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OBSERVATIONS ON THE *CHLORAEMIDAE*, WITH SPECIAL REFERENCE TO CERTAIN AUSTRALIAN FORMS.

By William A. Haswell, M.A., D.Sc., Edin., F.L.S., Challis Professor of Biology, University of Sydney.

[Plates xxvi-xxviii.]

The following notes have reference chiefly to a remarkable member of this family which occurs on the Queensland coast; but the opportunity has been taken to give some account at the same time of two other Chloraemids which have been found by the author in Port Jackson, and which have not hitherto been described.* A specimen of *Stylarioides monilifer* was investigated for comparison with the new species, and a few remarks on its structure will be found here and there in the following pages.

I. Description of Coppingeria longisetosa, n.g. et sp.

I have seen only two specimens of this remarkable Chaetopod. One was dredged in 1881 by Dr. Coppinger and myself in Port Molle, Queensland (lat. 20° S.), at a depth of 15 fathoms. The other was got long before by the Hon. Sir William Macleay during his expedition to Torres Straits and New Guinea in the "Chevert," and was dredged off Darnley Island. I have figured both of these specimens, as one is more complete in one respect and the other in another; and I find it advantageous to describe

* The only previously known Australian species of this family appears to be the *Siphonostomum affine* described by me in a paper published in the Proceedings of this Society. The same name had, unfortunately, been applied previously by Leidy to another species; but the latter, as pointed out by Grube, is probably a *Stylarioides*.

their external characters separately. The Port Molle specimen has been cut into sections ; the Darnley Island specimen remains in the Macleay Museum, in the University of Sydney.

Specimen A (that from Port Molle) has, apparently, had a portion of the posterior extremity broken off. Otherwise it is admirably preserved—particularly as regards the branchiæ, the tentacles and papillæ. Specimen B is entire as regards the segments; but the praestomium has been broken off, and the branchiæ and tentacles are therefore lost.

Specimen A (plate XXVI. fig. 1).—The body is sub-cylindrical, tapering gradually posteriorly, the greatest breadth being at a little distance behind the cephalic extremity, where there is a slight dilatation. Round the latter is a circlet of sixteen very large setæ, which are nearly as long as the body, thick at the base, finely tapering, and slightly curved towards the distal end. They are marked transversely by fine transverse lines, giving them the appearance of being composed of a number of segments. In most cases there is situated close to the base of each large seta a very much smaller accessory seta. All the large setæ in this specimen, as in the other, have attached to them numerous individuals of a species of *Loxosoma*.

There are twenty-six segments in the body (from which the posterior portion has been broken off). The number of the segments can only be reckoned by counting the bundles of setæ, except in the case of a few of the most posterior, which are separated from one another by distinct constrictions. All the segments behind the head bear setæ ; but the parapodia are not distinguishable. All, except the first seven, have dorsal and ventral sets of setæ separated from one another by a short space. The dorsal setæ alone are present in the first seven segments, or, at least, if ventral setæ are present in these segments, they do not project on the surface. In the first segment (behind those that bear the cephalic setæ) there are four very long and very fine dorsal setæ, stouter and longer than those of the succeeding segments, and directed forwards. The following segments,

except the first six, which have only dorsal setæ, have each a bundle of four fine, tapering dorsal setæ and three stouter, short ventral setæ, which are curved at the ends. (Plate XXVII. fig. 9.) The dorsal setæ are in fan-like groups directed forwards and outwards.

The body wall is tolerably firm. The surface is covered with closely-set papillæ, which vary in size, some being elongate, others very short; a number of those around the bases of the anterior large setæ are very long and slender, with slightly enlarged rounded ends: a detailed account of the papillæ is given further on.

The head (fig. 2) consists of a stout base, bearing distally a pair of tentacles, and a pair of branchiferous lobes. The base is 8 mm. in length, and at its posterior end is about half the thickness of the anterior part of the body, narrowing slightly towards its distal end; closely embraced behind by the bases of the ring of large anterior setæ and by the elongated papillæ; its surface is dotted over with papillæ similar to those covering the body, but smaller. It consists of the greatly produced peristomium surrounded, as by a sheath, by a thin prolongation of the first body-segment. The præstomium is produced in front laterally into the compressed bases of the branchiferous lobes; mesially in front is a small lobe bearing two pairs of eyes; in front of the mouth are borne the two tentacles. The branchiferous lobes are somewhat club-shaped, a little shorter than the head, and covered with branchiæ, about sixty on each. The two tentacles are cylindrical, longitudinally grooved bodies, which taper slightly towards the end, rather longer than the head, but scarcely a third of the diameter, devoid of papillæ.

The total length of the specimen, including the setæ, was 5 cm.; of the body excluding setæ and head-lobe, $2\frac{1}{2}$ cm. The head lobe with the branchiæ was 1·2 cm. in length. The greatest breadth of the body was ·5 cm.; the breadth at the posterior end ·2 cm.

Specimen B (fig. 3).—The form of the body is approximately cylindrical, broadest near the anterior end and gradually tapering

backwards. There are forty-three segments, which are quite distinct behind, but in front are not to be distinguished but for the bundles of setæ. The latter are situated on slight transverse elevations; there are four slender dorsal setæ directed forward and three curved ventral setæ; the latter first appear on the fifth segment. The head-lobe is similar to that of specimen A, but its extremity with the tentacles and the branchiæ has been lost; it is separated into two parts by a distinct narrow annular groove. The large setæ surrounding the head are twelve in number.

The total length, inclusive of the setæ, is 1 decimetre; that of the long setæ 4 cm. The remnant of the head-lobe is 1 cm. in length.

II. Position and relations of Coppingeria.

There can be no doubt of the relationship of this remarkable Polychaet to the members of the family *Chloraemidae*, both in external features, and, as will subsequently be shown, in internal structure. But there can I think be little more doubt that it is sufficiently far removed from its nearest relative—*Stylarioides*—to require a distinct generic appellation. The anterior setæ constitute the most striking feature; but perhaps a more important characteristic is the bifid and produced branchial apparatus with its numerous branchial filaments. I propose, to call the new genus *Coppingeria** and the species *longisetosa*. The characteristic features of the genus may be thus summarised:—

Body not greatly elongated, swollen in front, composed of a moderate number of segments which are not distinct except in the posterior portion of the body. Parapodia not prominent,

* After my friend Dr. R. W. Coppinger, M.D., Fleet-Surgeon, R.N., surgeon of H.M.S. "Discovery," during the Arctic Expedition of 1875-6, and of H.M.S. "Alert" during her southern cruise. In the account which he published of the latter voyage Dr. Coppinger thus refers to the worm under consideration :—"Among the Annelids was one with long glassy opalescent bristles surrounding the oral aperture and projecting forwards to a distance of one and a half inches from the praestomium."—(Cruise of the "Alert," p. 187.)

with two sets of setæ, except in a few of the most anterior segments; setæ of both sets few in number; those of the dorsal set very fine, tapering; those of the ventral set stouter, curved at the ends. The setæ of the most anterior segments greatly prolonged, forming a complete circlet directed forwards. The præstomium with two pairs of eyes. Branchiæ numerous, cylindrical, borne on a pair of club-shaped prolongations of the præstomium. Tentacles very long, cylindrical, smooth, with a ventral longitudinal groove. Peristomium produced, capable of being retracted together with the præstomium (and the branchiæ?) within a sheath formed for it by the following segment. Papillæ very numerous, not arranged in rows, and equally developed on all sides of the body; some of those around the bases of the anterior large setæ extremely produced.

III.—Description of two species of Stylarioides*.

Stylarioides cinctus (Plate xxvi. fig. 4).

The total length (exclusive of the setæ) is 2·25 cm. The longest setæ of the anterior segments are nearly one centimetre in length. The greatest breadth of the body is 3 mm. The total number of segments is 48.

The præstomium (fig. 5) is produced forwards on the dorsal side into a curved lamina, on the anterior edge of which are situated the branchiæ. Of the latter there are ten, all cylindrical filaments, the central pair considerably longer than the others and not very much shorter than the tentacles: each branchia presents a pair of longitudinal crimson bands. The antennæ are dorso-ventrally compressed, transversely corrugated, with a deep longitudinal ventral groove, about the length of the first four segments.

The body is cylindrical, somewhat dilated in the anterior portion, narrowing suddenly behind the twentieth segment; the posterior, narrow part tapering posteriorly. In a second specimen the ten

* As defined by Grube.

most anterior segments are constricted. The surface is of a dull brown colour, without a distinct layer of mucus, encrusted on the dorsal surface for some little distance at the anterior end with firmly fixed and closely set sand-grains.* The papillæ are not very numerous or very prominent, scattered over the surface, with a tendency to the formation of irregular transverse rows; they are equally developed on the dorsal and on the ventral surface. On the elevations from which the elongated setæ of the two anterior segments spring, there are papillæ of a slightly greater length than those on the general surface of the body. Each papilla is situated on a little elevated area.

The segments are not very distinct in the anterior swollen part of the body, but are much more evident behind. The parapodia do not project from the surface. The setæ of the first two segments are 40-50 in number, slender, slightly curved inwards, directed forwards. On each of the other segments there are three or four very slender dorsal setæ and three stouter ventral setæ. The former are transversely striated, as is usual in this family; they are rather longer than the segments; the latter have a short terminal segment, which is unjointed, curved, and pointed, articulating with the elongated, transversely striated basal portion; the ventral setæ project more prominently from the surface in the anterior segments than in the posterior.

Specimens of this species, together with the following, were got with the dredge near Watson's Bay in Port Jackson. It belongs to that section of the genus to which Grube refers *S. parmatus*, Gr., *S. Cariboum*, Gr., and *S. cingulatus*, Gr., and to which also *S. capensis*, McIntosh, belongs—all these forms being characterised by the presence on the dorsal surface of the anterior part of the body of a space covered with closely cemented sand-grains. I cannot identify the Port Jackson species with any of these.

* A similar feature is described by Grube ["Annulata Semperiana," 'Mém. de l'Acad. Imp. des Sci. de St. Pétersbourg,' vii. série, t. xxv. (1878)] in his *Stylarioides parmatus* from the Philippines, and by McIntosh in *Trophonia capensis* ("Challenger" Reports, Annelida).

STYLARIOIDES HORSTII, (Plate XXVI. figs. 6-8).

Both of the specimens of this species that are at my disposal are imperfect; the more complete of the two is 1·5 cm. in length. The longest setæ are 2·5 mm. in length. The greatest breadth is 3·5 mm. The number of segments is 39.

The head and branchial apparatus are retracted in both specimens, but, when dissected out, showed the following features:— The tentacles are of about the length of the first six segments of the body; their greatest breadth is about one-seventh of their length. They are deeply grooved longitudinally on the ventral side—the ridges bordering the groove being convoluted—and are very finely and closely corrugated transversely on the opposite side. The branchiæ, six (?) in number, are very long, cylindrical, and pigmented at the ends.

The body is cylindrical, of nearly uniform breadth as far as the 33rd segment, though rather narrower at the anterior end; narrowing suddenly behind the 33rd segment. There is no encrustation of sand-grains. The setæ of the first two segments, about a dozen in number on either side in each, are greatly prolonged; they do not form a ring, but are arranged in definite lateral bundles. They are exceedingly fine, and are divided by transverse lines into numerous joints; they are covered with stalked infusoria like the rest of the setæ. The setæ of the third segment, 4-5 in number, are more conspicuous than those of the rest of the body, and are about half the length of the second segment; there appear to be no ventral setæ on this segment. The remaining segments all have dorsal and ventral setæ, which are both longer than is usual in this genus. Of the dorsal setæ there are five to eight in each bundle, many-jointed, very slender, tapering,—their length nearly half the breadth of the body. The ventral setæ, of which there are 4-6—usually 5—in each fasciculus, are much thicker than the dorsal, unjointed, laterally compressed, often twisted, slightly hooked at the ends, much longer in the anterior segments than they are further back.

A remarkable feature is the arrangement of the papillæ. Those of the first two segments are elongated, especially round the bases of the fasciculi of setæ. On the dorsal surface of the body each papilla is elevated on a conical wart-like protuberance, while on the ventral surface these elevations are absent. They are more numerous than in the preceding species, smaller and with a tendency to form transverse rows only on the dorsal surface.

I am not quite clear as to the position of this species; but if Grube's definitions of the genera *Trophonia* and *Stylarioides* be followed, the retractile praestomium would place it in the latter genus. At the same time, the considerable development of the setæ behind the head brings it nearer the species of *Trophonia*. It has considerable resemblance to the European *T. plumosa*, Müller; but the tubercles on that species are described as being found all over the body instead of being confined to the dorsal surface.

IV.—Integument and papillæ.

In *Coppingeria* the cuticle, which is of considerable thickness over all parts except the branchiæ, is covered superficially with a layer of a granular-looking substance with included irregular particles, which is evidently the layer of mucus with entangled granules of foreign matter present in other members of this family. This layer, however, though represented in all parts except the præ- and peristomium, with the branchiæ and tentacles, is comparatively thin, being for the most part of about the same thickness as the cuticle. A similar layer of tough gelatinous matter has been noticed by all who have given attention to the structure of this family of Polychaeta. In *Siphonostomum* it is separable with a little trouble from the body of the worm; but in the present form, as in *Stylarioides*, it is firmly adherent, so as to appear as a definite layer of the integument.

In *Coppingeria* the cuticle has the appearance of consisting of a single layer. But in *Stylarioides cinctus* (Pl. xxvii. fig. 15) there are two, the more internal having many papillæ and ridges, which penetrate into the outer.

The epidermis (plate XXVII. fig. 15) is a very thin layer save in certain situations, only reaching a considerable development on the præstomium and part of the peristomium, the grooves of the tentacles and the branchial filaments. Beneath each of the papillæ the epidermis becomes modified as described below. It consists of flattened cells (fig. 16) of polygonal outline, the reticulated protoplasm of which presents smaller and larger vacuoles. The reticulated substance of neighbouring cells is separated by narrow uncolourable bands, which anastomose and present the appearance of a branching system of fine channels, which may be connected with the secretion of the mucus.

Like the adherent layer of mucus the *papillæ* are specially characteristic of the *Chloraemidae*, and appear to be present in one form or another in all the members of the family. They have been described under various names, "mucus-secreting papillæ," "poils," "tubercles," "granules." They attain their greatest development as regards length in *Siphonostomum*, where they are greatly elongated, so as to penetrate to the surface through the relatively very thick layer of mucus. In *Coppingeria* (plate XXVII. figs. 11-14) they occur over the entire surface of the body, giving it a very remarkable appearance when examined with a lens, owing to their resemblance to the tube-feet of a sporadipodous Holothurian. They are not of uniform length, but vary considerably in this respect, a fact which might be apt to produce the erroneous impression that they are extensile and retractile. They are specially developed around the bases of the cephalic setæ, where they attain a length of as much as 3 or 4 mm. In other parts they are much shorter, on an average ·5 mm. in length. Their form is subcylindrical, with a slight terminal knob-like enlargement; in the shorter forms there is usually a considerable amount of constriction at the base, and in these also the apex is pushed in to form a shallow cup-like concavity, which may, however, though very regular, have been produced, or at least increased, by the action of the alcohol.

The memoirs of Delle Chiaje not being at present accessible to me, the earliest detailed account of these papillæ which I have

met with is that of Dujardin. In his account of *Chloraema Edwardsii** he speaks of the sort of fleece or felt with which it is covered, composed of hollow flexible filaments, club-shaped at the extremity, and constituting a series of minute stalked glands secreting the mucus. Costa† in his account of *Siphonostoma diplochaïtos* makes mention of the papillæ or stalked glands, as he regards them. Those of *Lophiocephalus* he describes as vascular and as having an aperture at the extremity for the discharge of the mucus.

Leuckart in his "Beiträge zur Kenntniss der Fauna von Island"‡ also describes the papillæ of *Siphonostomum vaginiferum* as appendages of the vascular system; but he contends that, though the extremity may present a pit-like depression, it is never perforated. He is inclined to favour Rathke's and Costa's view that they have to do with the secretion of the mucus, but suggests that they may also be concerned in the process of respiration.

Schmarda§ in his description of *Trophonia xanthotricha* mentions the presence in each segment of a transverse row of little suckers which when retracted appear like minute warts. These, he states, the animal uses to fasten itself, and also employs them in locomotion, like the tube-feet of the Echinoderms.

Quatrefages|| gives the following account of these structures in *Chloraema Dujardinii*:—"Les poils recouvrent le corps tout entier à l'exception de la face ventrale. Ils sont formés par une tige très grêle, qui se renfle brusquement à l'extremité. Ce renflement est ordinairement presque piriforme aux poils voisins des pieds et simplement arrondi sur le reste du corps. A l'intérieur, on distingue des cloisons cellulaires irrégulières, qui rappellent

* "Observations sur quelques Annélides marines." 'Ann. des Sci. Nat.' 2e série, tome XI. (1839), p. 289.

† "Description de quelques Annélides nouvelles du Golfe de Naples." 'Ann. des Sci. Nat.' 2e série, tome XVI., 1841.

‡ Archiv f. Naturg. XXIX. (1849).

§ Neue wirbellose Thiere.

|| Histoire Naturelle des Annélés," tome I., p. 474 (1865).

celles de l'âme d'une plume . . . Partout ils sont noyés dans une mucosité parfaitement transparente." . . .

In his "Memoire sur la famille des Chlorèmiens,"* he had previously expressed the opinion that the granular contents, in the case at least of some of the papillæ, were continuous with the epidermis.

Claparède† gives the most complete account of the papillæ. In *Stylarioides monilifer* he states that their form appears usually cylindrical, but adds that that is due to the encrusting layer of mucus, on the removal of which the papilla appears in the form of a spherical button at the end of a pedicle. Both pedicle and button are formed of two layers, the more external of which is homogeneous and is a continuation of the cuticle, while the other, finely granular, is the subcuticular layer. He had not succeeded by means of any re-agent in discovering any nuclei in the granular layer. The same structures in *Trophonia eruca* he describes in similar terms.

In the case of *Siphonostoma diplochaïtos* the same author describes the peduncle of the papillæ as formed of a cuticular envelope and an axial granular layer with ill-defined longitudinal fibrillation. In this axial substance, numerous elliptical nuclei, having their long axes parallel with the axis of the peduncle, are brought into view under the action of acetic acid. The base of the club-like enlargement is filled with globular finely granular masses without cellular structure. Further on the central substance re-assumes its ill-defined fibrillar structure, and terminates in several pyriform bodies of a sulphur-yellow colour. He denies the asserted vascularity of the papillæ, and sets them down as without doubt tactile organs.

Grube‡ comes back to the view of Costa and Leuckart that the papillæ are concerned with the secretion of the layer of mucus.

* 'Ann. Sci. Nat.' 3e série, tome XII. (1849), p. 277.

† "Les Annélides Chétopodes du Golfe de Naples," p. 357 (1868).

‡ "Bemerkungen über die Familie der Chlorhaeminen." 'Bericht der Schles. Gesellsch.' 1876, p. 37.

Studer in his account of *Brada mammillata** describes the epithelium as consisting of narrow cylindrical cells, and gives an account of certain sac-like structures formed from groups of modified epithelial cells, which he regards as glands, leading by a duct to a pore on the summit of one of the tubercles. These so-called glands are the basal ganglia of the papillæ described below. Joyeux-Laffuie holds with Kölliker that there is every reason to regard the papillæ as tactile organs.

In most respects my own observations on this point agree with those of Claparède; and I have been able to add some details regarding the structure of the appendages in question which go to confirm his opinion of their function. In *Coppingeria* (figs. 11-14) all the papillæ have essentially the same structure. Most externally is a thick firm layer continuous with the cuticle of the general surface. Immediately below this is a thin layer continuous with the epithelium. These layers bound a cylindrical cavity, which is continued at the base into a narrow canal. Immediately below the base of each papilla is a little ganglion composed of a rounded group of cells with a mass of granular matter on its deeper face.† Delicate strands run outwards from this basal ganglion and, passing through the narrow neck of the papilla, enter a second ganglion in the base of the latter. From this there runs to the extremity of the papilla an axial strand of fibres with occasional nuclei, and from this run out a few similar but finer branch strands, which end in the epithelium. The axial strand breaks up at the end into a few delicate radiating fibres, which terminate in a group of cells, constituting what might be regarded as a third ganglion at the extremity of the papilla.

In view of their structure, there can be no doubt that these are sensory papillæ. They contain no muscular elements, and, therefore, can have nothing to do with locomotion or fixation. They contain no cells that can be construed as gland-cells, and therefore

* "Beiträge zur Naturgeschichte wirbelloser Thiere in Kerguelensland." 'Arch. f. Naturg.' 1878.

† The granular matter is not present in the case of the elongated papillæ at the anterior end of the body.

they cannot have specially to do with the secretion of mucus. Their structure is almost exactly similar in all essential particulars to that of the papillæ on the elytra of the *Polynoidae* (fig. 18), and I have no doubt that the function is the same in both cases.*

In *Stylarioides cinctus* the form of the papillæ (fig. 15) is similar to that of those of *Coppingeria*; but each papilla here is situated on the summit of a conical elevation, in which is contained the relatively large basal ganglion. In *Stylarioides Horstii* the papillæ (figs. 17*a* and 17*b*) are very long and slender, not unlike those of *Siphonostomum*, but with only a very faint terminal swelling. Each is covered, except at the extreme end, by a very thick layer of tough mucus. In *Stylarioides monilifer* (fig. 19) the form and structure of the papillæ is essentially similar to those of *S. cinctus*, the basal part being, however, relatively longer.

V.—Blood-vascular system; branchiæ; unpaired gland.

Considerable discrepancies exist between the descriptions of the vessels in the *Chloraemidae* given by different authors.

Dujardin† simply states that he had seen the green blood circulate in dorsal and ventral longitudinal vessels with numerous transverse branches.

Costa‡ describes the ventral vessel ("vaisseau abdominal ou veineux") in *Lophiocephalus* as not extending through the length of the body and not adhering to the body-wall, but as free, arising from the lower part of the œsophagus, increasing in size as it extends backwards, attaching itself to the walls of the stomach, again becoming reduced in size and losing itself in ramifications on that organ as well as on the wall of the body. From the ventral vessel it passes to the branchiæ, by which it returns through the dorsal vessel or heart, which in turn breaks up into

* *Vide* Jourdan, "Structure des élytres de quelques Polynoës," 'Zool. Anz.,' 8, p. 128.

† L.c. (8).

‡ L.c. (6).

branches on the stomach. In *Siphonostoma diplochaïtos* he describes the circulation as similar to that of *Lophiocephalus*, with the exception that both dorsal and ventral vessels have a dilatation situated much nearer the head.

Quatrefages* states that in *Chloraema Dujardinii* there are two dorsal trunks, which are united in front and behind in all the extent of the narrow part of the intestinal tube. But they become isolated and attain a more considerable size on arriving at the dilated portion possessing a layer of hepatic cells. Here each of them becomes cemented to one of the sides of the digestive tube, and they become united anew in the region of the œsophagus to form a thick fusiform contractile trunk, which drives the blood towards the branchiæ.

Claparède† describes the dorsal and ventral vessels in *Stylarioides* as both being simple, with lateral branches in each segment; the intestine is accompanied by two inferior enteric vessels situated close together. Grube‡ merely mentions the presence of dorsal and ventral vessels with transverse branches.

In his "Recherches sur le système vasculaire des Annélides"§ Jacquet describes at considerable length the vascular system in *Siphonostoma diplochaïtos*. He alludes to the observations of Delle Chiaje, Costa, Quatrefages, and Claparède, already referred to, with regard more especially to their interpretation of the character of what he calls the dorsal vessel. Referring to the statement of Claparède that the structure in question is a gland which has been mistaken for a blood-vessel owing to its colour, he expresses the opinion that this soi-disant gland only differs from the ordinary blood-vessels in its deeper colour, which is due to its larger size and the larger quantity of liquid which it contains as well as to the presence of pigmented elements in its walls.

* "Mémoire sur la famille des Chlorèmiens," 'Ann. Sci. Nat.' 3e. série, t. xii. (1849).

† "Annélides Chétopodes du Golfe de Naples," p. 363.

‡ "Bemerkungen über die Familie der Chloræminen," 'Bericht der Schles. Gesellsch.,' 1876, p. 39.

§ "Mittheil. a.d. zool. Stat. zu Neap.," vi. Bd. (1885), pp. 370-379.

His description begins with the branchial vessels. In each branchia there are two vessels, communicating with one another at the extremity of the filament. To the bases of the branchiæ the blood is carried by a canal coming from the neighbourhood of the end of the dorsal contractile trunk. This canal divides into branches for the branchial filaments (one to each), and also gives off a pair of branches to the tentacles.

The dorsal contractile trunk or heart, he states, is united directly with the ventral at a point below a pigmented spot which he regards as a visual organ. Further back it gives off various branches, the course of which is described. One of the two largest pairs of these is directed forwards; it is cemented to the inner surface of the skin in its dorsal part. The second pair, which is the larger, takes origin a little below the first and runs backwards; it is also cemented to the skin, and it terminates abruptly at the sixth pair of parapodia. Behind this there is no dorsal vessel proper. The heart terminates behind in the wall of the stomach in a system of sinuses, and Jacquet conjectures that the anterior dilated part may have a glandular wall secreting some digestive substance, which is carried to the stomach in the blood; the plexus of sinuses extends backwards in the wall of the intestine. A ventral vessel extends from one extremity of the body to the other. In the neighbourhood of the mouth it divides into two branches, which pass round the œsophagus to unite with the anterior end of the heart. He contrasts the arrangement described with that which is given by Quatrefages for *Chloraema*, and draws the inference that there is a considerable amount of difference in internal structure between the two genera.

There would thus appear to be a considerable amount of difference in the arrangement of the vessels in the various genera. As far as my own observations on this subject extend, the following would appear to be the *general* features of the vascular system in this family. There is a peri-intestinal sinus or plexus of sinuses in the wall of the alimentary canal. This terminates in front at the cardiac end of the stomach, and from it runs forwards a large median dorsal vessel or heart, which is subject

to regular peristaltic contractions, driving the blood from behind forwards. This vessel contains the unpaired cardiac gland, to which reference is made below. In the peristomial region it divides into two main afferent branchial vessels, each of which divides to give rise to the corresponding tentacular and branchial branches.

In *Coppingeria* the arrangement of the vessels conforms in all essential respects to that described by Claparède for *Stylarioides (Trophonia) monilifer*. There is a peri-intestinal sinus or rather plexus of sinuses in the wall of the stomach. From this, at the anterior end of the stomach, passes forwards the short dorsal vessel or heart, almost parallel with and on the dorsal side of the œsophagus. This bifurcates in the anterior part of the peristomium. Each branch enters the branchial stalk and breaks up anteriorly into a number of afferent branchial vessels (fig. 25, *br.*), each running to the end of one of the branchiæ. The blood returning from the extremities of the branchiæ by means of the efferent branchial vessels must be carried back by a trunk, which appears in my sections as a vessel of small size, running backwards just above the œsophagus. This bifurcates behind, the two branches thus formed embracing the œsophagus at its posterior end and uniting below with the ventral vessel. The latter runs forwards only a short distance in front of this junction, but is continued backwards throughout the body. On the dorsal side there is given off from the heart a dorsal vessel which runs backwards throughout the length of the body on the dorsal aspect above the alimentary canal.

Claparède (l.c., p. 360) describes the branchial vessels in *Stylarioides monilifer* as having lateral diverticula ("anses"), and in his figure of a portion of a branchia (plate XXV., 1B.) transverse dotted bands are described as the diverticula in question, covered with brown pigment. There are no lateral diverticula in *Coppingeria* nor in *Stylarioides cinctus*. The branchial vessels in the former are accompanied by bands of a granular material which colours deeply with haematoxylin and which may contain pigment; in the latter there is a reddish-brown pigment. These pigmented

elements remind one of the structures called "pigmented lymph-glands" by Eduard Meyer,* found on the branchial vessels of *Terebellidae* and *Cirratulidae*, and probably are of a similar character.

The epithelium covering the branchiæ is peculiarly modified in *Coppingeria*, the cells as seen in sections having straight sharply-defined lateral borders, as if they had acquired a stiff and rigid character; as there is no internal supporting layer, it is likely that this is actually the case, and that the ciliated epithelium acts to some extent as a supporting structure.

Considerable confusion has existed regarding the relations of an unpaired gland situated in the dorsal region of the anterior part of the body; it has been noticed and described by various observers, but by nearly all its position has been incorrectly interpreted.

The structure in question seems to be represented in Costa's figures, though it is neither referred to in the text nor in the explanation of the plates. It does not seem to have been noticed by Dujardin, by Quatrefages, or by Leuckart.

Claparède† states that it had been observed by Delle Chiaje in *Stylarioides* and regarded by him as a cœcum of the alimentary canal. Claparède describes it as a cœcal tube of an intense black colour, sometimes inclined to green, extending backwards as far as the stomach, to which it adheres by its blind posterior extremity. It appears to open in front on the dorsal wall of the buccal cavity. It is formed of two layers — an outer, very thick, colourless, muscular, and rich in vascular plexuses, the inner, an epithelium of intense blackness—the cells being loaded with dark granules. The functions of the gland he looks upon as entirely problematical.

In his account of *Siphonostoma diplochaïtos* the same author remarks (p. 370) that Max Müller, following Costa, had fallen into a grave error in describing this structure as a large blind vessel.

* "Studien über den Korperbau der Anneliden." 'Mittheil. a. d. Zool. Stat. zu Neapel,' vii., p. 645 (1887).

† L.c., p. 362.

Grube follows Claparède in his view of the structure in question.

Langerhans* describes in *Brada inhabilis* three glands as opening in the neighbourhood of the mouth, a median one, the cells of which contain brown pigment granules, and a pair, in the cells of which are round concretions.

Studer† describes the unpaired gland as opening in front over the œsophagus.

Jacquet comments (l.c., p. 373) on the numerous misconceptions to which the dorsal vessel has given rise, and, after quoting the opinion of Claparède, to which reference is made above, goes on to say:—"Nous verrons que Claparède en voulant relever une donnée qu'il considerait comme erronée, retombe dans les idées de quelquesuns de ses prédécesseurs, idées que je suis arrivé à considérer comme fausses. Cet auteur croit avoir trouvé la cause, qui a induit en erreur Costa, dans la couleur de cette glande. Si cette soi-disant glande est plus foncée qu'un vaisseau sanguin ordinaire, cela dépend de deux motifs. Comme cet organe présente dans sa partie la plus renflée un diamètre de plus de vingt fois celui d'un canal sanguin, il est naturel que contenant une beaucoup plus grand quantité de liquide, celui-ci paraîtra plus foncé. En outre, on remarque que les parois de cet organe contiennent des éléments pigmentés." Further on he conjectures that the anterior dilated part of the dorsal vessel may have a glandular wall secreting a substance calculated to facilitate digestion. He thus denies entirely the presence of anything but a thick dorsal vessel or heart with a pigmented and perhaps glandular wall.

Horst‡ was the first, so far as I have been able to determine, who gave an accurate account of this structure. He shows that it is the dorsal vessel *enclosing in its interior* an elongated narrow

* "Die Wurmfauna von Madeira," 'Zeitschr. f. wiss. Zool.' XXXIV. Band. (1880).

† "Beiträge zur Naturgeschichte wirbelloser Thiere in Kerguelensland" 'Archiv für Naturgesch.' 1878.

‡ "Ueber ein räthselhaftes Organ bei den Chlorœmiden," 'Zool. Anz.' VIII. (1885).

dark body, which is continuous behind with the wall of the stomach. This peculiar dark body is composed of different strands irregularly entwined and mostly with an oval transverse section, formed of cells filled with brown granules, the cell-structure not being always distinctly visible. He does not definitely suggest any function for the dark glandular body, but points out that it has its homologues in various sedentary Annelids—such as *Terebella* and *Cirratulus*—as well as in *Polyophthalmus*, *Ctenodrilus*, and *Enchytraeus*.

Cunningham* states that in *Trophonia plumosa* the somewhat cylindrical cords, of which the cardiac body is made up, are seen in sections not to be composed entirely of cells, but in most cases to possess a lumen, the cells around which form a glandular-looking epithelium of several layers—the more internal clear and vacuolated. He finds no trace of any opening either in front or behind. In *Flabelligera affinis (Siphonostoma)* the organ in question is very different; it is relatively narrow and occupies only a small part of the lumen of the heart; it has the form of a narrow irregular flat band, which in transverse section appears as an irregularly branching narrow tract without distinct lumen, the walls being in close contact. The clear vacuolated cells are absent—the epithelium consisting entirely of elongated columnar nucleated cells; and the granules are smaller and less numerous. Cunningham dissents from Horst's view that the organ in *Enchytraeus* is homologous with the cardiac body of the *Chloraemidae*. He states that in *Trophonia* there is no connection between the cardiac body and the intestinal epithelium.

In *Coppingeria*, *Stylarioides cinctus*, and *S. Horstii*, and *Siphonostomum affine*, this cardiac body is a greatly-elongated dark-coloured structure, which lies in the interior of the heart or contractile dorsal vessel. In front it is very narrow (fig. 20 *c. b.*) and does not nearly fill up the lumen of the vessel; but further back it is broader, and in sections appears completely to block up the cavity.

* "Some points in the Anatomy of the Polychæta," 'Quart. Journ. Micro. Sci.' vol. xxviii.

In a living specimen of *Siphonostomum affine*, however, it was seen that the vessel in a dilated state is considerably larger than the enclosed cardiac body. The latter consists of longitudinally arranged lobes, which in all the specimens examined had lost their cellular structure,—this being represented in the case of *Coppingeria* merely by nuclei and faint traces of cell-bodies. An examination of my sections confirms Cunningham's statement that there is no connection whatever between the cardiac body and the intestinal epithelium. In front it is continuous with the wall of the vessel; behind it is completely free and moves passively with the peristaltic contractions. Cunningham describes a lumen as being present in the cardiac body, but in this I think he is mistaken. The lobes are in some parts slightly separated from one another, leaving fissures here and there; sometimes there is a star-shaped fissure in the middle, but where this is the case the space is filled with blood. Whatever may be their condition at an earlier stage, the lobes in the specimens I have examined are solid and contain no lumen.

VI. Alimentary canal and nephridia.

The special features of the alimentary canal in this family have been described by various authors, and I have little to add with regard to *Coppingeria* to what has been already published. The anterior part is in the form of a narrow œsophagus, with a high epithelium of ciliated cells. The wide stomach, with its anteriorly projecting cœcum, is thin-walled, with a low epithelial lining; it is filled with particles of mud containing the remains of many microscopic organisms. The narrow intestine has a comparatively thick wall, with an epithelial layer of elongated ciliated cells; its lumen contains no food particles. The peculiar orange colour of the stomach in its anterior portion, which appears to be general in this family, is, of course, not to be detected in a specimen so long preserved in spirits, but is well-marked in *Stylarioides cinctus*. In this species the hinder part of the stomach (fig. 21) is bent on itself so as to run obliquely forwards for a little distance before passing into the intestine; the latter is bent round in the way

represented in the figure, before pursuing its straight course backwards towards the anus.

The nephridia were described by Otto as salivary glands, and the same view of their nature was taken by Quatrefages* as well as by Dujardin. They are only very obscurely referred to by Costa.

Leuckart (l.c., p. 166) expresses a doubt as to the correctness of Rathke's view that these represent salivary glands, and suggests that they may be comparable to the Polian vesicles of Echinoderms.

Claparède, to whom we owe the earliest recognition of the true nature of these bodies, states† that they had been seen by Delle Chiaje and Rathke as well as Kölliker. He remarks that there is a great resemblance, as had already been pointed out by the last-named observer, between these organs and the renal organs of the Gasteropoda. He describes them in *Stylarioides* as tubular glands opening externally near the mouth and terminating behind in a cul-de-sac at the sides of the stomach, in the eighth segment. They are full of spherical bodies resembling cells, but without evident nuclei, and each of them containing a single spherical concretion or several.

Grube's statement regarding these bodies is essentially a repetition of Claparède's.

Langerhans,‡ as already mentioned, describes three glands as opening in the neighbourhood of the mouth in *Brada inhabilis*, Rathke, the unpaired one being evidently the cardiac body and the lateral, containing round concretions, the nephridia.

Studer describes these excretory glands as opening in front into the anterior part of the pharynx.

In *Coppingeria* these glands are of large size and deeply lobed. They extend from the posterior part of the praestomium backwards through the following two or three segments, and are prolonged

* "Mémoire sur la famille des Chlorémiens." 'Ann. Sci. Nat.' 2e série, tome XII. (1849), p. 277.

† L.c., p. 362.

‡ "Die Wurmfauna von Madeira," 'Zeitsch. f. wiss. Zool.' XXXIV. (1880).

for some distance further back in the form of two comparatively narrow tubes, which lie close together on either side of the middle line of the dorsal part of the body-cavity. Their ducts meet in front below the œsophagus, and the median duct thus formed appears to open on the ventral aspect of the praestomium, but defects in the sections leave this doubtful. The glands are lined with an epithelium of large irregularly-shaped cells (fig. 22) with vacuolated protoplasm containing numerous rounded granules of various sizes, some of which are stained darkly by haematoxylin, the largest having the appearance of being made up by the coalescence of numerous extremely minute particles.

In *Stylarioides cinctus* these glands are in the form of narrow twisted tubes, the cells lining which are similar to those just described. The granules do not become stained by borax-carmine and a nucleus becomes revealed in each cell. In *Siphonostomum affine* the cells have the form represented in figure 23, mostly narrow at the base, with a rounded bulging at the free extremity, containing numerous minute granules scattered through their protoplasm and some larger ones at the base, where there is in most a zone of protoplasm which stains more deeply with haematoxylin than the rest.

VII.—Nervous system, eyes, and tentacles.

The remarkable position occupied by the ventral nerve-chain in the members of this family was remarked upon by Leuckart in his account of *Siphonostomum vaginiferum*, Rathke (l.c., p. 165). It is completely separated from the epidermis, and lies within the layer of circular and oblique muscular fibres of the body wall. The cord presents very distinct ganglionic swellings, which are bilobed externally, though completely fused internally; between the ganglia the cord is distinctly double. The œsophageal commissures are of great length in co-ordination with the retractility of the præ- and peristomia. The anterior part of the nerve cord in *Stylarioides cinctus* is represented in plate XXVIII. fig. 24.

The presence of eyes in members of this family has frequently been overlooked owing to the retractile character of the praesto-

mium on which they are situated. Quatrefages describes *Chloraema Dujardinii* as possessing a single pair of eyes placed close together. Leuckart describes two pairs of eyes in *Siphonostomum vaginiferum*, and Johnston* states that *Siphonostomum uncinatum* possesses four eyes. This is confirmed by Jourdan† as regards *S. diplochaïtos*, and by Joyeux-Laffuie‡ as regards *Chloraema Dujardinii*. I have observed the same to hold good in regard to *Siphonostomum affine*, *Stylarioides cinctus*, *S. Horstii*, and *Coppingeria longisetosa*. It seems probable in fact that the presence of four eyes is general in this family.

The two pairs of eyes in *Coppingeria* (fig. 26) are situated on a lobe, which is a process from the præstomium between the bases of the branchiæ. Into the interior of the oculiferous lobe projects a group of nerve-cells, forming an optic ganglion, which is really a lobe of the brain, with which it is in immediate connection—the optic nerves mentioned by Quatrefages§ not being represented. Both eyes project prominently on the surface, those of the anterior pair being the larger. The cuticle forms a concavo-convex thickening (*cu.*) over the eye, immediately internal to which is a layer of cells (*c*), which present no regular arrangement. Then follows a layer of thick crystalline rods (*r*), which are probably continuous with elements composing a cup-shaped layer of darkly pigmented substance (*pi.*), outside of which are the nerve-cells. In *Siphonostomum affine* and *Stylarioides cinctus* the eyes are less prominent, and are buried in the substance of the præstomial lobe.

In *Siphonostomum affine* (fig. 27) they differ slightly from those of *Coppingeria*. The pigment (*pi.*) forms an almost complete capsule, with only a small opening. Enclosed within this are a series of thick rods, which fill up the whole of the cavity—there being no nucleated elements in the interior of the pigment capsule.

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* "Catalogue of British Non-Parasitical Worms."

† "Etude anatomique sur le Siphonostoma diplochaïtos, Otto." 'Ann. Mus. d'Hist. Nat. Marseille,' Zool. t. 3, Mem. No. 2. This is known to me only through the abstract in the "Zool. Jahresb." (1887, Vermes, p. 64).

‡ "Sur l'organisation des Chlorèmiens." 'Compt. Rend.' t. 104, p. 1377.

§ "Hist. Nat. des Annélés," tome I., p. 471.

There is a sort of cornea-lens, however, formed of a number of elongated epidermal cells, which pass over the outer side of the eye.

The *tentacles* in *Coppingeria* are slightly corrugated transversely, and are marked by a deep longitudinal groove on the ventral surface. They are hollow, and the cavity is divided by a dorso-ventral longitudinal septum. In the septum runs the main blood-vessel. The wall of the tentacle contains a thin circular or oblique and a much thicker longitudinal layer of muscular fibres. The cuticle is very thin; the epidermis has the cells more elongated than in the body; here and there is a cell which stains more strongly than the others, of a spindle-like shape, perhaps a sensory cell. The epithelium (fig. 28) on the inner faces of the ridges bounding the ventral groove is specially modified. Many, or all, of the cells are provided with close-set short cilia. They are very long and narrow—many almost fibre-like,—and from their inner ends pass delicate fibres to a nerve situated (*n*) at the base of the ridge. We have here evidently an epithelium which is specialised not only in the direction of bearing cilia for driving food towards the mouth, but also in that of possessing numerous sensory cells, connected either with a specially developed tactile sense or with a sense of taste or smell.

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EXPLANATION OF PLATES.

Plate xxvi.

Fig. 1.—Port Molle specimen of *Coppingeria longisetosa*, three times the natural size.

Fig. 2.—Produced peristomium and præstomium with tentacles and branchiæ seen from the dorsal aspect: *br.*, branchiæ; *te.*, tentacle.

Fig. 3.—Darnley Island specimen, thrice the natural size; lateral view.

Fig. 4.—*Stylarioides cinctus*, magnified.

Fig. 5.—Anterior extremity of the same with the tentacles and branchiæ; ventral view: *br.*, branchiæ; *te.*, tentacles.

Fig. 6.—Anterior end of *Stylarioides Horstii*, from the dorsal side; magnified.

Fig. 7.—The same, from the side.

Fig. 8.—Ventral view of the same.

Plate xxvii.

Fig. 9.—Ventral seta of *Coppingeria longisetosa*, ×100.

Fig. 10.—Ventral seta of *Stylarioides cinctus*.

Fig. 11.—Section of one of the shorter papillæ of *Coppingeria*.

Fig. 12.—Section through one of the longer papillæ of the same: *m.*, mucus; g^2., g^3., ganglia.

Fig. 13.—A papilla of the same with the extremity inverted: *m.*, mucus; g^2., g^3., ganglia.

Fig, 14.—Papilla of the same showing the basal ganglion, g^1.; *cu.*, cuticle; *mus.*, outer muscular layers of body wall.

Fig. 15.—Section of the integument of *Stylarioides cinctus*: g'., basal ganglia; *m.*, layer of mucus; c'., external, and c''., internal layers of cuticle; *e.*, epidermis; *mus.*, muscular layer.

Fig. 16.—Surface view of epidermal cells of *Stylarioides cinctus*.

Figs. 17a and 17b.—Papilla of *Stylarioides Horstii*.

Fig. 18.—From section of an elytron of a species of *Polynoe*, showing sensory papilla: *n.*, nerve-branch; *g.*, ganglion.

Fig. 19.—Papilla of *Stylarioides monilifer*: g'., basal ganglion; *m.*, mucus.

Fig. 20.—Transverse section of the anterior part of the body of *Coppingeria longisetosa* to show the position of the cardiac body: *h.*, "heart;" *cb.*, cardiac body; *vv.*, ventral vessel; *œs.*, œsophagus; *lm.*, longitudinal bundles of muscular fibres.

Fig. 21.—Stomach, with œsophagus and beginning of intestine of *Stylarioides cinctus*.

Fig. 22.—Part of a section through one of the nephridia of *Coppingeria longisetosa*.

Fig. 23.—Part of a section through nephridium of *Siphonostomum affine*.

Plate xxviii.

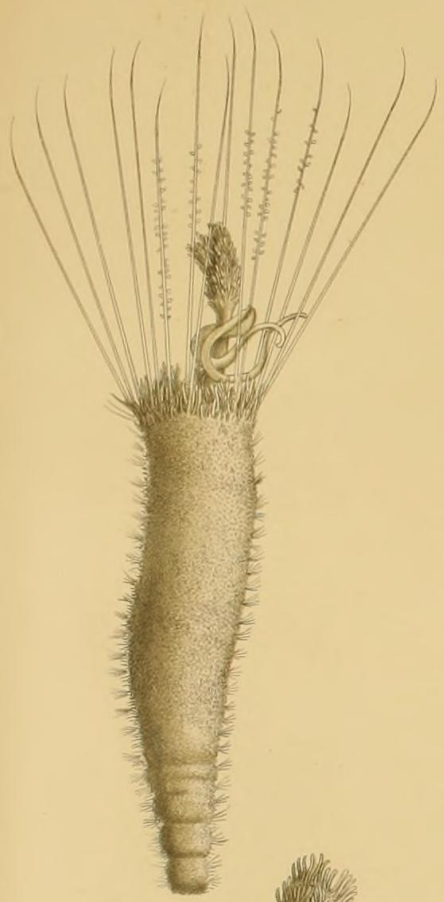
Fig. 24.—Anterior part of ventral chain of ganglia in *Stylarioides cinctus*: *c.*, commissures connecting cerebral and first ventral ganglia.

Fig. 25.—Section (nearly transverse) through the præstomium of *Coppingeria* in the region of the cerebral ganglion *(g)*: *dv.*, two main branches of the dorsal vessel; *br.*, afferent branchial vessels; *pi.*, pigmented (?) cords accompanying branchial vessels; *tv.*, tentacular vessel; *m.*, mouth.

Fig. 26.—Section of eye of *Coppingeria*: *cu.*, cuticle with its thickening over the eye; *c.*, layer of modified epidermal cells; *r.*, crystalline rods; *pi.*, pigment cup; *g.*, nerve-cells.

Fig. 27.—Section of eye of *Siphonostomum affine*: *co.*, cornea-lens; *pi.*, pigment cup; *r.*, crystalline body.

Fig. 28.—Lateral and ventral part of a transverse section through a tentacle of *Coppingeria*: *gr.*, ventral ciliated groove; *n.*, nerve.



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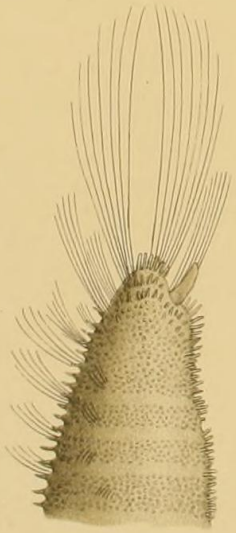

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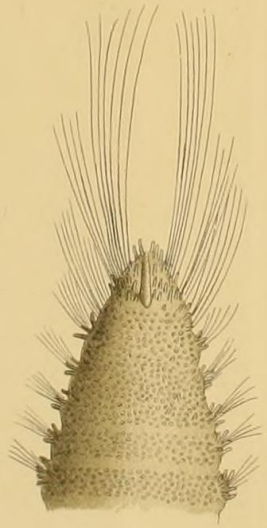

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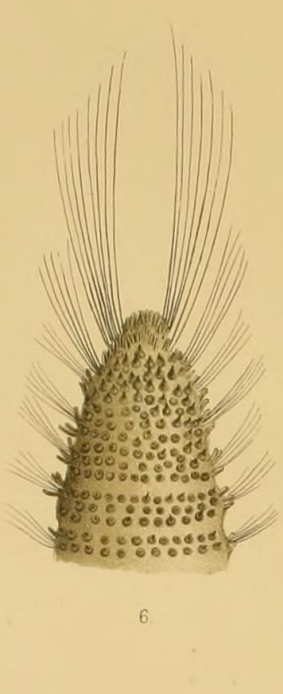

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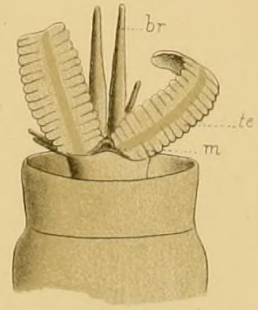

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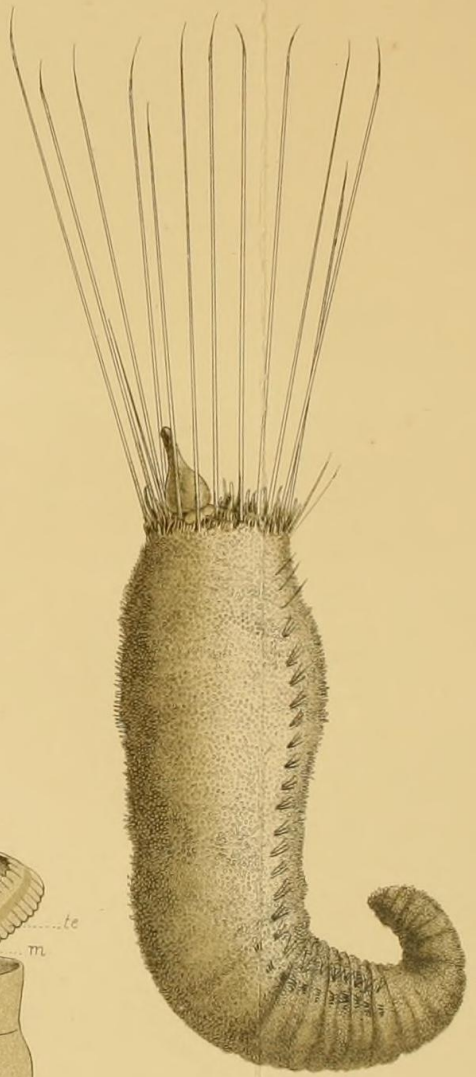

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Troedel Cooper & Co Syd.

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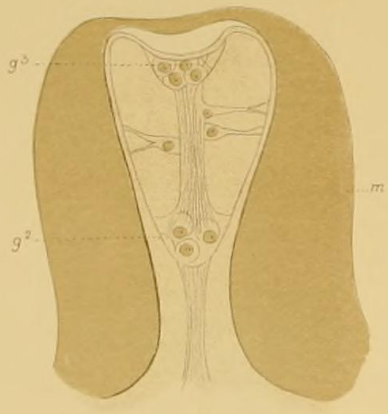

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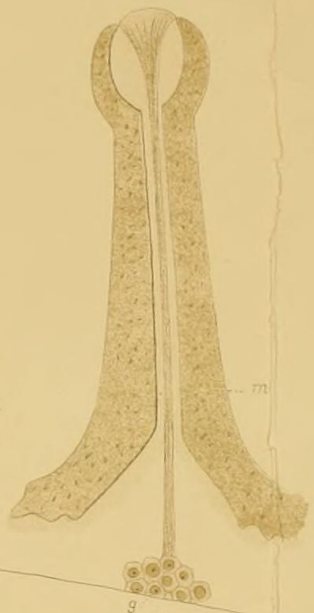

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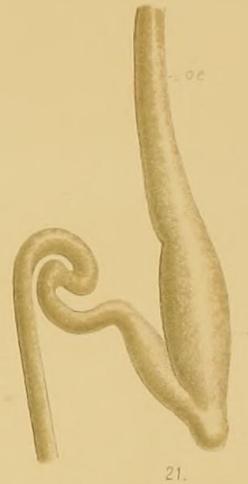

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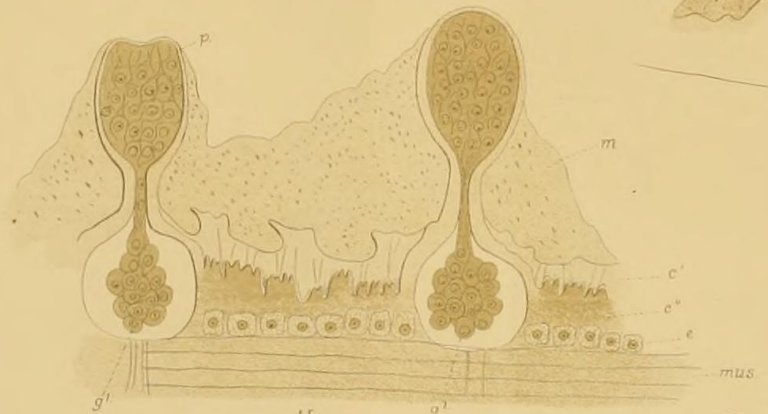

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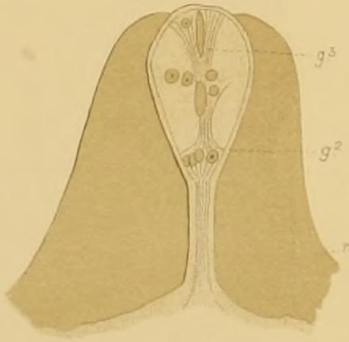

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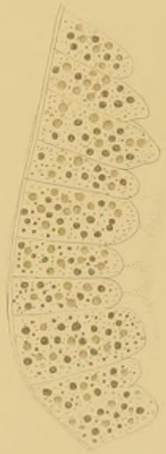

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Troedel Cooper & Co Lith. Syd.

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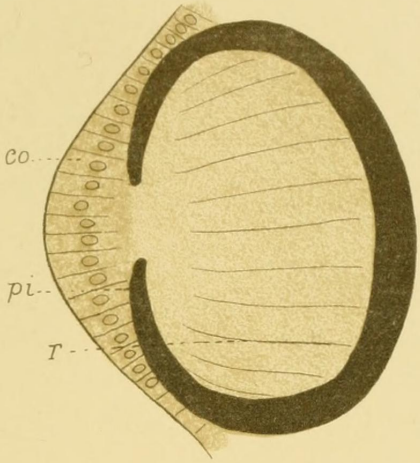

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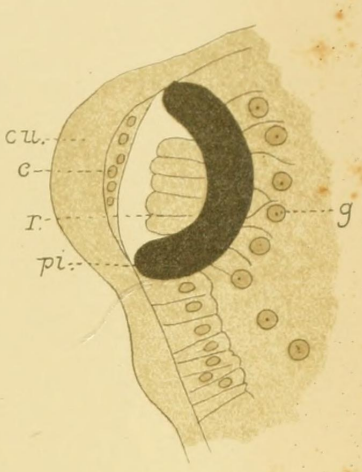

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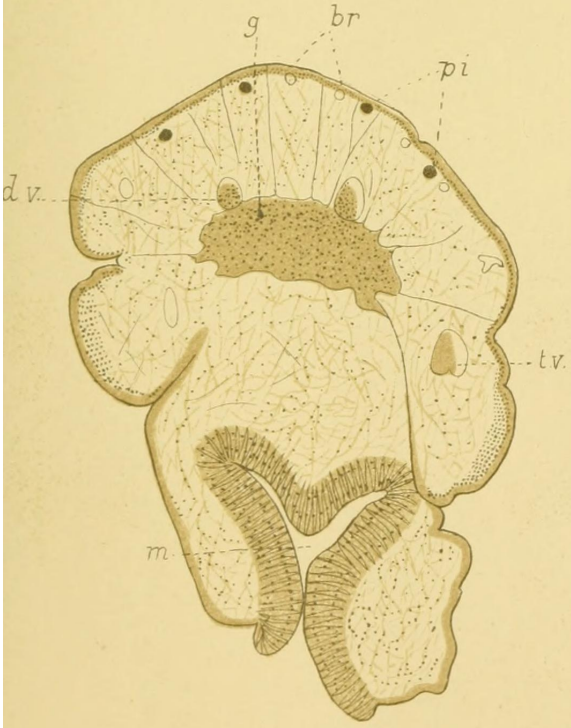

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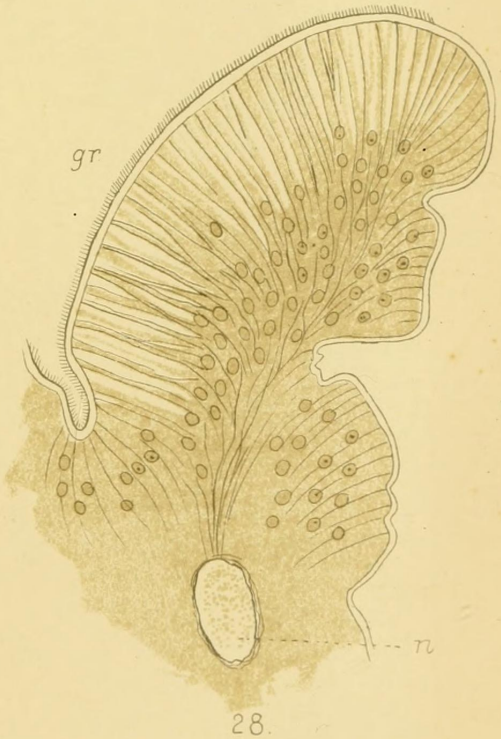

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