The Structure of Xenia Hicksoni, nov. sp., with some Observations on Heteroxenia Elizabethæ, Kölliker.

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With Plates 23—27.

Contents.

Introduction.

At the suggestion of Professor Hickson I undertook to examine a specimen of the Alcyonaceous coral Xenia, which he had collected on the reefs of Talisse Island, North Celebes, chiefly with the intention of working out the arrangement of the canals of the colony. As the investigation proceeded the preservation of the colony was found to be so exceptionally perfect that it seemed desirable to make a study of its histology, and as several new and interesting points were early observed I finally decided to work out in detail the complete anatomy and histology of the colony. Although many authors have described the external characters of various species of Xenia, few have paid any attention to their internal structure. Bourne (1895) has referred to the canal system, the mesoglœa, and the distribution of spicules in two species of Xenia, and in Heteroxenia Elizabethæ, and Kölliker (1874) described the anatomy of his new Heteroxenia Elizabethæ as far as its very imperfect preservation would permit. These two accounts contain practically the whole of our knowledge of the internal structure of these two genera, and hence, when the beautiful preservation of this colony of Xenia from Talisse was apparent, there was a strong inducement to attempt a more complete account of its detailed anatomy and histology.

The work has been carried on during the past two years in the zoological laboratories of the Owens College. My best thanks are due to Professor Hickson for the beautifully preserved specimen upon which most of my work has been done, and for advice and criticism given during the progress of the work. I am also indebted to Professor Lankester for a specimen of Heteroxenia Elizabethæ, to Mr. J. S. Gardiner for a specimen of Xenia from Rotuma, and to Dr. Arthur Willey for fourteen specimens of Xenia from various reefs in the Pacific.

External Characters of the Colony (Pl. 23).

The Xeniidæ are distinguished from all other Alcyonaria by their soft, fleshy consistency and non-retractile polyps. The former character is due to the fact that their spicules are very minute rounded or oval discs, which have an organic basis impregnated with only a small quantity of calcium carbonate.

This colony arises from a single stem, which is slightly expanded at its point of attachment to the rock, and measures about 15 mm. in diameter at that point. This basal portion is very short and thick, and supports four main stems, all of which divide into two or more, producing altogether thirteen stems or branches ranging in length from about 10 mm. to 30 mm., and in breadth from about 4 mm. to 10 mm. The total height of the colony from the point of attachment to the tips of the highest polyps is 50 mm.

The polyps are, for the greater part of their length, bound together in bundles of about forty to sixty, each bundle forming one stem of the colony. The free portions of the polyps arise from the slightly expanded umbrella-shaped area at the distal end of each stem. Many of the polyps stand almost perpendicularly to the convex disc, but those near the edge of the disc hang downwards towards the base of the colony. The polyps are closer together near the edge of the umbrella, being here ·5 mm. to ·7 mm. apart, whereas in the middle of the umbrella they are 1 mm. to 2 mm. apart.

Polyps (Pl. 24, fig. 2).—The polyps, or, more correctly, the free portions of the polyps, are non-retractile and moderately long and slender. The tentacles are half to two thirds as long as the body of the polyp. Each tentacle bears on its inner side numerous short, conical elevations with rounded ends. These correspond to the pinnules found on the tentacles of other Alcyonaria.

The colour of the colony in spirit is light brown.

As mentioned above, the free portions of about forty to sixty fully developed polyps project from the umbrella-shaped area at the distal end of each stem, but besides these there are several younger polyps or buds in various stages of development, and these are invariably situated on the edge of the umbrella.

In fully developed specimens the following are the measurements:—"Body" of the free portion of the polyp 4 mm. to

7 mm. long, and 1·0 mm. to 1·2 mm. broad. Tentacles 2 mm. to 5·7 mm. long, and ·75 mm. broad. The total length of the adult polyps is thus 6 mm. to 12 mm.

The body of the polyp is cylindrical and its wall moderately strong. In several of the Xeniidæ the body-wall of the polyp is so weak that when the colony is taken out of spirit the polyps fall together into a mass. In this species, however, the body-wall is just strong enough to support the polyps in an upright position, so that on removing the colony from spirit the polyps do not hang limply, but remain standing approximately in their natural positions.

Tentacles and Pinnules (Pl. 24, figs. 2 and 3).—Each polyp bears eight tentacles, each of which is provided with numerous pinnules. The pinnules on each side of the middle line of the tentacle are arranged in three longitudinal rows, and they form also somewhat oblique transverse rows of three pinnules rising from the oral towards the aboral side of the tentacle (fig. 3, *D*). When the tentacle is viewed from the inner or oral aspect, all the pinnules are generally visible (fig. 3, *B*, *D*), but on the outer or aboral side of the tentacle only the outer longitudinal row of each side is, as a rule, seen (fig. 3, *A*, *C*). The pinnules are often clearly separated into the two series of three rows in each by a narrow area which extends along the middle line of the inner face of the tentacle, from the base to within a short distance of the tip (fig. 3, *D*). This area, free from pinnules, may be ·25 mm. across, and may often be traced to within 1 mm. of the tip of the tentacle. In other specimens, however, it is entirely obliterated, and the median pinnules of the two series are in contact with each other, at any rate at their bases. The width of this area varies, not only in separate individuals, but in the different tentacles of the same individual. These variations are probably due to the different degrees of contraction of the tentacles on killing, and the condition in which the free area is well marked is seen only in those tentacles which have been killed in an expanded condition.

At the tip of the tentacle the pinnules are smaller than those in the middle. They are arranged more or less in two series, one on each side of the middle line of the tentacle, but three rows on each side are not distinguishable; at a distance of about 1 mm. from the tip of the tentacle, however, the typical arrangement of two series, with three rows of pinnules in each, is gradually assumed (fig. 3, *B*).

At the base of the tentacle the pinnules are much smaller but have the typical arrangement, except in the case of one or two of the proximal transverse rows. Here the pinnules appear to be in course of formation, the outer ones being formed first, the inner ones developing from without inwards (see fig. 3, *D*).

On looking at the tentacle from the outer side only the outermost row of pinnules is usually visible. These, which are about twelve to twenty in number on each side, are set close together and point towards the tip of the tentacle (fig. 3, *A*). At the tip of the tentacle the arrangement of the pinnules may be well studied, and, as in Alcyonium (Hickson, 1895), they are not paired (Pl. 24, fig. 2). The pinnules are conical elevations with rounded ends. Those in the middle portion of the tentacle are about ·5 mm. long and ·15 mm. to ·2 mm. broad, but those nearer the base and tip are smaller. The pinnules when fully expanded are about three times as long as they are broad, and each tapers gradually from its base to its blunt, rounded tip. When slightly contracted the pinnule is somewhat swollen at its base, and if further contracted becomes more swollen and globular at its base as its length decreases. Although the body of the polyp is non-retractile, the tentacles are often found slightly contracted, being in many cases curled inwards over the mouth. Several examples of tentacles in this condition are shown in fig. 1.

Diagnosis of the Species Xenia Hicksoni.

The species of Xenia are distinguished from each other by the general form of the colony, the size of the polyps and tentacles, the number of rows and shape of the pinnules, and the presence or absence of an area free from pinnules on the inner face of the tentacle.

After careful comparison with the accounts of all the hitherto described species, I am unable to refer this specimen to any of them, and therefore I have established for it a new species with the name Xenia Hicksoni. Its characters are as follow:

The colony consists of several cylindrical, usually branched stems, arising from a single thick stem or base. The stems range in length from 10 mm. to 30 mm., and in breadth from 4 mm. to 10 mm. From the arched or convex summit of each stem the free parts of the polyps arise. These are smaller and moderately close together near the edge of the summit, but larger and further apart in the middle of the arched end. The polyps (including tentacles) measure 6 mm. to 12 mm. in length, and 1 mm. to 1·2 mm. in breadth. The tentacles are moderately slender and 2 mm. to 5·7 mm. long. Each tentacle bears on the inner side two series of pinnules, each series consisting of three rows of twelve to twenty pinnules in each row. There is usually a narrow area free from pinnules extending along the middle line of the tentacle to within about 1 mm. of the tip. The pinnules are conical elevations with rounded ends. Those in the middle of the tentacle are about ·5 mm. long, and are about three times as long as they are broad; those nearer the base and tip of the tentacle are somewhat shorter. The body-wall of the polyps is moderately thick, and is strong enough to support the polyps in their natural position when the colony is removed from spirit. The spicules are round or oval discs measuring ·012 mm. to ·022 mm. in length, ·006 mm. to ·013 mm. in width, and about ·004 mm. in thickness. They are numerous in the ectoderm of the stem and of the body of the polyp, but are practically absent from the tentacles and pinnules.

Round the edge of the umbellate summit of each stem are a few buds or young polyps in early stages of development. The specimen is light brown in colour (in spirit).

Habitat.—The reefs of Talisse Island, North Celebes.

This species appears to differ from most, if not all other species of Xenia in the absence of spicules from the tentacles and pinnules. In general form of the colony this specimen most resembles X. umbellata, Savigny, but it differs from the latter in possessing smaller polyps, with much shorter and stouter pinnules, which do not leave the axis of the tentacle free along its whole length (cf. Klunzinger, 1877, pl. 3, fig. 3*a*).

General Anatomy.

Stomodæum and Mesenterial Filaments.—In the centre of the oral disc of each polyp there is a funnel-shaped depression about one third of a millimetre in depth leading to the mouth. This depression is formed by partial contraction of the oral disc; if the polyp were fully expanded this depression would not exist, but the mouth opening would be level with the oral disc. The mouth (*Mo.*) leads into the stomodæum (*St.*), which is 1·8 mm. to 2·2 mm. long. The stomodæum is long compared with the length of the free portion of the polyp, and in longitudinal section presents a striking appearance, running down, as it does, so far into the cœlenteron. The stomodæum is oval in transverse section, being somewhat flattened from side to side. It has a well-marked ventral groove or siphonoglyph (*Si.*), the cells of the lower third of which bear long flagella (*F.*). The groove is not as well marked in the upper as in the lower portion of the stomodæum, and is scarcely discernible at the mouth opening. The columnar epithelial cells forming the siphonoglyph are, as is usual, longer than those of the rest of the stomodæum, and these cells bear very long flagella (·07 mm.), which in some examples extend almost to the centre of the cavity of the stomodæum. The epithelium of the rest of the stomodæum is smooth and not folded in any way. Many of these epithelial cells bear short cilia on the free surface, but among these are numerous cells (*G.*), which are, like goblet-cells, swollen or flask-shaped, due to the presence of some secretion to which they give rise. These cells generally appear to be empty, having discharged their secretion, which in some cases can be seen issuing from the cell into the cavity of the stomodæum (Pl. 26, fig. 18). These secreting cells occur chiefly in the middle and lower portions of the stomodæum, and are most abundant on the lateral walls near the siphonoglyph. They

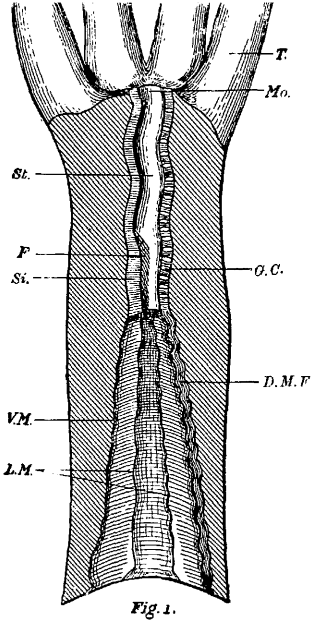

Fig. 1.

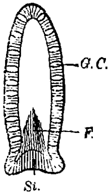

Fig. 2.

Fig. 1.—Semi-diagrammatic view of one half of a polyp which has been cut along the dorso-ventral line. Only the bases of the tentacles are shown × 20.

Fig. 2.—Transverse section through the lower third of the stomodæum (about the level of the reference letter *F* in Fig. 1) × 80.

D.M.F. Dorsal mesenterial filament on the edge of the dorsal mesentery; *F.* Flagella of siphonoglyph; *G.C.* Gland cells of stomodæum; *L.M.* Edge of lateral mesentery (mesenterial filament absent); *Mo.* Mouth; *Si.* Siphonoglyph; *St.* Stomodæum; *T.* Tentacle; *V.M.* Edge of ventral mesentery (mesenterial filament absent).

do not occur among the cells which form the siphonoglyph (Pl. 25, fig. 10). Secreting cells have not hitherto been noticed in the stomodæum of the Alcyonaria (Ashworth, 1898).

These goblet-cells of the stomodæum are the only secreting cells connected with the digestive cavity, as the six thick short ventral and lateral mesenterial filaments, which bear the gland-cells in other Alcyonaria, are absent in all polyps of this Xenia (see Woodcut, p. 252). Only the dorsal mesenteries possess thickened edges, forming two mesenterial filaments (*D.M.F.*) which have a similar course and structure to those of Alcyonium. The free edge of the ventral and lateral mesenteries is only very slightly thickened, and the thickening is due entirely to the greater amount of mesoglœa present at the edge of the mesentery. The cells which cover the edge differ in no way from those which cover the remaining portions of the mesentery.

New points in the anatomy of this Xenia are the presence of gland-cells in the stomodæum, and the absence of the six ventral and lateral mesenterial filaments usually present in the polyps of the Alcyonaria. Wilson (in Kophobelemnon, 1884) and Hickson (in Alcyonium, 1895) have shown that these mesenterial filaments bear the cells which produce the digestive secretion. I would suggest that the absence of these filaments in this Xenia is correlated with the presence of gland-cells in the stomodæum, and that the latter, judging from their appearance and position, perform some digestive function. As mentioned above, the cells are most abundant on the ventro-lateral walls of the stomodæum, near the siphonoglyph. As the flagella of the siphonoglyph create an inward current of sea water carrying food particles, which passes along the ventral groove, the greater abundance of secreting cells in the walls abutting on this groove is suggestive of the digestive function of the secretion, which can readily be poured out on to the ingoing food particles.

The siphonozooids which occur in some other Alcyonacea (e.g. Sarcophyton) and in Pennatulids are the only recorded examples of polyps in which the ventral and lateral mesenterial filaments are absent. According to Wilson (1884), these siphonozooids derive their food supply from the autozooids or feeding polyps, the dorsal mesenterial filaments of the former creating upward currents which cause a flow of fluid from the autozooids to the siphonozooids, through the canals which connect them together. Food undergoes digestion in the autozooids, and some of the products are passed on to the siphonozooids, hence the latter do not require cells to produce a digestive secretion.

In this Xenia the secretion in connection with the digestive cavity is formed, not by endoderm cells, but by cells which are derived from the ectoderm, as from a study of the buds I have found that the stomodæum is ectodermic in origin in this as it is in other Alcyonaria (Wilson, 1883). Since the absence of ventral mesenterial filaments in Xenia Hicksoni was proved I have carefully examined all the other specimens of Xenia at my disposal. These are sixteen in number, viz. one from Talisse Island, North Celebes, one from Rotuma, Fiji Islands, and fourteen from various reefs in the Pacific. In all these the ventral and lateral mesenterial filaments are absent, there being only a very slight thickening of the free edges of the mesenteries, this thickening being entirely due to a slight increase in the amount of the mesoglœa along the free edges. In all the specimens the two dorsal mesenterial filaments are present, and have the typical course and structure. In Heteroxenia Elizabethæ the two dorsal mesenterial filaments only are present. The absence of ventral and lateral mesenterial filaments may, therefore, be considered as one of the characters which distinguish the polyps of the genera Xenia and Heteroxenia from those of other Alcyonaria. In two at least of the specimens of Xenia[1] from Dr. Willey's collection some of the cells of the stomodæum are goblet-like, and similar to those described above in the stomodæum of Xenia Hicksoni.

Cœlentera of Polyps.—The other parts of the colony present a structure similar, in the main features, to that

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[1] X. crassa, Schenk, and X. viridis, Schenk.

of other Alcyonaria. The polyps are, for the greater part of their length, bound together in bundles of about forty to sixty, each bundle forming one stem of the colony. The external characters of the free portion of the polyp have been described above. The eight mesenteries of the polyp are arranged as in typical Alcyonaria. On their ventral faces they bear the retractor muscles, and on the opposite faces the protractor muscles, neither of which are well developed. This somewhat feeble development of retractor and protractor muscles accounts for the non-retractile nature of the polyps. The intermesenterial spaces are continued upwards into each tentacle and into each pinnule. In the free portion of the polyp, and particularly in the tentacles and pinnules, these spaces are to a large extent filled up by zooxanthellæ. The specimen is a male, and in the lower part of the free portion of the polyp, and in the upper part of the stem, the cœlentera are crowded with sperm-sacs containing spermatozoa in all stages of development, from the small masses containing only two or four primitive sperm-cells to the large mature sperm-sacs containing many hundreds of ripe spermatozoa.

Mesoglœa, its Canals and Cells.—In the stems the cœlentera of the polyps are bound together by a moderately large quantity of mesoglœa. The mesoglœa immediately round each polyp is slightly denser than that further away, so that in transverse sections of the stem, especially if the sections be taken through the upper part, one can distinguish the more deeply staining ring of slightly denser mesoglœa, which definitely belongs to the cœlenteron within it, from the less dense mass of mesoglœa between these rings, which cannot be assigned to any polyp or polyps (Plate 25, fig. 9). Traversing the mesoglœa of the stem are numerous canals, cords and strands of cells, which place all the parts in intimate communication with each other. The canals may be divided into two systems—a superficial system and an internal system.

The superficial canal system (figs. 8, 9, *Sup. Can.*) is formed by a plexus of numerous endodermic canals, which are situated in the outer portion of the mesoglœa, just beneath the ectoderm of the stem. This system of canals extends all round the cylindrical stems, and also runs on the umbrella-shaped areas from which the free portions of the polyps arise (fig. 8). The cavity of this system of canals is invaded throughout by zooxanthellæ, which are especially numerous in the canals in the upper part of the stem.

The internal canal system consists of a series of longitudinal canals (figs. 8, 9, *Long. Can.*) which run generally in a sinuous or zigzag course in the mesoglœa, between the cœlentera of the polyps. These canals lie in the mesoglœa, almost equidistant from the surrounding cœlentera, and they run in this position from the top of each stem to the base of the colony. These canals are also endodermic, and have usually only a small lumen. They communicate with the cœlentera of the polyps, with the superficial canal system, and with each other.

At the base of the colony the canal system is exceedingly complicated, due to the numerous branchings and anastomoses of the canals. The cœlentera are continued down to the base of attachment of the colony, where they are in communication with the numerous branches of the canal systems. The cœlentera are readily distinguishable from the canals by their greater size, and the presence in them of eight small ridges, to which the mesenteries in this region are reduced. Besides the superficial and longitudinal canals briefly described above, there are in connection with the longitudinal canals numerous small lateral or transverse canals, with small lumen, which pass from the canals either to other neighbouring canals or to the cœlentera (figs. 8, 9). The cœlentera of the polyps do not open into each other directly, but are indirectly connected by these canals.

The base of the cylindrical main stem is somewhat flattened out, and this basal portion is hard and horny; and, being closely applied to the rock, provided a firm basis upon which the other parts of the colony were supported.

Ectoderm.

The ectoderm is a moderately thick layer, in which large columnar and smaller interstitial cells may with difficulty be distinguished. If a section of a tentacle or pinnule, which was well expanded at the moment of killing, be examined, the ectoderm is then seen to consist of a row of cells elongated at right angles to the free surface, below which are smaller rounded cells which probably correspond to the interstitial cells of the ectoderm of Alcyonium and other cœlentera. (Pl. 25, fig. 11).

The protoplasm of the ectoderm cells is very finely granular; occasionally cells are met with containing a few small vacuoles. Many of the ectoderm cells of the tentacles and pinnules are produced at their inner ends into muscle processes which lie in the outer portion of the mesoglœa, parallel to the free surface. These muscles are all longitudinal in direction. The ectodermic muscles of the tentacles are much more strongly developed on the oral than on the aboral side, especially at the base of the tentacles, where the muscles of the oral side form a strong band beneath the cells quite eight times as thick as the band of muscles on the aboral side. Nearer the tip of the tentacle the muscles of the two sides become almost equal.

In the body of the polyp ectodermic muscles are present only in the distal portion around the base of attachment of the tentacles and for a distance of about a millimetre below this point. Myo-epithelial cells are absent from the ectoderm of the stem. The absence of muscle-cells from the ectoderm of the stem and the greater portion of the body of the polyp is connected with the non-retractile character of these parts. Their presence in the tentacles, pinnules, and distal portion of the body of the polyp confers on these parts some power of contraction, and an examination shows that the pinnules and tentacles vary somewhat in length and shape, and that the tentacles are often turned inwards over the mouth, due to the contraction of the muscles of the oral side. The absence of spicules from the tentacles and distal portion of the polyp renders the ectoderm softer and more pliable, and therefore more readily acted upon by the contraction and expansion of the muscle processes of its cells.

Among the ordinary columnar cells there are in the ectoderm of the stem and the body of the polyp large swollen cells which probably secrete the mucus which thinly covers the external surface of most of these parts (Pl. 26, fig. 17, *Muc. C.*). These mucus-cells are large and abundant in the angle of the Y-shaped piece formed where a stem divides.

The ectoderm cells present on their outer side a moderately plane surface, but on the inner side a more irregular one, as numerous processes pass from the cells inwards and establish communication either with the endoderm or with cells lying deeper in the mesoglœa (fig. 17).

On reaching the base of the colony the ectoderm curves inward, and was applied to the face of the rock to which the colony was attached.

The stomodæum is ectodermic in origin in this as in other Alcyonaria (Wilson, 1883), as may be seen from a study of the buds. The presence of a ventral ciliated groove and of gland-cells and other features of its structure have already been referred to (p. 251). The ectoderm of the stomodæum and the adjacent endoderm are connected by numerous cells or strands of cells passing through the thin mesoglœal lamina which separates the two cell layers (Pl. 26, fig. 18).

The ectoderm cells give rise to nematocysts and spicules.

Nematocysts.—The nematocysts are exceedingly numerous in the ectoderm of the tentacles and pinnules (Pl. 25, fig. 11, *Nem.*); there are large numbers in the ectoderm of the body of the polyp, rather fewer in the ectoderm of the stem, and a few in the ectoderm of the oral disc, in the funnel leading to the mouth, and also in the upper part of the stomodæum. The nematocysts are, as in other Alcyonaria, exceedingly small, their length being ·008 mm. and their breadth ·002 mm. to ·003 mm. They have bluntly pointed ends and are circular in transverse section. Each nematocyst is formed in a cnidoblast cell

(Pl. 25, fig. 12, *Cn. C.*), the nucleus and protoplasm of which lie flattened against the capsule on one side and a little nearer the inner than the outer end of the capsule. The filament or thread lies coiled up inside this capsule, there being about twelve coils distinguishable in the most favourable specimens. The thread appears to be quite simple, there being no barbs visible. Its length when shot out would probably be about 80 μ (·08 mm.). The nematocysts are usually placed with their long axes at right angles to, and their bluntly pointed ends level with or slightly projecting from, the free surface of the ectoderm. This can be especially well seen in sections of the tentacles and pinnules (see fig. 11). The nematocysts stain deeply with thionin, hæmatoxylin, and especially with iron hæmatoxylin (Heidenhain). Iron hæmatoxylin is exceedingly useful for staining the small nematocysts of Alcyonaria; in fact, without some good staining reagent it would be very difficult to find the minute capsules in many cases. Moseley (1881, p. 119) wrote that "no nematocysts were found in Sarcophyton," but by using the iron hæmatoxylin stain I have found them in sections passing through the ectoderm of the tentacles. They are very similar in shape to those of Xenia Hicksoni, but smaller in size, being only 6 μ to 7 μ long and 2 μ wide. The nematocysts of Alcyonaria are all very small, as may be seen from the following table:

Sarcophyton pauciflorum[1]	6 μ— 7 μ	long	and	2 μ	wide	(J. H. A.)
Alcyonium digitatum . .	7½ μ	,,	,,	2 μ—3 μ	,,	(Hickson)
Xenia Hicksoni	8 μ	,,	,,	2 μ—3 μ	,,	(J. H. A.)
Heteroxenia Elizabethæ .	9 μ	,,	,,	2½ μ	,,	(J. H. A.)
Clavularia viridis . . .	9 μ—10 μ	,,	,,	2 μ—3 μ	,,	(J. H. A.)
Heliopora cœrulea . . .	9 μ	,,	. .	. . . .	. .	(Moseley)
Clavularia prolifera . .	10 μ—15 μ	,,	. .	. . . .	. .	(v. Koch)

Spicules (Pl. 25, figs. 13—15; Pl. 26, fig. 16).—The spicules, the form of which was compared by Kölliker to that of red blood-corpuscles, are rounded or oval discs, which are, however, sometimes bilobed (fig. 13). They are ·012 mm. to

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[1] S. pauciflorum, Ehrenberg = Lobophytum pauciflorum, v. Marenzeller, 'Zool. Jahrb.,' i, 1886.

·022 mm. long, ·006 mm. to ·013 mm. broad, and ·003 mm. to ·005 mm. thick.

Spicules are absent from the tentacles and pinnules of all the polyps examined except one. In the latter a few small spicules (about 8 μ to 12 μ long) are present in the ectoderm of the tentacles, but only in the proximal ·4 mm.

In the deeper part of the ectoderm, just below the point of attachment of the tentacles, spicules are present in small numbers, while in the middle and proximal portions of the body of the polyp they are very numerous, a tangential section of the body-wall in this region showing that the spicules form an almost complete layer in the deeper part of the ectoderm. Spicules are numerous in the ectoderm of the stem, and especially numerous in the angle of the Y-shaped piece formed at the point of division of a stem. In the lowest parts of the colony, i. e. in the portion attached to the rock, they are present in enormous numbers, practically filling the entire mesoglœa in that region. The largest examples of spicules are to be found in the basal portion of the colony. (Those shown in fig. 13 are from this region.) The absence of spicules from the tentacles, pinnules, and from the body of the polyp around the base of the tentacles is correlated with the power of contractility, slight though it is, which is possessed by these parts. The presence of an almost complete layer of spicules forming a more or less rigid cylinder in the middle and proximal portions of the body of the polyp and in the stem, together with the absence of muscle processes from the ectoderm cells of these portions, sufficiently accounts for the non-retractile character of these parts of the colony. The increased number of spicules in the angle between two branches gives the required rigidity to this part, and prevents flexure of the branches and consequent closure of some of their canals and cœlentera.

Besides the extraordinary number of spicules present in the ectoderm and mesoglœa of the last few millimetres of the base of the colony, this part is further strengthened by much of the mesoglœa becoming converted into a dense and horny substance, so that the part of the colony attached to the rock is hard and quite different to the touch from any other part of the colony. This hard base would afford a firm attachment and a rigid support to the branches which arise from it.

The spicules are formed within cells which at first lie in the deeper parts of the ectoderm or have migrated into the outer parts of the mesoglœa (fig. 16). The arrangement of the spicules is not very regular, as they appear to present to the free surface their edge or their flat face indifferently. In nearly all preparations the nucleus and remains of the protoplasm of the spicule-forming cell can be seen. The spicules, which have a horny consistency, have an organic basis impregnated with only a very small amount of calcareous matter. They stain deeply with hæmatoxylin, especially with hæmalum. They do not dissolve when treated with acids, but shrink very slightly, probably owing to the solution and extraction of the small amount of calcareous matter which they contain. They do not offer any difficulties in section-cutting, as the razor cuts through them with little resistance, and sections 2 μ to 4 μ in thickness may be readily obtained, although the specimen has not been previously decalcified. On this account Xenia offers exceptional facilities for the study of the development of spicules. As mentioned above, each spicule is formed within a cell lying in the deeper part of the ectoderm. When the young spicule first makes its appearance in the cell its substance is scarcely distinguishable from the protoplasm of the cell; in fact, it is not until the spicule has attained a diameter of 3 μ to 4 μ that it is possible to clearly differentiate it (Pl. 25, fig. 15). The young spicule is then a small disc which stains with hæmatoxylin like the protoplasm of the cell, but its homogeneous structure enables the observer to distinguish it from the finely granular cell-protoplasm which surrounds it. From this stage the spicule grows regularly in length and thickness, and the protoplasm of the cell covering it becomes gradually thinner until, in a fully formed spicule, this protoplasmic sheath forms an exceedingly thin investment, in which at one part may be seen the small, somewhat flattened nucleus embedded in a small mass of protoplasm (figs. 13 and 14). In all the specimens, many hundreds in number, which I have examined, the spicule develops in a single cell with one nucleus. I have not been able to find any examples which showed that two cells or two nuclei were concerned in the formation of the spicule (cf. v. Koch's account of the development of the spicules of Clavularia prolifera, 'Morph. Jahrb.,' vii, p. 473, 1882).

Mesenteries (Pl. 26).

Mesenterial Filaments.—The stomodæum leads into the cœlenteron of the polyp, which is subdivided by the usual eight mesenteries (Pl. 25, fig. 10). Of these only the two dorsal ones possess thickened edges or mesenterial filaments (Pl. 26, fig. 19). The free edge of the remaining six mesenteries is only very slightly thickened, this being due entirely to the presence of a slightly greater amount of mesoglœa near the free edge of the mesentery. The cells which cover this thickened portion differ in no way from those covering the other parts of the mesentery (Pl. 26, fig. 20). The six ventral and lateral mesenterial filaments usually present in the polyps of the Alcyonaria are not found in this genus. The dorsal mesenterial filaments arise from the lower edge of the stomodæum and run in a sinuous course along the dorsal side of the cœlenteron. In the primary polyps they may be traced to the base of the colony. In transverse section the filament is slightly bilobed, i. e. there is a groove (of slightly varying depth) extending all the way down the middle of the free surface of the filament (fig. 19). The cells on each side of this groove bear long cilia (·0075 mm.). The dorsal mesenterial filaments are quite typical, and agree well with the accounts given of those of other Alcyonaria by Wilson and Hickson. They are probably ectodermic in origin, as they appear to be formed as two downgrowths from the inner end of the stomodæum. The cells of the filaments agree in structure with those of the stomodæum, being finely granular and non-vacuolated, and differing markedly from the much vacuolated neighbouring endoderm cells.

Muscles.—The retractor muscles are situated on the ventral faces of the mesenteries and the protractor muscles on the dorsal faces, as in Alcyonium. These muscles are somewhat feebly developed, as might be expected from the non-retractile nature of the polyps. Shortening of the retractor muscles produces a slight contraction of the oral disc and consequent formation of the funnel-like depression leading to the mouth, to which reference has already been made (p. 251).

Cells in Mesoglœa of Mesenteries.—On examining a transverse section through the mesenteries, there is seen to be a considerable quantity of mesoglœa between the two endodermic lamellæ covering the mesentery (fig. 20). In this mesoglœa there are cells which have the reticulate protoplasm and general appearance of endoderm cells. These cells migrate into the mesoglœa from the endoderm covering the surface of the mesentery, and even in a young polyp ·8 mm. long a few cells have already taken up their position in the mesoglœa. In older polyps there is a larger number of these cells in the mesoglœa of the mesentery, though they are not equally numerous in all parts. In the upper portion of the polyp, about the level of the stomodæum, the mesoglœal cells are few in number and small in size, but from this part downwards their number and size gradually increase, until in the mesenteries in the upper portion of the stem they are large and numerous, and in some cases completely fill up the mesoglœa, so that the mass of cells is in close contact on both sides with the endoderm covering the two sides of the mesentery. Towards the base of the stem the cells become fewer in number and slightly smaller in size. These cells are found in the mesoglœa of all the mesenteries, but they are less numerous in the dorsal mesenteries than in the remaining six. Many of the cells are at first somewhat elongated or pear-shaped, with one or more processes in connection with, or pointed towards, the endoderm; but later many of them become rounded and larger, and their nuclei become much larger.

The primitive genital cells are derived from these large rounded cells in the mesoglœa of the mesenteries at the base of the polyp and in the upper portions of the stem. That this is the case is shown by the following:

(1) These cells are most numerous in those parts of the colony where gonads occur in greatest numbers.

(2) In many cases one of these cells, surrounded by a thin film of mesoglœa, may be seen enclosed in a follicle of endoderm projecting from the edge of the mesentery. These are exactly similar to the neighbouring follicles which contain spermatozoa in various later stages of development.

(3) The nuclei of most of these cells are large and spherical, more vesicular than the nuclei of the adjacent endoderm cells, and resemble the nuclei of the genital cells (see Pl. 27, fig. 30).

(4) The ripe spermatozoa are situated in a follicle covered by a thin mesoglœal lamina, as well as by the endoderm cells outside this, i. e. the ripe spermatozoa are situated in the same layer as these cells, viz. in the mesoglœa.

The migration of genital cells from the endoderm of the mesenteries into the mesoglœa is similar to that described by O. and R. Hertwig in Actiniæ ('Die Actinien,' Jena, 1879, p. 95, and pl. 7).

Endoderm (Pl. 26).

The endoderm cells lining the cœlentera and the cavities of the tentacles have a similar structure throughout the colony. They are cubical or columnar, and contain many small vacuoles which give the protoplasm a reticulate appearance.

Cells which bear Flagella (figs. 20—25, 27).—Among the ordinary endoderm cells there are numerous cells, the inner or free end of which is produced into a long process, which is from four to eight times as long as the basal portion of the cell. This process may be slender or moderately stout, and its length may vary in different specimens from ·015 mm. to ·12 mm. The basal part of the cell from which the process arises has the reticulate protoplasm of an ordinary endoderm cell, and the nucleus of the cell is situated in this portion. The process is not vacuolated, and for the greater part of its length its protoplasm exhibits a homogeneous or very finely granular structure. Its basal part, i. e. the part in continuity with the vacuolated portion of the cell, stains deeply with hæmatoxylin, and in most cases shows very faint longitudinal striations which are visible only in the proximal third of the process.

The processes usually taper towards their free end, but in one instance this end is slightly broadened and flattened (fig. 25, *A*). In one case the process, which is a very large one, bears a short branch near the middle of its length (fig. 25, *B*). This is the only branched process found among many hundreds examined. The processes of most of the cells project outwards almost at right angles to the free surface of the endoderm (figs. 20, 21, 23, 24), but there are many similar to the one drawn in fig. 22, in which the process is strongly curved and apparently moderately flexible.

These curious processes are very numerous, and are found in all parts of the endoderm lining the cœlenteron and tentacles, but are most abundant in the portion of the cœlenteron situated in the body of the polyp and in the upper part of the stem (Pl. 25, fig. 9).

The nature of these processes is difficult to determine. In the preliminary note to the Royal Society (1898, written in February) I called them pseudopodia, but further investigation shows that the word flagella would probably better express their nature. The processes appear to be permanent, to have a moderately definite shape gradually tapering from base to tip, and to be flexible. The word pseudopodia implies more temporary structures with many different and continually changing shapes, while the term flagella implies tapering whip-lash-like processes of more permanent and definite shape. The homogeneous structure of the greater portion of these processes, differing so markedly from the vacuolated granular protoplasm of the rest of the cell, is also more in accord with their being flagella, as pseudopodia have the same structure as the body of the cell from which they are protruded.

It is difficult to suggest the probable function of these giant flagella. They are evidently motile organs, as they may be found in all stages of flexion, some being practically straight, while others are bent almost into a semicircle. Their action probably serves to keep the liquid in the cœlenteron in slow motion, thereby securing a more equal distribution of the nutrient substances contained therein to the cells in their vicinity.

Many of the endoderm cells are provided with "muscle processes," but these processes are not numerous in the pinnules and in the stem; they are more numerous in the endoderm of the tentacles and of the free portion of the polyp. The muscle-fibres (except those forming the retractors and protractors) have a circular direction, and are similar to those of Alcyonium. In Alcyonium, however, the endoderm cells of the tentacles do not possess muscle-fibres (Hickson, 1895, p. 376).

In teased preparations the muscle-fibres of the ordinary endoderm cells may be clearly seen (fig. 26). On looking at the flagella-bearing cells in the same preparations, it is seen that most of these cells bear at their inner ends two processes which appear to be less stiff than the muscle-fibres of the ordinary endoderm cells, and which are never in a straight line with each other, but are invariably bent more or less towards each other (fig. 27). It is possible that these are the modified muscle-fibres of the cell, as they appear to be homogeneous, and, when treated with fuchsin or iron hæmatoxylin, stain similarly to, though rather less deeply than, the muscle processes of ordinary endoderm cells. The bending inwards of the two processes from the inner end of the cell causes them to become rather more deeply embedded in the mesoglœa than the muscle processes of the ordinary endoderm cells, and the cell is therefore provided with a firmly fixed base upon which the giant flagellum can work as on a fulcrum.

It is worthy of note that throughout the whole of the colony the muscle processes of the endoderm cells (except the protractor and retractor muscles on the mesenteries) are circular in direction, whereas the similar processes (where present) of the ectoderm cells are longitudinal in direction.

Zooxanthellæ are exceedingly numerous in the endoderm of the pinnules, so numerous that, in many cases, the lumina of the pinnules are entirely closed. They are also numerous in the endoderm of the tentacles and of the free portion of the polyp, but in the cœlentera of the stem there are few, except near the upper end. There do not appear to be any large gaps between the endoderm cells in the lower parts of the cœlentera, as described by Hickson in Alcyonium, but the endoderm cells in this part are more or less spherical in shape, and are only loosely connected together.

Mesoglœa.

1. Of the Free Portion of the Polyp.—The mesoglœa of the body of the polyp varies in thickness from ·02 mm. to ·06 mm., while that of the tentacles is much thinner, averaging ·013 mm. The mesoglœa of the pinnules is exceedingly thin, especially when they are expanded (cf. figs. 11, 17).

Cells which connect the ectoderm and endoderm may be seen crossing the mesoglœa in all parts of the tentacles and body of the polyps. In the tentacles, however, these cells are few in number, but in the body of the polyp, where the mesoglœa is thicker, the cells are more numerous. They are usually elongated or fusiform cells, having their outer ends embedded in or connected with the ectoderm, and their tapering inner ends passing into the endoderm (fig. 17). In most cases the connection between the two cell-layers is established by means of a single cell, but in some cases two or more cells are placed end to end to form the connecting cord. In most cases the larger portion of the cell and its nucleus are situated in the ectoderm, and this, together with the nature of the cell, which closely resembles an ectoderm cell in appearance, points to the fact that these cells in the mesoglœa are derived from the ectoderm. Besides these moderately large cells, the protoplasm of which is finely granular and often contains a few small vacuoles, there are other cells of very much smaller size which bear several or many processes. Some of the cells lie close to the ectoderm, while others are near the endoderm. They are connected together by their exceedingly slender processes, which traverse the mesoglœa and unite with each other. These cells resemble, and are probably homologous with, the nerve-cells and nerve-fibres of Alcyonium and the Actiniæ. They will be further described below (see p. 277). The mesoglœa of the mesenteries and its included cells have already been described (see p. 263).

2. Of the Stem (see Pl. 25, figs. 8 and 9).—On examining transverse sections of the upper portion of the stem there is seen a slightly denser ring of mesoglœa (*Mg. D.*) around each of the cœlentera. This ring of denser mesoglœa is itself moderately free from cells, being crossed only at intervals by a cell or thin cord of cells, but it is bordered by an almost complete cordon of cells, interrupted only for the passage of endodermic canals. The canals of the stem are moderately large and very numerous, being much more highly developed than those of Alcyonium. The canals may be divided into the two systems described below.

The Superficial Canal System.—This system of canals is formed by numerous endodermic canals (*Sup. Can.*, figs. 8 and 9) which are situated in the stem about ·1 mm. beneath the ectoderm. This system is really a fine network of numerous canals, which have a similar structure and appearance in all parts of the colony. The canals are about ·08 mm. in diameter. In the intervals between these canals there are usually cords of ectoderm cells (*Ect. Str.*) which pass from the ectoderm to cells in the deeper parts of the mesoglœa. In many cases the superficial endodermic canals are themselves closely connected with the ectoderm by strands of cells passing across the mesoglœa from the ectoderm to the outer walls of the canal lying beneath. From the inner wall of these canals cords of cells frequently pass inward into the mesoglœa, and are connected with other cells, with the cœlentera, or with longitudinal canals.

The superficial canals are also present on the convex summit of the stem (see fig. 8), and form there a plexus of canals, with similar relations to those above described in the cylindrical portion of the stem. In this portion of the stem the canals embrace or pass round each cœlenteron at a distance of about ·2 mm., and communicate by means of branches with the cœlenteron and with the neighbouring longitudinal canals. The superficial canals on the convex summit are continuous at the edge of the summit with the corresponding canals of the cylindrical portion of the stem. In the stem the superficial canals frequently communicate with the neighbouring cœlentera and longitudinal canals. Thus, by means of branch canals, this superficial system of canals is placed in communication with the remaining cavities lined by endoderm, and by means of strands of cells is placed in communication with the ectoderm and with the neighbouring cells in the mesoglœa.

Where a stem divides there are extra canals which establish thorough communication between the superficial canals of the two branches.

As the base of the colony is approached there is a tendency for the superficial canals to send inwards wide branches, and in the lowest 2 mm. of the stem such branches are given off in large numbers, and unite with the complicated anastomosis of longitudinal canals present in that part of the stem.

This system of canals is of great importance, as all the young buds produced in the colony are formed by enlargement and growth outwards and inwards of one of these canals, the endoderm and lumen of the canal forming respectively the endoderm and cœlenteron of the young polyp (see also p. 291).

Histology of the Superficial Endodermic Canals.—The endoderm lining the cavity of the superficial canals is always much thicker on the outer side of the canal than on the inner side (Pl. 27, fig. 29). This is caused by the cells on the outer side being columnar and longer than the cubical or slightly flattened cells of the inner side of the canal.

The cells lining these canals resemble the endoderm cells of the cœlentera, but their protoplasm is somewhat less vacuolated, and therefore does not so markedly present the reticulate appearance which is so usual in the endoderm of the cœlentera. None of the cells of these canals bear flagella. Among the bases of the cells there are small cells which are probably stages in the formation of the larger ones. Some of the cells of the canals appear to be provided with very slender muscle processes. There are numerous zooxanthellæ in the lumen of the canals and embedded in the endoderm lining the cavity.

The Internal Canal System.—The canals forming the main portion of this system are chiefly longitudinal in direction, and commence in the umbrella-shaped portion at the top of each stem. Each canal runs in a sinuous or zigzag course in the mesoglœa, about equidistant from the surrounding cœlentera.

The longitudinal canal communicates with the superficial canals lying around its origin (fig. 8). During its course down the stem the longitudinal canal very frequently communicates by small transverse canals with the neighbouring cœlentera and canals, and the longitudinal canals in the outer portion of the stem communicate also with the superficial canals. Owing to the frequent occurrence of branches, the longitudinal canals are nearly always angular in transverse section, one (or more) of the angles being usually produced into a small branch canal. The branch canals vary greatly in size; in the upper and middle portions of the colony being small, and their lumen very small or obliterated altogether, while near the base of the colony the branches are almost as large as the main canal. At the base of the colony these longitudinal canals give off several rather larger lateral branches on all sides, some of which unite with similar branches from adjacent canals, while others open into neighbouring cœlentera. Owing to the presence of so many canals in this region of the stem, the mesoglœa is penetrated in all directions by a complicated network of canals, which place all the cavities lined by endoderm in intimate communication with each other. Very close to the base of attachment of the colony, a canal may usually be seen passing from each side of the lowest portion of each primary cœlenteron, so that in longitudinal section the cœlenteron and its two canals appear ⊥-shaped. The canal opens into the base of a neighbouring cœlenteron. These canals are probably the representatives of the original stolon from which all the primary cœlentera grew out.

The well-developed longitudinal canals running parallel to and between the cœlentera of the polyps of Xenia remind one of the cœnenchymal tubes of Heliopora cœrulea, described by Moseley (1881) and by Bourne (1895). The resemblance is more striking when we consider that in both cases the longitudinal tubes are lined by endoderm, and are connected near the upper surface of the colony with a network of superficial endodermic canals.

The differences between the canals of Xenia and the cœnenchymal tubes of Heliopora are chiefly due to the fact that in the latter only the outer portion of the coral is living, the internal parts consisting of calcareous skeleton only, whereas in Xenia the whole colony is penetrated by living cells. In Heliopora, therefore, the cœlentera of the polyps and all canals running into the colony must terminate within about 2 mm. of the surface, as this is the lowest limit of the living substance. The cœnenchymal tubes of Heliopora have an exactly similar course to the longitudinal canals of Xenia, as they run parallel to the cœlentera from their point of origin from the superficial canal system (just beneath the ectoderm covering the free surface) to the base of the living portion of the colony, where they and the cœlentera terminate blindly.

Moseley (1881) believed the cœnenchymal tubes of Heliopora to be degenerate siphonozooids from which the mesenteries had disappeared, but Bourne (1895) has shown that they cannot be so regarded.

In order to find a parallel to these cœnenchymal tubes of Heliopora, Bourne thought it necessary to go outside the Alcyonaria and compare the tubes with certain longitudinal canals of Millepora, described by Moseley (1876). After carefully studying the canal system of Xenia, it appears to me that this course is not now necessary, as the comparisons instituted above between the cœnenchymal tubes of Heliopora and the longitudinal canals of Xenia are perfectly justifiable. It is true the cœnenchymal tubes of Heliopora are more numerous than the longitudinal canals of Xenia, but this also is probably due to the different modes of growth of the two corals. In Heliopora the living part is, as it were, spread out in a thin film, and the polyps are a considerable distance (1 mm. to 2 mm.) apart, several cœnenchymal tubes being therefore required to place the cœlentera in communication with the intervening ectoderm, calicoblasts (or skeleton-forming cells), and mesoglœa. In Xenia each stem is an elongated, cylindrical, compact mass of living tissues, and the polyps are much closer together, the cœlentera being only about ·25 mm. to ·4 mm. apart in the stem, and therefore one longitudinal canal, situated in the mesoglœa between adjacent cœlentera (together with the auxiliary strands and cords of cells which are so well developed in this Xenia), is sufficient to provide efficient communication between the cœlentera and all parts of the narrow mesoglœal column between them.

Histology of the Longitudinal Endodermic Canals.—These canals are lined by a single layer of cells of equal thickness on all sides (cf. the superficial canals). The cells are more or less cubical in shape, and closely resemble the endoderm cells lining the cœlentera. None of the cells in the canals bear flagella, but some bear slender muscle processes which, like those of the endoderm of the cœlentera, are chiefly circular in direction. In the canals near the base of the colony many nematocysts, each in its cnidoblast cell, may be seen lying among the endoderm cells. In the upper portions of the colony nematocysts are seldom seen in the canals. Zooxanthellæ are present only in those longitudinal canals which are situated in the circumferential portions of the stem and in the upper portion of the canals, where they approach the summit of the stem.

Cells in the Mesoglœa.—On examining a transverse section of the upper end of a stem of the colony, an almost complete chain of cells is seen surrounding the denser ring of mesoglœa round each cœlenteron (fig. 9, *Ect. Ch.*). Each ring of cells is situated at a distance of about ·06 mm.—·07 mm. from the endoderm of the cœlenteron within. These cells are the ectoderm of the portion of the polyp enclosed in the stem, as can be seen on examining a longitudinal section through the upper part of the stem (see fig. 8), when this cylinder of cells is seen to be continuous and in line with the ectoderm of the free portion of the polyp. That these cells are ectodermic is further shown by the fact that spicules and nematocysts are found in them in moderate numbers, especially in the upper portion of the stem (figs. 8 and 9, *Sp. Nem.*). Adjacent cylinders of cells are placed in intimate communication by numerous cords of cells which traverse the mesoglœa between them.

Sections taken further down the stem show that the ring of cells becomes less complete and less definite, and each ring widens and recedes into the mesoglœa a little further from its cœlenteron. As they recede further and further, the rings of cells often coalesce in the mesoglœa at a point almost equidistant from their cœlentera; and, as the longitudinal canals also lie in this region, the cells come to lie in relation with, and form a plexus around, the canals. There is, therefore, still a cylinder of cells round each cœlenteron, but the cylinder is not quite so regular as in the upper portions of the stem, being interrupted at frequent intervals, and is further away (·15 mm. to ·2 mm.) from the enclosed cœlenteron.

In the upper portion of the stem the cylinder of cells has the same relation to the endoderm of the cœlenteron within it, as have the ectoderm and endoderm of the free portion of the polyp to each other. Crossing the denser ring of mesoglœa between the cylinder of cells and the endoderm are cells (viz. the vacuolated and granular cells, and the small nerve-cells) exactly like those observed in the mesoglœa of the free portion of the polyp.

Lower down the stem the cylinder of cells has been pressed further away from its cœlenteron, probably by the later growth of the mesoglœa, and is interrupted at intervals for the passage of canals and cords of cells which place all parts of the mesoglœa in intimate communication with the cœlentera, the canals, and the external ectoderm. Bourne (1895) has shown that in Xenia umbellata these rings of cells are ectodermic on account of their connection with, and general resemblance to, the ectoderm of the free part of the polyp, and the occurrence of spicules and nematocysts in some of them.

The cords of cells in the mesoglœa are then chiefly ectodermic, as they arise from the cylinders of cells around the cœlenteron, or, in the outer portion of the mesoglœa, migrate inwards from the inner irregular surface of the external ectoderm. The cells all present a similar appearance, being either rounded or rather elongated in shape, with somewhat vacuolated protoplasm. The elongated cells frequently taper at their ends into long slender processes which become connected with similar processes of adjacent cells.

Some of the cords of cells are, however, obviously formed by obliteration of the lumen of a small canal; these cells are, of course, endoderm.

Spermatogenesis (Pl. 27, figs. 30—35).

The specimen is a male, and shows beautifully all the stages in the development of the spermatozoa.

Gonads are most numerous in the upper portion of the stems of the colony, but many sperm sacs are found in the basal part of the free portion of the polyps, and a few also in the lower portions of the colony. Sections through the upper portion of the stems show that sperm sacs are so numerous that they practically fill up the cavity of the cœlentera of several of the older polyps (Pl. 25, fig. 8, *S. S.*). In these cases most of the sperm sacs are no longer spherical, but by mutual pressure have become angular, being usually pentagonal or hexagonal in section.

The genital cells are derived from the cells which lie in the mesoglœa of the mesenteries near their inner or free edge. These cells, as shown above (see p. 263), have migrated to their present position in the mesoglœa from the endoderm, so that the gonads are, in this as in other Alcyonaria, endodermic in origin.

Each sperm sac originates as a slight projection at the side or free edge (except in the dorsal mesenteries) of the mesentery, and consists of one of these genital cells covered by a thin sheet of mesoglœa, and by a single layer of endoderm cells continuous with the endoderm of the sides of the mesentery. The genital cell, the protoplasm of which is finely granular, or sometimes contains small vacuoles, is spherical and about ·01 mm. in diameter, and in the centre has a large spherical nucleus whose diameter is about half that of the cell.

The nucleus and protoplasm of the genital cell undergo division, which at first is apparently regular, as many cases of four or eight cells so produced may be seen (fig. 30). The divisions of the genital cell are accompanied by divisions of the endoderm cells covering it, and very soon the increase in size of the sperm sac causes it to project as a spherical or oval body from the mesentery, to which it always remains attached by a stalk consisting of a thin cord of mesoglœa surrounded by endoderm. When the sperm sac has reached a diameter of about ·06 mm. to ·08 mm. there appears in the centre a small cavity, free from nuclei, but containing some coagulable substance (fig. 31, *Cg.*). This central cavity continues to enlarge for some time, along with the growth of the sperm sac (fig. 32), and attains its maximum size in sacs about ·2 mm. to ·25 mm. in diameter, in which the central cavity reaches a diameter about one fourth that of the sperm sac. After reaching this size it is gradually encroached upon by the heads of the ripening spermatozoa (fig. 33, *Spz.*), and in the fully developed sperm sac, which is about ·35 mm. in diameter, the cavity has completely disappeared, the whole of the interior of the sperm sac being filled with a mass of somewhat loosely packed spermatozoa, many hundreds in number, produced by the continued division of the single primitive genital cell. There are no examples of karyokinesis in the many hundreds of sperm sacs I have examined.

The head of each ripe spermatozoon (fig. 34) consists of a blunt, conical, anterior piece fixed to the spherical nucleus. The length of the head is 7 μ, the nuclear portion being 4 μ in diameter. The tail is a slender filament about 27 μ long.

The spermatozoa closely resemble those of Alcyonium in their structure and development (Hickson, 1895). The endoderm covering the sperm sac appears to undergo certain changes as the sperm sac grows, and in thin sections from two to five nuclei may be counted in many of the endoderm cells. One of these nuclei is sometimes larger than the others. In the left upper cell of fig. 35 the large nucleus near the centre occupies the position of the original nucleus of the cell. The other four nuclei have probably been produced from it by division, but there has been no corresponding division of the protoplasm. The cell with four nuclei which was figured by Hickson (1895, pl. 39, fig. 45, f.) from the teased preparations of the sperm sacs of Alcyonium, was probably one of the cells of the endodermic follicle.

At first it appeared that the sperm sacs were situated on ventral and lateral mesenteries only, although, as pointed out above (see p. 263), the cells in the mesoglœa, from which the genital cells are derived, are found in the dorsal mesenteries as well. After examining a large number of sections, I have found only two clear cases of sperm sacs occurring on the dorsal mesenteries. In each case the sperm sac is situated on the side of the mesentery a little distance from the free edge, so that, although the sac is of considerable size (·15 mm. in diameter), it does not push the dorsal mesenterial filament out of position, and, judging from the sections, would not impede its action.

Empty sperm sacs the walls of which are collapsing may be seen in several sections. The spermatozoa are discharged into the cœlenteron by bursting of the follicle of the sperm sac, and are then swept out to the exterior through the stomodæum. In sections of two polyps in which spermatozoa were escaping, the spermatozoa are found along the dorsal side of the stomodæum, being doubtless driven out by the upward or outward current produced by the cilia of the dorsal mesenterial filaments. Although escaping in a mass they are not enclosed in the follicle, but lie loosely aggregated in the dorsal portion of the stomodæum. These two examples support the conclusion expressed above that the spermatozoa are discharged into the cœlenteron by rupture of the follicle, the collapsed remains of which retain for some time their attachment to the mesentery.

As spermatozoa are present in all stages of development, it is likely that the discharge of ripe spermatozoa continues over a considerable period,—in fact, probably throughout the year. This is perhaps due to the fact that, living on reefs in the shallow waters of tropical seas, this coral is not subject to any great variations in temperature and food supply. In this respect Xenia differs from Alcyonium digitatum, which occurs in the colder seas of Northern Europe. In the latter all the sperm sacs of a colony have reached a similar stage of development and are all ripe about the same time of the year, viz. December, and therefore the discharge of ripe spermatozoa occurs only over a limited period, probably over about a month (Hickson, 1895).

Nervous System.

In several sections there is a plexus of fine fibrils in the mesoglœa connected with very small cells in relation with the ectoderm and endoderm. This plexus appears to be homologous with the similar plexus described by Hickson in Alcyonium (1895, p. 371), and compared by him to the "Nervenschicht" of the Actiniæ.

In this Xenia the plexus is best seen in sections of a polyp in which the ectoderm is cut slightly obliquely. On examining in such a section (Pl. 26, fig. 16) the part where the ectoderm passes into the mesoglœa, very fine fibrils (*N. F.*) may be seen, forming an open network, upon which cells (*N. C.*) are situated at intervals. The fibrils can be best seen in the mesoglœa, but can be traced close to the ectoderm and endoderm. The cells of the nervous system are exceedingly small, and usually fusiform, triradiate, or stellate in shape, the angles of the cell being produced into nerve fibrils.

On tracing the fibrils outwards from the mesoglœa into the ectoderm, they are seen to be in connection with small cells which are situated in the deeper part of the ectoderm. Owing to the irregularity of the inner face of the ectoderm, and to the presence of spicules in the portion of the layer where the nerve-cells are situated, it is not possible to obtain a section which shows the ectodermic nerve plexus clearly, but small portions of it may be seen where the spicules are slightly less numerous.

In the case of the endodermic nerve plexus this difficulty does not exist, and an oblique section through the wall of a polyp shows that the plexus of fibrils in the mesoglœa is connected with minute stellate cells situated upon the outer face of the muscle processes of the endoderm cells. Hæmatoxylin (especially Heidenhain's iron hæmatoxylin and Meyer's acid hæmalum) stains the nerve-cells and fibres most clearly.

History of our Knowledge of the Buds of the Xeniidæ.

Besides the fully developed polyps, the description and measurements of which are given above, there are on most of the branches of the colony young polyps or buds in various stages of development. These buds are invariably found at the edge of the umbrella-shaped area at the end of the stem. On one stem (fig. 1, left) there are ten small buds varying in length from ·5 mm. to 3 mm., and about fifty larger polyps from 5 mm. to 10 mm. in length. The smallest buds have simple tentacles devoid of pinnules, and all stages between these and the adult polyps may be found. As the polyps (both young and old) of Xenia are non-retractile, this genus offers considerable advantages for the study of the development of the polyps, and the young polyps have been noticed by many observers.

Quoy and Gaimard (1833) first observed these small polyps in the Xeniidæ. They noticed them in Cornularia viridis, which appears to belong to the genus Xenia, and they suggested that these small polyps, the tentacles of which were devoid of pinnules, were young forms which had not yet attained the adult characters.

In 1874 Kölliker described Heteroxenia Elizabethæ, in which small individuals are very numerous. He regarded these small individuals as being of two kinds, some being young polyps in various stages of development, others being "zooids." Heteroxenia, therefore, is dimorphic. According to Kölliker, there are several essential differences between these two kinds of individuals.

I. The Polyps.—These are of large size, the adults measuring 20 mm. to 55 mm. in length, and about 3 mm. in breadth. There are also obviously younger polyps, 5 mm. to 20 mm. long, all of which are situated round the edge of the disc. The tentacles of the adult polyps bear two series (in each of which four rows are distinguishable at the base of the tentacles) of long cylindrical pinnules, one on each side of the middle line of the tentacle. The cœlentera of these polyps extend a considerable distance into the stem of the colony, and are crowded with ova.

II. The Zooids.—These are much more numerous than the polyps and much smaller, measuring only 3 mm. to 5 mm. in length, and from ·7 mm. to 1 mm. in breadth. The tentacles are eight short simple lobes, ·14 mm. to ·2 mm. in length, and they bear no pinnules. The cœlentera of these zooids extend at most only 3 mm. into the stem, and contain no gonads.

It should be noted that Kölliker saw two kinds of small individuals, and described the differences between them in size, structure, and position, viz.: (1) the young polyps, 5 mm. to 20 mm. long., found only round the edge of the disc; and (2) the "zooids," 3 mm. to 5 mm. long, found all over the disc among the bases of the larger polyps.

Klunzinger (1877), who described the Xeniidæ of the Red Sea, saw small polyps in a specimen of Xenia umbellata; he called them bud-like polyps, and said that their tentacles, which are at first simple, very soon show indentations or pinnules. He regarded such individuals rather as young polyps than as zooids. They were more numerous in the outer part of the arched end of the stem. In a new species, Xenia fuscescens, Klunzinger described the small polyps as very numerous, outnumbering the large polyps, and filling up the intervals between the bases of the latter. He wrote that these small individuals do not appear to develop into fully formed polyps, but to remain in the bud-like stage, with short, simple, mostly incurled tentacles. They are 1 mm. to 2 mm. long and ·5 mm. broad, and are cylindrical or club-shaped. On account of the large numbers of these small individuals, Klunzinger placed his Xenia fuscescens near the Heteroxenia Elizabethæ of Kölliker. There are no transition stages between these small individuals which do not appear to develop into larger polyps and the adult polyps, and from the description and figures they appear to be quite as distinct as the two kinds of individuals described by Kölliker in Heteroxenia.

Haacke (1887), who examined some of the Xeniidæ in Torres Straits, says that the small individuals are merely young polyps, and all stages of development between them and the adult polyps may be met with. Therefore he denies the occurrence of heteromorphism in the Xeniidæ.

Wright and Studer in the 'Challenger Report' (1889) record the observations of Klunzinger and Haacke noticed above. They agree with Haacke, and therefore propose the provisional abandonment of Kölliker's genus Heteroxenia.

Bourne (1895) observed in his new species, Xenia Garciæ, numerous imperfect polyps or buds in all stages of growth at the edge of the polyp-bearing summits of the stems. He remarked that "these are not siphonozooids, but stunted or developing polyps."

Bourne also described a specimen which he referred provisionally (being unable to procure Kölliker's original description) to the species Heteroxenia Elizabethæ. In his description were noted—

(1) The larger polyps with well-developed tentacles, with three rows of lateral pinnules on their margins, their cœlentera continued to the bottom of the stem or nearly so, and filled with ova. At the edges of the arched end of the stem there were numerous young polyps in all stages of development, many of which showed distinct pinnules on their tentacles.

(2) Closely applied sterile zooids which have no tentacles, but only eight radiate lobes round the mouth. The cœlentera of these individuals extend only a little way into the stem, and then communicate with the cœlentera of the polyps by anastomosing endodermic canals. Among these zooids there are never any individuals which show signs of pinnate tentacles nor which contain gonads. Bourne concludes that in this form there is distinct dimorphism.

Schenk (1896) mentions the occurrence of buds in eight new species of Xenia from Ternate, which he has described. He briefly describes the external characters of the buds in Xenia viridis, and figures three stages of development. The first figure represents a small bud about 3 mm. long, in which the tentacles are simple finger-shaped lobes. The other two are drawings of slightly larger polyps the tentacles of which bear, in one case six, and in the other about twelve pinnules on each side of the tentacle (seen from the outer side). In all the examples mentioned by Schenk the small individuals are young polyps in course of development, as pinnules have already appeared on the tentacles of many of them. Schenk (loc. cit., p. 53) remarks that he believes the zooids of Kölliker are merely young polyps, and therefore Heteroxenia Elizabethæ does not exhibit dimorphism; hence he renames it Xenia Elizabethæ, and places it near X. fuscescens, Klunzinger. Thus Schenk supports Haacke's view that there is no dimorphism of the polyps of Xenia.

From this short account of previous observations it will be seen that the nature of these small individuals in the Xeniidæ is not yet determined. That they are all buds or young polyps is strongly affirmed by Klunzinger, Haacke, Wright and Studer, and Schenk; while the opinion of Kölliker and

Bourne is that they are of two kinds, some being young polyps and others quite different individuals, termed zooids.

With a view to coming to some definite conclusion regarding the nature of these small individuals, I have examined them in the specimen of Xenia Hicksoni in great detail. I have also examined the sixteen other specimens of Xenia at my disposal, and a specimen of the Heteroxenia which Bourne has described and figured. These will be briefly described below.

External Characters of the Buds of Xenia Hicksoni.

In Xenia Hicksoni the small individuals are all buds or young polyps, as in this one specimen every stage in development may be seen, from the youngest polyp only ·32 mm. in length to the large adult polyp 12 mm. long; and the series is perfectly complete, there being no break at any point which would justify the division of the individuals into two kinds.

The buds are invariably found on the edge of the arched end of the stem. Their numbers vary on different stems, there being usually from six to ten buds less than 3 mm. long on each stem (Pl. 23, fig. 1, left). The smallest bud (Pl. 24, figs. 4, 4A) measures ·32 mm. in length and ·44 mm. in width. It is situated just under the edge of the umbellate summit of the stem. It is a short cylindrical outgrowth, at the distal end of which the developing tentacles are indicated as eight small rounded lobes about ·1 mm. long, divided from each other by shallow furrows. A slight depression in the centre of the distal end indicates the position of the future mouth, which is not yet open to the exterior. The tentacles increase in length rather more rapidly proportionately than the body of the polyp. In the smallest specimen they are less than one third the total length of the polyp, but in rather larger polyps they form from two fifths to one half the total length of the polyp. The tentacles remain simple lobes until the polyps attain a length of nearly 1 mm. In a specimen ·95 mm. long (fig. 5) the tentacles have reached a length of ·34 mm., and the tip of each tentacle is distinctly trilobed when seen from the outer side, i.e. there is an indication of the formation of the first two pinnules, one on each side of the axis of the tentacle.

From this point onwards the formation of pinnules takes place regularly as the tentacles increase in size, as may be seen from the table below. When the polyp (fig. 6) has reached a length of 1·42 mm. the tentacles, which are ·6 mm. long, are seen from the outer aspect to bear four pinnules on each side. If one of the tentacles be examined from the inner side it will be seen that an inner row of pinnules has already been formed (fig. 6A). The polyp from which fig. 7 was drawn was 2·27 mm. long, and its tentacles 1·30 mm. long. Seen from the outer aspect the tentacles show eight pinnules on each side. For a distance of about two thirds of a millimetre from the tip of the tentacle, there are on the inner face two rows of pinnules on each side of the middle line, but a little nearer the base of the tentacles the three rows of pinnules on each side, characteristic of the tentacles of the adult, may be seen (fig. 7A).

After the earliest stages of growth are passed the polyps grow quite regularly, and the length of the tentacles bears to the total length of the polyp an almost constant proportion. From the appended table of measurements it will be seen the tentacles form rather more than two fifths of the whole length of the polyp. With the increase in length of the tentacles there is a corresponding increase in the number of pinnules which the tentacles bear, and, as the following table shows, there is a perfect series of examples, beginning with the very young specimens, in which the tentacles are devoid of pinnules, and ending with the largest polyps, whose tentacles show from the outer aspect nineteen or twenty pinnules on each side of the middle line. The gradual transition from the youngest to the oldest polyps shows that the small individuals in this colony are undoubtedly young buds in various stages of development. They are all "polyps," using the word in the sense in which it was used by Kölliker.

Reference Number.	Total length of Polyp (Body and Tentacles).	Width of Polyp.	Length of Tentacles.	Number of Pinnules on each side of Tentacle (outer aspect).	
	mm.	mm.	mm.		
I.	·32	·44	·10	0	Pl. 24, figs. 4, 4A.
II.	·43	·4	·12	0	In section, Pl. 27, fig. 28.
III.	·56	·37	·19	0	—
IV.	·8	·4	·31	trace of first	—
V.	·95	·35	·34	Trilobed = 1	Pl. 24, fig. 5.
VI.	1·0	·34	·43	Trilobed = 1	In section, Pl. 25, fig. 8.
VII.	1·1	·5	·53	2	—
VIII.	1·42	·87	·6	4	Pl. 24, figs. 6, 6A.
IX.	1·6	·96	·7	4—5	—
X.	2·0	·86	·86	6	—
XI.	2·1	·8	1·03	7	—
XII.	2·27	·6	1·3	8	Pl. 24, figs. 7, 7A.
XIII.	2·8	·86	1·4	8	—
XIV.	3·2	·9	1·4	8—9	—
XV.	4·0	1·0	1·8	10	—
XVI.	6·1	·9	2·4	10—11	—
XVII.	6·5	·9	2·5	11—12	—
XVIII.	6·8	1·1	2·85	13	—
XIX.	9·1	1·2	4·2	14—15	—
XX.	12·0	1·2	5·1	17	—
XXI.	11·65	1·2	5·7	19—20	Pl. 24, fig. 2.

I find in all the sixteen other specimens of Xenia at my disposal, young buds in all stages of growth, similar to those described and figured in Xenia Hicksoni. Most of these young buds occur on the arched end of the stem, but in two of the colonies examined a few buds are found in the middle portion of the summit between the bases of the larger polyps. These buds, however, differ in no way from those round the edge of the summit.

External Characters of Heteroxenia Elizabethæ (Pl. 27, fig. 37).

Bourne (1895) has already described the external characters of a colony similar to this one, but a brief description will be given here. The colony is somewhat triangular in shape, the base of the triangle being formed by the polyp-bearing summit of the stem. The stem is slightly flattened, and is narrow at its lower end, gradually widening from below upwards. The total length of the stem is about 30 mm., its breadth at the base 12 mm. by 6·5 mm., its breadth at the top 23 mm. by 6 mm.

The non-retractile polyps (*A.*) are long and slender, and measure on an average about 15 mm. in length (including the tentacles), though a few specimens reach almost 30 mm. in length. The polyps are 1 mm. to 2 mm. broad. The tentacles of the polyps measure 4 mm. to 5 mm. in length, and bear on the inner side two series of rather slender pinnules, each series consisting of three rows of about sixteen to twenty-four pinnules in each row. In one or two of the tentacles examined, the pinnules at the base are so arranged that it is difficult to say whether they are in three or four rows on each side of the middle line. The pinnules in the middle of the tentacle measure about ·5 mm. in length, and are about four times as long as they are broad. The middle line of the tentacle is free from pinnules along the greater part of its length. The polyps are 1 mm. to 3 mm. apart, but they are closer together round the edge of the summit of the stem than on the middle portion of the summit. Around the edge of the summit of the stem there are many small polyps in all stages of development,—in fact, all the polyps near the edge of the summit are small ones, the large ones being situated in the middle portion of the polyp-bearing area.

The walls of the polyps are thin, and when the colony is removed from spirit the polyps fall together and form a confused mass on the end of the stem.

Between the bases of the polyps there are many closely apposed small zooids (fig. 37, *S.*), quite different in appearance from buds or young polyps. These siphonozooids are from six to ten times as numerous as the polyps or autozooids, and they occur all over the summit of the stem. The siphonozooids are all similar in appearance, being cylindrical or club-shaped, 2 mm. to 5 mm. in length and ·5 mm. to 1 mm. in diameter. The tentacles are eight small rounded lobes arranged round the mouth; they are never longer than ·25 mm., and never possess pinnules.

Bourne provisionally referred this specimen to Kölliker's species Heteroxenia Elizabethæ, and, after comparing the specimen with Kölliker's original account and figures (1874), I can confirm his conclusion. This specimen is much smaller than Kölliker's, its polyps being only about half the size, but there are many points of agreement between them, viz. general anatomy and proportion of parts, size, and structure of zooids; size, colour, and distribution of spicules; canals, &c.

After carefully examining the two kinds of small individuals (viz. young polyps and zooids), I have no doubt that they are entirely different in nature. The external characters are quite different, and there are important differences in their internal arrangements, to which reference will be made.

External Characters of the Young Polyps of Heteroxenia Elizabethæ.—The youngest polyp, which is also by far the smallest individual on the colony, is ·64 mm. in length (fig. 38). Its tentacles are finger-shaped lobes ·24 mm. to ·3 mm. in length. The tip of one of the tentacles is slightly three-lobed, but all the other tentacles have simple rounded ends.

A polyp 1·4 mm. long, the tentacles of which have attained a length of ·4 mm., are trilobed at their ends, i. e. the first pinnule on each side of the axis is being formed. The formation of pinnules proceeds regularly with the growth in length of the tentacles, and the adult size and characters are gradually attained. From the appended table it will be seen that there is a complete series of stages from the smallest polyp, ·64 mm. long, with simple tentacles devoid of pinnules, to the largest polyp, nearly 30 mm. long, the tentacles of which show on the outer face twenty-four pinnules on each side of the middle line. In this Heteroxenia the ratio between the length of the tentacles and the total length of polyp is not quite as constant as in the Xenia considered above. The tentacles form about one fourth to one third the length of the whole polyp.

Measurements of the Autozooids of Heteroxenia Elizabethæ.

Reference Number.	Total Length of Polyp.	Width of Polyp.	Length of Tentacles.	Number of Pinnules on each side of Tentacle (outer aspect).	
	mm.	mm.	mm.		
A 1 . .	·64	·3	·24—·3	0—1	Pl. 27, fig. 38.
A 2 . .	1·4	·5	·4	Trilobed = 1	—
A 3 . .	2·0	·7	·9	3—4	A 3, fig. 37.
A 4 . .	2·8	·9	1·0	5	—
A 5 . .	4·4	·7	1·3	7	A 5, fig. 37.
A 6 . .	5·8	1·1	1·7	8	—
A 7 . .	6·0	1·1	2·2	12—13	—
A 8 . .	9·1	2·0	3·1	15	—
A 9 . .	12·8	1·2	3·5	15—16	—
A 10 . .	14·0	2·4	4·3	16	—
A 11 . .	20·2	2·0	5·0	18	—
A 12 . .	28·4	2·4	5·2	24—25	—

External Characters of the Siphonozooids of Heteroxenia Elizabethæ.—The siphonozooids, like the autozooids, are non-retractile. These vary in length from 1·8 mm. to 5·0 mm., and are ·5 mm. to 1·0 mm. wide. Their tentacles are all in the same condition, and are mere lobes from ·2 mm. to ·25 mm. in length, and never show any traces of the formation of pinnules. It will be seen from the appended table that there is no development of the tentacles corresponding to the increase in length of the individuals, so that the tentacles of a zooid 5 mm. in length are very similar to those of a specimen less than half its size (compare S 1 and S 7 in table).

Table of Measurements of the Siphonozooids of Heteroxenia Elizabethæ.

Reference Number.	Total length of Zooid.	Width of Zooid.	Length of Tentacles.	
	mm.	mm.	mm.	
S 1 . .	1·8	·7	·2	—
S 2 . .	2·0	·8	·2	—
S 3 . .	2·3	·8	·23	—
S 4 . .	3·0	·8	·24	—
S 5 . .	4·5	1·0	·2	—
S 6 . .	4·8	·6	·25	—
S 7 . .	5·0	·8	·2	Figs. 37, 39.
S 8 . .	5·0	·9	·25	—

By means of their rudimentary, short, rounded tentacles the zooids may be readily distinguished from young polyps of the same size, whose tentacles are longer, pointed, and bear pinnules. Compare, for example, the young polyp A 5 (see table, p. 287) with the siphonozooid S 5. They are both about the same length, but the tentacles of the former are 1·3 mm. long, and, examined from outer aspect, show seven pinnules on each side of the middle line, whereas the tentacles of the siphonozooid are only ·2 mm. long, and are simple rounded lobes. Now if, as urged by Schenk and others, these two individuals are both young polyps, how can the differences in the size and character of their tentacles be accounted for? If the zooids are stages in the development of polyps, it is very difficult to account for so many being in the same stage of development (as the tentacles of all the specimens examined are in the same simple condition), when, on the same colony, other individuals of the same length, or even smaller, have already acquired some of the adult characters, viz. the pinnate tentacles. On the colony drawn in fig. 37 there are over two hundred zooids, all of which are similar in appearance, having simple round tentacles. The examples indicated in the above table are chosen haphazard from this large number, being arranged in order of length merely for convenience of reference. If these were young polyps we should expect to find a more or less constant increase in the length of, and alteration in the character of, the tentacles, with the increase in length of the individuals; but this is not the case. We should also expect them to resemble other individuals of the same length on the colony which are undoubtedly young polyps; but, as we have seen, they are very different.

It must be concluded, then, that these zooids are different in nature from young polyps, and that there are in Heteroxenia two kinds of individuals, polyps and zooids, or, to use Moseley's terms, autozooids and siphonozooids.

The Internal Anatomy of Heteroxenia Elizabethæ.

Owing to the very imperfect preservation of the specimen, it is impossible to give a detailed account of the internal structure of the colony, and therefore attention will be chiefly directed to the points in which Heteroxenia differs from the Xenia described in detail in the former part of this paper.

Autozooids.—Spicules are numerous in the ectoderm of all parts of the body of the autozooid, and are very numerous in the ectoderm of the outer face of the tentacles. They are also present in the pinnules. They are similar in size and shape to those of Xenia Hicksoni. They are whitish or bluish white by reflected light, but of a reddish-brown tinge by transmitted light. Nematocysts are exceedingly scarce and difficult to find. They measure 9 μ in length and $2\frac{1}{2}$ μ in width. The ectodermic muscles of the tentacles are well developed; the muscle band of the oral face is very much thicker than that of the aboral face.

The oral disc of each polyp is slightly contracted, producing a funnel-shaped depression leading to the mouth. The stomodæum is only 1 mm. to 1·5 mm. long, and is wrinkled or folded transversely. It bears a ventral groove or siphonoglyph, the cells of the lower half of which bear moderately long flagella. There are the usual eight mesenteries, bearing rather feebly developed retractor muscles on their ventral faces. Only the dorsal mesenteries bear mesenterial filaments, and these have a typical course and structure. Owing to imperfect preservation it is impossible to say anything definite about the cells of the other mesenteries, but no ventral or lateral mesenterial filaments are visible.

The cœlentera of the polyps may be traced a considerable distance into the stem, those of the primary polyps being continued down to the base of the colony. In the upper portion of the stem the cœlentera contain many ova, each of which is surrounded by an endodermic follicle attached to the mesenteries. The largest of these ova measure ·3 mm. to ·4 mm. in diameter.

Siphonozooids (fig. 39).—Spicules are not so numerous in the ectoderm of the zooids as in that of the polyps.

The stomodæum is very badly preserved in most of the specimens. A few of the zooids situated near the edge of the summit, however, are rather better preserved, and two of these (S 3 and S 7 in the table, p. 288) have been sectioned and the stomodæum examined. In the zooid 2·3 mm. long the stomodæum measures ·6 mm., and shows a well-marked siphonoglyph, the cells of the lower ·2 mm. of which bear flagella. The other specimen (S 7 in table, see also fig. 39) is 5 mm. long. Its stomodæum measures ·8 mm. long, and the cells of the lower ·4 mm. of the siphonoglyph bear flagella.

Thus both autozooids and siphonozooids of this specimen possess a siphonoglyph, the cells of the lower half or third of which bear flagella. This does not agree with the observations of Hickson (1883, p. 696) on a specimen of Heteroxenia, in the siphonozooids of which he found a well-marked siphonoglyph, but in the autozooids a complete absence of siphonoglyph.

The siphonozooids possess the usual eight mesenteries, but they are extremely thin, and retractor muscles are not visible upon them. The dorsal mesenteries bear mesenterial filaments (fig. 39, *D. M. F.*), which run in a sinuous course down the dorsal side of the polyp, and a short distance into the portion of the cœlenteron contained in the stem. The cœlentera of these siphonozooids cannot be traced more than two millimetres into the stem. At this depth the cœlentera terminate in connection with one or more of the numerous endodermic canals. Ova are not present in any of these cœlentera.

Stem.—No definite superficial endodermic canal system is distinguishable on the summit of the stem, except at its edge, where the young buds appear to originate from it. It is, however, present in the cylindrical portion of the stem, and has a similar appearance and relations to the corresponding canal system of Xenia Hicksoni.

The longitudinal canals are developed to a much less extent than in Xenia Hicksoni. They are small, and their lumen is often almost obliterated. Canals are most numerous in the upper part of the stem, especially in and immediately below the portion penetrated by the cœlentera of the siphonozooids. In this region of the stem there are very numerous short transverse canals which place the various cœlentera in intimate communication with each other.

The Origin and Internal Structure of the Buds of Xenia Hicksoni.

In this specimen the buds or young polyps arise on or just under the edge of the umbrella-shaped area at the end of the stem. In most other species of Xenia the buds generally arise in a similar position, but in two of the colonies I have examined, and in three of the new species described by Schenk (1896), buds occur not only round the edge, but a few also on the middle portion of the expanded end of the stem. The buds are much more numerous on the edge of the summit of the stem and in Xenia Hicksoni, and, in fact, in most specimens the buds are found only in this position.

On examining a transverse section of the upper portion of a stem of the colony, the cœlentera in the peripheral portion of the stem are seen to be smaller than those in the central portion, and some of them are obviously the cœlentera of very young polyps (Pl. 25, fig. 9, right).

1. The buds arise in connection with that portion of the superficial endodermic canal system situated at the edge of the summit of the stem. When a bud is about to be formed, the superficial canal becomes enlarged and the outer wall of the canal becomes pushed outwards towards the surface of the stem. This produces a small tubercle upon or immediately under the edge of the expanded end of the stem. The tubercle increases in size, and its distal end soon becomes divided into eight small pouches which become the tentacles of the polyp (Pl. 24, fig. 4). The divisions between the pouches are the mesenteries of the polyp, and they gradually grow inwards into the cœlenteron. The eight mesenteries are already formed in the young polyp shown in fig. 4.

In the centre of the free end of the bud there is a slight depression, and a small darker area which marks the position of the future mouth (fig. 4, *Mo.*), and also the ingrowing plug of ectoderm which forms the stomodæum. Sections of this bud show that the stomodæum is ·14 mm. long, and rather flattened laterally. Its oral end is still solid, but the inner portion has become tubular, and its cavity opens into the cœlenteron of the polyp. The distance from the depression indicating the position of the mouth to the innermost portion of the cœlenteron is ·4 mm. Mesenteries are distinguishable only in the upper three fifths of the cœlenteron. In other respects this polyp resembles the one described below, and drawn in fig. 28.

2. A slightly older polyp (No. II in table, p. 284, and drawn in section, fig. 28), ·43 mm. long, possesses tentacles which are not all of the same size. The dorsal and ventral ones are largest (about ·12 mm. long), the two lateral ones a little smaller, and the remaining four still smaller. These differences in size are very well seen in transverse sections through the polyp at the level of the mouth. A second specimen of the same size was cut longitudinally, and shows several interesting points (fig. 28). The stomodæum is about ·32 mm. long, and is tubular along the greater part of its length. The mouth is, however, closed partly by approximation of the walls

of the stomodæum and partly by a small plug of mucus. The siphonoglyph is not yet differentiated. The distance from the mouth to the inner end of the cœlenteron is about ·7 mm. The mesenteries may be traced almost to the inner end of the cœlenteron, and their retractor muscles are just distinguishable. The dorsal mesenteries are slightly thicker than the others, but their mesenterial filaments have not yet been formed. The cœlenteron is formed by enlargement of the superficial endodermic canal. An evagination of the outer wall of the canal forms the cœlenteron of the free portion of the polyp, and pushes outwards the mesoglœa and ectoderm, thus giving rise to the protuberance which forms the free portion of the young polyp. A diverticulum produced by the bulging inwards into the mesoglœa of the inner wall of the canal forms the inner part of the cœlenteron.

The endoderm of the outer wall of the superficial canal is much thicker than that of the inner wall (fig. 29). This difference enables one to see in section (fig. 28) that the endoderm of the whole of the free portion of the polyp is derived from the thick outer wall of the canal. The endoderm of the portion of the cœlenteron situated in the outer part of the stem is formed directly from that of the canal, while the endoderm of the inner portion of the cœlenteron is derived from that of the thin inner wall of the canal, which has grown inwards into the mesoglœa. The cœlenteron gives off a large canal at its base, which opens into the adjacent longitudinal canals. During its short course in the stem the cœlenteron communicates several times by means of short canals with the neighbouring superficial and longitudinal canals.

Among the endoderm cells of the middle portion of the cœlenteron there are a very few flagella-bearing cells. The flagellum is a short conical or finger-shaped process which in these sections is never more than 15 μ in length.

3. A slightly longer bud (No. III in the table, p. 284), ·56 mm. long, possesses, like the preceding example, tentacles of different sizes. In this specimen also the dorsal and ventral tentacles are largest, the lateral ones being next in point of

size, and the four intermediate ones somewhat smaller. Does this indicate the order of development of the tentacles? This bud resembles the preceding one in all essential particulars.

4. There are several important new structures noticeable in a young polyp ·8 mm. in length (No. IV in table, p. 284). The tentacles are very slightly indented a short distance from the tip; this is the first indication of the formation of pinnules upon the tentacles.

The stomodæum is ·57 mm. long, and oval in transverse section. It is open throughout its whole length, thus placing the cœlenteron in communication with the exterior. There is now also a marked ventral groove, which, however, is not distinguishable in the outer third of the stomodæum. The cells of the lower two thirds of the groove bear flagella, except for a very short distance near the inner end. Some of the cells of the lower half of the stomodæum contain a large cavity, and are similar to the goblet-cells described in the stomodæum of the adult. They are more numerous on the lateral walls of the stomodæum, and do not occur among the cells forming the siphonoglyph. The ectodermic muscles of the tentacles and the retractor muscles on the mesenteries are now quite obvious. The endoderm covering the mesenteries and lining the body-wall is very thick in the free portion of the polyp, (as in fig. 28), and the intermesenterial spaces are consequently very small. The mesenteries may be traced nearly to the end of the cœlenteron, i. e. about 1 mm. below the lower end of the stomodæum. Flagella-bearing cells are present in the middle and lower portions of the cœlenteron, but the flagella are still few in number and of small size, never exceeding $20\,\mu$ in length.

The most novel feature in this polyp is the presence of dorsal mesenterial filaments, which may be traced more than halfway (·6 mm.) down the free edge of the dorsal mesenteries. They have already acquired their typical structure, i. e. each is a band of ciliated cells on the somewhat thickened edge of each of the dorsal mesenteries, and there is a longitudinal groove down the middle of the band, so that in transverse section it is V-shaped. The filaments have a very sinuous course, and are therefore cut across two or three times each in the same section. These filaments are undoubtedly derived from the lower end of the stomodæum, with which they are perfectly continuous. Their cells are exactly like the cells of the stomodæum, being small and having homogeneous or finely granular deeply staining protoplasm and dark nuclei. Their cells differ markedly from the cells of the surrounding endoderm, which are larger, have reticulate protoplasm, stain more lightly, and have less distinct nuclei.

There is another very interesting feature worthy of note in this polyp, viz. that sexual cells are already clearly differentiated. Sections through the mesenteries in the lower part of the cœlenteron show that a considerable number of the endoderm cells covering the mesenteries are more spherical, and two or three times as large as their neighbours. They have clearer protoplasm than the ordinary endoderm cells, and their nuclei are large (5 μ in diameter) and vesicular, and possess a well-marked, deeply staining nucleolus (fig. 36 shows them in a slightly older polyp). These cells occur in all the mesenteries, but are more numerous in the ventral and lateral than in the dorsal ones. Some of the cells have already migrated into the mesoglœa of the mesenteries, but most of them still retain their position in the endoderm. These modified cells are present only in the portion of the mesenteries situated in the lower two thirds of the cœlenteron.

On comparing these cells with the primitive sperm cells of the adult the resemblance is so striking that I am convinced these modified endoderm cells are the sexual cells which have become differentiated at this early stage in the development of the polyp. This view is supported by the following facts:

a. They are at first endoderm cells covering the mesenteries, which, on becoming differentiated, migrate into the mesoglœal lamina of the mesentery. This agrees with the origin, migration, and position of the sexual cells traced in the adult polyps (see p. 263).

b. These cells are found in the mesenteries some distance below the lower end of the stomodæum. They are not present in the mesenteries of the free portion of the polyp, but in the portion enclosed in the stem. They are therefore in the position in which the genital products of the adult polyps are most numerous (see p. 263, and fig. 8).

c. They agree in size and are similar (especially their large vesicular nuclei) in appearance to the primitive genital cells of the adult.

Fig. 36 shows a section through a ventral mesentery of a slightly older polyp (No. V in table, p. 284). The genital cells are still more clearly marked than in the preceding polyp, and, as shown in the figure, are readily distinguished by their large vesicular nuclei. Many of them have already taken up their position in the mesoglœa.

On comparing the polyp ·8 mm. long with one about two thirds its size (·56 mm. long) it is seen that during the period in which the elongation of ·24 mm. was accomplished, many important adult structures were acquired, viz. the first indication of pinnules on the tentacles, the open mouth, the siphonoglyph, the goblet-cells in the stomodæum, the dorsal mesenterial filaments, and the primitive genital cells. A polyp which has reached this stage of development would probably be quite capable of supporting itself, as, by means of its siphonoglyph and dorsal mesenterial filaments, it would be able to create the currents necessary for its nutrition and for keeping up the circulation of liquid in the cœlenteron.

In a polyp ·95 mm. long (V in table, p. 284) the first two pinnules are distinguishable upon each tentacle. The stomodæum is ·6 mm. long, and the siphonoglyph extends along the ventral side of the lower, ·34 mm. The lips of the stomodæum are widely open below. Flagella-bearing cells are much more numerous in this polyp than in any of the young polyps previously described. They are fewer in number in the upper part of the cœlenteron than in the deeper portions. Their flagella are still short, not exceeding 30 μ in length (fig. 36, *G. F.*).

A polyp 1 mm. long (VI in table) is seen in section in Pl, 25, fig. 8. Its tentacles bear near the tip one pinnule on each side of the axis. The stomodæum is ·74 mm. long, and exhibits a well-marked siphonoglyph, bearing flagella in its lower half. The dorsal mesenterial filaments are well developed, and extend in a sinuous course nearly 1 mm. down the cœlenteron. The cœlenteron extends 1·4 mm. into the stem, curving so as to be parallel to the neighbouring cœlentera. Its connections with the longitudinal and superficial canals may be seen in the figure. The flagella of the endoderm cells attain 40 μ in length. The distribution of spicules, nematocysts, and zooxanthellæ is shown in the figure. In such a polyp all the adult structures are differentiated. In the growth of the polyp, from this point onwards to the full adult size, there are few features which call for comment. The chief of these are the formation of a greater number of pinnules on the tentacles; the elongation of the cœlenteron outwards (as the free portion of the polyp grows in length) and inwards into the mesoglœa, where it curves, so as to lie parallel to the neighbouring cœlentera (Pl. 25, fig. 8); the increase in number and size of the giant flagella on the endoderm cells, and the development of sperm sacs on the mesenteries.

GENERAL SUMMARY.

The following is a recapitulation of the new points to which reference is made (paragraphs 1, 2, and 6 have been already published in 'Proc. Roy. Soc.,' 1898):

1. The absence of ventral and lateral mesenterial filaments usually present in the polyps of the Alcyonaria. The only previously recorded examples of the absence of these filaments are the siphonozooids which occur in some other Alcyonacea and in Pennatulids.

2. The absence of these filaments is correlated with the presence of gland cells in the stomodæum, which occur especially in the ventro-lateral walls which abut on the siphonoglyph. Their position is suggestive of the digestive function of the cells, as their secretion can be readily poured out on to the ingoing food particles.

3. The non-retractile nature of the bodies of the polyps and of the stems is accounted for by the absence of muscle-fibres from their ectoderm cells, and by the presence of numerous spicules in these parts. The presence of ectodermic muscles in the tentacles, pinnules, and distal millimetre of the bodies of the polyps, together with the absence of spicules from these parts, confers the power of contractility, slight though it is, upon these parts. The muscle processes of the ectoderm cells (where present) are longitudinal in direction, while those of the endoderm cells are circular (except the protractor and retractor muscles on the mesenteries).

4. Nematocysts were found in Sarcophyton.

5. An extraordinary number of spicules is present in the basal part of the colony, and much of the mesoglœa is converted into a dense horny substance. Thus a firm base of attachment is provided which would afford a rigid support for the branches which arise from it.

6. Many of the endoderm cells lining the cœlentera and tentacles bear giant flagella, which may attain 120 μ in length.

7. In adult polyps the primitive genital cells are formed by differentiation of some of the endoderm cells which cover the mesenteries. These genital cells migrate into the mesoglœa of the mesenteries, and then move outwards, one at a time, each cell pushing the endoderm and a thin film of mesoglœa before it, and so forming a small tubercle on the side or end of the mesentery. By division of the genital cell the spermatozoa are produced. They remain until ripe, surrounded by a thin film of mesoglœa, and by a layer of endoderm cells, many of which contain from two to five nuclei.

8. The longitudinal canals which traverse the mesoglœa of the stem are very well developed, and are physiologically, and possibly morphologically, equivalent to the cœnenchymal tubes of Heliopora cœrulea.

9. The nervous system is similar to that of Alcyonium; the stellate cells immediately outside the endodermic muscle-fibres are very clearly seen.

10. A complete series of developing polyps is described, beginning with very young specimens, in which the tentacles are devoid of pinnules, and ending with the adult polyps with multi-pinnuled tentacles.

11. A similar series of polyps of Heteroxenia Elizabethæ is described and compared with the siphonozooids of the same colony. It is concluded that Heteroxenia is undoubtedly dimorphic, as stated by Kölliker and Bourne.

12. The origin of the buds of Xenia Hicksoni from the superficial canal system, their subsequent growth, and the appearance in them of the mouth, stomodæum, siphonoglyph, gland cells in stomodæum, mesenteries, dorsal mesenterial filaments, and flagella of the endoderm cells, are traced. It is remarkable that the sexual cells are already differentiated in a young polyp ·95 mm. long.

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EXPLANATION OF PLATES 23—27,

Illustrating Dr. J. H. Ashworth's paper on "The Structure of Xenia Hicksoni, nov. sp., with some Observations on Heteroxenia Elizabethæ, Kölliker."

List of Reference Letters.

A, A 3, A 5. Autozooids of Heteroxenia (the numbers refer to the table on p. 287). *Cg.* Coagulum in central cavity of sperm sac. *Cn.C.* Cnidoblast cell. *D.M.* Dorsal mesentery. *D.M.F.* Dorsal mesenterial filament. *Ect.* Ectoderm. *Ect. Ch.* Chain or cylinder of ectoderm cells round cylinder of denser mesoglœa. *Ect. Str.* Strands of ectoderm cells. *End.* Endoderm. *End. Can.* Endodermic canals. *F.* Flagella of siphonoglyph. *G. C.* Gland-cells in stomodæum. *G. F.* Giant flagella of endoderm cells. *Gen. C.* Genital cells in various stages of development. *Long. Can.* Longitudinal endodermic canals. *L. M.* Lateral mesentery. *M.* Mesentery. *Mg.* Mesoglœa. *Mg. D.* Denser cylinder of mesoglœa around each cœlenteron in stem. *Mo.* Mouth. *Muc. C.* Mucus cells of ectoderm. *M. P.* Muscle processes of endoderm cells. *N.* Nucleus. *Nem.* Nematocysts. *N. C.* Nerve cells. *N. F.* Nerve fibrils. *R. M.* Retractor muscles in mesenteries. *S.* S 7. Siphonozooids of Heteroxenia (the number refers to the table on p. 288). *Sec.* Secretion of gland-cells of stomodæum. *Si.* Siphonoglyph. *Sp.* Spicules. *Spz.* Spermatozoa. *St.* Stomodæum. *Sup. Can.* Superficial canal. *S. S.* Sperm sacs. *V. M.* Ventral mesentery. *Z.* Zooxanthellæ.

PLATE 23.

Fig. 1.—View of the colony of Xenia Hicksoni. From one of the stems on the left side all the larger polyps have been removed, so that the umbellate summit of the stem, with the young polyps growing round its edge, may be

more clearly seen. Note also that the polyps are smaller and closer together near the edge than nearer the middle of the summit. The stem immediately to the right of this also shows that the young and small polyps are on the edge, while the large polyps are near the middle of the summit. The colour of the drawing is, as nearly as possible, the colour of the specimen in spirit. × 3.

PLATE 24.

FIG. 2.—View of the polyp XXI in the table, p. 284. This is one of the largest polyps of the colony. The tentacles show from the outer aspect a single row of pinnules on each side, but from the inner aspect three rows on each side. Note that at the tip of the tentacles the pinnules are not arranged in pairs. × 12.

FIG. 3.—Views of the tentacle of a large polyp. *A* and *B* are views of the tip, *C* and *D* of the base of a tentacle. *A* and *C* show the outer or aboral side, *B* and *D* the inner or oral side. The narrow area free from pinnules, which extends along the middle line of the oral face of the tentacle, is well seen in *D*. At the tip of the tentacle, *B*, the pinnules are in two rows only on each side of the middle line. × 24.

FIG. 4.—Lateral view of the youngest polyp (·32 mm. long) in the colony (I in table). × 40.

FIG. 4A.—Oral view of the same polyp. The tentacles are eight rounded lobes. The depression (*Mo.*) in the centre of the oral disc indicates the position of the future mouth, and the darker area below it is the ingrowing plug of ectoderm which forms the stomodæum. × 40.

FIG. 5.—An older polyp ·95 mm. long (V in table). The tentacles are trilobed at the end, i. e. the first pinnules are being formed. × 24.

FIG. 6.—A polyp 1·42 mm. long (VIII in table). × 24.

FIG. 6A.—View of the oral face of a tentacle of the polyp shown in fig. 6. Two rows of pinnules on each side of the middle line are now present. × 24.

FIG. 7.—A polyp 2·27 mm. long (XII in table). × 24.

FIG. 7A.—View of the oral face of a tentacle of the polyp shown in fig. 7. In the middle part of the tentacle, three rows of pinnules on each side of the middle line are now distinguishable. × 24.

PLATE 25.

FIG. 8.—A thick longitudinal section through the upper part of one of the stems. The section passes along the dorso-ventral axis of a young polyp (VI in table, p. 284) growing out just under the arched summit of the stem. On the dorsal or upper side of the polyp one of the dorsal mesenteries (*D. M.*) is cut through obliquely for a short distance. The stomodæum (*St.*), siphonoglyph (*Si.*), the course of the dorsal mesenterial filaments (*D. M. F.*), the thin edge

of the ventral mesentery (*V. M.*), and the connection of the cœlenteron with the canal system are shown. Three cœlentera of older polyps are also shown. Two of them are crowded with sperm sacs (*S. S.*), many of which, owing to mutual pressure, have lost their original spherical shape and are pentagonal or hexagonal in section. The other cœlenteron contained a similar number of sperm sacs, but they have been omitted in order to more clearly show the dorsal mesenterial filament (*D. M. F.*) and the thin edge of the ventral mesentery (*V. M.*). The superficial (*Sup. Can.*) and longitudinal (*Long. Can.*) canal systems, and their relation to each other and to the cœlentera; the denser cylinder of mesoglœa (*Mg. D.*) with its surrounding ectoderm cells enclosing each cœlenteron; and the distribution of spicules, nematocysts, and zooxanthellæ are also shown. × 35.

FIG. 9.—A thinner transverse section through the upper part of one of the stems. The cœlentera in the peripheral part are smaller than those nearer the centre. The cœlenteron of a very young polyp is seen on the right. The cells in the mesoglœa of the mesenteries and sperm sacs in various stages of development, attached to the mesenteries of the older cœlentera, are also shown. The number of flagella cut across in one section is seen; thus an idea may be formed of their abundance and of their size relative to the endoderm and to the cœlentera. Many of the features to which attention was drawn in the description of the previous figure are also shown here. × 50.

FIG. 10.—Transverse section through a polyp at the level of the lower third of the stomodæum. The chief features shown are the gland-cells and siphonoglyph of the stomodæum, the somewhat feebly developed retractor muscles on the mesenteries, and the distribution of the spicules, nematocysts, and zooxanthellæ. × 50.

FIG. 11.—Transverse section of the outer wall of a pinnule showing the ectoderm containing nematocysts, the mesoglœa, and the endoderm cells with their reticulate protoplasm. × 800.

FIG. 12.—A nematocyst in its cnidoblast cell, from a section. One half of each coil of the thread in the upper part of the nematocyst was cut away in sectioning. × 2000.

FIG. 13.—Eight large spicules selected from those in the base of the colony. Each spicule is situated in a small cavity in the mesoglœa. The nucleus and remains of the protoplasm of the spicule-forming cell are seen. From sections. × 800.

FIG. 14.—A portion of the outer part of the mesoglœa from a transverse section of a polyp. Four of the spicules present their edge and two their flat face to the observer. × 800.

FIG. 15.—Two very young spicules in their respective cells. The spicule in *A* is $3\frac{1}{2}\ \mu$ long and $2\frac{1}{2}\ \mu$ broad. The spicule in *B* presents its edge to the observer. It is $7\ \mu$ long and $1\frac{1}{2}\ \mu$ thick. × 1000.

PLATE 26.

Fig. 16.—Section of the wall of a polyp which has passed very obliquely through the mesoglœa, to show the nervous system. Fine nerve fibrils in the mesoglœa are connected on the outer side with cells in the outer part of the mesoglœa, some of which send processes into the ectoderm. On the inner side, the fibrils pass into small stellate nerve-cells situated just outside the muscle processes of the endoderm cells. × 300.

Fig. 17.—Longitudinal section through the body-wall of a polyp, to show the general character of the ectoderm and endoderm cells, and also the processes of ectoderm cells which penetrate the mesoglœa and establish connection with the endoderm. × 400.

Fig. 18.—Longitudinal section of the ventro-lateral portion of the lower third of the stomodæum. The chief feature shown is the large gland-cells, some of which have discharged their contents and appear empty, while others are in the act of discharging their secretion. × 600.

Fig. 19.—Transverse section of the end of a dorsal mesentery showing the V-shaped mesenterial filament bearing cilia. × 600.

Fig. 20.—Transverse section of the end of a ventro-lateral mesentery to show the general character of the endoderm cells, the giant flagellum of one of them, and the cells in the mesoglœa. × 600.

Fig. 21.—Transverse section of the end of the same mesentery taken ·25 mm. higher, showing three flagella occurring close together. × 600.

Figs. 22, 23, 24.—Three flagella from sections of polyps to show their various degrees of flexion. × 600.

Fig. 25.—Two abnormal forms of flagella from sections. *A* from the tentacle of a polyp, *B* from the portion of a cœlenteron in a stem. × 600.

Fig. 26.—Endodermic myo-epithelial cells from teased preparations. In connection with the one on the right there is a small stellate cell with three long processes. This is probably one of the nerve-cells of the endodermic portion of the nerve plexus. × 500.

Fig. 27.—Isolated cells bearing flagella, from teased preparations. × 500.

PLATE 27.

Fig. 28.—Section of a stem at the edge of the umbellate summit, to show the formation of a young polyp ·43 mm. long (II in table, p. 284). Note that the endoderm of the free portion of the polyp is thick, while that of the inner part of the cœlenteron is thin. The neighbouring cœlentera are cut very obliquely. × 50.

Fig. 29.—The superficial canal indicated by the asterisk in Fig. 9 enlarged. The cells of the outer wall are longer and more columnar than those of the inner wall. × 500.

FIG. 30.—Thin transverse section (3 μ thick) of the end of a ventro-lateral mesentery, to which three very young sperm sacs are attached. In the one to the right the primitive genital cell has divided into four, three only of which are visible. × 500.

FIG. 31.—Section of a sperm sac a little older than the largest one shown in the preceding figure. The central cavity containing a coagulum has now appeared. × 150.

FIG. 32.—Section of an older sperm sac. × 150.

FIG. 33.—Section of a mesentery, on the end of which is a sperm sac in which the central cavity, having reached its greatest size, is now being encroached upon by the heads of ripening spermatozoa. Note that the spermatozoa are surrounded by a thin film of mesoglœa (represented in the distal part of the sac by the line inside the endoderm), and by an endodermic follicle, some of the cells of which contain from two to five nuclei. × 150.

FIG. 34.—Ripe spermatozoa.

FIG. 34A.—From a section of the stomodæum, through the dorsal portion of which spermatozoa are escaping. Only the head and point of attachment of the tail are seen. × 800.

FIG. 34B.—An entire ripe spermatozoon from a teased preparation of a large sperm sac. × 800.

FIG. 35.—Cells from thin sections (4 μ thick) of large sperm sacs, to show the two to five nuclei which may be present in each. × 800.

FIG. 36.—Transverse section of a ventral mesentery of a young polyp ·95 mm. long (V in table, p. 284; see also Pl. 24, fig. 5). The section is taken about ·5 mm. below the lower end of the stomodæum. Note the already differentiated primitive genital cells migrating from the endoderm into the mesoglœa, and the short finger-shaped flagella of three of the endoderm cells. × 500.

FIG. 37.—View of a colony of Heteroxenia Elizabethæ. The colony was split in two longitudinally and the proximal half drawn, hence only half the summit of the stem is seen. Note the autozooids with pinnate tentacles, and the very numerous short siphonozooids with short rounded tentacles, and also the young polyps growing near the edge of the summit. × 3.

FIG. 38.—View of the youngest autozooid on the colony, ·64 mm. long (A 1 in table, p. 287). The specimen has been flattened out by pressure against the side of the bottle which contained the colony. Note the long finger-shaped tentacles; the right proximal one is slightly indented near the tip, but the others have simple rounded ends. The stomodæum is indicated. × 40.

FIG. 39.—The largest siphonozooid on the colony (S 7, fig. 38, and table, p. 288). The short simple tentacles, the stomodæum, and the two dorsal mesenteries with their filaments are shown. × 15.

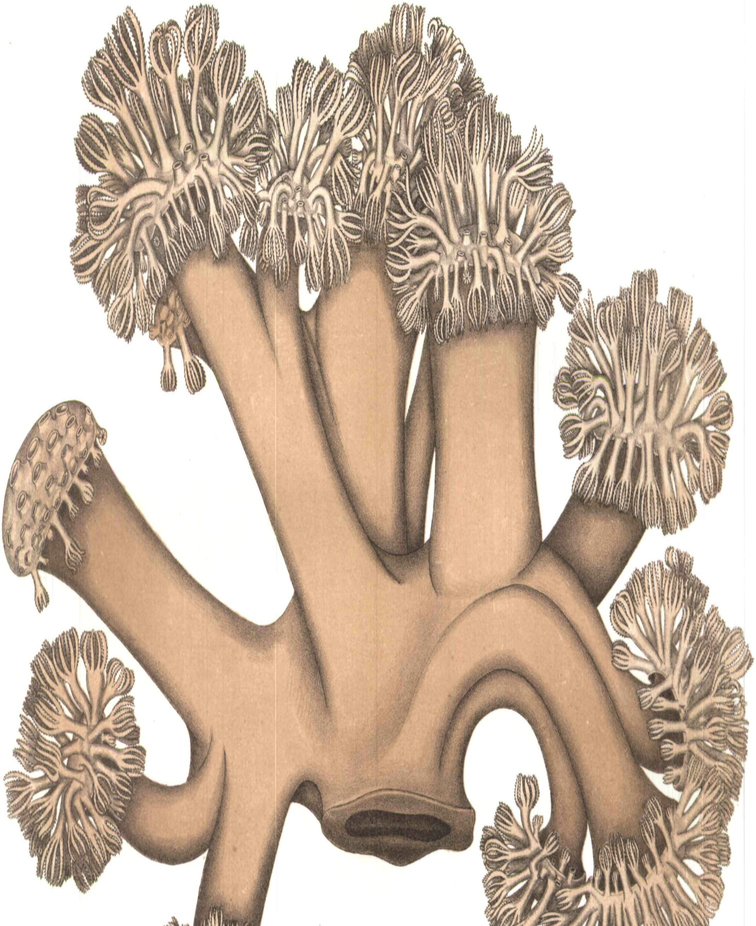
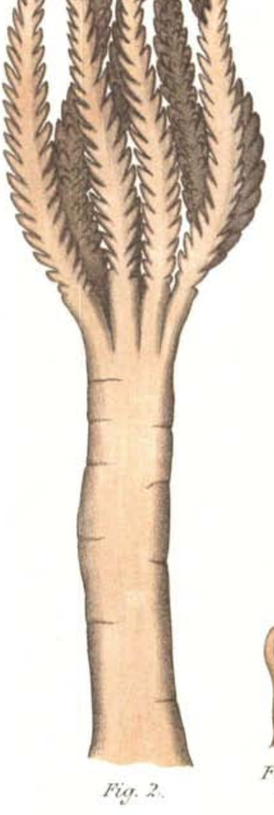


Fig. 1.

× 3.

J. H. Ashworth del.

F. Huth, Lith^r Edin^r



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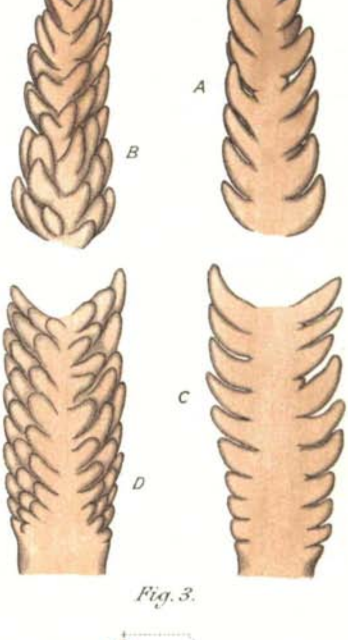

Fig. 3.

Fig. 5.

Fig. 7A.

Fig. 7.

Fig. 4A.

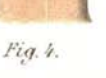

Fig. 4.

Fig. 6.

Fig. 6A.

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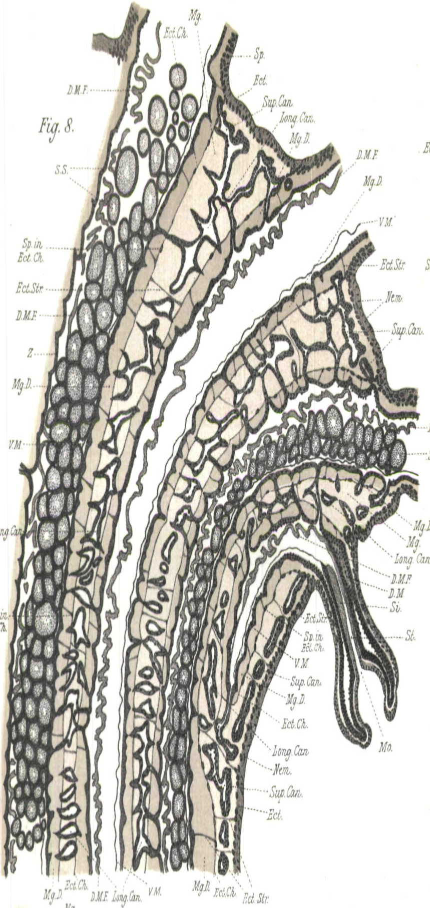
Fig. 8.



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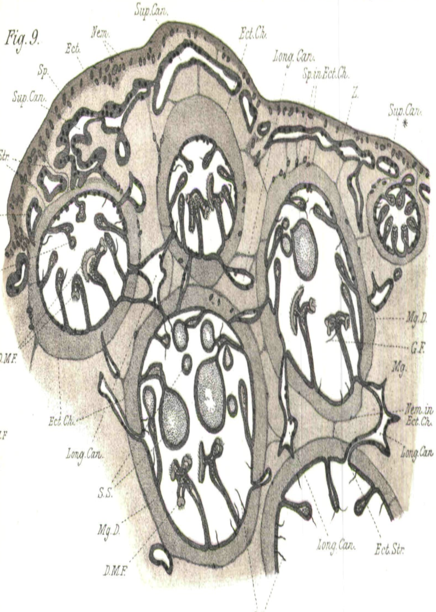

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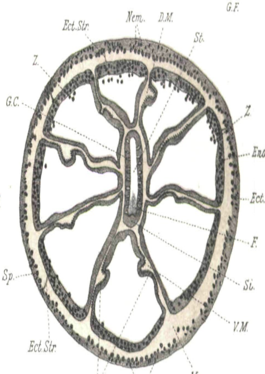

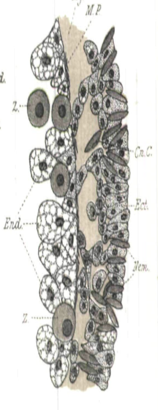

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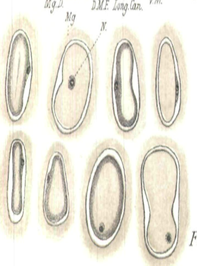

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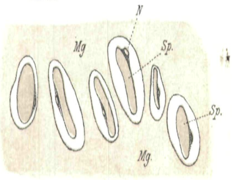

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Fig. 12.

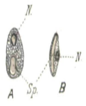

Fig. 15.

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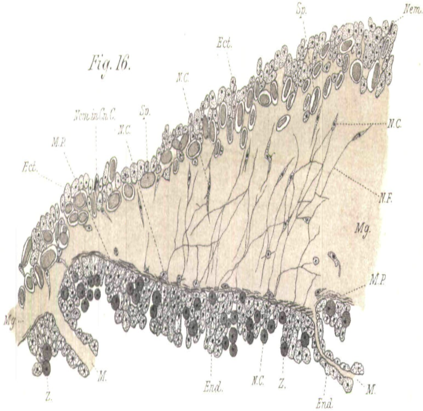
Fig. 16.



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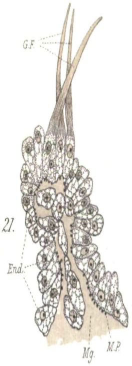

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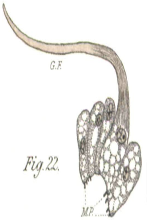

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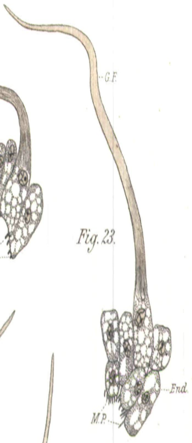

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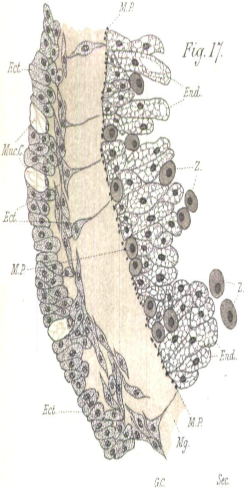

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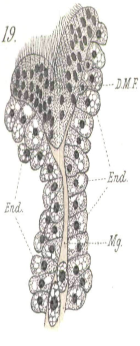

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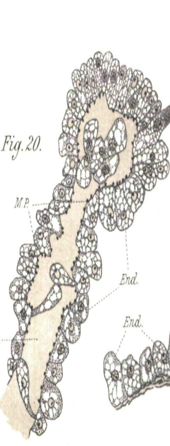

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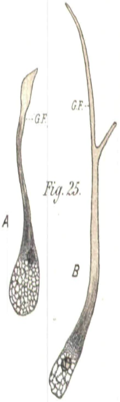
Fig. 25.



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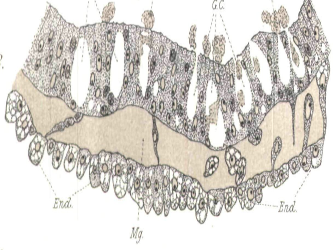

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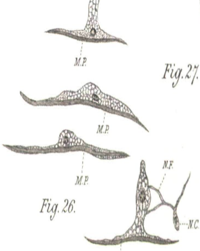

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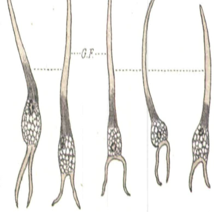

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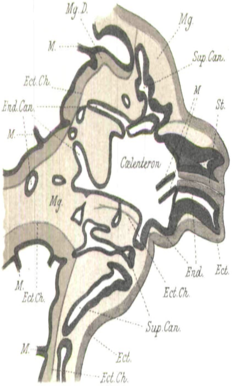

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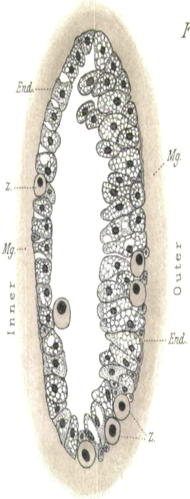
Fig. 29.



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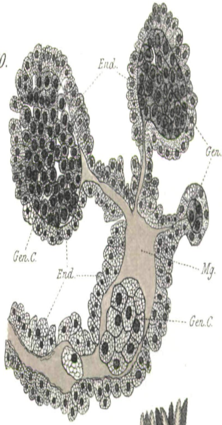

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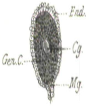

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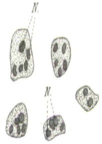

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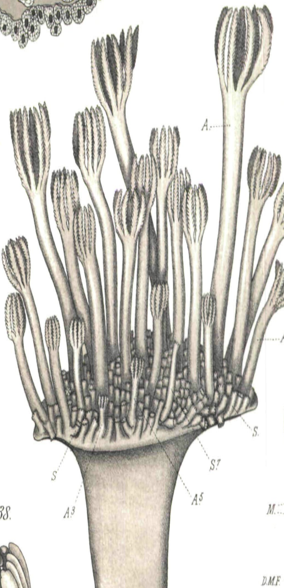

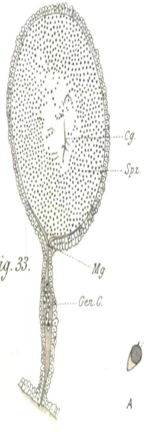

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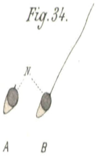

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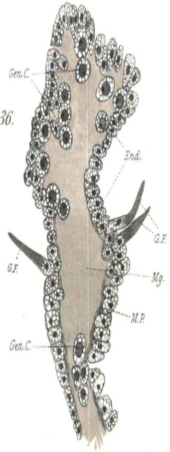

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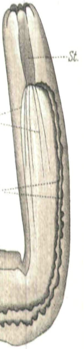

Fig. 39.

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