column-wall the mesenteries are narrow and then thicken abruptly, the retractor muscle extending nearly across the face, again terminating in an abrupt manner in the imperfect pairs, but gradually in the perfect members. The face of the mesentery where the retractor muscle is well developed is somewhat undulating. The endoderm is loaded with coarsely granular cells. The parieto-basilar muscle is weakly developed. The inner mesenterial stomata are large, while the parietal are small circular apertures. The basilar muscle is well developed, of the type represented for *Asteractis expansa* and *Bunodosoma spherulata*. Gonads may occur on all the mesenteries.

Localities: West Indies (Ellis), Guadeloupe, St. Thomas, etc. (Duchassaing & Michelotti), Bahamas (McMurrich), Jamaica (Duerden), Porto Rico (U. S. Fish Commission).

Another large West Indian Discosomid, *Homostichanthus anemone* (Ellis) Duerden, is rarer than the former, and is not represented in the *Fish Hawk* collections. Both species appear to be absent from the Bermudas, not being recorded by McMurrich or Verrill, but *S. helianthus* is plentiful at the Bahamas.

Carlgren (1900*a*, p. 76) has come to the opinion, first adopted by McMurrich, that Ellis's figures of *Actinia helianthus* and *A. anemone* are best regarded as representing only one species. In Turin, Carlgren had the opportunity of examining one of Duchassaing & Michelotti's specimens, which these authors had named *D. anemone*, and states that it is the same form as that described by McMurrich under this name. He then observes that Ellis's original figure of *A. helianthus* are without doubt referable to the same form as that which Duchassaing & Michelotti and McMurrich had under consideration, and therefore accepts my determination of it as *D. helianthus*. It becomes necessary, therefore, that the Jamaican form I identify as *D. anemone* should be given a new name. In the "Nachschrift" (p. 117) Carlgren suggests *Homostichanthus duerdeni*.

Carlgren's conclusions merit consideration, for, in addition to the opportunities above mentioned of studying the two forms, he has had for comparison specimens of both species which I have sent him from Jamaica. I have, unfortunately, not had the opportunity of examining Ellis's original figures, which are really the determining factors in the dispute. My conclusion that the rarer Jamaican species was *anemone* was based mainly upon the fact that Ellis records the angular form of disk of *anemone*, and that Duchassaing & Michelotti refer to the peculiar rapid color variation which the species undergoes. While certainly not very reliable characteristics, yet, knowing the fairly uniform distribution of the Actiniaria throughout the West Indian area, it seemed not unlikely that Ellis and Duchassaing & Michelotti might well have met with the two Discosomids which occur around Jamaica.

In a "Nachschrift" to his "Ostafrikanische Actinien," Dr. Carlgren takes the opportunity of criticising some of the results in my recent paper on the Jamaican *Stichodactylinæ*. With regard to the above species he remarks as follows:

"Bei allen von mir untersuchten Exemplaren von *Stochactis helianthus*—auch bei denen, die Duerden mir gütigst geschickt hat—stehen die Exocœltentakeln sozusagen in etwa demselben Cyklus wie die äussersten Endocœltentakeln, ja sehr selten etwas innerhalb der äussersten Endocœltentakeln. Die Figur Duerden's (Taf. XI, Fig. 7) wäre nach meiner Meinung richtiger, wenn Duerden in jedem Endocœl ausserhalb der äussersten Tentakeln noch einen Tentakel eingezeichnet hätte."

The criticism is very trivial, for, in the description of the species, I refer to the crowded character of the tentacles around the margin. The figure referred to is altogether diagrammatic, its main purpose being to show the important fact of the exocœlic origin of the outermost cycle, compared with the entocœlic origin of the radial rows.

With regard to the diagrammatic figure of the tentacles of *H. anemone*, Carlgren writes:

"Was schliesslich *Homostichanthus Duerdeni* (ich nenne diese Art so anstatt *H. anemone;* vergl. *St. tapetum*, p. 77) (p. 97) anbetrifft, so kann ich Duerden's Angabe von dem Vorhandensein mehrerer Tentakeln in jedem Exocœl bestätigen, aber die Figur Duerden's (Fig. 4, Taf. XII) von der Tentakelanordnung stimmt nicht gut mit meinen Untersuchungen überein. Eine solche Anordnung der Tentakeln in einfachen radialen Serien kann ich nur in den schwächsten Endocœlpartien finden. Von jedem stärkeren Endocœl entspringen dagegen nur in den inneren Mundscheibenpartien Tentakeln in einer Reihe, nach aussen hin in dem gefalteten Mundscheibenteil stehen zwei Längsreihen neben einander und in der Peripherie selten drei. Die Anordnung in bestimmten Reihen in den äusseren Partien der Endocœle ist jedoch, ganz wie in den Exocœlpartien, sehr unregelmässig, aber auf die Breite jedes Faches kommen 2–3 Tentakeln. Von den Exocœlen gehen in den peripherischen Teilen der Mundscheibe Tentakeln aus; nach innen hin steht ein Tentakel, nach aussen finden sich Reihen von zwei (selten drei) Tentakeln neben einander. Die Tentakelzonen der Exocœle bilden also trianguläre, mit der Basis nach aussen, der Spitze nach innen hin gewendete Partien. Man könnte einwenden, dass diese Anordnung durch die Kontraktion entstanden wäre; so weit ich finden kann, ist es entschieden nicht so; besonders bei dem einen untersuchten Exemplar sind mehrere Mundscheibenpartien, die die Tentakeln in oben geschilderter Weise tragen, gut ausgestreckt. Eine bessere Figur der Tentakelanordnung des *Homostichanthus* scheint mir also von Nöten zu sein."

In this case the difference between Carlgren and myself may be understood when it is remembered that my description was founded upon both the living and preserved appearances of the polyp, while Carlgren had for examination only the preserved specimens which I sent him. From dissections of the polyp I had obtained all the appearances which Carlgren refers to, and it is easy to understand how he has been led astray in his interpretation of the tentacular disposition, and to assume that I was in error. I think Carlgren will agree that the true external characteristics of any species are more likely to be appreciated in the living than in the preserved condition, and that in any case the living features should take precedence of those in the shrunken preserved animal. In my description I state (p. 168):

"Peripherally, the tentacles are so closely arranged that on a slight contraction of the polyp the apices press one against the other and assume a polygonal outline, and sometimes more than one row appears to communicate with a mesenterial chamber."

From the numerous living specimens which I had under observation, and the importance which I have attached to it in all the species described, it may be expected that I should satisfy myself as to the actual disposition of the tentacles in their relationships with the mesenterial chambers. Again examining dissections of my preserved specimens of *H. anemone* from within, I find that in most expanded individuals there is but slight evidence of the doubling of the rows peripherally, while in the most contracted examples two very distinct rows may be presented and, in places, evidence of the intercalation of a third row. It is obvious that the tendency to a disposition of the tentacles in rows upon shrinkage will be accentuated by the very crowded arrangement of the tentacles peripherally; where, as I show to be the case more centrally, the tentacles are less crowded, there is no lateral overlapping, and the tentacular apertures are arranged directly behind one another in a single row. Even in *Stoichactis helianthus*, where the tentacles are by no means so closely disposed in the living polyps, an overlapping arrangement, as if the tentacles arising from each interspace were in a double row, is at times presented by preserved polyps. The confusion which Carlgren has introduced simply emphasizes how very necessary it is, in dealing with such strongly retractile animals as anemones, that the polyps should as far as possible be studied in the living condition, as well as from preserved material.

Suborder HETERODACTYLINÆ.

Stichodactylinæ in which the tentacles are of two forms, usually marginal and accessory, and separated by a naked portion of the disk.

Family PHYMANTHIDÆ Andres.

Stichodactylinæ in which the tentacles are of two kinds. Marginal tentacles arranged in several alternating entacmæous cycles, laterally tuberculiferous or frondose; inner tentacles radially or irregularly arranged, very small, tubercular or papilliform.

Genus PHYMANTHUS Milne-Edwards.

Phymanthidæ in which the column is smooth or provided with longitudinal rows of verrucæ in its upper part, and usually terminated by a cycle of rounded acrorhagi. Sphincter muscle absent or endodermal and very weak.

Professor Verrill (1898, p. 496) has suggested that the generic term *Epicystis* should take the place of *Phymanthus* on the ground that Ehrenberg in 1834 had proposed *Epicystis* for the *Actinia crucifera*, *A. ultramarina*, and *A. granulifera*, all of Lesueur, and that the first was evidently different from Milne-Edwards's type of the genus *Phymanthus*, viz., *P. loligo*. Dr. Carlgren (1900*a*, p. 66), however, has shown that this alteration can not be sustained, that *Phymanthus crucifer* and *P. loligo* must belong to the same genus.

Phymanthus crucifer (Lesueur). Pl. III, Fig. 13.

Actinia crucifera, Lesueur, 1817, p. 174.
Cereus crucifer (*Actinia*), Duchassaing & Michelotti, 1866, p. 125, pl. VI, fig. 13.
Phymanthus crucifer, Andres, 1883, p. 501; McMurrich, 1889, p. 51, pl. II, fig. D; pl. IV, figs. 6–11; Duerden, 1900, p. 139, pl. X, fig. 1, 2; pl. XI, figs. 1, 2.
Epicystis crucifera, Verrill, 1898, p. 496.
Epicystis osculifera, Verrill, 1900, p. 556 (=*Actinia osculifera*, Les.).

Several specimens of this large, handsome anemone are included in the collection, but present a very different aspect from that of the polyps in their living condition, when buried in coral sand or coral rock with the expanded wavy disk alone visible. The marginal tentacles are greatly shrunk, but still display the oro-lateral thickenings, while the disk papillæ are very numerous and somewhat irregularly arranged. Owing to the absence of any sphincter muscle the polyps on preservation are incapable of infolding the disk and tentacles. One example is completely everted.

External characters.—The basal disk is adherent to rocks and stones, and exhibits coarse radial and fine concentric wrinklings, and is a little larger than the proximal region of the column.

The column is erect, thin-walled, and smooth in living polyps, but preserved specimens are wrinkled both vertically and transversely. When alive the polyps enlarge slowly from just above the rounded limbus until distally the diameter may be two or three times that below. The upper region of the column, along with the periphery of the disk, is sinuous, and *in situ* this rests upon the surface of the sea-floor. It exhibits rows of sucker-like verrucæ, corresponding with the principal mesenterial interspaces; four to six large verrucæ occur in each row, and a few rudimentary examples are continued below. A single apical verruca may alternate with the principal rows. A circle of prominent rounded acrorhagi occurs at the apex of the column, double in number the rows of verrucæ, and alternating with the outermost cycle of tentacles. Sometimes a smaller acrorhagus alternates with each of the larger. A shallow fossa intervenes between the acrorhagi and base of the tentacles. The column-wall is incapable of folding over the disk and tentacles. The marginal tentacles are arranged in numerous entacmæous cycles, and usually number between two and three hundred. They are shortly conical and overhanging, the oral face being longer than the aboral or outer. The members of the first and second cycles are situated some little distance from the other cycles. Normally the cycles are hexamerous, but irregularities are frequently met with. Usually the tentacles bear several transverse opaque thickenings, most strongly developed along the oro-lateral area, where a distinct bilobation is often observable. Six or seven pairs, arranged pinnately, the middle pairs being the largest, may occur on the larger tentacles, and a less number on the smaller tentacles. For some little distance from their origin the tentacles are smooth, and polyps occur in which the tubercles are altogether undeveloped. Among a number of polyps from one locality every stage could be obtained between the full development and total absence of the thickenings, some tentacles possessing the full number and others being wholly destitute of them.

The inner tentacles are small papilliform projections of the discal wall, varying much in size, and arranged mostly radially. They correspond with the interspaces of the first and second cycles of mesenteries, and sometimes with those of the lower orders.

The disk is large, thin-walled, and peripherally is thrown into eight to twelve sinuous folds, which overhang the column; the middle region is flat or slightly convex. The gonidial grooves are clearly indicated, the lips being thicker and lighter than the rest of the stomodæal wall.

The coloration is very variable, and all gradations can be traced in a large series of polyps. The disk colors are mostly brown and green, with opaque white spots and blotches; those of the column and base are scarlet and crimson on a white or cream ground. The center of the verrucæ is deep crimson; the tentacular thickenings usually appear as white bands. When the tentacles are smooth they are brown or reddish brown, with light crimson tips, and three longitudinal lighter lines traverse the oral aspect. The peristome is usually iridescent green.

The dimensions are likewise very variable, according to age. In many young specimens the column was only 1.1 cm. long, and the diameter 0.8 cm. The length of the column in adult specimens is about 6 cm., the middle diameter 1.7 cm., and the basal 2.5 cm.; the diameter of the disk varies from 5 to 9 cm.; the innermost tentacles are 0.7 cm. in length.

Anatomy and Histology.—The ectoderm of the base is a very broad columnar epithelium, with a few gland cells, and is much folded in sections. The mesoglœa appears strongly fibrous and contains numerous connective tissue cells. Numerous zooxanthellæ occur in the endoderm, and muscle fibrils are present.

The column-wall is of only medium thickness, becoming more delicate distally. The ectoderm is broad and deeply ridged, the elevations being followed by the mesoglœa. Clear and granular gland cells are abundant, and also small nematocysts. A nerve layer occurs, and what I consider to be a very delicate muscle layer in the upper part of the column. The endoderm is a deep layer containing zooxanthellæ, and the circular endodermal muscle is well developed on fine mesoglœal plaitings. The muscle is nowhere concentrated to form a special sphincter. The verrucal ectoderm shows an absence of gland cells and nematocysts.

Both the ectodermal and endodermal musculatures are well developed in the peripheral tentacles, supported on mesoglœal plaitings. The nematocysts in the ectoderm are exceptionally small. The tentacular swellings are due mainly to an increase in the thickness of the mesoglœa.

The disk is thin-walled and the endodermal circular muscle is well developed on mesoglœal folds. The discal papillæ are simple hollow upgrowths; the mesoglœa and endodermal musculatures become so thin as to be scarcely recognizable, and the ectoderm is thinner than elsewhere.

The stomodæum is very elongated in transverse sections, extending almost across the cœlenteron, the pair of directives at each extremity being shorter transversely than the other mesenteries. The walls are thin and the ectoderm is thrown into irregular vertical folds. The two gonidial grooves are clearly indicated, their ectoderm unfolded, and the mesoglœa not much thicker than elsewhere. Longitudinally the stomodæum is comparatively short, but the groove at each end is prolonged for some distance below the lateral walls. Narrow gland cells occur, and a weak longitudinal ectodermal musculature and ganglion layer are recognizable.

In mature polyps the mesenteries of the first three orders reach the stomodæum, though the third and second orders may not extend throughout its length; a fourth and a fifth order may also be developed, the formula being 6 6 12 24 48. The mesenteries are comparatively narrow in transverse section, and by no means crowd the cœlenteron. The retractor muscle is arranged on narrow, bifurcating mesoglœal plaitings, the enlargement commencing in a rounded or acute manner some distance from the column-wall. The mesenterial epithelium is narrow and highly vacuolated, the protoplasmic contents being aggregated toward the margin. The parieto-basilar muscle is well developed, situated on a strongly plaited pennon. The basilar muscle is strong and closely resembles that of *Asteractis expansa.* The perioral stomata are large, but the parietal are small and not easily distinguished. Trilobed filaments are borne by the members of the first three orders of mesenteries.

All the mesenteries may be gonophoric, and apparently the polyps may be monœcious or diœcious.

Localities.—Barbados (Lesueur), St. Thomas (Duchassaing & Michelotti), Bahamas (McMurrich), Bermudas (Verrill), Jamaica (Duerden), Porto Rico (U. S. Fish Commission).

In general the species is easily distinguished among West Indian anemones by the transverse white ridges on the oro-lateral aspect of the tentacles. The character, however, is not as readily recognizable on preserved specimens as on the living polyps. Further, at Drunkenman's Cay, beyond Port Royal, Jamaica, where *P. crucifer* occurs in abundance, specimens are occasionally found in which the tentacular swellings are altogether absent, while others exhibit all intermediate stages in their presence or absence.

In his most recent paper Verrill (1900, p. 556) identifies the form devoid of the tentacular ridges as the *Actinia osculifera* of Lesueur (1817, p. 175). If intermediate stages toward the full development or absence of a specific character mean anything at all, it is clear that the form Verrill identifies as *A. osculifera* can not be considered as a species distinct from *P. crucifer.* Verrill states:

"This species or variety scarcely differs from *E. crucifera* except in lacking the transverse white ridges on the tentacles, characteristic of the latter. The colors of the two forms are similar and are variable in the same way in each."

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EXPLANATION OF PLATES.

Figures 1*a*, 1*b*, are from photographs by Dr. A. M. Reese; figures 2 to 13 were drawn by Mr. C. H. Prinke under the supervision of the author; all the others were drawn by the author.

PLATE I.

Figs. 1*a*, 1*b*. *Stoichactis helianthus.* Photographic reproductions of two preserved polyps, showing the differences in character which may be assumed by the tentacles.

PLATE II.

Fig. 2. *Zoanthus pulchellus.* A colony of retracted preserved polyps in which the individuals are long and close, and hide the cœnenchyme.
Fig. 3. *Zoanthus pulchellus.* Portion of a preserved colony in which the polyps are shorter, and the intervening continuous cœnenchyme is partly displayed.
Fig. 4. *Zoanthus sociatus.* Portion of a colony of retracted polyps.
Fig. 5. *Isaurus duchassaingi.* Retracted polyp.
Fig. 6. *Protopalythoa variabilis.* A small irregular group of retracted polyps.
Fig. 7. *Palythoa caribæa.* A small colony of partly expanded polyps.
Fig. 8. *Asteractis expansa.* Polyp as seen expanded in a narrow glass vessel.
Fig. 9. *Bunodosoma granulifera.* Living expanded polyp.

PLATE III.

Fig. 10. *Bunodosoma spherulata.* Enlarged preserved polyp.
Fig. 11. *Aiptasia annulata.* Living expanded polyp.
Fig. 12. *Calliactis tricolor.* Living expanded polyp.
Fig. 13. *Phymanthus crucifer.* Living expanded polyp.

PLATE IV.

Fig. 14. *Zoanthus pulchellus.* Vertical section through the upper part of the column-wall, displaying the double mesoglœal sphincter muscle. Other details are omitted.
Fig. 15. *Zoanthus sociatus.* Vertical section through the upper part of the column-wall, displaying only the double mesoglœal sphincter muscle.
Fig. 16. Transverse section through the stomodæal region of a polyp in which the mesenteries are brachytypic on the left side and macrotypic on the right. At the slight magnification given only the outlines of the mesenteries could be indicated.

PLATE V.

Fig. 17. *Zoanthus sociatus.* Thick longitudinal section through the lower part of the stomodæal wal and along the edge of a complete mesentery. The stomodæal ectoderm is seen to be in continuity with the mesenterial filament along the free edge of the mesentery; the ciliated bands are removed a slight distance from the actual mesenterial border and are seen to be sinuous in sections, the appearance varying in different regions according to the actual direction of the section.
Fig. 18. Transverse section through the free edge of a mesentery a little below the level of the stomodæum. The intermediate streak (*int. st.*) of the mesenterial filament is seen on both sides as a thick layer separating the median glandular streak (*gl. st.*) from the ciliated band (*cil. bd.*); in this particular section the latter is almost covered by the endodermal-like tissues of the intermediate streak.
Fig. 19. Transverse section through the mesenterial filament immediately below the stomodæum. Histologically the tip of the filament very closely resembles the stomodæal ectoderm; the ciliated band (reflected ectoderm) is continued as two wings to the filament, and on the right side is in continuity with the tissue at the tip, while on the left side the continuity is interrupted by the presence of the intermediate tissue.

Fig. 20. Transverse section through a mesentery at the lower part of the stomodæal region. The ciliated band, or reflected ectoderm, extends for some distance up each face of the mesentery, in some parts free and in others in union with the mesenterial tissues. On the lower left-hand side the intermediate tissue in section is overlying the cells of the ciliated band.

Fig. 21. Transverse section through the free edge of a mesentery below the region at which the ciliated streak has terminated. The enlarged median part of the filament is altogether different in histological character from its condition in the uppermost part of its course; elongated granular gland cells and nematocysts are numerous. The mesenterial endoderm behind is also greatly swollen, and contains many deeply staining nutritive particles and gland cells.

Fig. 22. Transverse section through the lower region of the mesentery, showing the last traces of the mesenterial filament. The magnification is much less than in the former figures. The mesenterial epithelium is greatly swollen, nearly surrounding the filament, and is strongly charged with nutritive particles.

Plate VI.

Fig. 23. *Isaurus duchassaingi.* Transverse section through the stomodæal region of a polyp, showing the brachytype arrangement of the mesenteries and a large entocœlic outgrowth. At the slight magnification at which the section is drawn only the outlines of the walls can be represented, and the thin part of the mesenteries indicated by a simple line.

Figs. 24, 25. Thick sections through two different polyps, representing the relationships of the smooth and tubercular areas to the directive axis. The directive axis passes through the entocœle of the dorsal microdirectives and the ventral macrodirectives and includes the longer diameter of the stomodæum. In each figure the smooth area is at the upper right hand of the figure. The light areas represent the cut surface, the dark the tubercles projecting below.

Plate VII.

Fig. 26. *Isaurus duchassaingi.* Tangential section through the ectoderm, showing the manner in which it is broken up into subcubical blocks by the intrusion of the mesoglœal strands passing to the subcuticle.

Fig. 27. *Protopalythoa variabilis.* Vertical section through the upper part of a strongly retracted polyp, including the tentacles, disk, and upper part of stomodæal wall. Only the details of the single mesoglœal sphincter muscle and foreign incrustations in the column-wall and disk are represented.

Plate VIII.

Fig. 28. *Palythoa caribæa.* Vertical section through the upper part of a strongly retracted polyp, representing the single mesoglœal sphincter muscle. All the other structural details are omitted.

Fig. 29. *Asteractis expansa.* Section through one-half of a polyp, showing the stomodæal wall, oral disk, tentacle, sphincter muscle (*sp. m.*), acrorhagus (*ac. r.*), parieto-basilar (*p. b. m.*) and basilar muscle (*b. m.*), and inner and outer stomata. The mesentery is viewed on its exocœlic face.

Fig. 30. Vertical section through the upper part of the column-wall, including an acrorhagus, the circumscribed endodermal sphincter muscle (*sp. m.*), and the basal part of a tentacle (*t.*).

Fig. 31. Vertical section through a portion of the base, with a mesentery attached bearing the basilar muscle on each side.

Plate IX.

Fig. 32. *Asteractis expansa.* Transverse section of a sextant of a polyp through the lower part of the stomodæal region. Four orders of mesenteries are represented.

Fig. 33. Transverse section through part of the column-wall, including a verruca (*ver.*) opposite a mesenterial entocœle.

Fig. 34. *Bunodosoma granulifera.* Vertical section through the upper part of the column-wall, showing the evaginations (*ev.*), acrorhagus (*acr.*), disk, and the circumscribed endodermal sphincter muscle.

Plate X.

Fig. 35. *Bunodosoma granulifera.* Transverse section of a retracted, strongly fluted tentacle.

Fig. 36. *Bunodosoma spherulata.* Vertical section through the upper part of the column-wall, including an evagination (*ev.*), acrorhagus, and tentacle (cut obliquely), and showing the small pedunculated, circumscribed endodermal sphincter muscle.

Fig. 37. Vertical section through a portion of the base, showing the basilar muscle on each side of a mesentery.

Fig. 38. Transverse section through a mesenterial filament of the third cycle of mesenteries.

PLATE XI.

Fig. 39. *Bunodosoma spherulata.* Transverse section of a portion of the column-wall some distance below the stomodæal region, with a mesentery attached showing the circumscribed retractor muscle, the parieto-basilar muscle, and the simple filament.

Fig. 40. Transverse section of a polyp toward the termination of the stomodæum, indicating the sequence in which the pairs of the second order of mesenteries become free from the stomodæum.

Fig. 41. *Aiptasia annulata.* Oblique section through an expanded tentacle, showing the ectodermal thickenings (batteries of nematoblasts) and the distribution of the zooxanthellæ within restricted swollen regions of the endoderm.

Fig. 42. Vertical section through the middle region of the column-wall.

PLATE XII.

Fig. 43. *Aiptasia annulata.* Transverse section through the stomodæal region of a polyp. Four cycles of mesenteries are present, but only four bilateral pairs (Edwardsian mesenteries) are complete; the fifth and sixth developmental pairs are incomplete. All the incomplete mesenteries are gonad bearing.

Fig. 44. Transverse section through a trilobed mesenterial filament. The intermediate streak (*int. st.*) between the glandular streak and the ciliated band is of considerable extent and contains many zooxanthellæ.

Fig. 45. *Calliactis tricolor.* Vertical section through the upper part of the column-wall, showing the mesoglœal sphincter muscle.

Fig. 46. Vertical section through a portion of the basal wall, showing the weak basilar muscle on each side of a mesentery.

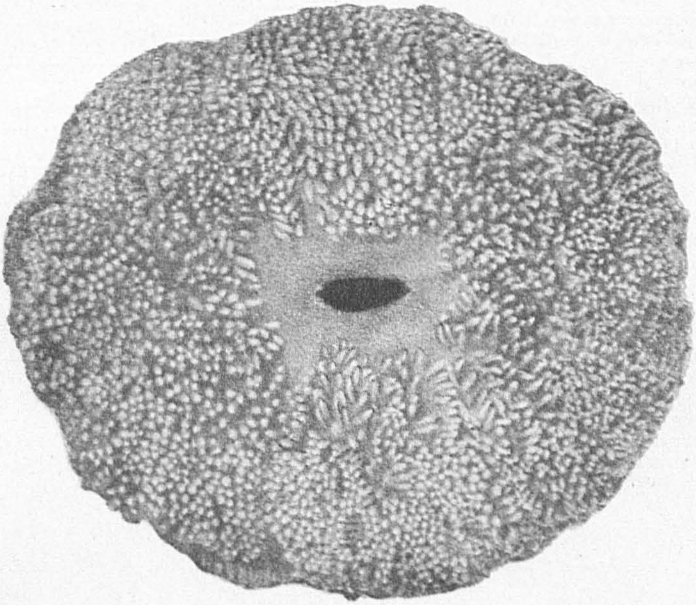
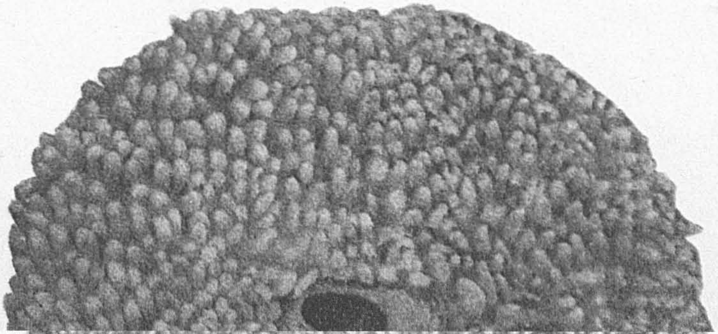
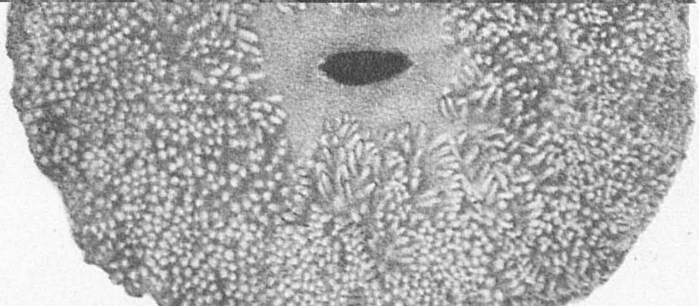


FIG 1a.





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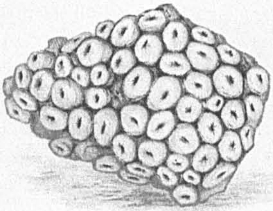

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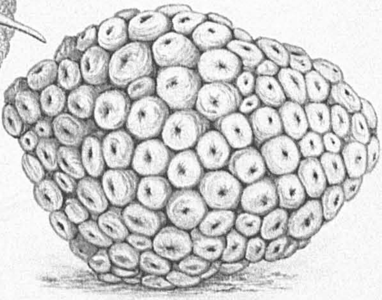

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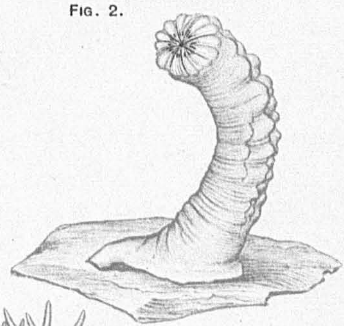

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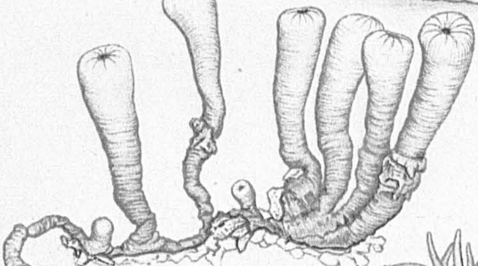

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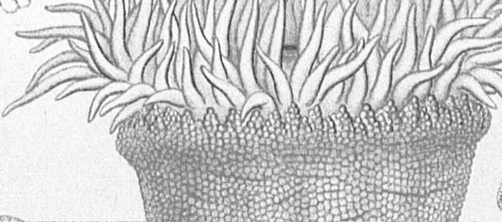

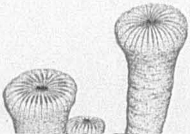

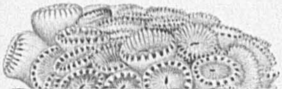

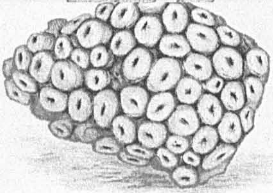

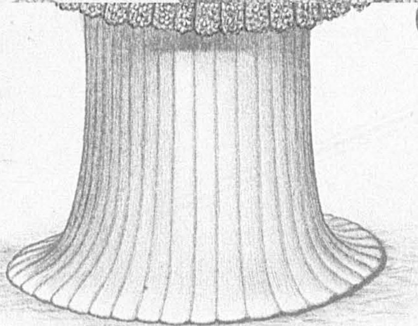

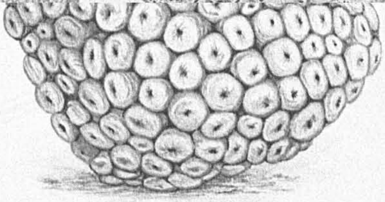

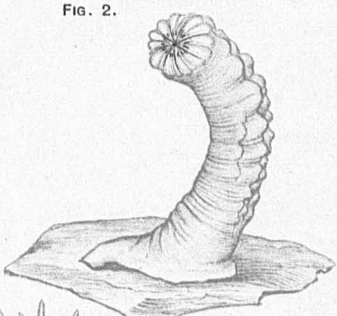

FIG. 3.
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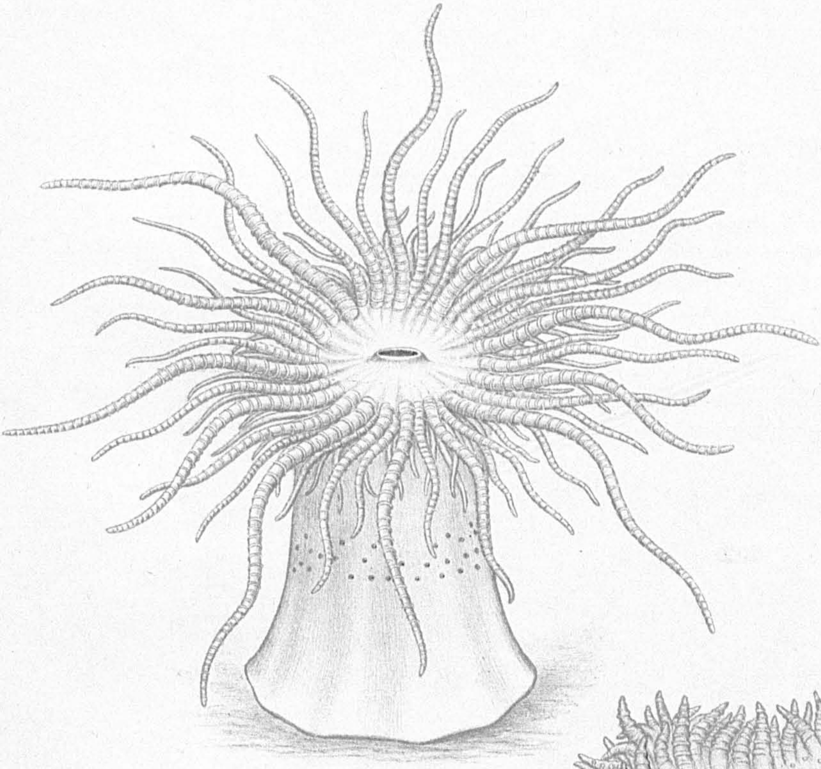

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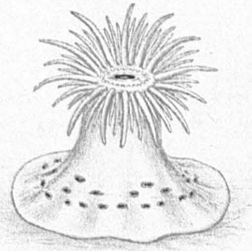

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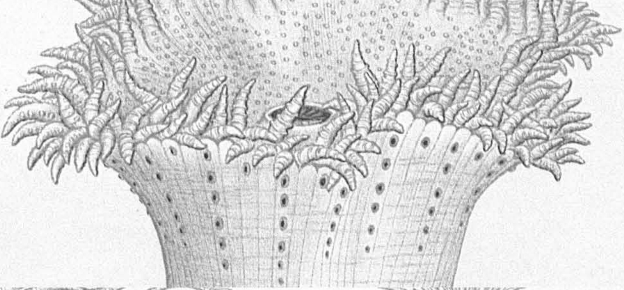

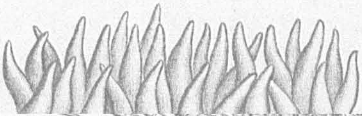

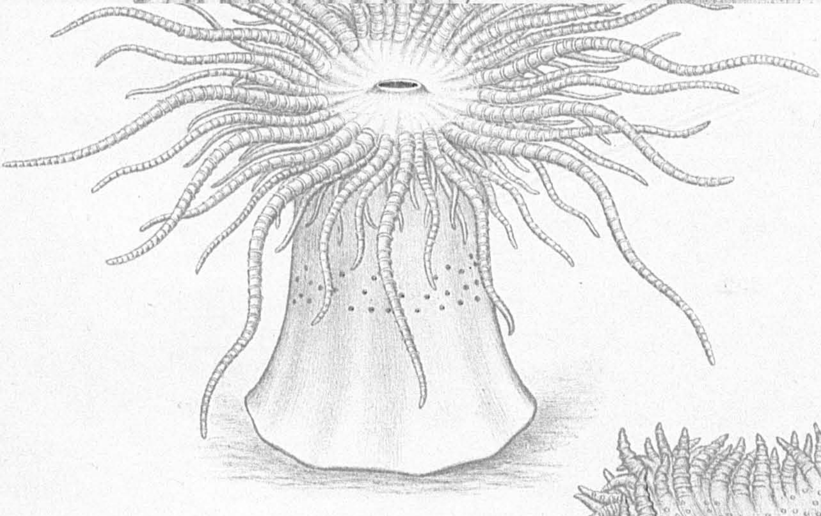

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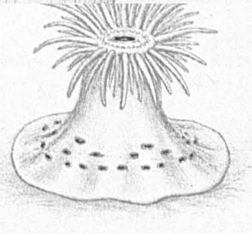

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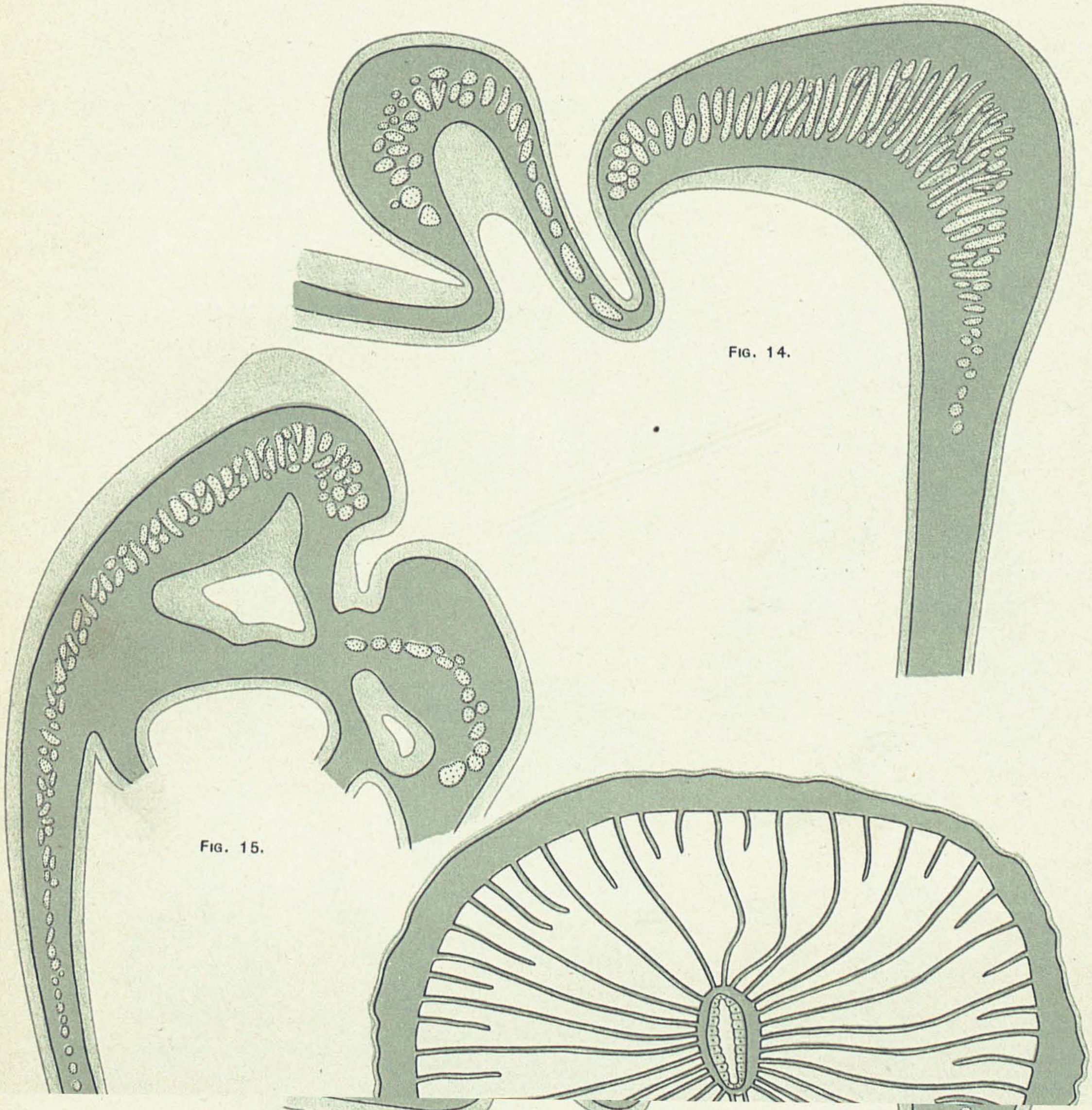

FIG. 14.

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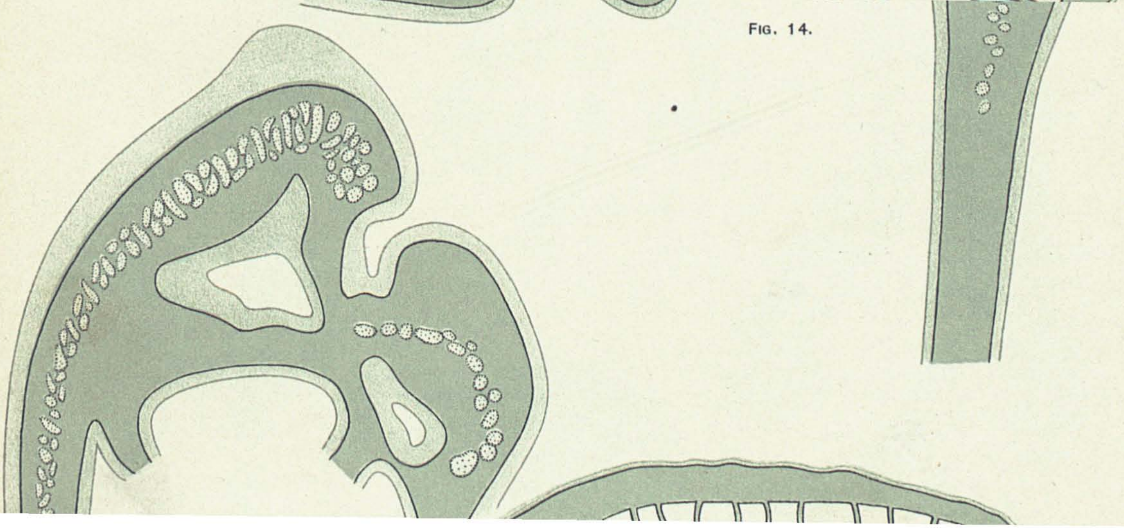

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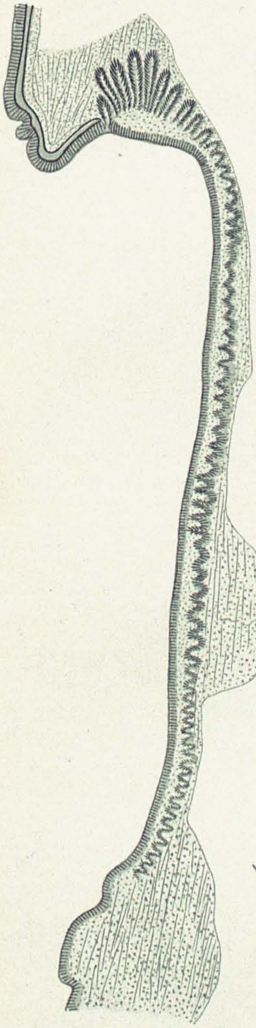

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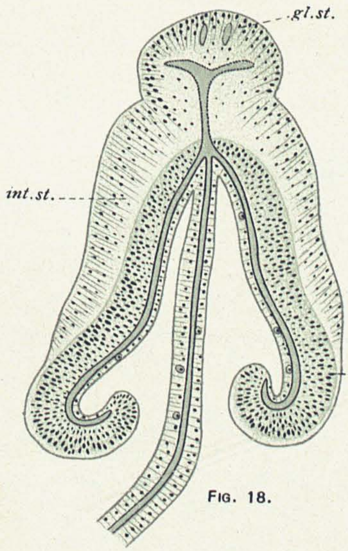

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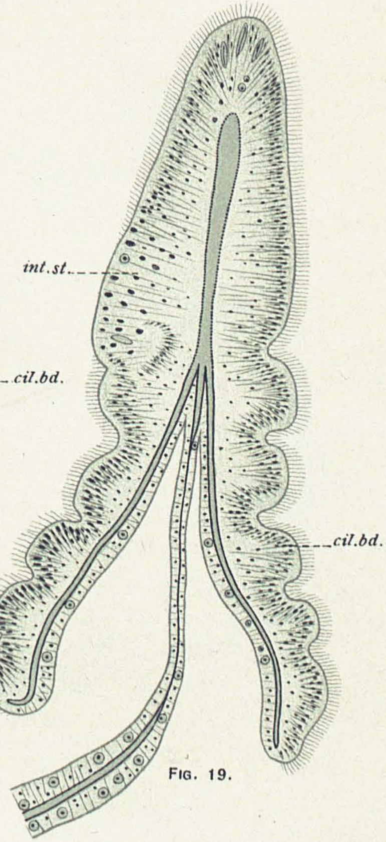

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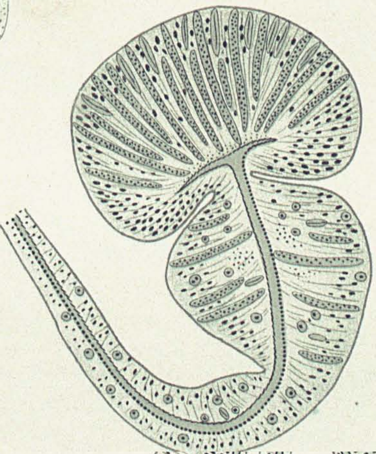

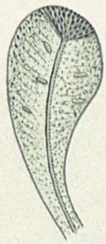

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FIG. 18.
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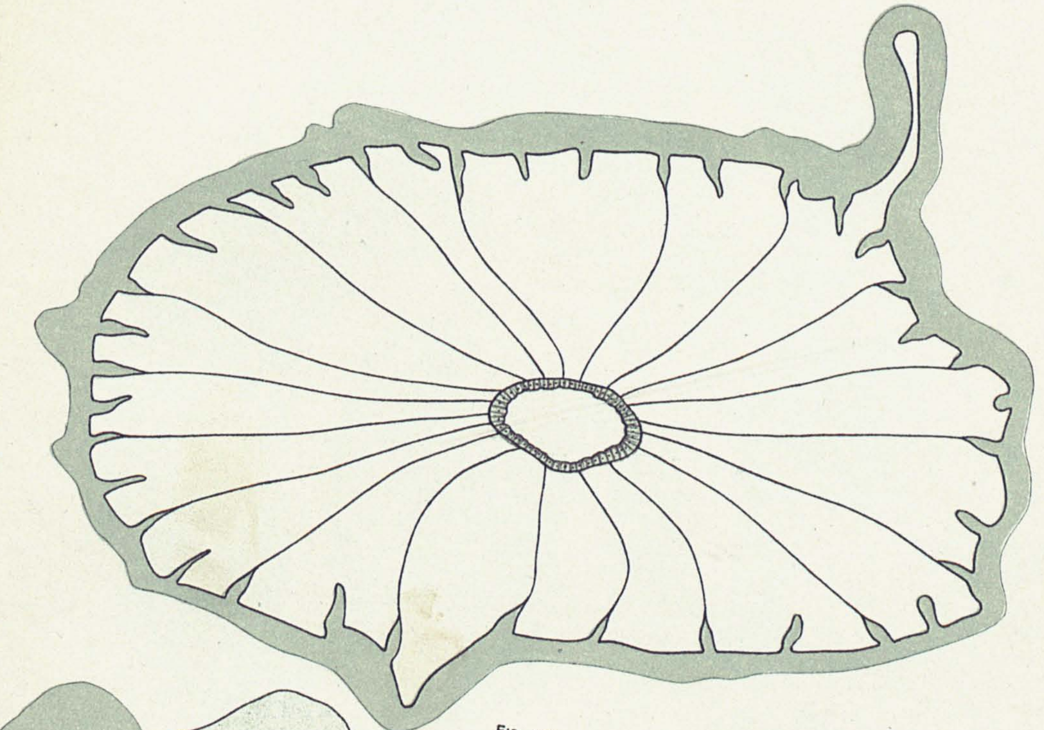
FIG. 19.

PLATE VI.



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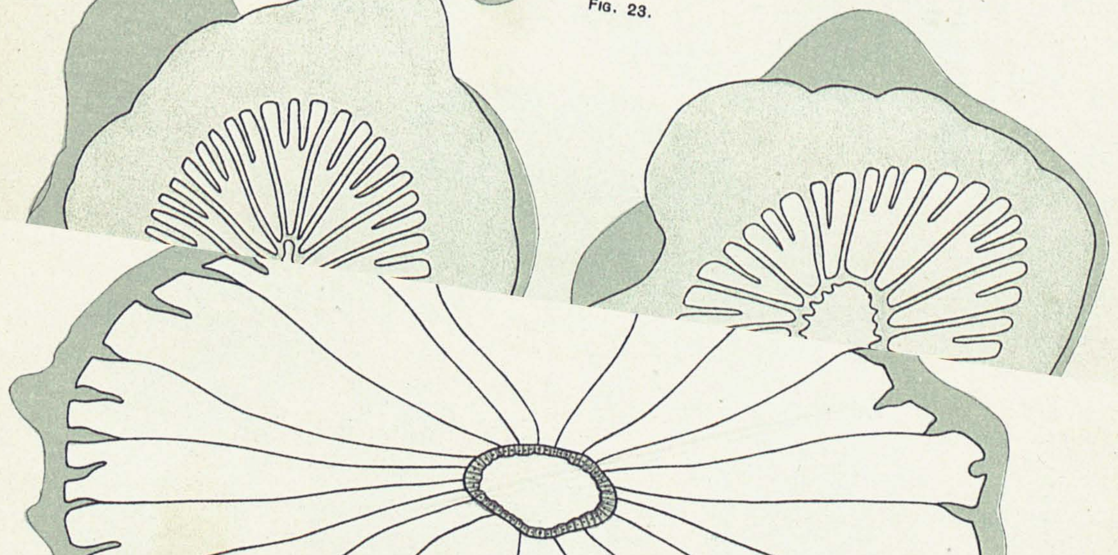
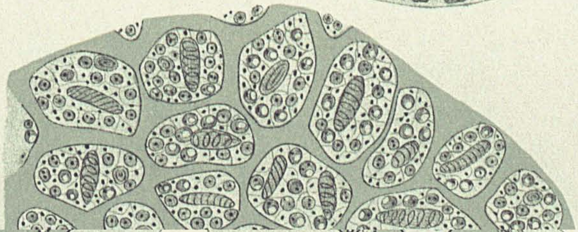
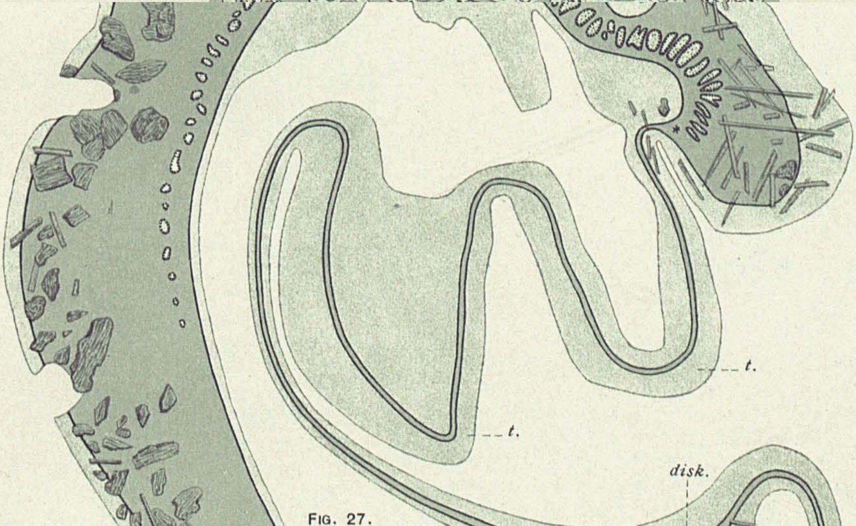


FIG. 23.

FIG. 27.

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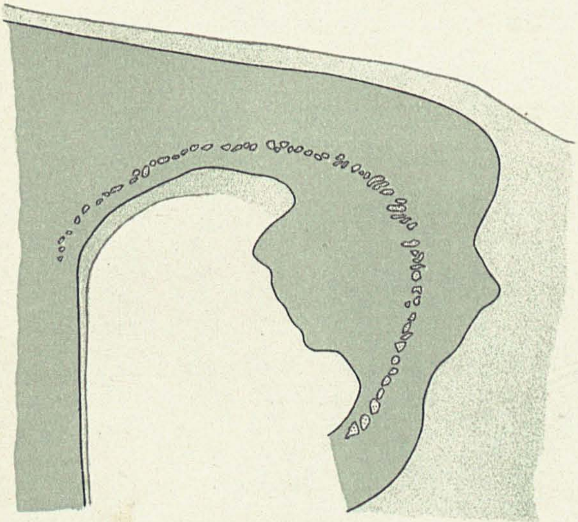

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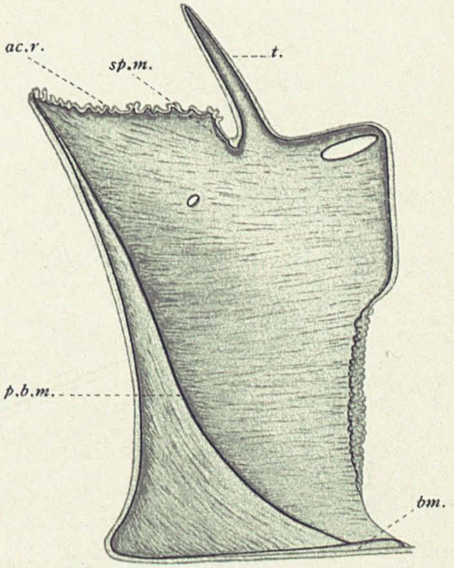

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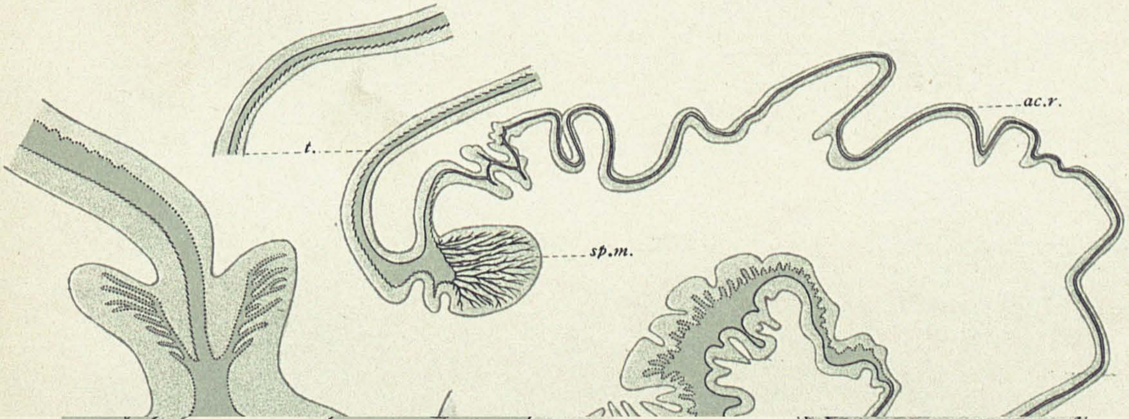

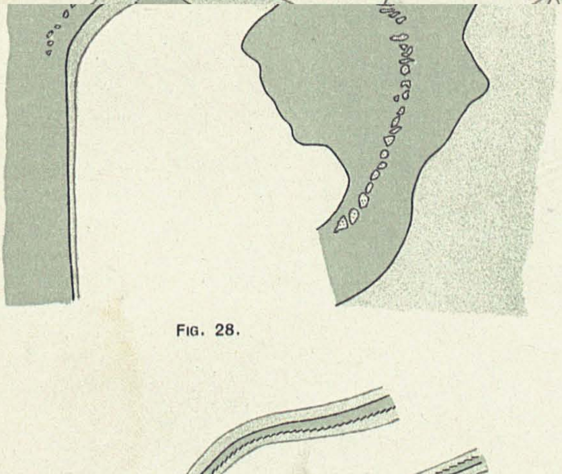

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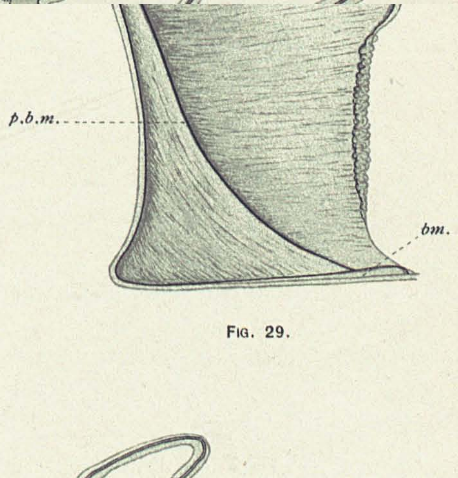

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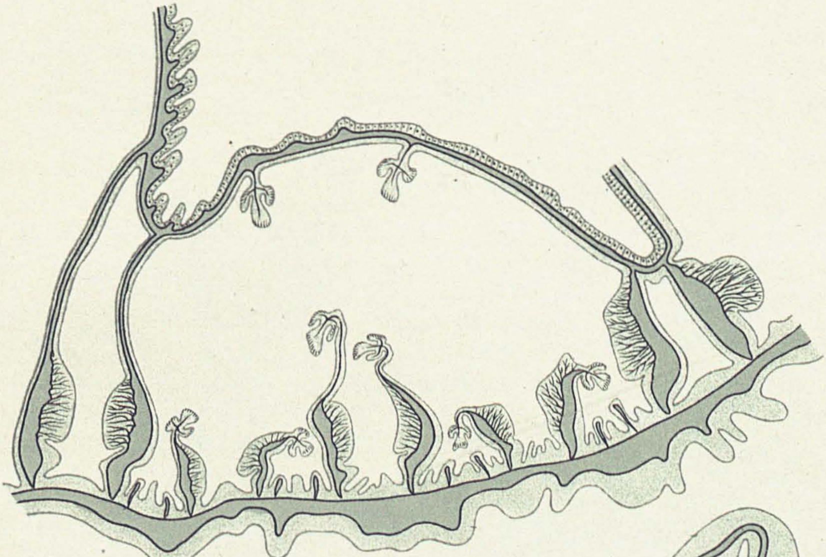
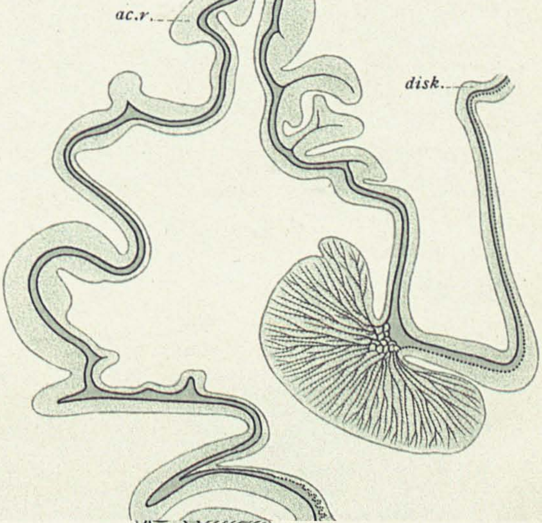
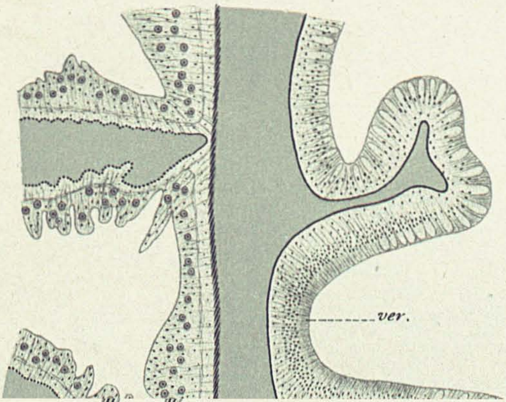


FIG. 32.





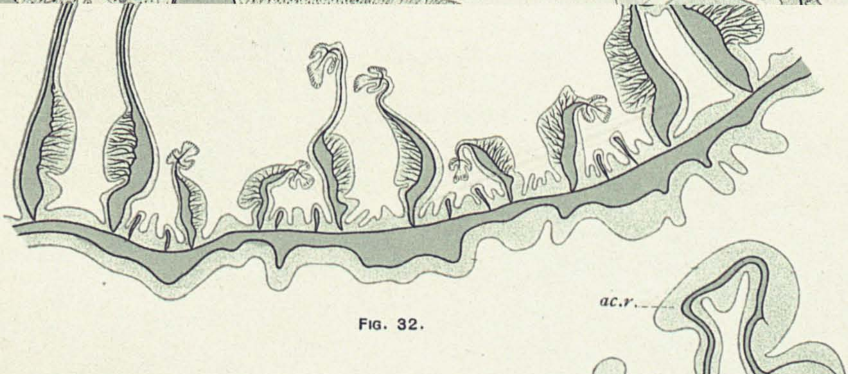
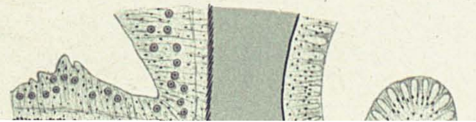


FIG. 32.



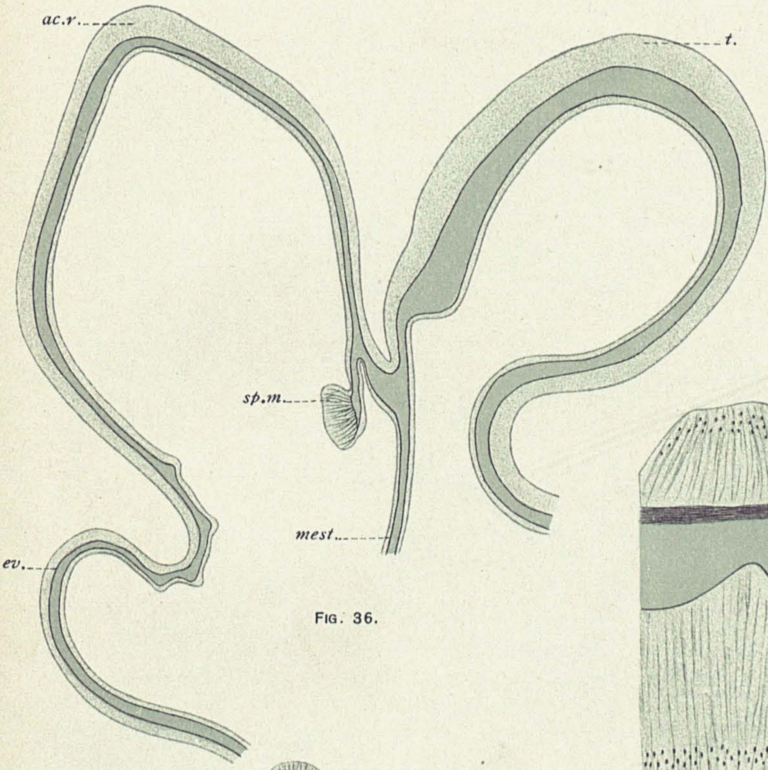


FIG. 36.

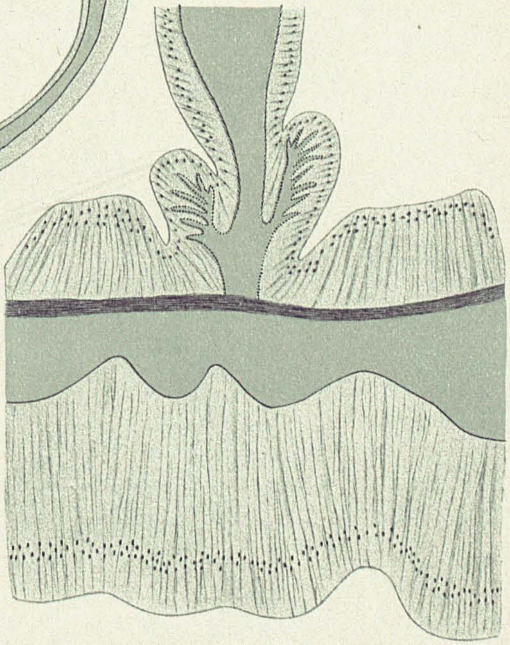
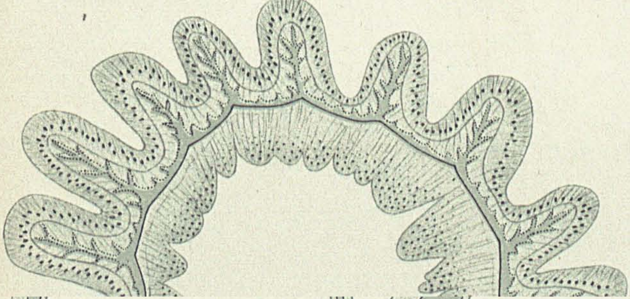
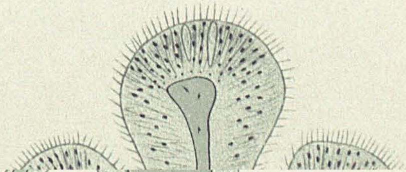


FIG. 37.





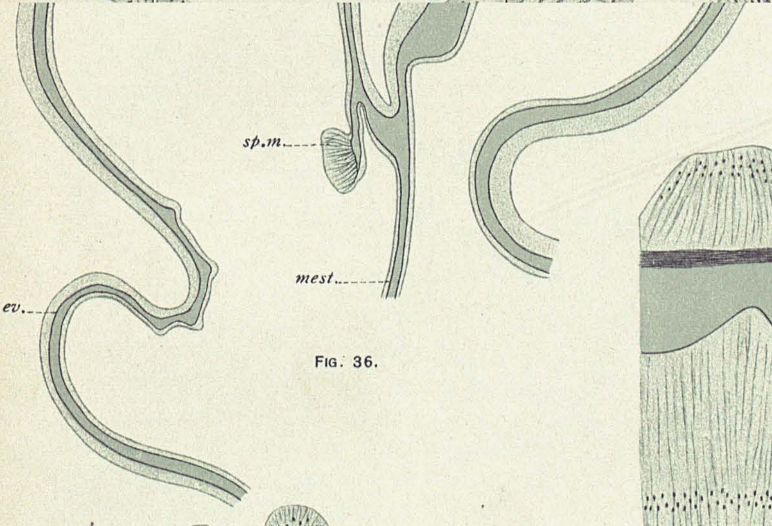
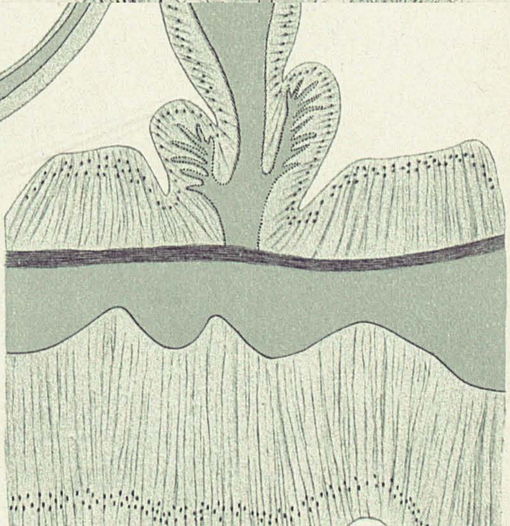


sp.m.
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FIG. 36.

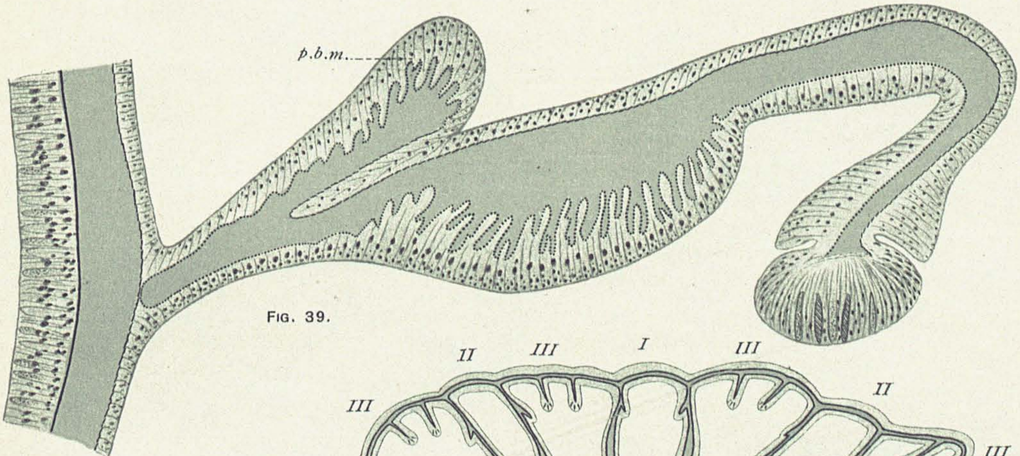


FIG. 39.

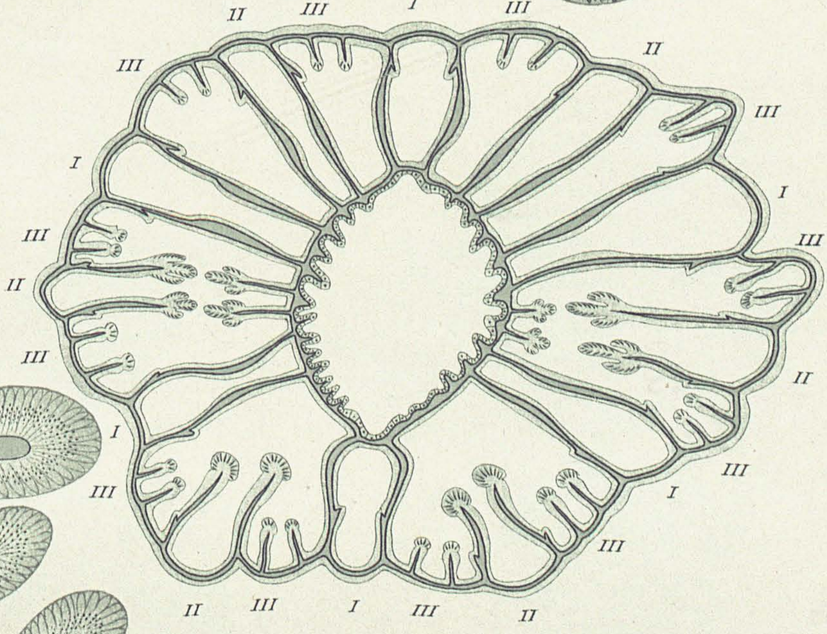
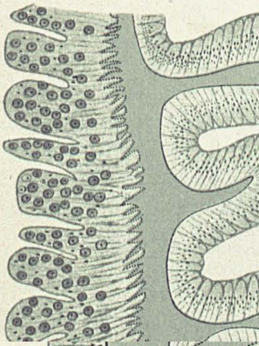


FIG. 40.



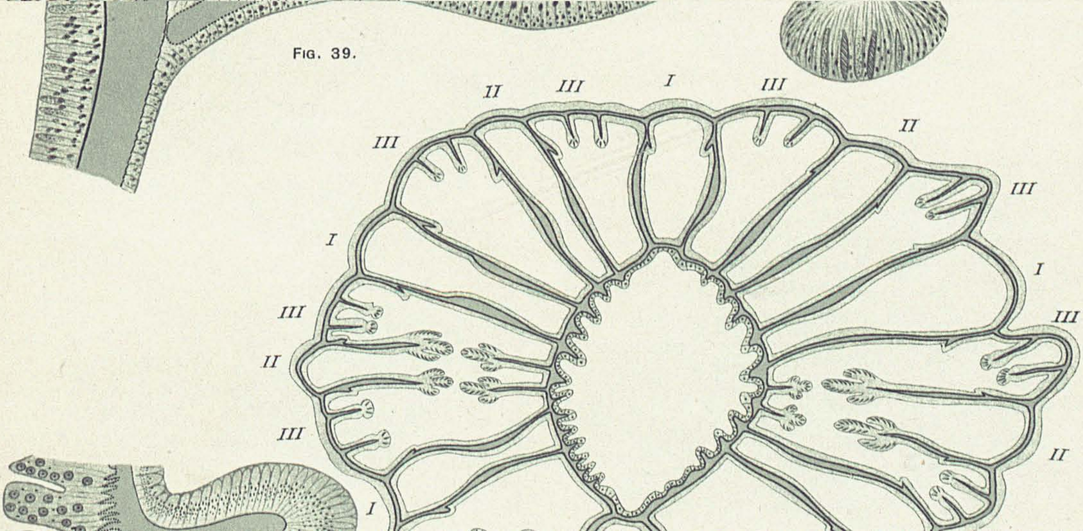


FIG. 39.

PLATE XII.

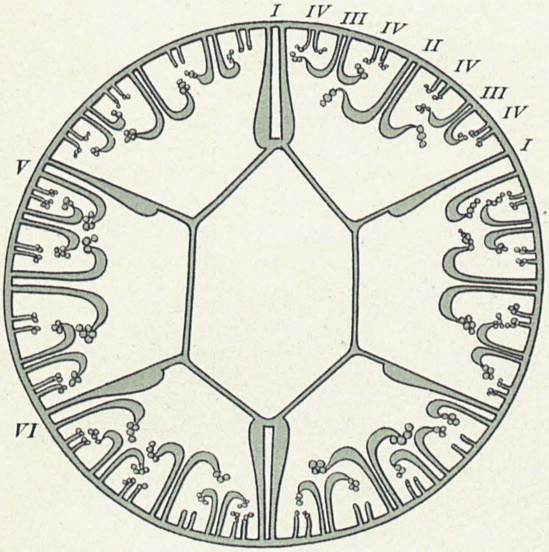


FIG. 43.

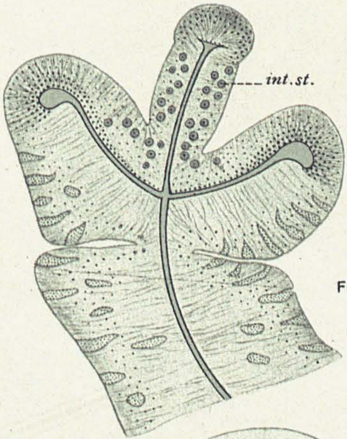
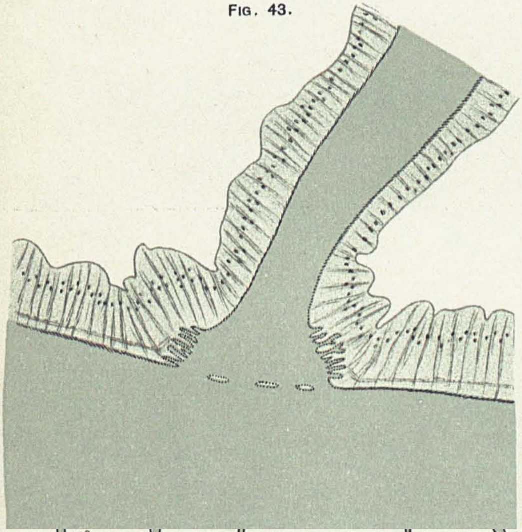
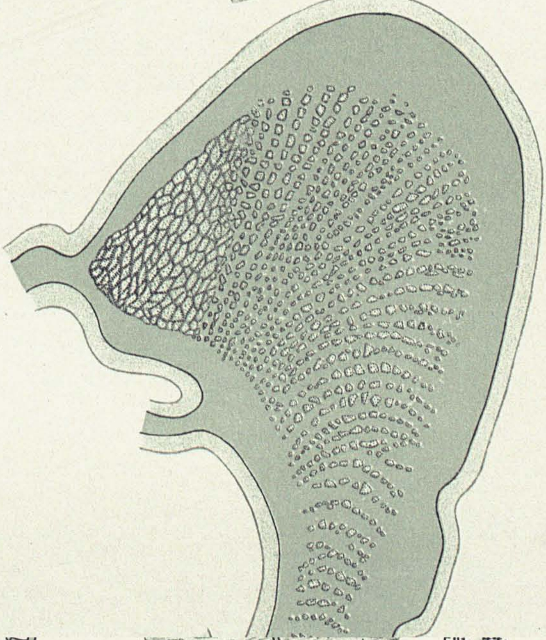
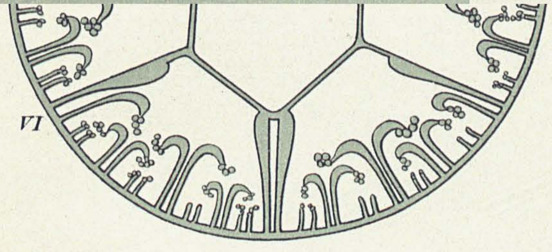


FIG. 44.







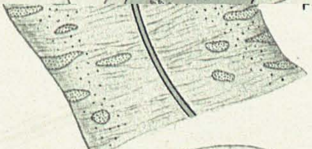


FIG. 43.