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v.33 (1885-1888): <https://www.biodiversitylibrary.org/item/129321>

Article/Chapter Title: The Polychaeta sedentaria of the Firth of Forth

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Subject(s): annelida, polychaeta, taxonomy, Scotland

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TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. XXXIII. PART III.—FOR THE SESSION 1886-87.

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[Issued October 20, 1888.]

XXVI.—*The Polychæta Sedentaria of the Firth of Forth.* By J. T. CUNNINGHAM, B.A., Fellow of University College, Oxford, Superintendent of the Granton Marine Laboratory; and G. A. RAMAGE, Vans Dunlop Scholar in Edinburgh University. (Plates XXXVI.—XLVII.)

(Read 15th July 1887.)

The studies of which the results are here set forth were carried on at the Granton Marine Laboratory of the Scottish Meteorological Society, in the years 1886 and 1887. Our memoir is by no means a monograph, although our original aim was to investigate every species taxonomically, anatomically, and embryologically. Much further study would have been necessary to carry out this aim at all completely, but in August 1887, both of us, for different reasons, had to abandon our work at Granton and leave Scotland. We have thought it better to publish the notes and drawings we had made, because they will probably be of service to British naturalists interested in the Polychæta, no extensive work on these forms having appeared in English since Johnston's *Catalogue of Non-Parasitical Worms in the British Museum*, which was published 1865, and which is now a very inadequate guide to the study of the subject. The greater part of the work of collecting, and much the larger part of the drawings, were done by Mr RAMAGE. A discussion of some anatomical points has been published separately by Mr CUNNINGHAM ("Some Points in the Anatomy of Polychæta," *Quart. Jour. Micr. Sci.*, 1887).

Fam. SPIONIDÆ, Sars, 1861.

Ariciæ naidinæ.—A. S. Oersted, Zur Classification der Annulaten, Arch. f. Naturges., x., 1844.

Spionidæ.—M. Sars, Christ. Vid. Selsk. Forh., 1861, p. 61.

OERSTED'S family Ariciæ included Aricia, Scoloplos, Aonis, Leucodorum, Nerine, Spio, Disoma, Sphærodorum, Cirratulus, Dodecaceria, Ophelina, Ophelia, and Eumenia. JOHNSTON, in his Ariciadæ, included the Cirratulidæ and Spionidæ, but separated the Opheliaceæ and Eumenia. SARS defined the Spionidæ by the characters common to Nerine, Spio, Leucodore, Spione, and Disoma, exclusive of any other genus; and MALMGREN accepts this definition, but splits up the genus Nerine into two, Nerine and Scolecolepis.

Characters of the Family.—A large number of usually short somites, all but the first and last provided with well-developed parapodia, and some or all of them with cirriform ciliated branchiæ. These arise near the base of the notopodium, and are bent towards the middle line of the dorsal surface. The

lamella of the notopodium is usually continued along the branchia. The neuropodium and notopodium each consist of a tubercle and short broad lamella. In the anterior parapodia setæ all simple and needle-shaped; in the middle of the body shorter uncini, bidentate at the apex and sheathed, appear in the neuropodium: farther back uncini occur, together with the needle-shaped bristles in both neuropodium and notopodium. The buccal somite bears no parapodia, but possesses two long cirriform tentacles, grooved and ciliated: these are probably homodynamous with the branchiæ. The præoral lobe is rudimentary, and continuous with a ridge on the dorsal surface of the buccal somite; this ridge ends in a conical projection, and bears the eyes, usually 4 in number. The anal segment variable; sometimes provided with a funnel-shaped collar round the anus, sometimes with a number of short processes. The nervous system is situated in the epidermis, and not very distinctly defined; between the cords is a very large median neural canal.

Genus *Nerine*, Johnston.

Nerine coniocephala, Johnst., Mag. Zool. and Bot., ii., 1838.

This genus was first defined by JOHNSTON in 1838, but the definition given by G. O. SARS in 1861 is much more exact. MALMGREN, in his *Annulata Polychæta*, 1867, split up the genus into two, one containing the species *Nerine coniocephala*, Johnst., the other *Scolecopsis*, containing *Nerine vulgaris* of JOHNSTON, with two other species of *Nerine* described by SARS. The definition of *Nerine* in this more restricted sense has never been given; it may be drawn up as follows:—

Segments very short, notopodial lamella coalesced with branchia along the whole length of the latter in the anterior part of the body; distinct in the middle of the body; in the posterior part the branchiæ are absent, and the body-walls very thin. Cephalic lobe as a small ridge on dorsum of first somite projecting into a rounded tubercle anteriorly, and having a minute occipital tubercle at its posterior end. Eye spots 4 on cephalic lobe. Anus dorsal in aspect with a sub-anal lobe. Uncini unidentate, sheath small. Ventral neural canal single and large.

Nerine coniocephala, Johnston.

Nerine coniocephala, Johnst., Cat. Brit. Mus., p. 201, plate xvii. f. 9–13.
N. foliosa, Sars, Christiania Vid. Selsk. Forh., 1861, p. 61; Malmgren, *Annulata Polychæta*, 1867; M'Intosh, Fauna of St Andrews.

SARS places a note of interrogation after the name *coniocephala*, Johnston, in his list of synonyms. JOHNSTON, in his Catalogue, affixes the same mark to

Nerine foliosa, Sars. MALMGREN also expresses a doubt as to the identity of the *coniocephala* of Johnston with the *foliosa* of Sars. We can find no reason for this uncertainty, as the description and figures of JOHNSTON obviously agree with the description given by SARS of *foliosa*.

Specific Characters.—The colour in the living animal is yellowish, the branchiæ being red, from the presence of pseudhæmal vessels, and the posterior part of the body having a green colour, due to the intestine seen through the body-walls.

A broad lamina extending along the whole length of the branchial filament in the anterior somites; posteriorly the lamina extends a less distance along the branchia, leaving an increasing distal portion free. The size is large, full grown specimens being over 6 inches long and $\frac{1}{4}$ inch broad; it is much larger than the following species.

Habits.—This worm is found at Granton burrowing in a stiff grey underclay, containing carbonised plant stems: it occurs in the littoral zone, and probably beyond it, at a depth of about 1 foot in the clay. It is also sometimes found under stones resting on muddy sand. When uncovered and placed in water, it is unable to crawl, but simply writhes and contorts itself, sometimes with great violence, and often breaks itself into pieces.

Anatomy.—The nephridia are not present in the anterior part of the body, where the notopodial lamina extends along the branchia. In the posterior segments the nephridium is lateral in position, on a level with the dorsal end of the neuropodial fascicle of setæ, and anterior to these. It consists of a spherical vesicle with internal and external ducts, both short. It is ciliated internally throughout. The internal duct passes through the mesentery in front of it, and opens into the cœlom by a funnel-shaped opening. We have been unable to find an actual aperture to the exterior, but the walls of the external duct become continuous with the epidermic cell layer. This duct is short, and passes horizontally forward from the vesicle, coming into relation with the epidermis at a point situated within the constriction of body-wall which separates adjacent somites. The ovary is a cellular mass attached to the dorsal side of the nephridial vesicle. In the centre of the ovary is a pseudhæmal vessel, and dorsally the cellular mass is produced into a flat band.

Nerine cirratulus, Claparède (Delle Chiaje).

Lambricus cirratulus, Delle Chiaje, Mém. su. gli. anim. s. Vert., iv. 196.

? *Nereis foliata*, Dalyell, Powers of the Creator, vol. ii. p. 155.

Nerine cirratulus, Clap., Chét. du Golfe de Naples, 1868.

Specific Characters.—Ocelli 4, two on each side on the cephalic ridge immediately in front of the base of the tentacles, forming a slightly curved

transverse line, concave forwards. First somite bears neuropodial and notopodial setæ, but no branchiæ. Branchiæ bent over the back in all the following somites; lamina extending along the outer edge of the branchia, little more than half-way in anterior somites, a less distance posteriorly. Length, 7–12 cm. Colour in life distinctly green; branchiæ red, from the blood within them. Segments longer than in *N. coniocephala*.

This species has not before been recorded as occurring on the British coasts. After careful comparison, we are obliged to conclude that our specimens are not specifically distinct from CLARAPÈDE'S *N. cirratulus*, though there are minute points of difference. It is not probable that these are to be attributed to inaccuracy on the part of CLARAPÈDE: it is more likely that the specimens from localities so far apart as the Firth of Forth and the Bay of Naples present differences which are too slight to separate the species into two. In CLARAPÈDE'S figure of the parapodium and branchia, the lamina of the latter extends nearly to the lip, and has at its own extremity a rounded outline. In the anterior somites of our specimens the lamina does not extend so far along the branchia, and has distally a pointed corner (fig. 2 A). In the posterior somites of our form the lamina is of still smaller extent, and is rounded as in CLARAPÈDE'S figure. That author describes the ova very accurately; their structure is peculiar in two respects. They have a well-developed vitelline membrane, which is covered externally with a reticulation of hexagonal meshes. The shape is that of a slightly flattened ellipsoid, and round the longest circumference is a single series of vacuoles in the external region of the vitellus. The meaning of these vacuoles is unknown. CLAPARÈDE observed that when, after the ova had escaped into the water, the vitellus contracted, the vacuoles were ejected from it as vesicles into the perivitelline space. We have seen the formation of the perivitelline space, but did not observe the ejection of the vesicles, but this phenomenon was observed by one of us in the ovum of *N. coniocephala* (figs. 1 D, 1 E), where the vesicles form a double series.

The early development of this species is very peculiar in certain points. The ova are plagic, and we recognised them early in February amongst the product of the tow-net worked close to the shore. In the vessels of the Laboratory the ova sank to the bottom, which shows that they are heavier than the water, and only kept in suspension by the agitation due to the tides and waves. The segmentation we have not studied in detail: but from the appearance of the single stage observed it seems that the segmentation is complete and unequal, and that a gastrula is produced by epibole, as in other Chætopoda. At a later stage two rings of long S-shaped cilia appear, one at the broader anterior end of the body, the other at the posterior end. The vitelline membrane persists at this stage, and for long afterwards forming a cuticle for the larva, and retaining

its characteristic honeycomb-like reticulum of projecting ridges. The bands of cilia project through this vitelline membrane (fig. 2 H). By proper focussing a bundle of cilia can be seen passing through one of the usually hexagonal meshes of the reticulum. The cilia doubtless pierce the membrane during their growth. In front of the anterior band of cilia the greater part of the surface of the larva is separated by a considerable space from the vitelline membrane, but a median anterior projection, shaped like a truncated cone, extends forwards to the membrane in the direction of the longer axis, and from this projection, that is from the apex of the præoral lobe, a bundle of long stiff sensory hairs projects through the vitelline membrane: these hairs are quite motionless, and are probably cuticular, not protoplasmic like cilia. Between the anterior and posterior rings of cilia is another space between the surface of the embryo and the vitelline membrane. At a later stage the embryo elongates, and the sides of the embryo come into contact with the vitelline membrane, especially at two points on each side, from which two pairs of fascicles of long setæ grow out. These setæ are directed backwards, and the anterior are much the longer. These bristles represent two pairs of parapodia (fig. 2 c). By the elongation of the embryo the vitelline membrane is brought into closer contact with the embryo, so that the spaces described above are more or less completely eliminated. The cilia have been described as forming rings, but we are not certain that the rings are complete: the anterior band is continuous across the dorsal side, but is formed of a number of tufts, not of a regular series. Apparently the mouth and anus are not yet formed, but a central cavity is seen in optical sections in the hypoblast. Two eye spots of dark pigment are present on the dorsal side in front of the anterior ciliated band. The larva is thus a telotroch. Figs. 2 I, 2 J, represent a later stage of the larva.

Anatomy.—The nephridia and ovaries in this species resemble those of the preceding, but the efferent duct of the nephridium is longer, and its external aperture more dorsal in position.

Genus *Scolecopsis* (Blainville), Malmgren.

MALMGREN (*Ann. Polych.*, p. 199) takes this name for a genus, in which he includes the *Nerine vulgaris* of Johnston and Sars, and *N. currata* and *N. oxycephala* of Sars. The name was used by BLAINVILLE in 1828 (in *Dict. Sci. Nat.*, t. 57, we presume) for the *Lumbricus squamatus* of Müller's *Zool. Dan.*, which is possibly identical with *Nerine vulgaris*, Johnston. We use the name as applied by MALMGREN. That author gives no definition of the characters of the genus, and we have not supplied the defect. We can only point out that the chief peculiarity is that the cephalic lobe is somewhat T-shaped, having

anteriorly on each side a slight transverse process, instead of ending in a point, as in *Nerine*. In other respects the genus resembles *Nerine*.

Scolecopsis vulgaris (Johnston), Malmgren.

Nerine vulgaris, Johnston, Cat. Brit. Mus.

Scolecopsis vulgaris, Malmgren, *loc. cit.*; M'Intosh, Fauna of St Andrews.

Common at Granton under stones near low-water mark, among blackened rotting sea-weed. The animal is long, and much more slender than *Nerine*. The external characters are represented in Pl. XXXVII. figs. 3, 3 A, &c.

Genus *Spio*, Oersted.

The name was first used by FABRICIUS, but defined in its present sense by Oersted (*Arch. f. Naturges.*, x. 1, p. 106).

The chief characters are—Body minute filiform, cephalic lobe notched at anterior extremity; occipital tentacles very long, and thick in proportion to the body; constrictions between somites deep; notopodia with setaceous bristles only; uncini in the neuropodia bidentate; branchial cirri continuous with laminae; anus provided with four short processes.

Spio seticornis, Fabr.

Nereis seticornis, Fabricius, Fn. Grönl., p. 306.

Spio seticornis, Fabr., Schr. Naturf. Freunde, Berlin, vi. p. 260.

Spio seticornis, Oersted, *Arch. f. Naturges.*, x. 1.

Specific Characters.—Branchial cirri on the 3rd segment (2nd setigerous) well developed, distinct from notopodial lamella; 2nd, 4th, and following somites without branchial cirri; these occur again on the 12th or 13th, and several following somites, disappearing again towards the posterior extremity; 8th and following neuropodia bearing only uncinatæ setæ. Tubes of sand, long, tough, and flexible (*vide* figs. 4, 4 A, &c.).

Habits.—We have always found the tubes of this species in the middle and upper part of the littoral zone, in clefts of rocks and under stones. The tubes are very abundant, but from their length and the fragile nature of the worm, it is difficult to extract the latter from its dwelling without injury.

Anatomy.—The nerve cords are wide apart, and there are no neural canals. The epidermis on the ventral surface of each somite is greatly thickened and glandular, containing a large number of mucous cells, which stain deeply. Ova are seen in transverse sections of the middle part of the body nearly filling the body-cavity.

Genus *Leucodore*, Johnston.

Leucodore ciliata, Johnst., Mag. Zool. and Bot., ii. p. 57.

Polydora, Bosc, Histoire Nat. des Vers, Paris, An. x.

Branchial cirri confined to middle of the body, absent at either extremity; tentacles shorter than in *Spio*; first four somites behind the buccal, bearing acicular setæ only; in 5th somite the dorsal setæ are much elongated uncini, only the points projecting beyond the skin; branchial cirri present on segments following the 5th, first being very small; an infundibuliform membrane, incomplete dorsally, surrounds the anus.

Leucodore ciliata, Johnston.

Leucodore ciliata, Johnston, *loc. cit.*; Malmgren, Ann. Polych.

Leucodore ciliatus, Johnston, Cat. Brit. Mus., p. 205.

Polydora ciliata, M'Intosh, Fauna, St Andrews, p. 127.

Specific Characters.—Those of the genus.

Habits.—This worm inhabits soft mud tubes which are not very firmly constructed, and which fill up narrow chinks and clefts in rocks. In some oysters which were kept in the summer of 1886 in floating cages in Granton Quarry, and which became coated with sediment, large numbers of this worm were found between the projecting edges of the shell laminæ, the end of the tubes often projecting some distance. It is stated by HUXLEY that *Leucodore ciliatus* bores holes in the oyster shells. We have not found this to be the case; the tubes of the worm did not actually pierce the shell in any case, and we have not observed them on oysters newly dredged from the middle of the Firth.

Anatomy.—The nerve cords are rather wide apart and there is no neural canal.

CLAPARÈDE (*Chétopodes du Golfe de Naples*, 1868) describes in, *Leucodore Agassizii*, a glandular sac beneath the base of each branchia in somites posterior to the 5th (the modified one). He also describes the nephridium as arising from an internal aperture beneath this sac, turning then in the next somite towards the lateral border of the body, then reflected on itself, and passing to open to the exterior near the dorsal median line. In *Leucodore ciliatus* we have made out by compression both the glandular sac and the nephridium.

The nephridium is easily distinguished in the living worm after compression by the black granular matter contained in its cells. This matter is doubtless composed of urinary concretions. The glandular sac is derived from the epidermis.

Fam. MAGELONIDÆ.

Magelona papillicornis, Fritz Müller.

Mæa mirabilis, Johnst., Cat. Brit. Mus.; M'Intosh, Fauna of St Andrews.

Magelona papillicornis, Fr. Müller, Anneliden-fauna der Insel Santa Catherina, Arch. f. Naturges., 1858; M'Intosh, Z. f. w. Z., Bd. 31.

This peculiar and interesting species is common at Granton, and is got in abundance by digging in sand in the littoral zone. We have formed a special family for it, as it cannot be admitted into the *Spionidæ*, with which it is most nearly allied, or into any other family. It has a richly corpusculated blood, contained in special vessels, a large flat præoral lobe, and two long occipital tentacles furnished with long movable papillæ. These tentacles bear no cilia. There is an anterior thoracic region, which is much more muscular than the rest of the body, flattened, and somewhat reduced in diameter (*vide* Pl. XXXVIII. figs. 6, 6 A, &c.).

Fam. ARICIIDÆ, Malmgren.

The principal distinction between this family and the *Spionidæ* is the absence in the former of the occipital tentacles, or cirri of the buccal somite. The family is equivalent to the *Ariciæ veræ* of Oersted (*Arch. f. Naturges.*, x., 1844), with the exclusion of *Aonis*, Grube, which is a synonym of *Nerine*. The family includes the genera *Aricia*, Savigny, *Scoloplos* (Blainville), Oersted, and *Theodisca* (Fr. Müller), Claparède.

Scoloplos armiger (Müll.), Blainville.

Lumbricus armiger, Müller, Zool. Dan., i. p. 22.

Scoloplos armiger, Oersted, Ann. Dan. Consp., p. 37; Malmgren, Ann. Polych.; M'Intosh, Fauna of St Andrews.

Abundant, burrowing in sand in company with *Magelona*. The anterior somites bear chætæ only, without tubercles. Farther back there are both long tubercles and simple branchiæ, and the parapodia are approximated together on the contracted dorsal surface. The anal segment bears a pair of long filaments (figs. 7, 7 A, &c.).

Theodisca mamillata, Claparède.

Got off Laminarian roots at the Birnie Rocks, near Granton Quarry.

Specific Characters.—One pair eyes. Cephalic lobe, obtusely rounded. Branchiæ dorsal, commencing on 5th setigerous somite. Notopodium, consisting of a single cylindrical process, in front of the base of which is a fascicle of long capillary bristles. Neuropodium, a mammiform projection with a nipple-like process at the end; on the anterior surface exteriorly are a row of capillary

setæ, proximally a large number of short thick setæ bifid at the apex; the latter are present only in the first 10–15 somites, not in the others. Among the dorsal bristles in the middle part of the body are some 2-pronged at the end (Pl. XXXVIII. fig. 8).

Fam. CIRRATULIDÆ, Vict. Carus.

Body round, parapodia near the ventral surface, the notopodia separated by a wide dorsal region. Parapodia themselves not prominent, with simple chætæ and acicula. Tentacular filaments in a transverse row on the dorsal surface near the anterior end. A pair of branchial filaments on several of the somites. Head long and conical.

Cirratulus cirratus, Malmgren (O. F. Müll.).

Cirratulus borealis, Lam., Anim. s. Vert., v. p. 302; Oersted, Annul. Dan. Consp., p. 43; Grönl. Annul. Dorsibr., p. 54; Grube, Fam. Annel., p. 67; Johnston, Brit. Mus. Cat., 1867, p. 210.

Lumbricus cirratus, Müll., Zool. Dan. Prodr., p. 214.

Cirratulus cirratus, Malmgren, Ann. Polychæta, p. 205; M'Intosh, Fauna of St Andrews.

Transverse series of tentacular filaments on 1st somite behind the buccal; this is also the 1st setigerous somite. Buccal somite with two constrictions. Branchial filaments on the body few and scattered, and their origin separate from the base of the notopodium.

There is no doubt that the species we have here is identical with JOHNSTON'S *C. borealis*. It is equally certain that it is the same as the *C. borealis*, Lam., of OERSTED; and as both JOHNSTON and MALMGREN affirm that OERSTED'S name designates the same worm as *Lumbricus cirratus*, Müller, we cannot understand why MALMGREN (*Annulata Polychæta*) expresses a doubt as to the identity of JOHNSTON'S *C. borealis* with his own *C. cirratus*, Müller.

Habits.—Common on the shores of Granton Quarry and on the shore in the neighbourhood. Found usually extended beneath stones which are partially buried in rather soft muddy ground.

There has been considerable uncertainty among authorities as to the character of the portion of the body in this worm which is anterior to the conspicuous transverse series of filaments. In front of the segment which bears the latter there are two constrictions, and in front of the most anterior of these projects the blunt-pointed præoral lobe, which bears a pair of transverse rows of eyes. JOHNSTON counts the part between the eyes and the 1st annulation as the 1st segment; thus, according to him, the thicker tentacular filaments in transverse series arise from the 4th segment. OERSTED takes in JOHNSTON'S 1st segment as part of the præoral lobe, and states that the branchial filaments arise

on the 3rd segment. We have come to the conclusion that there is nothing in front of the anterior transverse filaments except buccal somite and præoral lobe, the latter bearing the eyes. The buccal somite is longer than in most cases, equal in length to three of the succeeding somites. Longitudinal sections show that there are no mesenteries corresponding to the superficial annulations, and the ventral nerve cord does not extend in front of the 1st setigerous somite.

The real distinction between the dorsal tactile filaments of the anterior end and the lateral branchial filaments is, that the former are provided with a groove similar to that which occurs in the occipital tentacles of *Nerine*, &c.

CLAPARÈDE'S account of these filamentous appendages, which are so characteristic of this genus, and which give it its name, is not quite correct. There are two kinds of these filaments,—the tentacular, which are confined to the 1st setigerous somite in this species, to the 4th and 5th setigerous in the following, and the branchial, which are present on the sides of a great number of the somites. There is never more than one pair of branchial filaments to a somite in the present species; the attachment of the branchia is same distance dorsal of the notopodial bristles. The branchia is a thin flexible cylinder, composed of epidermis, muscular wall, and cavity. In the cavity run two longitudinal vessels continuous with each other at the distal extremity of the filament; a closely set series of transverse small capillary vessels connect these two main vessels; these run in the muscular layer close beneath the epidermis (see fig. 9 c). The tentacular filaments appear in the living animal opaque white, while the branchiæ are of a brilliant red: in spirit specimens the tentacular filaments are still white, while the branchial are dark, sometimes quite black, owing to the pigment, which is abundant in the epidermis of the latter. The tentacle also consists of epidermis, muscular layer, and cavity. In the cavity runs a *single* longitudinal pseudhæmal vessel, which ends cæcally at the distal extremity of the filament, and gives off no branches. On the ventral surface of the filament is a single deep groove running the whole length of the filament, and lined with a coating of extremely short cilia. When sections of the tentacle are made it is seen that the formation of the groove is entirely due to two parallel thickenings of the epidermis; no other structure in the tentacle takes any share in its formation. The number of the tentacles is considerable. In a large specimen we counted 10 pairs, and there is always attached to the tentacle-bearing somite a single pair of branchiæ in addition. These branchiæ are ventral in origin to the transverse series of tentacles. The number of the tentacles, however, is not constant, but increases with the age and size of the individual; in specimens 4 cm. long only 5 pairs are present. CLAPERÈDE attributes two grooves to the branchiæ, and none to the tentacles, but his account of the vascular supply is correct. He does not discuss the relations of the groove to the epidermis.

In both the branchiæ and the tentacles there are nerves. In either case these are seen in a prepared section as a pair of fibrillar strands situated in the deeper region of the epidermis, and running longitudinally. In the branchia the two nerves are at opposite sides of the filament; in the tentacles they are placed one on each side of the groove (Pl. XXXIX. figs. 9 D, 9 F).

The nerve cords in the body are not separated from the epidermis, though they are defined with considerable distinctness. The fibrillar portion of the cords does not stain in borax carmine. There is no differentiation of ganglia, the nerve cells being distributed uniformly along the ventral side of the cords.

The dorsal vessel in this and all other species of *Cirratulus* has a very peculiar structure, which has been described by CLAPARÈDE.* By examining the living animal under a low power, the dorsal vessel can be seen to contain a bright red liquid, and to be bordered by three black granular-looking cords, one dorsal and two lateral. The vessel is much constricted where it passes through the mesenteries, and much enlarged in the body of the somite. It also has a very tortuous course when the animal is in an average state of contraction. CLAPARÈDE studied the vessel in *Andouinia filigera* (= *C. tentaculatus*), and states that the wall is formed by a muscular tunic formed of annular fibres, within which the "cordons bruns" are placed. He was unable to decide whether these cords were between the muscular tunic and the vessel's own wall, or within the latter. Our sections show clearly the relations of the cords, and also their minute structure, on which CLAPARÈDE says nothing. It should have been mentioned that the dorsal cord is often interrupted, and occasionally coalesces with one of the lateral. The cords are in the interior of the vessel, and although they are usually in contact with the inner surface of the wall, they are not continuous with it: the pseudhæmal fluid is frequently seen in the sections between one of the cords and the wall of the vessel. The structure of the cords is very peculiar: it has a glandular character, but it is difficult to decide whether the organs have a glandular function, as they have neither lumen nor efferent duct, nor have we been able to trace any connection between them and any other organ of the body. The cords are composed of elongated cells placed perpendicularly to the interior of the cord, which is enclosed by an extremely thin basement membrane. In our sections the cells are not stained. They contain a number of minute rounded granules similar to those which are seen in the secreting cells of nephridia in several Chætopoda, and also somewhat similar to granules in the secretory cells of the epithelium of the intestine. These granules are in greatest abundance towards the external parts of the cells.

The dorsal vessel gives off on each side a large vessel in the 3rd somite, the branch passes backwards and forms a lateral vessel, from which the

* *Chétopodes du Golfe de Naples*, Genève, 1868.

afferent vessels to the branchiæ pass off. The dorsal vessel is continued to the anterior end as a thin trunk. The glandular cords end at the point where the lateral vessels are given off. We have not yet ascertained if there are communications in each somite, between the dorsal vessel and the lateral.

Reproduction.—We found a number of specimens swollen with eggs, at the end of March 1887, under stones, on the banks of Granton Quarry. These commenced to deposit their eggs when placed in a basin of sea water. The eggs were fastened together by transparent mucus, forming a soft mass without any definite shape, adhering to the stones and mud among which the animals were placed. On examination, the manner in which the ova escaped was ascertained without much difficulty. A female individual was isolated in a small glass vessel, and the surface of its body cleaned from eggs and dirt: in a short time a little group of eggs appeared on the side of each somite, and on examination with a lens, an egg could be seen half escaped, in several somites, a little ventral to the neuropodial setæ. When the animal was placed under the microscope, and viewed with a low power, and with reflected light on a dark background, a small round aperture was seen in the position just defined where the egg was seen escaping, that is ventral to the neuropodial setæ, and the eggs were seen escaping slowly one by one from this aperture. The process could be watched for a long time. The eggs as they escaped were enveloped in mucus excreted from the skin, and so formed little groups close to the aperture whence they escaped. A large individual, which though containing eggs, was not quite ripe, was next examined, and the genital apertures, although in this case contracted, could be seen. It was evident that these genital apertures were not formed temporarily by rupture, in order to let out the eggs, but definite permanent openings present throughout life. Some of the females were very large, the largest measuring 9 cm. in length by 5 cm. in diameter near the head. The males were much smaller, the largest being 5.5 cm. in length. The males had genital apertures exactly similar to those of the females. Subsequent preparation of series of sections from these specimens showed that the pores from which the genital product escaped were the external apertures of simple nephridia, present throughout nearly the whole length of the body. For a full account of the nephridial system, see a paper by one of us, *Quart. Jour. Micr. Sci.*, 1887.

C. tentaculatus, Fleming (Montagu).

Terebella tentaculata, Montagu, in Linn. Trans., ix. p. 110.

Cirratulus Lamarckii, Audouin and M. Edw., Litt. de la France, ii. p. 271.

Cirratulus tentaculatus, Johnston, Cat. Brit. Mus., p. 209.

Andouinia filigera, Clap., Chét. du Golfe de Naples.

Several long coiled tentacular filaments in transverse series, arising from

dorsum of 5th and 6th setigerous somites ; lateral filaments on some somites in front of these, annulations on the buccal somite. Lateral branchial filaments, arising immediately above the base of the notopodia. Larger than *C. borealis*, length 10–13 cm. and upwards, diameter 5 mm.

Habits.—Found in similar localities to those described for *C. cirratus*, but nearer low-water mark ; it also burrows more deeply than the latter species.

As JOHNSTON remarks, it is somewhat difficult to ascertain to which somite the tentacular filaments belong. Eyes are not visible in preserved specimens, but faint pigmented lines are to be seen on the cephalic lobe in the living animal. The region in front of the 1st chætiforous somite has the same characters as in *C. cirratus*. The origin of the lateral filaments is a constant and marked character of this species. The colour is dark red.

Chætozone, Malmgren.

Chætozone, Malmgren, Ann. Polych., p. 206.

This genus was established by MALMGREN, in 1867, for the following single species. The distinguishing character is the arrangement of the chætæ of the posterior somites, in an extended linear transverse series, so that they almost encircle the body.

Chætozone setosa, Malmgren.

Chætozone setosa, Malmgren, *loc. cit.*

Specific Characters.—Smaller than *Cirratulus cirratus*; only two tentacles which are much thicker than the branchial filaments, and arise immediately in front of the first pair of parapodia; tentacles with same characters as those of *Cirratulus*. Eyes wanting; anterior end of cephalic lobe acuminate; 6 annuli in front of 1st pair of parapodia. Branchial filaments arising close to base of notopodium, slightly behind it. Anterior pair of nephridia opening at base of 1st pair of parapodia, extending back through 2 or 3 somites, and visible to the unaided eye, on account of their brown granular appearance (Pl. XXXIX. fig. 11).

Anatomy.—There are 3 glandular cords in the dorsal vessel, as in *Cirratulus*, which are quite black, and very conspicuous in the living animal. The lateral branchial filaments occur on some of the somites throughout the body, and are not limited to a certain region, as in *Dodecaceria*. The chætæ are all long and setaceous.

Dodecaceria, Oersted.

Dodecaceria, Oersted, Annul. Dan. Consp., p. 44.

A genus also containing only a single species, the following:—

Dodecaceria concharum, Oersted.

Terebella ostree, Dalzell, Powers of the Creator, ii. p. 209.

Dodecaceria concharum, Oersted, Annul. Dan. Consp., p. 44; Johnston, Brit. Mus. Cat., 1865; M'Intosh, Fauna of St Andrews.

As only one species of this genus is known, a separate diagnosis of genus and species is unnecessary.

The form is allied to *Chætozone*, from which it differs principally in two points—(1) the absence of the peculiar arrangement of setæ in the posterior part of the body which characterises *Chætozone*; (2) the fact that there are only a few pairs of branchial cirri, confined to the anterior somites. Like *Chætozone*, the species possesses a single pair of cephalic cirri, which are thicker than the somatic, and usually twisted spirally. Anterior end of cephalic lobe cylindrical, obtuse, without the annulations seen in *Cirratulus*. Eyes none; mouth almost terminal. Posterior part of body considerably thicker than anterior. Colour dull olive-green (Pl. XXXIX. fig. 12).

Habits.—Not uncommon among roots of *Laminaria*. According to JOHNSTON, it lives in burrows drilled in the shell of *Cyprina islandica*, but we have not observed it in this condition.

Fam. THELETHUSIDÆ.

No cephalic tentacles: parapodia not prominent; arborescent branchiæ on several successive somites. Size large.

Genus *Arenicola*, Lamarck.

Arenicola piscatorum, Lam., Syst. d. Anim. s. Vert., 1802, p. 324.

Cephalic lobe rudimentary; tentacles and eyes absent; proboscis small and soft. Arborescent branchiæ commencing some distance behind anterior end; surface of somites marked with transverse ridges and furrows, and shallower longitudinal furrows. Burrows in mud or sand, which it devours.

Arenicola marina, Malmgren (Linn.).

Lumbricus marinus, Linnæus, S. N. xii. 1, 2, p. 1077.

Arenicola piscatorum, Lamarck, 1802, Syst. d. Anim. s. Vert., p. 234; Johnston, Cat. Brit. Mus.; Cuvier, Regne Anim. éd. accomp. de Planches, Annel., Tab. 8.

Arenicola marina, Malmgren, Annulata Polychæta, &c.; M'Intosh, Fauna of St Andrews.

Specific Characters.—Branchiæ on 7th to 19th chætiforous somites inclusive; caudal region of considerable length, without chætæ or branchiæ. Length, 8 inches to 1 foot, diameter about $\frac{1}{2}$ inch.

Habits.—Very common at Granton in flats of somewhat muddy sand on shore, and beyond low-water mark. The sides of its burrows are stained with the yellowish-green exudation from its body. The intestine is always full of the sand and mud in which it lives, and from which it derives its entire nourishment. This sand is ejected in a cylindrical rod from its anus, and this forms a spiral coil on the surface of the shore: near the “cast” is usually a wide hole, from which the head is protruded when the tide is up. The worm is usually found at least a spade’s depth from the surface when the tide is out.

Anatomy.—The 1st somite is destitute of bristles; the following 6 bear each a dorsal fascicle of hair-like bristles and a ventral torus uncinigerus, but no branchiæ. The following 13 bear both fascicle and torus, and in addition a pair of plumose branchiæ; the rest of the body, which is variable in length, is thinner than the rest, and has neither fascicle, torus, nor branchiæ, but is cylindrical, and covered uniformly with papillæ. This part forms the caudal appendage: the number of somites in it we have not determined.

On dissection, it is found that the body-cavity is a large and well-defined space in the anterior and branchial regions, but almost obliterated in the caudal appendage. Transverse mesenteries are only present in the anterior 4 somites, and here they are incomplete; in the rest of the body they are absent. There is a septum between the buccal and the 1st chætiferous somite, none between the 1st and 2nd chætiferous; one behind the 2nd, and one behind the 3rd chætiferous.

Between two successive parapodia are seen externally 5 constrictions, of which the 5th is the deepest. Between the 5th and the parapodia is a prominent ring ending in a sharp line. The mesenteries are attached to the body-wall at the 2nd constriction. There are 6 pairs of nephridia, visible in spirit specimens as brown glandular masses attached to the body-wall; they belong to somites 5–10. CLAPARÈDE, in his description of *Arenicola Grubii*, describes only 5 pairs of nephridia, belonging to the 4th to the 8th setegerous somites; that is, somites 5–9. He does not mention any difference in the case of *A. marina*. In the latter the first pair of nephridia is smaller than the succeeding, and is to that extent rudimentary. The internal opening of the 1st segmental organ is on the anterior face of the mesentery, between somites 4 and 5.

The nephridium is a wide thin-walled tube, showing on dissection a black colour, which is due to the concretions in the glandular cells lining the cavity. The peripheral end of the tube opens to the exterior by a pore visible in the fresh animal to the naked eye, and situated immediately behind the dorsal extremity of the torus uncinigerus. Anterior to the pore in a living uninjured animal the black tube of the nephridium is seen through the semitransparent skin, and is very conspicuous. The peripheral end of the tube, which is posterior in position, is somewhat dilated, and lighter in colour than the rest. Anterior

to this the tube, which is placed longitudinally, narrows ; but at the anterior end, which lies near the posterior extremity of the one in front, the tube is of considerable width. Across the internal side of the anterior portion, that is on the side turned towards the body-cavity, lies a membranous appendage, whose edge, which is turned towards the median ventral line of the animal, is seen to be furnished with a conspicuous vascular fringe of a bright red colour. The anterior extremity of the fringe is seen to be connected with a transverse blood-vessel passing from the body-wall immediately behind the dorsal fascicle of setæ, and proceeding to the ventral vessel. From this transverse blood-vessel the whole organ probably receives its blood supply. The nephridium is confined beneath the bands of oblique muscles, which pass from the ventral nerve cord to the lateral body-wall. When these are cut through, the whole nephridium can be removed without difficulty ; and examination of the membranous appendage shows that it is double, consisting of two membranes, between which is a long slit-like aperture leading into a membranous funnel which opens into the interior of the nephridial tube. The vascular fringe forms, in the original position of the parts, the dorsal border of this internal or cœlomic aperture, while the ventral border is entire and non-vascular. Both edges of the aperture, including the processes of the fringe, are covered with short cilia, while inside the aperture are seen very long cilia which extend throughout the tube.

In 1868, when CLAPARÈDE'S *Chétopodes du Golfe de Naples* was published, the gonads of *Arenicola* were unknown. CLAPARÈDE says that most authors had assigned the nephridia to the generative system, sometimes under the name of ovaries, sometimes under that of testes. QUATREFAGES (*Histoire Nat. des Annelés*) called them genital organs. GRUBE had assured himself that the ovaries were not to be sought in these organs, for he had seen the ova formed on the wall of the vascular cæca of the perivisceral cavity ; he was inclined to regard the nephridia as testicles. CLAPARÈDE says this is impossible, because *Arenicola* has the sexes separate ; he was of opinion that GRUBE was right as to the formation of the ova, and he gives a figure of one of the cæcal pseud-hæmal vessels with a layer of cells surrounding it. He then leaves the question of the genital organs, and proceeds to give a not very accurate description of the nephridia. We were for some time at a loss as to where the genital products really took origin. In February we found two or three specimens which had a few ova in the body-cavity ; in these cases, and in other specimens where mature ova were not present, loose cellular masses were often found in the neighbourhood of the nephridia, and against the posterior wall of the septum between somites 4 and 5. After considerable search, these masses were traced to a cord of cellular tissue attached to the membranous funnel of each nephridium. In most specimens the cells of this cord were so small and so

undifferentiated that it was not possible at first to be certain it was a gonad. But in specimens which contained but few ova in the cœlom, it was obvious enough that this mass of cells was the female gonad, some of the cells in it being distinctly recognisable as ova (fig. 13 D). The ova in the body-cavity were of various sizes (fig 13 E), and it was evident that they went through the greater part of their development after being detached from the gonad. Male elements were in other specimens found freely suspended in the liquid of the cœlom, but only in small quantity; they were in the form of sperm polyplasts, or bundles of spermatozoa (fig. 13 F). The gonad in this case showed, instead of ova and germinal cells, systems of small cells, 6 or 8 in each system, evidently derived from the segmentation of germinal cells, and destined to fall off into the cœlom, and there form sperm-polyplasts, and ultimately spermatozoa.

None of the worms examined in February and March were sexually mature, and it was afterwards found that *Arenicola marina* does not shed its genital elements till August and September. MAX SCHULTZE was, we think, mistaken in ascribing the ova and embryos whose development he describes (*Entw. von Arenicola, etc.*, Halle, 1856) to this species. As shown in the following section, the cocoons he gathered were most probably these of *Scoloplos armiger*. It is yet uncertain whether the present species forms cocoons at all, or sheds its ova separately in the mud.

Eggs and Larvæ belonging, according to Max Schultze, to Arenicola.

At the beginning of February, we found large numbers of gelatinous cocoons on the surface of the sands near the Station at low tide. From MAX SCHULTZE'S description (*loc. cit.*) we concluded at first that these were the spawn of *Arenicola marina*. That author discovered the cocoons he described as belonging to *Arenicola* on the flat shores of the island of Neuwerk, not far from Cuxhaven. In most points his account suits the spawn we obtained, but his cocoons had a pink colour, due to the ova within. We have not observed any colour in our specimens; the jelly was transparent, and the ova and embryos opaque white. The colour may not be a constant attribute.

The cocoons or gelatinous masses are about 2 cm. long and 1 cm. broad. They are pear-shaped, and the narrower end is produced into a long cylindrical stalk, about 3 cm. in length, which contains no ova. The stalk is usually imbedded in the sand.

It was very easy to keep these ova alive, and hatch them in captivity. They were simply placed in a shallow dish with sea water, and a little sand at the bottom. The larvæ lived several days after hatching. Pl. XL. figs. 14 A to 14 F, show a series of stages in the development of these larvæ. There are three transverse bands of cilia, which persist until the setæ begin to appear, and there

is also, as shown in fig. 14 D, a ciliated longitudinal line or groove in the median line of the ventral surface. The first transverse band is præoral, the second postoral, and the third perianal. There is a well-developed præoral lobe and a single pair of black ocelli. In these points the larva is more like the adult *Scolepos armiger* than the adult *Arenicola*; but the character which seemed to us to indicate more definitely the former species as the adult form is the pair of anal cirri which appear in the oldest stage of the larva figured (comp. Pl. XL. fig. 14 F, and Pl. XXXVIII. fig. 7 B). The first somite to be defined is the 1st postoral, and the others are constricted off in succession from the growing posterior end. Dorsal cirri appear on the two most posterior somites in the oldest stage figured.

Fam. HERMELLIDÆ.

Sabellaria, Lamarck.

Sabellaria spinulosa, R. Leuckart.

Sabellaria lumbricalis, Johnston, Cat. Brit. Mus.

Sabellaria spinulosa, R. Leuckart, Arch. für. Naturges., xv. 1; Malmgren, Ann. Polych., etc.; M'Intosh, Fauna of St Andrews.

We have identified our specimens with this species chiefly on account of the form of the paleæ of the outer row in the operculum. MALMGREN'S figure of the entire animal of this species far less resembles our specimens than his figure of *S. alveolata*, L. In the latter figure the branchiæ are long, as in our specimens (Pl. XLI. fig. 17 c); in the other figure they are much shorter. The position of the chætæ in the 1st and following few somites, and the breadth of the notopodia in the posterior somites, are other points in which MALMGREN'S figure of *S. alveolata* agrees with our specimens of *S. spinulosa*. It is difficult to avoid the conclusion he has by mistake interchanged the figures of the entire animal in the two species.

Habits.—The flat mud banks in the estuary of the Forth in the neighbourhood of Charleston contain myriads of this species, the tubes of which render these banks hard and firm. The dredge worked over these banks brings up large masses of these tubes, and scarcely anything else. We have also found specimens encrusting rocks, stones, and shells in the coralline zone near the Granton Laboratory, and inhabiting tubes of sand adhering to oyster, *Pecten*, and other shells dredged in the Firth.

Anatomy.—The morphology of *Sabellaria* offers a difficult problem, namely, that of deciding on the true significance of the cephalic processes on which the operculum is carried. Many zoologists have called these processes kopflappen, or cephalic lobes. It seems impossible that these lobes should be really cephalic, for there is no other case among the Chætopoda in which chætæ occur on the true cephalic lobes, or prostomium. It seems probable, from the

way in which the anterior parapodia are bent forwards, specialised in form, and increased in size, for the protection of the head in other cases, *e.g.*, in Trophonia, Ampharete, and Pectinaria (which form a progressive series), it seems probable from these examples that the operculum in Sabellaria, with its three rows of paleæ, is derived from the most anterior parapodia. And the examination of a series of longitudinal sections of the anterior end of Sabellaria shows evidence which supports this hypothesis. The cerebral ganglia are found to be placed immediately above the anterior end of the œsophagus, and in contact with the integument of the ventral surface of the base of the opercular peduncles. It follows then that the whole substance of the peduncles belongs to the region of the body behind the cerebral ganglia, that is, to the postoral somites, and not to the præoral lobe. If it were otherwise, the cerebral ganglia would of course be situated on the dorsal side of the peduncles. The question next arises, Do the paleæ of the operculum represent one pair of parapodia, or how many pairs? At present there seems to be no evidence on which to decide this question.

The bases of the peduncles are united dorsally, but terminally they are independent, and between them there is a conical process projecting from the tissue which unites their bases. Each peduncle is flat towards the median plane, or even slightly concave; externally it is convex. On the ventral side each bears a large number of thin flexible ciliated tentacles: these are arranged in a series of short transverse rows, each row being continuous at the base. There are 7 or 8 of these rows.

At the base of the opercular processes, within the cavity on their ventral side, and at the dorso-lateral corners of the mouth, arise a single pair of much thicker tentacles (Pl. XLI. fig. 17 A). These, which are also ciliated, are true præstomial tentacles similar to those of Nerine. In the parts around the mouth the præstomium, the buccal somite, and the ventral part of the opercular segment, must, according to our views, all be present, but they cannot be defined. Behind the opercular peduncles occurs the 1st normal somite, which bears the first pair of dorsal branchiæ, and two chætiferous lobes, one of which is notopodium, the other neuropodium. Each of these lobes runs out to a conical process anteriorly, and the ventral pair are in close relation to the mouth. The chætæ are quite simple. In the next three somites, the notopodial setæ are specially modified, the shape is shown in fig. 17 c 4, and it is seen that they approximate to the form of the outer opercular paleæ. These three somites, together with the preceding one, may be considered as forming the prothoracic region. The succeeding somites forming the thoracic region, all bear branchiæ, which diminish in size towards the posterior end. The notopodia are elongated fin-like processes, bearing uncini; the neuropodial setæ are simple, and very long. The abdomen or tail, which is bent up ventrally, bears neither branchiæ nor parapodia.

Ammotrypane aulogastra, Rathke.

Ammotrypane aulogastra, Rathke, Nov. Act. Nat. Cur., xx. 1, tab. x. f. 1-3.

Ophelina acuminata, Oersted, Consp. Ann. Dan., p. 45; Arch. f. Naturgesch., x. 1, p. 111.

Ophelia acuminata, Grube, Fam. Ann.; Johnston, Cat. Brit. Mus., 1865.

Ammotrypane aulogastra, Malmgren, Annulata Polych.; Of. k. vetensk. Akad. Förhand., 1865; M'Intosh, Fauna of St Andrews, 1875.

The specific characters as given by JOHNSTON are—Body fusiform; snout tipped with a small globule; branchial cirri to all the segments; anal extremity spoon-shaped, with two small fusiform appendages in front of the vent.

This is not quite correct: the 1st setigerous somite bears no branchia; and the spear-shaped anal extremity is provided with cirri round its posterior edge; and in addition to the two small fusiform appendages in front of the vent, a long cirrus arises between these. This median cirrus usually lies in the hollow of the spoon-shaped appendage, and is therefore not easily seen (figs. 15 to 15 c).

A species of *Opalina* commonly occurs in the intestine of this species; it is of an elongated cylindrical shape, and towards one end repeated transverse fissions take place, the resulting segments remaining for some time connected so as to form a linear series (Pl. XLII. fig. 15 D).

Genus *Ophelia*, Savigny.

Generic Character.—Longitudinal constriction limited to posterior two-thirds of the body.

Ophelia limacina, Sars (Rathke).

Ammotrypane liniacina, H. Rathke, Nov. Act. Nat. Cur., xx. 1; Johnston, Cat. Brit. Mus.; Quatrefages, Ann. ii.

Ophelia bicornis, Oersted, Grönl. Ann. Dors.

Ophelia limacina, Sars, Nyt. Mag., vii.; Malmgren, Ann. Polychæta, *loc. cit.*; M'Intosh, Fauna of St Andrews.

The worm is thicker than the preceding species; the notopodial cirri are shorter and thicker, and confined to the posterior part of the body. The longitudinal constriction begins behind the 8th somite (7th chætiferous). The posterior extremity has a circlet of small papillæ.

Found between tide marks at Granton.

Eumenia crassa, Oersted.*Polyphysia crassa*, Quatrefages, Annelès, ii.*Eumenia crassa*, Oersted, Ann. Dan. Consp. Arch. f. Naturges., x. 1; Sars, Nyt. Mag., vii. 12 (description); Johnston, Cat. Brit. Mus.; Malmgren, Ann. Polychæt.; M'Intosh, Fauna of St Andrews.

The body is cylindrical, the thickest part near the anterior end. The first six chætiferous somites bear branchiæ in the form of a thick cluster of papillæ sprouting from a central stem, and situated in front of the notopodium (Pl. XLII. fig. 18 A). Each division of the parapodium consists of a pointed lamella towards the outside of the parapodium, and a fan of simple acicular chætæ towards the centre of the same. Such parapodia are present on all the somites except the buccal and anal. The anterior end is conical, terminating in two small divergent points; the anal segment is without appendages.

Habits.—Dredged in the Firth.*Lipobranchius*, n. g.*Lipobranchius Jeffreysii* (M'Intosh).*Eumenia Jeffreysii*, W. C. M'Intosh, On the Structure of British Nemer-teans, and some new British Annelids, Trans. Roy. Soc. Edin., 1868.

This worm we have not examined in detail: it evidently belongs to the family Scalibregmidæ, being similar in many respects to *Eumenia*, in which genus M'INTOSH placed it. We have formed a new genus for it on account of the entire absence of branchiæ or branchial cirri. It is fusiform, both ends being conical, and it is not easy at first to distinguish which end is anterior and which posterior. The worm, in fact, looks like a maggot. Parapodia are present on all the somites except the buccal and anal, and are all similar in structure. Each consists of two similar mammillate processes bearing a few small chætæ at the apex. The ventral body-wall is much more muscular than the dorsal, and in spirit the former is contracted so that the body is curved (Pl. XLII. fig. 19). On each somite there are about three transverse corrugated ridges, but there are no definite constrictions between adjacent somites, which are only indicated by the parapodia.

Large numbers of specimens of this form were dredged in several places in the Clyde by the "Medusa." The worm is found only on muddy bottoms, and lies enclosed in a thick tube formed from the mud hardened by an excretion from the skin.

M'INTOSH says the chætæ are of two kinds—one kind simple, the other bifurcated into two large branches. He also says there are two short thick tentacles on the head, and several elongated processes round the anus. We

have not seen these, but our specimens were contracted, and we have not dissected them. Our specimens were identified by Prof. M'INTOSH himself, and our only object here is to record the occurrence of this curious form in the Clyde sea-area, as the specimens sent to Prof. M'INTOSH were taken by Mr JEFFREYS among the Hebrides in 1866, and off Shetland in 1867. We have never found the species in the Firth of Forth, but have nevertheless taken this opportunity of mentioning its occurrence in the Clyde.

Fam. AMMOCHARIDÆ.

Genus *Owenia*, Delle Chiaje.

Owenia filiformis, Delle Chiaje; Claparède, Chæt. Naples.

Commonly got by dredging, inhabiting very thin flexible sand tubes, from which it is very difficult to detach it entire.

In small specimens the mouth is surrounded by a funnel-shaped lip quite entire except for a ventral notch. It is only in the larger specimens that the branched processes are seen. It seems from this that they are merely out-growths from the periphery of the mouth, and have not really any connection with the branchiæ of the Serpulidæ, as suggested by CLAPARÈDE.

Fam. AMPHICTENIDÆ.

Pectinaria belgica, Lamarck (Pallas).

Nereis cylindraria belgica, Pallas, Misc. Zool., p. 122.

Pectinaria belgica, Lam., Amm. s. Vert., p. 350; Johnston, Cat. Brit. Mus.; Malmgren, Nordiska Hafs-Annulater Svensk. Akad. Forh., 1865, p. 356; M'Intosh, Fauna, St Andrews.

Mr HARVEY GIBSON ("Notes on some of the Polychæta," *First Report on the Fauna of Liverpool Bay*, Lond., 1886) has, by carefully neglecting the distinguishing differences between this species and *Amphitrite auricoma*, Müller, attempted to prove that the two forms are identical. He points out that in the original figures of PALLAS of *Nereis cylindraria*, variety *belgica*, "the stiff golden comb shows one continuous and uniform series of teeth, not two series, as in *P. auricoma*;" and that figures by subsequent authors, e.g., M'INTOSH and MALMGREN, show the two combs in *Pectinaria belgica* with perfect distinctness. Moreover, certain references in PALLAS'S text imply that his species had two distinct combs. Mr HARVEY GIBSON concludes—"Either PALLAS'S draughtsman has made an error in most of the figures of *P. belgica*, and failed to represent the comb with sufficient accuracy, hence leading MÜLLER into error when comparing his form with that of PALLAS, or PALLAS'S figures are correct (although his references in the text are wrong), and his species is distinct from that of MÜLLER (for the condition of the comb appears

to be the only important difference between the two). Looking at the inaccuracy of the drawings as compared with var. *capensis* in PALLAS'S work, and taking into account the indistinctly double series of teeth shown in figs. 5, 8, and 9 of var. *belgica*, I think that probably the former view is the most likely to be the correct one. In that case *P. auricoma* of MÜLLER disappears, and becomes *P. belgica* of PALLAS." How a zoologist, after actually referring to the description and figures given by MÜLLER of *Amphitrite auricoma*, and to the description and figures of both species given by MALMGREN in the *Nordiska Hafs-Annulater*, could suppose the condition of the comb to be the only important difference between the two species, is perfectly incomprehensible. The two distinguishing features of *Amphitrite auricoma* given by MÜLLER are (1) the curvature of the tube, (2) the serration of the margin of the flattened area behind the palmulæ. MALMGREN mentions both these characters and figures them, and he examined specimens of both species; only MALMGREN made the two characters generic instead of specific, and calls MÜLLER'S species *Amphictene auricoma*. We can state with certainty that in our specimens the tube is perfectly straight, and the margin of the area behind the palmulæ perfectly entire. The presence of two separate combs is a constant character throughout the whole family Amphictenidæ.

Habits.—We obtained this species at low tide at Granton, on the surface of sandy flats. The tubes are often half buried, with the thin end projecting straight or obliquely from the sand. We have also taken it with the dredge.

MALMGREN states there are 17 pairs of fascicles of capillary setæ, and 13 pairs of uncinigerous pinnulæ, beginning at the 4th setigerous somite; but we find the last two pairs of parapodial projections before the "scapha," or abdominal region, are destitute of both capillary setæ and uncini; there are thus only 15 pairs of fascicles of setæ, and 11 pairs of uncinigerous pinnulæ, the latter commencing at the 4th setigerous somite. The first three pairs of fascicles of setæ are smaller than those following. In front of the 1st setigerous somite are two pairs of branchiæ. The pair of combs, which at first sight seem to belong to the buccal somite, probably really belong morphologically to the 1st branchial, of which somite they represent the notopodial setæ. The semicircular membrane between the tentacles and the palmulæ belongs to the buccal somite, while the tentacles themselves belong to buccal somite and præoral lobe. That this is the real interpretation of the combs is proved by comparison with *Ampharete*; in that genus the branchial somite, which follows the buccal, bears ventral to the branchia a dorsal fascicle of setæ, specialised into a palmula, and there can be little doubt that it is simply the great development of this palmula of the 1st post-buccal somite which has produced the condition seen in *Pectinaria*, and in the other genera of the Amphictenidæ.

The "scapha" represents the reduced abdominal region, and commences at

the 21st somite, counting the buccal as the 1st. It consists of 5 or 6 somites; it is bent down towards the ventral side; its first somite bears two series of spines, representing the notopodia; the dorsal surface of the scapha is concave, and its lateral margins are thin and crenulated; it terminates in a spatulate membrane overhanging the anus. The scapha fills up the lumen of the tube, which the animal inhabits, posteriorly, as the palmulæ, and the flat surface behind them occlude the tube anteriorly.

Anatomy.—(See Pl. XLII. fig. 20 E).—In *Pectinaria* the arrangement of the dorsal blood-vessel is similar to that seen in *Amphitrite*; the intestine close behind the mouth is bent into a long S-shaped loop; the pharynx is narrow, then opens into a thick-walled smooth portion, extending nearly to the posterior end of the thorax, this turns forward as a thin-walled yellow portion, which reaches forward to the pharynx, and then turns back again, as a very thin-walled transparent portion full of sand. The dorsal blood-vessel on the first of these portions is ventral, and is formed by blood-sinuses on the gut communicating with a ventral sinus; the latter at the commencement of the narrow pharynx forms a circumintestinal ring, which opens into the dorsal “heart,” as in *Amphitrite*. The heart contains a cellular “cardiac body.”

There are three pairs of nephridia in *Pectinaria*, of which the first pair are the largest; all the organs are of the usual type, each consisting of a tube bent upon itself, and provided with a nephrostome, and an opening to the exterior. There is a transverse septum separating the buccal somite from the following. The nephrostome of the 1st nephridium is on the anterior side of this septum; the nephridia are brown or black in colour, and this most exterior one reaches dorsalwards above the intestine. The anterior nephridium opens to the exterior, some little space ventral of the origin of the 1st branchia. Between the nephridial opening and the root of the branchia is the opening of a peculiar glandular organ, whose function we have been unable to ascertain. On dissection of a fresh specimen, this gland is seen as a milk-white opaque cylindrical body, about $\frac{1}{8}$ th inch long (Pl. XLII. fig. 20 E, *w*), free everywhere, except at the point where it is continuous at its external aperture with the body-wall. The efferent duct of this gland is lined by a high columnar epithelium, of which the component cells are solid and columnar; throughout the rest of the gland, though there is a layer of long solid nucleated cells near the basement membrane, these are covered by other layers of large vacuolated cells, whose walls form a network almost, but not quite obliterating the lumen of the gland. The wall of the gland is well supplied with pseudhæmal vessels. The 2nd branchiferous (*i.e.*, 3rd) somite and the following are unprovided with nephridia; but the latter, *i.e.*, the 4th somite, contains a nephrostome belonging to the nephridium of the 5th somite; the 6th somite is also provided with a nephridium, whose nephrostome is in the 5th somite. The nephrostomata are

simple elongated funnels, with their apertures directed forwards; they are not provided with such a series of digitate processes as are seen in *Lanice* and *Arenicola*. The gonads are of the usual type, masses of indifferent cells attached to the exterior of the nephrostomata, on the mediad side. The reproductive cells become detached at a very early stage, and pass through the rest of their development in a detached condition in the cœlom. It is certain that the spermatozoa reach the exterior by passing through the nephridia. In a series of sections of a ripe male, we saw the nephrostomata and various parts of the nephridial tubes quite distended with spermatozoa. Between the two posterior nephrostomata and the body-wall, pass membranes which are rudiments of transverse septa. There is also a rudiment of a septum between somites 2 and 3 (*i.e.*, 1st and 2nd branchiferous). The ventral epidermic glandular tissue, so conspicuous and extensive in *Terebellidæ*, is restricted in *Pectinaria* to the first two somites.

Fam. AMPHARETIDÆ.

Ampharete gracilis, Malmgren.

Ampharete gracilis, Malmgren, *Nordiska Hafs-Annulater*, p. 365.

Dredged near Inchkeith, 29th October 1886; depth about 9 fathoms.

Specific Diagnosis.—Abdominal segments, 13. Palmula composed of 12 to 14 setæ, very slender, attenuated at extremity. Branchiæ filiform, attenuated at end, long, unequal; anterior longer than the posterior. Uncini 5–6 dentate. Anal somite crenulated at apex, without cirri.

Length of our specimen, 30 mm.

Analysing the somites here, as usual, we have cephalic—præoral lobe and buccal somite. Branchial—3, the 1st bearing palmulæ=modified notopodial fascicle, and 4 branchiæ on each side, the other two bearing only notopodial fascicles. Thoracic—12, each bearing notopodial fascicle borne on tubercle, and transverse uncinigerous torus, with 5–6 dentate uncini. Abdominal—13 with uncinigerous torus=neuropodium only, + anal segment without cirri (*vide* Pl. XLII. figs. 21 to 21 c).

Genus *Melinna*.

M. Sars, in describing *Sabellides cristata* (*Fauna Littoralis Norvegiæ*, ii. p. 19), says that it perhaps deserves to be placed in a separate genus, but decides provisionally to retain it under *Sabellides*. MALMGREN made the separation suggested by Sars, and instituted the genus *Melinna* (*Nordiska Hafs-Annulater*, p. 371), of which he gives the following diagnosis (in Latin):—Præstomium smooth, without elevated frontal part, with anterior margin transverse. Buccal segment produced into a ventral lip equal in length to the

præstomium. Palmulæ wanting. Branchiæ filiform, 4 on each side. A single small spine in form of a hook, curved backwards, on each side behind the insertion of the branchiæ. The three anterior setigerous somites coalesced, forming as it were a sheath, free in front, aduate behind, inferiorly and laterally surrounding the oral and branchiferous region. 4th setigerous somite furnished dorsally with a membranous crest, which is equally denticulated on its anterior edge. Fascicles of capillary setæ present in 18 segments, the 3 anterior without a tubercle, 15 following furnished with a subcylindrical tubercle. Uncinigerous pinnulæ commencing from the 4th setigerous segment, and present up to the end of the body. A minute subconical papilla above the uncinigerous pinnula in the segments of the posterior part of the body, which are destitute of capillary setæ. Capillary setæ slightly curved, winged (limbatæ). Uncini pectiniform, subtriangular, with rounded angles, about 4 teeth.

Melinna cristata (Sars), Malmgren.

Sabellides cristata, Sars, Fauna Littoralis Norvegiæ, ii. p. 19.

Melinna cristata, Malmgren, Nordiska Hafs-Annulater, Svensk. Akad. Forh., 1885; M'Intosh, Fauna of St Andrews.

Dredged north of Inchkeith; also on Middle Bank opposite Granton, 6 fathoms, August 1886. M'INTOSH at St Andrews records it merely as frequent in the stomachs of cod.

Examination of this species has shown that neither the description of SARS nor that of MALMGREN is rigidly correct. From its external characters the body may be divided into 5 regions—(1) the cephalic, including the buccal somite; (2) the branchial; (3) the thoracic; (4) the abdominal.

The cephalic region is composed of the præstomium and buccal somite. The præstomium is but slightly developed; from it spring a number of filiform tentacles which can be withdrawn into the mouth, a condition they usually retain in spirit specimens.

The branchial region consists of 4 somites, not 3, as MALMGREN and SARS believed; these somites form a collar. A ridge projects from the anterior part of the 2nd somite ventrally, and is continued laterally on each side as far as the posterior boundary of the 4th somite. Between the lateral ridges is a deep dorsal depression, from the bottom of which the branchiæ, 4 on each side, arise. The branchiæ are filiform, but thicker than the tentacles; they belong to the 2nd and 3rd somites, or to one of these. Posteriorly the dorsal depression is bounded by a denticulated transverse ridge which projects from the dorsum of the 5th setigerous somite. The 4th setigerous somite bears, immediately ventral to the edge of the ridge, a fascicle of long notopodial setæ, and a single series of neuropodial short setæ. Between the notopodium and the

neuropodium is a short space. On the 3rd setigerous somite there are similar setæ, but there is no interval between the notopodium and neuropodium. In the first two setigerous somites the notopodial and neuropodial setæ form a single series, and the former only differ from the latter by being slightly thinner and longer, and in colour; the neuropodial setæ are coloured brownish-yellow, the notopodial are colourless. MALMGREN states that the pinnulæ uncinigeræ are absent in the three anterior somites; but, as we have shown above, their homologues are present. SARS also believed the ventral branch of the feet to be entirely wanting in the first three somites. The neuropodial setæ of the branchial region are not uncini, they are simple short bristles cylindrical in shape, and of uniform thickness nearly to the end, terminating in a short transparent slender point. The end of the thick part is strongly pigmented, having a brownish-yellow colour.

The strong curved hook behind the origin of the branchiæ is probably a chæta of the 2nd notopodium specialised.

The thoracic region consists of 14 somites, each of which is provided with a notopodium and a neuropodium. The notopodium consists of a small fascicle of capillary setæ, each having a terminal winged blade (fig. 22 D). The setæ are of two lengths, some projecting far from the body, others much shorter, only the blade emerging. The fascicle is borne by a small tubercle flattened antero-posteriorly. The neuropodium consists of a single series of 4-toothed uncini, borne on a transverse "torus."

The abdomen includes the rest of the body, and comprises about 42 somites. This region is distinguished by the entire absence of the notopodial setæ, though the notopodial tubercle is recognisable in the first few somites. The uncini, borne on a torus which diminishes in size towards the posterior end, are present in all the somites.

Fam. TEREBELLIDÆ.

Subf. AMPHITRITINÆ.

Amphitrite Johnstoni (Malmgren).

Amphitrite figulus, Dalyell, Powers of the Creator; M'Intosh, Fauna of St Andrews.

Terebella nebulosa, Johnston, Brit. Mus. Cat.

Amphitrite Johnstoni, Malmgren, Nordiska Hafs-Annulater, p. 377.

With regard to JOHNSTON'S synonym, it is to be remarked that his description applies to the species here in question, but according to MALMGREN some of the British Museum specimens catalogued by JOHNSTON as of this species really belong to *Thelepus circinnata*.

In this species there are 90 to 100 somites. The prostomium bears a large

number of long simple filamentous tentacles. The prostomium has two prominent margins, one anterior and the other posterior, and on the surface between these the tentacles arise. On each side the prostomium runs out into a lappet or lobe, which increases the tentaculiferous surface. Next follows the buccal somite, which is well developed, but not otherwise remarkable. Then follow three somites, each bearing a pair of branchiæ. The branchiæ consists of a number of branches arising from a short, rather thick stem, which is directed forwards, and bears the branches on its posterior surface, and each branch immediately divides into two or more filaments, which are somewhat long, and are spirally curled, especially when contracted; the whole forms a large bushy plume or brush. The first notopodial fascicle of chætæ is borne on the 3rd branchiferous somite. There are 24 pairs of notopodial fascicles; behind the 26th post-buccal somite they are absent: in one specimen, however, a single fascicle was present on one side on the 27th post-buccal somite. The chætæ have a peculiar point or blade: there is a well-developed pair of lateral wings which extend to a short distance from the end, the rest of the blade being slightly curved and minutely denticulated on the concave side. The series of tori uncinigeri begins at the 4th post-buccal somite, and extends throughout the body, the posterior ones becoming shorter and much more prominent. The uncinus is short, and provided with tendons: it has 3 or 4 minute teeth on the outer edge of a single large one. On the ventral surface of each of the first 14 post-buccal somites, there is a single median "scutum ventrale," of which the last is small and rudimentary: the others occupy the whole ventral region of the somite between the ventral ends of the neuropodial tori (Pl. XLIII. fig. 23, 23 A, 23 B).

Habits.—Common between tide marks among Laminarian roots and under stones: it lives in mud, and does not form a very perfect tube; the mud in its immediate vicinity is merely glued together by the secretion of the worm's body to form a case. The worm reaches a considerable size, some of our specimens being over 15 cm. long and 12 mm. broad in the anterior part. MALMGREN also gives these as the maximum dimensions. Specially fine specimens are abundant on the shore at Joppa.

Anatomy.—There are 15 to 17 pairs of nephridia in the first 15 to 17 post-buccal somites. As in *Trophonia*, there are median vertical vessels passing from the ventral vessel to the intestine. In the anterior portion of the body the dorsal vessel is represented only by a perienteric sinus, which is most developed on the ventral side of the intestine, but at the extreme anterior end this sinus opens into a free dorsal contractile vessel forming a heart. This heart contains a cellular cardiac body, as in *Trophonia* (*vide* Pl. XLIII. fig. 23 c).

Amphitrite cirrata, Müller.

Terebella cirrata, Montagu, in Linn Trans., xii. p. 342; Johnston, Cat. Brit. Mus.; Leuckart, Archiv f. Naturges., i. 1849.

Amphitrite cirrata, Müller, Prodr. Zool. Dan.; Malmgren, Nordiska Hafs-Annulater, p. 375.

Two or three specimens obtained in the dredge on one occasion, on the Röst, north of Inchkeith, October 29, 1886.

Specific Diagnosis.—Chætiferous tubercles in 17 segments. Prostomium behind the tentacles without lateral lobes. Branchia with very short stem, from which spring a number of elongated filaments nearly equal in length, and spirally curled. A minute conical papilla in six segments, the 3rd chætiferous to the 9th. Ventral scutes, 10 in number, rectangular in shape; tube of mud or clay (Pl. XLIII. fig. 24).

Terebella Danielsseni, Malmgren.

T. Danielsseni, Mgn., Nordiska Hafs-Annulater; Stockholm Forhandlingar, 1865.

Specific Characters.—Segments short; branchiæ flabelliform, decreasing much in size posteriorly, branching dichotomously from a short stem; ultimate twigs very short. Two secondary teeth on the uncinus, one distinct the other minute; the manubrium of the uncinus with an entire curved outline at the corner beneath the teeth (*vide* Pl. XLIII. fig. 25).

Middle Bank, opposite Granton, 6 fathoms, August 11, 1886; only one specimen dredged.

Genus *Lanice*, Malmgren, 1865.

The points which distinguish this genus from *Terebella* are not very marked. Both have 17 pairs of notopodial fascicles; both have 3 pairs of arborescent branchiæ: the principal difference is the shape of the buccal somite, which in *Lanice* is produced anteriorly so as to form a large under lip, which is absent in *Terebella*. Eye spots are present in *Terebella*, absent in *Lanice*. In *Lanice* the 2nd post-buccal somite has a large vertical lobe on each side, and the glandular scuta ventralia form a continuous area, of a bright red colour in the living animal, instead of forming a metameric series.

Lanice conchilega, Mgn. (Pallas).

Nereis conchilega, Pallas, Misc. Zool., p. 131.

Terebella conchilega, Savigny, Syst. Annel.; Johnston, Brit. Mus. Cat.

Terebella littoralis seu arenaria, The Sand Mason, Dalyell, Powers of the Creator.

Lanice conchilega, Malmgren, Nord. Hafs-Annulater, p. 380; M'Intosh, Fauna of St Andrews.

Only one species of the genus is known, and it would be better to dismiss the genus and call the species *Terebella conchilega*. JOHNSTON, in his description of *T. conchilega*, does not mention the fringes at the mouth of the tube; but his original is *Nereis conchilega*, Pallas, which is undoubtedly this species, as the following quotation from the *Miscellanea Zoologica* will show:—"Subtus tænia prominens plana, pulchre rubra ad caput rotundato initio incipit, ultraque mediam corporis longitudinem producta, angustatur, tandemque evanescit. Caput animalis squamis quatuor planiusculis carnosis munitum est; quarum binæ majores contiguæ semiovatæ; exteriorque ad latera utrinque una cui setæ dorsales primi paris respondent." Johnston's *T. littoralis* is simply Dalyell's *T. littoralis seu arenaria*; and although the latter counted only 16 fascicles of chætæ, he mentions a "broad, taper, smooth, velvet bright carmine stripe along the belly between a transverse row of ellipses," which proves that his Sand Mason is our *Lanice conchilega*. Dalyell also mentions the fringe of branched filaments, made of particles of sand, round the mouth of the tube which the worm inhabits: he says this fringe occurs at both ends of the tube, but this must be a mistake.

Habits.—The tube is made of particles of sand, and at Granton we have always found it buried vertically in sand, with only an inch or so protruding above the surface. The tube is very long, and as the animal is always at the deep end of it, careful digging is required to extract it uninjured. The filaments of the fringe are hollow, and when the head of the worm is protruded the tentacles are partially contained in them, and so protected. The projecting part of the tube, with its tuft of tubules, has a very characteristic appearance on a sandy shore, and there are probably few sandy shores on the coast of Europe where these tufts are not to be seen. The worm also occurs to some distance beyond low-water mark (*vide* Pl. XLIII. fig. 26).

For an account of the nephridia, which in this species form a continuous tube on each side by coalescence, see a paper "On some Points in the Anatomy of Polychæta," by J. T. Cunningham, *Quart. Jour. Micr. Sci.*, 1887.

Scione maculata (Dalyell).

Terebella maculata, Johnston, Cat. Brit. Mus., p. 240; Dalyell, Pow. Creator, ii. p. 203.

We have placed this species in MALMGREN'S genus *Scione*, because it has 16 pairs of setigerous tubercles, and only one pair of branchiæ. Our specimens agree closely with MALMGREN'S *Scione lobata*, but that in ours there are numerous ocelli behind the tentacles, while MALMGREN'S generic diagnosis includes the words "oculi nulli." The species agrees with *lobata*, in having a lateral semicircular lobe projecting on each side from the 3rd somite, the one immediately behind the branchiferous. These lobes are evidently the "pair of short, obtuse, pellucid stumps not distinguished by obvious peculiarities," mentioned by DALYELL. We have no doubt that our specimens are of the species *Terebella maculata* as described by DALYELL, and it is extremely probable that that species is really a synonym of *Scione lobata*, Malmgren. The chætæ are limbate, with an entire point; the uncinus has two secondary teeth above the principal one. The tentacula are few in number, and in the living animal spotted. Round the anus are 6 or 7 conical papillæ (Pl. XLIV. fig. 27).

Habits.—We dredged several specimens, Nov. 11, 1886, on the Röst, north of Inchkeith, in 7 or 8 fathoms; bottom, shells, stones, and black muddy sand.

Genus *Thelepus*, Malmgren (R. Leuckart, 1849).

The two distinguishing features of this genus, as defined by MALMGREN, are the presence of fascicles of capillary setæ throughout the whole length of the body, and the presence of numerous filiform branchiæ, arising separately in a transverse series on each side, in two of the anterior somites.

The genus was named by R. LEUCKART (*Arch. f. Naturges.*, xv. 1), who founded it on a fragment containing only a few of the posterior segments of a single specimen. LEUCKART believed his specimen to form both a new species and a new genus. MALMGREN retained the generic name, but identified the characters of the species with those given by previous authors, under other names.

Thelepus circinnata, Malmgren (Fabr.).

Amphitrite circinnata, Fabr., Fauna Groenl., p. 286.

Terebella conchilega, Dalyell, Pow. Creator.

Thelepus circinnata, Mgn., Nordiska Hafs-Annulater.

Thelepus circinnatus, M'Intosh, Fauna of St Andrews; Leslie and Herdman, Inv. Fauna of the Firth of Forth.

Venusia punctata, Johnston, Cat. Brit. Mus.

Specific Diagnosis.—That of the genus.

Description.—The filiform branchiæ are borne on the first two somites

behind the buccal; the first of these has no chætæ of any kind; fascicles of capillary chætæ are present on all the somites, from the 2nd branchiferous to the end of the body. Uncinigerous tori are present from the 3rd chætiferous somite to the end of the body. The uncini have 2 teeth. Behind the series of tentacles, on a narrow transverse band, bordered by two ridges, are numerous ocelli. The dorsal surface of the animal is uniformly marked with clear oily-looking spots. Glandular scuta ventralia, one on each of the first 16 somites. The tube is slightly sinuous, flexible. It is formed of a thin transparent membrane resembling mica, which is covered externally with pieces of shell, small stones, fragments of Polyzoa, &c.

Habits.—We took it in the dredge off Anstruther, and obtained it also from fishermen's lines, worked 50 miles E. by S. from the May Island; depth about 30 fathoms. It is rather a deep-water form, not found between tide marks, though JOHNSTON says it is very common in the coralline region. According to MALMGREN, it is common on the arctic and northern shores of Europe, and extends as far south as the Mediterranean, ranging from 3 to 250 fathoms in depth.

Subf. POLYCIRRINÆ.

No branchiæ.

Ereutho Smitti, Malmgren.

Ereutho Smitti, Malmgn., Nordiska Hafs-Annulater, p. 391.

Polycirrus Smitti, M'Intosh, Fauna of St Andrews.

We have identified this form from MALMGREN'S diagnosis; GRUBE'S genus *Polycirrus* has fasciculi of capillary setæ on 40 of the anterior segments; the genus *Ereutho*, as defined by MALMGREN, on only 13. MALMGREN gives the following analysis of the Subf. Polycirridea:—

Uncini nulli. Fasciculi setarum	in 6 segmentis,	Lysilla, Malm.
Uncini hamati. Fasciculi setarum capillarium,	in 13 segmentis,	Ereutho, Malm.
	in 19 to 22 segmentis,	Leucariste, Malm.
	in 40 seg. vel ultra,	Polycirrus, Gr.

Uncini elongati, sublineares aciculiformes. Fasciculi setarum in 10 segmentis, Amæa, Malm.

Habits.—Not uncommon, frequently found in holes among roots of *Laminaria*, also under stones in the littoral zone, dredged occasionally on the middle bank, in 5 to 7 fathoms. It lives in holes in mud, sand, or debris, and does not form a separate tube for itself.

The prostomium forms a considerable tongue-shaped projection, which bears along its dorsal edge the numerous simple flexible tentacula: the buccal somite is not conspicuous. There is a single ventral scuta behind the mouth, corresponding to the buccal and 1st setigerous somite: behind this are 8 pairs of scutes belonging to somites 2 to 9.

One of the most peculiar features of the genus is the entire absence of uncini or uncinigerous tori, that is of neuropodial elements, in the 13 somites which bear the capillary setæ. Behind the 13th somite, small uncinigerous tori only are present: the uncini are small, uniserial, with two small teeth on the dorsal end.

This worm is of yellowish-white colour when alive, and is somewhat transparent. It writhes when placed in clean water into complicated contortions. The anterior region is swollen, the rest of the body cylindrical.

Subf. CANEPHORIDEA.

One branchia divided distally into 4 comb-like processes.

Terebellides Strœmi, Sars.

Terebellides Strœmi, Sars., Beskriv. og Jakttag., p. 48; Malmgren, Nordiska Hafs-Annulater, p. 396; M'Intosh, Fauna of St Andrews.

Dredged 1 mile from Isle of May; N.W. of Inchkeith, 13 to 16 fathoms, on muddy ground. We have never found the species on the shore. It is evidently restricted to muddy ground at depths of over 10 fathoms. M'INTOSH found large specimens in stomachs of cod and haddock. MALMGREN gives as its distribution Spitzbergen, Greenland, Iceland, Scandinavia, Britain, Baltic Sea, and, according to GRUBE, the Adriatic Sea, on muddy ground, 10 to 250 fathoms depth, everywhere rather abundant.

This form is peculiar among the Terebellidæ; it is the only species of the genus, and MALMGREN places the genus by itself in a separate subfamily, the Canephoridea.

The prostomium is membranous and flexible, the edge being sinuously plicate, and bearing the numerous short thin tentacles at its edge dorsally. The ventral part of the buccal somite is enlarged, and the dorsal contracted, so that the mouth is thrown to the dorsal side, and the end of the body appears truncated. The ventral part of the buccal somite carries a transverse membranous projection or crest. There is one single branchia attached to the 1st setigerous somite; the structure of this is unlike that of any other branchiæ in the family. It consists of a peduncle transversely flattened, which bears four pectiniform processes, in two pairs, the anterior pair being much larger than the posterior, and overlapping them. Each process is formed by a stem running backwards and bearing on its upper side a series of thin laminae semicircular in shape. The laminae are placed transversely to the axis of the stem and to the longitudinal axis of the worm, and are so closely crowded together that the branchia seems, on a cursory examination, solid. The stem of the posterior pectinate process is of a conspicuous opaque white colour. There are notopodial

fascicles of capillary setæ in 18 somites, commencing with the somite behind the buccal. These setæ are almost straight, with a very long attenuated extremity, winged. From the 6th setigerous somite to the 18th the neuropodial element is an uncinigerous torus, bearing uncini in a single series: these uncini have a long handle or manubrium inserted in a socket in the torus. Behind the 18th somite the notopodial element is wanting; the neuropodial is a flat pinnula provided with uncini of the typical kind, *i.e.*, pectiniform and short, with three or four teeth (*vide* Pl. XLIV. fig. 29).

Anatomy.—There is but one pair of nephridia, situated in the first chæterous somite.

Larva belonging to the Terebellidæ.

In fig. 30 is shown the appearance under the microscope of a pelagic larva obtained by the tow-net near shore at Granton, and believed by us to belong to some species of the family Terebellidæ. This larva was contained in a transparent tube, evidently secreted by itself; it is not an uncommon thing for the larvæ of tubicolous forms, even when leading a pelagic existence, to be provided with tubes. The intestine in this particular specimen is slightly convoluted, a point in which the larva differs from any adult Terebellid. Larval tentacles are growing from the prostomium, and there are a pair of otocysts behind the anterior end, probably closely connected with the œsophageal nerve commissures. Anteriorly the somites are provided with fascicles of acicular chætæ; but on the posterior half there are curious thin knobbed processes, a larval form of parapodia, which we have not further investigated. The whole larva was very transparent.

Fam. SABELLIDÆ = SABELLACEA, Malmgren.

The Sabellidæ were separated from the Serpulidæ by MALMGREN: the distinguishing characters are as follows:—Body almost cylindrical, or but slightly depressed, straight, pointed at the posterior end, consisting of two parts—an interior of few (5 to 12) somites, in which the tori uncinigeri are ventral, and the fascicles of capillary chætæ dorsal, and the rest of the body in which the tori uncinigeri are dorsal and the fascicles of capillary chætæ ventral. In the posterior part there is a ventral longitudinal sulcus, sometimes continued on to the dorsum of the anterior part. The first segment has a collar. The branchiæ are long straight filaments, in two groups, those of each coadnate at the base; each filament being provided interiorly with a double series of short thin processes; exteriorly the branchial filaments are usually naked, but sometimes provided with eye-spots, or short spatulate processes. Tube of the animal straight, cylindrical, membranous, usually coated with black mud, sometimes with grains of sand or other particles.

Sabella, Lin.

Ventricular sulcus not continued on to the dorsum of the thoracic region. Collar narrow, divided, with widely separated projecting corners dorsally, and reflected ventral lobes. Fascicles of capillary chætæ commencing on the collar somite, tori uncinigeri on the somite next to the collar. Uncini of the anterior region in double series, of two forms, one avicular the other cuspidate (Pl. XLIV. fig. 31 D). Branchiæ connected only at the base, dorsal appendages none, ocular spots sometimes present. Two tentacles, shorter than, and underneath the branchiæ.

Sabella pavonia, Sav.

Sabella penicillus, Lin., Syst. Nat., xii. p. 1269 (excl. syn. Rond., Ellis, et Syst. Nat., x.).

Amphitrite penicillus, Lam., Hist. Nat. Anim. s. Vert., 1818, v. (excl. syn. Fabr. et Brug.).

Sabella pavonia, Savigny, Syst. des Annél. Desc. de l'Égypte, 2nd. edit., 1826, xxi.; Malmgren, Nordiska Hafs-Annulater; M'Intosh, Fauna of St Andrews.

Specific Characters.—Size large, 12 to 15 inches in length. Segments of thoracic region 8 to 12. (In our figure 31 A, Pl. XLIV., the number shown, 15, is incorrect.) Branchiæ 35 to 45 on each side, long, thin flexible; no ocular spots; white, with minute purple spots or bands at equal distances. Two grooved tentacles, $\frac{1}{4}$ th or somewhat more than $\frac{1}{4}$ th the length of the branchiæ.

Habits.—Tube always covered densely with fine black mud, and usually enclosed in a colony of *Alcyonium digitatum*, which has usually a smooth surface without digitate processes. We obtained it not very frequently from haddock lines worked in about 30 fathoms, off the mouth of the Firth of Forth, the hooks catching easily in the coating of Alcyonium. The coating of Alcyonium shows that the tube projects far from the surface of the sea bottom.

Figs. 31 B, 31 C, show longer and shorter capillary chætæ from the thoracic region; figs. 31 D, the two forms of uncini.

Laonome Kröyeri, Malmgren.

Laonome Kröyeri, Malmgren, Nordiska Hafs-Annulater, p. 400.

One specimen got in dredge on Middle Bank, October 29, 1886.

Genus *Chone*, Kröyer.

Described by MALMGREN as follows:—Body somewhat round, sublinear, pointed posteriorly, with the abdominal furrow very conspicuous, and continued on to the dorsum of the anterior part of the body; anus terminal; no ventral cleft; somites divided into two by a transverse furrow. Collar adpressed to the

branchiæ, divided into two parts dorsally, entire, without ventral or lateral incisions. Anterior part of the body composed of eight somites. No ventral scutes. Setigerous tubercles beginning from the collar somite, with setæ of two forms in the anterior part of the body, the longer form bordered, the apex much attenuated and slightly curved; the shorter form, subspatulate, the apex shortly mucronate, unequally bordered on both sides, one margin having a much broader border than the other; in the posterior part of the body all the capillary setæ of the same form, with a narrow border, and the apex long and tapered. Uncinigerous tori beginning from the second setigerous somite with a single row of uncini, in the anterior part of the body, beaked, with a somewhat elongated manubrium, and the vertex of the rostrum subserrulate, but in the posterior part of the body they are short and avicular. Branchiæ forming a semicircle on each side, connected by membrane for more than half their length; their apices free, bordered on each side, with no dorsal appendages nor eye spots. Tentacular cirri round, filiform, unequal, many on each side.

Chone infundibuliformis, Krøyer.

Tubularia penicillus, Fabricius, Fauna Grœnl., p. 438.

Chone infundibuliformis, Krøyer, Om. Sabellerne, Danske Vid. Selsk. Forh., 1856, p. 33; Malmgren, Nordiska Hafs-Annulater, p. 404.

On the Röst and North Channel, north of Inchkeith, 1st November 1886; also west of Oxcars, November 1884.

The specific characters as given by MALMGREN are as follows:—Body of 50 to 80 somites, the breadth equal to a twelfth or eighth part of the length. Collar moderately produced, of equal height on both sides; anterior margin entire, running down into a vertical sinus, and divided by a deep dorsal furrow, linear and not gaping. Branchiæ having their free apex of moderate length, and entirely enclosed in a leaf-like bordering membrane. Colour in spirit entirely white; branchiæ in most living animals intensely purple, especially towards the apex, either all of one colour or spotted with yellowish-white; in the smaller specimens, the branchiæ paler red, spotted with white or pale yellow. It inhabits a tube of yellowish membrane, covered with a coat of sand externally, fixed to stones, or often to Ascidians. Length 15 to 18 mm., breadth 1·7 to 6·5 mm.; length of branchiæ may reach 27 mm. (Pl. XLIV. fig. 32).

Genus *Amphicora*, Ehrenberg (1836).

Fabricia, Blainville (1828), Leuckart, Claparède.

Othonia, Johnston (1834), Gosse.

The characters of this genus are as follows:—Body of 13 somites, the

first nine of which belong to the thorax, and the last four to the abdomen. All are setigerous except the first and last. In the thorax the notopodial setæ are capillary, and the neuropodial setæ unciniate. In the abdomen the arrangement is reversed, the notopodial setæ being unciniate, and the neuropodial setæ capillary. Branchiæ with three branches in each tuft. Eye spots two, towards the sides of the first somite. A large labium or under lip bounds the mouth ventrally. Last somite closely united with that which precedes it, with a sort of post-anal lobe projecting backwards dorsally to the anus, and bearing two eye spots. Capillary setæ limbed on one side, curved, and much drawn out at the tip. Uncini with a long curved manubrium, and several teeth on the vertex.

Amphicora Fabricia (Müll.).

Tubularia Fabricia, Prodr., Z. Danicæ, n. 3066.

Othonia Fabricia, Johnston, Cat. Brit. Mus.

Amphicora sabella, Ehrenberg, Mitth. Ges. Nat. Freunde in Berlin, 1866, p. 2 (Heligoland).

Amphicora Fabricia, Malmgren, Annulata Polychæta, p. 225; M'Intosh, Fauna of St Andrews.

Fabricia quadripunctata, Claparède, Etudes Anat. Annel. Turbel. etc. in Mém. Soc. Phys. et Hist. Nat. Geneve, xvi. 1.

Occurs abundantly on the roots of Fuci growing on shale rocks at Granton. Colour reddish, length three or four lines. Inhabits a slender tube of mud two or three times the length of its body. When a few of these tubes are teased up in a watch-glass the minute worms come crawling out, wriggling along very actively, and moving usually tail first. This is the more curious, when we observe the post-anal lobe and eye spots described on the last somite.

Fam. ERIOGRAPHIDEA, Malmgren.

Genus *Myxicola* (Koch), Grube.

Arippasa, Johnston, Cat. Brit. Mus.

Eriographis, Grube, Fam. d. Annel.

Is described by MALMGREN as follows:—Body round, somewhat thick, giving off a quantity of mucus; somewhat attenuated towards each end, more so posteriorly than anteriorly; anus terminal; collar none. First somite produced inferiorly into a very short triangular acuminate process, pointing forward. Ventral furrow not conspicuous, but continued into the dorsum of the anterior part of the body. Anterior part of the body composed of eight somites, with slender capillary setæ with a narrow limb, and a few elongated uncini, with sub-rostrate apex beneath the minute fascicles of setæ. Posterior part

of body of numerous subannular somites, with fascicles of setæ disappearing and very small uncini very shortly hooked, with a much elongated tooth on the vertex, very numerous, and forming a transverse series from the dorsum round the ventral surface, both above and below the fascicle of setæ. Branchiæ forming a semicircle on each side, almost completely connected by membrane; rays filiform, disposed in two rows internally. Eyes none. Two very short broad compressed rounded tentacles surrounding the mouth on each side.

Myxicola Steenstrupi, Kröyer.

Myxicola Steenstrupi, Kröyer, Dansk. Vid. Selsk. Forh., 1856, p. 17.

Myxicola Sarsi, Kröyer, *loc. cit.*, p. 9; Sars, Christiania Vid. Selsk. Forh., 1861, p. 130.

Myxicola Steenstrupi, Malmgren, Nordiska Hafs-Annulater, p. 409.

Arippasa infundibulum, Johnston, Cat. Brit. Mus.

This species is not mentioned by M'INTOSH in his Fauna of St Andrews. We have dredged it on the Middle Bank on shelly ground on several occasions.

MALMGREN describes the specific characters as follows:—"Body of 45 to 70 somites, in the posterior part more or less distinctly biannulate, short in middle of body, length equalling a fifth to a seventh part of the breadth. Branchiæ with from 15 to 22 branches on each side, equalling or slightly surpassing a third part of the length of the body, with apex naked, involuted, tapered, edged by membrane, almost equalling a fourth part of the length of the branchiæ; radii of moderate length, very thin, tapered, nearly flexible." Colour dull greenish, branchiæ tinged with purple, especially towards the tips. Always found enveloped in transparent mucous.

Fam. SERPULIDÆ, Malmgren.

We have not minutely studied either the literature or the animals in this family, but we believe the following account to be correct.

Gen. *Serpula*, Lin., Philippi.

Serpula vermicularis, Linn.

Serpula vermicularis, Linn., S. N., xii. p. 1266; Malmgren, Annulata Polychæta, p. 228; M'Intosh, Fauna of St Andrews.

Common in deep water.

Genus *Filigrana* (Oken).

Branchiæ with eight branches, two of which are expanded at their extremity, and obliquely truncated, so as to form opercula. Tubes calcareous, very slender, and adhering together in masses.

Filigrana implexa, Berkeley.

Filigrana implexa, Berkeley, Zool. Journ., v. p. 427; Sars, Faun. Litt. Norv., i. p. 86; Malmgren, Annulata Polych.; M'Intosh, Fauna of St Andrews.

Protula Dysteri, Huxley, Anatomy of Invertebrates, 1871.

A large mass of the tubes of this species was obtained from Newhaven fishermen; it was brought up on haddock lines, some distance outside the May. We dredged a number of masses of the tubes, with the worm living within them, on the Röst, November 1, 1886.

JOHNSTON mentions no specimens of Huxley's *Protula Dysteri*, the description of which he quotes, and there is nothing in that description to differentiate the worm from *Filigrana implexa*, of which JOHNSTON gives the characters from his own examination of specimens from Devonshire. Our identification of the two names is made on the authority of Professor M'INTOSH. Our figure of the larva was taken from some which were found among living specimens of the worm (Pl. XLV. fig. 35).

Genus *Pomatocerus* (Phil.).

Branchiæ with many branches in each tuft; opercular tentacle thick, with two processes near the upper end. Tube entirely adherent, white, with a distinct keel on its upper surface, and a spine over the aperture.

Pomatocerus triqueter, L. Mörch.

Serpula triquetra, Sars, Reise, 1849; Danielssen, Reise, 1857.

Pomatocerus triqueter, Mörch, Revisio critica Serpulidarum Natur. Tidskr., 3 R. 1 B., 1863; Malmgren, Ann. Polych.; M'Intosh, Fauna of St Andrews.

Vermilia triquetra?, Philippi, in Ann. and Mag. Nat. Hist., xiv. 156, pl. iii. f. F.; Grube, Fam. Annel., 92.

Serpula conica, Johnston, Cat. of Worms in British Museum.

Very abundant everywhere, attached to rocks, stones, and shells.

Colour deep rich blue on the thorax, abdomen red in the females, and whitish in the males when sexually mature; branchiæ barred, and spotted with deep brown, blue, orange, white, and sometimes red. The distribution of the colour is subject to considerable variation. Capillary setæ in thorax curved, limbed, and finely pointed; those of the abdomen with the limb immensely expanded on one side, and serrated; uncini with ten points, and the manubrium all but obsolete (Pl. XLV. fig. 36).

Spirorbis borealis, Mörch.

Serpula spirorbis, Linn, S. N., xii. p. 1265; Müller, Prodr. Z. D., p. 236.

Spirorbis borealis, Mörch, Naturh. Tidskr., 3 R. 1 B., 1863; Malmgren, Annulata Polychæta; M'Intosh, Fauna of St Andrews.

Common on Fuci on the shore. Very common on *Fucus serratus* at Dunbar. We found it there breeding freely at the beginning of June. The ova form a cylindrical cord, consisting of two or more linear series, and lying beneath the animal in the tube, not in the operculum. The embryos were well advanced in development before hatching (Pls. XLV. and XLVI. fig. 37).

Spirorbis lucidus (Mont.), Mörch.

Serpula porrecta and *spirillum*, Fabr., F. Gr., p. 378.

Serpula spirillum, Müller, Prodr. Z. D., p. 236.

Spirorbis lucidus, Mörch, Malmgren and M'Intosh, *loc. cit.*

Common on hydroids dredged in the Firth (Pl. XLV. fig. 38).

Fam. CHLORHÆMIDÆ.

Trophonia plumosa, Johnston, (Müll.).

Amphitrite plumosa, Müller, Prodr. Z. D. n. 2621, p. 216.

Trophonia plumosa, Johnston, Cat. Brit. Mus.; Malmgren, Annulata Polychæta; M'Intosh, Fauna of St Andrews.

Common in the mud among Laminarian roots, also under stones in the Laminarian zone.

The pseudhæmal system consists of a dorsal and a ventral longitudinal vessel, united by a pair of lateral commissures for each somite. The posterior portion of the intestine receives its blood supply by vessels passing vertically upwards from the ventral longitudinal trunk. The long backward loop is supplied by two trunks arising one behind the other from the ventral longitudinal vessel, in about the 9th and 10th somites; from these the fluid finds its way into a series of lacunar spaces in the intestinal wall, through which it passes forward to flow into a large heart placed over the œsophagus. The heart is somewhat pyriform, being thicker at its posterior end, where it receives the blood from the intestine, and tapering anteriorly, where it divides into two trunks just behind the cerebral ganglion. These give off vessels to supply the branchiæ. The dorsal longitudinal vessel opens into the heart about the middle of its length.

The above account differs very much from that given by HORST (*Zool. Anz.*, viii. p. 12), who from what he saw in transverse sections of *Bryda*, concluded that in Chlorhæmidæ the only representative of a free dorsal vessel was the

heart of the anterior region, the dorsal vessel of other annelids being represented by the blood-sinus in the wall of the intestine. HORST, therefore, asserted that the Chlorhæmidæ possessed the same relations in the pseudhæmal vessel as the Enchytræidæ according to the researches of VEJDOVSKY. The view which seems to us the true one to take of the condition of things found in Trophonia is as follows:—Behind the loop of the intestine there is a series of vessels passing from the intestinal walls to the dorsal trunk. The dorsal vessel is to be regarded as continued by that part of the heart which is in front of the point where the dorsal vessel joins it. The part behind this represents (enormously enlarged) simply the vessels connecting the looped part of the intestine with the dorsal vessel. It is probable that the loop of the intestine corresponds to just two somites, for there are two vessels passing from the ventral vessel to the loop: the posterior part of the heart corresponds to two corresponding dorsal communicating vessels.

The meaning of the glandular body contained in the heart is difficult to surmise. HORST considers it to have been originally derived from the intestinal epithelium. We have found that in the adult Trophonia the cardiac body is entirely separate from the intestine, although at the posterior end of the heart the glandular body and the intestinal body-wall are in extremely close contact. The continuity of the blood-sinuses in the intestinal wall with those of the heart is obvious enough in sections. The minute structure of the cardiac body is closely similar to that of a nephridium. The whole organ or gland consists of a number of tubes having for the most part a longitudinal direction; some of these tubes have a lumen, the walls being lined with transparent nucleated cells containing granules, while in other tubes similar cells completely fill the cavity. (See Cunningham, "Some Points in the Anatomy of Polychæta," *Quart. Jour. Micr. Sci.*, 1887.)

There is only a single pair of nephridia placed longitudinally in the head. They extend posteriorly as far as the 6th to 8th somite. In colour they are yellowish green or white to the naked eye. They open anteriorly on the invaginated first somite at the side of the tentacles. We have not been able to discover any cœlomic opening or nephrostome.

When a piece of the nephridium is taken in the fresh condition and slightly teased in a drop of sea water, the whole structure of the glandular epithelium is beautifully seen. Scattered all over the field of the microscope are seen globular gelatinous-looking bodies, each with a slight globular concretion at its centre. In places a number of these gelatinous globules are seen united together: there are also spherical cells with delicate walls, each containing 10 or 12 of the globules. Again, there are a number of smaller cells, each containing several of the black concretions of smaller or larger size, and each cell bearing a single large cilium or flagellum, vibrating either very

rapidly or more slowly. There is usually only one cilium to a cell, but occasionally a cell is seen bearing two. These ciliated cells vary much in size, and the smaller ones are not spherical, but have an irregular outline. It is evident that these smallest cells, which are quite transparent, are almost entirely composed of unaltered protoplasm; even the smallest usually contain a single minute concretion. In the ciliated cells of moderate size it is seen that the substance containing the concretions is modified protoplasm, and it forms a separate spherical mass surrounded by a delicate layer of protoplasm which is continuous with the cilium. In the oldest and largest cells both cilium and protoplasm have disappeared, and nothing is left but a thin-walled vesicle containing a group of gelatinous globules, each with its concretionary nodule at the centre. These vesicles easily break up, and thus the gelatinous globules are scattered over the slide. The process of secretion then here consists in the successive evolution of minute protoplasmic ciliated cells into the large non-ciliated vesicles carrying concretions; the vesicles drop off in succession from the epithelium into the gland cavity, and so reach the exterior. A similar mode of secretion can be made out in the nephridia of all Chætopods, and also of Mollusca.

The ovaries in the female and testes in the male have similar positions and relations. There are in each sex four gonads in two pairs, lying on either side of the intestine. Each organ is a much elongated thick band or mass. In the natural condition all four organs are rolled up with the loop of the intestine into a smooth cylindrical mass, enclosed by a membrane. When the organs are disentangled the elongated form of the gonads is seen, and it becomes evident that they are free everywhere except at the anterior end, which is attached to one of the metameric transverse vessels of the body-wall. A single blood-vessel given off from the lateral vessel is seen running the whole length of the organ, and supplying it with capillaries. No efferent vessel was to be seen. The somites to which the gonads thus belong are the 7th and 8th setigerous. The ovaries have a bright green colour; the testes are pale yellow. The male specimens, as far as our observations go, are larger than the female. We have no clue as to the manner in which the generative products escape (Pl. XLVI. fig. 39).

Genus *Flabelligera*, Sars, 1829.

The distinguishing characters of the genus *Flabelligera* are the presence of a thick mucous sheath surrounding the body, and containing long, knobbed epidermic processes, and the large number (*circ.* 40) of branchial filaments on each side of the head. The usual single pair of ciliated tentacles are present, ventral to the branchiæ; these are much thicker than the branchiæ. The bristles of the 1st setigerous somite only are directed anteriorly, and being long

and numerous, form a kind of palisade round the head region, which is completely retractile. In the rest of the somites the dorsal fascicle contains only 4 or 5 bristles, which terminate in slender points: a number of the epidermic projecting cells, of a special form, surround the dorsal bristles, climbing up them, as CLAPARÈDE says, like a climbing plant up a tree, and terminating at the same level as the bristles.

Flabelligera affinis, Sars.

Flabelligera affinis, Sars, 1829, Bidrag til Söedyrenes Naturalh., i. p. 31;

Beskriv. og. Jakt., p. 47.

Siphonostomum vaginiferum, R. Leuckart, Arch. Naturg., xv. 1, p. 164.

Siphonostoma uncinata, Johnston, Cat. Brit. Mus., p. 223.

Flabelligera affinis, Malmgren, Annulata Polychæta, p. 193; M'Intosh, Fauna of St Andrews.

Dredged on Middle Bank in August 1886. Also found occasionally at Granton in the Laminarian zone under stones, at low water, spring tides.

It seems in the highest degree probable that the *S. diplochaites* described by CLAPARÈDE (*Chet. de Naples*, p. 369) is the same species as the present one; that the Mediterranean and northern forms are all of one species. That this is so is shown by comparing the synonymy given by MALMGREN (*Ann. Polyc.*) and CLAPARÈDE: both give *Chloræma Edwardsi*, Dujardin, as synonyms. MALMGREN gives *Siphonostoma uncinata*, Johnston, as a synonym: JOHNSTON and CLAPARÈDE both give *S. Edwardsi*, Grube (*Fam. Annel.*), as a synonym.

In *Siphonostomum* the arrangement of the pseudhæmal system is closely similar to that described in *Trophonia*, but there are some slight differences. The dorsal vessel is not so large, and is confined to the anterior part of the body. At the extreme posterior part of the body no distinct dorsal vessel is present; the transverse lateral vessels of the integument form a network. But the anterior part of the vessel, as in *Trophonia*, receives the lateral vessels of the integument, and the vessel joins the heart a short distance in front of its posterior end. Into this vessel, near its junction with the heart, open several median vessels, bringing blood from the lateral vessels of the integument in front of the junction.

In *Flabelligera affinis* there are 6 pairs of gonads, instead of 2 as in *Trophonia*. They have the same relations as in the latter genus; each is supplied by a central vessel from the ventral longitudinal trunk, and the longer posterior gonads are bound up together with the loop of the intestine into a cylindrical mass, by means of a thin confining membrane. As in *Trophonia*, the ovaries are green, the testes white.

The same bending of the intestine occurs as in *Trophonia*; the blood in the

sinus round the posteriorly directed limb of the loop passes backwards, and the successive waves can be seen passing backwards in the living animal, through the transparent epidermis. The heart has similar structure and relations to those described in *Trophonia*. CLAPARÈDE mentions the tubular excretory glands at the side of the pharynx, without recognising their homology with nephridia. They have the same structure as those of *Trophonia* (Pl. XLVI. fig. 40).

Fam. MALDANIDÆ.

Genus *Nicomache*.

This genus was first defined by MALMGREN, in his *Nordiska Hafs-Annulater*, as follows:—Body subcylindrical, posteriorly somewhat attenuated, of 26 segments, 22 of which are setigerous, while the two very short præanal somites are naked. Cephalic lobe coalesced with the naked buccal somite, oval, convex, inclined, and without a projecting border. *Superior setæ* capillary; some thicker, smooth, bordered, with the apex long and attenuated; others thinner, shorter, not bordered, smooth inferiorly, superiorly beset with very minute spines, adpressed in two series. *Inferior setæ*: in the three anterior setigerous somites, there is only one kind of seta, conical in form; in the rest, many minute uncini in a single series, with a tridentate beak at the vertex, with a fascicle of hairs bent over it beneath the beak. Anal segment infundibiliform, the margin surrounded by short cirri. Anus terminal in the bottom of the funnel.

Nicomache lumbricalis, Malmgren, Fabr.

Sabella lumbricalis, Fabricius, Fauna Grönl., p. 374, n. 369.

Clymene lumbricalis, Sars, Fauna littor. Norvegiæ, ii. p. 16, Tab. ii. f. 23–26; Christiania Vid. Selsk. Forh., 1861, p. 92.

Clymene borealis, Johnston, Dalyell, Pow. Creat., ii. 255, pl. xxxv. f. 5.

Commonly found among Laminarian roots, also occasionally under stones.

Specific Characters the same as those of the genus. Colour pinkish. The dorsal surface of the first few somites is abundantly spotted with red and white (Pl. XLVII. fig. 41).

Genus *Axiothea*, Malmgren.

First defined by MALMGREN, in his *Nordiska Hafs-Annulater*, as follows:—Body subcylindrical, of 24 somites, 18 of which are setigerous, and the 4 præanal naked. Cephalic lobe coalesced with the naked first somite, inclined with a projecting border, and anteriorly projecting into a short process. Superior setæ capillary; some longer, smooth and bordered; others shorter and thinner, finely pinnate on each side towards the tip. Inferior

setæ : a single row of uncini numerous in all the setigerous somites, but in the three anterior fewer than in those following; vertex of the rostrum 4-dentate, with sometimes a 5th tooth, very small, disappearing or obsolete; a fascicle of hairs arising beneath the rostrum and bent over it. Last somite infundibuliform, with the margin ciliated. Anus terminal in the bottom of the funnel.

Axiothea catenata, Malmgren.

Got in great numbers inhabiting fine tubes buried in the sand, with only their upper ends protruding. The tubes often have a branch in the lower part of their course, and extend down to a depth of 6 or 8 inches. The upper end is quite plain and open. The worms lie in their tubes with either their head or their tail uppermost indifferently, so that they can evidently turn in them. The locality whence our specimens were got was the flat sands for two or three hundred yards to the west of the Birnie Rocks, where the upper ends of the tubes form a sort of miniature forest all over the surface. Length 3 or 4 inches when fully extended, but when contracted, it is much less. Colour pinkish, paler towards the anterior end, with broad bands of deep red surrounding the body at intervals (Pl. XLVII. fig. 42).

Fam. CAPITELLIDÆ (HAELMINTHIDÆ, Mgn.).

Genus *Capitella*, Blainville.

Capitella Fabricii, Blan., Dict. des Sci. Nat., tome lvii., 1828.

Body very extensile, somites long and numerous: no branchiæ, parapodia rudimentary, represented by slight dorsal and ventral tubercles on the middle and posterior region of the body. Setæ of two kinds, subulate and uncinata, also genital setæ: subulate setæ confined to the anterior 6 or 8 somites, uncini to the rest. Male genital opening single, dorsal, between 8th and 9th somites; female, between 7th and 8th. Ocelli, 2 or more small lateral on præoral lobe. Two pits immediately behind eyes from which two ciliated knobbed processes can be protruded. Head conical and pointed.

Capitella capitata, Van Beneden, (Fabricius).

Lumbricus capitalus, Fabricius, Fn. Grönl., p. 279.

Valla ciliata, Johnston, Cat. Brit. Mus.

Capitella capitala, Van Beneden, Bullet Acad. Roy. Belgique, 2 ser., iii., 1857; Malmgren, Annulata Polychæt.; M'Intosh, Fauna of St Andrews.

Habits, &c.—Very common under stones in the littoral zone. The two ciliated retractile processes not seen unless the animal is watched with a low power for some time in the living condition.

Specific Characters.—Two minute eye-specks, just in front of the pits, whence the ciliated processes proceed.

As was pointed out by CLAPARÈDE (*Annélides Chéteopodes du Golfe de Naples*), the male genital aperture is single, situated between the 8th and 9th somites, and the notopodial setæ of these somites are modified for copulation. These setæ are long, thick, and bluntly pointed; there are 4 fascicles of them,—the 4 notopodial fascicles of the two segments, which have been shifted towards one another and towards the median dorsal line. In one male specimen, we investigated by examination, under the microscope, after compression, the distribution of the two kinds of setæ, with the following result:—In the neuropodia of the 8th and 9th somites, sheathed uncini only present. In the 6th somite, the notopodium has one uncinus on the dorsal side, the other setæ being all subulate; in the neuropodium all the setæ are subulate. In the first 5 somites there are only subulate setæ. Behind the 9th somite, sheathed uncini only present in both neuropodia and notopodia.

There seems to be still some doubt as to the process of copulation and reproduction in *Capitella*. VAN BENEDEN has regarded a pouch in connection with the genital opening in the male as testicle, but CLAPARÈDE doubts this interpretation. According to CLAPARÈDE, there are a pair of ovaries in the females in each segment, except a few of the most anterior. It is probable that the semen is somehow retained by the female near the genital opening, and the ova fertilised as they are expelled.

There are several segmental organs in each of the segments behind the genital opening, except the most anterior. These have been described by EISIG in "Die segmental organe der Capitelliden," *Mitth. Zool. Stat. Neapel.*, Bd. i., 1879. He says that, previously to his paper, of the generative apparatus of *Capitella capitata* only the greifhaken of the ♂, discovered by V. BENEDEN, and the pores of the female discovered by CLAPARÈDE, were known (V. BENEDEN, *Bull. Acad. de Belg.*, 1857, iii., Nos. 9 and 10; CLAPARÈDE, *Annélides Chétopodes du Golfe de Naples*, p. 274).

CLAPARÈDE, *loc. cit.*, says it is easy to find the sexual pores of the females, which are in the form of transverse clefts, on the ventral surface between the 7th and 8th somites, a little internal to the line of the "external" fascicles of bristles.

CLAPARÈDE was apparently aware that the copulatory setæ were dorsal. He speaks of these setæ as the *internal* fascicles of bristles transformed; and in speaking of the *ventral* female pores, he says they are internal to the external bristles. EISIG found that the pair of ventral pores described by CLAPARÈDE occurred in both sexes, and were in both the apertures of internally ciliated tubes; these tubes, if homologous with segmental organs, belong to the 8th somite; the 7th and 9th somites have nephridia in the larva; the 8th, none

except the tubes referred to. EISIG found these tubes full of spermatozoa in both sexes, and believes that in the ♂ they act as penis, in the female as vulva plus receptaculum seminis.

As can easily be seen in a specimen of 8 mm. length, mounted whole in Canada balsam, the ganglion of the 9th setigerous somite is continuous ventrally with the epidermis; dorsally it receives the anterior nerve cord, and in front of this point both cord and ganglia are internal to the longitudinal layer of muscles; posteriorly both cord and ganglia are external to the circular layer of muscles, and in contact with the epidermis.

There are no pseudhæmal vessels; the body-cavity is crowded with red nucleated corpuscles, which are present in great numbers (Pl. XLVII. fig. 43).

Notomastus latericius (Sars).

Notomastus latericius, Sars, Fauna littoralis Norvegiæ, pl. ii., 1856.

Capitella rubicunda, Keferstein, Z. f. w. Z., Bd. xii.; Claparède, Beob. über. Anat. etc. an den Küste von Normandie, Leipzig, 1863.

Notomastus latericius, Malmgren, Ann. Polychæta; Of. Kongl. Vet. Akad. Förhandlingar, 1867.

The genus *Notomastus* was established by M. SARS, with the following diagnosis:—Anterior part of the body composed of 12 somites, each divided by a transverse constriction into 2 rings: 1st somite without, the other 11 with, on each side, two fascicles of capillary setæ; no parapodial processes. Posterior part of the body longer and thinner; on each side two slight parapodial tubercles transversely elongated, and bearing uncini in a transverse series.

It is extremely characteristic of this genus, that, as described by SARS in his account of the animal, in the first 8 to 13 segments of the posterior or unciniate region, the two notopodial ridges coalesce into a single prominence in the dorsal median line.

GRUBE placed his genus *Dasybranchus* in the family Telethusidæ, with *Arenicola*. SARS thought *Notomastus* also belonged to the same family. But *Notomastus latericius* has no pseudhæmal vessels, and has numerous red corpuscles in the cœlomic fluid, in which respects its affinity to *Capitella* is clearly shown. There can be little doubt that the *Capitella rubicunda* of Keferstein and Claparède is identical with the *N. latericius* of Sars, and the discovery of the corpusculated cœlomic fluid in *Notomastus* belongs therefore to CLAPARÈDE.

We refrain from giving a specific diagnosis, because the species of the genera have not been sufficiently compared. The colour is red.

Habitat.—Several specimens were dredged in November 1886, in 6 to 12

fathoms, in mud N.W. and W. of Inchkeith. They were found by sifting the mud, and were always broken; no complete specimen being obtained. Sars found his specimens on the N.W. shores of Norway, some in the Laminarian zone, some at 50 to 60 fathoms, some at 20 to 30 fathoms. CLAPARÈDE found it in the littoral zone on the coast of Normandy.

Anatomy.—The ventral nerve cord lies internal to both circular and longitudinal layers of muscles, throughout the body: the cord is not in immediate contact with any other organs, but is suspended in the coelom by strands of muscular and connective tissue, which pass from the sides of the sheath surrounding the cord into certain strands connected with the circular muscles. There are no differentiated ganglia; the cord is of uniform width throughout its length, except where slight constrictions mark the boundary between contiguous somites. The sheath surrounding the cord is fibrous, and contains small nuclei. A neural canal runs along the dorsal median line of the cord. On the dorsal side there are no neural cells, but these form a continuous layer at the sides and ventrally, the layer being thickest laterally. The internal core of the cord is composed of minute fibrils.

The intestine is very narrow, both in the anterior and posterior regions of the body, but especially in the latter.

The arrangement of the muscles is noticeable. The longitudinal layer is very strongly developed (Pl. XLVII. fig. 44).

DESCRIPTION OF PLATES.

PLATE XXXVI.

- Fig. 1. *Nerine coniocephala*, anterior end. 1 A, parapodium from anterior region, with branchia and produced dorsal lamina; 1 B, parapodium from middle region, with branchial cirrus; 1 C, uncinus; 1 D, ripe unfertilised ovum; 1 E, ovum, with four segments.
- Fig. 2. *Nerine cirratulus*, anterior end with proboscis everted. 2 A, parapodium and branchial cirrus from anterior region; 2 B, parapodium and branchia from middle region; 2 C, uncinus; 2 D, anterior end, with proboscis retracted; 2 E, posterior end, dorsal surface; 2 F, longitudinal vertical section, showing nephridia and ovaries; 2 G, larva of *Nerine*, with 2 somites provided with provisional chætæ.

PLATE XXXVII.

- Fig. 2 H. Trochosphere of *Nerine*, dorsal surface, from life. E, Zeiss, Oc. 2, Camera, Feb. 21, 1887; 2 I, advanced larva of *Nerine*, dorsal surface; 2 J, same, ventral surface.
- Fig. 3. *Scolecopsis vulgaris*, anterior end. 3 A, posterior end; 3 B, parapodium from anterior region, and branchia; 3 C, parapodium and branchia from middle region.
- Fig. 4. *Spio seticornis*, anterior end. 4 A, posterior end; 4 B, uncinus.
- Fig. 5. *Leucodore ciliatus*, anterior end. 5 A, posterior end; 5 B, modified dorsal chætæ of 5th chætiferous somite; 5 C, uncinus.

PLATE XXXVIII.

- Fig. 6. *Magelona papillicornis*, anterior end, dorsal surface. 6 A, same, lateral surface; 6 B, posterior end, dorsal surface; 6 C, parapodium; 6 D, uncinus.

- Fig. 7. *Scoloplos armiger*, anterior end, dorsal surface. 7 A, same, lateral surface; 7 B, posterior end, dorsal surface; 7 C, transverse section, middle region; 7 D, 7 E, 7 F, 7 G, chætæ.
 Fig. 8. *Theodisca mammillata*, anterior end, lateral surface. For remaining figs. of this species see Pl. XL.
 Fig. 9. *Cirratulus cirratus*, anterior end, dorsal surface. 9 A, same, ventral surface; 9 B, same, lateral surface.
 Fig. 10. *Cirratulus tentaculatus*, anterior end, dorsal surface. 10 A, same, lateral surface.

PLATE XXXIX.

- Fig. 9 C. Branchia of *C. cirratus*, optical longitudinal section, fresh—*bl*, *bl*, the two main blood-vessels; *tr*, *tr*, transverse connecting small vessels. 9 D, transverse section of branchia—*bl*, *bl*, as before; *n*, *n*, nerves; *c*, *c*, cœlomic cavity. 9 E, tentacle, optical longitudinal section, fresh—*bl*, single blood-vessel; *g*, longitudinal groove. 9 F, transverse section of tentacle—*bl*, blood-vessel; *c*, *c*, cœlomic cavity; *g*, longitudinal groove; *n*, *n*, nerves. 9 G, anterior end showing anterior pair of nephridia; 9 H, nephridium.
 Fig. 10 B. Chætæ of *Cirratulus tentaculatus*.
 Fig. 11. *Chætozone setosa*.
 Fig. 12. *Dodecaceria concharum*, anterior end.
 Fig. 13. *Arenicola marina*. 13 B, 13 C, chætæ and uncinus.

PLATE XL.

- Fig. 13 D. Portion of immature ovary of *Arenicola marina*, fresh, Zeiss DD, Oc. 2; 13 E, immature ova from body-cavity, February, fresh, Zeiss DD, Oc. 2; 13 F, sperm polyplast from body-cavity, same time, same power, fresh.
 Fig. 14 A. Embryo probably of *Scoloplos armiger*, early stage, taken from pear-shaped gelatinous cocoon, Feb. 3, 1887, Zeiss CC, Oc. 3; 14 B, later stage, Feb. 4th; 14 C, same stage as previous figure, optical section; 14 D, more advanced, some days after hatching; 14 E, later stage, chætæ commencing to appear; 14 F, latest stage observed.
 Fig. 8 A. *Theodisca mammillata*, anterior end, dorsal surface. 8 B, posterior end of same species; 8 C, capillary chætæ; 8 D, 8 E, uncini of same.

PLATE XLI.

- Fig. 15. *Ammotrypane aulogastra*, anterior end, dorsal surface. 15 A, anterior end, lateral surface—*a*, soft proboscis; *b*, cephalic organ. 15 B, posterior end, lateral surface; 15 C, parapodium and branchia as seen in a transverse section.
 Fig. 16. *Ophelia limacina*, entire specimen, lateral surface.
 Fig. 17. *Sabellaria spinulosa*, entire specimen, lateral surface. 17 A, anterior end, ventral surface, highly magnified; 17 B, anterior end, lateral surface; 17 C, paleæ of the operculum; 17 D, chætæ of neuropodium, and uncinus of the notopodium.

PLATE XLII.

- Fig. 15 D. Opalina from the intestine of *Ammotrypane aulogastra*.
 Fig. 18. *Eumenia crassa*, lateral surface. 18 A, anterior parapodium, with branchia; 18 B, posterior parapodium of same.
 Fig. 19. *Lepobranhus Jeffreysi*, lateral view.
 Fig. 20. *Pectinaria Belgica*, lateral surface. 20 A, anterior end, dorsal surface; 20 B, anterior end, ventral surface; 20 C, capillary chætæ; 20 D, uncinus. 20 E, specimen dissected from ventral surface—*w. l*, white gland; *ne*, nephridia.
 Fig. 21. *Ampharete gracilis*, lateral view. 21 A, head, anterior surface; 21 B, capillary chætæ; 21 C, uncinus.
 Fig. 22. *Melinna cristata*, lateral view. 22 A, anterior end, dorsal surface, magnified; 22 B, anterior end, ventral surface; 22 C, dorsal hook, magnified; 22 D, capillary chætæ; 22 E, uncinus; 22 F, chætæ.

PLATE XLIII.

- Fig. 23. *Amphitrite Johnstoni*, lateral view. 23 A, capillary chætæ; 23 B, uncinus. 23 C, specimen opened from dorsal surface—*ht*, heart; *ne*, nephridia; *int*, intestine. 23 D, nephridium separated, magnified.

- Fig. 24. *Amphitrite cirrata*, lateral view. 24 A, capillary chæta; 24 B, uncinus.
 Fig. 25. *Terebella Danielsseni*. 25 A, capillary chæta; 25 B, uncinus.
 Fig. 26. *Lanice conchilega*. 26 A, uncinus.

PLATE XLIV.

- Fig. 27. *Scione maculata*. 27 A, posterior end, magnified; 27 B, chæta; 27 C, uncinus.
 Fig. 28. *Ereutho Smitti*, ventral surface. 28 A, chæta; 28 B, uncinus.
 Fig. 29. *Terebellides Strœmi*. 29 A, chætæ; 29 B, uncinus.
 Fig. 30. Larva of a species of the Terebellidæ.
 Fig. 31. *Sabella penicillus*. 31 A, ventral view of anterior end; 31 B, thoracic chæta; 31 C, abdominal chæta; 31 D, uncini.
 Fig. 32. *Chone infundibuliformis*. 32 A, dorsal surface, anterior end.

PLATE XLV.

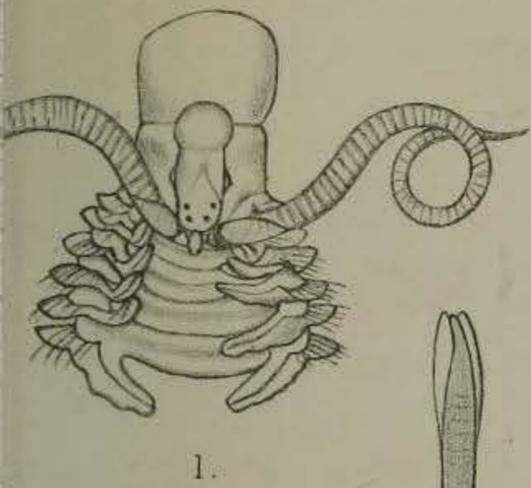
- Fig. 32 B, 32 C, thoracic chætæ. 32 D, thoracic uncinus; 32 E, abdominal seta; 32 F, abdominal uncinus.
 Fig. 33. *Amphicora Fabricia*. 33 A, chæta and uncinus.
 Fig. 34. *Myxicola Steenstrupi*. 34 A, chæta and uncinus.
 Fig. 35. *Filigrana implexa*, ventral surface. 35 A, larva.
 Fig. 36. *Pomatocerus triqueter*. 36 A, abdominal chæta; 36 B, thoracic chæta; 36 C, uncinus.
 Fig. 37. *Spirorbis borealis*. 37 B, uncinus.
 Fig. 38. *Spirorbis lucidus*. 38 A, chæta of 1st thoracic somite; 38 B, chæta of 2nd thoracic somite; 38 C, chæta of abdomen.

PLATE XLVI.

- Fig. 37 C, Part of a string of ova of *Spirorbis borealis*, from the shell; June 15, 1887; Zeiss, CC. Oc. 2.
 Fig. 39. *Trophonia plumosa*, anterior end, with the buccal somite fully protruded, as it often is when the animal is killed with spirit—*a*, branchiæ; *b*, tentacles; *c*, mouth. 38 A, dissection of *Trophonia plumosa*—*a*, inverted buccal somite; *b*, retractor muscle; *d*, nephridia; *e, e*, ovaries; *f*, heart; *g*, dorsal pseudhæmal vessel; *h*, ventral pseudhæmal vessel; *i*, intestine. 38 B, from the epithelium of the nephridium, Zeiss, CC. Oc. 3.
 Fig. 40. *Flabelligera affinis*. *a*, branchiæ; *b*, tentacles; *c, c*, nephridia; *d*, heart; *g*, intestine; *h*, setæ of notopodium; *i*, uncini of notopodium; *j*, glandular papillæ. 40 A, glandular papillæ, × 400; 40 B, uncinus of notopodium.

PLATE XLVII.

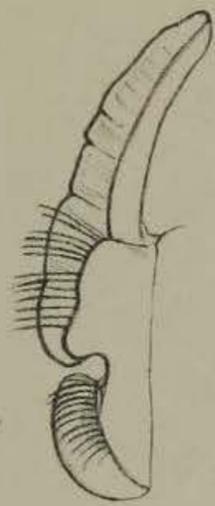
- Fig. 41. *Nicomache lumbricalis*, anterior end, lateral view. 41 A, posterior end, lateral view; 41 B, uncinus.
 Fig. 42. *Axiothea catenata*, anterior end, lateral view, proboscis protruded. 42 A, anterior end, ventral surface; 42 B, anterior end, dorsal surface; 42 C, posterior end; 42 D, chæta; 42 E, chæta; 42 F, uncinus.
 Fig. 43. *Capitella capitata*, anterior end. 43 A, chæta; 43 B, uncinus. 43 C, copulatory armature—*a*, pouch. 43 D, corpuscles of body-cavity, after treatment with acetic acid, Zeiss E, Oc. 3.
 Fig. 44. *Notomastus latericius*, anterior end, dorsal surface, proboscis everted. 44 A, same, lateral surface; 44 B, uncinus.



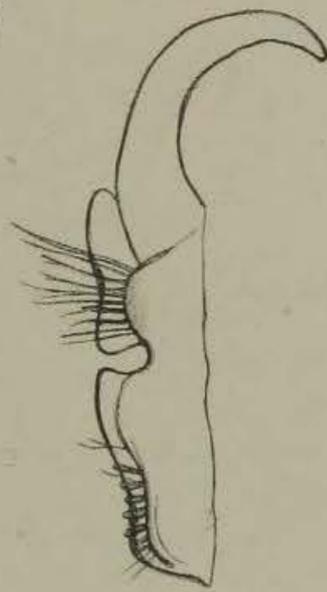
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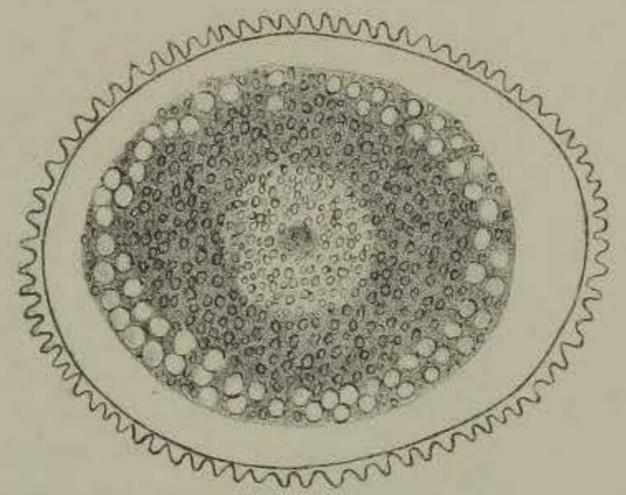
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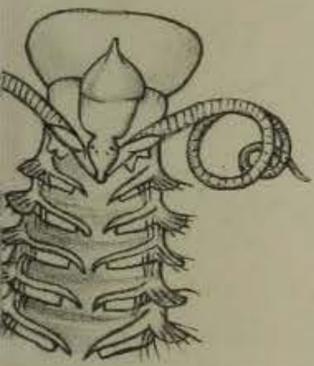
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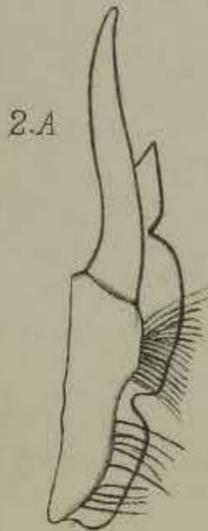
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1.D



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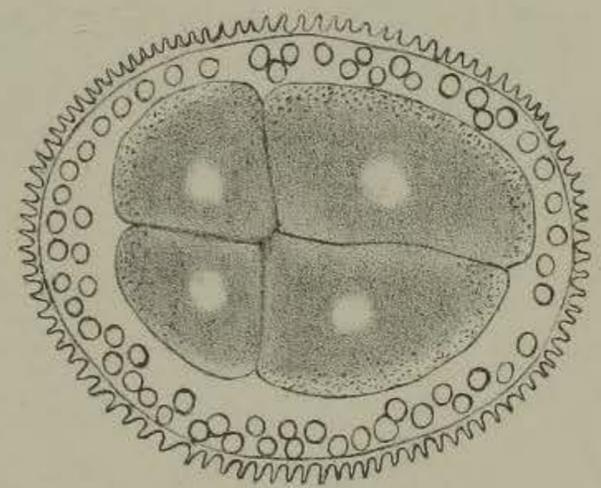
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2.B



2.C



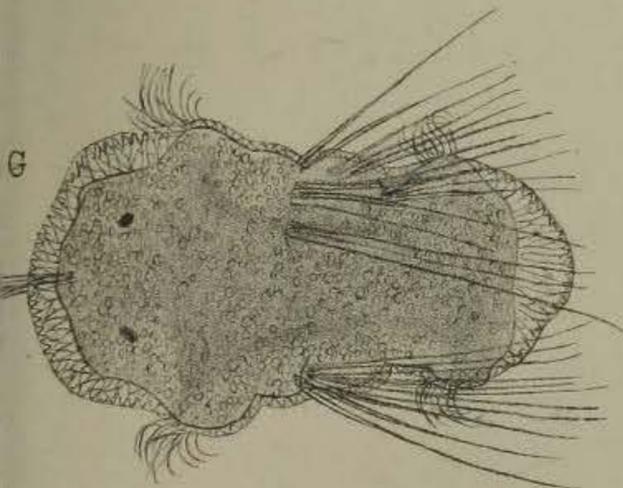
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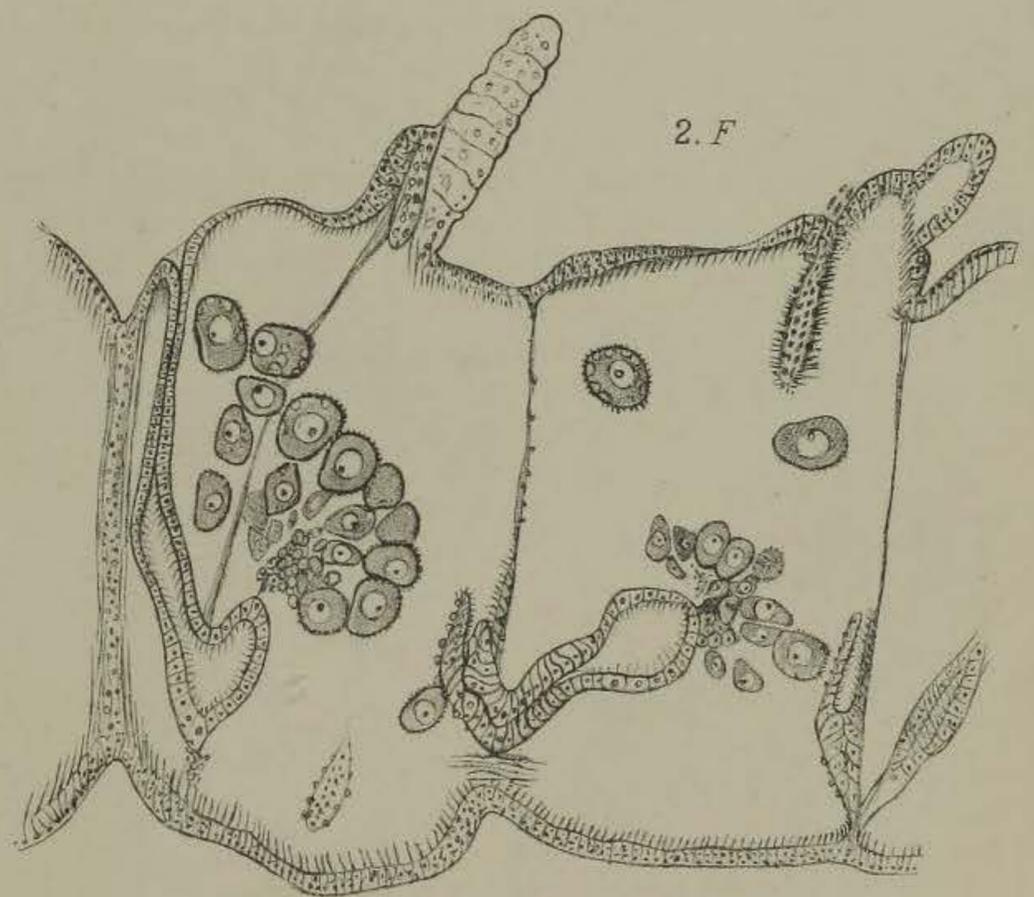
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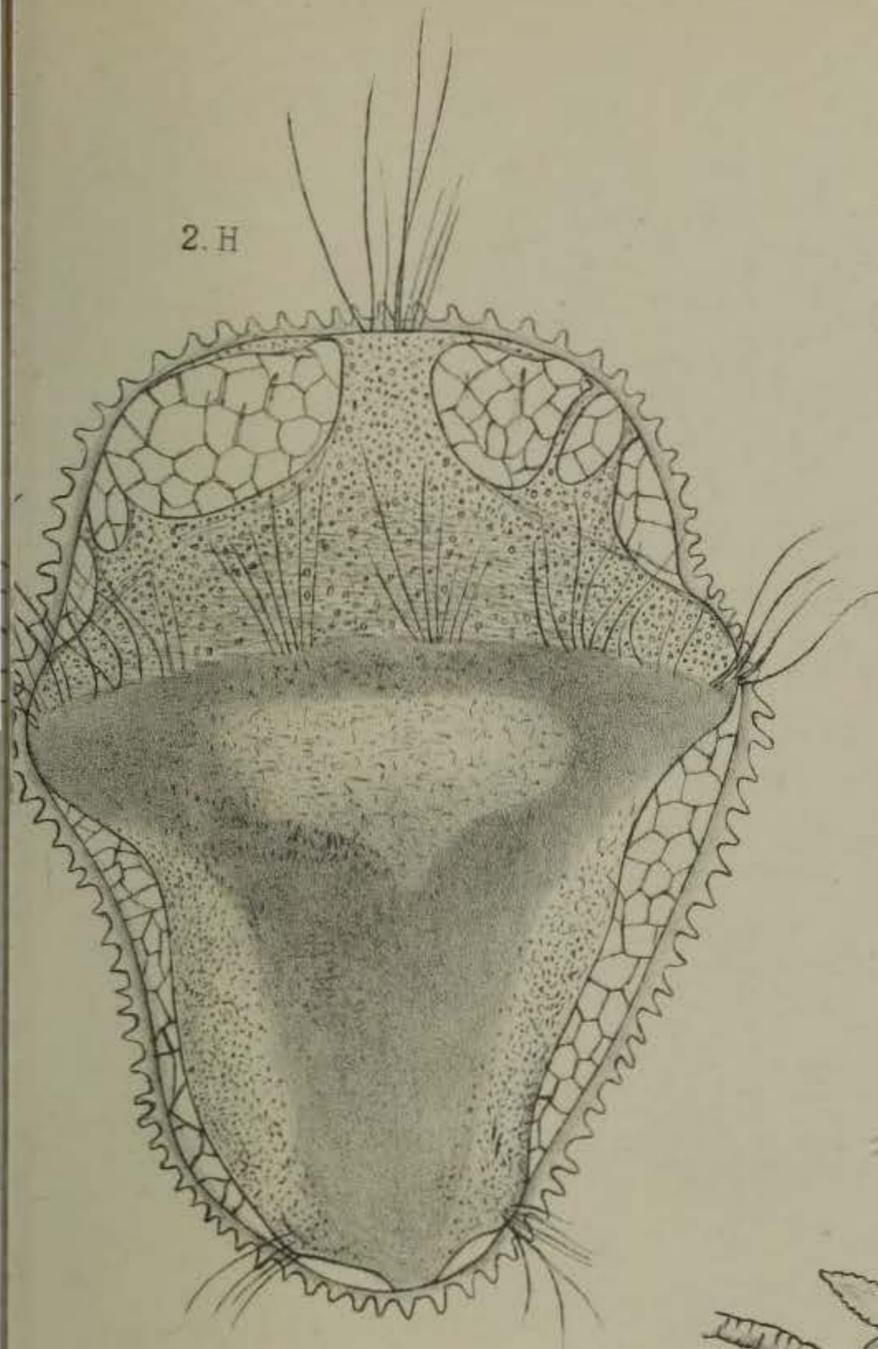
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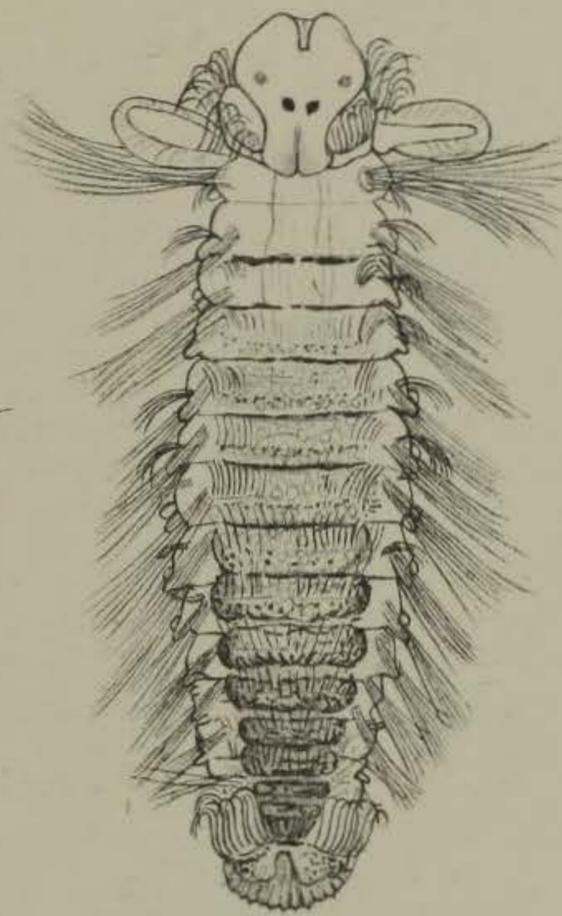
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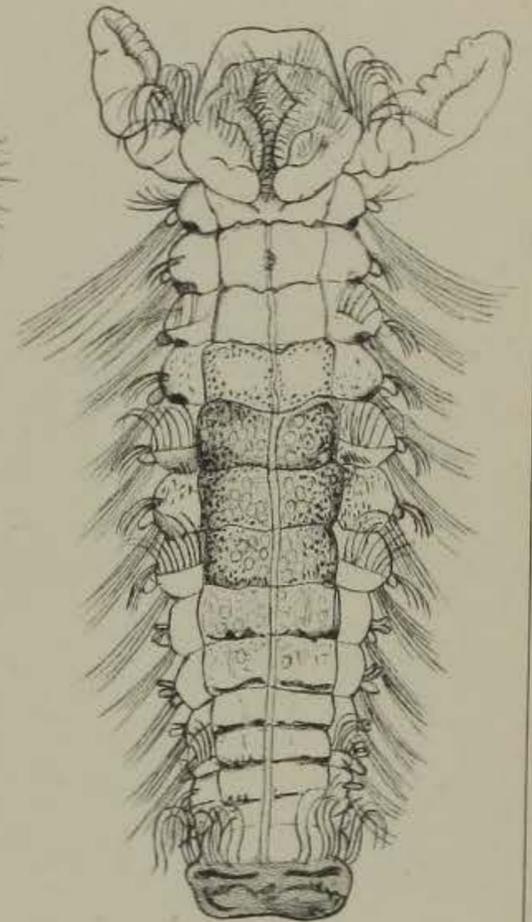
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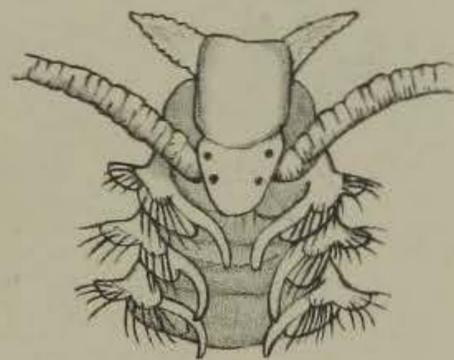
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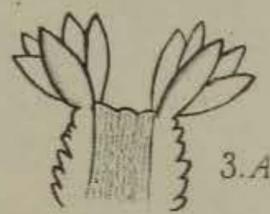
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2.J

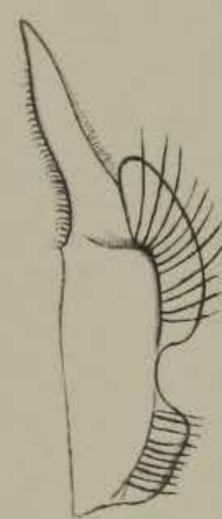
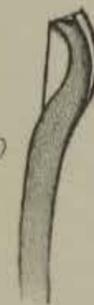


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3.A

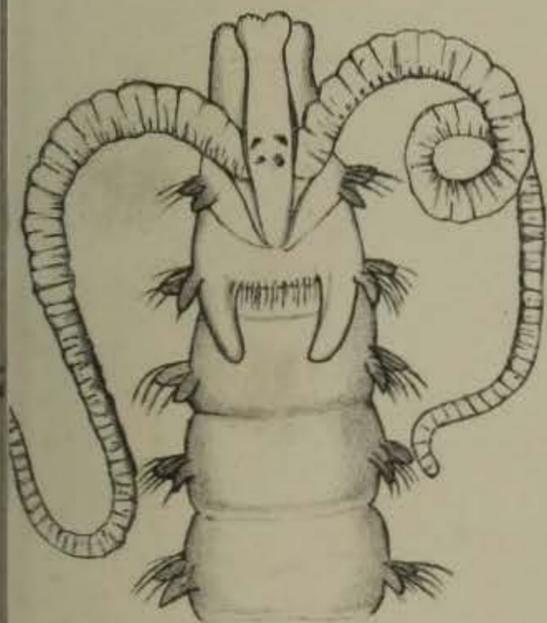
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3.B



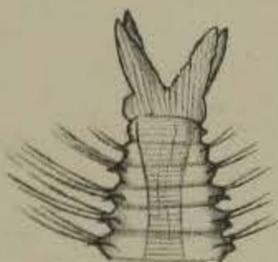
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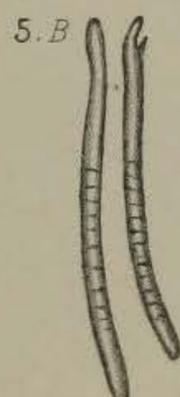
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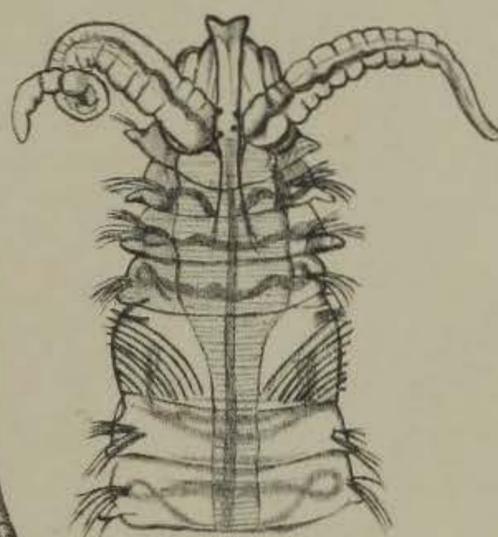
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4.A



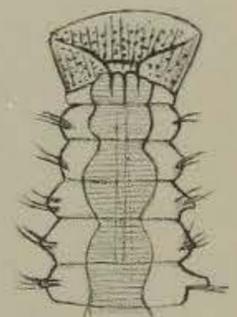
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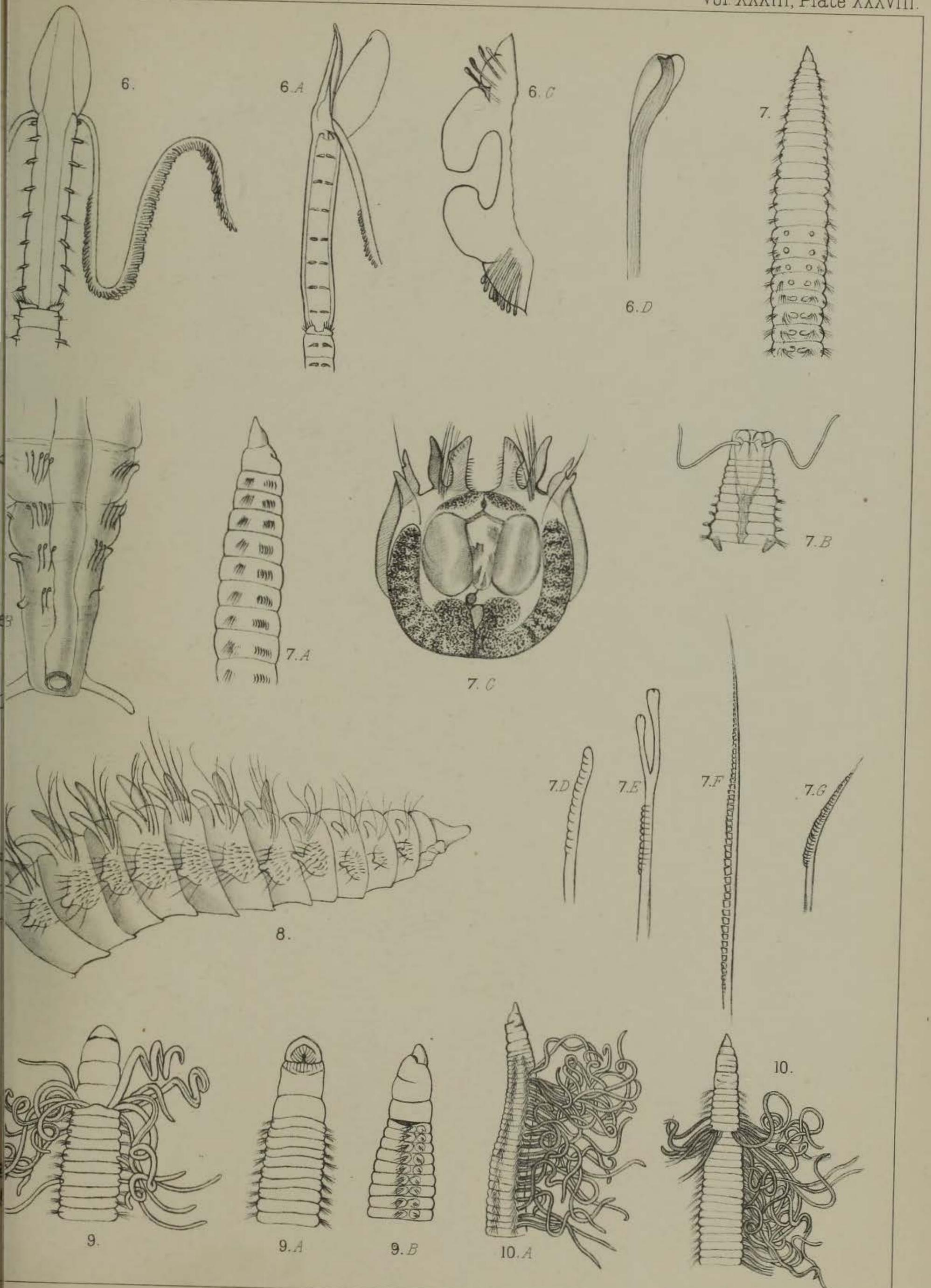
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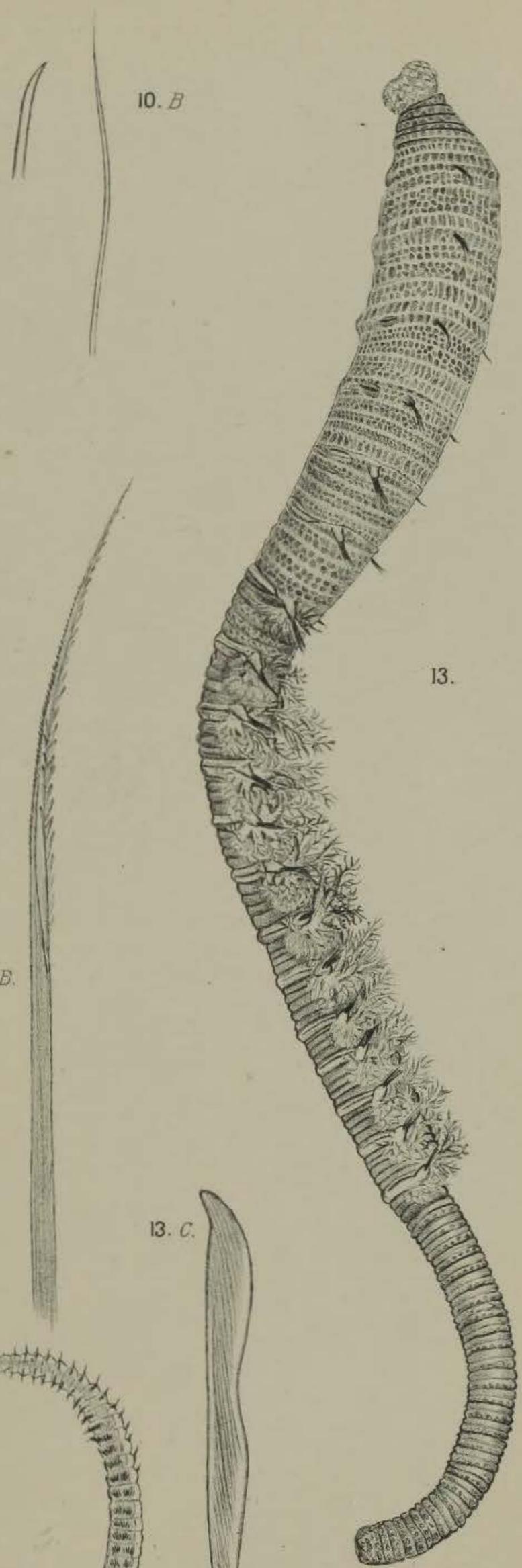
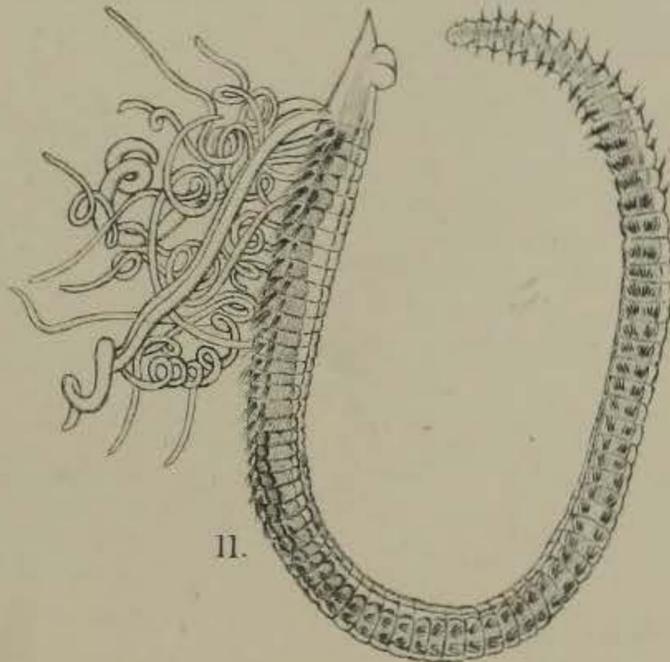
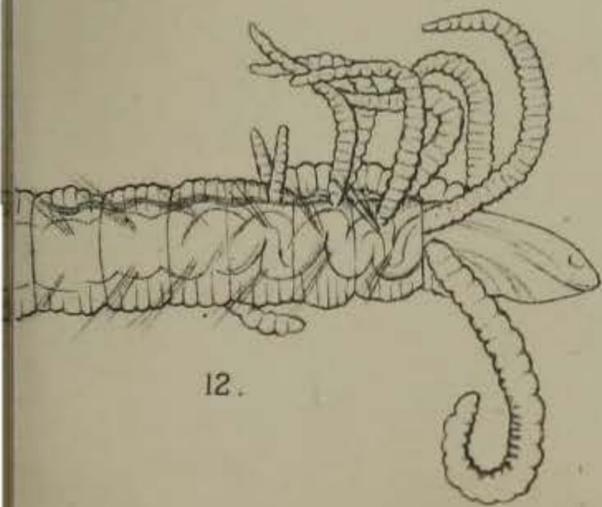
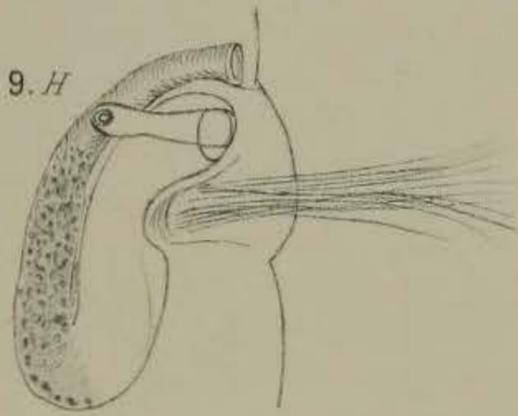
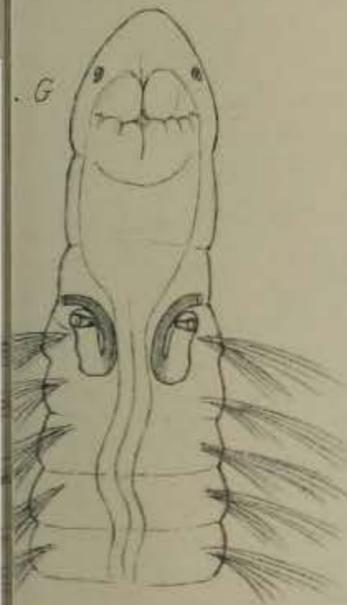
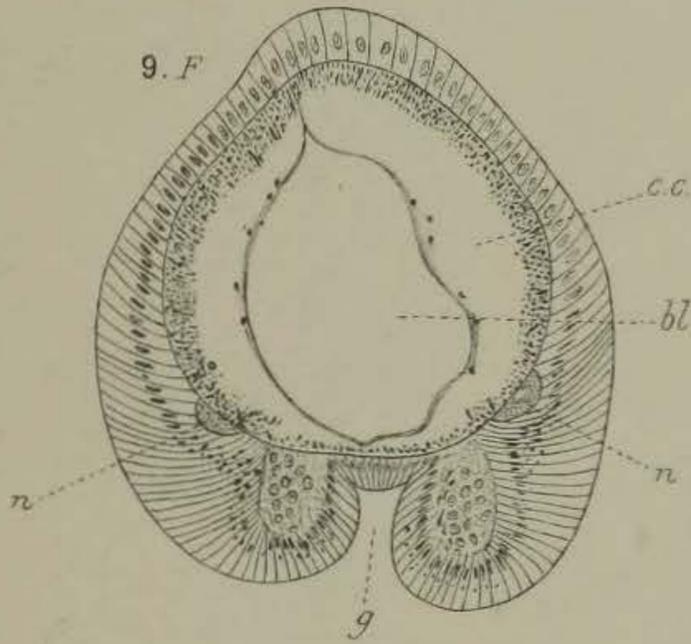
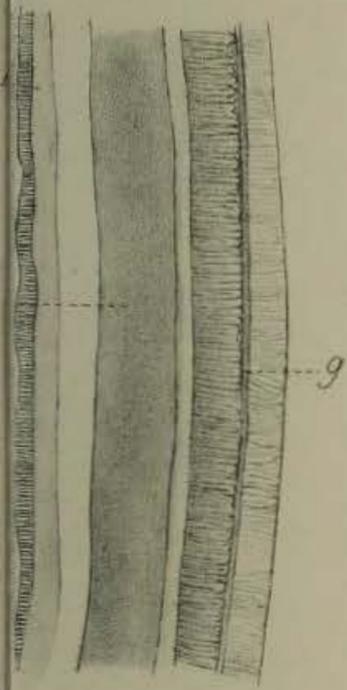
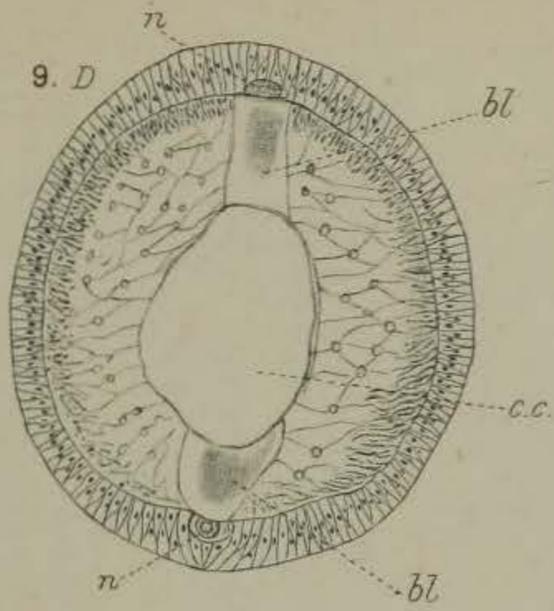
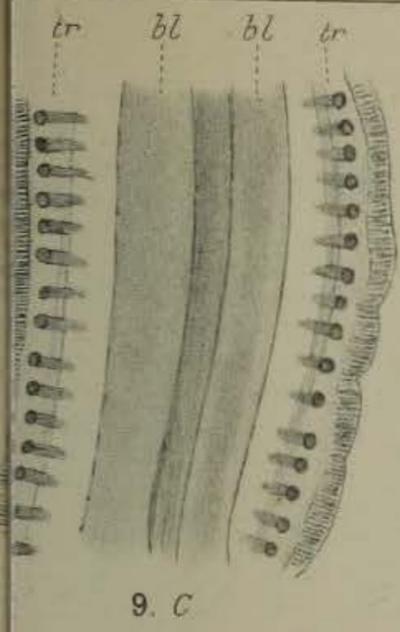


5.C



5.A



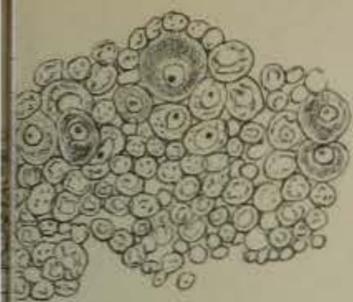


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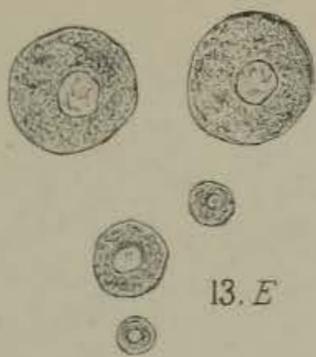
13. C.

12.

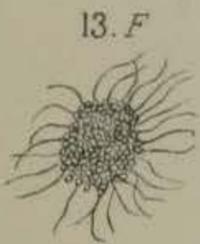
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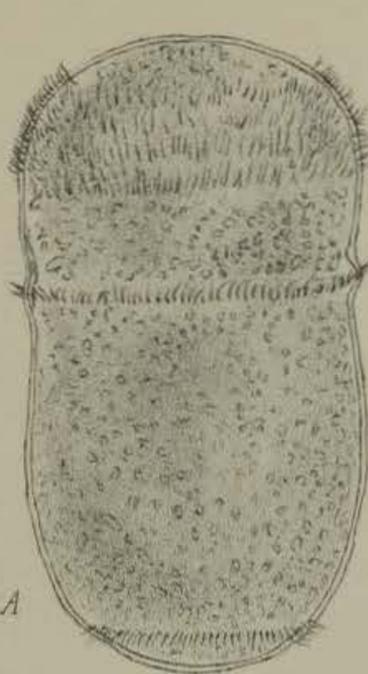
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13. E



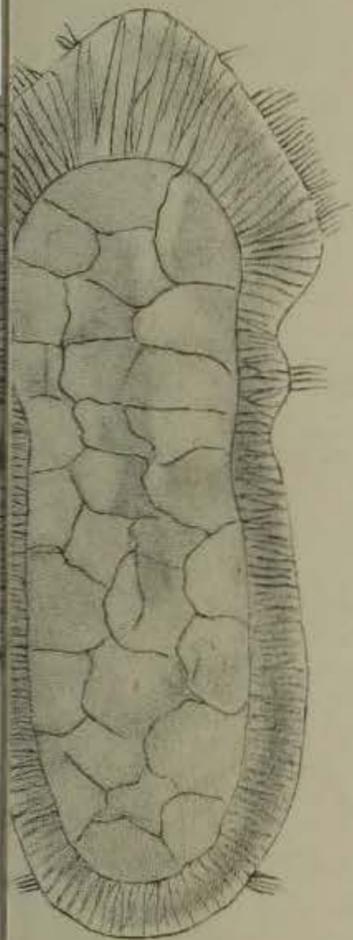
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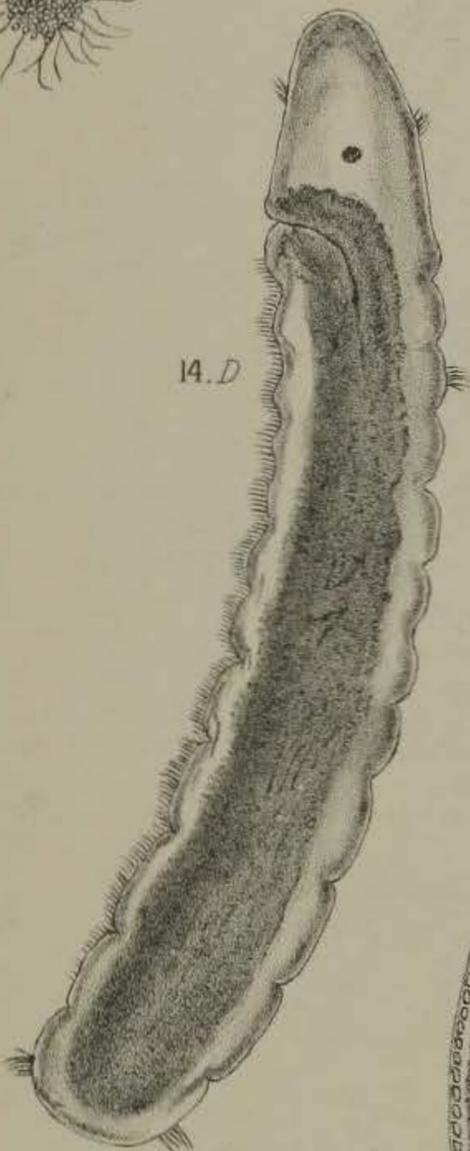
14. A



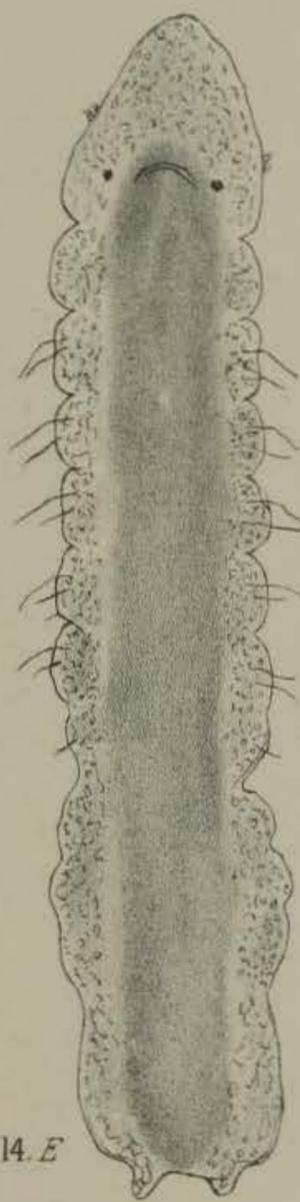
14. B



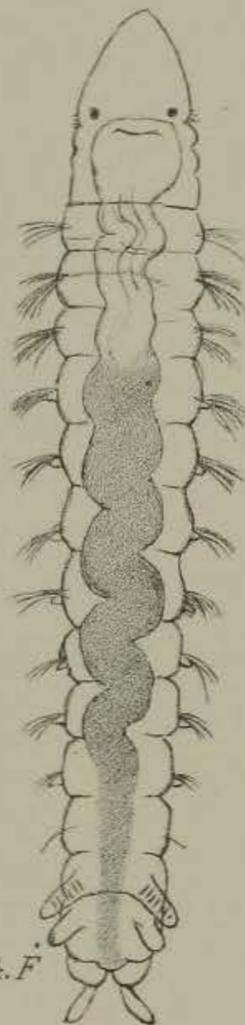
14. C



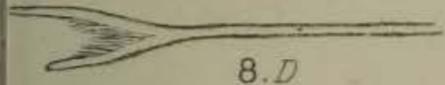
14. D



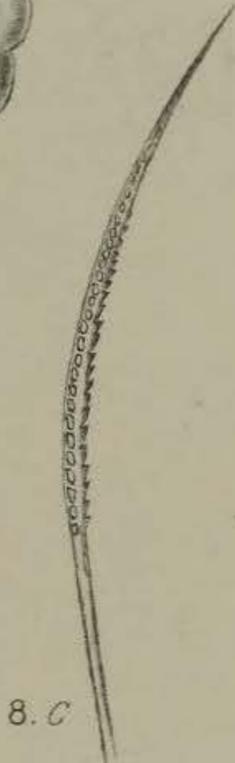
14. E



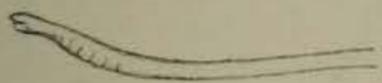
14. F



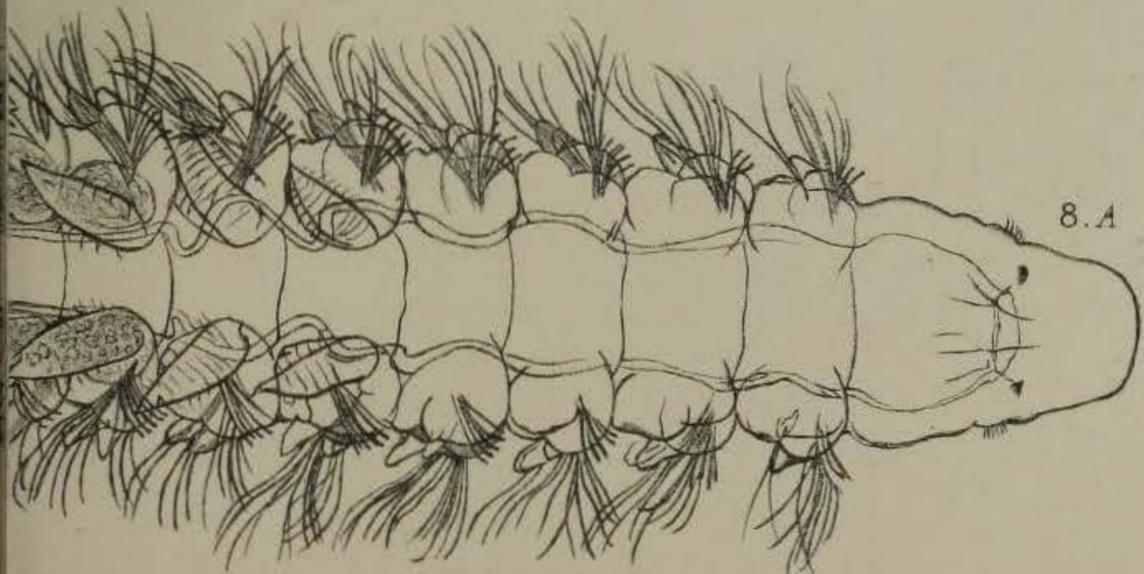
8. D



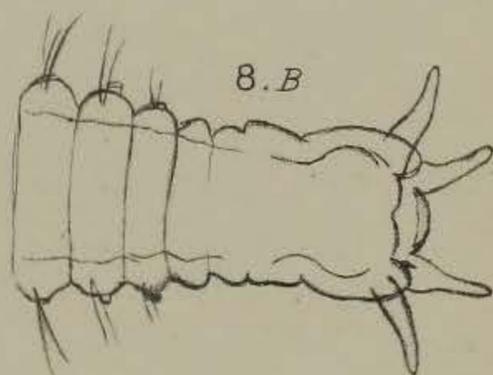
8. C



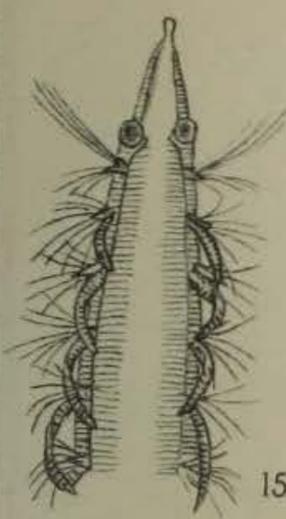
8. E



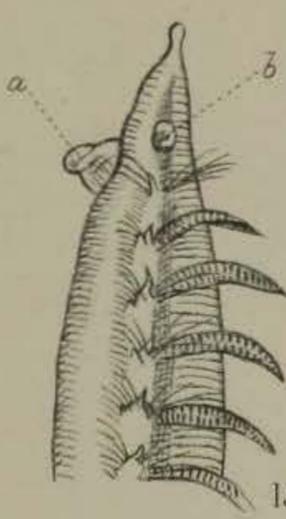
8. A



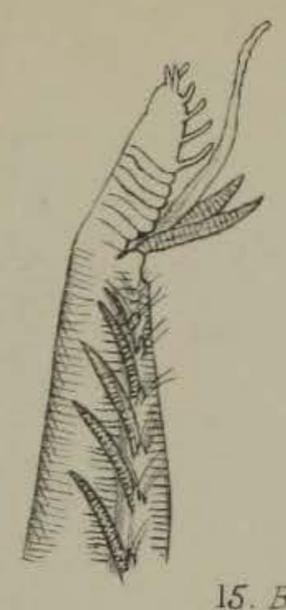
8. B



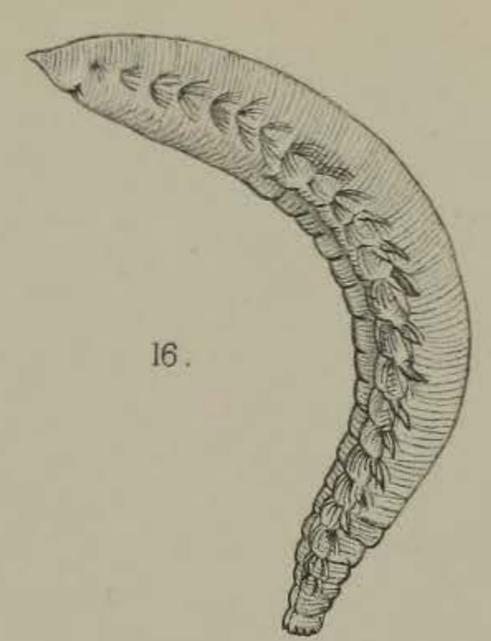
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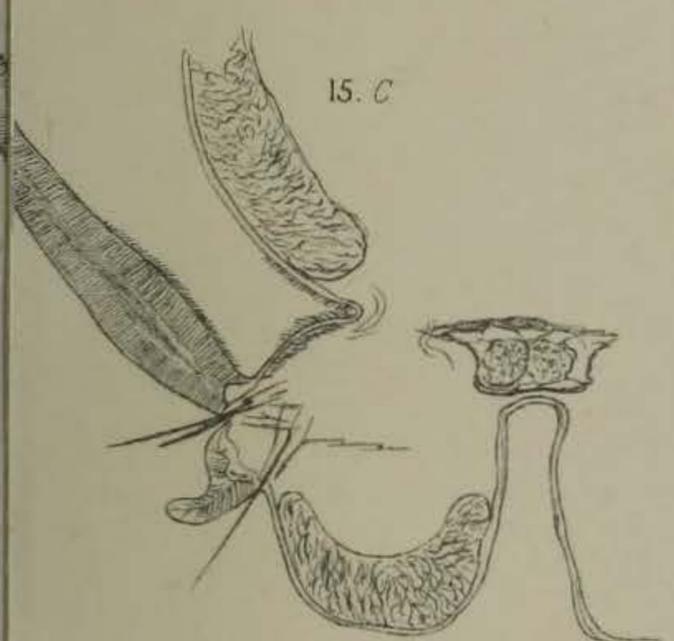
15.A



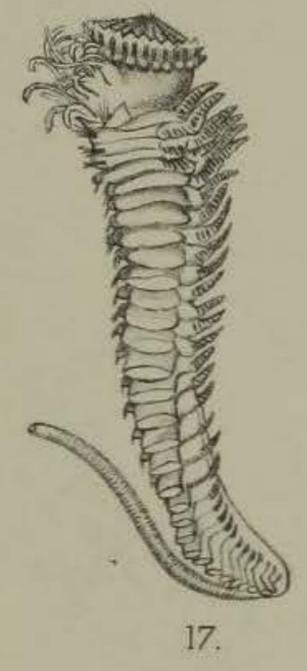
15.B



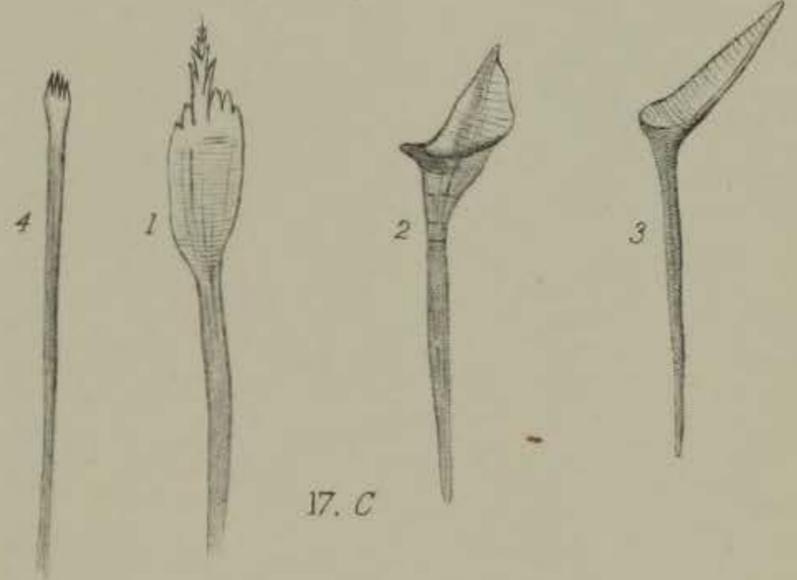
16.



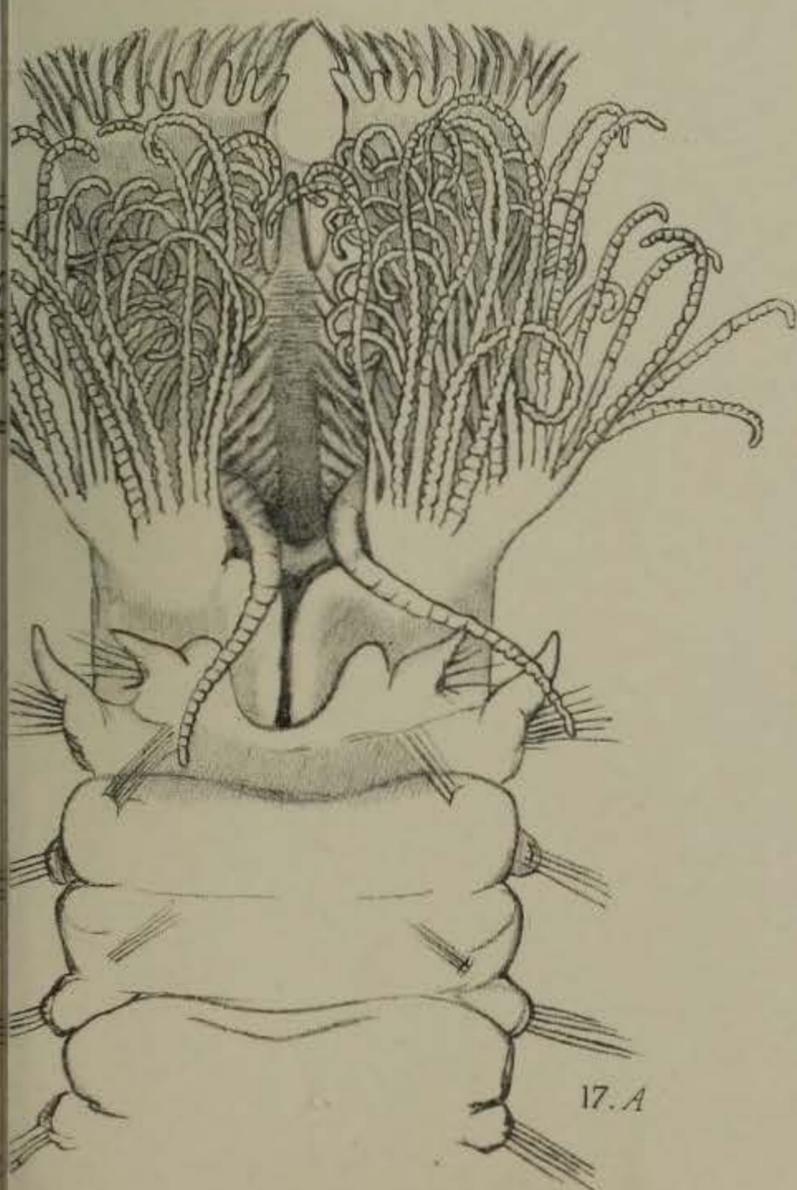
15.C



17.



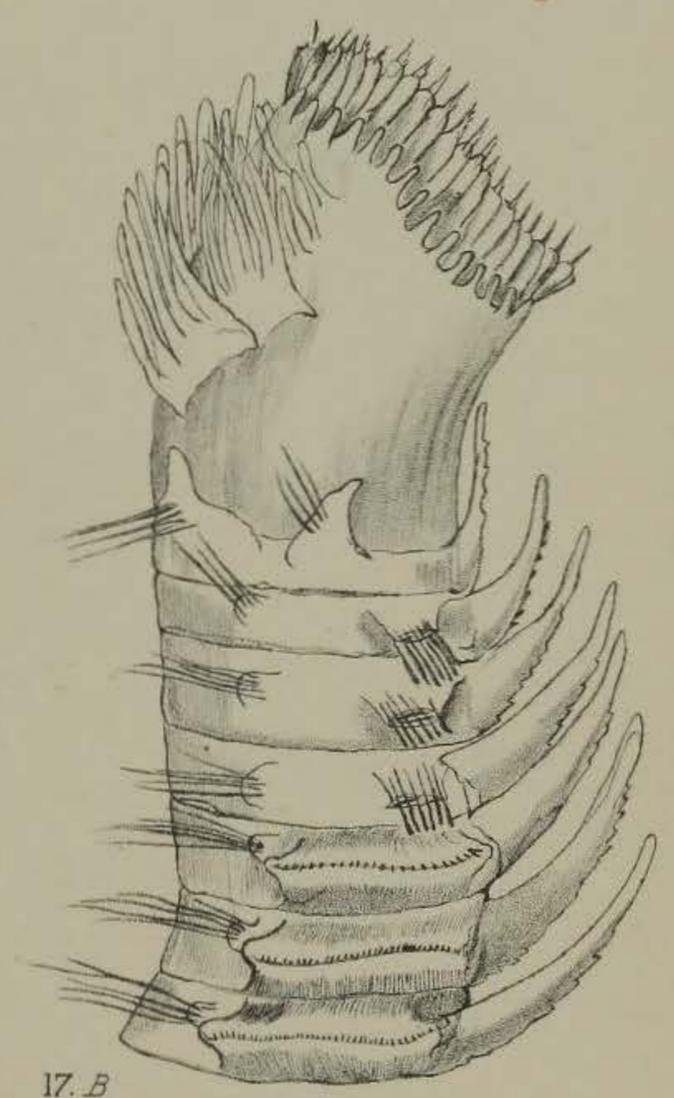
17.C



17.A

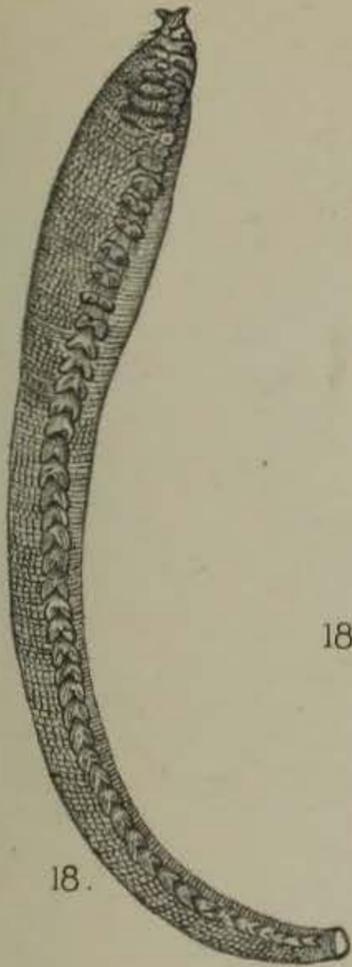


17.D

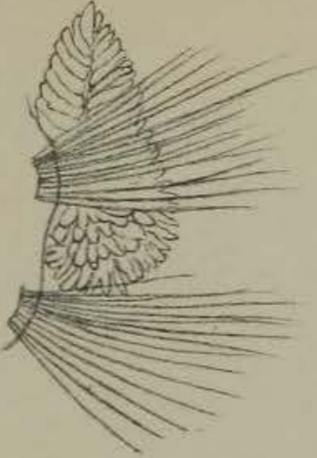


17.B

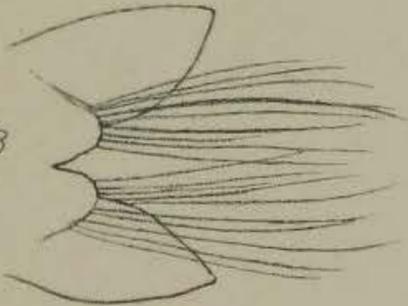
15.D



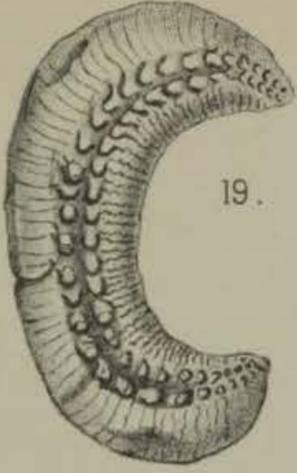
18.A



18.B



18.



19.

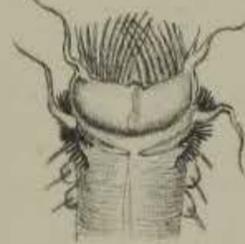
20.



20.C



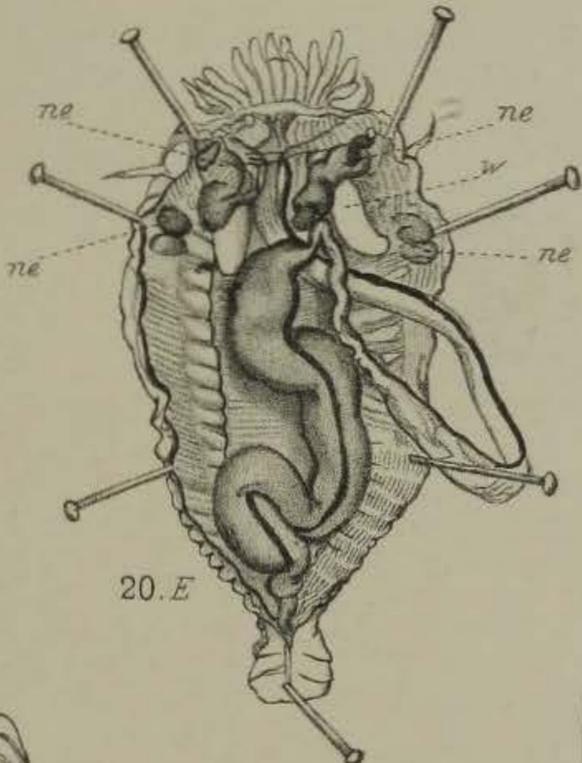
20.A



20.B



20.D



20.E

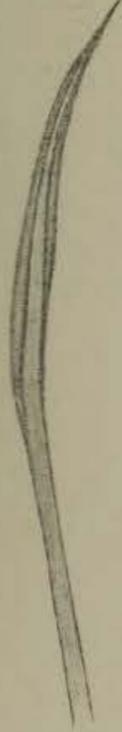
21.A



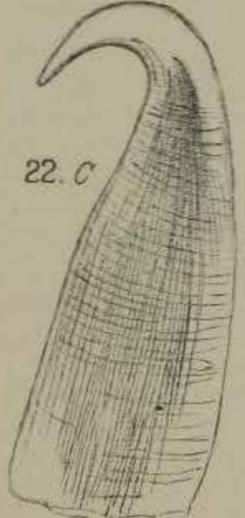
21.C



21.B



22.C



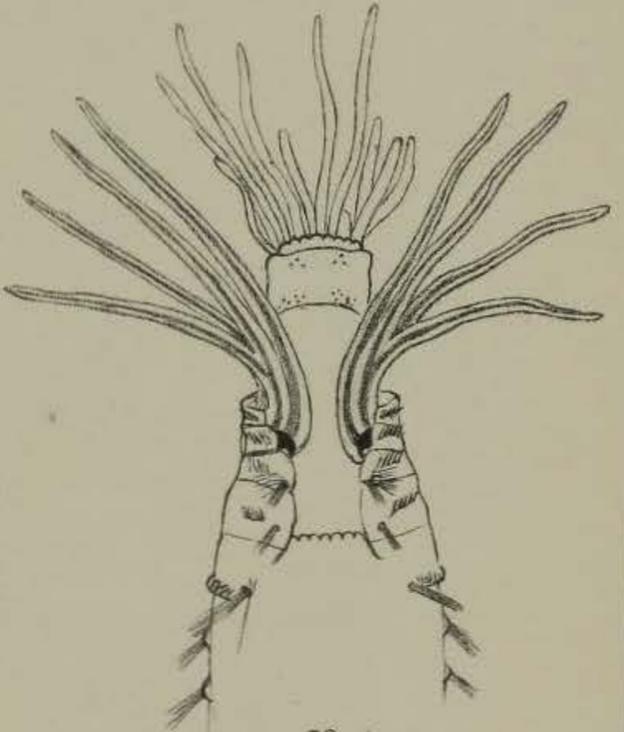
22.D



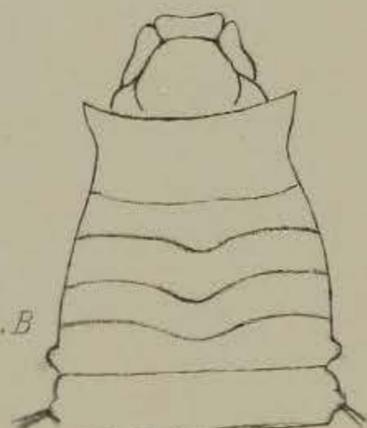
22.



22.A



22.B



22.F



22.E



