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On *Cyathocormus mirabilis* nov. gen., nov. sp., the Type of a New Family of Compound Ascidians from Japan.

By

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With 3 Plates and 6 Text-figures.

Although the Ascidiae Salpaeformes or Luciae have all along been regarded as a subdivision of the Order Ascidiacea, the difference between the free swimming *Pyrosoma* and an ordinary fixed compound ascidian is certainly very striking. No form has as yet been made known which might be considered intermediate between these two groups. Even the curious unattached colony, *Coelocormus huxleyi*, which was believed by Prof. HERDMAN to be a transition form between them, has in reality nothing in common with *Pyrosoma* beyond the tubular shape of the colony. On the other hand, there are some recent investigators who regard *Pyrosoma* as more closely related to *Salpa* and *Doliolum* than to the ascidians. NEUMANN ('09), for instance, in BRONN's Klassen und Ordnungen des Tierreichs, has transferred the family Pyrosomidae to the Thaliacea in which it constitutes the group Synthaliacea ; and PARKER and HASWELL ('97 & '10), in their excellent text-book, have also adopted a similar view.

The new genus of compound ascidians described in the present paper is quite unique in combining the characters of the compound ascidians and the Ascidiae Salpaeformes. In shape and general appearance of the colony it very much resembles the latter, while it agrees with some of the former in the possession of

a peduncle by which it is attached to some foreign body. The colony proper or head, which alone is composed of zooids, has the form of a short hollow cylinder, about as long as it is wide and closed at one end where it joins the stalk. Unlike *Pyrosoma* there is no diaphragm at the open end, so that the terminal aperture is of the same width as the central cavity. The peduncle is short, columnar, and dilated at the lower extremity to form a base of attachment. The entire animal, in consequence, is so perfectly cup-like in appearance that I could think of no better generic name than the one given in the title of this paper.

The zooids forming the wall of the hollow cylinder are arranged in vertical lines which run distinctly in pairs. Looked at from inside each double row of zooids with their common investing mass is found to form a cushion-like longitudinal ridge projecting into the central cavity and separated from its neighbours on both sides by narrow deep furrows. The zooids are imbedded in the common test in such a manner that the branchial apertures all open on the outer surface of the colony, and the atrial cavities all communicate directly with the longitudinal furrows just mentioned, which, of course, are nothing but the peripheral portions of the central cavity. There are no definite atrial apertures present, since the wall of the peribranchial cavity is wanting in the greater part of the thoracic region and the stigmata of the branchial sac as well as the anal and genital apertures open immediately into the adjacent longitudinal furrow. Thus the central cavity serves, as in the case of *Pyrosoma*, as the common cloaca of the whole colony which may be regarded as consisting of a single system of zooids, but this system is, in the present case, divided into groups of zooids whose atrial cavities are partly fused together to form a large continuous peribranchial space.

It is perfectly obvious that a compound ascidian with such characters as those mentioned above can not be included in any of the recognized families, and I consider myself fully justified in forming a new family for its reception. Since, however, only one genus of this family is at present known, I believe it would be of

no use to consider the diagnostic characters of the family and the genus separately. They are naturally the same and may be summed up as follows:

Cyathocormus nov. gen.

Colony fixed, stalked; the head having the form of a short hollow cylinder closed at one end and open at the other.

Systems—only one present, the terminal aperture being the common cloacal opening, and the central cavity the common cloaca.

Zooids placed in a single layer with their anterior ends external and their posterior ends internal. Body divided into two regions, thorax and abdomen, the latter provided with a long vascular appendage. Branchial apertures opening on the outer surface of the colony, not lobed. Peribranchial wall imperfectly developed, stigmata of the branchial sac as well as the anal and genital apertures opening directly into the centrally placed common cloaca.

Test soft, gelatinous, and transparent; no calcareous spicules, bladder cells very numerous.

Branchial sac large and well developed, with four rows of stigmata; no internal longitudinal vessels present. Stigmata very long and narrow.

Tentacles simple.

Dorsal lamina represented by a series of languets.

Alimentary canal forming a simple loop placed posteriorly to the branchial sac. Stomach ellipsoidal and smooth walled, no cœcum. Duodenal portion of intestine distinctly bounded, fine tubular intestinal gland well developed.

Reproductive organs not conspicuous. Incubatory pouch present. Larva tailed.

It will be seen at once from the above diagnosis that the present genus exhibits in certain essential points a close relationship to the Pyrosomidae, while in other characters no less important it markedly approaches the Distomidae (Polycitoridae) among the compound ascidians. It agrees with *Pyrosoma*, on the one hand, not only in the form and general appearance of the colony already referred to, but also in the structure of the alimentary canal, which is practically the same in both forms. On the other hand, the presence of numerous bladder cells in the test naturally reminds of the condition found in the genera *Colella* (=*Sycozoa*) and *Distaplia* (=*Holozoa*) among the Distomidae (Polycitoridae), in some members of which these cells form by far the greater part of the investing mass. The stalk, too, much resembles that of some species of the genus *Colella*, e.g. *C. quoyi*; but this is unimportant, as similarly stalked forms are also met with in some other families.

One of the most notable points about this form is without doubt the partial fusion of the peribranchial cavities in a number of zooids. So far as I am aware, there is but one member of the Ascidiae compositae in which all the zooids exhibit a similar structure. According to LAHILLE ('90), the zooids of *Diplosomoides lacazei* (=*Polysyncraton l.*) have their peribranchial walls very imperfectly developed so that the greater part of the branchial sac is uncovered. Since other species of the genus do not present the same condition, this character ought to be looked upon as simply specific. In the present family, however, of which no other genera or species are known yet, it must be left doubtful whether this peculiarity should be regarded as a family character or as of only generic or even specific importance.

This genus contains the single species *C. mirabilis*.

Cyathocormus mirabilis nov. sp.

The colony is cup-shaped and is attached by the base of a short peduncle. The head has the form of a short hollow cylinder nearly as long as it is wide. The outer surface shows a number of

very shallow longitudinal depressions separating as many slightly elevated longitudinal zones upon which double rows of very short branchial siphons are placed. The inner surface has a number of deep longitudinal furrows corresponding to the shallow depressions on the outer surface. In the ridges separated by them the dark coloured contents of the intestines look conspicuously through the test and body wall. The stalk is shorter than the head, columnar in shape, and is dilated at the lower end to form the base of attachment.

Size—head 18—22 mm. in length and 15—21 mm. in width; the stalk about 12 mm. in length and 4—5 mm. in diameter.

The test is soft, gelatinous, and perfectly transparent in the head, and considerably harder and more or less opaque in the peduncle.

The zooids are of moderate size and are entirely imbedded in the common test. They are 3—4 mm. in length and about $1\frac{1}{2}$ mm. in greatest breadth. The body is divided, though not very distinctly, into thorax and abdomen, the latter provided with a long vascular appendage.

The mantle is very thin, muscle fibres being found only in the anterior region where they form a sort of sphincter around the branchial aperture.

The branchial sac is well developed but delicate. The transverse vessels are narrow and are all of the same size. The stigmata are very long and narrow with rounded ends.

The endostyle is conspicuous. It is plicated dorso-ventrally through the greater part of its length.

The dorsal lamina is represented by three short pointed languets projecting from the dorsal parts of the transverse vessels.

The tentacles are usually sixteen in number. Four are long and meet in the centre of the branchial aperture when laid flat; four others alternating with these are somewhat shorter, while the remaining eight are only half as long as the former.

The dorsal tubercle is very prominent, being unusually large in proportion to the size of the branchial sac. The aperture is a

simple oval slit placed transversely on the anterior wall of the tubercle.

The alimentary canal forms a simple loop lying almost entirely behind the branchial sac. The stomach is only moderately large and is rather thick walled. The duodenal portion of intestine is somewhat pyramidal in shape with the base next the stomach, its wall is very thin. Anal aperture without lobes.

The reproductive organs are mostly atrophied in fully grown individuals. A large oval incubatory pouch containing a single larva is seen alongside the branchial region.

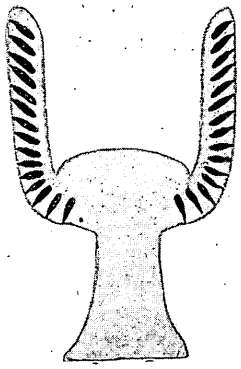
There are at present only two examples of this species known to me, both attached to a colony of a white coral. According to the statement of the collector, K. Aoki, they were obtained in the deeper parts of the Sagami Sea together with *Euplectella*, *Metacrinus*, etc., but the label having been lost, the exact date and locality of their capture can not be ascertained. A brief account of these colonies with remarks upon the systematic position of the species was given by me at the meeting of the Tokyo Zoological Society in January of the year 1907. The type specimens, partly injured by dissection, are deposited in the zoological collections of the College of Science, Imperial University, Tokyo. They are preserved in a mixture of alcohol, glycerin, and water, and seem not to have lost much of the original transparency.

Description of the Colony.

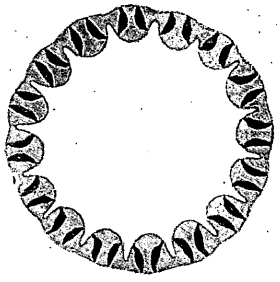
General appearance. The colony has exactly the shape of a drinking cup (Pl. I., fig. 1.) and may, for convenience of description, be divided into the stalk and the head. The stalk is attached by its lower extremity to some foreign body, and bears the head on its upper end. It is short and rather thick. It is of equal width throughout from the point of junction with the head to within a short distance of the lower end, where it expands to form a base of attachment. The diameter of the base measures 8—12 mm., that is, nearly as much as the length of the stalk and more than twice its diameter in the upper part. Its surface is quite smooth,

showing neither longitudinal striae nor transverse wrinkles. It is almost transparent except the axial portion which is more or less opaque and whitish with a tinge of pale yellow, especially near the lower end. The stalk is made up entirely of the test substance, and no zooids, whether adult or in developmental stages, are found imbedded in its tissue.

The head has the form of a hollow cylinder open at one end and closed at the other. Viewed from the side, the lateral walls of the cylinder are nearly straight. At the open end the wall terminates



Text-fig. 1.
Diagram showing the longitudlinal section of a colong.



Text-fig. 2.
Diagram showing the cross section of a colong.

quite abruptly, there being no thinning out of the investing mass to form a particular marginal zone (text-fig. 1). The bottom of the cylinder is somewhat lens-shaped, convex on both outer and inner surfaces. It is at the centre of its outer or lower surface that the peduncle joins the head. Like the stalk this part is entirely composed of the common test and contains no zooids. Near the periphery of the basal surface, however, a number of very small zooids, apparently in early stages of development, are to be seen. The side wall of the cylinder shows on its external surface a number (12 and 16 in the two colonies examined) of very shallow longitudinal depressions separating as many slightly elevated longitudinal zones. Under a low power of microscope these zones are found each to be composed of a double row of hexagonal areas representing the

anterior ends of zooids with a short branchial siphon at the centre. Looked at from inside, each double row of zooids forms a cushion-like ridge projecting into the central cavity and separated from its neighbours by narrow deep furrows. These furrows correspond in position to the shallow longitudinal depressions on the outer surface of the colony. A cross section through the middle of the head has therefore the shape represented in text-fig. 2. It consists of thick and thin portions placed alternately in a circle, the former being each a mass of the investing substance containing two rows of zooids, while the latter are nothing but a thin layer of the common test forming the bottom of the deep longitudinal furrows just referred to. As the test and body-wall are transparent the intestines with their dark coloured contents stand out very conspicuously on the inner surface as dark brownish loops (see Pl. I., fig. 1). Under a lens the stomach is also very clearly visible.

Arrangement of zooids. As stated before, the zooids are arranged in longitudinal rows which run distinctly in pairs. In one of the two colonies examined by me there are sixteen of such double rows present, while the other one, which is somewhat smaller, though not much shorter, has only twelve. Each row begins at the very margin of the lateral wall of the head and ends on the basal surface at some distance from the top of the peduncle. The number of zooids which form a longitudinal row is generally twelve or thirteen, not counting a few small buds situated on the basal surface of the head. The zooids in a pair of lines are placed alternately, and as the amount of the test substance intervening between them is proportionally very small, the anterior ends of the zooids are visible externally as hexagonal areas with the branchial siphon projecting from the centre. The whole external surface of the head therefore looks like a pavement composed of equal sized polygons (Pl. I., fig. 2) in which, however, the longitudinal rows are grouped in pairs separated from one another by narrow zones free of zooids.

The thoracic regions of the zooids are as a rule placed nearly at right angles to the outer surface of the colony. At the bound-

ary between the thorax and abdomen the body is generally bent downwards, i.e., towards the closed end of the cylinder, in consequence of which the individuals overlap, so that the abdomen of one zooid covers the thorax of its neighbour below on the inner surface (Pl. I., fig. 4). For the same reason a cross section passing through the branchial sac of one individual cuts also the alimentary canal of one or even two individuals lying above it (Pl. I., fig. 3). Moreover, the median plane of each zooid does not lie parallel to the main axis of the colony, but, as shown in Pl. I., fig. 2, the zooids in a pair of rows have their endostyles turned toward one another, while their dorsal edges are next the space between that row and the adjacent one. In this respect the arrangement of zooids in the present form exactly agrees with that found in some species of *Colella* (=*Sycozoa*, Less), e.g. *C. pulchra* ('86, Herdman, Challenger Reports, Part 2, Pl. XV., fig. 6) and *C. tenuicaulis* ('99, Herdman, Australian Museum Catalogue, Pl. Dist. I., fig. 3). As will be described further on, the course of the intestinal loop is not the same in all the individuals, but is different according to the position of the zooid in a double row. Those of the left side have their intestines opening into the longitudinal furrow lying on the left side, while those belonging to the right hand row have their anal apertures looking to right, although in both cases the intestine is bent invariably to the left side of the stomach (see Pl., I. fig. 3).

Test. The test is only weakly developed in the side walls of the head. Here the bodies of the zooids themselves form by far the greater part of the mass, while the test exists only in the form of thin covering round each zooid. In some places it forms an exceedingly thin partition between the zooids, so that the latter seem to be separated only by a delicate membrane. Along the median line of the longitudinal ridges formed by double rows of zooids, however, the test substance is found to take the shape of more or less thickened masses. On the outer surface of the head the test forms a thin layer of nearly uniform thickness (0,035-0,045 mm.) covering the anterior ends of the zooids.

The extent and relative amount of the investing mass in the

wall of the head may be most clearly understood by examining the transverse and longitudinal sections of this region. In Pl. I., fig. 3, representing a part of cross section of the head, the test is found to comprise the following parts: 1) a superficial layer covering the outer surface of the head, 2) thin partitions separating the thoracic regions of various zooids, and 3) more or less thickened masses in which their abdominal regions are imbedded. The superficial layer, which is nearly of the same thickness throughout, not only covers the external surface of the anterior ends of the zooids, but is turned inwards at the branchial aperture and reaches the bases of the tentacles so as to form an internal lining of the branchial siphon. The walls of test substance forming partitions between the thoracic regions of the zooids are in some places much thicker than the superficial layer, but in other places they are exceedingly thin. Their thickness depends on the configuration of the zooids the interstices between which they fill up, but on the whole the test is not particularly well developed in these parts. It is in the inner half of the longitudinal ridges that the common test attains its highest development. Here it is found to form masses of more or less considerable thickness in which the abdominal parts of the zooids are completely imbedded. The masses also contain blood vessels to be described further on. The extent of the common investing mass in the longitudinal ridges is perhaps better shown in Pl. I., fig. 4, which represents a part of longitudinal section through the side wall of the head. From this figure it will be seen that the posteror halves of the abdomens are imbedded in a continuous mass of test substance running longitudinally, while the anterior halves containing the oesophagus and stomach are covered separately by a thin layer of test. Where the peribranchial wall is wanting, as shown in the figure, the branchial sacs as well as the anterior portions of abdomens are separated from one another simply by the common peribranchial space (*prb.*) directly continuous with the adjacent longitudinal furrow. The transverse walls of test intervening between the anterior regions of the branchial sacs are as a rule of the same thickness as the super-

ficial layer, and terminate quite abruptly at the level where the first row of stigmata begins to appear. As already metioned, the basal part of the head as well as the whole peduncle is entirely composed of test substance which is somewhat firmer and a little more opaque than that of the side walls of the head.

The test consists of a hyaline homogeneous matrix in which two kinds of cells are imbedded, the bladder cells and the test cells. The former are very large, oval, spherical, ellipsoidal, or polygonal in shape, and have only a thin layer of protoplasm lining the inner wall, against which the nucleus lies (Pl. I., fig. 5, *b.c.*). The nuclei are very distinct, oval or fusiform in shape, and are always situated close to the inner wall of the cell. There is often a little mass of protoplasm at the point where the nucleus lies. The bladder cells are exceedingly numerous throughout, forming by far the greater part of the test tissue. In some places they are so numerous that the matrix exists only in the form of delicate membranes surrounding the large vesicles which have become polygonal by mutual pressure. The test cells are found wherever a small patch of matrix can be seen (Pl. I., fig. 5, *t.c.*). They are small (0.005—0.006 mm. in diameter), oval or ellipsoidal in shape, and consist of a large nucleus surrounded by a small quantity of protoplasm.

In the superficial layer of test forming the external covering of the head the tissue consists mainly of bladder cells generally arranged in a single layer with only a little mass of matrix about them (Pl. I., figs. 7,9,10,11). This layer, therefore, is throughout its whole extent only just as thick as the greater diameter of the bladder cells. The walls of test substance intervening between the branchial regions of the zooids are in some places much thicker than the surface layer and may contain a large number of bladder cells grouped irregularly, but in other places they are extremely thin and are entirely composed of matrix, being in fact too thin to contain a bladder cell. In the thickened masses of common test enclosing the abdominal regions of the zooids the bladder cells are also abundant, but small patches of matrix are found here and there, and in such places the test cells are very clearly visible (Pl. I., fig. 5).

Discription of the Zooid.

Form. As the zooids are attached to the common test rather firmly at the branchial aperture and at certain regions of the thorax, it is almost impossible to dissect out a zooid uninjured from the investing mass. It invariably breaks in the middle of the branchial region where it is weakest, since the body wall is here very imperfectly developed and the delicate longitudinal vessels of the branchial sac lie exposed on the outer surface. At other places, however, the body wall seems to be only loosely attached to the common test, since in sections of preserved specimens empty spaces are commonly found surrounding the zooids, apparently in consequence of contraction of the latter.

The body of the zooid may be divided into two regions, the thorax and the abdomen. They are about of the same size, and the boundary between them is not very distinct. The thorax comprises chiefly the branchial sac and its accessory organs, while the abdomen is composed of the remaining parts of the alimentary canal together with the heart and the reproductive organs. A vascular appendage springing from the posterior end of abdomen traverses the common test towards the base of the colony. The zooids, without the appendage, are 3—4 mm. in length and nearly half so much in breadth; when fresh and fully expanded they measured, of course, somewhat more.

The thorax is roughly cylindrical in shape. The anterior end is only slightly convex and hexagonal in outline, with the branchial siphon placed at the centre. The side walls of the thorax are very incomplete, as the external wall of the peribranchial space is developed only on the ventral side. Dorsally as well as laterally there is no body wall, and consequently the branchial sac is quite exposed on these sides (Pl. I., fig. 3). This condition may perhaps be considered as the result of the atrial aperture having become disproportionally widened so as to occupy the greater part of the surface of the thoracic region. As mentioned before, there is only one species of compound ascidians in which a similar condition is met with. Lahille, in his "Recherches sur les Tuniciers" ('30) describes the thoracic region of the zooids

of *Diplosomoides lacazei* GIARD in following words: "La paroi péribranchiale, fort réduite, laisse la branchie presque entièrement à découvert", and this is exactly what takes place in our species, though very probably we have here a case of convergence rather than that of a direct phylogenetical affinity. The posterior limit of the thorax is marked for the most part by the bottom of the branchial sac, at one point of which the funnel-shaped oesophagus commences. The terminal portion of intestine lying just beneath the branchial sac is also comprised in the thorax (Pl. II., fig. 8).

The abdomen is irregularly ellipsoidal and somewhat flattened from side to side. Its shape is determined principally by that of the intestinal loop, since the heart and other organs contained in the abdomen are all placed between the stomach and ascending part of the intestine. As the investing mass as well as the thin body-wall is perfectly transparent and colourless, the external form of the abdomen is hardly recognizable to the naked eye, while the intestine itself is rendered very conspicuous by its dark coloured contents. The vascular appendage, whose lumen is continuous with the blood spaces of the zooid, starts from the posterior end of the abdomen and runs, as will be more minutely described hereafter, inwards and downwards through the common investing mass to the base of the colony.

Body wall. The body wall or mantle forms the outer covering of zooids and lies immediately under the test, with which, however, it is in the greater part of its extent not closely connected. In preserved specimens a cavity in which the zooid lies is distinctly visible (Pl. I., fig. 3; Pl. II., figs. 7, 8; Pl. III., fig. 20, *sp.*). In the living animal, however, when the contractile tissues were relaxed and the viscera were filled with water, the body wall was doubtless in contact with the test throughout, and there was therefore no cavity around the zooid. In those places where the test ends with a free margin, the body wall is more firmly attached to the test and remains closely connected with it even when preserved. Such places are found at the base of the branchial siphon and along the border of the body wall in the thoracic region.

The body wall is composed mainly of three elements—the ectodermal epithelium, the connective tissue, and the muscular fibres. The ectodermal epithelium is present throughout the whole extent of the mantle and is in direct contact with the test. The cells of this layer are generally flattened (Pl. II., fig. 7, *ect.*), especially so in the walls of abdomen where they form a thin pavement epithelium, but at the margin of the branchial siphon they are considerably thicker and almost cubical in shape (Pl. II., fig. 9, *ect.*). The connective tissue is present in the form of a hyaline homogeneous mass containing scattered cells and perforated by blood spaces. The cells are fusiform or stellate in form and have distinct nuclei. The stellate cells are found generally in such places where the layer of connective tissue is rather thick, and are then scattered equally all over. Where the connective tissue forms a thin layer more fusiform cells are met with, sometimes with their longer axes perpendicular to the plane of the adjacent ectodermal epithelium.

The musculature is on the whole very feebly developed. Over the abdomen not a fibre is visible, and on the thorax the body wall has only a few scattered fibres here and there except on the anterior surface where they are more numerous. In the wall of the branchial siphon the fibres are placed transversely, forming a sort of sphincter round the external opening. Longitudinal fibres are also present, but are much less numerous. Compact bands of muscle fibres, such as are frequently met with in other genera, do not occur in any part of the body wall.

Branchial sac. This organ occupies the greater part of the thorax, and is only partly covered by the body wall. When fully expanded it is somewhat barrel-shaped and extends from the anterior wall to the basal part of the thorax (Pl. I., fig. 3, *br. s.*) In most zooids examined by me the branchial sac was strongly contracted, and it was with great difficulty that the exact form and structure of the organ could be made out. In a few exceptional cases, however, it could be satifactorily observed under a dissecting microscope.

The endostyle runs along the ventral, and the row of languets

along the dorsal edge of the branchial sac, while the circlet of tentacles, the dorsal tubercle, and the peripharygeal band are situated at its anterior extremity (Pl. II., fig. 8). All these organs will be described further on. Very often one or two small copepod crustaceans were found living in the branchial cavity as commensals.

The stigmata occur over the whole extent of the sac, from the peripharyngeal band anteriorly to the base where the oesophagus opens posteriorly, with the exception of a narrow band along the dorsal and ventral edges, where the median dorsal vessel and endostyle are placed. They are arranged in horizontal (transverse to the antero-posterior axis) rows, and are separated by transverse and longitudinal vessels (Pl. II., fig. 12). There are four such rows and more than twelve stigmata in a row on each side. In shape they are elongated slits with parallel sides and rounded ends. The width of the stigmata is about equal to that of the fine longitudinal vessels separating them.

Examined under a moderate power of microscope, each longitudinal vessel is found to have the form of a rectangular pillar, the sides of which are made of two kinds of cells. On the sides facing the branchial and atrial spaces the wall is very thin and is composed of flattened polygonal cells. On the sides surrounding the stigmata, on the contrary, the cells are of considerable height. Seen from the interior or exterior of the branchial sac each of the stigmata appears to be surrounded by a single row of ciliated cells (Pl. II., fig. 12). A transverse section of the longitudinal vessels, however, shows most clearly that what looked like a single cell is in reality a group of very narrow cells placed side by side (Pl. II. fig. 13), and consequently what appeared as a single row of cells is in reality a longitudinal band of ciliated epithelium extending down the side of the vessel. The ciliated cells vary somewhat in shape, being taller and more columnar at the ends of the stigmata. The most common form is nearly semicirculer, the flat face being next the vessel and the curved one next the stigma. As they are grouped regularly in transverse rows they look somewhat like a pile of coins cut in halves. The nuclei are distinct and placed rather below the

middle of the cells. The cilia are long and delicate. They are from five to ten on each cell, attached to the more or less convex outer edge, and when fully extended they are more than twice the height of the cells.

The transverse vessels are three in number and are all of the same size. They are about twice as wide as the fine longitudinal vessels and contain delicate muscle fibres (Pl. II., fig. 12, *tr. v.*). When contracted the branchial sac is always strongly constricted along these vessels. The zone devoid of stigmata along the dorsal edge of the branchial sac is very narrow, so that the rows of stigmata of one side appear to pass over to the opposite side without much interruption. The median dorsal vessel also contains muscle fibres in its walls and is found strongly contracted in most zooids.

Endostyle. The endostyle runs along the ventral edge of the branchial sac (Pl. II., fig. 8). It begins anteriorly at the base of the branchial siphon immediately behind the peripharygeal band and runs backwards to the base of the sac, ending at a short distance from the oesophageal aperture. The ends are bluntly conical, otherwise it is of the same width throughout. In the greater part of its course it forms a series of minute dorso-ventral undulations. Whether or not this is a result of contraction of the branchial sac I am not able to say. At any rate, in all the zooids examined by me the endostyle invariably showed this character. The anterior end of the endostyle is turned inwards forming a sort of blind sac at the point of bending (Pl. II., fig. 7, *end.*), so that in certain sections passing through this region the endostyle appears as a canal.

The endostyle is a groove with greatly thickened sides formed of columnar epithelium, while the base is covered with somewhat shorter cells (Pl. II., fig. 14). The summits of the edges are continued up as lip-like folds. A tract along each side and the base are richly ciliated. As shown in the figure several kinds of cells can be distinguished in the wall of the endostyle. Those forming the base stain deeply with haemalaun and are provided with very long cilia, reaching, if not exceed-

ing, the free edge of the lateral lips. On each side of the base there is a zone of large columnar cells without cilia which stain only faintly and seem to be glandular in nature. Beyond this glandular zone the cells are again ciliated, but the cilia are very short, and the cells bearing them become successively shorter as they are traced away from the base. On the inner surface of the lips there is again a zone of ciliated epithelium composed of cubical cells. The cilia are very short. On tracing these zones anteriorly they are found to be continuous with the band of ciliated epithelium covering the peripharyngeal ridge to be described below. Seen from the dorsal or ventral aspect, the endostyle shows a pair of thick semi-opaque bands separated by a more translucent area (Pl. I., fig. 6, *end.*). The opaque bands are caused by the thickened sides, separated by the less massive floor of the groove. The narrow dark lines seen along both sides of the endostyle are the zones of ciliated epithelium on the lateral lips of that organ.

Dorsal lamina. The dorsal lamina is represented by a series of three short triangular languets springing from the dorsal edge of the branchial sac. Each languet is placed at the intersection with a transverse vessel and is ciliated at the sides. They seem to arise directly from the inner wall of the vessel, there being no ridge or membrane present to unite their bases.

Tentacles. The tentacles are placed in a circle round the base of the branchial siphon just at the entrance of the branchial sac. The branchial siphon is a short funnel with the rim turned outwards, and when wide open its diameter is about double its height. Its inner surface is lined by an invagination of the superficial layer of test, which is nearly of the same thickness as that layer and extends as far down as the tentacular circlet.

The tentacles are simple and rather stout. When directed upwards they project beyond the external opening of the branchial siphon (Pl. II., fig. 8, 10). They are generally sixteen in number and are of three different sizes. Four are long and meet in the centre of the branchial aperture even when the latter is wide open. Four others alternating with these are somewhat shorter, while

the remaining eight are only half as long as the longest ones. Two of the longest tentacles are placed in the median plane of the zooid, the other two making right angles with them. At the level of their attachment a sphincter composed of loose circular muscle fibres encircles the base of the branchial siphon (Pl. II., figs. 9 & 10).

Each tentacle is attached separately and has a round tapering and generally curved stem and a rather blunt apex. The wall of tentacle is formed externally by an epithelium of flattened or cubical cells and is nowhere ciliated. The interior of the tentacle is filled with the homogeneous matrix of connective tissue with some scattered cells. A few delicate longitudinal muscle fibres are sometimes distinguishable under the epithelial layer. Whether the blood spaces are continued into the interior of the tentacles, though very probable, could not be ascertained.

Peripharyngeal band. In the present species the peripharyngeal band is remarkably well developed, resembling in many respects that of simple ascidians. It consists of two parts, a thin membrane and a ciliated ridge (Pl. II., fig. 9, *prph. m.*, *prph. r.*) For the greater part of their course they run close to and parallel with each other, forming between themselves a narrow groove, the "gouttière péricoronale" of French authors. They encircle the top of the branchial sac at a short distance from the bases of tentacles. The peripharyngeal membrane, called the "Ringfalte" by German writers, is a thin membrane of nearly equal breadth throughout, and is composed of flattened cells without cilia. At the ventral median line the membranes of both sides meet each other at the pointed anterior extremity of the endostyle. Dorsally the membrane reaches the dorsal tubercle where it is continued for some distance along the lateral region of that organ (Pl. II., fig. 11, *prph. m.*). Throughout its whole extent the breadth of the peripharyngeal membrane is about equal to the height of the ciliated ridge forming the other lip of the groove.

The peripharyngeal ridge is composed of a band of ciliated epithelium running parallel with the peripharyngeal membrane on its posterior side. It is connected at its ventral and dorsal ends

with the anterior extremity of the endostyle and the dorsal tubercle respectively. By tracing the ridge ventrally it is found to be directly continuous with the ciliated band on the inner surface of the lip of endostyle. Near the dorsal end the ridge forms the greater part of the side wall of the dorsal tubercle and gradually disappears towards its free extremity. The cells composing the ridge are high and columnar, and the cilia are very short throughout.

Dorsal tubercle. This organ is placed at the anterior end of the dorsal edge of the branchial sac, and is very conspicuous on account of its unusually large size. As shown in Pl. II., figs. 8 and 10, it projects into the branchial cavity just below the base of the branchial siphon on the dorsal side and is clearly visible from outside when the branchial orifice is moderately open. It is conical in shape, with blunt apex, and attached obliquely to the anterior wall of the thorax in such a manner that the apex is directed towards the axis of the body. The aperture of the neural gland is situated on its anterior surface about half way between the apex and the base of the organ where it joins the base of the median dorsal tentacle (Pl. II., fig. 10). The aperture is simple, oval in outline, and is placed transversely in reference to the axis of the organ. As the peripharyngeal ridge is continuous with the ciliated patch covering the apex of the dorsal tubercle, and the peripharyngeal membrane almost reaches the anterior surface of the organ before it is lost to sight, these two components of the peripharyngeal band well deserve the names of "anterior and posterior lips", as they are sometimes called in simple ascidians. At the apex and on both sides the wall of the organ is made up of cubical or columnar cells. In the immediate neighbourhood of the aperture the cells are rather high and ciliated. In other places the tubercle is covered with an epithelium of flattened cells.

Nerve ganglion. The nerve ganglion is in its usual position on the dorsal side of the branchial sac immediately beneath the ectodermal epithelium of the body wall. It is oval or elliptical in outline and sends out nerve trunks both anteriorly and posteriorly.

The nuclei of the cells are found mostly in the peripheral parts, the centre being mainly composed of fibrous substance (Pl. II., fig. 10). The longer diameter, which is placed antero-posteriorly, measures almost 0,1 mm.

Neural gland. The neural gland lies immediately beneath the nerve ganglion and is nearly of the same size as that organ. It is bladder-like in structure with uniformly thick wall and a large cavity in the interior. The wall is composed throughout of a single layer of cells, the cytoplasm of which, however, seems not to be clearly bounded, forming rather a sort of syncytium. The dorsal portion of the wall is in close contact with the nerve ganglion, but the boundary between them is everywhere quite distinct, and there is no area in which the tissues of the two organs gradually pass over to each other[1] (Pl. II., fig. 10).

The central cavity of the neural gland communicates with the exterior by means of a short duct which opens on the anterior surface of the dorsal tubercle. This duct is of the same width throughout except the terminal portion which is somewhat widened so as to form a sort of funnel. At the very margin of the opening, however, the duct is again a little constricted (Pl. II., fig. 10). The wall of the duct is made up of cubical cells all over. In the terminal portion of the duct, where it is widened, the cells are provided with long vibratile cilia.

A cross section though the middle part of the dorsal tubercle is shown in Pl. II., fig. 11. At the centre of the figure the ciliated terminal portion of the duct of the neural gland is seen cut across. On both sides the wall of the dorsal tubercle is formed for the greater part by an epithelium of ciliated columnar cells, which is the direct continuation of the epithelial layer of the peripharyngeal ridge mentioned above. The peripharyngeal membrane is also seen immediately on the dorsal side of this epithelium. The posterior wall of the dorsal tubercle is formed of a thin epithelium

1 According to M. M. Metcalf ('00), who made a special study of the intersiphonal organs of various groups of Tunicata, there is in all the compound ascidians a region where the cells of the ganglion and the neural gland merge into one another and are indistinguishable.

of simple flat cells. The undulations of this epithelium shown in the figure are, I believe, due to contraction incident to preservation.

Alimentary canal. The alimentary canal is contained partly in the thorax and partly in the abdomen. Excluding the branchial sac, which is the foremost portion of the canal, it may be divided into three parts, the oesophagus, the stomach, and the intestine (Pl. III., fig. 15).

The oesophageal opening is placed at the posterior end of the branchial sac, nearer the dorsal than the ventral edge (Pl. II., fig. 8, *oe.*). It is separated from the hind end of the endostyle by a narrow space where the bottom of the branchial sac is lined with thin epithelium. As shown in the figure, the terminal portion of intestine lies immdiately beneath this part in close contact with the oesophagus. The oesophagus is rather short and funnel-shaped, with the wall thrown into irregular longitudinal folds (Pl. III., fig. 15). Generally the course of the oesophagus is a little curved. The anterior margin of its wall is somewhat raised and forms a distinct ridge or lip (Pl. III., fig. 18). Posteriorly the oesophagus projects into the cavity of the stomach considerably and seems to perform the function of a valve (Pl. III., fig. 16). The wall of the oesophagus is lined with columnar epithelium and is finely ciliated all over. In sections stained with haemalaun the zone formed by inner halves of these cells is coloured dark blue and stands out very conspicuousiy. In the part projecting into the interior of the stomach the cells do not show any such differentiation.

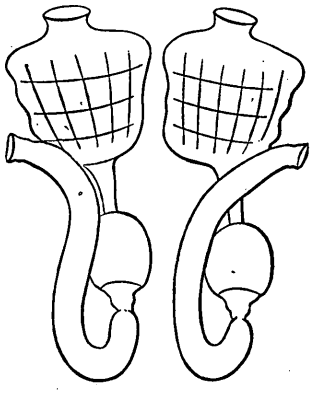
The stomach is oval-shaped with smooth and uniformly thick wall. The anterior end of the organ is rounded with an invagination at the centre, forming a sheath for the oesophagus which proceeds a short distance into the interior (Pl. III., fig. 16). The posterior end, on the contrary, terminates quite abruptly and without any constriction. The stomach, therefore, is comparable in form with an egg from which the posterior third (next the pointed end) has been cut away. The wall is of considerable thickness being lined with an epithelium of tall columnar cells.

It is perfectly smooth both externally and internally, and no folds or thickenings, such as are frequently met with in other compound ascidians, are to be seen. The stomach is nowhere ciliated.

The intestine begins at the posterior end of the stomach, runs backwards for a short distance, then turns to left and runs forwards till it reaches the bottom of the branchial sac; here it is curved either to right or to left and opens into the longitudinal furrow separating the double rows of zooids. A short tract of the intestine lying immediately behind the stomach and clearly bounded by a costriction posteriorly differs from the rest of the canal in many respects, and may, for the sake of convenience, be distinguished as "duodenum." It corresponds exactly to the "post-estomac" of some French authors and the "Mitteldarm" of German writers. The remaining portion of the canal exhibits nearly the same character throughout, though it may conveniently be divided into three regions in referrence to the area occupied by the intestinal gland.

The duodenal part of intestine has the shape of a truncated cone attached by the broad base to the posterior end of the stomach. The wall, which is generally a little wrinkled, is lined with a layer of cubical cells without cilia and stains very deeply with haemalaun. The alimentary canal has thinnest wall in this part, and, as the stomach lying immediately in front of it is the thickest walled part of the canal, the contrast in thickness of the walls is very striking.

The intestine, exclusive of the duodenum, may be divided into three regions of nearly equal length. The first third lying next the duodenum occupies the hindmost region of the abdomen and is bent somewhat in the form of the letter U. Next comes the middle third which is distinguished by the presence of the fine tubular intestinal gland covering the outer surface of the wall. The last third, which may be called the rectum, is simply tubular in form and opens by the anal aperture into the common peribranchial space. In microscopical structure of the wall, however, there is no noticeable difference between these parts. The course of the rectum is a little different according to the position of the



Text-fig. 3.
Two zooids placed side by side to show the difference in the course of intestine.

zooid in the colony. In those zooids situated on the left side in a pair of rows the rectum turns to left and terminates in the anus without crossing the oesophagus. In those belonging to the right half of a pair of rows, on the other hand, the rectum turns to right and crossing the oesophagus on its dorsal and right side, opens into the longitudinal furrow lying next it on that side (see textfig 3). That the intestine lies mainly on the left side of the stomach in either case is clearly seen in a cross section through the lateral wall of the colony (Pl. I., fig. 3).

The intestine, with the exception of the duodenum, is nearly of the same width through its entire length. Its diameter is a little less than that of the stomach, but is greater than that of the posterior end of the duodenum. The relative sizes of these parts are shown in Pl. III., figs. 15 and 16 (*st.*, *d.*, *int.*) For the greater part of its length the intestine is smooth walled, exhibiting only slight wrinkles at the place of bending and in the terminal region just in front of the anus. The wall of the intestine is lined with low columnar cells with the nuclei situated near the base, and is, in comparison with that of the stomach, considerably thinner. A glance at Pl. III., fig. 20, representing a cross section of the abdomen, will suffice to make clear the difference in the thickness of walls of these organs. On the lips of the anus, however, the cells are taller. At the anal opening the wall of the rectum is turned outwards so as to form a sort of lip (Pl. III., fig. 17). Just in front of the anus the rectum is surrounded by a set of ring muscle fibres which no doubt perform the function of a sphincter.

In the middle third of its course the intestine is embraced externally by a system of fine branching tubules, corresponding to the digestive gland found in many simple ascidians. The duct from this system runs across from the intestine and opens into the

stomach (Pl. III., fig. 19). The tubules are round or oval in cross section and measure 0,02–0,025 mm. in diameter. They are placed on the outside of the intestinal epithelium and are generally in close contact with it (Pl. III., fig. 21). The course of these tubules is wavy throughout. For the greater part they run parallel with the axis of the intestine. In the part lying nearest to the stomach, however, they are found to form two or three rings encircling the intestine. The duct is lined with cubical cells (Pl. III., fig. 19), but the tubules themselves are composed of much flatter cells.

Blood vascular system. The heart lies in the loop formed by the alimentary canal between the stomach and the ascending portion of the intestine. It is a fusiform tube with undulating walls, and is enclosed in an outer delicate membranous sac, the pericardium, which fills the greater part of the space between the stomach and the intestine (Pl. III., fig. 20). The heart is attached to the pericardium along a line on that side which lies next the intestine. The wall of the heart is not of the same thickness throughout, but is thinnest along the line where it joins the pericardium and becomes gradually thicker as it is traced to the other side, where it is sometimes as thick as the wall of the intestine. (Pl. III., fig. 25). A number of muscle fibres are clearly discernible in its tissue. In some sections it can be distinctly made out that the walls of the heart and pericardium are directly continuous with each other, and that the heart is simply an invagination of the pericardium.

The heart is open at both ends. The blood flowing out of the heart passes into definite canals channeled out in the connective tissue filling the space between the body wall and the internal organs (Pl. II., fig. 14; Pl. III., figs. 18 and 25, *bl. sp.*). The blood corpuscles are round or oval cells with distinct nuclei (Pl. III., fig. 23). They are gathered in some of the blood spaces while they are wholly absent in others.

As stated before, each zooid sends out from the posterior end of abdomen an ectodermal appendage. This is a thin walled tube of varying width divided longitudinally into two cavities by a delicate septum, so that in reality it is formed of two vessels run-

ning side by side (Pl. III., fig. 24). It passes through the test substance of the longitudinal ridge downwards towards the base of the colony. The lumen of these tubes is continuous with the blood spaces of the zooid to which they belong. Their number increases as they are traced downwards. They run mostly parallel with one another and, so far as I could ascertain, there is no anastomosing among them. In sections the vascular appendages are found to be surrounded by a space separating them from the test substance, but this is no doubt the result of contraction of the neighbouring tissues.

Reproductive Organs. Unfortunately in all the zooids examined by me the reproductive organs were not in full development. Neither the testes nor the ovaries could be made out with certainty. The genital duct, however, was tolerably large and very clearly visible. This fact, I believe, renders it very probable that the zooids examined by me had already passed through the period of sexual maturity rather than that they were still on the way of development. The duct runs along the rectum for some distance and opens quite near the anus, somewhat covered over by the expanded margin of that aperture. Its wall is lined with cubical cells (Pl. III., fig. 22).

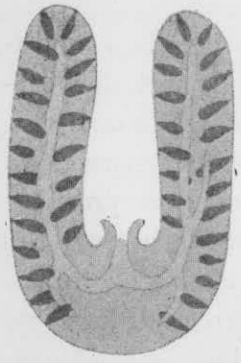
Incubatory Pouch. In one of the colonies examined by me nearly all of the zooids situated near the free margin of the head are provided with an incubatory pouch. It is an appendage to the mantle, being merely an enormous diverticulum of the peribranchial or atrial cavity. It is oblong in shape, nearly twice as long as it is wide, and contains only a single embryo in the middle where it is widest. The tadpole-like larva has three large adhesive papillae and a long tail, and looks very much like that of *Diplosoma*. Since the other colony, though somewhat larger, shows no individual provided with a pouch, it is highly probable that the species is dioeceous.

Systematic Position.

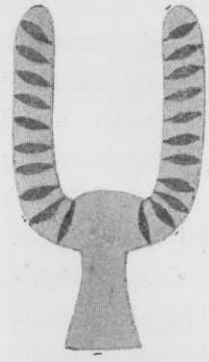
The external form of colony is, generally speaking, not a character of much importance in determining the systematic posi-

tion of a compound ascidian, but it should certainly be taken into consideration when it is so highly specialised as in the present species. It is in fact one of the chief diagnostic characters by which the family Cyathocormidae differs from all the other recognized families of the Ascidiae compositae.

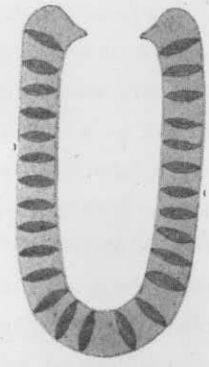
The hollow cylindrical form of the colony of *Cyathocormus* is so utterly different from that of other compound ascidians that it seems at first sight almost impossible to reduce it to one of the typical forms of colony prevalent among these animals. On the



Text-fig. 4.
Coelocormus



Text-fig. 5.
Cyathocormus



Text-fig. 6.
Pyrosoma

contrary, its extraordinary shape recalls the arrangement seen in *Pyrosoma*, where the zooids and their investing mass form the walls of a hollow cylinder closed at one end. As shown in the accompanying woodcuts (text-figs. 4, 5, and 6) the mode of arrangement of the zooids is practically the same in *Cyathocormus* (text-fig. 5) and *Pyrosoma* (text-fig. 6), whereas in *Coelocormus* (text-fig. 4), which was considered by Prof. Herdman to be the most *Pyrosoma*-like compound ascidian, the arrangement is quite different. Here the whole surface, both the outside of the colony and also the lining of the axial cavity, is morphologically the outer surface, and the branchial apertures of the zooids are found distributed all over it. It is therefore evident that although the form of the colony in *Coelocormus huxleyi* somewhat resembles that of *Pyrosoma*, still the inner surface lining the central cavity is homologous with part of the outer surface of an ordinary compound

ascidian and not with the inner surface lining the central cavity of *Pyrosoma*. In *Cyathocormus* the case is wholly different. The central cavity of *Cyathocormus*-colony exactly corresponds with that of *Pyrosoma* both morphologically and functionally, the cavity in question representing in both cases the common cloaca of the whole colony. That a diaphragm is present in one form and lacking in the other is not of much importance, since the mode of life is entirely different in these animals, and the diaphragm, though highly useful in making the jet of water more powerful in a swimming animal, would be of no use in a sedentary colony.

So far as I can judge, the form of colony of *Cyathocormus* might most naturally be deduced from that of *Diplosoma*, such as is figured in BRONN's Klassen und Ordnungen des Tierreichs, III. Suppl. p. 184, or in LAHILLE's work ('90) p. 112. If we imagine the base of attachment of such a colony to become smaller and the common cloacal opening larger, until the shape of the colony has become cylindrical, we would have practically the same form of colony as it really occurs in *Cyathocormus*. In all probability, the thoracic region, lying nearest the superficial layer of test, would have kept its position perpendicular to the walls of the cylindrical head, while the abdomen, being connected with the base of the colony by means of the vascular appendage projecting from its posterior end, would be bent downwards and cover the thorax of the zooid lying next below on the inner side. In like manner, the test substance enveloping the vascular appendages of various zooids now arranged in longitudinal rows would fuse together to form compact masses. In short, the colony would be converted to one exactly similar to that of *Cyathocormus*.

It is, however, equally possible that the colony of *Cyathocormus* has been produced in the following way. Suppose a club-shaped colony of compound ascidian, such as *Colella murrayi* or *C. quoyi*, for example, has lost a part of the test substance at the top as well as in the interior of the head. The colony would in this case also become cup-shaped and would very much resemble a *Cyathocormus* colony. Moreover, the mode of formation of the colony might, in all probability, be much the same. In *Cyathocormus*, as in the

genus *Colella*, the buds seem to be produced near the base of the colony and gradually pushed to the outer surface of the head. Here, probably, they soon reach maturity, the female individuals producing also a tailed larva from an egg fertilized by the spermatozoa of the older zooids. They are then constantly pushed upwards, and finally, having lived through the entire length of the head, they reach the free margin as old zooids, die and drop off. This is, I believe, the reason why we do not find young buds or functionally active reproductive organs in the zooids situated in the distal part of the head.

The similarity in the arrangement of zooids within the colony in *Cyathocormus* and in some members of the genus *Colella* (=*Sycozoa*), such as *C. pulchra*, *C. tenuicaulis*, etc. is also very striking. The zooids form, in both cases, longitudinal rows grouped in pairs, in which they are placed alternately in such a manner that the endostyles are turned towards one another. Moreover, in the last species the head is sometimes truncated at the top and much resembles that of *Cyathocormus*, so that if the head became hollow inside the colony would have exactly the same form as that of our species.

Turning now to the anatomy of the individual zooids we again find that the present genus is closely related to *Colella* among the Distomidae and to *Diplosoma*. In all these forms the body is divided into thorax and abdomen, to which a vascular appendage is attached. The branchial sac has four rows of stigmata. The intestine forms a simple loop lying posteriorly to the branchial sac. The stomach is smooth walled. In the possession of a large incubatory pouch, however, *Cyathocormus* agrees with *Colella* and differs from *Diplosoma*. If, in addition, the colonies of *Cyathocormus* should turn out to be really dioeceous, which is very probable, the relationship between the two genera would become decidedly closer.[1] In the unlobed condition of the branchial aperture, on the other hand, *Cyathocormus* differs

1. According to the researches of CAULLERY ('95) members of the genus *Colella* (=*Sycozoa*), with the single exception of *C. thompsoni*, are all dioeceous.

2. *Astrallium spongiforme* GIARD ('72) has unlobed branchial aperture.

from both *Colella* and *Diplosoma*,[2] but agrees with *Pyrosoma*. As stated before, the only other compound ascidian in which the peribranchial wall is so imperfectly developed as to expose the greater part of the branchial sac, is found among the family Diplosomidae.

In short, it seems highly probable that the new family is more closely allied to some members (genus *Colella*) of the Distomidae than to any other group of the Ascidae compositae. Though it is sufficiently characterised by the hollow cylindrical form of the colony with a large centrally placed common cloaca, this form might be regarded as a modification of the colony form actually met with in certain genera. If, in future, transition forms should happen to be discovered, it might of course become necessary to unite the Cyathocormidae with one of the closely related families. At present, however, it seems best to consider our form as the type of a distinct family and place it, in a phylogenetic classification of the Tunicata, somewhere in the neighbourhood of the Distomidae, representing a special branch leading in the direction of the Pyrosomidae. By the intervention of the present family the Ascidiae Salpaeformes would be much more closely connected with the rest of the Ascidiacea than was hitherto the case, rendering it doubtful whether we are justified in separating *Pyrosoma* from other compound ascidians and placing it along with *Salpa* and *Doliolum* in a different order, the Thaliacea.

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List of the Abbreviations used in the Plases.

a.	Anus.	*b. c.*	Bladder cells.
bl. c.	Blood corpuscles.	*bl. sp.*	Blood spaces.
bl. v.	Blood vessel.	*bl. ap.*	Branchial aperture.
br. s.	Branchial sac.	*d. n. gl.*	Duct of neural gland.
d. int. gl.	Duct of intestinal gland.	*du.*	Duodenal portion of intestine.
d. t.	Dorsal tubercle.	*end.*	Endostyle.
ect.	Ectoderm of body wall.	*h.*	Heart.
g. d.	Genital duct.	*int. gl.*	Intestinal gland.
int.	Intestine.	*n. gl*	Neural gland.
n. g.	Nerve Ganglion.	*prb.*	Peribranchial cavity.
œ.	Oesophagus.	*prph. m.*	Peripharyngeal membrane.
prc.	Pericardial cavity.	*rct.*	Rectum.
prph. r.	Peripharyngeal ridge.	*sp.*	Space between test and body wall produced by shrinking.
sg.	Stigmata.		
st.	Stomach.	*t.*	Test.
t. c.	Test cells.	*tn.*	Tentacles.
tr. v.	Transverse vessel of branchial sac.		

Plate I.

PLATE I.

Fig. 1. Two colonies attached to a coral. Nat. size.
Fig. 2. External surface of colony. 8/1.
Fig. 3. Part of cross-section of colony. 15/1.
Fig. 4. Part of longitudinal section of colony. 15/1.
Fig. 5. Section of test. 400/1.
Fig. 6. Branchial aperture, seen from inside. 80/1.

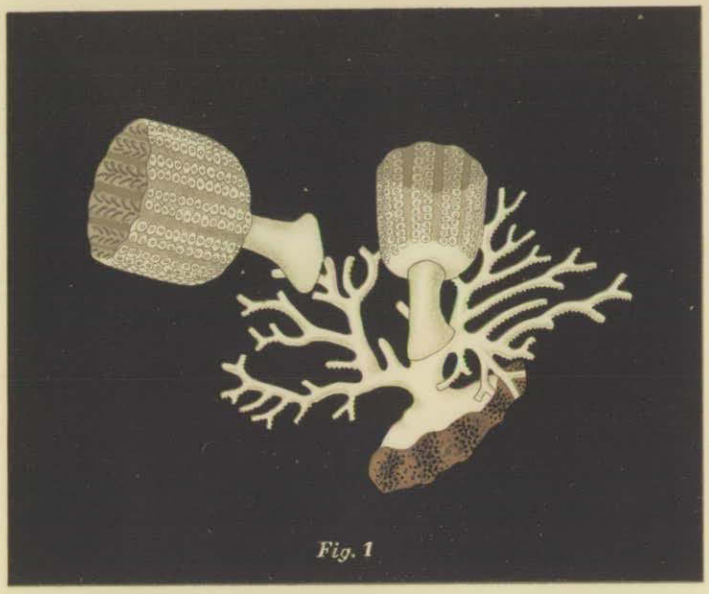


Fig. 1

Fig. 2.

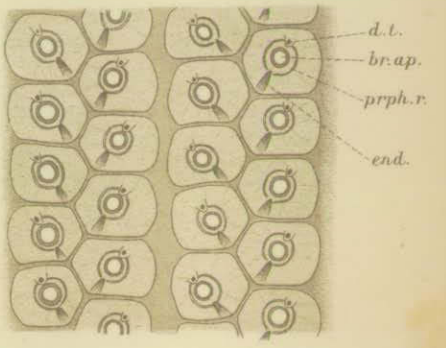


Fig. 3

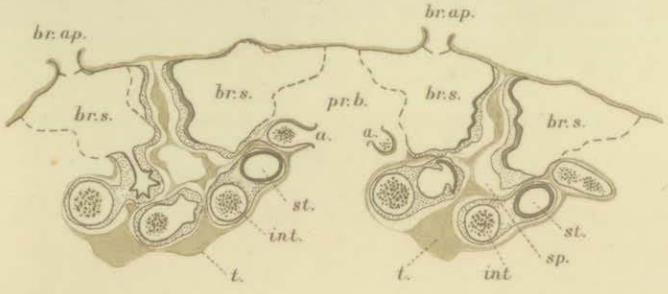
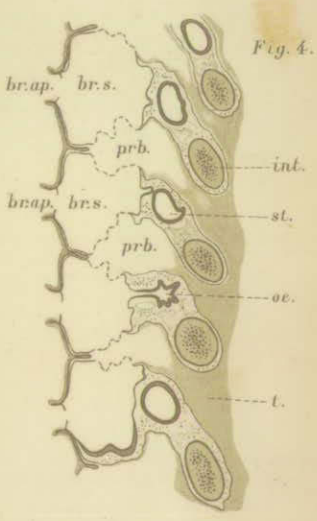


Fig. 4.



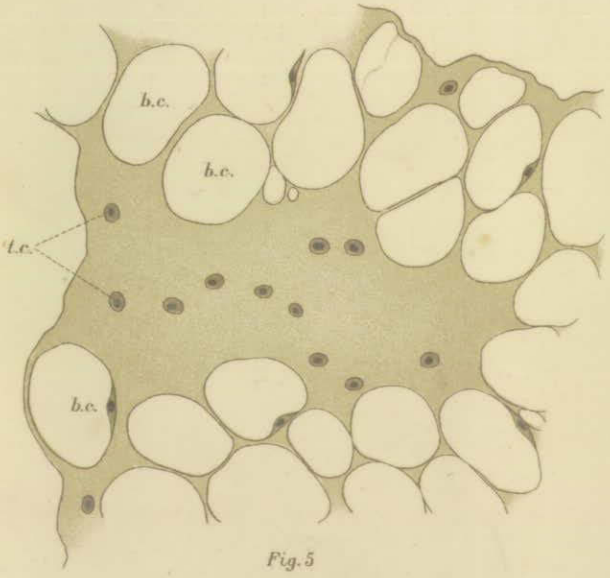
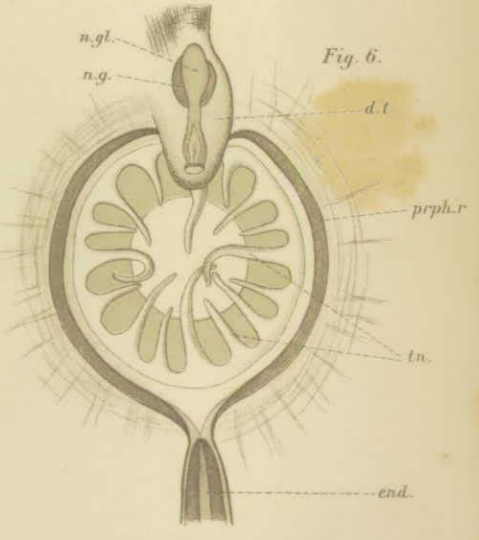


Fig. 5

Fig. 6.



A. Oka : *Cyathocormus mirabilis.*

Plate II.

PLATE II.

Fig. 7. Longitudinal section through endostyle. 200/1.
Fig. 8. Longitudinal section through thorax. 40/1.
Fig. 9. Longitudinal section through the wall of branchial siphon. 200/1.
Fig. 10. Longitudinal section through dorsal tubercle. 200/1.
Fig. 11. Cross-section through dorsal tubercle. 200/1.
Fig. 12. Part of branchial sac. 200/1.
Fig. 13. Cross-section of longitudinal vessels. 200/1.
Fig. 14. Cross-section of endostyle. 200/1.

Fig. 7.

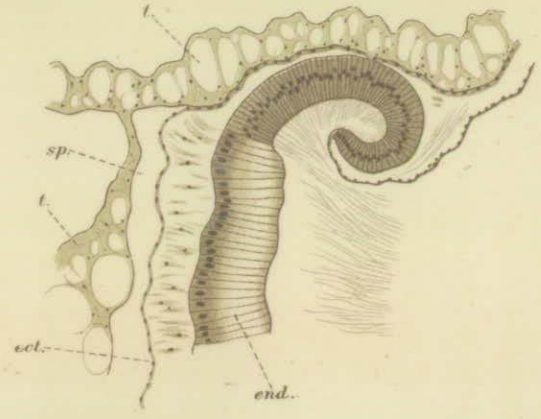


Fig. 8.

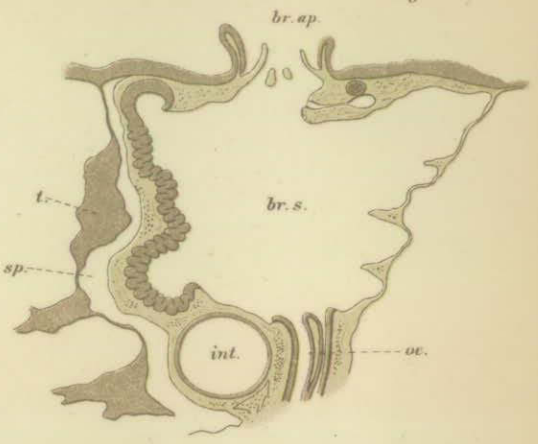
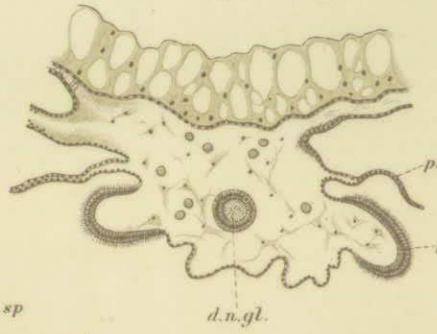


Fig. 11.



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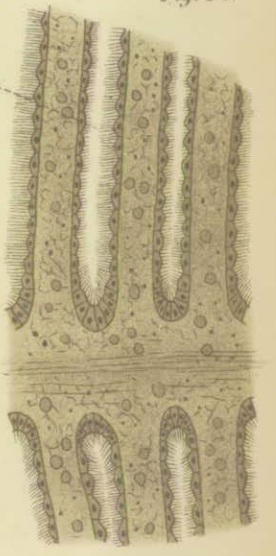

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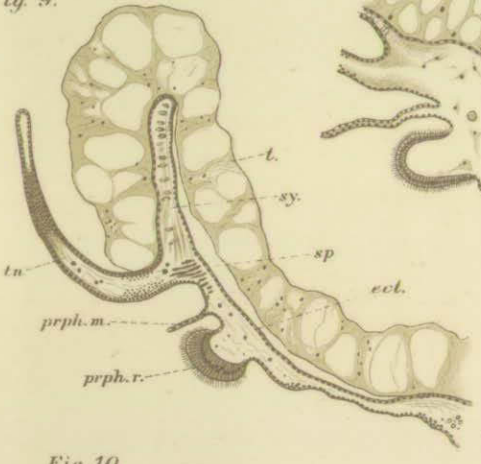
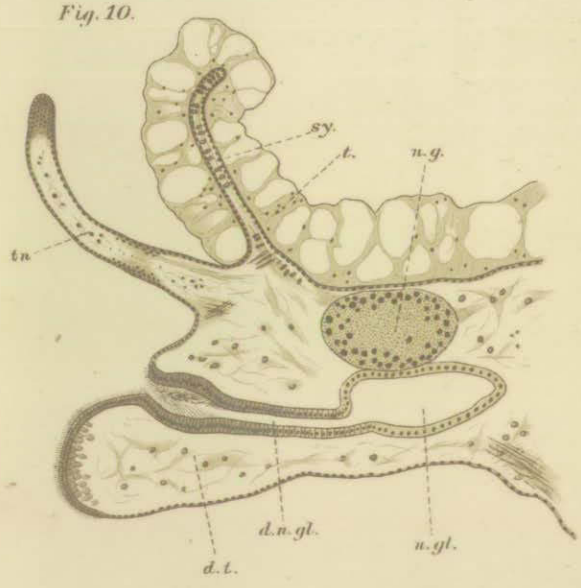


Fig. 13.

Fig. 10.



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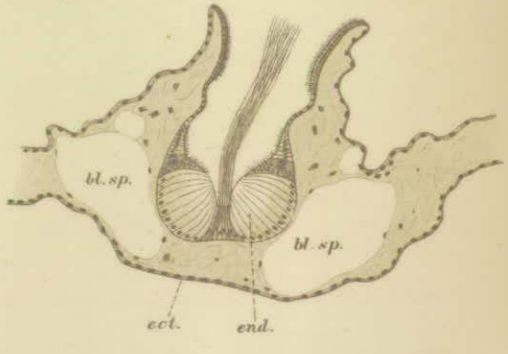


A. Oka : *Cyathocormus mirabilis.*

Plate III.

PLATE III.

Fig. 15. Alimentary canal. 25/1.

Fig. 16. Longitudinal section through oesophagus, stomach, and intestine. 40/1.

Fig. 17. Longitudinal section through rectum. 80/1.

Fig. 18. Longitudinal section through oesophogus. 80/1.

Fig. 19. Opening of intestinal gland into stomach. 200/1.

Fig. 20. Cross-section through abdomen. 80/1.

Fig. 21. Section through intestinal wall with gland. 200/1.

Fig. 22. Section through genital duct. 200/1.

Fig. 23. Blood cells. 400/1.

Fig. 24. Blood vessels in test. 200/1.

Fig. 25. Section through heart and pericardium. 200/1.

Fig. 15

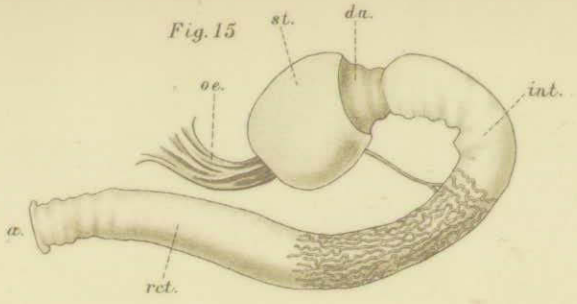
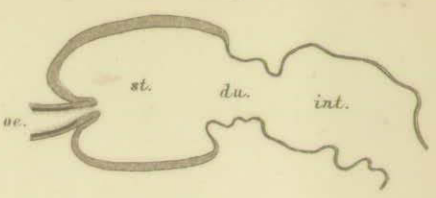


Fig. 16.



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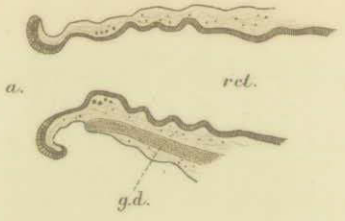

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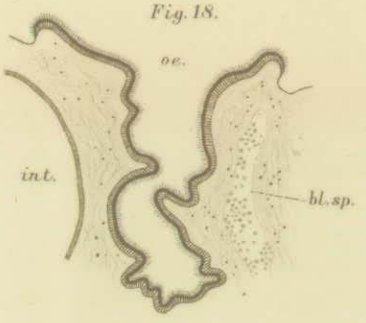

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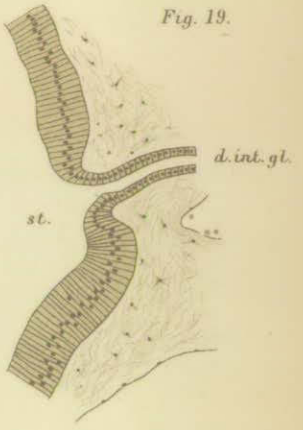

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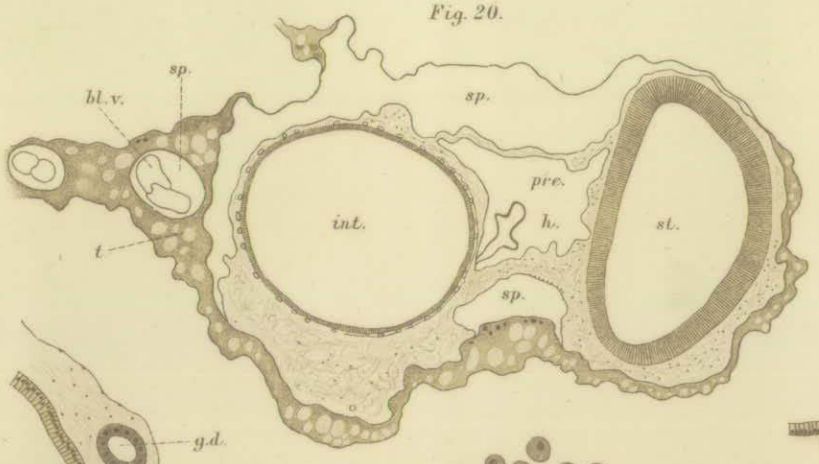

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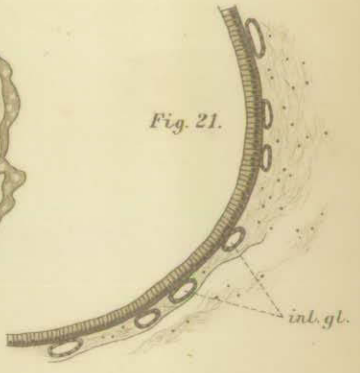


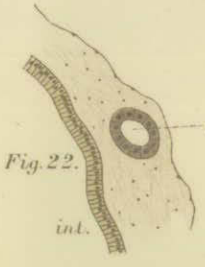


Fig. 22.

Fig. 23.

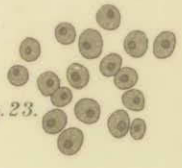
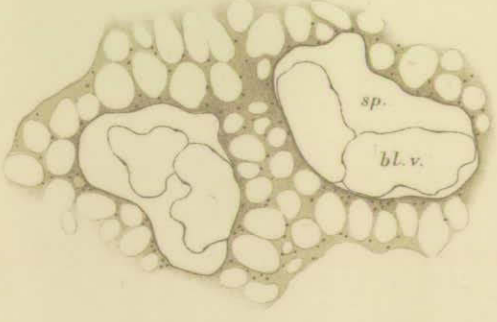


Fig. 24.



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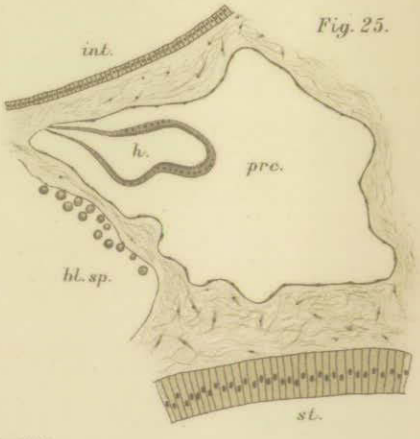

A. Oka : *Cyathocormus mirabilis.*