

ART. I.—*On the Anatomy of an Arenaceous Polyzoon.*

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During the last Easter vacation I was enabled, through the kindness and hospitality of Mr. J. Bracebridge Wilson, to accompany him on several occasions while engaged in dredging operations at various localities near Port Phillip Heads. On one of these occasions we obtained a considerable quantity of a very remarkable arenaceous organism attached to the base of a mass of Ascidians. On my return to the University I examined my spirit-preserved specimens of this organism with some care, but without being able to elucidate its true nature. As it promised to prove of unusual interest I wrote to Mr. Wilson, asking him if he could send me some more specimens in a living condition. In consequence of my request Mr. Wilson devoted a considerable amount of time and trouble to again searching for the organism in question, and succeeded in a few days' time in sending me living specimens, not only of the species which I had previously obtained, but also of another quite distinct species of the same genus. These specimens reached me in excellent condition, and a glance at the living animal at once proved it to be a Polyzoon of very novel and peculiar form.

The genus, which is new to science, would appear to be not uncommon in Port Phillip, for Mr. Wilson informs me that he has been familiar with it for many years, and has often dredged it by the handful. He has also kindly suggested that, considering the difficulty experienced in determining its true character, the generic name *Cryptozoon* would not be inappropriate, a suggestion of which I am very happy to be able to avail myself.

I propose to call the species with which I first became acquainted *Cryptozoon wilsoni*, in honour of the well-known discoverer of this and many other new and remarkable

marine forms. The second species may be called *Cryptozoon concretum*, from the manner in which the sandy "nodes" have grown close together, with corresponding shortening of the chitinous internodes.

The new genus may be briefly diagnosed as follows:— "Ctenostomatous Polyzoa, with tubular, chitinous zoecia enveloped in common aggregations of sand. Polypides provided with a muscular gizzard containing two horny teeth."

Before proceeding to describe the distinctive characters of the two species I will give a general account of the anatomy of the genus, so far as I have been able to work it out in such an unfavourable subject for investigation.

The chief difficulties in the way of a study of the soft tissues in *Cryptozoon*, consist (1) in the very minute size of the individual polypides; and (2) in the difficulty experienced in separating them from the mass of sand grains in which they are enveloped, and to which the zoecia firmly adhere.

In the living animal I was able only to study the anatomy of so much as is protruded beyond the margin of the sandy mass when the animal is in a state of expansion (Fig. 1), that is to say, only the tentacles and a very small portion of the body, including the mouth and anus, together with the soft retractile portion of the zoecium. Moreover, owing to the impossibility of separating the polypide in a living condition from the sandy mass, I could only examine it with a low power of the microscope.

Somewhat curious and more or less satisfactory results were obtained by teasing up with needles the masses of sand containing living polypides on a slide in a drop of sea water, then staining with carmine or magenta, and replacing the sea water by glycerine. After this process, there remains on the slide a quantity of more or less isolated sand grains, with here and there scattered about amongst them a polypide which has been forcibly torn from its zoecium.

The most interesting point about this method is that the polypides are killed in an expanded condition, *i.e.*, with the lophophore expanded and the tentacles spread out at length, and separate from one another, instead of being all curved in and massed together in a compact bunch, as is the case in spirit-preserved specimens. Sometimes the lophophore, with the tentacles, is torn off from the remainder

of the polypide and can be examined from the surface, when it presents the appearance shown in Fig. 6.

The greater part of my observations were, however, made upon spirit-preserved material. Small portions of the zoarium, comprising several of the sandy masses, were stained *in toto* in borax carmine, according to the usual method. After dehydrating and clearing, the material was transferred to a slide and teased up with needles in a drop of balsam. The teased preparation was examined with a low power of the microscope, and it was possible with care to pick out the individual separated polypides on the point of a fine needle and mount them by themselves on fresh slides.

When a separate polypide was thus mounted it was possible, by carefully pushing the cover-glass with a needle, to roll it over into various positions, as might be required.

THE CŒNŒCIUM.

The Cœnœcium is dichotomously branched, and the branches come off in several planes (Figs. 2, 3, 4.) It consists primarily of a slender chitinous tube. At fairly regular intervals, usually at each angle of the branching system, this tube breaks up suddenly into a number of very delicate tubular zoecia, which are invested in a common sandy mass.

Thus the whole cœnœcium is divisible into what may be termed, for the sake of convenience, *nodes* and *internodes*. The nodes are dense aggregations of grains of sand, enveloping and firmly held together by the chitinous zoecia (Figs. 1, 2, 3, 4, 5, N.) The internodes are longer or shorter, slender chitinous tubes, connecting the nodes together.

I have already mentioned that the cœnœcium, as a whole, is dichotomously branched. This results from the fact that whereas only a single tubular internode enters the lower surface of each arenaceous node, there are usually two such tubes originating from its upper surface. The branching, however, is not always a perfectly regular dichotomy; sometimes more than two internodes come out from the upper surface of a node. Thus in *Cryptozoon concretum* I have observed in one instance no less than six short tubes coming out from the surface of a terminal node, in addition to the internode on which it was supported. As the node

from which these six tubes originated was the terminal node of a branch, and probably had not as yet reached its full development, it is impossible to say how many of the six young tubes would have developed into perfect branches. Each one of them was short and had a rounded apex.

It is especially worthy of note that the tubular internodes are not continuous through the substance of the sandy nodes, but each one breaks up on entering the sandy mass into a kind of *rete mirabile*, formed chiefly of the delicate tubular zoecia.

In *Cryptozoon wilsoni*, the type of the genus, the chitinous internodes are comparatively long, and the sandy nodes are well separated from one another. In *C. concretum*, however, the internodes are very much shortened, and the sandy nodes are brought close together, and in the older parts may even be confluent, forming a continuous sandy mass (cf. Figs. 2, 3 and 4).

The zoecia are very delicate and adhere firmly to the sand grains, so that it is impossible to separate them. Perhaps in *Cryptozoon*, as in those horny sponges which take on an arenaceous habit, the chitinous portion of the skeleton is actually reduced in consequence of the addition of the sand, which may be considered as supplementing, and possibly, to a certain extent, replacing the chitin.

However this may be, it is very difficult to obtain an idea of the true shape and arrangement of the zoecia. I can only say that they are tubular, and appear to spring one from another in an irregular manner (Fig. 11). The mouth of the zoecium, as in all the Ctenostomata, remains soft and unchitinised, and, when the polypide is retracted, is pulled into the hinder part by a special series of muscular bands (Fig. 11, *m.*)

The points where the zoecia arise from one another are marked by oval scar-like areas—the rosette plates (Fig. 11, *r.p.*)

The structure of the internodes of the cœnœcium may best be studied in *Cryptozoon wilsoni*. In that species they are short, somewhat dumb-bell-shaped tubes (Fig. 5 *Inn.*), with swollen extremities, breaking up suddenly on reaching the sandy node at either end into small, irregular branches, or giving rise directly to the zoecia (Fig. 5). The wall of each internode appears in optical longitudinal section (Fig. 10), to be clothed internally with a deeply staining epithelium (*ep.*) I have not succeeded in demonstrating

with any degree of certainty the existence of nuclei in this layer, but there can be no doubt that it is composed of cells which secrete the chitinous wall of the tube. Very often this chitinous wall is roughened on its inner surface by minute, sharp prominences and ridges (Fig. 10, *p.*), which mark the points where secretion is most actively taking place. There can be no doubt that the epithelium lining the internodes is a direct continuation of the coelomic epithelium of the polypides, and it appears to be the only organic connection between the different polypides of the colony.

THE POLYPIDE.

The structure of the Polypide is essentially the same in both species. As much of it as can be made out in the living animal is represented in Fig. 1, while a more extensive view, such as is represented in Fig. 12, can only be obtained by teasing out the polypides in the manner already described.

The lophophore (Fig. 6) is of course circular. From its margin spring from 10 or 12 (in *C. wilsoni*) to 14 (in *C. concretum*) tentacles. Within the circle of tentacles are the mouth (*o*), placed somewhat excentrically, and the nerve-ganglion (*n.g.*), lying to one side of the mouth. The anus is outside the circle of tentacles, and is so placed that it lies in a line with the mouth and nerve-ganglion (Fig. 12).

The tentacles are hollow cylinders closed at their distal extremities. The wall of the cylinder, as already pointed out by Allman in the case of the fresh-water Polyzoa, is composed of two layers—an inner, apparently structureless layer (Fig. 7, *s. l.*), and an outer, epithelial layer. The epithelium does not present the same character all over the surface of the tentacle. Over the greater part of the surface it is composed of the ordinary, somewhat flattened, nucleated cells (Fig. 7, *ep.*), but on the in-turned face of each tentacle there are two parallel longitudinal rows of small columnar cells (Fig. 7, *c. c.*), each containing a relatively large, deeply-staining nucleus.

When the tentacles are examined in the living condition each one is seen to possess two rows of vibratile cilia, projecting on each side beyond its margin. Each cilium is nearly as long as the tentacle is thick, and they always move in a perfectly definite and regular manner, although detachments of them are capable of temporarily ceasing

their movement, while the remainder go on. If we imagine the inner face of the tentacle to be anterior and the outer posterior, the cilia are seen always to move upwards on the right hand side and downwards on the left.

Although I have not succeeded in observing the cilia in my mounted preparations, yet we may with safety conclude that they are definitely related to the two longitudinal rows of columnar cells just described, and that each of these cells bears a single cilium as represented in Fig. 7.

The alimentary canal is very complex, and we can distinguish no less than five perfectly distinct regions, viz., *pharynx*, *oesophagus*, *gizzard*, *stomach*, and *intestine*.

The mouth, as already observed, is excentrically placed within the circle of tentacles (Fig. 6, *o*.) It leads directly into a dilated pharynx lined by columnar cells (Fig. 12, *ph*.) The inner surface of the pharynx, *i.e.*, that turned towards the stomach, is more strongly curved than the outer surface, and the constriction at the lower end of the pharynx, which separates it from the oesophagus, is formed chiefly by a deep inward fold of the inner surface. A sharp re-entrant angle is thus formed, and over this angle the columnar epithelium is higher than elsewhere.

The oesophagus (Fig. 12, *œ*.) is a simple, thin-walled, saccular organ, interposed between the pharynx and the gizzard.

The gizzard (Fig. 12, *giz*.) is certainly the most remarkable portion of the whole alimentary canal. It is globular in shape and has thick muscular walls, consisting mainly of a stout circular band of muscles (Fig. 8, *c. m. b.*; Fig. 12, *c. m. b.*), oval in section and composed of a great number of delicate fibres, surrounding two relatively large chitinous teeth (*t*.) The teeth are squarish in shape, and flattened. They are planted within the muscular mass in such a manner that their broad surfaces lie parallel with the plane of the loop of the alimentary canal. This arrangement will be best understood by reference to Figs. 8 and 12.

The gizzard opens directly into the side of a very large, elongated, saccular stomach, of the shape shown in Figs. 9 and 12. The stomach is differentiated by the character of its lining membrane into two totally distinct regions—an upper, non-digestive, and a lower, digestive portion. The upper portion, next to the intestine, is lined, like the pharynx, by columnar epithelium, and the cells of this epithelium are ciliated (Fig. 9, *c. e., cil*.) At about the upper level of the

opening of the gizzard the walls of the stomach thicken, and the single layer of columnar cells gives place to several layers of spherical cells (Fig. 9, *s. c.*), containing yellow granules. As was the case in the pharynx the walls of the digestive part of the stomach are thicker in certain places than elsewhere, as shown in the figures.

In *Cryptozoon concretum* (Fig. 9) the difference between the digestive and non-digestive portions of the stomach is more strongly marked than in *C. wilsoni*, and it is in the former species alone that I have succeeded in detecting the cilia at the upper end, although there is no reason to doubt that they occur also in the latter. It should be noted, that these cilia are also figured by Allman in certain fresh-water forms.

A rather narrow aperture (Fig. 9, *o. i.*) places the upper end of the stomach in direct communication with a saccular, very thin-walled intestine (Fig. 12, *int.*), terminating at the anal opening (*a.*), the position of which, outside the circle of tentacles, has already been indicated.

The entire alimentary canal, which in all Polyzoa has the form of a loop, is clothed externally by a delicate, closely-fitting, flattened epithelium—the cœlomic epithelium (Fig. 9, *ep.*; Fig. 12, *n. e.*), the nuclei of which are plainly discernible over the greater part of its surface. On the intestine, these nuclei are in places elongated in the transverse direction, and this takes place especially in the region just opposite to the nerve ganglion, giving rise to a deceptive appearance of columnar epithelium in this locality.

To the lower portion of the stomach is attached the funiculus or posterior mesentery (Figs. 11 and 12, *fun.*) in a perfectly normal manner.

The muscular system is well developed. There are:—(1) A circle of short retractor muscles (Fig. 11, *m.*) attached above to the introversible portion of the zoecium. Of these muscles, each of which is composed of a band of simple fibres, I have counted four, and they appear to be all attached at the same level. It is possible that a fifth occurs, but has escaped notice owing to its being hidden behind the others; (2) A broad band of long fibres (Fig. 11, *r. m.*; Fig. 12, *m.*) attached above in a semi-circle just beneath the bases of the tentacles, around the margin of the lophophore remote from the anus. These fibres converge below to a point (Fig. 11, *a. m.*) deep down on the near side of the wall of the zoecium. This band is the great retractor muscle of

the polypide, by means of which it can be withdrawn right inside the zoecium, as in Fig. 11. Each of the long muscle fibres (Fig. 12, *m. f.*) appears to consist of a single cell, and at a point about the middle of each there is an oval swelling; here the fibre stains more deeply than elsewhere, and this spot must doubtless be regarded as the position of the nucleus (Fig. 12, *n. m. f.*)

All that I have been able to observe concerning the nervous system of *Cryptozoon* is the presence of an oval ganglion, situated in the usual position between mouth and anus.

So far as I am aware, *Cryptozoon* is the only *Polyzoon* which makes use of sand in the formation of its skeleton, and it is interesting to find a *Polyzoon* acquiring a habit with which we are already familiar in other groups, such for example, as Foraminifera, Sponges, and Annelids. The genus is obviously closely allied to *Bowerbankia*, as is shown by the presence of the gizzard, and the aberrant structure of its cœncecium may perhaps be best understood by comparison with that genus. In *Bowerbankia pustulosa*, for example, the cœncecium is entirely chitinous. It branches dichotomously, and at each angle of the ramification there is a close-packed group of tubular zoecia. We have only to imagine these zoecia to become more irregularly and diffusely arranged and invested in a common sandy matrix, beyond the surface of which the tentacles are protruded, and we shall arrive at the condition of *Cryptozoon*. *Cryptozoon*, therefore, may be regarded as a *Bowerbankia*, which, for the sake of additional protection, has acquired the habit of agglomerating particles of sand on to the zoecia.

It might perhaps even be doubted whether there exist sufficient differences to separate *Cryptozoon* from *Bowerbankia*, but the fact that there are at least two totally distinct species which form arenaceous nodes seems to me to render desirable the erection of a new genus.

I will now briefly enumerate the distinctive characters of the two species.

CRYPTOZOON WILSONI.

The zoarium (Figs. 2, 3) forms dense, bushy masses attached to foreign objects. Sometimes it appears to be provided with a common basal agglomeration of sand

particles, but sometimes it springs direct from the substratum on which it grows.

It is, as a rule, dichotomously branched, and the branches come off in many planes. The ramification is very profuse, which gives to the whole colony a reticulate appearance, but I have not succeeded in detecting any actual anastomoses.

The fully grown sandy nodes are spherical, and usually about 1 mm. in diameter. They are perfectly distinct from one another, and the internodes are well developed, being a little shorter than the diameter of the nodes. The terminal, young nodes are much smaller than the older, fully grown ones.

The polypides have up to 12 tentacles, although sometimes it is possible to count only 10 or 11. In the living animal the fully expanded tentacles are about 0.2 mm. long.

In one slight varietal form (Fig. 3) the nodes are somewhat larger and nearer together than in the typical form. It is this slight variety which I was able to examine in the living condition, and from which the anatomical figures are drawn.

CRYPTOZOON CONCRETUM.

The zoarium (Fig. 4) forms dichotomously branched tree-like masses, provided with a common sandy base. The entire growth is very much coarser than in *C. wilsoni*, and the branching, which takes place in several planes, is less copious and intricate. Sometimes, but only rarely, the branches appear to form anastomoses.

The internodes are reduced almost to nothing, and the nodes usually touch one another, or are actually fused together. It is only in the upper, younger portions of the colony that separate spherical nodes can be distinguished. In the lower, basal portions, they fuse together into common, stem-like, sandy masses. The diameter of a stem, near the base of a colony and above the basal expansion, is about 2 mm.; while the nodes which are in process of fusion and still separate gradually decrease in diameter as they approach the ends of the branches. The polypides are larger than in *C. wilsoni*, their tentacles being 0.3 mm. long in the fully expanded, living animal. The number of the tentacles is 14. The differentiation of the stomach, into digestive and non-digestive regions, is somewhat more strongly marked than in *C. wilsoni*.

DESCRIPTION OF PLATES.

PLATE I.

- Fig. 1. A node of *Cryptozoon wilsoni*, with the polypides alive and their tentacles protruding from between the grains of sand. Owing to the manner in which the node is viewed the polypides are visible only around the margin, though, of course, occurring all over the surface. (*pop.*) Projecting portion of polypide. (*s.g.*) Sand grains. (*Inn.*) Chitinous, tubular internodes.
- Fig. 2. Portion of cœnœcium of *Cryptozoon wilsoni*, more typical form. x 10. (*N.*) Nodes. (*Inn.*) Internodes.
- Fig. 3. Portion of cœnœcium of *Cryptozoon wilsoni*, larger variety. x 4. (*N.*) Nodes. (*Inn.*) Internodes.
- Fig. 4. Cœnœcium of *Cryptozoon concretum*. x 4. (*B.e.*) Basal expansion. (*N.*) Nodes. (*Inn.*) Internodes, in this case almost entirely suppressed.

PLATE II.

- Fig. 5. A tubular internode of *Cryptozoon wilsoni*, separated by teasing, with a number of sand grains, held together by the chitinous branches and the zoecia, still adherent at either end. (*Inn.*) Internodes. (*s.g.*) Sand grains. (*ch.*) Remains of chitinous branches and zoecia, cementing the sand grains together.
- Fig. 6. Lophophore of *Cryptozoon concretum* seen from above; from a specimen teased up alive. (*o.*) Mouth. (*n.g.*) Nerve ganglion. (*ten.*) Tentacles (bases only represented).
- Fig. 7. Diagrammatic longitudinal section of a portion of a tentacle of *Cryptozoon*, passing through one of the longitudinal rows of columnar ciliated cells. (*can.*) Central canal. (*s.l.*) Inner structureless lamella. (*ep.*) Ordinary epithelium. (*c.c.*) Columnar cells. (*ci.*) Cilia.
- Fig. 8. Diagrammatic section through the gizzard of *Cryptozoon*, showing the chitinous teeth implanted in the muscular mass. The section is supposed to pass through the two openings of the gizzard, and at right angles to the plane of the paper in Figs. 11 and 12. (*c.m.b.*) Sections of circular muscle band. (*t.*) Sections of chitinous teeth.
- Fig. 9. Optical longitudinal section through the stomach of *Cryptozoon concretum*, passing through its two

openings, and showing the differentiation into non-digestive region above and digestive region below. (*o. g.*) Opening from gizzard. (*o. i.*) Opening into intestine. (*ep.*) The cœlomic epithelium, which invests the entire alimentary canal. (*c. e.*) Columnar epithelium of the upper, non-digestive portion of the stomach. (*cil.*) Cilia of the columnar, nucleated cells. (*s. c.*) Spherical cells containing yellow granules, forming the wall of the lower, digestive portion of the stomach.

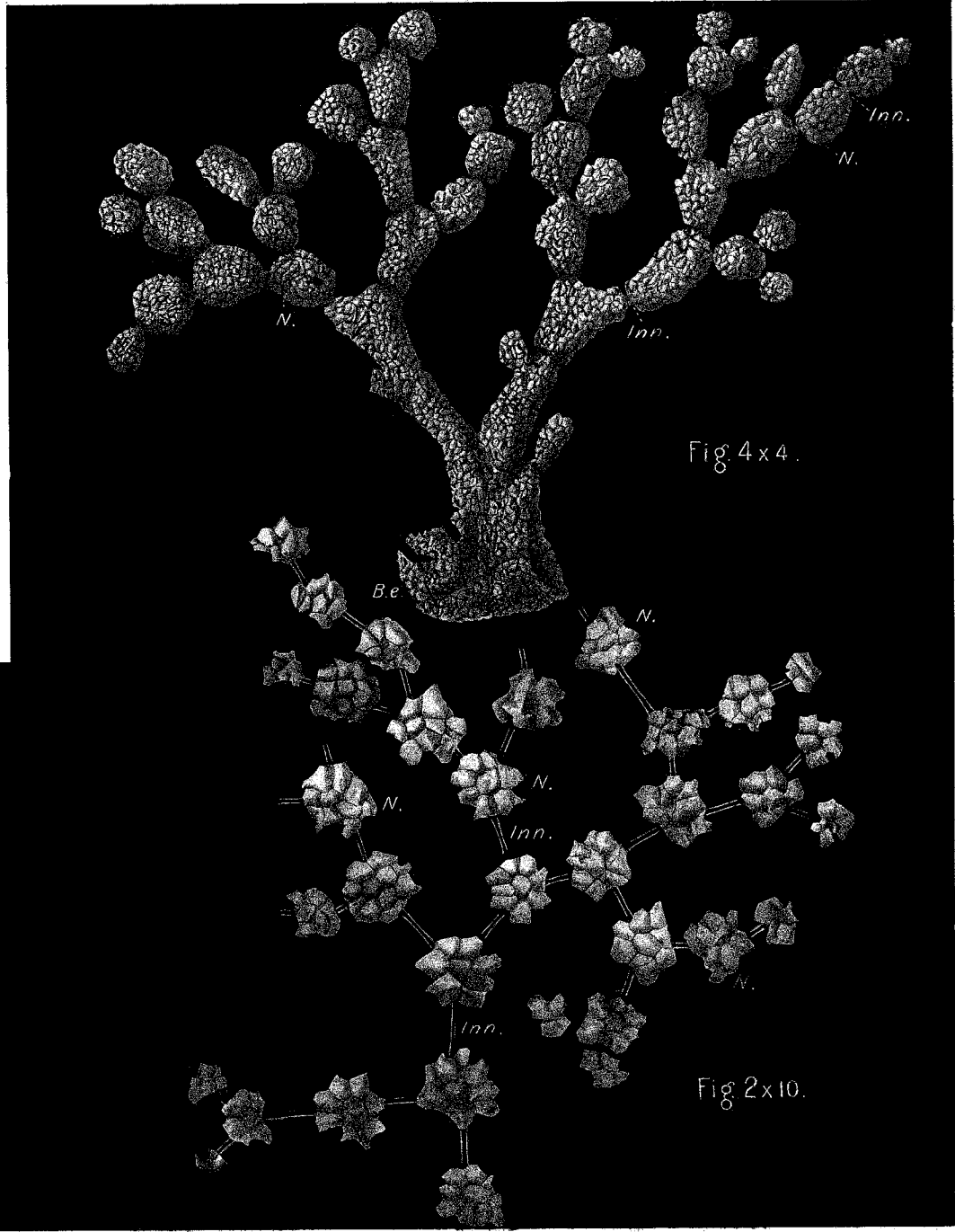
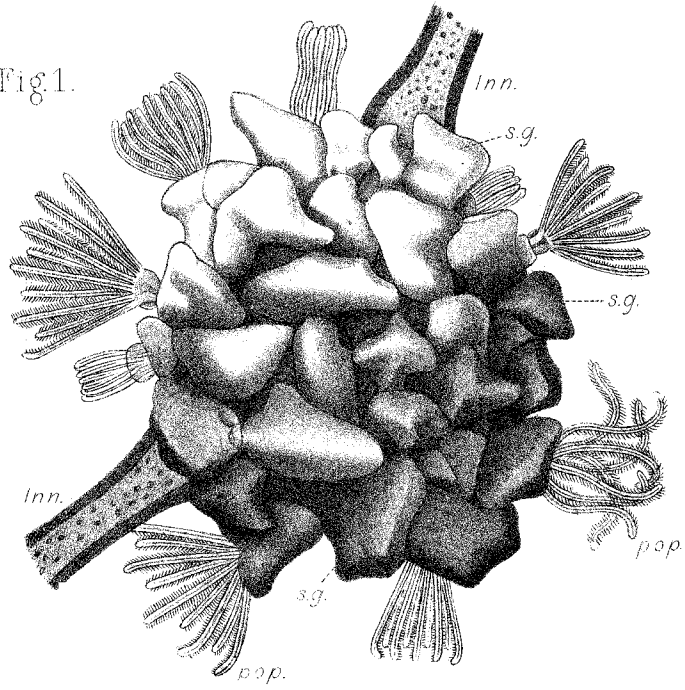
Fig. 10. Optical longitudinal section through the wall of an internode of *Cryptozoon wilsoni*. (*chi.*) Chitinous wall, raised here and there into angular prominences—(*p.*) (*ep.*) Deeply staining epithelium clothing the inner surface of the tube.

Fig. 11. A tubular zoœcium of *Cryptozoon wilsoni*, containing a retracted polypide. The zoœcium has been separated by teasing, but portions of other zoœcia are still adherent on the right-hand side, and two sand grains are still attached near the mouth of the zoœcium. (*s. g.*) Sand grains. (*w. z.*) Wall of zoœcium. (*inv.*) Invaginated portion of zoœcial wall. (*mo.*) Mouth of zoœcium. (*m.*) Retractor muscles of invaginated portion of wall of zoœcium. (*r. m.*) Retractor muscle of polypide. (*a. m.*) Attachment of retractor muscle to wall of zoœcium. (*r. p.*) Rosette plates, indicating where other zoœcia have been attached. (*ph.*) Pharynx. (*œ.*) Œsophagus. (*giz.*) Gizzard. (*st.*) Stomach. (*int.*) Intestine. (*b. b.*) Brown body (?). (*fun.*) Funiculus. (*n. g.*) Nerve ganglion.

PLATE III.

Fig. 12. A polypide of *Cryptozoon wilsoni* separated from the zoœcium by teasing, and seen from the side as a transparent object. (*ten.*) Tentacles. (*ph.*) Pharynx. (*œ.*) Œsophagus. (*giz.*) Gizzard. (*st.*) Stomach. (*int.*) Intestine. (*fun.*) Funiculus. (*a.*) Anus, represented open for the sake of clearness, though normally closed. (*n. g.*) Nerve ganglion. (*m. f.*) Fibres of retractor muscle. (*n. m. f.*) Nuclei of muscle fibres. (*t.*) Horny tooth of gizzard. (*c. m. b.*) Circular muscle of gizzard seen in section. (*n. e.*) Nuclei of the cœlomic epithelium investing the alimentary canal.

Fig. 1.



The Anatomy of Cryptozoon.

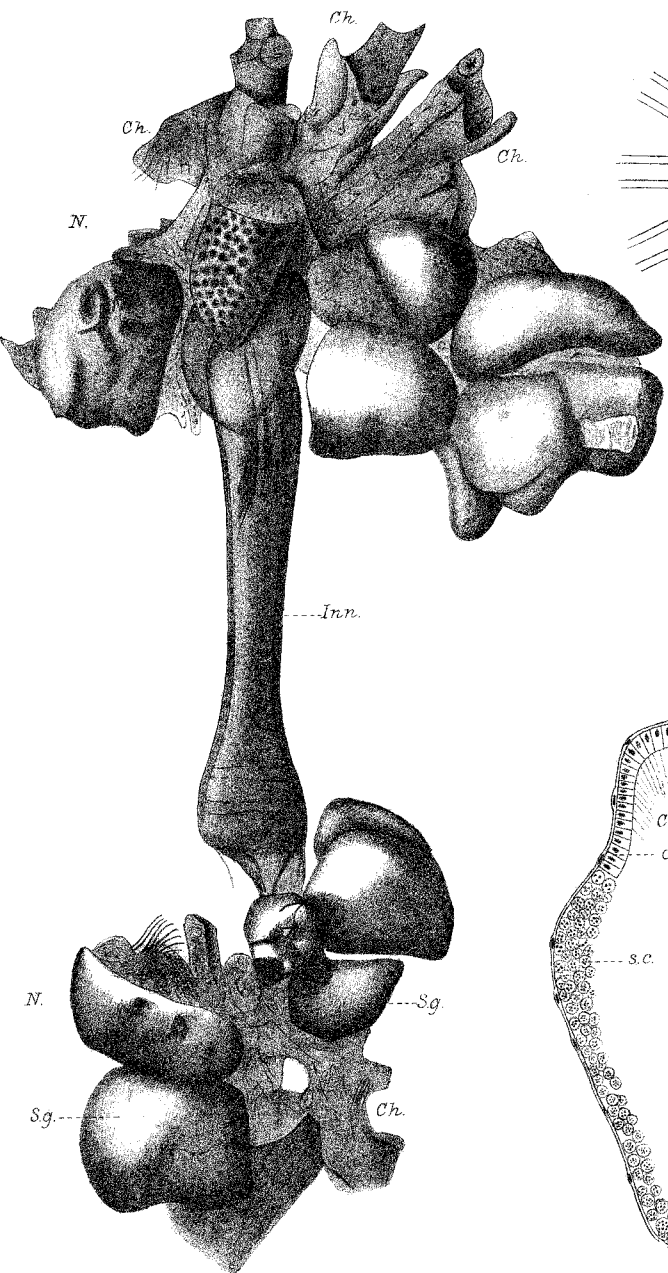


Fig 5.

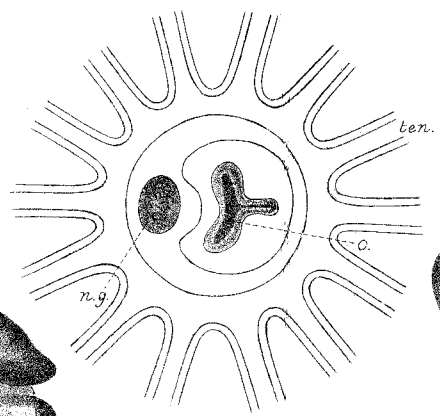


Fig 6.

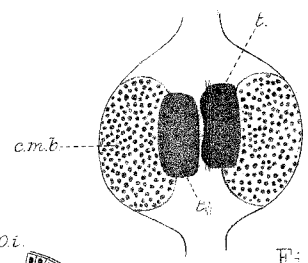


Fig 8.

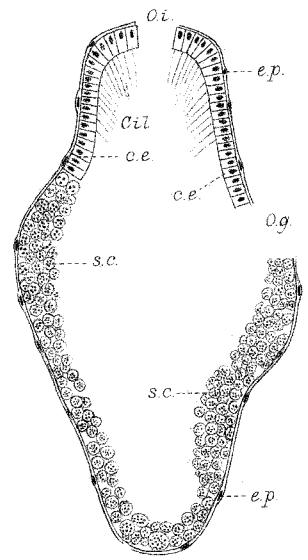


Fig 9.

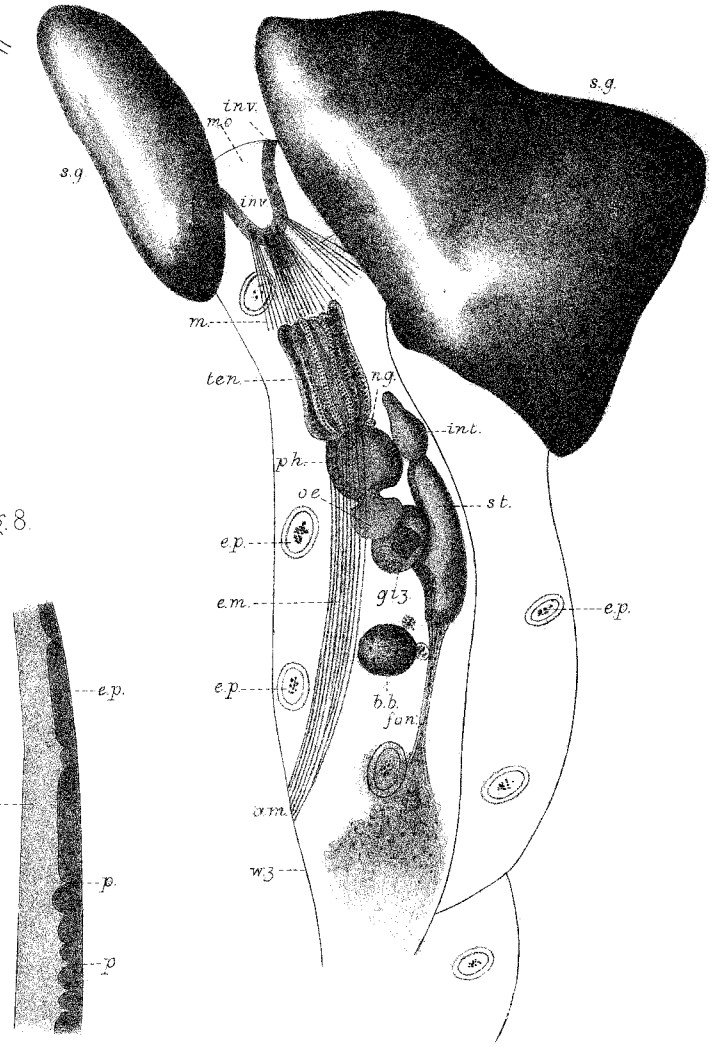


Fig 10.

Fig 11.

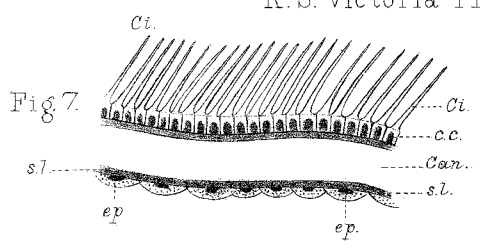


Fig 7.

The Anatomy of Cryptozoon.

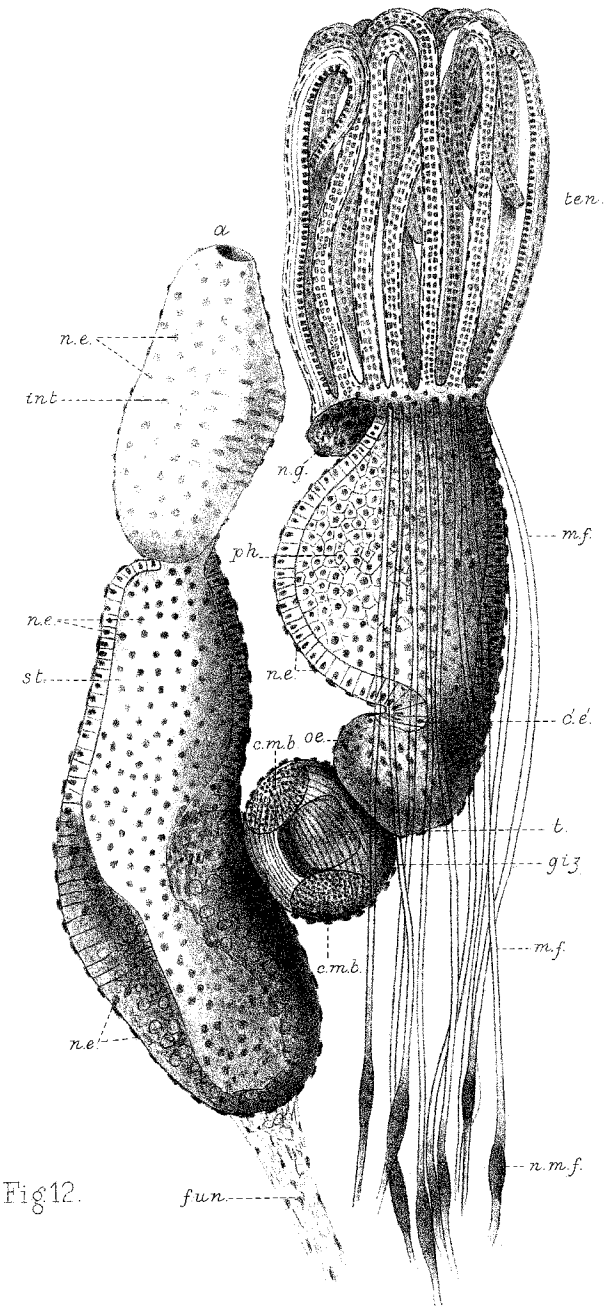


Fig 12.

The Anatomy of Cryptozoon.