III. *On the Structure of a Species of* Millepora *occurring at Tahiti, Society Islands. By* H. N. Moseley, *F.R.S., Fellow of Exeter College, Oxford, Naturalist to the 'Challenger' Expedition. Communicated by Professor* Sir C. Wyville Thomson, *F.R.S., Director of the Civilian Scientific Staff.*

Received March 6,—Read April 6, 1876.

[Plates 2 & 3.]

In a paper treating mainly on the structure of the *Heliopora cærulea*, which was communicated to the Royal Society in the autumn of last year (1875), I gave a short account of the results at which I had arrived from the examination of two species of *Millepora* obtained at Bermuda and at the Philippines, and expressed my intention of further prosecuting the subject at the Sandwich Islands and Tahiti, should material be forthcoming.

At Honolulu no *Millepora* was met with; and this form apparently does not occur at the Sandwich Islands, the water being too cold for it. At Tahiti a *Millepora* is very abundant on the reefs in from one to two feet of water, and is very conspicuous because of its bright yellow colour.

I failed in an attempt to procure the animals of this species in an expanded condition; but my colleague, Mr. J. Murray, succeeded on two occasions, and on the second occasion showed me the expanded zooids, and handed the living specimens over to me for examination. I am greatly indebted to Mr. Murray for having thus afforded me the opportunity of studying the zooids of *Millepora* in the expanded condition, and I do not think that I should ever have succeeded in arriving at a satisfactory knowledge of their structure without this aid. Mr. Murray further, who had had better opportunities of observing the living coral than I, first drew my attention to the fact that the central zooid of each system had a mouth. No species of *Millepora* appears hitherto to have been known to occur on the reefs of the Society Islands. In Dana's work on Corals* no *Millepora* is mentioned as occurring at Tahiti, and this locality is not given for any species of *Millepora* by MM. Edwards and Haime. It is impossible to determine with any certainty the species of such a form as *Millepora* without access to museum collections. The Tahitian species, of which the structure is here described, resembles closely in form *M. tuberculosa* (*M. gonagra*) figured by MM. Edwards and Haime†. Like this species it never forms foliaceous expansions, but is tuberculate and irregular

* United States Expl. Exped. vol. vii. Zoophytes, by J. D. Dana. Philad. 1846.

† Hist. Nat. des Coralliaires, pl. F 3. figs. 1^a, 1^b.

in shape, and often encrusting, commonly overgrowing the dead fronds of *Lophoseris cactus*, which is a principal component of the Tahitian reefs. The present species seems, however, to differ from *M. tuberculosa* in that its calicles are disposed over the surface of the corallum in well-marked and separated systems, and in this respect is more closely allied to *M. plicata*, *M. foliata*, and *M. Ehrenbergii* as described by MM. EDWARDS and HAIME*.

In the fresh condition the growing tips of the lobes of the coral are of a bright gamboge-yellow colour, which shades off into a yellowish brown on the sides and bases of the lobes. The expanded zooids have the appearance of a close-set pearly white down upon the surface of the corallum.

The zooids seem to be somewhat capricious in the matter of expansion. I made one attempt to obtain them expanded, in which I carefully cut off masses of the coral by means of a chisel, and transferred these to a glass vessel without lifting them above the surface of the water. The zooids did not expand. Mr. MURRAY succeeded on both occasions on which he collected specimens, although he exposed his to the air for a moment on transferring them to a vessel. DANA, POURTALES, and others speak of the peculiar difficulties attending the observation of the animals of *Millepora.* The corallum is so hard that it is almost impossible to break off a small flake without damaging the soft structures to such an extent that the animals fail to expand. The animals, as expanded on larger masses of the corallum, can only be examined with very low powers of the microscope, which, on account of the very small size of the animals, are unable to show sufficient details in their structure. A momentary view of one mouthless zooid was, however, obtained under HARTNACK'S objective No. 4, eyepiece No. 3. I obtained the view of the expanded zooids only on the morning on which H.M.S. 'Challenger' was steaming out of Papute Harbour. The animals remained expanded about two hours, but the motion of the ship interfered considerably with the investigation of them.

A summary of the literature extant on the subject was given in the paper on *Heliopora cærulea* above referred to. It is needless here to recapitulate.

Methods.

Sections of the corallum were prepared in the usual manner by grinding. Portions of the living coral were placed in various solutions for subsequent examination, viz. in absolute alcohol, chromic acid, and glycerine. Portions were further treated with osmic acid, and then transferred to glycerine or absolute alcohol. Fragments of the hardened coral were subsequently decalcified with hydrochloric acid, and the residual

* NOTE, Feb. 28, 1877.—I have submitted a specimen of the corallum of the Tahitian species here treated of to my friend Dr. F. BRÜGGEMANN, who is at present engaged in arranging and determining the collection of corals in the British Museum, and he has kindly determined it for me to be *Millepora nodosa*, Esper, Pflanzenthiere, vol. i. p. 199, Millep. pl. l. (1791); mentioned by M. EDWARDS under *M. gonagra*, Hist. Nat. des Cor. iii. p. 230.

soft structures were either mounted entire for examination, or cut in the usual manner into fine vertical and horizontal sections. The sections were stained with carmine or magenta. The specimens hardened in osmic acid, and decalcified after subsequent immersion in absolute alcohol, yielded the best histological results. Those which had been hardened in absolute alcohol alone gave the best results as to the coarser anatomy. The specimens preserved directly in glycerine preserved most perfectly the forms of the several histological elements, and especially yielded good preparations of the thread-cells, preparations of which are best procured by grinding up between two glass slides a zooid and its immediately surrounding calcareous bed, removed with the point of a scalpel. A view of the structure unacted upon by acids is thus obtained. The specimens placed in chromic acid were of little service for sections, owing to a thick crystalline deposit of sulphate of lime which formed upon them in the solution; but they showed best, on the under surface of the decalcified superficial film, the ramifications of the soft parts of the hydrophyton.

Structure of the Corallum.

The structure of the corallum is illustrated on Plate 2. The corallum has a widely spread encrusting base covering rocks, dead corals, &c., and at its surface presents a series of projecting, short, irregular tubercles and lobules, which never rise to any considerable height. Fig. 3 represents the appearance of two lobules of the corallum and a portion of a third, enlarged two diameters. The surface of the lobules is uneven and covered with slight rounded elevations. The calicles, or pores, of the zooids are dispersed over the entire surface both of the lobules and of the flatter encrusting portions of the corallum, being absent only at the tips of some of the lobules, which are possibly those that are in rapid growth. The calicles are disposed in irregularly circular groups, a larger calicle being in the centre of each group or system, with usually from five to eight smaller calicles arranged around it. These systems of calicles often occupy small rounded prominences on the surface of the corallum, and in parts of some specimens almost every system appears to have its separate small prominence. In some regions of the corallum the systems are scarcely defined, the calicles appearing irregularly placed; but such an arrangement is only exceptional in the present species. An entire system of calicles has been accurately drawn for me by Mr. J. J. Wild, and is represented in Plate 2. fig. 4, enlarged eighty diameters. The outlines of the calicles are seen to be extremely irregular; their cavities are encroached upon in all directions by projections of the contorted trabecular cœnenchymal tissue of the corallum. The larger central calicles of the systems measure about 1·5 millim. in diameter.

The main mass of the corallum is composed of trabeculæ of dense calcareous matter which forms a spongy-looking mass traversed in all directions by tortuous canals. In some species of *Millepora* the corallum is much more dense than in the Tahitian one, and in these might rather be described as a compact mass in which a series of tortuous channels are excavated for the reception of the soft structures. In such species of

Millepora, in finely ground sections of the corallum, the tortuous canals become filled with opaque débris, and show out, when the section is viewed by transmitted light, dark on a light ground. In a species of *Millepora* obtained at Zamboangan the corallum was of this nature. The appearance presented by a thin section of its corallum is shown in Plate 2. fig. 7. In *Millepora alcicornis* and in the Tahitian species the canal-systems and trabeculæ of calcareous matter seem to form equally complex interpenetrating meshworks. The canal-systems present in the coralla of the species of *Milleporidæ* are perfectly characteristic structures, and distinguish the coralla formed by these Hydroids most clearly from all other recent coralla whatever*. They of course correspond to, and in the recent state contain, the ramifications of the soft parts of the hydrophyton. The canals form regular branching systems with main trunks which give off numerous branches, from which arise secondary branches, and from these again smaller ramifications. The whole canal-system is connected together by a freely anastomosing meshwork of smaller vessels, and communicates freely by numerous offsets with the cavities of the calicles. In Plate 3. fig. 12 part of one of these canal-systems is shown, being there drawn from a decalcified specimen, and thus representing the soft tissues which in the recent state occupied corresponding calcareous canals. In Plate 2. fig. 6 a secondary branch of one of the canals is seen to communicate with a calicular cavity, C′. The course of the smaller vessels being tortuous, only short lengths of them are exposed in the remainder of this section. Similar secondary branches are seen in vertical section in Plate 2. fig. 5, B, B.

Where a *Millepora* encrusts foreign bodies, the investing film of corallum formed is usually extremely thin. At Bermuda, *Millepora alcicornis* is frequently found encrusting glass bottles thrown into the harbours. The film of corallum can, in such specimens, easily be detached in flakes from the glass, and does not measure more than from $\frac{1}{8}$ to $\frac{1}{5}$ of a millimetre in thickness. In the same manner at Bermuda the dead fans of a *Gorgonia* are found entirely encrusted with a thin film of *Millepora*, so thin that the fenestrations of the horny meshwork of the *Gorgonia* are not obliterated. Such thin encrusting films, if obtained in the living condition, would, no doubt, be excellently adapted for the study of the soft parts of *Millepora*, since they are thin enough to transmit a considerable amount of light. When dead and dry they show extremely well the ramifications of the canal-systems and their connexions with the calicles. In such films the calicles, larger and smaller, are fully developed, though necessarily very shallow; and it is evident that such a thin film of corallum is all that is absolutely necessary for the existence of the *Millepora*, and, in fact, in all *Milleporæ* it is such a thin film only which is actually living, covering the surface of the corallum. In a *Millepora* forming tubercular or ramified masses a superposition of a series of such films takes place and constitutes the coral mass.

In the films encrusting bottles the under surface in contact with the glass is perfectly

* NOTE, June 1877.—Excepting the coralla of the Stylasteridæ, since found by me to be also Hydroids and not Anthozoans (Proc. R. Soc. no. 172, 1876, p. 93).

continuous and highly polished, and is exactly moulded on the surface of the glass, reproducing casts of the most minute splinterings or scratchings.

In homology with this continuous layer, layers more or less continuous occur in the more massive coralla, appearing in vertical sections as lines of calcareous matter running parallel to the surface of the corallum, and indicating successive stages of growth; and the tubercles of which the mass of the Tahitian *Millepora* is made up, when cut through vertically to the surface, show a series of such lines of growth following the contour of the surface. It is in connexion with these layers that are developed the successive transverse laminæ or tabulæ which divide the cavities of the calicles into a series of chambers (Plate 2. fig. 5). As the corallum is extended in growth at certain intervals, possibly after each period of generative activity, a tabula is formed, reducing the depth of the calicle and shutting off the living tissue from the abandoned dead structures below. The larger canals and their branches ramify in planes parallel to the surfaces of the corallum, being confined within each successively added thin layer of the corallum, and never take a vertical course leading from the depths of the coral to the surface. A free vertical communication is, however, established by the smaller vessels (Plate 2. fig. 5). In the thin films of *Millepora alcicornis* the trabeculæ of hard tissue run with remarkable uniformity in straight lines parallel to one another, whilst the main canals cross them with a serpentine course.

Histological Structure of the Corallum.

In histological structure the hard tissue composing the corallum of *Millepora* seems to resemble closely that of the coralla of *Heliopora* and most Anthozoa. It is composed of lamellæ of fibro-crystalline calcareous matter (Plate 2. fig. 8), the fibres of the superposed lamellæ crossing one another at all angles in the mass. In some places, in thin sections of the corallum, the appearance shown at *a* (Plate 2. fig. 8) is clearly to be seen. The calcareous fibres of the hard tissue terminate towards a cavity in the corallum as a series of short points, seeming to show a composition of the hard tissue out of definite rod-like elements. Such an appearance is only to be met with sparingly, and possibly occurs at spots where the corallum was in active growth. The hard tissue is bored in all directions by parasitic vegetable organisms (Plate 2. figs. 6 & 8).

Chemical Composition of the Corallum.

Although the animals forming the corallum of *Millepora* differ so widely from those by which all other corals are secreted, their coralla appear to agree in chemical composition with those of other corals as closely as they do in histological structure. Analyses of the coralla of two species of *Millepora* are given by Professor DANA. One is an analysis of *Millepora tortuosa* from the Fijis, by Mr. LILLIMAN, Jun.* The composition was found to be as follows:—

* 'Structure and Classification of Zoophytes,' by J. D. DANA, A.M. Philadelphia: LEA and BLANCHARD, 1846. Appendix, p. 130.

Carbonate of lime	94·226
Phosphates and fluorides . . .	1·200
Organic matter	4·574

Mr. S. P. SHARPLES* found the corallum of *Millepora alcicornis* to consist of:—

Carbonate of lime	97·46
Phosphate of lime	0·27
Water and organic matter . . .	2·4

There is no marked difference between these results and those obtained from ordinary corals.

Structure of the Soft Parts.

Structure of the Zooids.—The calicles of the *Millepora* are occupied by two kinds of zooids. In each system of calicles the central larger one is occupied by a short and broad zooid provided with a mouth, whilst the surrounding smaller calicles lodge longer and more slender zooids which have no trace of mouth. A system of expanded zooids is shown in Plate 3. fig. 9, one of the mouthless zooids being omitted in the drawing in order to show the central mouthed one more clearly.

The mouth-bearing zooids are much shorter and broader than the mouthless ones. They were not directly measured, but were estimated to be about ·5 millim. in height. They are cylindrical in form, with a short conical hypostome, and four, five, or six tentacles arranged equidistantly in one whorl just below the short hypostome. The tentacles consist of a short, stout, cylindrical stem, with a spheroidal knob-like tip composed almost entirely of thread-cells. At the summit of the hypostome is the mouth, which in the living expanded animal has a conspicuous glistening white appearance—no doubt because light is strongly reflected by the large gastric cells which surround the aperture.

The mouth-area is circular in outline (in *M. alcicornis* quadrangular sometimes), Plate 3. fig. 11, MZ. The circular area is occupied by a series of large, elongate, transparent gastric cells, which are disposed in a radiating manner around the centre of the area. The actual mouth-orifice takes the form either of a threefold or cruciform slit between the gastric cells. The gastric cells (Plate 3. fig. 15) are elongate, irregularly cylindrical in form, and transparent and bladder-like in appearance, and without any trace of a nucleus. They line the internal cavity of the zooid for at least one third of its length, but to what extent exactly was not ascertained. They appear to be closely similar to the pyriform cells described by ALLMAN, and figured by him as occurring in *Gemmaria implexa*†. They are here termed gastric, because the fact that they occur only in the mouthed zooids seems to render it probable that they exercise a digestive function. The mouthless zooids are long and slender in comparison with the mouthed ones. They differ very much in length, as will be seen from the figure; the longest of them measure about $1\frac{1}{2}$ millim. in length. They are cylindrical in form, tapering towards

* 'Corals and Coral Islands,' by J. D. DANA (London, 1872), p. 105.

† ALLMAN, 'Gymnoblastic and Tubularian Hydroids,' pl. viii. fig. 5.

the upper extremity. They have no trace of a mouth, nor of any of the gastric cells of the mouthed zooids in their body-cavity. They bear tentacles at irregular intervals from near the bases to the summits of their bodies. The tentacles are very variable in number; some zooids have only five tentacles, whilst all numbers from 5 to 20 (and possibly, in exceptional cases, a slightly greater number) occur in others. From 12 to 15 is the most usual number. The tentacles consist of a cylindrical stem, longer and more slender than in the mouthed polyps, and a spheroidal tip resembling that of the tentacle of the mouthed zooid, but smaller. The body of the zooid terminates sometimes in two, sometimes in three tentacles, springing from a common point.

The mouthless zooids expand far more readily and quickly than the mouthed zooids, of which latter it is comparatively difficult to obtain a view in the expanded condition. The short mouthed zooids appear to remain perfectly quiescent when expanded, whilst the mouthless zooids are in constant serpentine motion. The mouthless zooids carry their bodies seldom extended straight, but usually bent in several curves; they appear to bend over towards their mouthed zooid from time to time, as if to convey food. All the zooids are retracted on alarm with remarkable suddenness, disappearing entirely within the calicles.

When a portion of the coral has been placed living in reagents, it is found, when hardened, to be bristling all over with sheaves of threads shot from the thread-cells around the mouths of the calicles. By some accident, on one small portion of a coral placed in absolute alcohol, the mouthless zooids all remained partially protruded. This was only over a small area of about $\frac{1}{4}$ of a square inch in dimensions, enough to yield a single microscopical preparation. From a very large quantity of the coral prepared in an exactly similar manner, no second preparation could be obtained, though it was all searched over carefully for similarly expanded zooids. This fact, however, shows that perhaps it might have been possible to obtain a larger quantity of expanded zooids in the hardened condition by the gradual addition of alcohol or fresh water to the sea-water in which the living animals were expanded, or by some similar means; or perhaps by sudden addition of osmic-acid solution as recommended by F. E. SCHULZE*.

The body of the zooids, when seen in transverse section, is found to consist (fig. 15) of an ectodermal layer, beneath which is a layer of membrane, and an internal mass of endodermal cells. The ectodermal layer, as studied in sections of hardened specimens, appears to consist of well-defined cells, most of which contain small thread-cells, whilst some contain simple nuclei. The membranous layer is apparently structureless; it extends throughout the body and tentacles. Beneath the membranous layer, and in close union with it, are the muscular structures to be presently described, and within these, in the case of the mouthed zooids, are, in the upper region of the body, the gastric cells already described. The structure of the endoderm in the lower part of the body of the mouthed zooids, and in the mouthless zooids, was not well ascertained.

* Anleitung zu wissenschaftlichen Beobachtungen auf Reisen. Herausgegeben von C. NEUMAYER, Hydrograph der kaiserlichen Admiralität. Berlin, 1875. Wirbellose Seethiere von K. MÖBIUS, p. 424.

In transverse hardened sections the body-cavity is seen to be entirely filled with the pigmented yellow cells, which also fill the canals of the hydrophyton. In the tentacles of the mouthless zooids, however, of which a glance was obtained under a high power, the transverse lines or apparent septa, so characteristic of the Hydroids (fig. 13), and considered by ALLMAN to be in reality the opposed walls of large adjacent endodermal cells, were clearly seen, and also multiramified amœboid-looking corpuscles occurring in the endoderm (RC, fig. 13), and resembling those figured by ALLMAN as occurring in the tentacles of *Coryne pusilla*, and considered by him to be the nuclei of the large endodermal cells *.

The body-cavities of the zooids were seen in the living condition to be filled with the yellow pigmented cells, and a few of these cells were seen occasionally to penetrate a short distance into the cavities of the tentacles, which cavities are continuous by widely open mouths with those of the bodies of the zooids. Ciliation of the somatic cavities could not be seen. The spheroidal heads of the tentacles are composed of masses of closely-set thread-cells of various sizes and stages of development, but all of one peculiar kind (Plate 2. fig. 2), the larger ovoid thread-cells never occurring in them. A thin hyaline, apparently structureless ectodermal layer extends between these agglomerated thread-cells, its marginal outline not being circular but depressed in short curves between the somewhat projecting tips of the cells (Plate 3. fig. 13).

The mouthed zooids, when retracted, viewed directly from above, show the mouth in the centre, and four, five, or six tentacles arranged at equal distances around. The mouthless zooids, when retracted, have their tentacles closely drawn together, so as to form a hemispherical mass composed of the closely-set spheroidal tips of the tentacles (Plate 3. figs. 10 & 11). It can easily be understood how a vertical section through such a mass of retracted minute tentacles would give the appearance of a large compound tentacle, the small tentacles appearing to constitute the pinnæ. I was misled by such a preparation; and in my paper upon *Heliopora cærulea*, lately presented to the Royal Society †, I stated my belief that the tentacles of *Millepora* would prove to be compound.

The body-cavities of the zooids terminate inferiorly in blind ends at the bottoms of the calicles, but are continued outwards at their bases in all directions into the canals of the hydrophyton, which join them all around, being disposed in an irregularly radiate manner (Plate 3. figs. 10 & 14).

Muscular fibres, having a longitudinal disposition, are extremely well developed in the zooids. They arise for the most part in bundles from the radiating vessels of the hydrophyton, which spring from the bases of the zooids, and pass up the walls of the bodies of the zooids, extending in the mouthed zooid nearly as far as the mouth. In the contracted zooids, when viewed directly from above or below, they have necessarily a radiate disposition, as shown in fig. 14. Not all the fibres are gathered into the bundles; but some sparsely spread ones occupy the interval between these bundles, maintaining a like radiate course. The bundles may be traced for a considerable distance along the

* ALLMAN, 'Gymnoblastic and Tubularian Hydroids,' pl. iv. fig. 3.

† Phil. Trans. vol. 166. pt. 1.

radiating vessels. In vertical sections from osmic-acid preparations the muscular elements can be observed as isolated excessively fine fibres (as far as was seen, without nucleus), which appear to be distinct from the membranous layer of the zooid, though in close relation with it. These bundles of longitudinal fibres are plainly to be seen in preparations of all kinds, and no doubt it is to their presence that the zooids owe their power of almost instantaneous retraction. In several osmic-acid preparations an appearance indicating the existence of a set of circularly-directed fibres lying externally to the longitudinal fibres, or possibly of circular fibrillation of the membranous layer, was seen, but the existence of such structure was not determined with certainty.

Structure of the soft parts of the Hydrophyton.

The canals and spaces within the calcareous corallum are occupied, as has already been stated, by a network of soft tissue. This, together with the hard parts, constitute what, according to ALLMAN'S nomenclature, must be termed the hydrophyton, or "common basis by which the several zooids of the colony are kept in union with one another." In the case of *Millepora* the hydrophyton appears from its structure to be homologous with the hydrorhiza of other hydroids, the hydrorhiza here being extraordinarily developed, so as to form a thick network surrounding cavities into which the zooids are retracted, and forming by means of its ectoderm a massive calcareous structure. Only a thin layer at the surface of the coral is living. This layer separates from the underlying dead matter when the coral is decalcified in acids, and appears as a soft membrane about ·5 millim. in thickness. When the entire corallum is dissolved away there remains besides this membrane only a greenish gelatinous mass, which consists of the mycelium and spores of the parasitic organisms, which were the sole living occupiers of its deep parts. The living part of the hydroid seems to be entirely confined, as is the case in *Heliopora cœrulea*, to the region superficial to the last-formed tabulæ.

The soft parts of the hydrophyton consist of a series of ramifying canal-systems, which occupy in the recent condition the canals already described as existing in the corallum. The branches and secondary branches of the canals are joined by a complex network of smaller vessels, which join in all directions the body-cavities of the zooids (Plate 3. fig. 12), and thus maintain a vascular connexion between the various zooids of the colony of the freest character. In some cases comparatively large tertiary branches of the canals join the zooid-cavities directly. The large main canals run sometimes for long distances, and in a species of *Millepora* obtained at Zamboangan, Philippines, are plainly visible to the naked eye on the surface of the corallum, extending sometimes for as great a distance as $1\frac{1}{2}$ inch. The ramifications of the hydrophyton are best seen on the under surface of the superficial living film decalcified in chromic acid and viewed by reflected light. The appearance presented in such a preparation is accurately represented in Plate 3. fig. 12. The appearance of the soft parts of the hydrophyton, as seen in vertical section, is shown in Plate 3. fig. 10. In the more superficial region of the living layer the elements of the network take a direction more or less vertical to the surface. The horizontally directed main canals and their branches lie near the under surface of the layer on a level with bases of the zooids. The histological structure of the hydrophyton is shown in Plate 3. fig. 16. The canals and vessels forming the network are composed of an ectodermal layer, with a membranous layer developed beneath it, and of endodermal lining.

The ectodermal layer consists, in the greater part of the network, of fusiform cells with a finely granular appearance, and a well-defined oval nucleus, but with the cell-boundary often very indistinct. These cells form in some places much thicker layers than in others. Towards the most internal part of the hydrophyton they become entirely lost, their place being taken on the surface of the thin-walled cyst-like innermost elements of the network by a thin layer of structureless protoplasm (Plate 3. fig. 16, B).

Narrow strings of this ectodermic protoplasm (Plate 3. fig. 16, S) cross over here and there between adjacent vessels of the innermost part of the network, being possibly the remnants of effete vessels. The ectoderm covering the parts of the network near the surface is much thickened and modified, a large proportion of its cellular elements being there found converted into the parent-cells of thread-cells, and being thus inflated and occupied by thread-cells in all stages of development. At the actual surface the ectodermal cells undergo still greater modification, forming a superficial layer of elongate prismatic transparent cells, which shows on the surface a series of irregularly hexagonal areas corresponding with the summits of the cells. These cells contain oval nuclei and thread-cells of both kinds in various stages of development. The most superficial film showing the hexagonal areas separates often in osmic-acid preparations as an exceedingly thin membrane, as is shown on the right-hand side of Plate 3. fig. 16. There is some uncertainty as to the exact structure of the superficial layer of the ectoderm. The figures represent what, after a careful investigation, was concluded to be the arrangement existing. The layer is seen well only in preparations from specimens hardened in osmic acid. The lateral boundaries of the prismatic cells were never seen well defined, but the polygonal areas corresponding with their summits were seen well in various preparations. It could not be demonstrated with certainty that this layer extends uniformly all over the external surface of the hydrophyton. It is extremely transparent, and difficult to trace in preparations viewed from the surface, over the cavities caused by the removal of the hard parts by decalcification. The exact arrangement of the superficial layer in its connexion with the mouths of the calicles and zooids is also somewhat uncertain. The layer certainly is prolonged into the calicular cavities, and contains the mass of large oval thread-cells which surrounds each zooid. In most preparations the zooids are far retracted through the action of reagents, and the mouths of the calicles are closed above by a layer of tissue, which shows a radiate striation or slight plaiting around a very small circular central orifice, which orifice leads down a short tubular cavity formed by the superficial layer drawn everywhere inwards to the retracted zooids of the calicle. The layer of tissue thus contracted over the calicle nearly or sometimes completely closes it, and thus usually the zooid can be seen in preparations in which the hydrophyton is viewed from the surface only by focusing the objective into the depths of the tissue. The orifices of the calicles of retracted zooids were unfortunately not carefully examined in the living condition of the coral; hence it is uncertain whether the superficial tissue contracts in this manner in the living condition so as to close the orifice of the calicle and protect the zooid, or whether such extreme contraction occurs only through action of reagents. It seems probable that it does occur in the living animal, since by its means the masses of large thread-cells are brought as a protection directly between the zooid and the exterior. Just as in one small portion of the coral the zooids died in the expanded condition, so more often, in certain specimens, they die and are preserved with the superficial ectodermal layer not closed in over the mouth of the calicle, but with the calicle open and their retracted tentacles remaining fully exposed to view from above. In Plate 3. figs. 10 & 11 both zooids figured are shown in this latter condition. The connexion between the superficial ectodermal layer within the calicle and the adjacent vascular network of the hydrophyton was not made out. It represents probably merely the largely developed ectodermal layer of that part of the network, but the connexion not having been seen is not indicated in Plate 3. fig. 10. The superficial layer of the hydrophyton being a special development of the ectodermal cells of the vascular network, and the interspaces in this network being occupied by calcareous trabeculæ, it follows either that the tips of the trabeculæ at the surface of the hydrophyton must be directly exposed, or that the superficial ectodermal cells of the network must close in over them. The latter arrangement seems to occur; and in vertical sections of the decalcified hydrophyton numerous spaces left by removed calcareous structures are seen in the superficial ectodermal layer (see Plate 3. figs. 10 & 16), with the ectodermal cells arching over to cover them. I should have had no doubt in this matter had I not observed that in the living *Millepora* the soft parts of the hydrophyton appear to be retracted below the surface of the corallum when the zooids are in their retracted condition. It can, however, hardly be the case that any part of the corallum is directly exposed to the water. It is probably always covered everywhere by the superficial layer of the ectoderm, which, however, is in the recent condition so transparent as to escape observation. The calcareous tissue of the corallum must obviously be deposited by the ectoderm, with which alone it is in contact. It spreads by extension of the trabeculæ at the surface; and since there it is seen to be often in contact only with the cells of the superficial layer, it seems that these cells must have the power of producing it. The calcareous network undergoes thickening in the deeper parts of the hydrophyton, as must necessarily be the case, because of the formation of the tabulæ and lines of growth. In these parts no doubt the fusiform nucleated cells of the ectoderm are the instruments of the deposition of the carbonate of lime. No special calciferous tissue was observed, such as exists in *Heliopora cœrulea.*

Beneath the layer of ectodermal cells in the vascular network of the hydrophyton lies a layer of apparently homogeneous membrane, which appears to form everywhere a wall to the vessels and canals. The cavities of the vascular network are lined by, and in many places nearly filled with, cellular elements of two kinds—pigmented cells and small transparent globules. The pigmented cells (Plate 3. fig. 17) closely resemble those of other hydroids. They are spheroidal in form, with transparent wall and contents composed of irregular granules, which are of a bright gamboge-yellow colour. It is these cells which give the bright yellow tinge to the tips of the living corallum. The cell-contents in these cells are frequently to be seen divided into two, each half having its own nucleus, or sometimes more rarely into four (Plate 3. fig. 17, *b*, *c*). The more superficial part of the vascular network of the hydrophyton is in most places almost crammed full of these pigmented cells, and they are abundantly present also within the somatic cavities of the zooids. They become less abundant towards the deeper parts of the living layer, and in certain of the deepest ramifications of the network are entirely absent, their place being taken by transparent globules. In some parts of the corallum large quantities of the pigmented cells are met with which are coloured dark brown instead of yellow. These belong probably to the older parts of the coral, which have in the living condition a brown appearance, it being only the growing tips which are bright yellow. Such, however, was not ascertained to be the case.

At the under surface of the living layer of the hydrophyton the vascular network has in connexion with it, or is prolonged into, a network of extremely transparent thin-walled vessels, many of which terminate in blind extremities, as shown in Plate 3. fig. 16, B. These vessels are distended with small exceedingly transparent and highly refractile globules, without any admixture of pigmented cells. These transparent globules are found scattered amongst the pigmented cells throughout the vessels of the hydrophyton, but occur in masses only as above described. No clue to the function of these transparent globules, nor explanation of their being thus agglomerated in the deeper parts of the living layer, was obtained; the masses of them probably point to a fatty degeneration of the effete deep regions of the network of the hydrophyton.

Thread-cells.

The thread-cells are of two kinds. They are shown, carefully drawn to measurement, in Plate 2. figs. 1 and 2. One kind is that which appears to be confined to Hydrozoa, and not to occur at all in Anthozoa, viz., that in which a bladder-like enlargement of the thread occurs at that part of it which is immediately next the mouth of the cell, the bladder being armed near its summit by three spines set in one whorl. The three spines in this form of thread-cell in *Millepora* are remarkably long, and directed at right angles to the axis of the thread, instead of recurved, as usual. These thread-cells vary very much in size. The one figured is one of the largest observed, being of about two thirds of the length of the ovoid thread-cells. The larger examples of these three-spined thread-cells are of comparatively rare occurrence, only a few being present in some of the tentacles, and being more commonly present in the tentacles of the mouthed zooids. The smaller thread-cells of this form have not more than $\frac{1}{6}$ of the length of the larger ones. They form the bulk of the spheroidal tips of the tentacles of the zooids; but both large and small thread-cells of this kind occur also in the hydrophyton. The larger ovoidal thread-cells are also such as occur in hydroids, but are not of so characteristic a form as the three-spined kind. They have been already figured by the late Professor AGASSIZ from *Millepora alcicornis.* These thread-cells never occur in the tentacles of the zooids, being confined to the hydrophyton, and being present in the greatest abundance in zonal masses around the bases of the zooids lying in the superficial layer of the ectoderm. Both these forms of thread-cells occur together in *Gemmaria implexa*, and with a similar distribution.

Both kinds of thread-cells occur, in all stages of development, in the ectoderm of the vascular network of the hydrophyton, extending in position to a considerable depth from the external surface of the coral (Plate 3. fig. 16).

The thread-cell appears to be developed out of the nucleus of the ectodermal cell, the ectodermal cell becoming much enlarged and forming a wide chamber, in which the process of development takes place. The ovoid nucleus becomes enlarged together with the cell, but not at all in the same proportion, the cell always appearing as a wide cavity around it. The nucleus, as it enlarges, has a rounded nucleolus developed at one end of it. The nucleolus has large granules developed within it, whilst the nucleus becomes finely granular. In the next stage one large coil of the thread appears in the nucleus. Nothing further could be made out from the hardened specimens as to the development of the thread-cells.

Most unfortunately no trace of generative organs could be detected in connexion with any of the zooids, neither in the *Millepora* from Tahiti nor in the other two species examined. These other two species have essentially the same structure as the Tahitian species, having mouthed and mouthless zooids. They have both of them closely similar thread-cells of both forms and with a similar distribution. Moreover the larger thread-cells have very nearly the same dimensions in all three species; they are a trifle smaller only in *Millepora alcicornis.* This latter species and the Zamboangan one differ from the Tahitian species mainly in not having their zooids grouped in distinct systems.

Vegetable Parasites.

I have already, in my paper on *Heliopora cærulea*, referred to the vegetable organisms infesting the corallum of *Millepora.* I have here only to add that the mycelium and spores are not confined to the calcareous structures, but occur also in abundance amongst the soft superficial tissues; and it appears probable that they become included within the calcareous tissue by the calcareous matter being deposited around them as the corallum is extended by growth. They are extremely abundant in the Tahitian species, and have a decided green colour*.

* These organisms have, since this paper was written, been made the subject of two memoirs by Prof. P. MARTIN DUNCAN, F.R.S. See "On some *Thallophytes* parasitic within recent Madreporaria," Proc. Roy. Soc. no. 174, 1876, p. 238; "On some Unicellular Algæ parasitic within Silurian and Tertiary Corals, &c.," Quart. Journ. Geol. Soc., May 1876, p. 205.

Conclusions.

The discovery of the hydroid nature of *Millepora* was made by Prof. AGASSIZ as long ago as 1859*. AGASSIZ determined that there were two forms of zooids present in the coral—the one form broad, with from four to six knobbed tentacles; the other slender, with numerous similar tentacles disposed along their whole length. His conclusions with regard to *Millepora* have received only partial acceptation; they have been universally adopted in America and Germany. CLAUS and others have placed *Millepora* with Hydroids in their zoological systems. M. M.-EDWARDS, however†, did not accept, at all events in 1860, Prof. AGASSIZ's results, and more recently Prof. ALLMAN has expressed his uncertainty in the matter on the ground of our ignorance of the generative system of the Milleporidæ‡, and awaits the result of further researches. Although, most unfortunately, no evidence as to the structure of the generative system of *Millepora* was obtained by the present investigations, the results obtained yield, nevertheless, I think, convincing proofs that this interesting form of coral is a true Hydroid. The peculiar structure of the hydrophyton, the forms of the zooids, the absence of all trace of mesenteries, the apparent septa present in the tentacles, the presence of the thread-cells of the form peculiar to Hydrozoa, and in fact every item of histological structure point irresistibly to the same conclusion. Professor AGASSIZ considered the Millepores to be allied to the Hydractiniæ, and CLAUS remarks on their resemblance in some points to the Corynidæ. Both *Hydractinia* and *Podocoryne* resemble *Millepora* in having a hydrophyton which forms a continuous encrusting layer; and in essential structure the hydrophyton of these two genera seems closely to resemble that of *Millepora*. The genus *Podocoryne* (Sars) has a "hydrophyton consisting of a continuous adherent expansion formed by adnate inosculating canals, the deeper part, with its component canals, invested by a chitinous perisarc, while a layer of naked cœnosarc spreads over the free surface" §. In *Millepora* the canals are not adnate, being separated by the stout trabeculæ of calcareous matter which here take the place of the chitinous perisarc. The layer of naked cœnosarc on the surface is probably homologous with the layer in the hydrophyton of *Millepora* described in the present paper as the superficial layer of the ectoderm. The structure of the hydrophyton of *Hydractinia* is essentially similar to that of *Podocoryne*. Distinctive features in the hydrophyton of *Millepora* are the presence in it of calicular excavations into which the zooids are retracted, the presence of large main branching canals, and the formation of successive superposed layers of hydrophyton, and consequent formation of lines of growth and tabulæ in the calcareous skeleton. In having zooids of two kinds, mouthed and mouthless, the Millepores resemble *Hydractinia echinata*, which bears likewise alimentary (mouthed) and spiral (mouthless) zooids. In the form of the zooids, however, and shape and arrange-

* Bibl. Univ. de Genève, Arch. des Sciences, Mai 1859, p. 80.

† Hist. Nat. des Coralliaires, t. iii. p. 224.

‡ ALLMAN, 'Gymnoblastic and Tubularian Hydroids,' p. 3.

§ ALLMAN, *l. c.* vol. ii. p. 348.

ment of the tentacles, and in the nature of the thread-cells*, *Millepora* seems to resemble such a form as *Gemmaria implexa.* The real affinities of *Millepora* amongst the Hydroids cannot, however, be determined until the mode of reproduction is discovered.

It is a remarkable fact that the corallum of *Millepora* seems undoubtedly to be generated by the ectoderm. In Anthozoa this is not the case, the corallum being developed from a mesoderm, as appears certain in the latest accounts of the matter from M. LACAZE-DUTHIERS'S† researches on *Astroïdes calycularis*, and from those of KOWALEWSKY‡ on *Astræa* and on *Alcyonium digitatum.* In *Alcyonium* two elements are recognized by KOWALEWSKY as composing in the embryo the "intermediate layer" (mesoderm), viz. a homogeneous membrana propria, which lies internally and penetrates the mesenterial folds, and a peculiar thin layer of cells, which lies externally to this membrana propria. It is from this thin layer of cells that the gelatinous connective tissue, the spicules, and canal networks are formed. This special layer does not exist in other corals nor in *Cerianthus.*

The close resemblance in the histological structure of the coralla formed by animals so different as Alcyonaria (*Heliopora cærulea*), Zoantharia, and Hydroida is a remarkable fact. The corallum of *Millepora* is distinguished from all other coralla by the presence within it of systems of canals branching in an arborescent manner. The presence of such structures in fossil corals will be sufficient evidence of the affinities of such corals with *Millepora* and the Hydroida. Now that *Heliopora* has been shown to be an Alcyonarian, there remains only one living genus, *Pliobothrus* (POURTALES), to form with *Millepora* the family Milleporidæ. Of *Pliobothrus* the soft structures have not been examined.

No representative of the genus *Millepora* appears to be known as existing in the fossil condition, at least none such is mentioned in QUENSTEDT'S 'Petrefactenkunde' or by M. MILNE-EDWARDS. A careful study of the internal structure of the various extinct corals which have been associated with *Heliopora* and *Millepora* amongst the Tabulata would show which of them have real affinities with *Millepora.* It would be well if the term Tabulata were dropped altogether, since it has reference to a structure common to certain Alcyonaria, Zoantharia, and Hydroida, and being not characteristic of any natural group only tends to confusion.

H.M.S. 'Challenger,' S.E. Pacific,
24th December, 1875.

* *Note.*—It would seem that a classification and nomenclature of the various forms of thread-cells is much needed, since these forms appear to be of classificatory value in the Cœlenterata. Certain forms are peculiar to Hydroids, *e.g.*, others to Alcyonaria.

† LACAZE-DUTHIERS, H. DE. "Développement des polypes et de leur polypier," Comptes Rendus, 1873, t. lxxvii. (HOFFMAN und SCHWALBE, Jahresberichte, 1875.)

‡ KOWALEWSKY, A. "Untersuchungen über die Entwicklung der Cœlenteraten," Nachrichten der kaiserlichen Gesellschaft der Freunde der Naturerkenntniss, der Anthropologie und Ethnographie. Moskau, 1873. (*Ibid.*)

Postscript, *added February* 22, 1877.

I have, since the above was written, discovered that the group of stony corals known as the Stylasteridæ is composed of true Hydroids, and have suggested that these should be grouped with the Milleporidæ in a special suborder, to be termed Hydrocorallinæ. (See Proc. R. Soc. no. 172, 1876, p. 99.)

Description of Plates illustrating the Structure of Millepora.

All the figures, with the single exception of fig. 5, Plate 2, represent the structures occurring in *Millepora* found at Tahiti, Society Islands, viz. *Millepora nodosa*.

PLATE 2.

Fig. 1. Ovoid thread-cell, confined in position to the bases of the zooids and general superficial layer, not occurring in the tentacles.

a. The cell unexpanded.

b. The cell with the thread fully projected.

The respective lengths of the various parts of the thread and cell are drawn exactly according to measurements.

Fig. 2. Three-barbed thread-cell, of the form peculiar to Hydrozoa, occurring in the tentacles of the zooids and also sparingly on the general surface of the coral.

a. The cell with its head protruded and thread partially projected.

b. The cell in the unexpanded condition. The figures are drawn exactly to measurements.

Fig. 3. View of a portion of the corallum, magnified 2 diameters.

Fig. 4. View of the surface of the corallum, magnified 80 diameters, showing one com plete system of pores, composed of a central calicle, which contained in the recent condition a mouthed zooid, and eight surrounding smaller calicles of mouthless zooids.

Diameter of the central calicle =0·25 millim.

Largest diameter of the whole group =1·5 „

Drawn by Mr. J. J. Wild, Artist to the 'Challenger' Expedition.

Fig. 5. Enlarged view of a vertical section of the corallum.

C. Zooid-cavity or calicle.

B, B. Branches of the canal-system.

Fig. 6. Section of the corallum cut parallel to its outer surface, showing a portion of a system of zooids.

C. Calicle of mouthed zooid in horizontal section.

C′, C′. Calicles of mouthless zooids.

B′. Branch of a canal-system which communicates by means of a lateral offset with one of the zooid-cavities.

The dark linear bodies represented as embedded in the calcareous matter are cavities bored by parasitic vegetable organisms, the black dots being spore-cavities. In one of the calicles a branched mycelial thread is seen to cross over between the tubular cavities bored in the corallum.

Fig. 7 shows the appearance presented under transmitted light by a thin horizontal section of the corallum of a species of *Millepora* from Zamboangan, Philippines, in which the calicles and canal-systems have become filled with opake matter. The black streaks thus shown represent the ramifications of the canals of the hydrophyton within the tortuous canals in the substance of the corallum, and show their anastomoses with the calicular cavities.

Fig. 8. Portion of a fine section of the corallum, as seen under HARTNACH'S objective No. 8, eyepiece No. 3.

The canals bored by the parasitic fungus are seen traversing the calcareous matter.

At (*a*) the fibro-crystalline elements of the hard tissue project in a series of points.

PLATE 3.

Fig. 9. View of a group of zooids in the expanded condition. In the centre is the short mouth-bearing zooid, provided with only four tentacles. Grouped around are seen five mouthless zooids. A sixth such zooid belonging to the group is omitted from the drawing for the sake of clearness.

Fig. 10. Vertical section of the decalcified living superficial layer. A mouthed zooid and a mouthless zooid are shown in the retracted condition. In the mouthed zooid one tentacle is omitted for the sake of clearness. The open spaces in the network of the hydrophyton are in the recent condition occupied by the calcareous network. The vessels are in places cut through, and have the pigmented endodermal cells exposed to view.

E. Superficial layer of the ectoderm.

Z. Mouthless zooid.

MZ. Mouthed zooid.

A. One of the spaces occupied by calcareous matter in the recent condition.

B. Secondary branch of one of the canals of the hydrophyton.

O. One of the cut openings into one of the vessels.

Fig. 11. View of a group of zooids as seen in the contracted condition. One mouthed and three of the surrounding mouthless zooids are shown. The mouthed zooid here has five tentacles. The surface of the decalcified coral is here

represented as seen when viewed from above with the microscope focused somewhat into the depths of the structure. A deep focus is necessary in order to reach the far-retracted zooids. The deeper reticulations of the hydrophyton are thus brought into view.

MZ. Mouthed zooid.

Z, Z. Mouthless zooids.

Fig. 12. View of the inferior surface of the superficial living layer, from a specimen decalcified in chromic acid and viewed by reflected light. The figure shows the ramifications of the canals and vessels of the hydrophyton and their connexions with the zooids of one complete group or system.

MZ. Under surface of mouthed zooid.

Z. One of the seven surrounding mouthless zooids.

C. Canal.

B, B. Branches of this canal.

B′, B′. Secondary branches, from which and from B B arises a complicated network of finer vessels.

Fig. 13. Enlarged view of a tentacle of a mouthless zooid.

K. Spherical head of the tentacle filled with thread-cells of various sizes.

E. Ectodermal layer.

RC. Ramified cells or nuclei of the endodermal layer.

M. Membranous layer.

P. Pigmented cells within the cavity of the tentacle.

C. Body-cavity continuous with that of the tentacle.

Fig. 14. Diagram showing the arrangement of the muscular fibres in a mouthed zooid. The longitudinal muscles are gathered into bundles, which pass outwards for insertion on to the radially disposed vessels of the hydrophyton. Other fibres, less densely placed, occupy the interspaces between these bundles.

O. Mouth of the zooid.

A, A. Radially disposed vascular offsets from the base of the zooid.

LM. Longitudinal muscular bundles.

CM. Circular muscular fibres.

Fig. 15. Transverse section of a mouthed zooid.

E. Ectodermal layer, containing thread-cells in various stages of development.

M. Membranous layer.

LM. Longitudinal muscular fibres seen in section as a series of dark points.

G. Gastric cells.

The narrow dark zone between the longitudinal muscles and membranous layer indicates a possibly existing circular muscular layer.

Fig. 16. Small portion of a vertical section of the hydrophyton, much enlarged, showing the histological structure of the vascular network. The vessels are seen cut open in almost their entire course. The walls of the deeper vessels are very thin, and these vessels are filled with transparent spherical globules. More superficially the walls of the vessels become thickened, and the cells composing their ectodermal layer are seen in several places to be in process of development into thread-cells. At the actual surface the cells of the ectoderm assume an elongate prismatic form. The vessels of the more superficial parts of the network are filled with the pigmented cells, mingled with transparent globules.

E. Superficial layer of the ectoderm.

M. Membranous layer of the hydrorhizal vessels.

C, C. Pigmented cells lying in the cavities of the vessels.

B. Transparent globules filling the deeper vessels.

T, T. Developing ovoid thread-cells.

T′. Developing thread-cells of the form peculiar to Hydrozoa.

S. Band of gelatinous tissue passing between the walls of two neighbouring vessels.

A, A. Spaces occupied in the recent condition by calcareous matter.

A′. Such a space in the superficial ectodermal layer.

O. Opening in a vessel cut at right angles to its course.

Fig. 17. Pigmented cells, of which the endoderm of the hydrorhizal vessels is mainly composed, and which are abundant also within the body-cavities of the zooids.

a, *d*, *d*. Examples of the cells, showing various forms and arrangements of the pigmented granules and vesicles which compose their contents.

c. Cell showing a division of its contents into two.

b. Cell showing a further division of its contents into four.

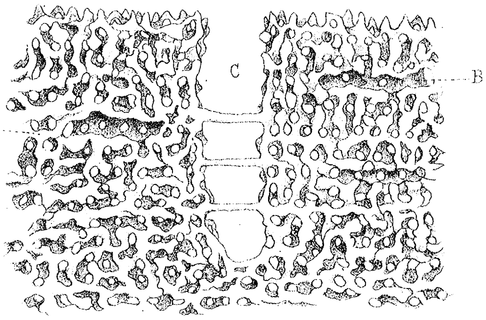


Fig. 5.

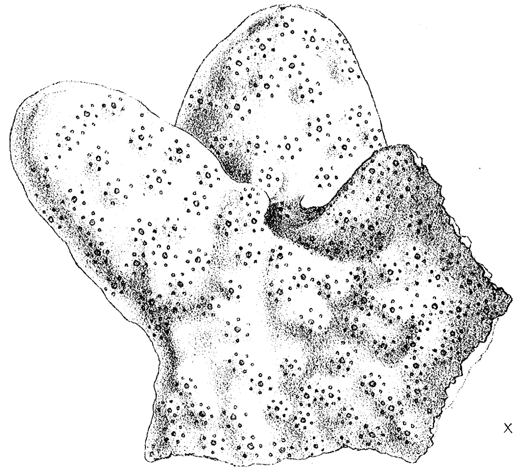


Fig. 3.

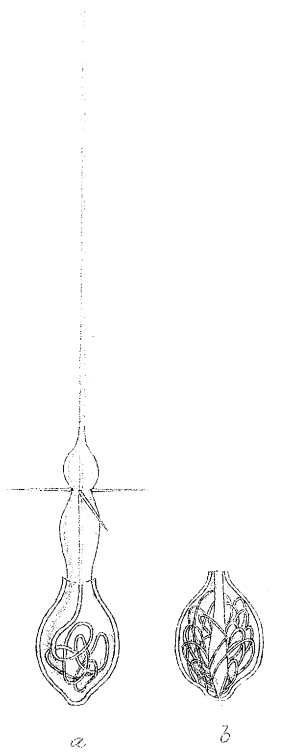


Fig. 2.

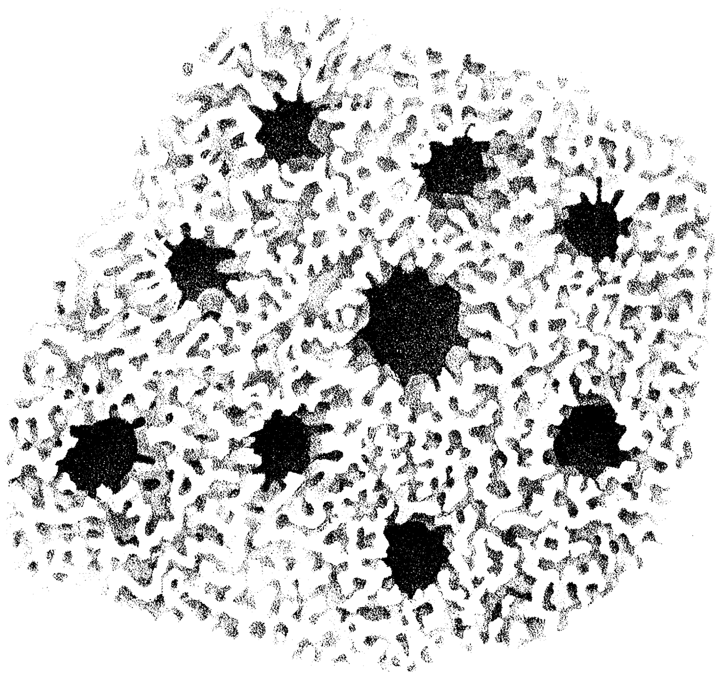


Fig. 4.

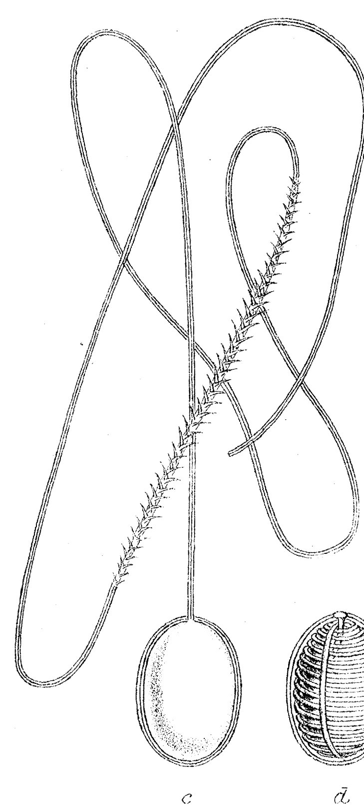


Fig. 1.

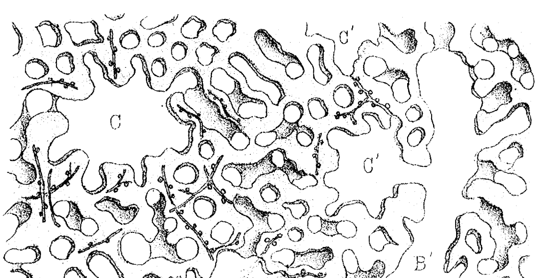


Fig. 6.

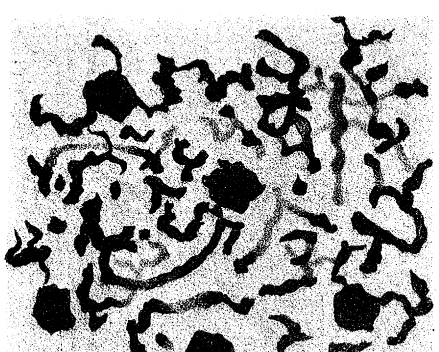


Fig. 7.

Fig. 8.

J. J. Wild & H. N. Moseley, del.t

F. Huth, Lith.r Edin.r

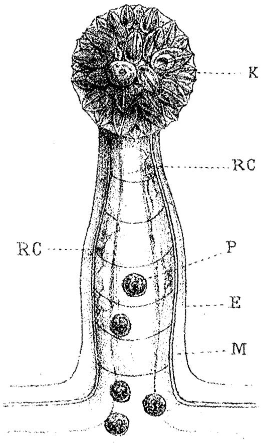


Fig. 13.

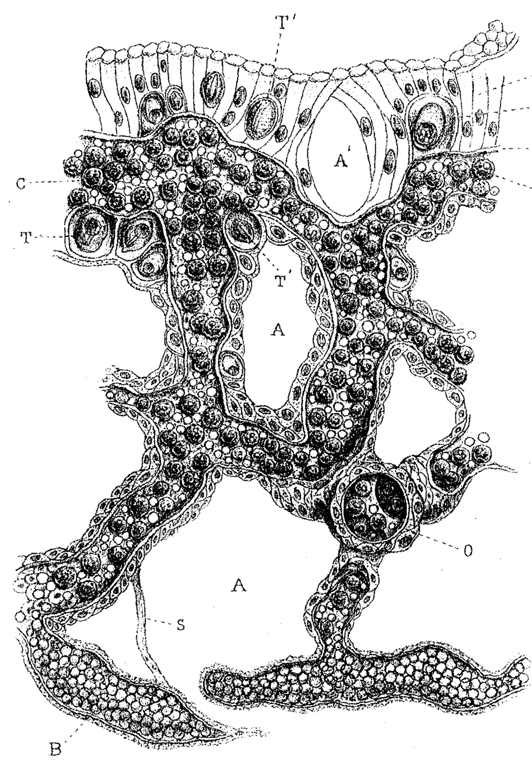
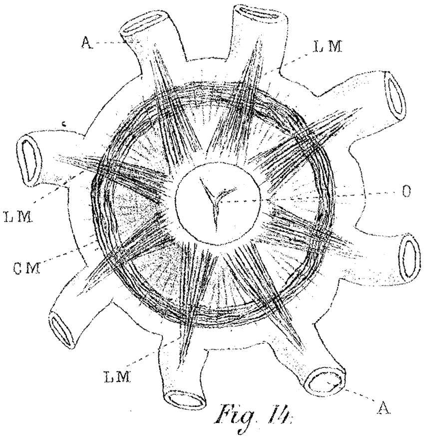


Fig. 16.



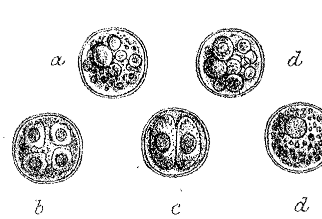


Fig. 17.

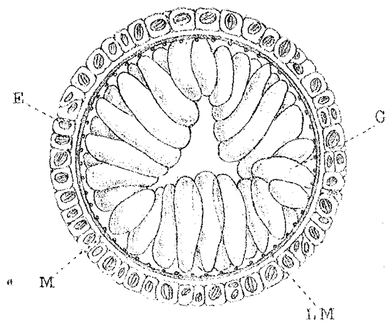


Fig. 15.

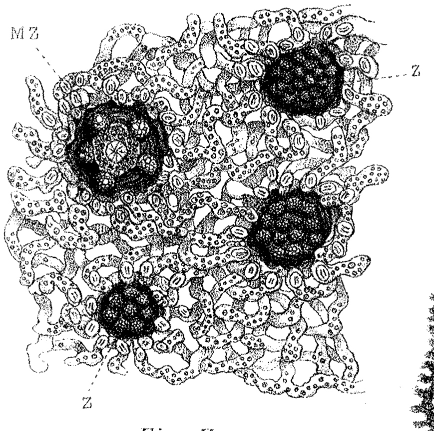


Fig. 11.

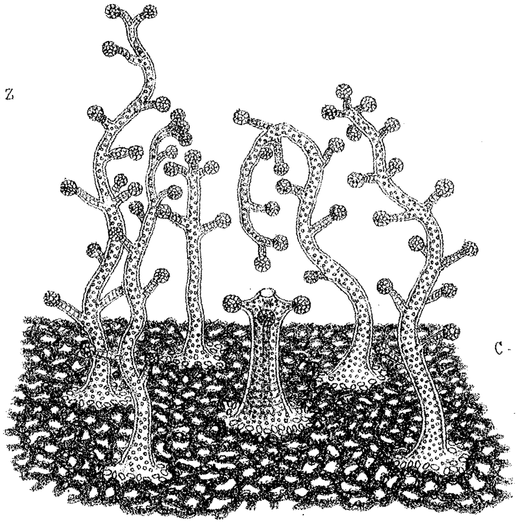


Fig. 9.

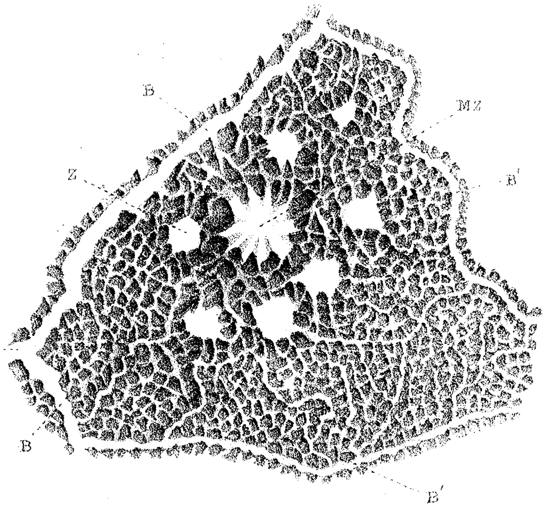


Fig. 12.

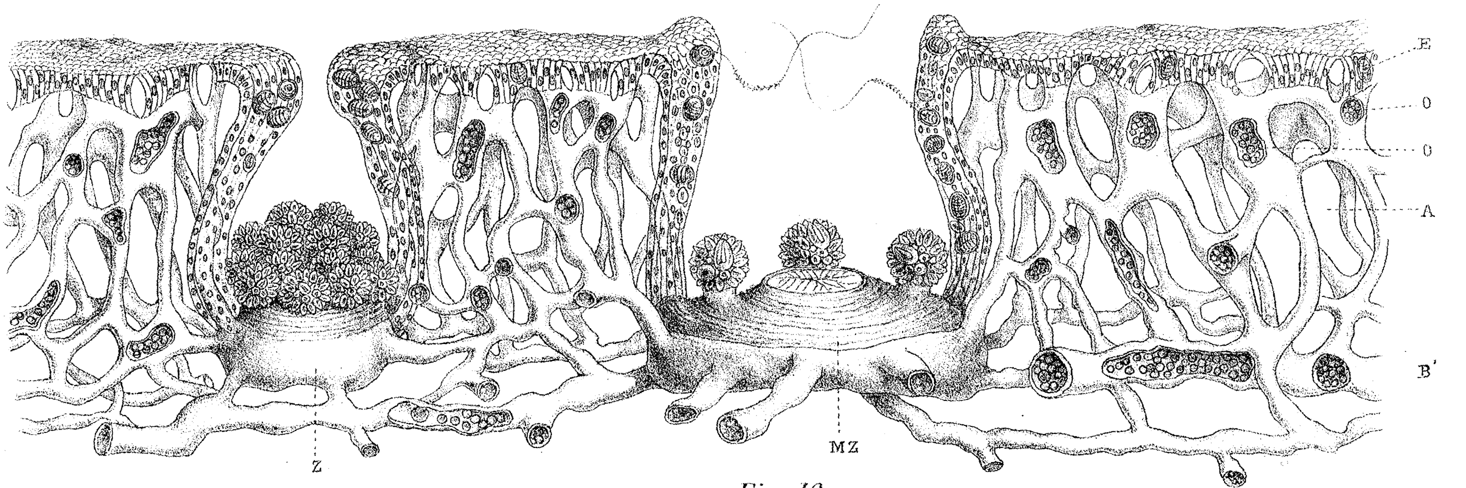


Fig. 10.

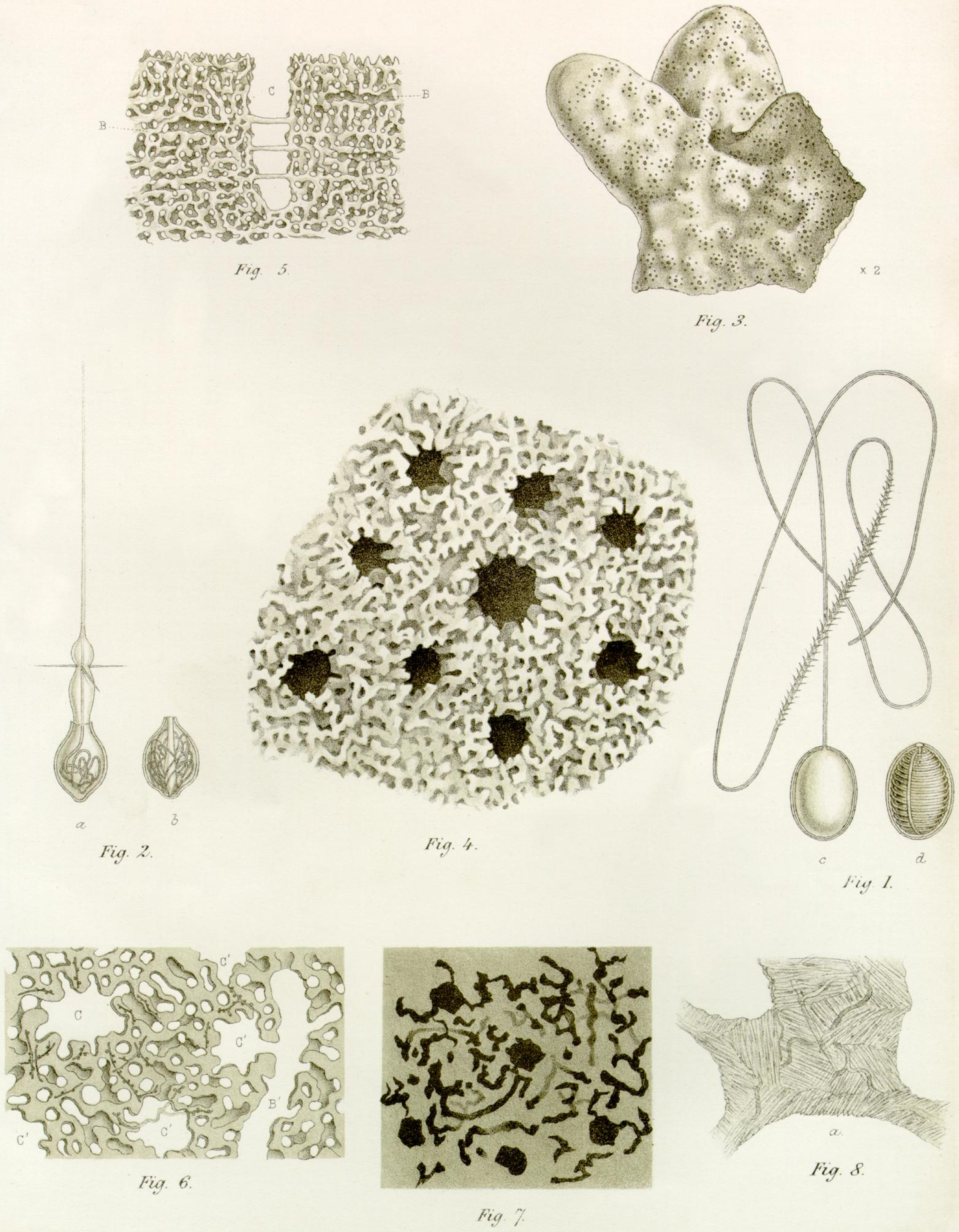


PLATE 2.

Fig. 1. Ovoid thread-cell, confined in position to the bases of the zooids and general superficial layer, not occurring in the tentacles.

a. The cell unexpanded.

b. The cell with the thread fully projected.

The respective lengths of the various parts of the thread and cell are drawn exactly according to measurements.

Fig. 2. Three-barbed thread-cell, of the form peculiar to Hydrozoa, occurring in the tentacles of the zooids and also sparingly on the general surface of the coral.

a. The cell with its head protruded and thread partially projected.

b. The cell in the unexpanded condition. The figures are drawn exactly to measurements.

Fig. 3. View of a portion of the corallum, magnified 2 diameters.

Fig. 4. View of the surface of the corallum, magnified 80 diameters, showing one com plete system of pores, composed of a central calicle, which contained in the recent condition a mouthed zooid, and eight surrounding smaller calicles of mouthless zooids.

Diameter of the central calicle =0·25 millim.

Largest diameter of the whole group =1·5 „

Drawn by Mr. J. J. Wild, Artist to the 'Challenger' Expedition.

Fig. 5. Enlarged view of a vertical section of the corallum.

C. Zooid-cavity or calicle.

B, B. Branches of the canal-system.

Fig. 6. Section of the corallum cut parallel to its outer surface, showing a portion of a system of zooids.

C. Calicle of mouthed zooid in horizontal section.

C', C'. Calicles of mouthless zooids.

B'. Branch of a canal-system which communicates by means of a lateral offset with one of the zooid-cavities.

The dark linear bodies represented as embedded in the calcareous matter are cavities bored by parasitic vegetable organisms, the black dots being spore-cavities. In one of the calicles a branched mycelial thread is seen to cross over between the tubular cavities bored in the corallum.

Fig. 7 shows the appearance presented under transmitted light by a thin horizontal section of the corallum of a species of *Millepora* from Zamboangan, Philippines, in which the calicles and canal-systems have become filled with opake matter. The black streaks thus shown represent the ramifications of the canals of the hydrophyton within the tortuous canals in the substance of the corallum, and show their anastomoses with the calicular cavities.

Fig. 8. Portion of a fine section of the corallum, as seen under HARTNACH's objective No. 8, eyepiece No. 3.

The canals bored by the parasitic fungus are seen traversing the calcareous matter.

At (*a*) the fibro-crystalline elements of the hard tissue project in a series of points.

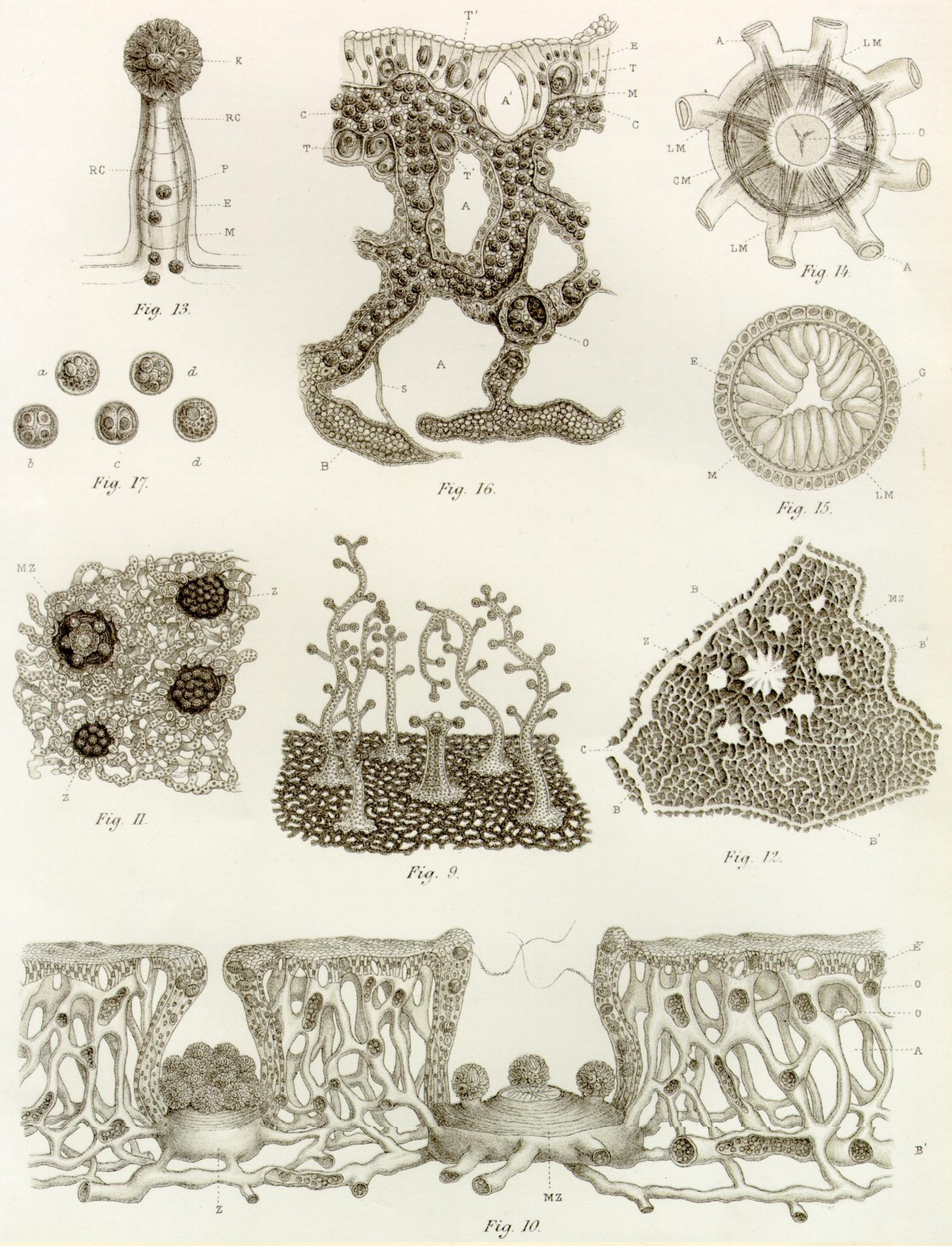


PLATE 3.

Fig. 9. View of a group of zooids in the expanded condition. In the centre is the short mouth-bearing zooid, provided with only four tentacles. Grouped around are seen five mouthless zooids. A sixth such zooid belonging to the group is omitted from the drawing for the sake of clearness.

Fig. 10. Vertical section of the decalcified living superficial layer. A mouthed zooid and a mouthless zooid are shown in the retracted condition. In the mouthed zooid one tentacle is omitted for the sake of clearness. The open spaces in the network of the hydrophyton are in the recent condition occupied by the calcareous network. The vessels are in places cut through, and have the pigmented endodermal cells exposed to view.

E. Superficial layer of the ectoderm.
Z. Mouthless zooid.
MZ. Mouthed zooid.
A. One of the spaces occupied by calcareous matter in the recent condition.
B. Secondary branch of one of the canals of the hydrophyton.
O. One of the cut openings into one of the vessels.

Fig. 11. View of a group of zooids as seen in the contracted condition. One mouthed and three of the surrounding mouthless zooids are shown. The mouthed zooid here has five tentacles. The surface of the decalcified coral is here represented as seen when viewed from above with the microscope focused somewhat into the depths of the structure. A deep focus is necessary in order to reach the far-retracted zooids. The deeper reticulations of the hydrophyton are thus brought into view.

MZ. Mouthed zooid.
Z, Z. Mouthless zooids.

Fig. 12. View of the inferior surface of the superficial living layer, from a specimen decalcified in chromic acid and viewed by reflected light. The figure shows the ramifications of the canals and vessels of the hydrophyton and their connexions with the zooids of one complete group or system.

MZ. Under surface of mouthed zooid.
Z. One of the seven surrounding mouthless zooids.
C. Canal.
B, B. Branches of this canal.
B′, B′. Secondary branches, from which and from B B arises a complicated network of finer vessels.

Fig. 13. Enlarged view of a tentacle of a mouthless zooid.

K. Spherical head of the tentacle filled with thread-cells of various sizes.
E. Ectodermal layer.
RC. Ramified cells or nuclei of the endodermal layer.
M. Membranous layer.
P. Pigmented cells within the cavity of the tentacle.
C. Body-cavity continuous with that of the tentacle.

Fig. 14. Diagram showing the arrangement of the muscular fibres in a mouthed zooid. The longitudinal muscles are gathered into bundles, which pass outwards for insertion on to the radially disposed vessels of the hydrophyton. Other fibres, less densely placed, occupy the interspaces between these bundles.

O. Mouth of the zooid.
A, A. Radially disposed vascular offsets from the base of the zooid.
LM. Longitudinal muscular bundles.
CM. Circular muscular fibres.

Fig. 15. Transverse section of a mouthed zooid.

E. Ectodermal layer, containing thread-cells in various stages of development.
M. Membranous layer.
LM. Longitudinal muscular fibres seen in section as a series of dark points.
G. Gastric cells.

The narrow dark zone between the longitudinal muscles and membranous layer indicates a possibly existing circular muscular layer.

Fig. 16. Small portion of a vertical section of the hydrophyton, much enlarged, showing the histological structure of the vascular network. The vessels are seen cut open in almost their entire course. The walls of the deeper vessels are very thin, and these vessels are filled with transparent spherical globules. More superficially the walls of the vessels become thickened, and the cells composing their ectodermal layer are seen in several places to be in process of development into thread-cells. At the actual surface the cells of the ectoderm assume an elongate prismatic form. The vessels of the more superficial parts of the network are filled with the pigmented cells, mingled with transparent globules.

E. Superficial layer of the ectoderm.
M. Membranous layer of the hydrorhizal vessels.
C, C. Pigmented cells lying in the cavities of the vessels.
B. Transparent globules filling the deeper vessels.
T, T. Developing ovoid thread-cells.
T′. Developing thread-cells of the form peculiar to Hydrozoa.
S. Band of gelatinous tissue passing between the walls of two neighbouring vessels.
A, A. Spaces occupied in the recent condition by calcareous matter.
A′. Such a space in the superficial ectodermal layer.
O. Opening in a vessel cut at right angles to its course.

Fig. 17. Pigmented cells, of which the endoderm of the hydrorhizal vessels is mainly composed, and which are abundant also within the body-cavities of the zooids.

a, *d*, *d*. Examples of the cells, showing various forms and arrangements of the pigmented granules and vesicles which compose their contents.
c. Cell showing a division of its contents into two.
b. Cell showing a further division of its contents into four.