IX. *On the Actinian Bunodeopsis globulifera, Verrill.* By J. E. DUERDEN, Ph.D., A.R.C.Sc.(Lond.), Bruce Fellow, Johns Hopkins University. (Communicated by Prof. G. B. HOWES, F.R.S., Sec. Linn. Soc.)

(Plates 25 & 26.)

Read 20th February, 1902.

IN a preliminary paper on the Jamaica Actiniaria (1898) I briefly described a new West Indian *Bunodeopsis*, without assigning it any specific name. The year previous I had given a fuller account of two other species of the same genus, and it was intended to institute a comparison with these. In 1899, Prof. A. E. Verrill figured, without any comment in the text, a Bermudas Anemone which he identified as the *Viatris globulifera* of Duchassaing and Michelotti (1860). Upon the appearance of the paper I drew Prof. Verrill's attention to the similarity between his drawing and the new *Bunodeopsis* which I had obtained, and the year following appeared his description of the form as a new species, *Bunodeopsis globulifera*. The description is limited, however, to an account of the external characters, and gives no attention to the peculiarities of anatomy and minute structure.

A study of the internal structure and histology of the two species of *Bunodeopsis* in 1897 had revealed the presence of a well-developed ectodermal muscle and nerve-layer on the column-wall, along with several other exceptional features, whose significance was not then realized. About this time Dr. Oskar Carlgren (1893, 1900) was directing attention to the importance in Actinian phylogeny of the occurrence of an ectodermal columnar musculature, and its usual association with the absence of gonidial grooves in the stomodæum, absence of ciliated bands from the mesenterial filaments, the non-development of the basilar muscles, and the occurrence generally of a weak internal musculature. Every species of *Bunodeopsis* thus becomes of special interest in connection with this latest phase of the morphological study of the Actinians.

The genus *Bunodeopsis* has been thus defined by me (1897, p. 6):—"Tissues very delicate. Tentacles elongate, readily retractile. Column short, beset proximally with pedunculate or sessile vesicles, the vesicular area much broader than the capitulum. Sphincter muscle feebly developed. More than six pairs of perfect mesenteries."

The genus at present is included within the family Aliciidae, which in the same paper (p. 2) is characterized as follows:—"Hexactineæ with a large, flat, contractile base. Tentacles simple, subulate, and entacmæous. Column with simple or compound outgrowths or vesicles over more or less of its surface, arranged mostly in vertical rows. No cinclides. Sphincter muscle endodermal and diffuse, variable in amount of development. Perfect mesenteries few or numerous. No acontia." In addition to

Bunodeopsis, the family contains the genera *Alicia*, *Cystiactis*, and *Thaumactis*, and in 1898 Carlgren included the genus *Phymactis* of Milne-Edwards and Haime.

As a result of the discovery of the ectodermal columnar musculature in *Bunodeopsis*, and also in *Thaumactis*, Carlgren (1898, p. 17 ; 1900, p. 28) considers that the family Aliciidae as at present constituted is made up of heterogeneous members, and indicates that it will be necessary to remove the two genera mentioned and associate them with the Tribe Protanthææ. He further states that he is preparing a revision of the family. With the many representatives at his command Carlgren is in a much better position for carrying out such a revision than any other student of the Actiniæ, and it is desirable that a fuller account of Verrill's species of *Bunodeopsis* should be available.

BUNODEOPSIS GLOBULIFERA, Verrill.

Bunodeopsis, n. sp., Duerden, 1898, p. 456.

Viatrix globulifera, Verrill, 1899, p. 146, fig. 20.

Bunodeopsis globulifera, Verrill, 1900, p. 559, pl. 67. fig. 4.

The base is loosely adherent or free, broad, flattened or encircling marine plants, approximately circular, and thin-walled. In preserved specimens it is usually irregular in form, the middle deeply concave, and the periphery irregularly sinuate; concentric and radiating grooves are also present.

The column is erect, thin-walled, partly transparent, contractile, broad below and gradually narrowing above, passing directly into the tentacles. The limbus is circular in living, but strongly crenulated and lobed in preserved specimens. The lower region of the column, for about two-thirds of the total height, is nearly covered with small spheroidal vesicles, the upper one-third is naked and smooth. The naked region is much more limited in extent in preserved polyps than in living specimens, and Verrill's drawings and description would seem to have been founded upon the former. The apex of the column is devoid of acrorhagi. It is very rarely infolded, but where this takes place the disc, tentacles, and naked part of the column become hidden, and only the region bearing the vesicles remains exposed.

The disposition of the vesicles sometimes appears irregular, though as a rule they are seen to be arranged in vertical rows of different heights, but no regularity in longer and shorter cycles has been established. Towards the base two or three rows of minute tubercles may alternate with a row of large outgrowths. In both his figures Verrill represents the vesicles as irregularly distributed, with scarcely any variation in size, though in the text he notes that larger and smaller ones are mingled together. The species undoubtedly varies greatly in its outward appearance.

The evaginations are simple, sessile or sub-pedunculate, hollow, smooth throughout, opaque, and thick-walled in comparison with the column-wall generally. They are variable in size, some appearing as mere rounded tubercles, while others are seen as distinct vesicular outgrowths; most are spheroidal, but the larger examples may be reniform. Different sizes are intermingled, but in general the organs increase in size from below upwards, at the same time diminishing in numbers.

The tentacles are marginate, strongly entacmæous, and very variable in number and size. Any number from twelve to forty-eight may be present, according to the size of the polyp. Verrill records examples with 18, 20, 22, 24, and 26 tentacles. Three or four cycles are represented, but no regular arrangement, hexamerous or otherwise, has been made out. The inner members are mostly very long and slender, tapering towards the extremity, and are smooth, very delicate, and transparent, and sometimes appear minutely spotted. Very often the tentacles are imperfectly developed at some particular region of the periphery, several appearing much shorter than the others, or represented only by mere papillæ. As a rule one such imperfect area will occur, but there may be two, separated by one or more fully developed tentacles (Pl. 25. fig. 1 *b*).

The tentacles are generally overhanging in living polyps, and in preserved specimens they remain nearly erect and tapering, and a little shortened. On one or two occasions they have been found completely infolded, with nothing but the vesicular part of the column showing. Though such a strongly infolded condition is rather exceptional in the present species it is very frequent in *B. antilliensis*, Duerd., and is somewhat remarkable considering the practical absence of a sphincter muscle on the column (p. 302). So complete is the infolding that the tentacles may even pass into the mesenterial chambers, as shown in fig. 11. A basal constriction often occurs at the origin of the tentacle from the disc (fig. 1 *c*), and occasionally a tentacle has become detached, its former position at the margin of the disc being indicated by a circular aperture. The tentacles are thickest just above the basal constriction.

The disc is smooth, circular, flat or slightly convex, and transparent the mesenteries and stomodæum showing through in the living condition. The central part as a rule is elevated in preserved polyps. The mouth is slit-like in living polyps, but in preserved specimens it is widely open and circular, and the lips are thickened and protruding. The stomodæal walls are smooth, and no gonidial grooves are distinguishable.

The polypal wall throughout is nearly transparent and only slightly coloured. During partial contraction the lower part of the column is sometimes a bright, opaque, yellowish green, with brown or black lines or spots. On full distention, the vesicles and column are a clear, delicate, yellowish brown, due to the yellow cells within the endoderm. The tips of the larger vesicles may be a little darker than the rest of the wall, probably owing to the greater concentration of the stinging-cells (fig. 5).

The diameter of the base of the largest specimens is 1.2 cm.; the height varies from 0.5 cm. to 1.3 cm. The length of the inner tentacles is about 1 cm., or nearly the same as the height of the column.

The polyps are essentially shallow-water forms, being usually met with around Jamaica at a depth of three or four feet, with their base encircling the long, narrow, cylindrical stems of the marine weed *Ruppia*, or more rarely adherent to the flattened fronds of *Dictyota* and leaves of *Thalassia*. It occurs in some abundance at Port Antonio, and I have also found it around Kingston Harbour. In this latter area the closely allied *B. antilliensis* is very abundant, but I have not met with it at the former locality.

The polyps are easily detached from the marine plants to which they are adherent; indeed, in transferring the leaves from the sea, or from one jar to another, the polyps will often slide off. It is doubtful if an actual adherence really takes place, any more than in the case of such organisms as Nudibranchs and Turbellarians. The presence of a basal ciliation, to be described below, would indicate that the contact with foreign bodies is not very close. The extremely weak parieto-basilar muscles and absence of basilar muscles are no doubt the structural features correlated with the incapacity for firm fixation. In the laboratory specimens often free themselves, and, suspended in the water with the tentacles fully expanded, may move slowly around, gradually coming to rest against the sides of the vessel. Probably their movements are assisted by the strong ciliation on the base and column-wall. I have never observed any decided rhythmic movements in swimming. When free the base may be upwards, with the tentacles hanging gracefully downwards; or it may be in its normal lower position, the tentacles then directed upwards and partly overhanging.

Carlgren (1900) also mentions that the *Bolocerooides McMurrichi*, obtained by Dr. Stuhlmann from Zanzibar, was likewise found to be able to detach itself and carry on swimming movements much like a Medusa. Like *Bunodeopsis*, the genus *Bolocerooides* is considered to belong to the primitive Protanthææ, as is also *Gonactinia*, another form capable of swimming. Probably such loosely adherent Actinians should be regarded as in some ways intermediate between the free Anemones with a rounded aboral extremity and forms with a flattened firmly adherent base.

ANATOMY AND HISTOLOGY.

Base.

The base is thin-walled, all the three constituent layers being very narrow (Pl. 25. fig. 2). In sections it is usually .03 mm. across. The ectoderm is remarkable for the short, coarse cilia with which it is covered, and which are recognizable in basal sections even when unpreserved in other parts of the polyp. In most preserved polyps only traces of the external ciliation on other parts of the body-wall persist, while the ectodermal stomodæal ciliation is usually very obvious, and less so that of the mesenterial filaments and of the endoderm of the cœlomic cavity. Probably the basal ciliation assists in the movements of the polyps over the leaves of the marine plants on which they settle; or it may help the polyp when it assumes the floating habit. Its presence is incompatible with any firm adherence of the polyps by their base.

The basal ectoderm is constituted mainly of supporting cells, narrow granular gland-cells, and a few clear gland-cells. A small nematocyst, measuring .012 mm., occurs very sparingly. A rudimentary musculature and nerve-layer probably occur, but their presence could not be determined with absolute certainty.

The mesogloea is narrow, and contains a few minute connective-tissue cells. Elsewhere throughout the polyp the mesogloea preserves the same character, that of a narrow, homogeneous layer, containing but a few connective-tissue cells.

The basal endoderm varies much in thickness in different places. Where very narrow,

the cell-contents stain deeply, being highly protoplasmic, and *Zooxanthellæ* are absent or nearly so; where the layer is broader the cells are more vacuolated, the free surface is somewhat irregular, and the symbiotic algæ are found in large numbers. Throughout the endoderm of the polyp similar broad and narrow areas are represented, according as *Zooxanthellæ* occur in abundance or are practically absent. A weak circular endodermal musculature can be detected on the base, and in some specimens a nerve-layer separated from the muscle-band by a fibrillar layer. The latter, however, was not recognizable in the section from which fig. 2 was taken.

Column-wall.

The proximal and distal regions of the column-wall vary somewhat in structure. The former is broad and irregular in outline, owing to the occurrence of the evaginations, while the naked area is very thin and delicate, measuring in sections only .03 mm. across (fig. 4).

The ectoderm of the column-wall is weakly ciliated throughout, and both transverse and vertical sections of the upper part often exhibit fine ridges and grooves as a result of unequal shrinkage (fig. 3). These appearances, however, are more characteristic of the tentacular ectoderm, as shown in the same figure. The constituents are mainly supporting cells and clear gland-cells; nematocysts occur very sparingly, except in the evaginations of which they are very essential elements. A layer of delicate ectodermal muscle-fibres occurs throughout the extent of the column, and in some places the mesogloea is very slightly plaited for its support. The muscle-fibres are arranged with the long axis vertically, so that they are cut cross-ways in transverse sections of the polyp, and constitute a delicate but clearly-marked layer, the fibrils being highly refractive. Outside the band of muscle-fibres occurs a weak nerve-layer (*nr.l*), the two distinctly separated by a narrow interval crossed by fine fibrillar strands (figs. 3, 5, 16).

The nature of the fine strands occurring between the band of muscle-fibres and the nerve-layer, and continued in some cases beyond the latter, is not readily determined. They occur practically throughout the polyp, on both the ectodermal and endodermal surfaces, but are much more definite in some individuals than in others. McMurrich (1890, p. 143) refers to a somewhat similar appearance in various parts of the body-wall of *Cerianthus americanus*, and regards the processes as mesogloæal prolongations. Carlgren (1893, p. 26) describes a nearly similar structure in *Protanthea simplex*, and also considers it to be due to very fine continuations of the mesogloea, which here and there bear strongly refractive bodies, resembling sections of muscle-fibrils. In Carlgren's preparations the details vary greatly according to the manner of preservation of the specimens, and McMurrich's two specimens of *Cerianthus* likewise differed.

The specimens now under consideration were preserved in formol and then transferred to alcohol, and the interval between the mesogloea and the ganglion layer varies greatly in width in different polyps, and even in different regions of the same individual. Usually it is more pronounced on the endodermal side than on the ectodermal, and on

the former the strands sometimes appear slightly reticular in character. Small nuclei occur among the fibrils, and are regarded as the nuclei of ganglion-cells.

The same fibrillar layer is still better developed in some polyps of *B. antilliensis*. It may occur on both the ectodermal and endodermal faces of the mesogloea, and what seem to be the continuations among the ectodermal cells are clearly seen (1891, pl. i. figs. 3, 4). In *Protanthea*, Carlgren (1893, pl. iii. figs. 4, 5) represents the mesogloéal continuations, both on the ectodermal and endodermal aspects, as constituting a nearly compact zone, while in the preparations of *Bunodeopsis* they appear as very distinct coarser strands, rather widely separated one from another.

The nerve-layer in *Bunodeopsis* is, as a rule, very narrow in sections, and appears made up of interlacing fibrils, some seen longitudinally and others in section. In Carlgren's figures of *Protanthea* the layer is represented by minute dots only, indicating the cut ends of the fibrils. Such an appearance also occurs in the stomodæal ectoderm of *Bunodeopsis* (fig. 7, *nr.l.*).

The mesogloea of the column-wall is thin throughout, and both its inner and outer surfaces are smooth, or very slightly plaited to afford additional support for the ectodermal and endodermal musculatures.

The endoderm is broad in the lower region of the polyp, where, as a rule, the cells contain many *Zooxanthellæ*; but the layer becomes very narrow above, as the symbiotic algæ are either absent or very rare, and the cells are then more charged with protoplasmic contents. The endodermal free surface is everywhere feebly ciliated.

The circular endodermal muscle occurs throughout the column-wall, usually supported on very delicate mesogloéal plaitings. A slight increased development takes place towards the upper extremity, but never to such a degree as to give rise to what may be regarded as a sphincter muscle (fig. 3, *end.m.*). A nerve-layer is usually seen, situated at some distance from the mesogloea, and a little better developed than in the ectoderm.

The evaginations (figs. 4 & 5, *ev.*) are simple, hollow, rounded outgrowths of the lower part of the column-wall, and in transverse sections are seen to be both entocœlic and exocœlic in position, though without any regular alternation. In sections the walls at their thickest are about 0.065 mm. across. The cavity communicates by a large aperture with that of the cœlenteron. Both the ectoderm and endoderm have undergone certain histological modifications compared with the character of the layers in the column-wall generally. The ectoderm (fig. 5) is broad, somewhat strongly ciliated, and a very distinct zone of oval nuclei occurs just within the outer margin, while smaller, rounded nuclei occur here and there throughout the thickness of the layer. The characteristic elements, however, are the large, thick-walled nematocysts (*nem.*), which occur in some abundance in the outer area of the evaginations. Seen in sections, the nematocysts exhibit few or no structural details, but appear as smooth-walled, nearly homogeneous bodies, irregularly distributed among the supporting cells. The deeper examples more especially are arranged at varying angles with the surface of the ectoderm, but the outer are practically parallel with the supporting cells. The former are probably individuals in process of development and are strongly curved, while when they assume their

mature position at right angles with the surface, they are nearly straight. In macerations the nematocysts appear as represented in fig. 8 *b*. They possess a thickened wall, and exhibit a tubular appearance within, representing the thickened basal part of the thread, but no trace of the finer portion of the thread can, as a rule, be made out.

The musculature and nerve-layer (fig. 5, *nr.l.*) on both sides of the mesogloea are extremely delicate in the evaginations, but can be clearly recognized in favourable sections. The endoderm is broader than that of the column-wall generally, and is more strongly ciliated. Its cells are usually crowded with *Zooxanthellæ* (*zoox.*), though in some cases the algæ are very sparse or altogether wanting. The histological character, as a whole, would indicate that the columnar evaginations are to be regarded as special nematocyst-bearing organs.

The size, character, and distribution of the nematocysts possess a certain importance in systematic studies of the Anthozoa, and may be fittingly referred to here as represented throughout the different tissues of the present species.

Carlgren (1900, p. 3) believes that the nematocysts may be made of great assistance in the identification of species of Actiniæ, and even in the recognition of genera. For the time being he roughly divides them into "thin-walled nematocysts," in which the internal spiral thread shows distinctly, and "thick-walled nematocysts," which appear quite smooth. Very often the internal spiral thread is not seen within the latter, while in others it may be recognized, but not so clearly as in the thin-walled form. With regard to their general distribution in the polyp, Carlgren finds the thin-walled variety to occur mostly in the tentacles and disc, but in certain species and genera in the column-wall and stomodæum also. The thick-walled forms are found in all parts of the ectoderm of the column-wall, and their length is fairly constant for the species. As a rule the longest thick-walled nematocysts occur in the stomodæum; those in the tentacles are as long or somewhat shorter; while they are the shortest in the disc, column-wall, and base. The longest nematocysts usually occur in the acrorhagi, or in any other special outgrowths of the column-wall which may be developed.

Usually it is only in the living polyps that the stinging-cells can be examined in their fully extruded state and their complete characteristics determined, including the swollen basal part and the simple or complex evaginated thread. But certain distinctions can be made out in macerations of preserved polyps, or even in sections. In the species now under investigation the occurrence and character of the stinging-cells are briefly as follows:—They are very sparingly represented in the basal ectoderm by an extremely small form of the thick-walled variety, measuring only $\cdot 012$ mm. In the column-wall they have been found only within the ectoderm of the evaginations. Here they are all of one kind: large, thick-walled, slightly curved, and varying in length from $\cdot 038$ mm. to $\cdot 044$ mm., with a diameter of about $\cdot 008$ mm.

The tentacular nematocysts include the two varieties. By far the majority are thin-walled with the spiral thread showing very distinctly, and are broad at one end and narrow at the other (fig. 8 *a*). They range in length from $\cdot 018$ mm. to $\cdot 028$ mm. The thick-walled form is numerous, and nearly as long as in the columnar evaginations, their

length varying from .034 mm. to .04 mm. They are invariably a little narrower than in the evaginations, measuring only .006 mm., and are nearly always perfectly straight.

In the disc stinging-cells are concentrated within the thickened lips, and are similar to the thin-walled representatives in the tentacles.

The nematocysts within the stomodæal ectoderm include only one representative of the curved columnar variety. They are very uniform in size, measuring .025 mm.

The mesenterial filaments are somewhat exceptional in being very sparingly supplied with nematocysts, even in the lower region. They are all narrow and straight, and are nearly of the same length as those in the stomodæum, namely .025 mm.

No nematoblasts occur anywhere within the endodermal epithelium.

It is thus clear that practically every region of the polyp possesses its own distinctive nematocyst. Though generally distributed throughout, the thick-walled variety differs slightly either in size or outline, or in both, in the different areas where it occurs. Examples intermediate in type are to be found mingled with the others, so that it is only when taken in numbers that the distinctive characteristics become of taxonomic value.

Tentacles.

As the column-wall is rarely overfolded in preserved polyps, and the tentacles are usually only slightly retracted, the latter are generally seen in their normal relationship in both vertical and transverse sections (Pl. 25. fig. 4 & Pl. 26. fig. 13). A transverse section, such as is represented in fig. 13, demonstrates that the tentacles are outgrowths of both the entocœlic and exocœlic mesenterial chambers. In some instances, as at t_4 and t_5 , t_7 and t_8 , t_{12} and t_{13} , it appears as if two tentacles originated side by side from a single mesenterial chamber, but on more close examination a pair of rudimentary mesenteries (III.) can always be detected, so that one of the tentacles is entocœlic and the other exocœlic. Such conditions prove that the appearance of a new mesenterial pair is followed very closely by the outgrowth of a tentacle from its entocœle. In the polyp from which fig. 13 was taken no exotentacles had as yet appeared between the entocœlic members t_5 and t_6 , t_6 and t_7 , t_{11} and t_{12} . For a short period, therefore, during the growth of new mesenteries, the number of tentacles may be less than the number of mesenteries, due to the lagging behind of the exotentacles; but in the end the sum is the same, a tentacle arising from each chamber, whether entocœlic or exocœlic.

The tentacular ectoderm and endoderm are both comparatively broad layers, but the mesogloea is very narrow. In sections the wall is about .055 mm. across. The ectoderm is usually thrown into minute rounded ridges separated by deep narrow grooves, the cells being elongated in the former and very short between (fig. 3). Nematocysts are distributed in a peripheral zone with approximate uniformity throughout the length of the tentacle, and are mainly of one kind: thin-walled, with the close spiral thread showing distinctly, and broad at one end and narrow at the other (fig. 8 a). Numerous examples of the larger, thick-walled variety, such as occurs in the evaginations, are also present, but are slightly shorter and much narrower.

The longitudinal ectodermal muscle is supported upon the mesoglœa, which is usually thrown into slight folds to give it increased area, especially towards the proximal end. The nerve-ganglion layer is also clearly developed.

The endodermal epithelium is rather broad in the partly retracted tentacles, and exhibits an irregular free surface, while Zooxanthellæ are only sparsely distributed. The endodermal muscle (*end.m.*, fig. 3) is comparatively well developed, the mesoglœa presenting delicate plaits for its support, best seen just above the tentacular septum (*t.c.s.*).

The tentacular cavity is separated from the general polypal cavity by a circular transverse partition, perforated in the middle, and situated a very short distance from the origin of the tentacles (figs. 3, 4, 6). The septum is covered on both sides by endoderm, and the supporting mesoglœa is narrow and lined by delicate muscle-fibres on its inner and outer surfaces, continuous with the circular musculature of the tentacles. Its central free margin is thickened, and the mesoglœa becomes plaited (*t.sph.*, figs. 3 & 6) in a sub-dendroid manner to afford additional support for the muscle-fibres, which here constitute a circular sphincter muscle. Various appearances of the partition in section, showing its relation to the cœlomic and tentacular cavities, are indicated in figs. 4 and 13, and the sphincter muscle (*t.sph.*), more highly magnified, in Pl. 25. figs. 3 and 6. Where in fig. 13 the section includes the middle of the partition the two free edges are seen to be in the main directed downwards into the polypal cavity, so that the membrane must be concave on its tentacular aspect and convex on its cœlomic side. In fig. 13, tentacles t_1 , t_2 , and t_{10} are partly constricted at their origin, and such a condition has been noted among the external characters (fig. 1 c). No doubt the constriction is brought about by the action of the sphincter. In fig. 3 the tentacular wall immediately below the partition is seen to have become much thinned.

The presence of a tentaculo-cœlomic septum and sphincter has already been recognized in the genus *Bolocera*, including also the genus *Boloceroides* of Carlgren (1899, p. 43; 1900, p. 15). Carlgren (1893) describes and figures the formation at the base of the tentacles in *Bolocera longicornis*, and the musculature is there not much better developed than in *Bunodeopsis*. In *Bolocera* the contraction of the sphincter often leads to the detachment of the tentacles from the disc. In one or two of the Jamaica specimens of *Bunodeopsis globulifera* circular apertures occur in the tentacular zone, indicating that tentacles have disappeared therefrom, but I have never actually observed the process taking place in the living polyp. In *B. antillensis*, however, the tentacles were found to be readily detached on handling the polyps, and in this species also a tentacular septum and sphincter occur. Carlgren has pointed out that the partition comes off along with the tentacles, and such would certainly be presumed from the great narrowing which takes place immediately below the membrane, as represented in fig. 3.

McMurrich (1893, p. 154, pl. xxii. fig. 27) also describes and figures the tentacular sphincter in *Bolocera occidua*. In many of his specimens, mesenterial filaments were found protruding from the openings at the margin of the disc formed by the falling off of the tentacles. The same author includes the deciduous character of the tentacles

within the definition of the family Boloceridæ. Kwietniewski (1898, p. 394, pl. xxv. fig. 10) has also described and figured the sphincter in *Bolocera McMurrichi* (= *Boloceroides McMurrichi* (Kwietn.), Carlgren, 1899).

The occurrence of a perforated tentaculo-cœlomic septum and sphincter would appear to be somewhat restricted within the Actiniaria. So far, it is known only in the genera *Boloceroides*, *Bolocera*, and *Bunodeopsis*. Its presence would seem to be associated with deciduous tentacles, for the phenomenon is characteristic of all the forms above mentioned.

According to Carlgren (1899), the genera *Polystomidium* and *Polyopsis*, described by R. Hertwig in the report on the 'Challenger' Actiniaria as destitute of tentacles, are really *Boloceræ* from which these organs have become detached. Haddon (1898) had independently come to the same conclusion. Carlgren suggests that the detachment of the tentacles may be a means of protection to the polyp.

McMurrich (1893) had already surmised, and later was able to confirm his suspicions by an actual examination of the specimens at the British Museum, that the 'Challenger' Actinian, *Liponema multiformum*, is also a *Bolocera*, from which the tentacles have been detached.

Disc.

The oral disc (*disc*, Pl. 25. figs. 4 & 6) is thin-walled peripherally, and continues thus until the lips are reached, when it becomes swollen before terminating at the stomodæum (*st.*). The discal ectoderm contains many clear gland-cells, and the radial muscle- and nerve-layers are comparatively well developed. At the lips the ectodermal cells are much longer, and thin-walled nematocysts occur, similar to those in the tentacular ectoderm, but stinging-cells appear to be absent from the remainder of the disc.

The discal mesogloea (fig. 6) is very narrow, and may be delicately plaited on both its outer and inner surfaces. At the lips it becomes much thickened and more strongly plaited, affording an increased area for the support of the circular endodermal muscle. This latter becomes so strongly developed as to constitute what must be regarded as a special endodermal circumoral sphincter (*or. sph.*, figs. 4 & 6). The action of the sphincter muscle must have become relaxed during the narcotization of the polyps, permitting the radial musculature to act, for in all the preserved specimens the oral aperture is large and rounded.

A sphincter muscle in this position is very exceptional among the Actiniæ, but a like concentration of muscle-fibres has been described by the brothers Dixon for *B. verrucosa* (1889, p. 322). It may be considered doubtful as to how far a special muscular development would be represented when the oral aperture returns to its living, slit-like condition.

Other than in its concentration of muscle-fibres the discal endoderm presents no special features. Comparatively few Zooxanthellæ are present.

Stomodæum.

The stomodæum is widely open in sections and usually somewhat irregular in outline (figs. 9-15). Its walls are very delicate, measuring only .045 mm. across. It is

comparatively long, extending into the gastro-cœlomic cavity for nearly one-half the height of the polyp, its inner free margin being reflected (Pl. 25. fig. 4). The ectoderm is often thrown into vertical folds, which are without any regular disposition, not necessarily corresponding with the mesenteries. The layer exhibits the same structure all the way round, being in no way modified to form special gonidial grooves opposite the directives. Prof. Verrill, in his description of the external characters of the Bermudas specimens, mentions the occurrence of gonidial grooves, but such are certainly not indicated in the histology of the stomodæum of the Jamaica representatives, and were not recognizable in the living polyps. In other species of Actiniæ where gonidial grooves occur, the ectoderm lining them usually offers a marked contrast with that along the lateral walls; the cilia are more strongly developed, and fewer gland-cells and nematocysts occur than elsewhere.

The stomodæal ectoderm (*ect.*, Pl. 25. fig. 7) is strongly and uniformly ciliated all round, and contains nematocysts (*nem.*) and granular gland-cells. The former are sparse towards the upper extremity, but as the lower free end is approached they become very numerous, and are all of the thick-walled variety, such as occur in the columnar evaginations, but slightly smaller, measuring .025 mm. in length. In the inner part of the layer they are irregularly arranged at all angles with the free edge, but towards the surface they become parallel with the other constituents. The ectodermal muscle (*ect.m.*) and ganglion-layer (*nr.l.*) are only feebly developed.

The mesogloea is extremely delicate throughout, and remains smooth on both sides. The endoderm closely resembles that lining the cœlomic cavity generally, and contains a few Zooxanthellæ in some places, while in others they are absent, in which latter case the epithelium is very narrow. The circular endodermal musculature is recognizable in vertical sections.

Intermesenterially the stomodæum narrows gradually towards its free lower extremity and becomes reflected, as on the left side of fig. 4; mesenterially the ectoderm appears continuous with the filament at the free edge of the perfect mesenteries. The stomodæal wall on the right side of fig. 4 terminates in a section of a mesenterial filament.

Mesenteries.

The mesenteries are very variable in number in the many polyps examined, and also in their cyclic relationships; for a long time it seemed impossible to establish any hexameral or other regular system of arrangement. The conditions encountered will be best understood by reference to Pl. 26. figs. 9 to 15, representing outline sections through the stomodæal region of six different polyps.

In fig. 9 only three pairs of complete mesenteries occur, and two pairs which are incomplete. The lower complete pair (*d.*) are directive mesenteries, having the longitudinal muscle on the faces looking away from one another. The polyp from which fig. 10 was taken possessed three pairs of complete mesenteries, including a pair of directives and a single member of another complete pair. Within the wide interval on the right side are nine, short, incomplete mesenteries, which present some

indication of alternating large and small pairs. In this and the other figures the pairs are numbered according to the order to which they belong, so far as this can be determined with certainty. In the polyp whose mesenterial plan is represented by Pl. 26. fig. 11 a regularity of alternating complete and incomplete pairs is presented on the left side, but the right side is a region of irregularities. A mesentery also stretches across from one part of the column-wall to the other, and encloses a rudimentary mesenterial pair. In fig. 12 the left side possesses perfect dicyclic hexamerous symmetry, while the development at the upper right-hand region is very irregular. As before, many incomplete mesenteries occur at the upper right-hand corner.

Fig. 14 is the completed mesenterial plan of the polyp of which fig. 13 represents a little more than half. As before, the first and second cycles on the left side are regularly developed, and in addition three rudimentary pairs of the third cycle occur, a pair in each of the primary systems. The new pair in the dorso-lateral chamber is situated on the ventral aspect of the second cycle pair, but on the dorsal aspect in the middle and ventro-lateral chambers. On the right side the ventro-lateral system corresponds with that on the left, but the middle and dorsal systems are irregular.

Fig. 15 completes the series so far as I have been able to establish it. On the left side of the directive axis all the pairs of the first, second, and third orders of a hexamerous polyp are represented. The second-order mesenteries (II.), with the exception of the dorso-lateral pair, have reached the stomodæum. One mesentery only is missing on the right side from the number necessary to complete the hexamerous plan, but at the dorso-lateral region they are all incomplete and irregularly paired.

From the conditions thus presented there can be no doubt that normally the mesenteries should be arranged in alternating hexamerous cycles, with two pairs of directives, and that members of the second order should also reach the stomodæum. The increase in the number of the mesenteries, however, does not proceed throughout the polyp according to the usual order established for the Hexactiniæ. According to this, the six primary pairs of mesenteries appear successively in a bilateral manner; then the members of the second cycle arise successively in unilateral pairs within the six primary exocœles, as a rule on each side of the polyp from the dorsal to the ventral aspect; the third cycle pairs appear as single unilateral pairs within one of the two exocœles in each of the six primary systems, and then later in the remaining exocœle in each primary system. In fig. 14 the sequence of the third cycle pairs seems to follow the rule that a pair is developed in each of the primary systems before a second pair arises to complete the radial symmetry.

All the figures of *Bunodeopsis* indicate that on one side of the polyp the increase takes place in a fairly normal and regular manner, but that such is not the case for the other side. In all the polyps a definite region of irregular growth occurs, both as to the number of mesenteries which are present and also as to their paired relationships. Evidently the hexamerous cyclic regularity becomes more pronounced as the polyps grow larger and the number of mesenteries increases, but I have met with no specimen in which perfect regularity was attained. Probably some of the polyps obtained are as

yet immature, but no larger were to be met with, and, judging from the number of tentacles and the dimensions, Verrill's Bermudas examples were in much the same condition as the Jamaican.

Undoubtedly the imperfect development of the tentacles within a restricted area, noticed among the external characters, is determined by the imperfect growth of the mesenteries. The two are associated phenomena; the rate of tentacular growth is regulated by that of the mesenteries, and where the latter are irregular the tentacles will be the same.

This regional irregularity of growth of the polyp would appear to be connected in some way with an asexual method of reproduction. In the more common *B. antillensis* I have found that new polyps are produced by the process which Andres (1881) has described as "Scissiparity." Fragments of varying size become gradually detached from around the base of the column, attain an independent existence, and develop into new polyps with tentacles and oral disc. Andres has followed the process of development of the new individuals as it occurs in *Aiptasia lacerata*, and in this species the normal hexamerous disposition of the organs appears to be early assumed. I have not observed scissiparity in *B. globulifera*, but the other Jamaican species presents exactly the same tentacular and mesenterial irregularities.

Irregularities would be much more likely to occur in polyps thus originating than in individuals developed directly from the larva. The two species of *Bunodeopsis* occur in large numbers within restricted localities, and such a distribution is most probably the result of a like method of reproduction in each. The West Indian *Aiptasia tagetes* (Duch. & Mich.) also reproduces in a most prolific manner by scissiparity, and an examination of its mesenteries and tentacles reveals many departures from the hexamerous regularity. McMurrich (1889), on the other hand, describes the Bahamas representatives of this species as hexamerous, without mentioning any asexual reproduction. G. H. Parker (1899), who has made a detailed study of the effects of longitudinal fission in *Metridium marginatum*, finds the mesenteries are very irregularly arranged in what may be assumed to be fission polyps.

Returning to the individual mesenteries, the members of the first order are found to extend the whole length of the stomodæum, and some are continued as far as the base of the polyp, across which they extend to the middle (Pl. 25. fig. 4). The complete members of the second order may become free before reaching the stomodæal termination. At first the free edge of the mesenteries is straight, but soon it becomes greatly folded and contorted, some mesenteries becoming much more complex than others, so that they may appear several times in the same section (fig. 4). The incomplete mesenteries first appear in the uppermost part of the column-wall, but all except the youngest are better developed in the middle part of the polyp. Very often the mesenterial mesogloea and that of the column-wall are seen to be interrupted, the continuity of the circular endodermal muscle of the column-wall being thereby preserved (Pl. 26. fig. 17).

Within the stomodæal region of most polyps the mesenteries are extremely narrow, and, except at their origin in the column-wall, the musculature is so weak as to

be discerned with difficulty. Near its insertion in the column-wall the mesentery is usually a little broader, and the retractor muscle is represented as a smooth layer of fibrils. In other polyps the mesenteries are thicker, and muscle plaits are very distinct in the middle of their transverse length. Below the stomodæal region all the mesenteries become much broader, both the endoderm and mesogloea increasing in thickness, and the latter forms numerous plaitings for the support of the retractor muscles (*ret.m.*, Pl. 26. figs. 16 & 17). The retractor muscle in fact assumes somewhat of a circumscribed character, but the outline in transverse section is scarcely alike in any two mesenteries. For a short distance from the column-wall the muscle-band is smooth; the plaitings beyond are at first minute, then gradually become larger and more complicated, and terminate very abruptly, the mesentery afterwards being very narrow and continued for some distance (fig. 16). At the central termination of the complicated part of the muscle one or more of the mesogloéal plaitings may become greatly elongated and minutely plaited, almost as if the mesentery were about to branch (fig. 17, *ret.m.*).

The transverse musculature is comparatively strongly developed. In tangential sections near the base the mesogloea of the mesentery is irregularly folded for its support (fig. 2, *trans.m.*). When a complete mesentery is mounted as a microscopic object, the vertical and transverse muscle-fibrils are seen crossing one another at right angles.

The mesenterial endoderm is usually very narrow, and includes clear gland-cells and but few Zooxanthellæ. Traces of the nerve-layer, continuous with that on the column-wall, can usually be followed (*nr.l.*, fig. 16) for some distance beyond the insertion of the mesentery in the column-wall. In the lower region the mesenterial epithelium becomes swollen just behind the mesenterial filaments (*cf.* figs. 16 & 17), and in some polyps this region contains many clear spheroidal bodies, which stain very deeply and stand out as distinct objects from the rest of the tissue; a few small particles are black and irregularly shaped. Probably these foreign bodies are ingested nutrient particles, and they are practically absent from some individuals. Where present in quantity they may occur also in the endodermal epithelium of the lower part of the stomodæum, and sparsely in the endoderm of the column-wall, and even in the tentacular endodermal epithelium. The particles are easily distinguished by their homogeneous, deeply staining character from the Zooxanthellæ, which they greatly resemble in size and outline.

The swollen mesenterial endoderm immediately behind the mesenterial filament is generally regarded as a special region for intracellular digestion (McMurrich, 1899, p. 262), and in *Bunodeopsis* the greatest number of foreign particles occurs there; but their presence in other regions of the endoderm would imply that ingestion is by no means restricted to the region. The endodermal enlargements in the present species are often somewhat irregular in outline (fig. 17), not smoothly rounded as in most other forms.

At the origin of the mesenteries in the column-wall a delicate layer of muscle-fibrils, arranged nearly vertically, occurs on the face bearing the transverse musculature. This is the only trace of a parieto-basilar muscle; in no instance does the mesogloea become plaited or afford any indication of the formation of a pennon, such as is characteristic of Actinian species with a well-developed muscle.

A vertical section through a portion of the base, including a tangential section of a mesentery, is represented in Pl. 25. fig. 2. On the mesentery the mesogloal folds which support the transverse muscle (*trans.m.*) are strongly developed, and the muscle-fibres are seen in section. At the basal termination of the mesentery, however, no foldings are indicated; the muscle-layer is here perfectly smooth. Such an appearance can scarcely be regarded as in any way indicating an incipient basilar muscle, for no corresponding development takes place on the opposite face which bears the retractor muscle. In such sections, the muscle-fibres of the latter are seen lengthways. Where present in other species the basilar muscle is, as a rule, arranged on more or less strongly developed mesogloal plaitings on each side of the insertion of the mesentery on the base, the muscle-fibres extending in a radial direction. The present species is therefore characterized by possessing a parieto-basilar muscle of the weakest character, while the basilar muscle is altogether undeveloped.

The polyps are too small to permit of the presence or absence of mesenterial stomata being determined by means of dissection. But in serial transverse sections interruptions occur in all the perfect mesenteries close to the stomodæum and at its upper extremity. These represent the inner or perioral stomata, but no corresponding series has been found near the column-wall, such as may represent the outer parietal stomata.

Mesenterial Filaments.

Mesenterial filaments occur at the free edge of all the mesenteries except the most rudimentary. They appear on the complete mesenteries as these sever their connection with the stomodæum, while usually they are not developed on the incomplete mesenteries until below the stomodæal region. The filaments follow the contortions of the free edge of the mesenteries, so that in the lower part of the polypal cavity the filament belonging to one of the mesenteries may be seen cut through several times in the same section (fig. 4).

The filaments on the complete mesenteries are at first trilobed and exceptionally wide, and both the glandular streak and ciliated bands are clearly represented (fig. 18). The ciliated bands are far apart, and the tissue intermediate between them and the glandular streak is irregularly thickened, so that the outline assumed by the filaments is somewhat exceptional among the Actiniæ, and varies greatly in different sections. A little within the base of the filament the mesenterial mesogloa divides into three very narrow branches, each of which passes into a lobe, and there terminates in a clear expansion, practically devoid of any cell-enclosures.

The middle portion of the trefoil is low, and the glandular streak at its apex (*g.s.*, fig. 18) is at first quite rudimentary in the degree of its development, merely capping the middle of the filament as a more densely staining tissue. In addition to the supporting cells, the glandular streak contains a few granular gland-cells and thick-walled nematocysts.

On each side of the glandular streak, and sharply separated from it, occurs an accumulation of undifferentiated endodermal-like cells, rarely regular in its outline, recalling in

this respect the irregular endodermal thickenings on the mesenteries immediately behind the simple filaments. The cells are much vacuolated, and here and there Zooxanthellæ may occur. To this tissue (*i.s.*, fig. 18), which is partly developed on both the middle and lateral lobes of the filament, and separates the glandular streak from the ciliated bands, I have already (1900, p. 146) given the name of *intermediate streak*. It is recognizable in most trilobed Actinian filaments, and McMurrich (1899, p. 259), in describing the filaments of *Zoanthus sociatus*, has also independently applied the designation *intermediate epithelium* to what appears to be the corresponding tissue in the Zoanthean filament. In the present species it often appears as if folding over or partly covering the first portion of the ciliated bands, and is more truly endodermal in character than in most Actiniæ. In some longitudinal sections through the filaments it presents a distinctly banded appearance, with the deeply staining tissue of the ciliated bands at the bottom of the depressions, as is so well displayed in McMurrich's figures of *Z. sociatus* (1899, p. 259).

The ciliated bands are strongly developed and nearly encircle the lateral mesogloæal lobes. They are constituted altogether of ciliated supporting cells. On the front face of the lateral mesogloæal axes they are continued in many transverse sections as a very narrow band towards the middle of the filament, diminishing all the way, and overlaid by the intermediate epithelium, as represented in fig. 18. In other sections the prolongations are not recognizable. Posteriorly the ciliated bands pass into what I have termed the *reticular streak*, which here closely resembles the mesenterial epithelium and is continuous with it.

In the glandular, intermediate, and ciliated areas the trilobed mesenterial filament thus presents three wholly distinct varieties of cellular tissue. That constituting the glandular streak bears the closest resemblance to the stomodæal ectoderm; the intermediate tissue is in no way distinguishable from the endodermal epithelium; while that of the ciliated bands, consisting wholly of long narrow supporting cells, is very specialized and different from any other of the polypal tissues.

Prof. McMurrich in his study of the mesenterial filament of *Z. sociatus* has devoted special attention to the relationship of the ciliated bands and the intermediate region. With its long, well-developed filaments, the species is specially fitted for such an investigation. Discussing the endodermal origin or otherwise of the intermediate epithelium, McMurrich affirms that it is certainly continuous with the stomodæal ectoderm above, and not with the endoderm, and from all the evidence before him is inclined to regard it as being ectodermal like the rest of the ciliated band epithelium. So far as histological evidence can be depended upon, an endodermal origin would be assigned it in the present species; in character it is wholly distinct from the ciliated and glandular streaks and stomodæal ectoderm.

The trilobed condition of the mesenterial filaments in *Bunodeopsis* is continued only for a short distance down the mesenteries, when it becomes replaced by the simple filament; but the species is not suitable for tracing the actual passage from the one to the other. McMurrich (p. 264) states "that in *Z. sociatus* there is neither a histological continuity

nor a histological identity of the upper part of the median streak of the filament with the lower or glandular streak proper." Embryological considerations also point to the conclusion that a different origin must be assigned the apical median part of the mesenterial filament in the uppermost region as compared with the whole filament below. From the researches of McMurrich, H. V. Wilson (1888), Appellöf (1900), and myself (1899), there is good reason to suppose that the former is a downgrowth of the stomodæal ectoderm, according to my interpretation, to meet the upgrowing endodermal filament.

In *Bunodeopsis* the ciliated bands quickly disappear along with the two lateral mesogloæal lobes which supported them, and the simple filament remaining is altogether different from the middle lobe of the more complex filament, although it corresponds with it in position, representing as it does the termination of the free edge of the mesentery. The unmodified endodermal tissue, which constituted the intermediate streak of the complex filament, and covered the middle lobe laterally, is likewise no longer represented in the simple lobe (Pl. 26. fig. 16).

The cellular constituents along the front and sides of the simple filament, however, most closely recall those of the glandular streak of the compound filament, consisting mainly of ciliated supporting cells and coarsely granular gland-cells, with the addition of a few thick-walled nematocysts. The posterior part of the filament on both sides is constituted of much shorter cells, which seem to be all ciliated supporting cells, no nematocysts nor gland-cells being recognizable. Histologically, and probably physiologically, the hinder region of the simple filament most nearly approaches the ciliated bands, though no morphological identity seems possible.

At first the mesenterial mesogloæa as it enters the posterior part of the filament remains swollen as in the trilobed filament, but in the lower part of the filament it becomes flattened and rapidly thins out at each side. The anterior surface of the mesogloæa is provided with a layer of extremely delicate muscular fibrils.

In the lower region of the polyp the filaments and free edge of the mesenteries are greatly folded and contorted, but they by no means crowd the gastro-cœlomic cavity (Pl. 25. fig. 4).

No gonads were developed within any of the polyps examined.

In its essential features, *B. globulifera* closely resembles *B. strumosa* and *B. antilliensis*, which were incompletely described in the paper (1897) "The Actinarian Family Aliciidae." An important external specific distinction is that the columnar evaginations in the first are smooth and thick-walled throughout, while in the two older species they are thin-walled in places, and the large nematocysts occur in restricted thickened bands or tubercles. In sections this difference is indicated by the practical uniformity in thickness of the ectodermal evaginations of *globulifera* (fig. 5), and their alternating narrow and broad outline in *strumosa* and *antilliensis*, according as nematocysts are absent or present.

The three agree in such important characteristics as the presence of an ectodermal columnar and stomodæal muscle- and ganglion-layer, the absence of gonidial grooves, the absence of a basilar muscle and of a well-developed parieto-basilar and endodermal sphincter muscle, and the presence of ciliated bands on the mesenterial filaments.

In accordance with these later results, the definition of the genus *Bunodeopsis* may be emended as follows:—

Genus BUNODEOPSIS, Andres.

Actiniaria with ciliated flattened base, feebly adherent. Column-wall beset proximally with simple or complex, sessile or pedunculated evaginations, bearing large thick-walled nematocysts; distal part of column smooth and delicate. Column with ectodermal and endodermal muscle- and ganglion-layers; sphincter muscle very feeble or absent. Tentacles elongated, deciduous, separated from the polypal cavity by a circular perforated septum provided with a sphincter muscle. Disc with thickened lips and circumoral sphincter muscle. Stomodæum with ectodermal muscle and ganglion-layers, without gonidial grooves.

Mesenteries normally hexamerous, two pairs of directives, more than six complete pairs, often irregularly developed. Parieto-basilar muscle very feeble. Basilar muscle absent. Mesenterial filaments with ciliated bands. Without acontia and cinclides.

From the foregoing account it is clear that, while in many respects *B. globulifera* possesses primitive Actinian characteristics, yet in others it is highly differentiated. If the conclusions of Carlgren (1900) as to the nature of the primitive Actiniæ be correct, among the former must be reckoned the occurrence of an ectodermal columnar and stomodæal muscle- and nerve-layer, the absence of gonidial grooves from the stomodæum, the absence of a basilar muscle, and the weakness of the internal musculature generally. Among the latter will be included the division of the column into two distinct regions, of which the upper is naked, and the lower bears hollow evaginations with the ectoderm broadened and charged with thick-walled nematocysts; the occurrence of a tentaculo-cœlomic septum provided with a sphincter muscle; the circumoral ectodermal thickening (lips) charged with thin-walled nematocysts; the circumoral endodermal sphincter muscle; and the regional differentiation of growth of the tentacles and mesenteries.

The first-mentioned characters are those upon which Carlgren has founded the Tribe Protanthæ, which includes the lowest Actiniæ, as contrasted with the Tribe Nynanthæ, under which are placed all the more differentiated Actiniæ. Carlgren regards as the most important characteristic of the Protanthæ the presence of the ectodermal longitudinal muscle- and nerve-layer in the column-wall, and gives second place to the absence of the basilar muscle. Wherever the first-mentioned structures occur, Carlgren would separate their possessors from the forms with which they have been associated, and place them under the Protanthæ, whatever the other characteristics of the species might be.

In a forthcoming report on the Porto Rican Actinians, to be published by the U.S. Fish Commission, I have discussed these proposals somewhat, so that it is

unnecessary to here enter into the subject in detail, except as concerns its bearing on the present species. Suffice it to say that, while disposed to recognize the primary character of the ectodermal columnar musculature in Actiniæ, writers such as McMurrich, Haddon, and van Beneden are not prepared to accord it the taxonomic importance which Carlgren claims for it. Rather they would regard any species in which such a structure is retained as among the lowest members of its own particular group. And this is the view which seems most likely to result in a natural grouping of the Actiniaria, one which will recognize both the primitive and the differentiated characteristics of a species.

Undoubtedly characteristics such as the presence of the ectodermal columnar musculature, the absence of a basilar muscle, and of ciliated bands from the mesenterial filaments, are in themselves of vastly greater phylogenetic value than such features as columnar modifications, the origin of one or more tentacles from a mesenterial chamber, the nature of the sphincter muscle, the number and characteristics of the mesenteries, &c. But these latter are the differentiations which alone are available for classificatory purposes within the Nynanthæ, and to wholly separate the lowest forms possessing them would seem to take away the possibility of a phylogenetic grouping. The possessors of the ectodermal columnar musculature do not appear to represent a homogeneous assemblage.

Bunodeopsis is a good example of a genus in which, while certain primitive characteristics are retained, important structural modifications have taken place in other respects. To arrange it with others, on account of the former alone, would be to neglect those differentiations upon which the classification of the Actiniæ is mainly founded.

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EXPLANATION OF PLATES 25 & 26.

Reference letters.

I., II., III., = orders of mesenteries. *c.s.* = ciliated band. *col.w.* = column-wall. *d.* = directive mesenteries. *disc* = disc. *ect.* = ectoderm. *ect.m.* = ectodermal muscle. *end.* = endoderm. *end.m.* = endodermal muscle. *ev.* = columnar evagination. *g.s.* = glandular streak. *i.s.* = intermediate streak. *mes.* = mesogloea. *mest.* = mesentery. *m.fil.* = mesenterial filament. *nem.* = nematocyst. *nr.l.* = nerve-layer. *or.sph.* = oral sphincter. *ret.m.* = retractor muscle. *st.* = stomodæum. *t.c.s.* = tentaculo-cœlomic septum. *t., tent.* = tentacle. *t.sph.* = tentacular sphincter. *trans.m.* = transverse muscle. *zoox.* = Zooxanthellæ.

Fig. 1, *a, b, c*. Three different polyps, somewhat enlarged: *a* and *b* in the living expanded condition; *c*, a preserved polyp.

2. Vertical section through a portion of the basal disc, including a tangential section of a mesentery. No basilar muscle occurs at the insertion of the mesentery on the basal wall. × 400.
3. Vertical section through the upper region of a polyp, including a part of one side of a tentacle, the upper part of the column-wall, and one side of the tentaculo-cœlomic partition with the tentacular sphincter at its free extremity. The polypal wall in all its three layers is here more swollen than usual. × 400.
4. Median vertical section through an entire polyp, but including only the basal part of two tentacles. The stomodæum is slightly protruding, and several mesenteries are cut obliquely. × 70.
5. Vertical section through a columnar evagination. × 400.

- Fig. 6. Vertical section through the basal part of a tentacle with the tentaculo-cœlomic septum attached, the disc, and upper portion of the stomodæal wall. $\times 300$.
7. Transverse section through a portion of the stomodæal wall. $\times 400$.
8. Nematocysts: *a*, thin-walled form from the tentacular ectoderm; *b*, thick-walled form from the columnar evaginations; *c*, from the stomodæum; *d*, from the mesenterial filaments. $\times 1200$.
9. Transverse section of a polyp with only three pairs of complete mesenteries. $\times 70$.
10. Transverse section of a polyp with three pairs of complete mesenteries, one moiety of another pair, and at one region numerous incomplete pairs. $\times 70$.
11. Transverse section of a polyp with four pairs of complete mesenteries, a moiety of two other pairs, and a region with many incomplete pairs. A section of a tentacle which has intruded within the polypal cavity is represented at the upper right-hand corner. $\times 70$.
12. Transverse section of a polyp in which for the most part hexameral regularity prevails, but at one region growth is proceeding irregularly. $\times 70$.
13. Transverse section through part of the stomodæal region of a polyp, including the tentacular zone. The relations of the tentacles to the mesenterial chambers and the tentaculo-cœlomic septa are clearly shown. $\times 70$.
14. Transverse section of the same polyp at a slightly lower level. Mesenterial pairs belonging to the first, second, and third orders occur regularly throughout the greater part of the polyp, but the sequence is irregular at the upper right-hand side. $\times 70$.
15. Transverse section of a large polyp in which three orders of mesenteries are regularly developed, except on the right upper side. Most of the pairs of the second order have become inserted on the stomodæum. $\times 70$.
16. Transverse section of a portion of the column-wall a little below the stomodæal region, with a mesentery attached, bearing a simple mesenterial filament. $\times 400$.
17. Transverse section of a mesentery and the portion of the column-wall to which it is attached. $\times 300$.
18. Transverse section through a trilobed mesenterial filament. $\times 400$.