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No. 9. — *Studies from the Newport Marine Zoölogical Laboratory.*

Communicated by ALEXANDER AGASSIZ.

XIII.*

On the Development of Certain Worm Larvæ. By J. WALTER FEWKES.

Prionospio tenuis VERR. (?).

Plates I. and II.

The youngest larva (Pl. I. Fig. 1, Pl. II. Fig. 7) of this worm has a transparent head and a body which is 2–3 mm. long, tapering uniformly from anterior to posterior extremity. The head (Pl. I. Fig. 1) has four eye-spots, or

* The present paper, which is the first to appear under the above title, is one of a series from my Newport Laboratory, of which the following have already been published: —

I. The Development of Salpa. By WM. K. BROOKS. pp. 58. 34 cuts. March, 1876. Bull. Mus. Comp. Zoöl., Vol. III. No. 14, p. 291.

II. On the Young Stages of some Osseous Fishes. By A. AGASSIZ. I. Development of the Tail. pp. 10. 2 plates. 1877. Proc. Amer. Acad., Vol. XIII. p. 117.

III. The Development of Lepidosteus. By A. AGASSIZ. pp. 11. 5 plates. 1878. Proc. Amer. Acad., Vol. XIV. p. 65.

IV. On the Young Stages of some Osseous Fishes. By A. AGASSIZ. II. Development of the Flounders. pp. 24. 10 plates. 1878. Proc. Amer. Acad., Vol. XIV. p. 1.

V. On some Young Stages in the Development of Hippa, Porcellana, and Pinnixa. By WALTER FAXON. pp. 16. 5 plates. April, 1879. Bull. Mus. Comp. Zoöl., Vol. V. No. 11, p. 254.

VI. On the Development of Palæmonetes vulgaris. By WALTER FAXON. pp. 27. 4 plates. September, 1879. Bull. Mus. Comp. Zoöl., Vol. V. No. 15, p. 303.

VII. Contributions to a Knowledge of the Tubular Jelly-Fishes. By J. WALTER FEWKES. pp. 20. 3 plates. March and April, 1880. Bull. Mus. Comp. Zoöl., Vol. VI. No. 7, p. 127.

VIII. On some Points in the Structure of the Embryonic Zoëa. By WALTER FAXON. pp. 7. 2 double plates. October, 1880. Bull. Mus. Comp. Zoöl., Vol. VI. No. 10, p. 159.

IX. Studies of the Jelly-Fishes of Narragansett Bay. By J. WALTER FEWKES. pp. 42. 10 plates (3 double). February, 1881. Bull. Mus. Comp. Zoöl., Vol. VIII. No. 8, p. 141.

X. On the Development of the Pluteus of Arbacia. By J. WALTER FEWKES. pp. 10. 1 double plate. May, 1881. Mem. Peabody Acad. Sci., I. 6.

XI. On the Acalephæ of the East Coast of New England. By J. WALTER FEWKES. pp. 19. 1 double plate. April, 1882. Bull. Mus. Comp. Zoöl., Vol. IX. No. 8, p. 291.

XII. On the Young Stages of some Osseous Fishes. III. By A. AGASSIZ. pp. 32. 20 plates. 1882. Proc. Amer. Acad., Vol. XVII. p. 271.

ALEXANDER AGASSIZ.

ocelli, each of a reddish color. Two of these are placed near the median line, and two appear near the bases of appendages called cephalic tentacles (*t*), Both pairs are situated in the dorsal walls of the head. In the cephalic walls below the median eye-spots there is a greenish spot of triangular shape. Similarly colored spots are also situated in the dorsal walls of the head under the lateral eyes.

Two pairs of appendages, known as the cephalic tentacles (*t*) and the cephalic setæ (*s*), arise from the head. Both of these cephalic appendages are embryonic.

The tentacles (*t*) are long, flexible bodies, which are sometimes closely coiled about their bases, and at other times widely extended. These appendages are transparent, of a slightly reddish color, and unjointed. Their surface is covered with short stiff spines or hairs, which are especially numerous near their distal extremities. Each appendage has a cavity throughout its length, opening into the body cavity, and through the walls the circulation of a fluid contained within can be easily seen. There are two of these cephalic tentacles, both of which arise from the dorsal region of the head, a little above the lateral lines of the body. They are probably homologous to dorsal cirri.

The cephalic setæ (*s*) are smooth, easily deciduous spines projecting from ear-like lappets on the dorsal side of the head below the cephalic tentacles. Their length varies, but in young specimens it is about one half that of the body. Although generally carried separated in a fan-like manner, they are often folded closely together, parallel with the sides of the body (Fig. 6). The cephalic setæ are probably homologous with the embryonic spines of (*Nerine*) *Spio*, and may be regarded as the setæ of a single segment of which the head is formed. It is a significant fact that these spines, as far as known, are only found in those annelid larvæ which are free swimming. In the young *Arenicola*, for instance, which passes its youth enveloped in a mass of slime, these embryonic spines never appear. This fact leads one to ask if they are not special organs for defence rather than ancestral features descended from fossil forms, which according to A. Agassiz they sometimes closely resemble. Their peculiar positions when a *Nerine* or *Prionospio* larva is alarmed leave no doubt of their defensive function.

The mouth is terminal and slightly ventral. The proboscis is short when retracted, not extending back of the posterior part of the head. It is protrusile even in this early condition, and bears a chætinous (?) toothed body of red color, visible through the mouth opening. The position of the posterior extremity of the proboscis is marked by a pair of diverticula (*g*) from the intestinal tract, whose walls are here pigmented with brown and yellow. They lie near the medial dorsal line, one on each side of the junction of proboscis and œsophagus. These "glands" begin to form as small lateral diverticula from the œsophagus, and extend forward in the body cavity, one on each side of the proboscis. Later in their growth yellow pigment appears in their walls, and they assume a superficial likeness to glands. In the dorsal medial line, upon the intestinal tract between them, there is a pulsatile sac

opening into a large anterior vessel. The pulsatile sac resembles a heart; the vessel opening from it, an artery which may distribute blood to the head and cephalic tentacles. Of the true homology of these organs there is, however, some doubt.

The body of the youngest *Prionospio* (Fig. 1) is composed of nine anterior segments, bearing as many pairs of long provisional setæ and four smaller terminal segments without spines. Consequently, it will be seen that in the youngest larva two segmented regions can be distinguished in the body; the anterior (*a r*) forming its great mass and bearing provisional setæ, and the posterior (*p r*) relatively almost inconspicuous in size and without spines. The terminal segments of the latter are colored by bright red pigmentation. The diameter of the intestinal tract narrows uniformly from the head to the anal extremity, with little variation in different regions.

Marked changes of most important character have taken place in the head and body of the next oldest larva (Figs. 2, 3, 4, 5). The arrangement of the tentacles, setæ, and eye-spots on the head is about the same as in the former larva, and the dorsal walls have extended forward above the mouth into a lip which had a rounded border, forming a structure which persists into the adult, and will be called, in subsequent larvæ of this worm, the præoral lobe. This nomenclature, however, does not imply that it is homologous with the structure which has the same name in certain other Annelid larvæ. The body of this larva has dropped, either normally or abnormally, most of its embryonic setæ, and three regions, an anterior, a middle, and a posterior, have differentiated themselves in it. Almost the whole of the body is still taken up as formerly by the anterior region. The middle region (*m r*) is smaller than the anterior, has its walls more thickly pigmented, and retains the embryonic setæ even when the larva is kept in confinement for some time. This region is formed from the originally undivided posterior part of the former larva. The posterior body region is the smallest of the three, and is the same as the non-spinous part of the body of the youngest larva.

The anterior region of the body in the present larva is composed of nine segments, the lines of separation between each pair of which, however, are not well marked. The lateral spines of this part are short and small. The body walls are very transparent. On the sides of the body near the fourth pair of spines there is a cluster of reddish pigment spots (*m s*), which persist even into the oldest larvæ which have been taken (Fig. 13).

The middle body region, which is developed from the original posterior portion, is formed of four segments, the constrictions between which are deep and well marked. The segments are sometimes swollen to a diameter greater than that of the transparent anterior portion of the body. The walls are thicker than those of the transparent part described above, and are more densely pigmented with yellow and brown. That portion of the digestive tract which lies in the middle body division is here considered the stomach. The posterior division of the body has a smaller diameter than either of the others, and is without appendages. It is, however, segmented, and later in its

growth becomes spiniferous. The terminal segments bear small papillæ, and are colored with crimson pigment.

The next following larvæ (Figs. 6, 7, 8, 9), which are slightly more mature than the last, differ from it in several particulars. The most important changes which have taken place in the form of the head (Fig. 9) are an antero-posterior lengthening of the whole segment of which it is formed, and a still greater projection of the præoral lobe, which also becomes more pointed. Perhaps the most significant of the general changes which have occurred is the appearance of a basal joint in the cephalic tentacles. These appendages, which in all the younger larvæ are almost uniform in size throughout, in this are found to be marked at a short distance (*b f*) from their origin with patches of red pigment. The color is first seen on the anterior wall of the appendage. The walls of the tentacle, where this pigment first appears, are somewhat thickened, and a slight corrugation forms on the tentacle at this point (Fig. 9).

The body of the larva has meanwhile become more elongated, and two additional bundles of setæ have arisen on each side in the anterior or transparent region of the body. The backward growth, leading to an increase in the distance between the "glands" (*g*) found at the posterior part of the head and the cephalic tentacles, has greatly increased, while the size of the "glands" has diminished. The portion of the intestinal tract which lies in the transparent anterior region of the body, between the glands mentioned above and the first of the four segments which compose the middle body region, fills most of the body cavity, and lies on the dorsal side. Each parapodium of the anterior body region is double, consisting of a dorsal and ventral protuberance, both bearing a small bundle of setæ. The parapodia of the middle and posterior regions have a single protuberance of similar character.

The general appearance of a larva a little older (Figs. 10, 11) than the last is somewhat different by reason of the loss of the temporary embryonic setæ (*s*) formerly found on the head. It is extremely difficult to indicate definitely the time when these bristles normally disappear, but it is probable that the disappearance takes place when the larva is in about the condition figured in Fig. 11. The internal modifications of structure which have taken place in passing into this larva are important. The diverticula ("glands," *g*) mentioned above have changed their position relatively to the crimson pigment spots (*m s*) of the fourth pair of bristles. They are now situated in the same segment as these spots, and a diameter connecting opposite clusters of setæ passes through them both. Important changes have also taken place in the cephalic appendages. The basal portion (*b t*) of the tentacle has enlarged at the expense of the distal, which is the remnant of the embryonic appendage. Fully one half of the old tentacle (*t*) now enters into the formation of the new basal joint, which ultimately becomes a permanent cephalic appendage. The distal end of the same is not changed from the condition which it formerly had. The corrugations of the anterior wall of the basal joint have risen into small appendages, which gradually increase in size as one compares those found near the head with those at the

distal end of the joint near its articulation with the distal article. These appendages cease at the point of division between the basal and terminal joints. Patches of reddish pigment are found at intervals corresponding with the positions of the parapodia along the anterior region of the body. Although their color is less conspicuous on other segments than on the fourth, it is as a general thing best marked on the anterior somites. The protuberances ("auricles") from which the embryonic spines (*s*) of the head formerly arose, are also marked with crimson (Figs. 10, 11).

In this stage, the peculiar crochet spines (*c h*) hanging to the posterior region of the body first appear.* On each segment three pairs of these bodies were counted. They arise from the dorsal region of the parapodium. In addition to these appendages the posterior body segments also bear on a ventral elevation smooth spines similar to those on the anterior and middle regions of the body. Later, the hook-like setæ (Fig. 13, *b*) appear on the segments of the middle body region, and rudiments of them may exist in the middle division of the body of the larva we are considering.

The last segment of the posterior region of the body (Fig. 12, *a*) has an oval elongated shape, and is dark red in color. It is flattened ventro-dorsally, broadening into small lateral expansions. Minute papillæ are found on the terminal segment. The anterior body region is now formed of nine, the middle of five, and the posterior of ten segments. The oldest larva of *Prionospio* which was found (Fig. 13) was raised from the last, and differs from it in many particulars. The præoral lobe (*p l*) is much larger and more prominent than formerly. The cephalic tentacles have wholly absorbed the embryonic appendages, whose place they now occupy, appearing as two tentacular bodies with appendages (branchiæ ?) on their anterior outer walls. The tentacles found on the head in the youngest larva have been wholly absorbed into the proximal joint (*b t*). The separation between the middle and posterior divisions of the body is not as well marked in the oldest larva as in those which we have already considered. The posterior limits of the anterior division is easily recognized from its transparency. Although this portion is more transparent, its division into different segments is not as evident as in the middle region. It bears nine bundles of setæ, arranged at regular intervals on each side, and we may regard it as made up of nine segments.

Each parapodium consists of a dorsal and ventral prominence, upon each of which there is a small bundle of setæ. The cluster of crimson (*m s*) opposite the fourth bundle of spines is still well marked. The "glands," which in earlier larvæ were so prominent, have in this very much diminished in size, or completely disappeared.

The intestinal canal does not now occupy comparatively so large a part of

* These spines were first noticed in a larva of this age. They may have escaped observation in earlier larvæ. The embryonic spines of all Annelid larvæ easily fall off when kept in confinement, and there is no uniformity in the appearance of the larva when they disappear under these conditions.

the cavity as formerly, and its course is more tortuous, especially in the posterior region of the body, than in the preceding. Not only have the temporary cephalic bristles fallen off, but also the long spines found on the body have been replaced by shorter and less conspicuous setæ. The most persistent of these deciduous spines are situated in the middle region of the body. In this larva, however, these have given place to minute bristles, and to the "crochet hooks" (Fig. 13, *b*) of the terminal region. I am inclined to think that the temporary body bristles are confined to that portion of the body which is described above (Fig. 1, *a r*) as the anterior region.

The colors of the oldest larva (Fig. 13) are similar to those of the younger. The præoral lobe has little color except in the green regions near the eye-spots. There is in the cephalic dorsal walls, in front of each of the lateral eye-spots, a hemispherical green body. Just below and in advance of the median pair of eye-spots there is a body of the same kind, which has a median prolongation extending nearly to the anterior margin of the præoral lobe. The cephalic tentacles are reddish in color. The lateral lobes on the head, from which the spines formerly arose, are likewise red. The body of the worm is green and brown, with red pigment spots.*

The temporary cephalic tentacles are homologous with the dorsal cirri, while the temporary setæ are strictly the same as those found on the segments of the body.

It will later be seen, in a description of the young (*Nerine*) *Spio*, which likewise has embryonic spines on the head, that two long dorsal cephalic appendages or tentacles also exist in this genus. Here likewise these bodies may be regarded as homologous with dorsal cirri, and as belonging to the same segment as the embryonic cephalic spines, which are later dropped. The median and lateral antennæ and the palpi are not represented in *Prionospio*. From this absence of the appendages last mentioned, we are not to suppose that they indicate in *Lepidonotus* a larger number of cephalic segments than that which exists in *Prionospio*.

In the account given above, the two long appendages to the head are called tentacles, from the fact that in younger larvæ they resemble so closely the tentacles of other Annelides, especially those of the *Spionidæ*. In function, however, they are probably in later larvæ branchiæ, and ultimately assume a form approximating that of the branchiæ in other Annelides. In the growth of the worm, additional branchiæ must also be formed, if we are right in our reference of this larva to *Prionospio*. Intermediate larvæ between that last mentioned and the adult may show that a new identification must be made, and that the larvæ do not belong to *Prionospio*.

* Professor Verrill has kindly examined some of my sketches of this worm, and writes me that they can perhaps be referred to the Annelid which he has mentioned in Amer. Jour., November, 1882, under the name of *Prionospio*. (See also Trans. Conn. Acad., Vol. IV., Pl. XXVII. Fig. 3.)

Spio sp.

Plate II.

The embryos of a species of *Spio* are among the most common larval worms found at Newport. They are very characteristic in form, and on that account are seldom confounded with the larvæ of other genera.

The youngest *Spio* (Fig. 3) is telotrochal, and has a large, præoral lobe bearing an equatorial ring of cilia and embryonic spines, which arise from ear-like backward projections of the head. There are no paired cephalic appendages, and no cephalic eye-spots, although scattered pigment marks the future position of the latter organs on the dorsal region of the head. The embryonic spines are about double the length of those on the body. Each embryonic spine, even when slightly magnified, is found to bear small lateral spurs at regular intervals along its length. When the larva is alarmed, the spines are raised, and project at all angles to their point of origin.

The body is unsegmented, and, like that of other telotrochal Annelid larvæ, bears at its posterior end a ring of vibratile cilia, which arise from a thickly pigmented caudal segment.

In a larva still older* (Fig. 1) than the last, several marked changes have occurred. One of the most important of these is a division of the body into somites, although no parapodia are yet visible along the lateral lines. When seen from the dorsal side, the ridge which bears the ring of cilia will be observed standing out more prominently from the body than in early conditions. Along the anterior or upper part of this ridge there is a row of pigment spots. Slightly removed from the median line, and a little in advance of the ciliated ridge last mentioned, there are four eye-spots, called lateral ocelli. An additional pair of median eye-spots is placed near together on a slight backward extension of the head, behind the ciliated ridge. These, apparently, are wanting in a similar larva of *Nerine*,† of about the same age.

The cephalic appendages (Fig. 2) are short and blunt, and have a length of about one third that of the body. They correspond to the dorsal cirri of the segment which forms the head. Small ventral cirri of the same segment are also found on the same side of the head as the mouth. The body consists of five segments and a terminal joint, which bears a well-marked circle of anal cilia. Each intermediate body segment is pigmented in the following pattern. When seen from the dorsal side, five narrow parallel bands of black pigment extend across the body in the interval between a line on the body opposite the extremity of the dorsal cephalic cirri and the anal circle of cilia. Each of these lines corresponds to a body segment, and, extending through about one

* This larva is of about the same age as that figured and described by Leuckart and Pagenstecher in Müller's Archiv for 1858, Taf. XXIII.

† See A. Agassiz, On the Young Stages of a Few Annelids, Ann. Lyc. Nat. Hist., Vol. VIII., 1866.

fourth the circumference of the body, lies midway between anterior and posterior border. Five similar lateral lines of black pigment alternating with those of the dorsal region are found on the sides of the larva. These markings are placed in two lines, and are found on each segment, but do not join the dorsal series of markings, since they are placed in different regions of the body segments, which are not continuous. On the ventral side of the larva, similar lines of black pigment also appear; but, instead of extending across the medial line, as the markings on the back, they are arranged in two series of parallel markings, of which there is a row on either side of the median line.

The number of segments in the next oldest larva has increased to seven, or, if we include the terminal, to eight. The pattern of color in each segment is the same as that in the younger larva already described. In this, the number of pigment spots on the head has also increased. At the base of the cephalic appendages, near their origin under the ciliated ridge, more especially in the ear-like protuberances ("auricles") which carry the embryonic setæ, there will also be noticed prominent patches of crimson pigment.

Spines indicating the position of future parapodia have appeared in the body segments, although the lateral protuberances are still quite small. The spines of the penultimate segments in many specimens are much longer than the others. The intestinal tract, with the exception of the bend which the œsophagus makes just before it opens into the stomach, follows an almost direct course from the mouth to the vent. The lips and walls of the œsophagus are richly ciliated. The external walls of the body are sparsely covered with small black pigment dots.

Aricidea sp. (?).

Plates II. and VI.

A series of larval Annelides referred to the genus *Spio* has been described by Claparède and Metschnikoff.* The youngest larva, which is here considered the young of *Aricidea*,† closely resembles the oldest which they describe.

The youngest larva of this genus has a close likeness to the young *Spio* (p. 173), but differs from it in having three pairs of setæ, one upon the head, a second on the body at about two thirds the distance from the mouth to the posterior end of the body, and a third at or near the posterior terminal segment. In very young larvæ these spines are very short. The head is more rounded than that of *Spio*, but like it has two ear-like lappets from which the temporary bristles below the ring of cilia arise. There are no eye-spots, and instead of well-bounded ocelli irregular patches of pigment are found on the dorsal surface of the head in a position where eye-spots are later to be seen.

The temporary head bristles are smooth, and destitute of the lateral spurs

* Zeit. Wiss. Zool., XIX., 1869.

† *Aricidea* Webster is not found in our waters. It was taken by H. E. Webster on the Virginian coast. Trans. Albany Inst., Vol. IX., 1879.

already spoken of in *Spio*. There is no well-defined ciliated cephalic ridge bounding the præoral lobe. The body is divided into two segments by a deep constriction just in advance of the first of the two bands of body cilia. The segment which forms the anterior portion of the body shows a number of annulations; the posterior part of the body is thickly pigmented in irregular patches. The final segment bears laterally a pair of long setæ, which extend backward beyond the posterior end of the body. The anterior body segment seems destitute of lateral spines. Bands of black pigment mark the position of the two circles of cilia which accompany the body segments.

In the next oldest larva, raised from the last, we find that the body has become more elongated, and is now marked with two deep constrictions forming three body segments. The anterior of these is crossed by a number of lines forming the annulations to which reference has already been made. The second bears a pair of lateral setæ and a band of pigment. The third body segment carries two ciliated rings, each encircled with bands of pigment. That portion of the head which is in advance of the irregular patches of pigment already mentioned bears a small band of cilia.

An older larva has a body even more elongated than those already described, which is divided into four segments, the first and second of which bear lateral spines. Two pairs of ocelli have differentiated themselves from the irregular masses of pigment formerly found in the dorsal walls of the head.

The next oldest larva was not raised from the last, but has so many resemblances to it that it seems identical with the larvæ already described.

The head has the same general form as that of the preceding, although the præoral lobe is less prominent. It has four eye-spots. The body is divided into fifteen segments, each with lateral spines, and a single terminal segment which is destitute of these bodies although richly ciliated. The spines of the anterior segments are much longer than those of the following. Almost the whole interior of the body is occupied by a stomach, which narrows abruptly in the twelfth segment, passing into a tubular uncoiled intestine. The head of a larva (Pl. VI. Fig. 10) following the last in age is different from that of its predecessor, in possessing a single median antenna (*m t*). The body of the same has fifteen segments, and still retains the embryonic setæ, although their length has very much diminished. The head bears four eye-spots. The cephalic auricles as well as the terminal body segment are still richly ciliated. The stomach ends in the neighborhood of the tenth body segment. The intestine is narrow and straight.

The loss of the embryonic setæ of the head occurs at about this age in the growth of the worm, and in a larva of about the same age as the last, having still fifteen body segments and a ciliated caudal one, these long spines have fallen off, leaving the cephalic "auricles" projecting prominently outward back of the head and in advance of the anterior body segment. This is the oldest larva of the series which was taken.

The above history of the larvæ which are referred to *Aricidea* is of interest on account of the fact that the worm has in the oldest larvæ the long pro-

visional setæ, yet wants the other cephalic appendages of the larval *Spio*. In other words, the appendages, which have been homologized with the dorsal cirri of a head segment, are never developed in this genus, while the spines are formed only to disappear in subsequent growth of the worm as it matures. The median antenna and other cephalic appendages are subsequent growths, and may be looked upon as appendages of the originally single segment.

Polytrochal Larva.

Plate VI.

A single polytrochal larva was taken about the end of the summer. The body is elongated, wormlike, and bears on the sides of the head two flat circular ear-like appendages ("auricles"). Two small well-marked median cephalic eye-spots are well developed. There are no tentacles, palpi, nor tentacular cirri. The rudiments of two appendages resembling tentacles yet of a circular shape point to a relationship between this larva and some member of the *Spionidæ*. The body is composed of twenty-four segments. The posterior terminal body segment ends in two protuberances. Each of the body segments is pigmented on its posterior border. Along the dorsal region of the larva there is also on the median line a similar although larger mass of pigment. There are ten small pigment spots, ring-shaped and of black color, which are placed at regular distances on one side of the body. Each lies on a ciliated segment, and is situated in a median line on the ventral side of the larva.

The pigmental rings (*p r*) on the ventral side of the body of the above-described polytrochal larva seem to have a morphological meaning. At the same time with our collecting of *Spio* larvæ we captured many young worms (Figs. 2, 3, 4), which in outward appearance resemble very closely the older stages in the growth of the same. These larvæ, however, have one very interesting difference, which allies them more intimately with the polytrochal larva described above. As in many Annelid genera, *Phyllodoce*, *Prionospio*, *Telepsavus*, and others, the fourth body segment is modified by the introduction of different-shaped spines, or by pigmentation of the body walls, we naturally expect in other genera to find this segment individualized as compared with its neighbors. In a worm larva, somewhat resembling the polytrochal just described, we find on the ventral side of the fourth body segment a pair of pigmented eye-spots (ocelli?), and that the fourth body segment bears a belt of large cilia similar to those found on the head and caudal extremity. While we recognize in these pigment spots the homologue of the ring-shaped pigmented regions in the median ventral line of the polytrochal larva, we can see in this larva an intermediate larval form between the telotrochal and polytrochal conditions. The pigment spots are probably homologous with the pigmented regions (*m s*) already described in *Prionospio*, where, however, they are forced more laterally, and the ciliated ring on the same segment is lost.

Telepsavus (?).

Plates III. and VIII.

The most common mesotrochal larva at Newport is similar to one supposed by Claparède and Metschnikoff* to be the young of *Telepsavus*. The adult *Telepsavus* has not been found in Narragansett Bay, and the allied genus *Spiochætopterus*, to which Dr. E. B. Wilson † doubtfully refers larvæ from the Chesapeake Bay with many points of resemblance to those which are about to be described, has also not yet been recorded from the locality where my studies were made.

A very common worm larva, which has the whole surface ciliated and an apical compound flagellum, but in which no equatorial ring of cilia had formed, is very commonly found at Newport in our dip-nets. These larvæ (Pl. VIII. Figs. 12, 13, 14) resemble closely the young of *Chætopterus*, but are larger, and in older stages more elongated. They resemble closely the young *Telepsavus* figured by Claparède and Metschnikoff, and on that account are here referred to this genus, although they have not been raised into any member of the present series. They might equally well, however, be connected with the larvæ which have been identified as belonging to the closely allied genus *Phyllochætopterus*.

The young *Telepsavus* (Pl. III. Figs. 6, 7) is quite large as compared with other Annelid larvæ, and can with the unaided eye be easily distinguished swimming about in the water. The body is swollen into an almost globular shape, and is divided into two regions by a mesial ring of cilia. In the youngest stages of growth neither of these divisions is segmented. A fleshy triangular lobe, rounded in front, is largely developed, and extends beyond the mouth on the dorsal side of the head. The lower lip is bilobed. There are two cephalic eye-spots in the youngest larva. The whole body is covered with cilia, and a prominent median cilium is found on the præoral lobe near its rim. The mouth (*m*) has a triangular shape, opening below the lobe, and is surrounded by fleshy lips. No tentacles or cephalic appendages are yet developed.

The posterior portion of the body is short, tapering to the posterior pole of the larva, which bears a segmented (?) tail (Fig. 7, *a*). The anus is dorsal in larvæ of this age.

Almost the whole interior of both cephalic and caudal regions of the body is taken up by a large cavity (*s*) called a stomach, which occupies the greater part of the anterior body region, and extends a short distance into the posterior part. Its walls have a green color, while those of the body are brown and pink. A diverticulum from the stomach extends forward in the ventral region of the body cavity below the œsophagus. The œsophagus in its course bends twice upon itself, and opens into the stomach on the dorsal side. Its walls are

* Zeit. Wiss. Zool., XIX., 1869.

† Observations on the Early Developmental Stages of some Polychætous Annelides, Stud. f. Biol. Lab. Johns Hopkins Univ., Vol. II. No. 2.

thicker than those of the stomach. The intestine is short, slightly coiled, and opens externally through a dorsal anus. The "ventral gland" (*v g*), indicated by a depression in the external body wall on the ventral side of the anterior body region, has not yet appeared.

The above larva is easily distinguished from the young *Phyllochætopterus* (Fig. 16) of about the same age, by the absence of dorsal median eye-spots near the long cilium on the præoral lobe of the head.

In the next oldest larva (Fig. 5) of *Telepsavus*, we find that a new pair of lateral eye-spots has formed, and two slight projections, one on each side, at the base of the head, now appear. These last-formed bodies are the beginnings of cephalic appendages, which later attain a great development. In other particulars, the two larvæ differ very slightly from each other.

The next oldest larva (Figs. 8, 9) to that last described is one in which we have few changes, except those which result from the growth of the cephalic tentacles. Segmentation of the body has begun in the posterior hemisphere, but it has not yet appeared in the anterior. The present larva is almost identical with one of those figured by Claparède and Metschnikoff.*

A larva somewhat older (Figs. 10, 12) than that last mentioned shows more striking resemblances to other Annelid larvæ than any of those which have been spoken of above. Anterior and posterior portions share about equally in the elongation of the whole body. Very slight changes have taken place in the head, although the præoral lobe has elongated and become more prominent, and the median cilium has fallen off.

On the ventral side of the body, a deep infolding ("ventral gland," *v g*) of the body wall has taken place, at a point about one third the distance from the ciliated belt to the front edge of the lower lip. Eight simple lateral protuberances, each bearing a small cluster of spines, are found in the interval between the cephalic appendages and the ring of cilia. On the fourth of these parapodia, counting from the anterior, there are spines (*m s*) which can be homologized with the cluster of spines on the fifth segment of *Polydora*.† These bodies occupy in *Telepsavus* nearly the same position as the crimson pigment spots (*m s*) near the "fourth segment" in *Prionospio*. The portion of the body behind the equatorial ciliated circle has become segmented. The segmentation constrictions are clearly defined, especially on the ventral side of the body. Two pairs of lateral branchiæ (*b*) appear on the segment just behind the ring of cilia, and a single pair on the following.‡ These appendages are richly ciliated over their whole surface. The œsophagus (*œ*) extends through the anterior part of the body cavity from the mouth to the seventh segment of the

* *Op. cit.*

† In *Polydora*, according to A. Agassiz, these spines are found on the fifth segment, which is really the fourth body segment if we regard the head as a single somite. The clusters of red pigment in *Prionospio* are also found on the fourth body segment.

‡ In Dr. Wilson's larva "two pairs of branchiæ" appear "on each of the two segments behind the thickened ciliated ring."

anterior body region. The stomach (*s*) fills most of the body cavity from that point to the sixth segment of the posterior region. The intestine (*i*) is coiled in the posterior part of the body cavity behind the stomach. The anus, as before, opens dorsally. The "tail," a median terminal appendage, is segmented and slightly enlarged at the distal end into a knob or button.

The oldest larva (Fig. 11) gives no more definite information than others already known in regard to the genus to which it belongs.* The posterior part of the body of this larva is swollen, leaving the band of cilia about midway in its length. The præoral lobe has become more contracted, and the external surface of the body is covered with small papillæ. Another pair of pigment spots — the cephalic eye-spots — has been added to the two already existing. The cephalic appendages have elongated so that their tips extend downward to the vicinity of the ring of cilia. There are now ten parapodia in the anterior region of the body between the cephalic appendages and the band of cilia.

The posterior portion of the body is almost hemispherical. The median anal appendage is greatly reduced in size, appearing as a slight projection, on either side of which there are similar lateral knobs. The intestine is slightly coiled, and lies wholly in the posterior body cavity.

Phyllochætopterus sp.

Plate III.

The youngest larva (Figs. 16, 17), of this genus which we have obtained resembles closely a young *Telepsavus*. It is mesotrochal, and has a large præoral lobe, which, like that of the older form of the same figured by Claparède and Metschnikoff,† bears six eye-spots upon the dorsal region. These eye-spots consist of a pair of median and two lateral ocelli on each side. The oral lobe carries on its rim, just in advance of the median pair of ocelli, a flagellum, as in *Telepsavus*. The young *Telepsavus* has four eye-spots; the median pair failing even in a larva in which the tentacles have begun to form on the sides of the head. The youngest *Phyllochætopterus*, even when it has developed into a larva possessing six eye-spots, is still destitute of lateral cephalic tentacles.‡

* Professor Verrill (Trans. Conn. Acad., Vol. IV., Pl. XVIII. Figs. 16, 17) figures this larva, and in MS. explanation of plates, which he has kindly sent me, refers it doubtfully to *Spiochætopterus*. His larva is a little younger than that which is here figured in Fig. 19.

† *Op. cit.*

‡ The Annelid larva (*Mesotrocha sexoculata*) described by Johannes Müller (Müller's Archiv, 1846), by Busch (Ibid., 1847), and by Max Müller (Ibid., 1855), seems more closely allied to this than to the preceding (*Telepsavus larva*). Like the *Phyllochætopterus larva*, it has six eye-spots and two mesial rings of cilia separated by a wide segment. In the figures, however, which are given by the above-mentioned authors, there is no representation of a tuft of cilia (flagellum) situated on the præoral lobe between two of these eye-spots, as is mentioned in the larvæ of

The body of the youngest *Phyllochætopterus* is divided into a large thick anterior, and a smaller posterior region. The mouth opens as a triangular slit on the ventral side, near the anterior extremity of the former. The posterior extremity of the posterior region of the body bears a short median appendage. The mesial band of cilia thus separates the body of the larva into two regions. The anterior of these, which lies in advance when the Annelid is in motion, has a slight depression in its ventral region which marks the position of the "glandular body" described in the larva of *Telepsavus* (and *Spiochætopterus*). The œsophagus, stomach, and intestine can easily be seen through the walls of the body. The anus opens on the dorsal side of the posterior body region, just in advance of the medial caudal appendage. A still older larva (Fig. 18) shows one in which two rows of cilia, separated from each other by a broad segment, are well developed. A segmentation of that part of the posterior body region which is behind the smaller ring of cilia, as well as the more elongated form of the whole larva, is to be noticed in this worm. No cephalic tentacles have yet formed, and the external surface of the body is still covered with small cilia. The globular appendage to the posterior region of the body, figured by Claparède and Metschnikoff,* was not observed. The discovery of the youngest ot these two larvæ of *Phyllochætopterus* is interesting, as showing how close the resemblance between the youngest known *Phyllochætopterus*† and the so-called *Telepsavus* larva is ; or, that the young *Phyllochætopterus* larva has but one ring of cilia between the anterior and posterior openings of the digestive canal, as other mesotrochal larvæ. The second and smaller ring is a later addition.

Nephthys sp.

Plate IV.

The very little which is known of the development of *Nephthys* we owe for the most part to Claparède and Metschnikoff.‡ Larvæ similar to those which they describe, yet in different stages of growth, were raised or fished up in great numbers in our work.

The youngest of these (Fig. 1) are telotrochal, and may be classed with the larva of *Polygordius*. The præoral lobe is very large, and imparts an almost spherical shape to the upper hemisphere of the larva. Equatorially about the larva there runs a ridge upon which a circle of large and powerful cilia is borne. The upper hemisphere or præoral lobe is rounded ; the lower more pointed. The whole larva has a green color, is somewhat transparent, and is

both *Telepsavus* and *Phyllochætopterus*, by Claparède and Metschnikoff, and in the present paper.

* *Op. cit.*

† The adult *Phyllochætopterus* has not been recorded in our waters. (See Verrill's Check List.) Chaparède and Metschnikoff's identification of the larva has been followed in my studies.

‡ *Op. cit.*

ciliated on its outer walls. The ridge upon which the large cilia arise is colored light red. At the lower pole near the vent there is a ring of small cilia. No segmentation has yet appeared in the lower hemisphere. There are conspicuous pigment spots in the lateral walls of the præoral lobe, but they appear in irregular patches of red and brown color. The general disposition of the internal organs is easily seen through the transparent body walls. By far the greater part of the interior of the larva is taken up by the stomach (*s*), a globular inflated sac with gall-green colored walls. It occupies most of the interior of the oral lobe of the larva above and in advance of the ciliated equator. The digestive tract communicates with the external water through two orifices. The first of these is a mouth, and the vestibule intermediate between it and the stomach is probably the œsophagus. The mouth opening lies on one side (ventral) of the larva, just below its ciliated equator. The lower lip of the mouth is richly ciliated. The double row of cilia which together make up the prominent mesial ring divides in the vicinity of the oral opening, one half, composed of smaller cilia, passing below the mouth on the lower lip; the other, or larger, skirting the border of the upper lip. The inner walls of the œsophagus and stomach are likewise ciliated. The lower pole of the larva is placed at an unequal distance from the equator measured on ventral and dorsal sides of the body. Almost the whole of the lower part of the cavity of the embryo, below the plane of the equatorial band of cilia, is taken up by the intestine, which is an elongated sac-like body opening into the stomach on one side, and into the external water through the vent on the other.

The pattern (Fig. 1, *a*) of color on the anal pole of the larva is characteristic in *Nephthys*, and on that account has been of great service in identifications of larvæ of different ages, whenever one could not be raised from another. The pigment is here arranged as follows. Two small areas of green color are found on either side of the anal pole. These areas coalesce with each other on the dorsal, and are distinct on the ventral side. Slightly in advance, and removed from them by a colorless zone, there is a narrow parallel band of green, closed on the dorsal, and open on its ventral side, encircling the body. This unclosed band marks the position of an anal ring of vibratile cilia. It persists with the same characteristic form in very late stages in the development of the worm.

The next oldest larva (Fig. 2) to that described has assumed a slightly different form from the last. The body is no longer spheroidal, but the lower hemisphere has elongated to double its original length. In this growth the præoral lobe has taken, comparatively speaking, no share, and still remains of about the same shape as before. A zone of green appears about the pole of the præoral lobe, and most of the scattered cilia on the external surface of the body have disappeared. The lower or body hemisphere, on the other hand, has become elongated and segmented, although no parapodia have yet appeared in the several body segments. The intestine has lengthened considerably. Its walls, as well as those of the stomach, have a green color, as in younger larvæ.

In a larva still older (Fig. 4) the growth of the body hemisphere has gone

on, and new segments have been interposed between the ciliated ridge and the anal pole. A pair of pigment spots (*k*) resembling ocelli, or "eye-dots," appear in the dorsal walls of the præoral lobe. The general appearance of this larva from the ventral side is characteristic. The præoral lobe is no longer hemispherical, but the elevation of the pole and the formation of a circular ridge or zone a short distance above the ciliated equator imparts to it a characteristic shape. The rounded projection or polar elevation of the præoral lobe above this zone is crowned by a cluster or tuft of cilia. A black spot is found on each side of a median dorsal line passing to the apex of this protuberance. The green zone which was formed in the cephalic region of Fig. 2, while the præoral lobe had a regular hemispherical shape, has now increased in width, and the wall in which it lies bulges out, forming a collar about the lobe. This collar has a more greenish color than the rest of the larva. About its lower rim, however, there is considerable black and some red pigment. The mouth lies near the equator, situated similarly to that of the young *Polygordius* ("Loven's larva"), between two rows of cilia.

The most important change which results in passing from that represented in Fig. 4 into the next oldest *Nephthys* (Fig. 5) is a still further elongation of the body, and consequent diminution in size of the præoral lobe. The most important addition is the formation of the parapodia, the spines (Fig. 6, *b*) of which even in this early stage are serrated, like those of the known species of *Nephthys*. The number of body segments is nine. Each parapodium (Fig. 12, *b*) has a dorsal and ventral cirrus, and bears two bundles of setæ, each composed of several short, serrated spines. The form of the stomach and intestine is more elongated than in the earlier larvæ.

A larva a little older (Fig. 6) than that last described, although not unlike it in general contour, differs considerably from it in some particulars. This difference is a result of changes which have taken place in the internal organs. On looking at the larva from the ventral side, the mouth can be seen just below the equatorial ring of cilia. Behind the mouth through the body walls appears the œsophagus, which when seen from the ventral side has a circular profile. Below the mouth, extending to the region of the seventh body segment, is the stomach. At this point (seventh segment) the intestine begins, and from it is continued into the terminal body segment. Just below the junction of the œsophagus and stomach, on the right-hand side of the figure representing a larva of this age seen from the ventral side, there will be noticed an indentation in the stomach walls, forming by the enlargement a space in the body cavity, in which lies a globular sac. The pulsations of the sac in this and subsequent larvæ can be plainly seen through the body walls. The terminal body segment ends bluntly in two lateral prominences, which are colored green. In the median line between them on the dorsal side there is a small unpaired appendage, which persists in subsequent stages into the oldest larva of *Nephthys* which was studied.

Fig. 7 represents a larva of *Nephthys* still older than the last. The whole larva, more especially the body region below the circle of cilia, has become

longer, and additional segments have formed in the body, by which a still greater likeness to the adult worm has been acquired. It is still, however, free-swimming, although sometimes resting upon the bottom of the glass in which it is confined. The penultimate as well as the terminal body segments, are destitute of spines. The œsophagus has lengthened considerably, and through its walls the jaws (*j*) can be easily seen between the third and fourth segments.* The stomach walls are opaque and colored green.

The "pigment dots" (*k*) found on the apex of the præoral lobe have now changed their position in the head, and moved somewhat backward towards the middle of the body. Each lies on the outside border of a transparent body of spherical shape, which touches on the median line of the larva a similar body on the opposite side. Both are situated in the dorsal walls, and are almost invisible when the larva is viewed from the ventral side. The rows of cilia about the neck are very active, as are also those near the posterior end of the body. The head retains its comparatively large size, and is without appendages.

The next stage (Fig. 9) in the development of *Nephthys* shows us one where the reduction in the relative size of the head and body has gone on, and the cilia, which once formed such a prominent feature about the lower part of the former, have almost wholly disappeared. The head bears a single pair of short antennæ. The body is composed of ten setiferous parapodia and a pair of terminal somites, which are without spines. The segments are separated by deep constrictions, and each parapodium is composed of a ventral and dorsal protuberance, both of which bear serrated spines. The ventral cirrus is short and blunt ; the dorsal long and slender.

The œsophagus has elongated to such an extent that its posterior end now extends backward in the body cavity to the eighth segment. The " eye-spots " (*k*) lie in the dorsal walls of the third body segment. When the œsophagus is protruded outside the mouth opening, these bodies retain their relative position as regards the segment, and are not moved with it, which indicates that they are not connected with the digestive tract, as might at first be supposed. The mandibles, with which they might be confounded, lie between the sixth and seventh segments, and can be protruded with the proboscis.

The oldest larval *Nephthys* (Figs. 11, 12) which was observed has ten body segments which bear spines. I was able in one specimen to detect on the head the beginning of a single representative of a second pair of antennæ, although such could be seen only on one side. In this larva, which is shown in Fig. 11, the head is quite small as compared with the body. The distance from the tip of one lateral spine on a body segment to the end of another, on the opposite side of the body, is three or four times the breadth of the middle of the body. The dorsal region of the head has a green color, in which are irregular patches of black and red. The black pigment probably later concentrates into those

* In the oldest *Nephthys*, figured by Claparède and Metschnikoff, they lie opposite the first body segment.

special pigment spots of the head which are called ocelli. The original "pigment dots" (*k*) lie in the third body segment. The point of separation between the stomach and œsophagus is near the seventh and eighth body segments. The formerly enclosed anal ring of green color and the two regions of green pigment on the last body segment have coalesced, so that the whole terminal segment has the same yellow and green color as the head. The intestine is slightly tortuous in its course, and is clearly differentiated from the stomach. Scattered red pigment spots appear on the external body walls along the dorsal and ventral median lines.

The oldest worm in the series described above was raised from the youngest through the successive stages mentioned. Although the larvæ as a rule bear confinement with little discomfort, I was never able to raise them into the adult *Nephthys*.

The identification of the larvæ of a related species by Claparède and Metschnikoff has been followed, since three forms of the larvæ which are here figured will be found to resemble "stages" which they have already represented. The oldest larva which was studied is much more developed than the oldest which they had, and approaches the adult form more closely, which seems to me to add new evidence to confirm the identification which they made. Until, however, it is raised into an adult, or the youngest is traced back to the mother through the egg, the identification must be regarded as provisional. The homology of the black spots originally found on the apex of the præoral lobe, but now in the fourth body segment, is doubtful. The theory that they are homologous with the embryonic otoliths of *Terebella*, has little to recommend it. It is not known whether they are lost in later growth in older larvæ or not.

Claparède and Metschnikoff speak of these "eye-spots" as eyes with lenses, and the neighboring transparent "cells" as brain lobes. In the oldest larva which they represent in their figures (Pl. XIV. Fig. 3, *c*) these bodies are situated in the head. In the oldest larva which is described in the present paper, they lie in the fourth body segment. Similar bodies have been figured by Bobretsky * in the larvæ of *Pholoë*.

The movement of the "eye-spots" from the head into the fourth body segment is probably brought about by the growth forward of the head and the anterior body segments. The means by which this has been accomplished is not, however, perfectly clear.

* КЪ ИСТОРІИ РАЗВИТІЯ АННЕЛИДЪ, Pl. IX. Figs. 3, 4. The copy of this paper which I have used is from Zapiski Kiefskavo Obshto Yestestvois-pitatalyei.

Lepidonotus squamatus (?).

Plates III. and IV.

The youngest * larva (Pl. IV. Fig. 14) of this genus is monotrochal. The body has a globular shape, upon which the arrangement of the circle of cilia is not perfectly equatorial. The pole of the cephalic hemisphere is pointed, and bears two eye-spots connected over the dorsal surface of the præoral lobe by a double row of pigment spots. Parallel with the mesial circle or circles of cilia are two rows of pigment spots on the upper and two on the lower (posterior) hemisphere of the body. The lower half of the embryo is more elongated than the upper. The mouth is widely open, and lies just below the rim which bears the larger cilia. The lower lip is fringed with a row of smaller cilia. The interior of the larva is occupied by a stomach, œsophagus, and intestine, which are not clearly differentiated from each other.

The next oldest larva (Figs. 16, 17), *Lepidonotus*, is characteristic.† The body has elongated itself, although it has not yet become worm-like in shape. The oral lobe is hemispherical, without appendages, and bears scattered cilia upon the pole. There are four eye-spots arranged in two pairs. The body bears three pairs of lateral appendages, and the terminal segment is prolonged into two short protuberances. When seen from below, each of these will be found to consist of a single appendage, from which arises a bundle of spines. Each of these spines ends in a small tooth and a short terminal articulation (Fig. 16, *a*). Upon the back of the larva we find rudiments of the elytra as diminutive circular plates hanging from the bases of the parapodia, which, however, do not cover these bodies. The interior of the larva is taken up by an œsophagus, a large stomach, which fills most of the præoral lobe and extends downward in the body cavity to the second appendage (parapodium), and a long, straight, narrow intestine, which diminishes gradually in size from its union with the stomach to the vent. Cephalic appendages first appear in a larva a little older than the last. (Pl. III. Figs. 1, 2.) The first of these to arise is the median antenna, which first appears as a stout median protuberance of the cephalic walls on the dorsal side of the head between the eye-spots. The larva now has six ocelli, three on each side. The two lateral antennæ form at about the same time, and have at first very much the same general appearance as the single median appendage.

In the oldest larva (Figs. 3, 4) which I have studied all the cephalic appendages have grown more prominent, while the head itself has become considerably reduced in size. In addition to the median and lateral antennæ,

* The larval stages of *Lepidonotus* given above confirm closely in essential points the account of the metamorphosis of *Polynoë* contained in Max Müller's account published in Müller's Archiv for 1851. The segmentation and early development of the egg up to the formation of the monotrochal larva of an Annelid closely allied to Max Müller's *Polynoë* are figured by Sars (Wieg. Arch. 1845).

† This larva was not raised from the former.

two palpi and two pairs of tentacular cirri have also formed. The anal cirri have greatly increased in length, and now resemble simple filaments.

When such a larva is seen from the dorsal side (Fig. 4), four large circular elytra can be observed above the parapodia. The setæ of the lateral appendages of the body terminate in a short joint, as in the youngest larva, which has already been described. Rudiments of a fifth pair of elytra, the next to appear, can be seen just behind the most posterior of those already formed, or between it and the posterior body segment.

The body of the larva is only partially transparent, although an intestinal tract is visible from the dorsal side through the elytra and dorsal body walls. The parapodia are well developed, and eight in number on each side of the body. Each parapodium is single, undivided, and bears a cluster of long bristles and a long dorsal cirrus. Each seta has a terminal joint and a basal articulation, which carries a small tooth, as in the younger larvæ which have been mentioned above. The elytra are still of diminutive size, although they cover the bases of the parapodia. The point of separation between the stomach and the œsophagus lies just behind and beneath the first pair of elytra. The stomach sends off lateral extensions in pairs corresponding to the second, third, and fourth parapodia.*

Larva of Nereis sp. (?).

Plate VI.

The young of a doubtful species of *Nereis* bears upon the head two lateral tentacles, and two short palpi, each with a basal and terminal joint, the latter of which is richly ciliated. There are also upon the head three well-developed tentacular cirri. The dorsal surface of the head has six eye-spots, two of which are placed near the anterior dorsal rim, and four near the posterior. All are widely separated from a median line.

The body is composed of ten segments, nine of which bear pairs of setæ. The parapodia are very prominent.† Each parapodium has a dorsal and ven-

* The young of an unknown Annelid (Pl. IV. Figs. 13, 13ª) is easily mistaken for the youngest *Lepidonotus* mentioned above. Although monotrochal it wants the paralleled rows of black pigment spots situated above (anteriorly to) and below (posteriorly to) the mesial row of cilia. This embryo is exceptional among monotrochal larvæ, in possessing a single caudal appendage, which is well developed before lateral caudal cirri appear. The unpaired median appendage is not unlike that found in the mesotrochal larvæ of *Chætopterus*, *Telepsavus*, and *Phyllochætopterus*. Does this larva belong to the genus *Harmothoë*, or is it the young of some Bryozoan?

† Compare this larva, as well as the young *Nephthys* (Pl. IV. Fig. 12), in this particular, with the strange genus *Tetraglene* Verr. In respect to its color, size, cephalic appendages, and other particulars, the two are very different. Many specimens of *Tetraglene* have been taken in our work at Newport. (See Verrill, Trans. Conn. Acad., Vol. IV., Pl. XXV. Fig. 10.)

An unknown pelagic worm (Pl. VI. Fig. 5) was found on several excursions,

tral cirrus. The final segment is destitute of lateral spines and has two long anal cirri.

The mandibles can be easily seen through the body walls, and are well developed in this early condition of the worm. The stomach extends from the second to the third or fourth body segment, and the intestine is a small straight tube. The body is transparent, colorless, or of a slight green or brownish tinge.

Pilidium recurvatum sp. nov.*

Plate V.

One of the most interesting of the worm larvæ found at Newport is a *Pilidium* which has many structural relationships to *Tornaria*, the larva of *Balanoglossus*, and to *Actinotrocha*, the young of *Phronis*. This *Pilidium* is the nurse of a worm which has many resemblances to the Nemertean genus *Lineus*. As it differs widely from any known species of *Pilidium*, I have given it for convenience in description the provisional name of *P. recurvatum* on account of the characteristic curvature at its upper end. The new *Pilidium* from Newport differs very greatly from any known species of this genus. The upper hemisphere of the larva is not greatly unlike that of the other species of the genus *Pilidium*, but the outlines of the lower hemisphere are so very exceptional that it is almost impossible to homologize it with any known forms. *P. recurvatum* has not the two circular lappets of *P. gyrans*, nor the arm-like bodies of *P. brachiatum* and *P. auriculatum*. The ring of cilia about the lower hemisphere of *P. recurvatum* is not represented in any other species of *Pilidium*, unless we homologize it with a part of the ring of large cilia on the rim of the body and along the edges of the circular oral plates of *P. gyrans*.

The youngest form of *P. recurvatum* which was taken is represented in Plate V. Fig. 1. The body is elongated, egg-shaped, with the upper end recurved and the mouth downward. The walls are of glass-clear transparency, but always in the same condition, so that it is impossible to tell its age, although it seems to be immature. This worm is of very dark brown or black color, especially in the anterior body segments. The head is small and of spherical shape, although totally destitute of appendages. The eyes are large rounded bodies, two in number, deeply sunken into the anterior dorsal cephalic walls. They have a brownish or chocolate color.

The first six (?) anterior body segments have a black color, and bear small permanent setæ. The following segments of the body are furnished with very long spines, which are very conspicuous as the worm swims in the water. The posterior body segments resemble the anterior in bearing very short spines, although their color is lighter brown and contains more yellow than those of the middle body region. There are in all over fifty body segments. One or two specimens of this worm are taken each year, generally by night fishing.

* This nomenclature is provisional. The larva is not a true *Pilidium*.

and their outer surface is ciliated. The lower hemisphere at a short distance from the lower pole is girt about by a ring of large cilia, which by their constant movement impart onward and various rotary motions to the embryo. It sometimes moves forward in the line of its length, and then whirls on its axis without any direct forward motion. Both of these movements are the results of ciliary action. From the thin outer wall to the cavity* within extend many muscular fibres, which are sometimes simple and sometimes compound, and are generally disconnected with each other. Two of these muscular threads are more prominent than the rest, and extend from a thickening at the apex of the larva to the junction of the œsophagus and stomach. These are regarded as homologous to those muscular strings in *P. gyrans*, which were long ago noticed by J. Müller, and regarded by him, and later by Metschnikoff, as nervous elements.

From the apical thickening of the walls of the larva there arises a short, flexible flagellum, which waves back and forth as the larva moves through the water. The interior of the larva is occupied by an œsophagus, and an amniotic cavity which contains a growing Nemertine worm. The œsophagus fills almost the whole of the bent portion of the larva under the apex. It opens externally by a mouth with ciliated lips. Internally it is continued into the intestinal cavity of the Nemertean. Its walls are muscular, ciliated internally, and contractile. The external lips are slightly pigmented. No intestine or anal opening was seen in the larva. The interior of the body, from the inner end of the œsophagus to the walls which form the lower pole below the ring of cilia, is taken up by a sac, which has been homologized with the amnion of *P. gyrans*. In this sac is formed the young worm. The most conspicuous regions of the amnion are the upper, which is a prolongation toward the apex from the vicinity of the inner terminus of the œsophagus, and the lower part, near the anal pole, which occupies most of the body of the larva. Both of these regions have the walls of the amnion thickly pigmented, as shown in the figures. In the blind sac which constitutes the upper of these pigmented regions lies the future proboscis of the worm. This last structure is movable in the pigmented sheath in which it lies. It sometimes completely fills its sac, and when withdrawn leaves the pigmented amnion in the shrunken condition shown in the figure. The pigmented regions are composed of small granules of a dark red color closely crowded together. They are represented in Bütschli's figure† of *P. gyrans* by a single large and irregular pigment spot. This amniotic pigmentation is not the same as the colored bodies described by

* An *Amnion* such as has been described in *P. gyrans* is already formed in the youngest larva of *P. recurvatum* which was taken.

† In the young of *Polygordius* (Loven's larva), we have described around the margin of the disk a number of problematical bodies, which are very similar to those spoken of by several authors as existing on the rim of *Pilidium*. In both genera they may be foreign bodies, and not patterns of pigmentation. In some specimens of a large undescribed *Pilidium*, found at Newport, they were present; in others, apparently of the same species, absent.

several authors about the rim of the disk and the margin of the oral lappets in the same species.*

Two different sides may be distinguished in the larva. These may arbitrarily be known as the dorsal and ventral. The term dorsal as here used refers to the flexure of the body diametrically opposite that on which the drooping mouth hangs, while the mouth may be regarded as opening on the ventral side. In the imprisoned Nemertean there is also a corresponding dorsal and ventral side. The worm is fastened to the larval nurse by the ventral region, and is free from the amnion at all other points. It hangs in the amniotic cavity in such a manner that its ventral side lies in the same direction as the ventral side of the larva, and the proboscis extends into the recurved portion and lies in an extension of the amnion above the œsophagus. The posterior end of the body of the Nemertean in older stages of its growth is bent at right angles to its length, the extremity being bent upward on the ventral side.

Fig. 2 represents the youngest larva of *P. recurvatum* as seen from the dorsal side. The proboscis is so drawn back that it does not inflate the upper pigmented region of the amnion. The recurved outline of the upper part is turned away from the observer. The lower portion of the body is short and thick. The diameter from one side to the other is less than that measured dorso-ventrally. The general shape of the larva from this side is pyriform. One of the most prominent organs in the structure of the Nemertean enclosed in the *Pilidium* is a pair of spherical organs (*c s*), shown in both Figs. 1 and 2, just below the origin of the proboscis at its point of differentiation from the body of the worm. These bodies lie one on each side of a dorsal median line, and have lateral openings into the amniotic cavity in which the worm is contained, and are ciliated. They may be known as the cephalic sacs, and are probably the same as the "Saugnäpfe" mentioned by J. Müller. These organs are among the earliest structures to differentiate themselves in the growth of the worm, and in older stages of growth each opens externally on the sides of the head by a small ciliated orifice. Four of these bodies were mentioned by Müller, and Bütschli speaks of and figures four in *P. gyrans*. Two only were seen in this stage of *P. recurvatum*. Another pair is of later growth. In the stages of growth older than Figs. 1, 2, the external shape of the larva is somewhat changed, but the increase in size of the Nemertean contained in and borne about by the free swimming nurse takes place without any changes of great importance in the external contour of the larva.

A larva of *P. recurvatum* slightly older than that represented in Fig. 1 carries its snout in a very exceptional manner. In this larva that extremity of the body which is in the majority of cases simply dependent is carried projected outward at right angles to the longer axis of the body. This mode of extending the mouth was observed in a single specimen, and may have been an individual peculiarity. It shows, however, the capabilities of movement which the snout has.

The proboscis of a worm shown in Fig. 3 is very movable in the sac of the

* Arch. f. Naturges., 1873, Band I.

amnion in which it lies. It is here represented as filling the whole sheath, although it seldom remains long in this state, but is drawn back and forth as if even at this early stage in its career its larval life was soon to terminate. The walls of the cavity of the proboscis are well seen in a larva of the age shown in Fig. 2, especially when it is extended so as to fill its amniotic sac. Fig. 4 is another larva of about the same age as that represented in Fig. 3, which carries its snout turned down as in the majority of specimens captured. Fig. 5 is slightly older than Fig. 4, and is a view of the last from the dorsal side. It has at the lower pole a short flagellum, smaller than that found at the apex of the larva, but prominently larger than the majority of vibratile cilia with which the whole external surface of the larval body is covered.

Figs. 6, 7, 8, represent stages in the development of the worm which show a progressive growth of the contained Nemertean. It will be noticed that the whole larva has considerably lengthened its body and become slighter, while the pigmented sac which encloses the proboscis has become much larger. It is also to be noticed that the projecting snout upon which the mouth of the nurse is situated has become contracted in size, and that, as shown in Fig. 7, it has dwindled to a slight prominence. The œsophagus also keeps pace with this reduction in size of the projection in the cavity of which it lies.

In Fig. 9 the relative size of the "nurse" and the contained Nemertean is very different from that shown in previous figures. The proboscis now forms a large and prominent body in a pigmented amniotic sac, filling most of the upper portion of the larva. It moves back and forth in a most restless manner within its prison walls, and seems attempting to escape. The muscular threads which formerly united the apex of the larva with the cavity have disappeared. The lower end of the worm has grown so long that it is folded upward on the ventral side of the nurse, reaching a short distance above the region of the larva in which the ring of cilia lies. The whole of the amnion in which the posterior end of the worm lies is pigmented a fine dark red color similar to that upon the proboscis. On the ventral side of the Nemertean there is an enlargement which is the unabsorbed part of the contents of the amnion transmitted from younger conditions of growth. The walls of the amnion fit tightly upon the worm within, but in places they can be very easily distinguished from those of the worm. The cephalic sac is well marked, the cavity of the proboscis clearly evident, and a well-marked organ on the dorsal side of the Nemertean is probably the primitive formation of the dorsal water-tubes.

In Fig. 10 is represented the oldest *Pilidium* which we have observed. The contained worm has outgrown its narrow confinement, and there remains one important change by which it can extricate itself. If in order to hasten on this change, somewhat akin to evisceration, the larva be put in a small quantity of water, as in a watch crystal, the worm thus confined will be observed to move in the amniotic cavity even more briskly than before, and to fret more strongly against the barrier which envelops it. This hastens on the "critical

stage," similar in some respects to a metamorphosis which has been described in some Gephyrean worms. The enclosed Nemertean, drawing back its proboscis out of the pigmented sheath, protrudes it outside the body walls through an orifice at the lower end of the larva. In a single specimen (Fig. 15) in which the "critical stage" was observed, this opening was seen below the ring of cilia on the lower end of the larva. After resting a moment, suddenly, either normally or abnormally, the half-protruded proboscis is forced still farther outside the larva, turning the *Pilidium* in such a way that it is everted, and appears as a shrunken remnant, forming a marked enlargement at the posterior end of the body. No part of the "nurse" is unabsorbed, and even the pigmented regions of the amnion described above can be detected in the enlargement which characterizes the posterior extremity of a Nemertean which has just passed through the critical stage. In other species of *Pilidium* a majority of authors declare that the original larva, with its enclosed amnion, lives independently for some time after the escape of its Nemertean. Such is not the case in a single specimen of *P. recurvatum*, which was made to pass through the critical stage in the way described above. The body of the larva with the amnion is here absorbed into the posterior end of the body of a growing worm, which it carried in a way not unlike that in which the pluteus bears the young Sea-urchin. The absorption of the larval envelope in *Pilidium recurvatum* is in reality a true Echinoderm feature, and seems to me one more characteristic pointing to the close affinities of these worms and the Echinoderms.

The form of the worm, after it has passed through the wonderful metamorphosis which has just been described, is shown in Figs. 11 and 12. It is now no longer free-swimming, as formerly, and, although ciliated over its whole exterior, is slow moving, and immediately sinks to the bottom of the aquarium in which it is confined. The worm just after the metamorphosis from the *Pilidium* is elongated in shape, pointed at the anterior, and swollen almost globular at the posterior extremity. It is ciliated on its whole external surface. The body is semitransparent, and large patches of pigment appear in the enlargement at the posterior end of the body. Cephalic sacs, with ciliated linings, are well marked, but no eye-spots are seen on the head of the Nemertean immediately after its escape from the *Pilidium*. According to Bütschli the fully grown *Nemertes* of *P. gyrans* is probably destitute of ocelli. In the few specimens of *P. recurvatum* which were found at Newport, no ocelli were observed, while the worm was contained in the amnion previous to the critical stage, and it was only later that the two eye-spots were formed. The oldest form which we have obtained of the Nemertean derived from *P. recurvatum* is yet a long distance structurally speaking from the adult, but yet has so many resemblances to *Lineus* that I have referred it provisionally to this genus. Its general appearance from the dorsal side is shown in Fig. 14.

Many prominent differences between this and the last stages which have been described are found in the general outlines of the body. The great enlargement at the posterior extremity of the worm just escaped from the larva,

as shown in Figs. 11, 12, and 13, has become reduced in size, so that now the greatest diameter is found just behind the cephalic sacs, and the body tapers from this point backward to its posterior end. The larva has three pigmented regions, viz. the very anterior end of the snout, the region just behind the cephalic sacs, and the posterior end of the body. The eye-spots are found on the sides of the head just in advance of the cephalic sacs. These last-mentioned organs are relatively smaller than formerly, and are ciliated in their interior and on the inner walls of the tubes which lead to them from the external orifices.

The internal organs differ slightly from those of the adult *Lineus*. A large stomach, the movements in the walls of which could be easily seen, fills most of the interior of the larva. There is in this larva no visible anus. The sinuous tube (*w t*) which lies on the dorsal side of the stomach has been identified as a water vessel. A similar organ is figured by Leuckart and Pagenstecher in *P. gyrans*.

The form of this singular larva and the strange development of the enclosed worm suggest very interesting theoretical questions. The external outlines of the larva ally it to animals widely separated in our classification from the Nemertean to which it gives origin. Busch, Leuckart and Pagenstecher, and others, have pointed out that in the similar relationship of *Nemertes* to its *Pilidium* we have a parallel condition to that which exists between an *Echinus* and its *pluteus*. In the species of *Pilidium* which they studied, not only the stomach of the larva, but also its œsophagus and mouth, were found to be directly changed into the same organs in the contained Nemertean. In *P. recurvatum* the resemblance which they suggested is even closer than in those species which they have studied, for here not only is the larval mouth and œsophagus only indirectly if at all changed into the same organ in the adult, but also the lower portion of the embryo has a true brachiolarian form which is highly suggestive. Our larva, even more than those of other species of *Pilidium*, shares with *Tornaria* and *Actinotrocha* many Echinoderm characteristics.

The history of the opinions which have been advanced by Müller, Busch, Leuckart and Pagenstecher, Huxley, A. Agassiz, and others, in relation to the resemblance or want of likeness of *Tornaria* to the young Echinoderms, is too well known to be repeated here. If *Balanoglossus* were the only worm whose larva resembles the young Holothurian, the fact might be explained by the abnormal character of the adult. With the Nemerteans, however, the case is somewhat different, for in them we have a large group, whose larvæ have many points of resemblance to the embryonic Echinoderm. Nowhere is that likeness carried so far as in the strange *Pilidium recurvatum*, which has been described above. It would seem at first sight that the circular belt of cilia described in this larva would be an argument against its close affinity with the larval Echinoderm. The same thing may be said of this, which has already been said of a similar belt in *Tornaria*. Far from being an unknown feature, it is a peculiarity in some Echinoderm young, as in *Comatula* and the Holothurians, which are the closest allies of the worms. We find in some young

Holothurians the body girt by several parallel belts of cilia. One only of these rings of large cilia remains unchanged in *Tornaria* and in *Pilidium recurvatum;* but in the former genus two others, very much modified in position and never parallel, form the loop-like bands between which the mouth opens. These bands, quite simple, as I shall later show in the young *Tornaria*, have a very tortuous course later in their career, but never attain the complexity which marks the course of homologous bands on the young of our common Starfish or Sea-urchin. Much greater than its resemblance to the young Echinoderm is the likeness of our new *Pilidium* to the well-known *Tornaria*.

On the same plate with my figures of the larvæ of *P. recurvatum* are introduced for a comparison two illustrations of very young stages in the growth of *Tornaria* (*Balanoglossus*). These are still younger than any larvæ which are yet known of our American *Tornaria*, and present many very interesting features. The closeness of the relationship between them and the younger members of the series of *Pilidium* which they accompany is not the least interesting of the many comparisons which they suggest.

In the youngest (Fig. 16) we have a *Tornaria* of an irregular pear-shaped form, with well-marked œsophagus, stomach, and intestine. A mouth opens on one side of the body and an anus is found at its lower pole. The external surface of the body is crossed by two simple ciliated bands. These have a common union at the upper pole of the larva, but a very divergent course on its external surface. The shorter of these ciliated bands forms a loop varying slightly from the form of a ring, which extends from the upper pole nearly to the equator, but never into the lower hemisphere. The larger band has a more tortuous course than the other, which it resembles in its loop-like form. It is much longer, and extends into the lower hemisphere almost to the lower pole. It meets in its course the smaller band only at one point, which is at the upper pole of the embryo. The mouth opening of the young *Tornaria* lies on its equator under the eaves of a projecting upper hemisphere, and between these two ciliated bands. At the common junction of the two ciliated bands is found a pair of eye-spots, above which rises a small tuft of cilia. The *Tornaria* swims with this region uppermost in the water. From that part of the larva upon which these ocelli are borne, extending internally to the neighborhood of the union of œsophagus and stomach, passes a muscular thread very similar to like threads already mentioned in *Pilidium*. An unpaired tube extends from the point of union of the œsophagus and stomach, on its dorsal side, to the middle of the dorsal flexure, opening externally by a "dorsal pore" about diametrically opposite the mouth. The sac or enlargement of this tube at its inner terminus has not yet reached any great size.

In this youngest *Tornaria* there are, as appears also in Müller's original description of *Tornaria*, *no ring of large cilia* near the anal pole and *no lateral bodies* ("lateral plates," "lappets," A. Agassiz) by the side of the stomach, such as we find in the older *Tornariæ*. All theoretical questions which consider a comparison of these last bodies to the water-tubes of the Starfish larvæ must take cognizance of the fact that the median water-tube, which

passes to the dorsal flexure from the internal end of the œsophagus, is fully formed before any trace of the anal ring of cilia or the lateral bodies ("lappets") found near the stomach have appeared.

The second of the two figures of *Tornaria* (Fig. 17) is taken from a larva still older than the last, from which it differs in one or two particulars. The most important character which has been acquired in the growth of the former is a belt of cilia not far removed from the anal pole, which is found in all later stages in the development of the worm up to its metamorphosis into *Balanoglossus*. The same ciliated belt we also find in the larva *P. recurvatum*, the young of the Nemertean worm which we have studied, but it does not exist in the known species of *Pilidium*, which are the nearest allies of our new Nemertean larva. It is, however, represented in *Actinotrocha*.

A noticeable fact is that the lateral bodies found near the stomach in older *Tornariæ* have also not yet appeared in the growth of the internal organs at this stage of development.

There is another difference between the second and the first of these two larval youngest stages of *Tornaria*. On either side of the œsophagus, originating from the inner end of the muscular thread which arises from the eye-spots at the apex of the larva, is found a pair of rein-like bodies in the form of threads, which extend to points on either side of the mouth. It is not known what their function is, but their position is the same as that of like threads which have been described elsewhere in this paper, for the first time, in our common Loven's larva, similar to its European representative, referred by Schneider and Hatschek to the strange genus *Polygordius*. There is also another characteristic in the very young Loven's larva never yet observed by others, which seems to me of some importance in theoretical questions concerning the affinities of *Polygordius*. A very young Loven's larva was found, in which a long vibratile cilium is borne upon the apex, just as has been mentioned in *Pilidium* and the larva of the above-described Nemertean. Moreover, this cilium, which has the character of a flagellum as far as size goes, rises from a specialized portion of the body of the larva upon which eye-spots are borne. The flagellum in Loven's larva is an embryonic structure, and the portion of the larva which carries it is directly changed into the head of the future worm. In the Nemerteans, however, the flagellum is embryonic, like that of Loven's larva, but the body of the larva plays no part in the formation of the head of the worm, but by its wonderful metamorphosis makes the whole posterior extremity of the larva. No *Tornaria* has been observed with this flagellum at its apex, unless we homologize with it a small tuft of cilia larger than the others on the surface of the body, found at the apex of our youngest larva. Close as the resemblances between *Tornaria* and *Pilidium recurvatum* are, there are many very intimate relationships between the latter and the young of the Gephyrean worm *Phoronis* when known as *Actinotrocha*. The rapidity of the transformation of the *Pilidium* into the Nemertean, more especially the apparent evisceration and turning inside out of the larva at that time, led me at first to regard my larva as the young of some unknown worm allied to

Phoronis. Indeed, I have borrowed from those who have written on the metamorphosis of *Actinotrocha* the term "critical stage," on account of this likeness. I have no hesitation now in identifying *Pilidium recurvatum* as a young Nemertean, rather than a young Gephyrean, although I am doubtful whether I know the generic name of its parent.

Prominent among the characteristics which *Pilidium recurvatum* shares with *Actinotrocha* is the existence in both of a belt of cilia which divides the body into such unequal parts. These regions thus marked out resemble each other in general shape, and probably, if a younger larva of *Pilidium* could be compared with those already known of *Actinotrocha*, before the arms had formed, even closer resemblances might be traced between them. Whatever likenesses there are earlier in the internal organs, they have now been completely masked by the progress of the development. It is very difficult to compare the youngest known *Pilidium recurvatum* with *Actinotrocha*, as far as the internal organs are concerned, notwithstanding there is such a similarity in external outlines.

Polygordius ("Loven's Larva").

Plate II.

The writings of A. Agassiz, Schneider, and Hatschek,* on the development of the very common larva known as Loven's larva, have given a history of its metamorphosis from a somewhat advanced larva into the adult form. All is still dark, however, in regard to the segmentation of the egg and the earliest forms which the larva passes through. As any contribution to either of these parts of the subject must have a value, figures and descriptions of two larvæ younger than any of this worm yet described are here introduced. These take us one step nearer a complete knowledge of the growth and early history of this most interesting worm.

Loven's larvæ are among the most common Annelid larvæ taken in the dip-net at Newport. They are found in all conditions and of all sizes, sometimes swarming in numbers in the collecting glasses. The youngest larva which was found, Fig. 10, has a general structure as follows.

The body of the larva is spherical, transparent, and as gelatinous as that of a Medusa. In its movements in the water it tumbles about, moved principally by the strokes upon the water of an equatorially placed double belt of cilia. The larva has a slightly irregular spherical form, rounded above, somewhat flattened below, and girt midway by two † rings of motor cilia. The hemisphere above these ciliated bands may be called the upper hemisphere, and that below the lower. The upper hemisphere is, with the exception of a slight prominence on one side, regularly rounded and dome-shaped ; the lower is flattened,

* According to the last-mentioned authors, Loven's larva is the young of the strange genus *Polygordius*.

† See Balfour, Treatise on Comparative Embryology. Our *Polygordius* larva is like the European in having two ciliated belts.

broken by an eccentric protuberance on one side. Both mouth and anus open through the lower hemisphere ; the former on one side just below the upper of the equatorial ciliated bands, and the latter on the eccentric prominence already mentioned. The whole exterior surface of the body is ciliated, and the equatorial band consists of two parallel rings, which extend side by side for most of their course, and separate from each other in the region of the mouth, the larger passing above and the smaller below this orifice. This position of the two ciliated rings in an older larva can be seen in Loven's original figures of the European larva. The upper hemisphere has its walls unbroken by any orifice, and is of regular dome-like shape. At its pole arises a short flagellum (*f*), which waves back and forth as the larva moves through the water. The flagellum found at its apex is an embryonic structure, and appears to be lost in more advanced larvæ. On the body walls just below the pole, in a granular zone surrounding the point from which the flagellum arises, there is a collection of cells more or less scattered, the thickness of which decreases more and more near the ciliated equatorial band. This granular mass is the first appearance of that nervous centre which later aggregates about this pole of the larva, and bears the ocelli. Slightly removed from the base of the flagellum, in the walls of the larva, are two pigment spots, one on each side, with well-marked lens, which as the larva grows older and older approximate closer and closer, until they are brought into the immediate vicinity of the pole, in connection with the consolidated collection of cells already mentioned. In the youngest larva, however, they are widely separated ; later, they grow nearer each other. Two prominent clusters of cells (*c d*) are found in the lower hemisphere in the walls diametrically opposite the cluster on the upper hemisphere. These also later form a nervous centre at this extremity of the worm. Around the rim of the larva, in the slight ring-shaped protuberance from which the cilia arise, many brown and yellow colored cellular bodies (Fig. 10[a], *p*) of a problematical character can be found. These bodies vary somewhat in color and size, being generally brownish, yellowish, or greenish, and have a regular spherical shape. They appear to be suspended in membranous dilatations of the disk rim, and to hang from it by a slight attachment. Their disposition on the bell margin is irregular, and not constant. Can this be an instance of the symbiosis of an algous growth on a worm larva ?

The interior of the larva is occupied for the most part by three cavities, each with its own walls separate from those of the body cavity. Two of these have external openings into the medium in which the larva lives. The greater part of the interior of the larva is occupied by the largest of these three organs, which is called the stomach. This structure, which is almost globular in shape, has two openings, one into each of the two smaller cavities. It does not communicate with the surrounding water, and its whole inner surface is ciliated. Of the remaining two internal sacs, one is an œsophagus, and the other an intestine. The œsophagus opens externally through the mouth, and internally into the stomach. Its walls are muscular, contractile, and the inner surface is ciliated. Granules of food in masses were observed in its cavity.

The intestine is more globular in shape than the œsophagus, opening internally into the stomach, and externally through the anus. Its inner walls are ciliated, and its cavity is partially filled in many specimens with fæces.

In a second slightly older larva (Fig. 11) of *Polygordius*, several additions in structure have been made, and marked modifications in form have taken place. In the general outline, the most important change is the flattening of the whole larva, especially on the lower hemisphere, by which the equatorial axis is relatively very much increased. The flagellum on the apex of the upper hemisphere has disappeared, and the two ocelli have drawn still more closely together; so that both now lie very close to the apical pole. The stomach has become more elongated in shape, while the œsophagus has assumed a more tubular form. The beginnings of the funnel-shaped bodies described by Hatschek in the European Loven's larva can be seen as two globular sacs (*e*), one on each side of the stomach, on a level just above a plane passing through the equatorial ring of cilia. Two prominent fibres arise from the collection of cells upon which the ocelli are placed, and pass to the lips above the mouth. Two other threads have a similar origin, and extend meridionally on each side of the stomach to the clusters of cells on the inner walls of the lower hemisphere, at the anal pole of the body. A third pair of threads, hitherto unnoticed, take their rise from the same clusters of cells at the anal pole, and extend parallel with each other to the lower lips of the mouth. They end near two pigment bodies which are constantly found in this region.

The different larval stages in the development of Loven's larva which lie between that represented in Fig. 11 and the adult Fig. 18 have been figured by Hatschek for the European species, and for the American representative by A. Agassiz. New figures of the American larva are introduced in order to show the peculiar brown bodies found about the bell margin, which seem to be characteristic, and the two ventral "nerve cords" shown in Fig. 14, *v n*, which are unrepresented in any drawings of these larvæ which have been published. With the exception of these two differences, our common Loven's larva is similar to the European.

Capitella (young).

A larva referred to the genus *Capitella* has been taken several times in our Newport fishing. These were always in the same condition as that figured in Plate III. Figs. 19, 20, and do not differ essentially from one already represented by Claparède and Metschnikoff.*

Lumbriconereis.

Plate VII.

The cove near the laboratory is the home of many genera of Annelides which live in the fine mud covering the bottom in many places. In the months of June, July, and August, a plentiful supply of eggs in all stages of growth,

* *Op. cit.*

which were identified as belonging to the genus *Lumbriconereis*, were collected at low tide from this locality. They were found attached to the surface of the mud in the form of gelatinous clusters glued together in spherical masses of slime, which, when the flats are covered with water, wave to and fro with passing currents. In size and general external appearance, they closely resemble similar clusters of mollusk eggs found in the same place. The worm embryos, however, have a more greenish color than that of the mollusk, and can after a little practice be distinguished by the unaided eye.

The segmentation of the *Arenicola* egg, which is identical with that of *Lumbriconereis*, has been described and figured by several naturalists, so that the changes which take place in the egg up to the formation of the planula are well known. The series of larval forms which are described and figured in this paper opens with one where a segmentation of the ovum is completed, and extends to a larva in which certain generic structures of *Lumbriconereis* are well marked.*

In Fig. 1 we have represented the egg at that period in its development when the smaller spheres, "micromeres," have partially grown about the larger "macromeres," two of which seen in profile appear at one pole. When the pole at which thc macromeres lie is seen from above, so that they occupy the centre of the circle of vision, four macromeres surrounded by the encroaching micromeres can be easily seen. When viewed in profile, as in the figures given, only two of the larger spheres appear. In an egg a little older, the forming micromeres encroach still more on the pole at which the macromeres approach the surface of the ovum, until ultimately the latter are wholly surrounded by the smaller cells.

The youngest of the planula series has a spherical and slightly ovate form, bearing at one pole a clear projection easily distinguishable from the remaining parts of the embryo. This projection may be called a cephalic prominence. The whole interior of the larva is occupied by large nucleated cells, which are easily seen through a transparent outer layer. On the pole opposite that capped by the transparent cephalic projection which has been mentioned, there has been differentiated from the outer surface a thin layer which marks the beginning of the body of the worm. The cap-shaped cephalic prominence at the upper pole is the first appearance of a head. The whole external surface which lies between these prominences of the larval body is a broad ciliated zone, which occupies the greater part of the external surface of the worm.

The first important additions to a simple larva girt by a broad band of cilia, which we have just described, is the formation, at either pole, in the clear spaces which we have mentioned, of small prominent pigment spots. Five of these are formed at the cephalic, and four at the caudal pole. Those which appear in the cephalic prominence are three in number, placed one medially, with one on each side near the pole, and one on each side near the equatorial

* These larvæ resemble closely the young *Arenicola marina* (*piscatorum*) of Max Schultze (Abhand. d. Natur. Gesell., 1856), or those of *A. cristata*, Stimp., described by Dr. E. B. Wilson, *op. cit.* The larvæ doubtfully referred to *Lumbriconereis* by Claparède and Metschnikoff (*op. cit.*) are generically different from mine.

band of cilia. The caudal embryonic spots are arranged in a row side by side, near the lower or caudal pole. From each pigment spot, cephalic or caudal, pass towards the centre of the larva a number of delicate threads, which are ultimately lost in the larval body. The cephalic protuberance is formed of two layers, an outer transparent, and an inner more opaque. The large cells, macromeres, in the interior of the larva, are smaller in number, and do not occupy as large a part of the embryo as formerly. The ciliated band has narrowed relatively to the length of the whole embryo.

Fig. 4 is taken from a larva still older than the last. In this embryo, the cephalic protuberance has been but little changed, while the caudal has grown much larger than formerly. The most important additions in this embryo are two rows of lateral pigment spots on the posterior margin of the ciliated band. These lateral spots persist into very late stages in the growth of the worm, and are identical with those collections of pigment found on the auricles which bear embryonic cephalic spines in *Nerine*, *Spio*, and other genera. The row of lateral ocelli (?) cross the body of the embryo following the lower edge of the ciliated band in an oblique direction. Around the dorsal surface of the larva the ciliated band is uniform in breadth, but on the opposite or ventral side it contracts and narrows to fully two thirds its former width. The oblique direction of the lateral lines of pigment is due to this narrowing of the ciliated band. Posterior to the narrowest part of the ciliated band is a clear space, into which, on the ventral side, the mouth opens.

The posterior or caudal portion, which is in reality the growing body of the worm, now becomes more elongated, and the two layers which form its walls become more and more evident. The central part is not yet differentiated into stomach and intestine, but is made up of large and small clusters of original macromere cells.

In Fig. 7 is seen the formation of the first body segment with its solitary spine. The head is now more pointed than formerly, and through its walls, near the upper margin of the ciliated band on the ventral side, two small clusters of cells, the origin of the infraœsophageal ganglia, appear. The body has become more elongated, and is swollen midway in its course, at the points in which the first parapodia are formed. One or two more pigment spots have formed at the posterior terminus of the body.

The spines first appear as needle-like bodies, enclosed in the lateral walls midway between the posterior border of the ciliated band and the caudal pole of the embryo. It is only after they break through the walls which surround them, and greatly increase their size, that their extremity is modified in the manner shown in the figure.

In Fig. 8, a still older larva than that last described, it can be seen that the spines of the first parapodium have already broken through the external body walls, and a second segment has begun to form behind the first. As in the former only a single spine at first appears on each side, so here there forms on the second parapodium a simple spicule imbedded in the body walls. The whole worm has lengthened very considerably, and a mouth has broken through

into a clear space beneath the ventral surface, the beginning of the œsophagus. No ciliary ring has yet appeared at the anal end of the larva.

The embryo, although possessing spines which can be projected from the body, and a ring of cilia about the head, is still with others enclosed in the mass of slime in which they were laid. All have very limited movements, even when artificially set free from the cluster in which they are bound together. Their bodies, especially the central part, have a dirty green color, while the head, ciliated band, and body walls are more transparent.

In the subsequent changes which the external form of the larva passes through, there is little of interest to be mentioned. Parapodium after parapodium is added, increasing the length of the body of the worm. The new segments always arise back of that which is previously formed, while in advance of all, between the first body segment and the posterior border of the ciliated band, marked on the sides by the lateral rows of pigment spots, there are no lateral appendages to the external body walls. From its position and its subsequent history, this bare part of the body immediately behind the head is probably homologous with the anterior body region (*a r*, Fig. 1), which has been already elsewhere described in the genus *Prionospio*.

In my figure of the larval *Lumbriconereis* with two pairs of well-formed spines, it will be noticed that the digestive tract has already differentiated itself into two regions, an anterior, larger, and more capacious, and a posterior more tubular portion. The former of these is later changed into the stomach, while the latter is destined to form the intestine. The point of separation of one of these from the other is not yet well marked.

At the anterior end of the stomach, on one side, a globular body is constricted from the stomach walls at about this time. The ultimate history of this organ has not been traced, and its function is unknown. A similar body has been mentioned in the young *Nephthys*. The jaws in the larval, as in the adult *Lumbriconereis*, are very complicated, and consist of two parts, a dorsal and a ventral. The ventral jaw is formed of a single crescentic chætinous plate, the horns of which extend forward. The regularity of the concavity of the anterior edge of the jaw is broken by a single small median tooth. The posterior edge of the jaw is continued backward into two elongated projections, which extend parallel with each other, and are separated by a narrow slit.

The dorsal jaws are still more complicated than the ventral. They consist of four pairs of chætinous articulations which act as teeth, and are arranged in pairs the members of which are placed opposite each other. The two anterior of these are simple teeth with smooth edges, the former with a triangular outline ; the latter is more elongated, narrower, and more pointed.

The body of the dorsal jaws is formed of two flat or slightly curved oblong plates, whose opposite edges are serrated. By the approximation of these borders, the true function of this complicated mechanism is accomplished. To these oblong, serrated plates, on their posterior border, are articulated the last pair of bodies which form the dorsal jaws. These take a triangular shape, and have for their function a firm attachment for the remaining parts of the jaw.

They have a ligamentous junction with the posterior border of the oblong serrated plates which form the body of the jaw.

In their simplest form there is a remote resemblance between these jaws and the chætinous teeth of the species of *Branchiobdella* found parasitic on the crayfish.

Nectonema agilis VERR.

Plate VIII.

Almost every summer for a number of years we have captured at Newport a worm of doubtful affinities, which seems to be the same as that described by Prof. Verrill as *Nectonema agilis.** The only description of *Nectonema* known to me is found in the Proc. Nat. Mus., 1879, p. 187. The present account will be found to confirm in the main the excellent observations recorded there by Prof. Verrill, and I hope add something to what little is at present known of its highly interesting anatomy. As no figures have yet appeared of this worm, a few are introduced in Plate VIII. to illustrate its general form.

Three specimens of *Nectonema* were collected in 1883. These were found free-swimming, and were taken in evening fishing

The body is long, thread-like, round, with the lateral lines slightly flattened. It has a light brown or straw color and nearly opaque walls. *Nectonema* moves through the water with great rapidity, coiling and uncoiling itself with tireless energy as it swims. The length of the body varies in the specimens studied, from four to six inches.

The external body walls are smooth and unsegmented. Generally opaque, in some specimens internal organs can be seen through its sides. The two extremities are for the most part the most transparent.

From one extremity to the other on each side there extends a well-defined, broad, lateral band, which is laid out in squares marked in outline by black pigment. This superficial marking may define a deeper anatomical segmentation, or it may be confined to the surface of the body and the walls immediately adjacent below the surface. Each square is separated from its neighbors by a raised band. The dorsal † sides of the squares appear the most densely pigmented. A granulated line of cells extends from one end to the other through all the lateral squares which make up the lateral bands.

In some specimens there is found on the lateral bands two rows of hairs closely crowded together, so that they sometimes appear in bundles. These hairs seem to be connected by a muscular web, and are generally covered with mucus and foreign matter which has become attached to them.

Although the two extremities closely resemble each other, there exists a marked difference between them in minute anatomy.

* My attention was called to his description by Prof. Verrill, on being asked to identify one of my specimens.

† Dorsal and ventral lines of the body of this filiform worm are very difficult to distinguish.

The anterior end (Figs. 5, 6, 7, 8) is blunter than the posterior (Fig. 10), and in one specimen has a clear cavity within, easily seen through the cephalic walls, in which, as Verrill has already mentioned, four transparent, nucleated, cells lie. The mouth cannot be observed very distinctly, but is discovered by close observation on the ventral side of the head as a narrow longitudinal * slit. There are no cephalic tentacles or other appendages to the head. A pigment spot was noticed in the walls of the head just in advance of the transparent region, but whether it is an ocellus or not was not determined. The digestive tract, which is of varying diameter, but always small as compared with that of the body cavity, extends from one extremity of the crown to the other. The walls are muscular, and at times have a rhythmic pulsatile motion, which may be seen through the body walls. The anus is terminal, and mounted on a curved caudal prolongation of the body, slightly enlarged at its extremity. According to Prof. Verrill the posterior end of the male and female *Nectonema* differ from each other, and he speaks of a peculiar "papilla" found in this region of the female.

The stomach and intestine often become so inflated that they fill the body, so that they cannot be distinguished from those of the body cavity. The "yellowish white organ [ovary ?] extending from near the head to the tail," mentioned by Prof. Verrill, was observed in one specimen.

The affinities of this singular worm with known genera are somewhat doubtful. Prof. Verrill, with an implied expression of doubt, refers it to the Nematodes. That reference seems to me a proper one, but from what little is known of its anatomy it can find few near relatives among the genera now known in this group of worms. It must, if a Nematode, take its place near the *Chætosomidæ*, or perhaps by the side of that strange worm *Eubostrichus*, of even more problematical affinities, described by Greef,† from the North Sea. If near the latter, it is as a giant with a pygmy, for *Eubostrichus* is but 8 mm. in length, while *Nectonema* is ten times as large. The matted covering, formed of hairs, which characterizes *Eubostrichus* according to Greef, does not exist in *Nectonema*. There is, however, a tendency for something like this covering to form on the hairs along the lateral lines. *Nectonema* is a genus with close affinities on the one side with the Nematodes, while on the other it presents strongly marked Chætopod characters. The segmentation so pronounced on the lateral bands, and the double row of hairs upon the sides, point to the Annelides as its nearest allies. The connecting web of the lateral hairs recalls the lateral fins of *Sagitta*.

* In Prof. Verrill's specimen, "a *transverse* whitish band seemed to indicate the position of the mouth."

† Arch. f. Naturg., 1869.

CAMBRIDGE, December, 1883.

EXPLANATION OF THE PLATES.

PLATE I.

Prionospio tenuis VERR.

a r. Anterior region of the body.
a g. Anal gland.
b t. Basal joint of the tentacle, which, as the larva grows older, increases its size at the expense of the embryonic tentacle (*t*).
c h. "Crochet hook" spines.
g. Glandular body which originates as a sac-like prolongation of the stomach cavity, becomes pigmented, and is ultimately lost in older larvæ.
h. Heart.
m. Mouth.
m s. Cluster of pigment spots found on the fourth body segment.
o. Ocellus.
p. Proboscis.
p l. Præoral lobe.
p r. Posterior region of the body.
s. Embryonic setæ.

Figs. 1, 2. Young larvæ of *P. tenuis*.
" 3. Young of the same, a little more advanced in age.
" 4. Head of the last larva from the ventral side.
" 5. Still older larva in which an articulation has appeared at the base of the cephalic tentacle.
" 6. The same, with the cephalic setæ pressed to the sides of the body.
" 7. Still older larva.
" 8. Side view of the last.
" 9. Ventral view of the head of the same.
" 10. Side view of an older larva.
" 11. Older larva, in which the cephalic spines have disappeared (dorsal view).
" 12. More developed larva in which the provisional cephalic tentacles have been replaced by the permanent branchiæ.
" 12 . Posterior segment of the last larva (dorsal view).
" 13. Oldest observed larva of *P. tenuis*.
" 13 . "Crochet hook" spines of posterior segments.
" 13[b]. One of the same magnified.

PLATE II.

Spio, Aricidea, and Polygordius.

a. Anus.
at. Tuft of cilia arising from the caudal extremity of the body on the dorsal side of the vent.
c. Cluster of cells near the anal pole of the larva.
cs. Ciliated pits.
d. Cluster of cells which later concentrate into a cephalic ganglion.
e. Funnel-shaped organ described by Hatschek.
f. Flagellum.
frs. Larger ciliated belt.
i. Intestine.
ln. Lateral nerves.
m. Mouth.
mp. Pigmented bodies on the lower lip.
n. Nerve from apical ganglion to upper lip.
o. Ocellus.
œ. Œsophagus.
p. Spherical bodies on rim of the disk.
r. Characteristic pigment band on the dorsal region.
s. Stomach.
srs. Smaller ciliated belt.
u. Transparent projection on the dorsal side at the junction of anterior and posterior body regions.
vn. Ventral nerve, extending from the caudal end of the larva to the spherical bodies found on the lower lips.

Fig. 1. *Spio* larva (dorsal view).
" 2. More advanced larva of the same.
" 3. *Spio* larva (side view).
" 4. *Aricidea* larva (dorsal view).
" 5. The same, with embryonic spines elevated.
" 6. Older larva of *Aricidia*.
" 7. Youngest larva of *Prionospio tenuis* Verr.
" 8. Posterior region of the last.
" 9. *Capitella* larva.
" 10. Youngest "Loven's Larva" (*Polygordius*).
" 10ª. The same, from above.
" 11. Still older larva of the same.
" 12. Older Loven's Larva.
" 13. More advanced larva (side view).
" 14. View of the same from above.
" 15. Magnified portion of the rim of the last.
" 16, 17. Pigmentation of posterior end of *Polygordius* larva (16, anus closed; 17, cloacal wall extruded).
" 18. Adult *Polygordius* raised from the above larva.

PLATE III.

Lepidonotus, Telepsavus, and Phyllochætopterus.

a. Anus.
b. Branchiæ.
e. Elytron.
i. Intestine.
m. Mouth.
m s. Modified fourth segment.
œ. Œsophagus.
pl. Præoral lobe.
s. Stomach.
t. Tentacle.
v g. Ventral gland.

Fig. 1. Side view of a young larva of *Lepidonotus*.
" 2. Ventral view of a still more advanced larva of *Lepidonotus*.
" 3. Older larva of the same.
" 4. Oldest larva of *Lepidonotus* (dorsal view).
" 5–15. *Telepsavus* (?). (Figs. 8–15 drawn by A. Agassiz.)
" 5ª. Youngest larva of *Telepsavus* (dorsal view).
" 6. Older larva of *Telepsavus* (ventral view).
" 7. Side view of the last.
" 7ª. Tail of the last.
" 8. Older larva of *Telepsavus*.
" 9. Side view of the last.
" 10. Side view of a still older larva.
" 11. A larva still older (dorsal view).
" 12. Oldest *Telepsavus* larva.
" 13. Mouth and præoral lobe of the same.
" 14, 15. Differently formed spines of the oldest larva.
" 16–18. Larvæ of *Phyllochætopterus* (?).
" 16. Youngest larva of *Phyllochætopterus*.
" 17. Side view of the same.
" 18. Older larva of the same.
" 19, 20. Larvæ of *Capitella*.

PLATE IV.

Nephthys and Lepidonotus.

d c. Dorsal cirrus.
i. Intestine.
j. Jaws.
k. Cephalic spots (ocelli ?).
m. Mouth.
p s. Pigment spots.
s. Stomach.
v c. Ventral cirrus.

Fig. 1. Youngest larva of *Nephthys*.
" 2. Older larva of the same.
" 3. The same.
" 4. Still older larva from the ventral side.
" 5. Later stage (ventral view).
" 5ª. Lateral view of the last.
" 6. Larva with well-developed parapodia.
" 6ª. Single parapodium of the same.

Fig. 6ᵇ. Serrated spine of parapodium.
" 7. Larva of *Nephthys* older than the last. View from the dorsal side.
" 8. The same. View from the ventral side.
" 9. Larva of *Nephthys* in which the cephalic tentacles have begun to form.
" 10. The same. View from the dorsal side.
" 11. Still older larva.
" 12. Oldest larva of *Nephthys*.
" 12ᵃ. Head of the same.
" 12ᵇ. Parapodium of fourth segment.
" 13. Larva of *Harmothoë* (?).
" 13ᵃ. The same seen from above.
" 14. Youngest larva found of *Lepidonotus squamatus*.
" 15. The same, more advanced in growth (lateral view).
" 16. More advanced stage of *Lepidonotus* than the last (dorsal view).
" 17. The same (ventral view).
" 18. Telotrochal larva allied to the young of *Polygordius*.

PLATE V.

Pilidium (?) and Tornaria.

a. Anterior end of the worm.
c o. External opening of the cephalic sac.
c s. Cephalic sac.
d p. Dorsal pore.
i. Invagination in the lateral wall of the larva.
m. Mouth.
œ. Œsophagus.
r. Half-absorbed remnant of the larva.
s. Stomach.
w t. Water vascular system.

Fig. 1. Youngest Nemertean larva with well-developed œsophagus and stomach.
" 2. Dorsal view of the same.
" 3. Older larva with extended snout.
" 4. Larva still older than the last.
" 5. Dorsal view of the same.
" 6. Older larva with lengthened proboscis.
" 7. Larva just before the extrusion of the worm.
" 8. Larva of the same age as that shown in Fig. 3, yet without cephalic sacs.
" 9, 10. Larva just before the birth of the contained Nemertean.
" 11. Young worm just transformed from the larva.
" 12. Dorsal view of the same.
" 13. Side view of the last.
" 14. An older Nemertean which probably developed from the last.
" 14ᵃ. Proboscis, seen from below.
" 14ᵇ. The same, from one side.
" 15. Critical stage in the metamorphosis from the original larva.
" 16. Youngest *Tornaria* found at Newport.
" 17. Still more mature *Tornaria*, also from Newport.

PLATE VI.

Aricidea, Nereis, and Unknown Genera.

m. Mouth.
m s. Mandibles.
m t. Median tentacle.
œ. Œsophagus.
p r. Ring-shaped pigment regions on ventral side of body.
q. Two ventral pigment spots on fourth body segment.
r. Dorsal pigment bands.

Fig. 1. Larva of *Aricidea* (dorsal view).
" 2. Unknown Annelid larva with two ventral pigment spots.
" 3. The same, slightly older.
" 4. The same, older (Figs. 2, 3, 4, ventral view).
" 4ª. Side view of Fig. 2, showing the prominence (*g*) upon which the ventral pigment spot is borne.
" 4ᵇ. Side view of ventral prominence in Fig. 4.
" 5. Unknown pelagic worm larva.
" 6. Larva of *Nereis*.
" 6ª. Head and jaws of the last.
" 7. Larval Annelid with pigmented ventral rings, described in the text as polytrochal larva (ventral view).
" 8. The same, dorsal view.
" 9. The same, lateral view (head represented downward).
" 10. Larva of *Aricidea* more advanced than that shown in Fig. 1.

PLATE VII.

Lumbriconereis.

a p. Anterior pole.
a r. Anterior body region.
c b. Ciliated band.
c p. Caudal pigment spots.
i. Intestine.
j. Jaws.
l o. Lateral ocelli.
l p. Lateral pigment spots.
m. Mouth.
ma. Macromeres.
mi. Micromeres.
n c. Ventral nerve cells.
œ. Œsophagus.
p p. Posterior pigment spots which ultimately become the caudal pigment spots, *c p.*
s. Stomach.
z. Unknown organ developed from stomach.

Fig. 1. Egg of *Lumbriconereis*, in which the micromeres have almost wholly surrounded the macromeres.
" 2. Larva of *Lumbriconereis*, in which the anterior prominence (*a p*), the ciliated band, and the external layer have formed. The large macromere cells are to be seen in the middle of the larva through its walls.
" 3. Still older larva of the same, more elongated, and with the anterior prominence pointing to one side.
" 4. Larva of *Lumbriconereis*, in which the internal large cells are less distinct, and in which cephalic and caudal ocelli have appeared.
" 5. The same larva, a little older, in which lateral pigment spots, as well as those mentioned in the preceding figure, are seen.
" 6. A larva still older, the caudal segment of which has begun to lengthen into the future body of the worm.

Fig. 7. Larva of *Lumbriconereis*, showing the formation of the mouth and first body segment (1) below the ciliated band. The two clusters of cells above the upper border of the same, near the medial line, are the beginnings of cephalic ganglia. (Ventral view.)

" 7ª. Lateral view of a larva a little younger than the last.

" 8. Larval *Lumbriconereis* older than that shown in Fig. 7.

" 9. Still more mature larva of the same, with the rudiments of a second (2) and third (3) body segment.

" 10. The same larva still more mature.

" 11. Larva with three well-defined parapodia and rudiments of two segments posterior to the last.

" 12. A more mature larva with extended setæ and well-developed jaws.

" 13. The oldest form of the larval series referred to *Lumbriconereis* possessing seven pairs of setæ, the most anterior of which are doubled, while the immature forms of new spines can be seen in the more posterior segments.

PLATE VIII.

Lumbriconereis, Nectonema, and Unknown Genus.

a. Anus.

cp. Ciliated pits on the sides of the head.

is. Immature setæ at the base of those already formed in the body walls.

l. Lateral lines.

lj. Lower jaw.

sg. Division between two segments.

uj. Upper jaw.

w. Segmental orifice.

wb. Body walls.

1, 2, 3, 4, in Fig. 3ª, articulations which together form the lower jaw. Of these No. 1 is anterior.

Fig. 1. Setæ and muscular attachments of the same in *Lumbriconereis* larva. (The spine is represented as retracted.)

" 2. The same, extended.

" 3. Larval *Lumbriconereis* with three parapodia.

" 4–10. *Nectonema agilis* Verr.

" 4. The adult *Nectonema*.

" 5. Enlarged view of the head of the same.

" 6. The head from dorsal side.

" 7. Clear space with contained cells (ova ?) in the head.

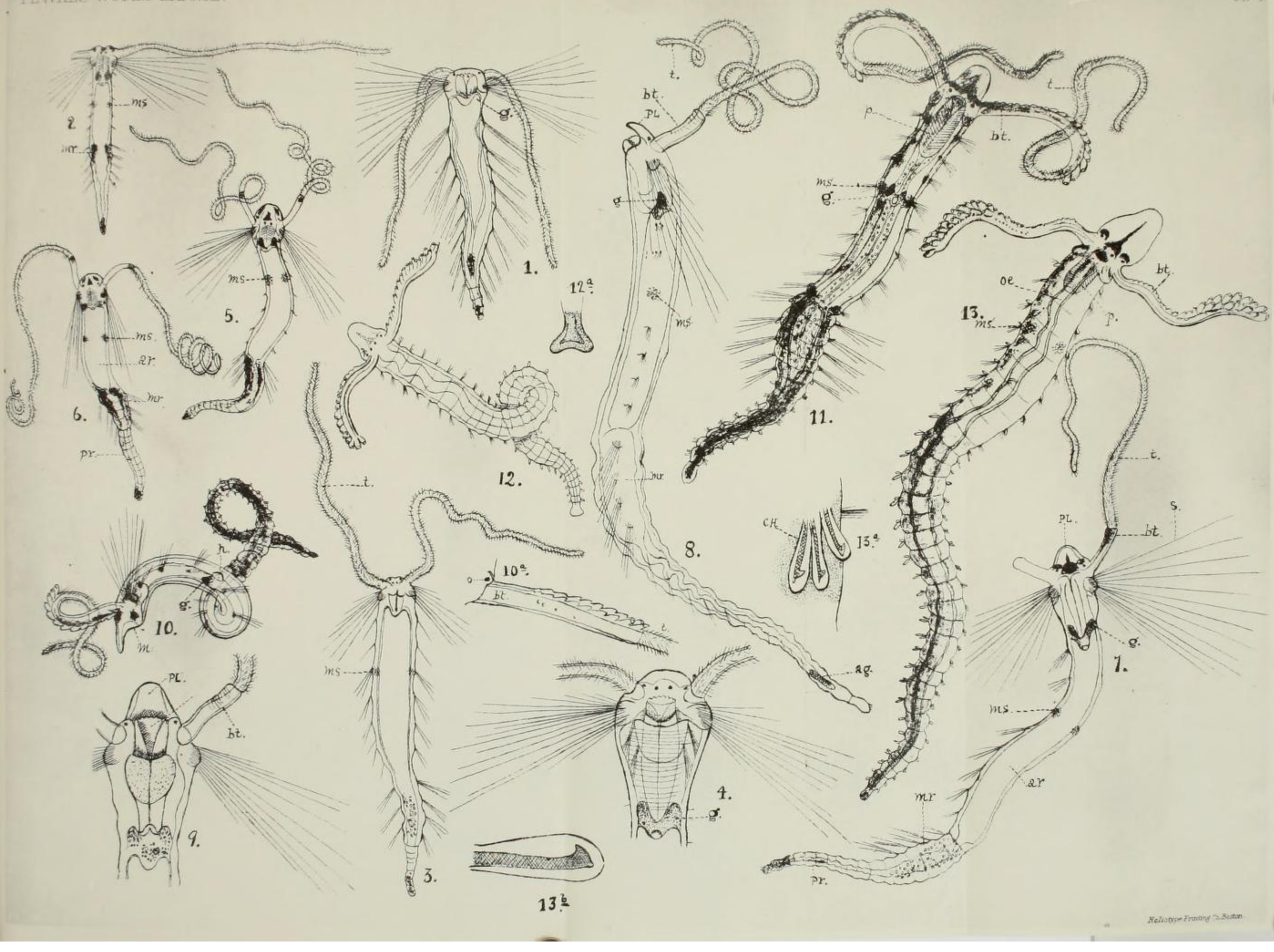
" 8. The same from dorsal side.

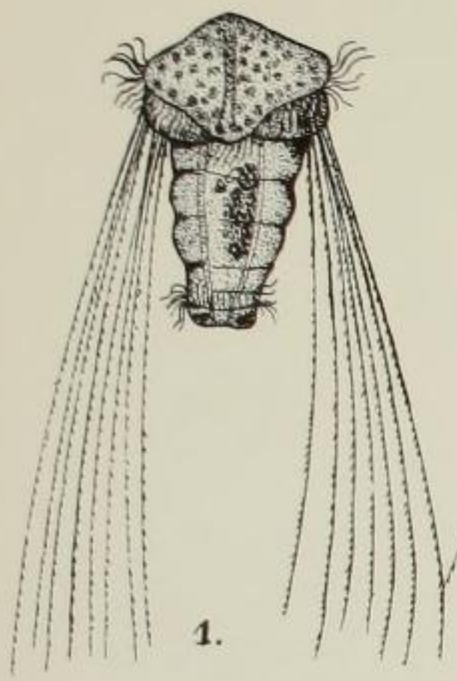
" 9. Magnified view of a section of the lateral line, destitute of lateral spines and "connecting web." These last structures were not found in this specimen.

" 10. Posterior end of the body (♀ ?).

" 11. *Cephalotrix linearis* (young).

" 12–14. Three larval stages in the development of a mesotrochal Annelid, probably *Telepsavus* or *Phyllochætopterus*. (Younger than those figured in Pl. III. See text.)

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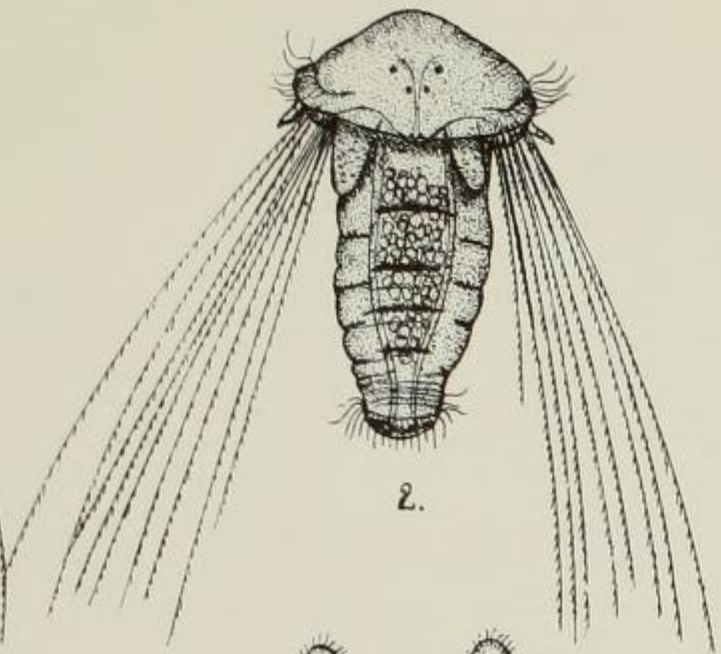
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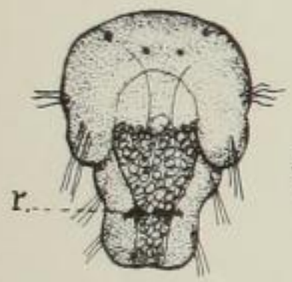
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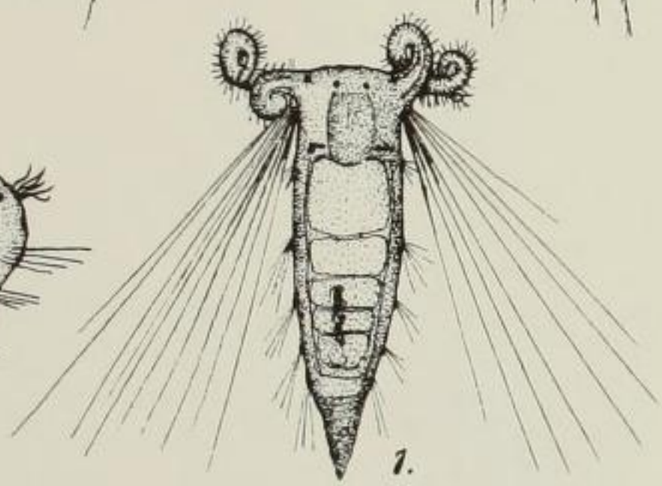
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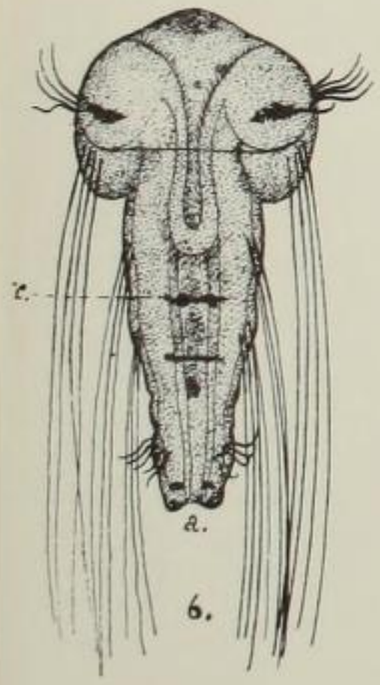
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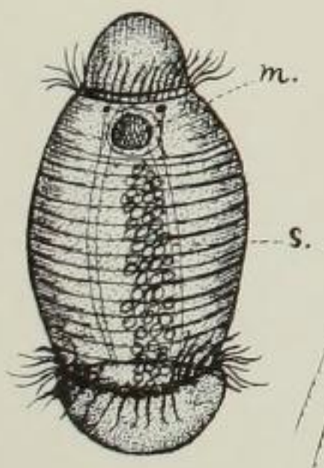
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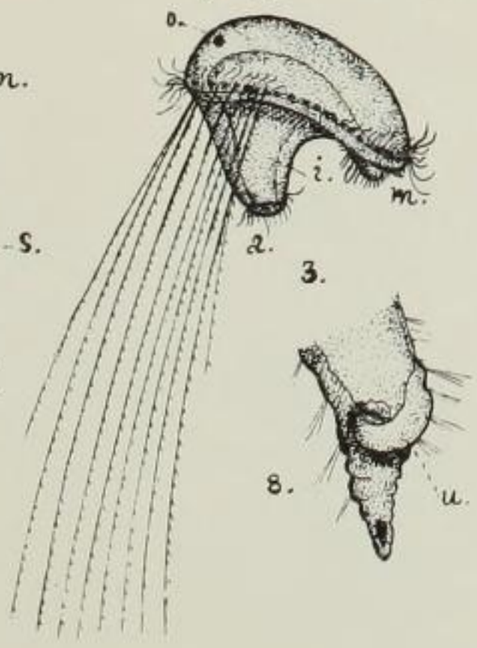
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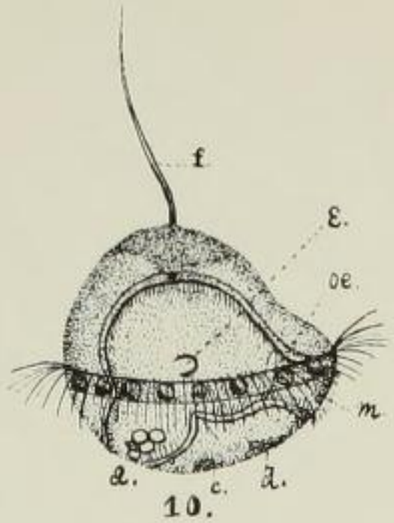
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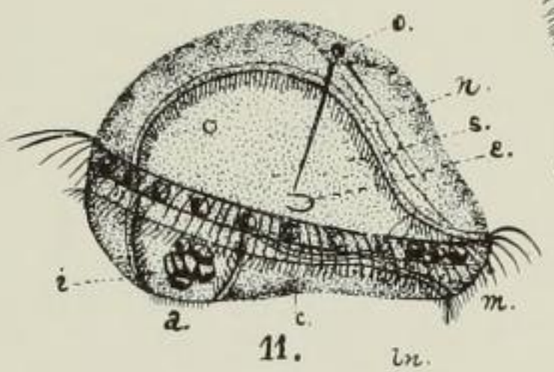
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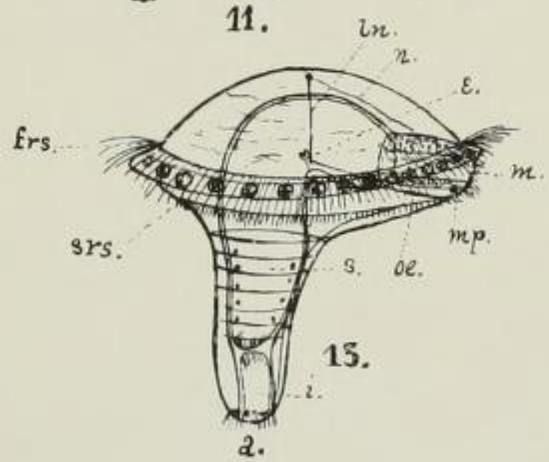
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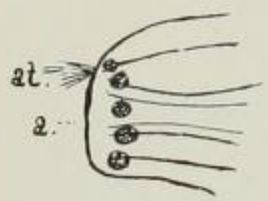
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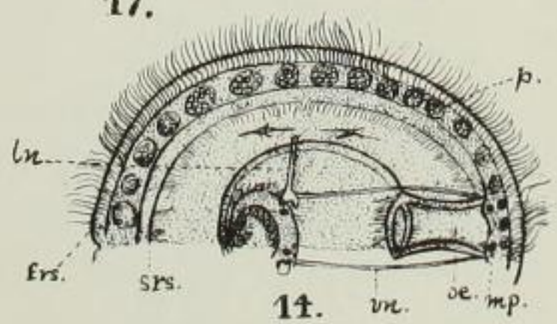
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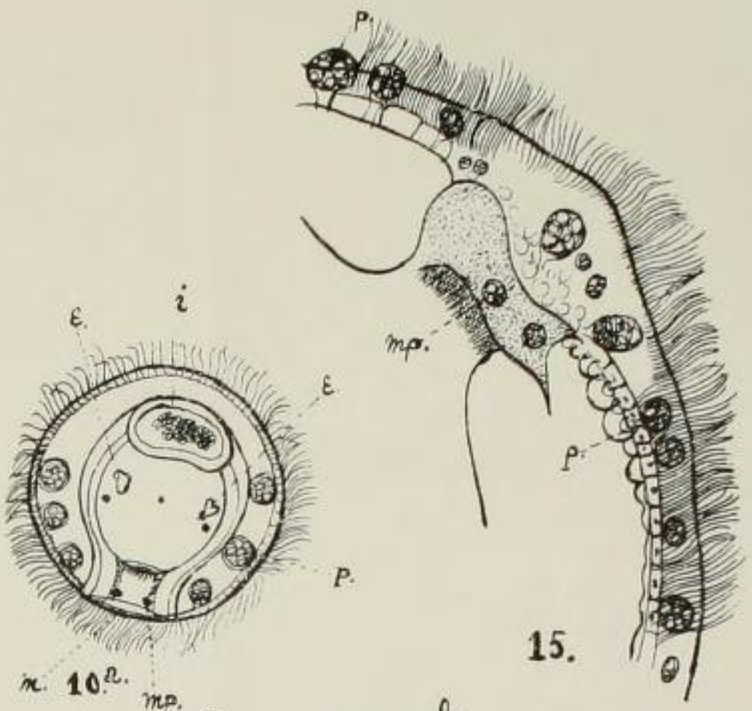
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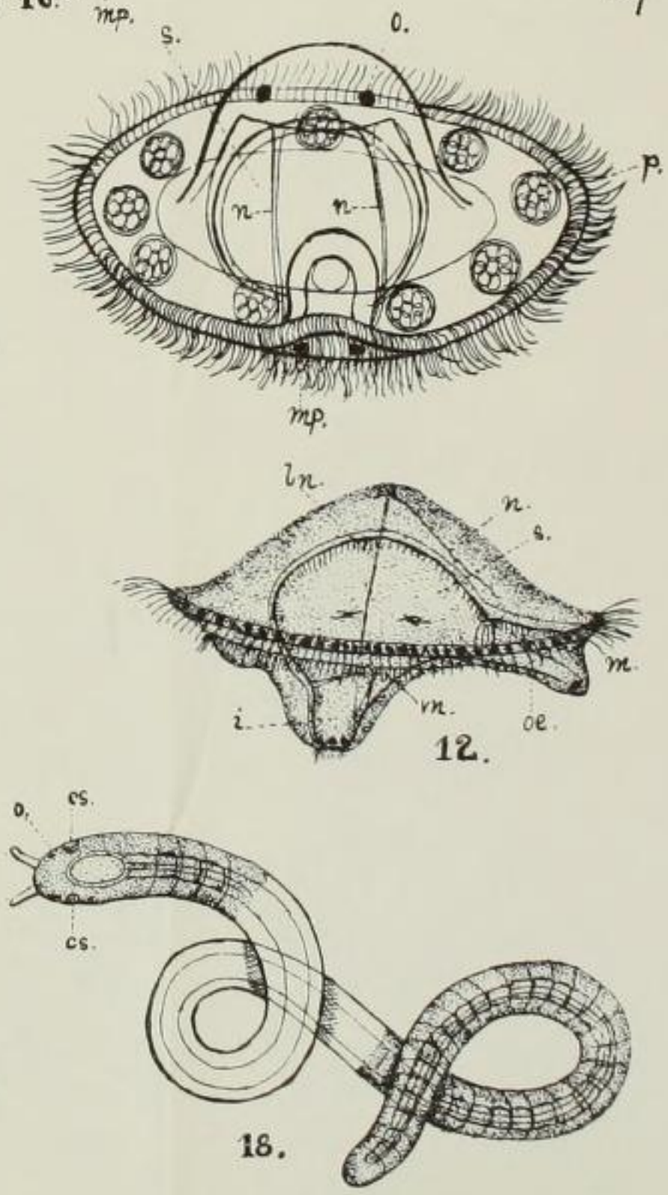
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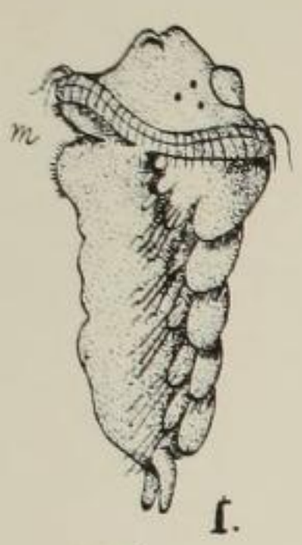

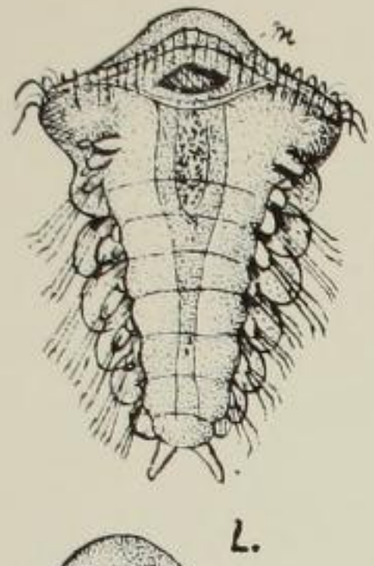

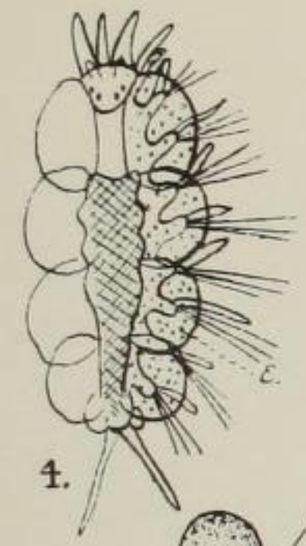

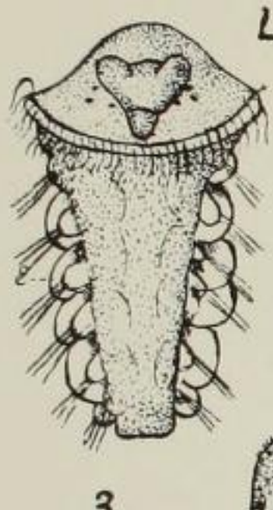

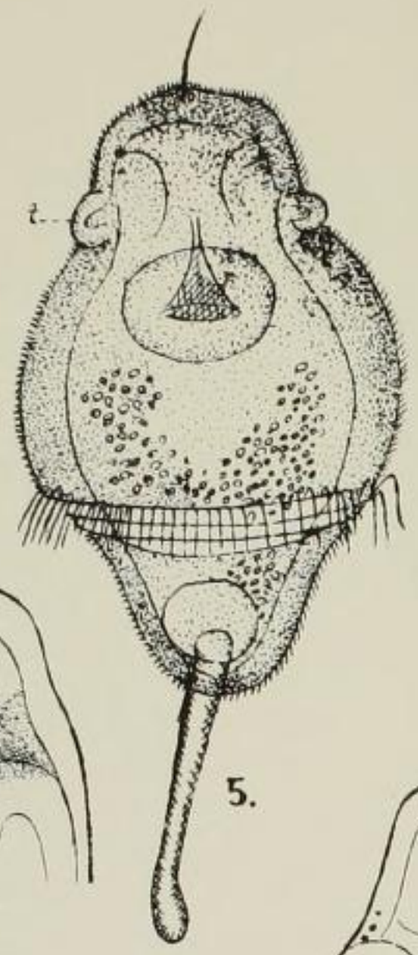

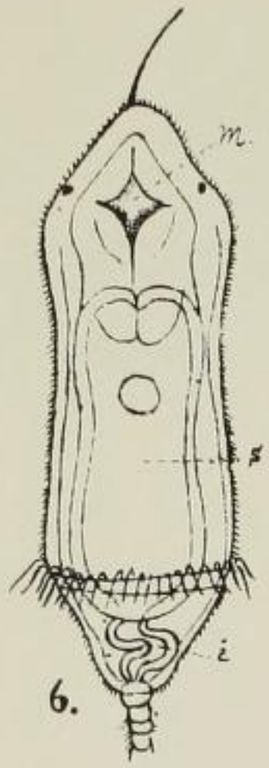

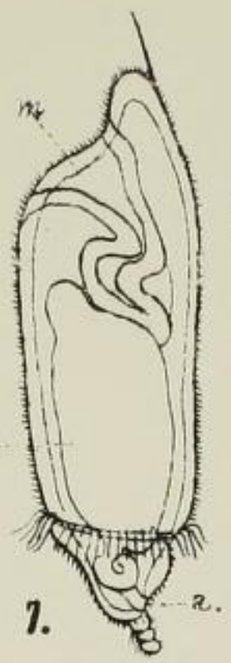

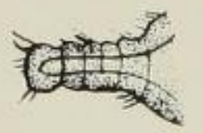

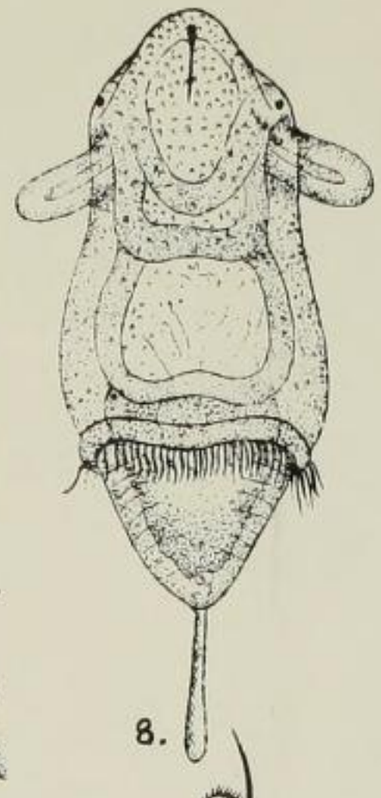

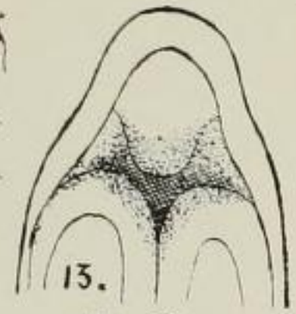

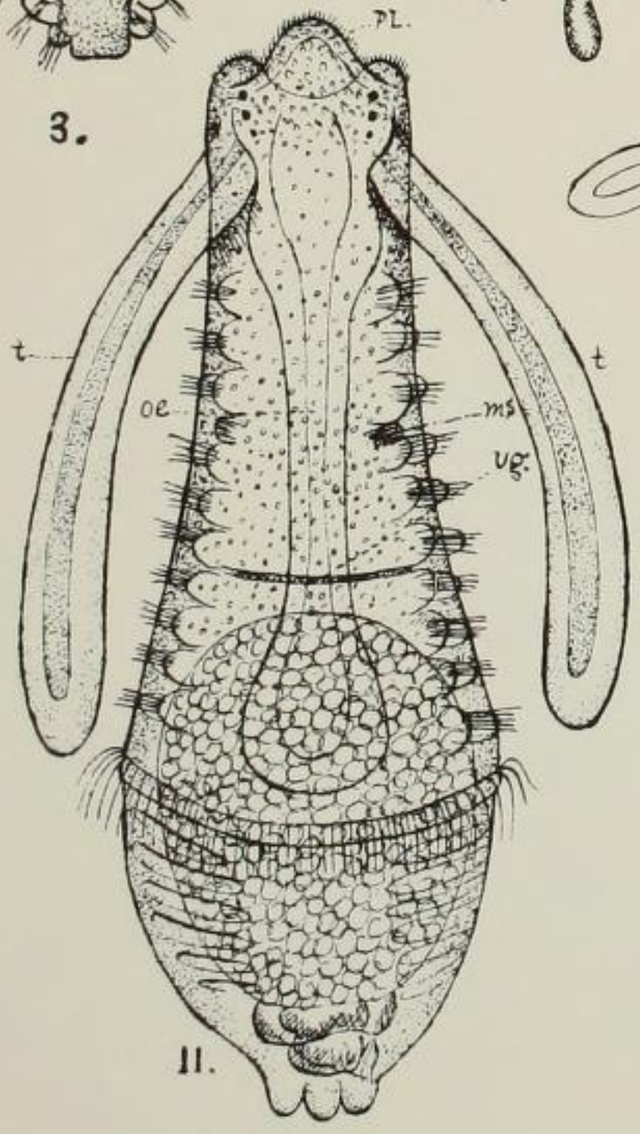

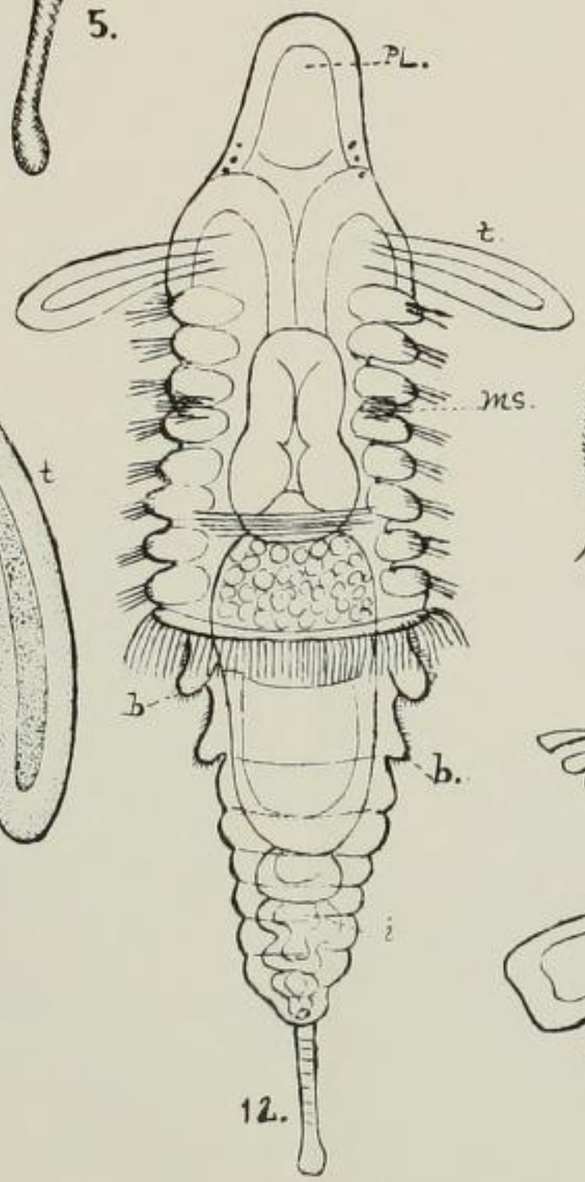

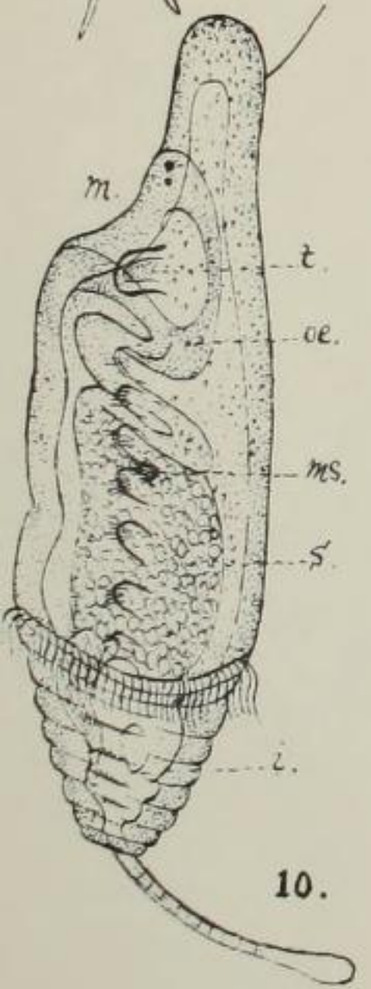

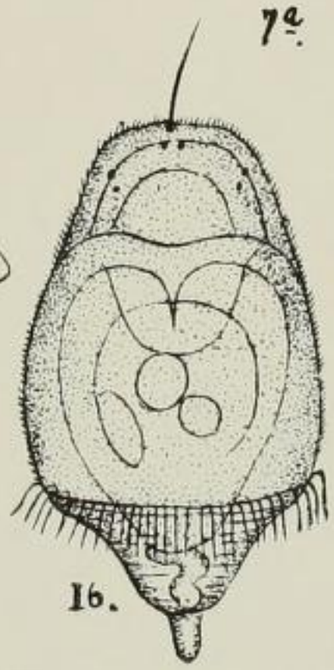

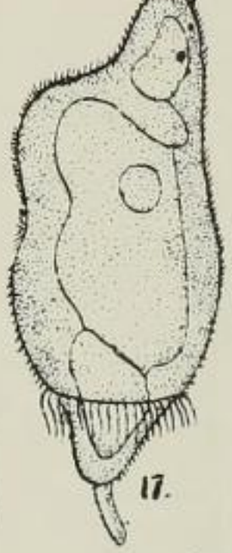

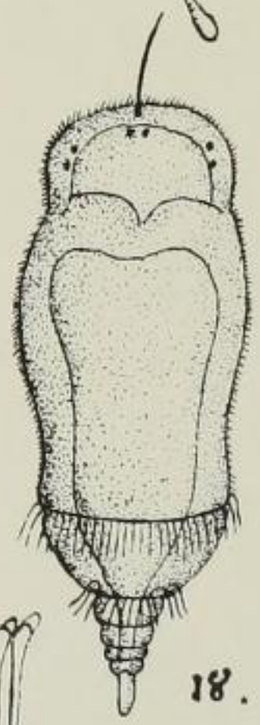

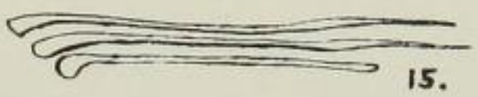

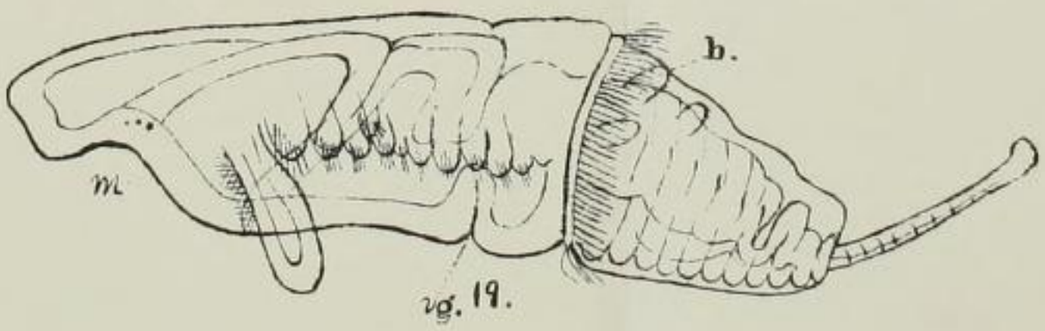

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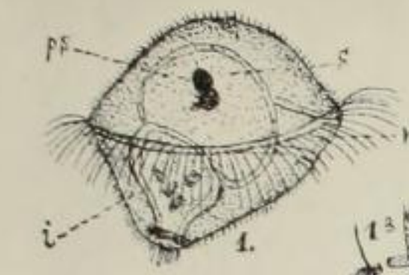
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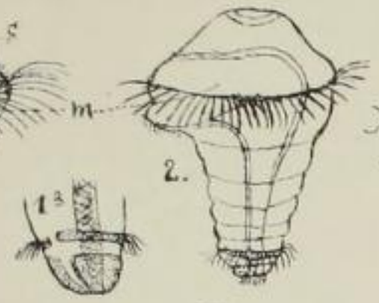
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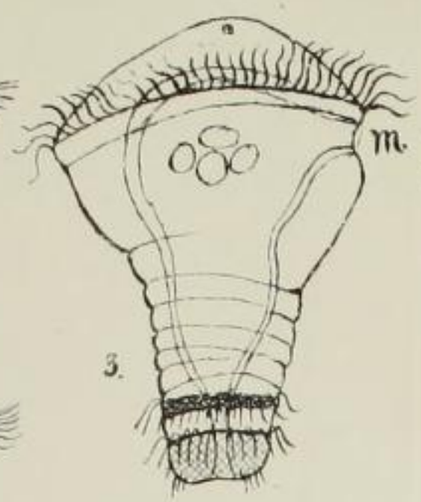
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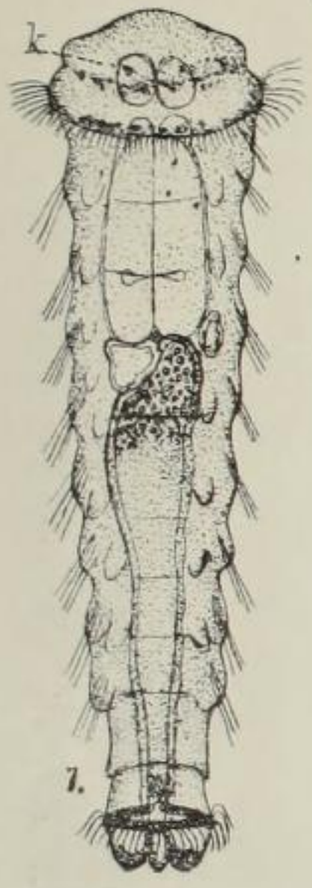
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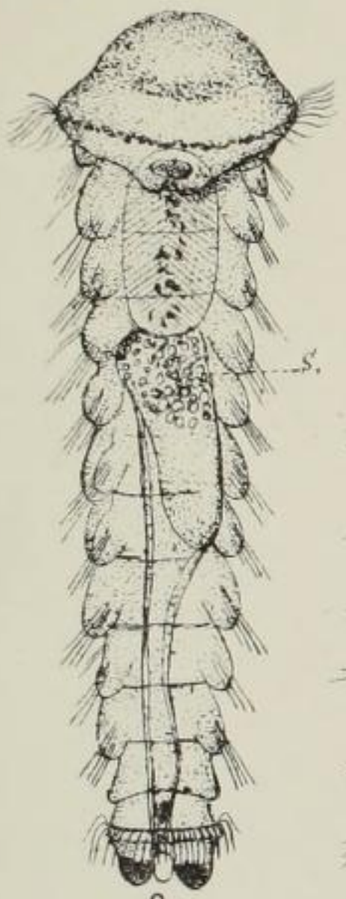
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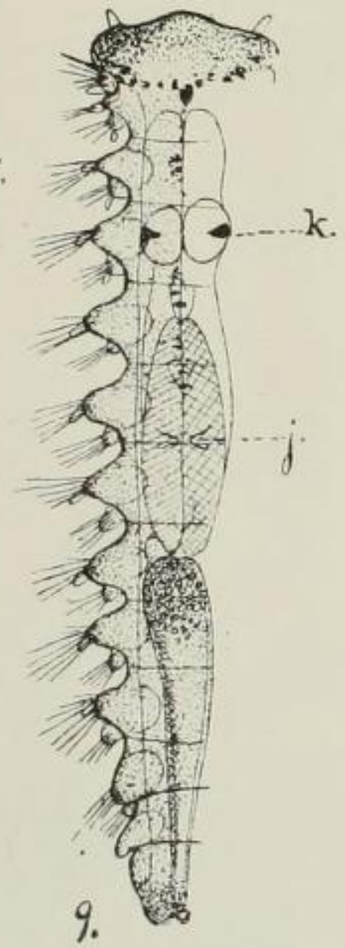
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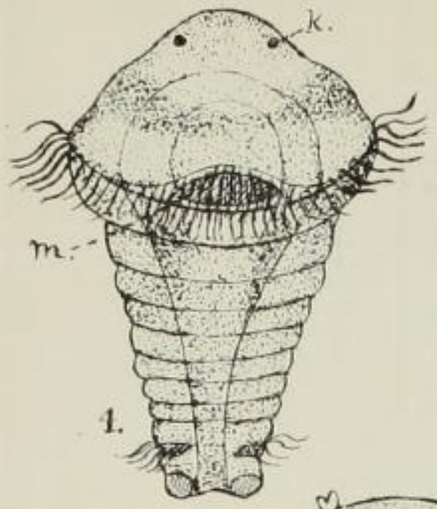
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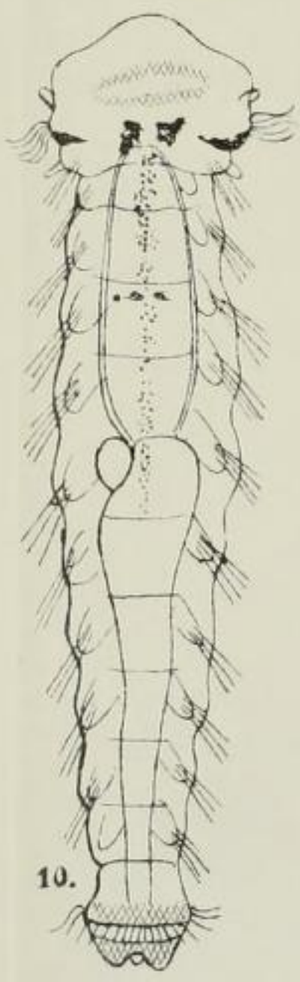
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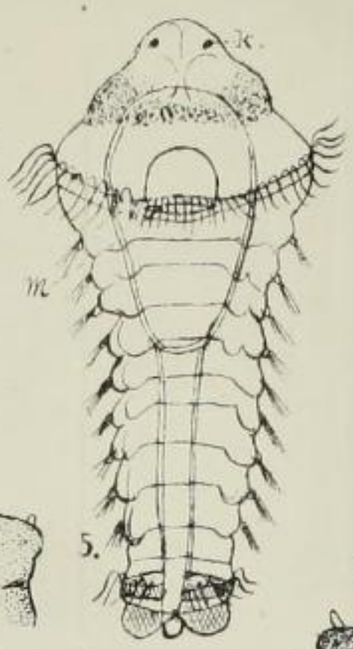
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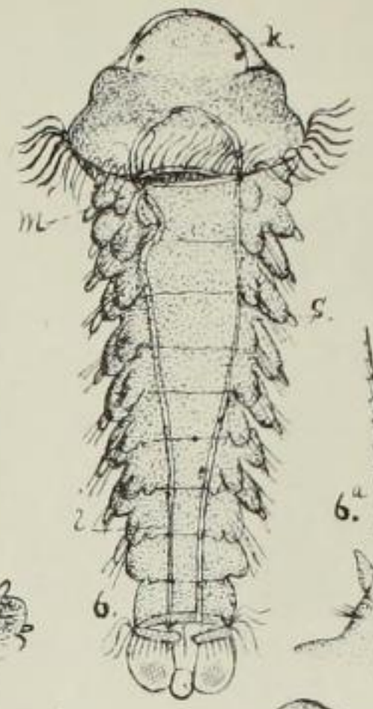
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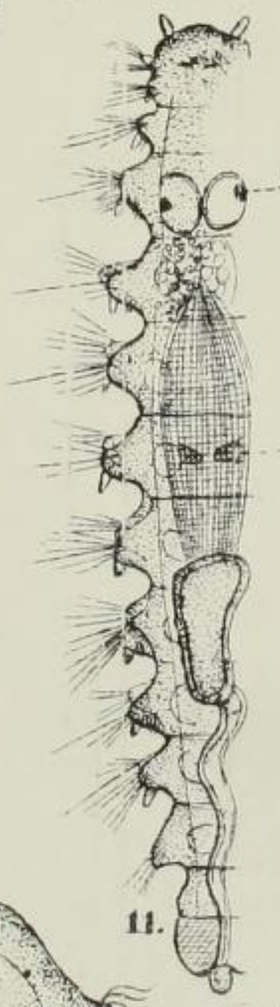
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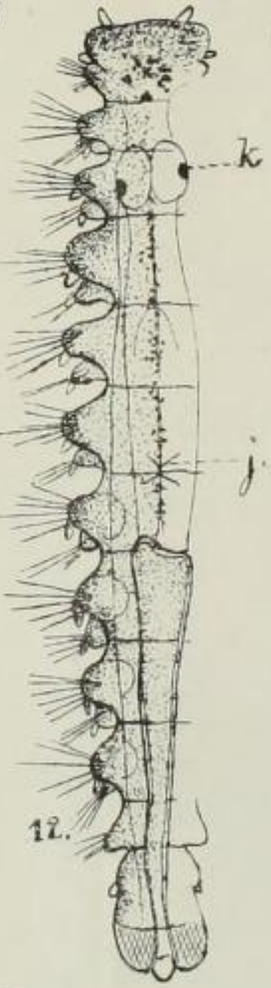
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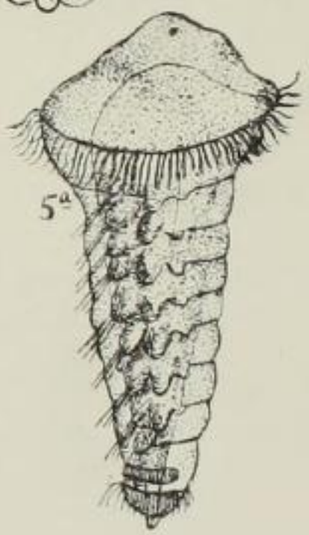
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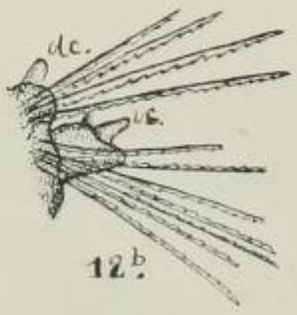
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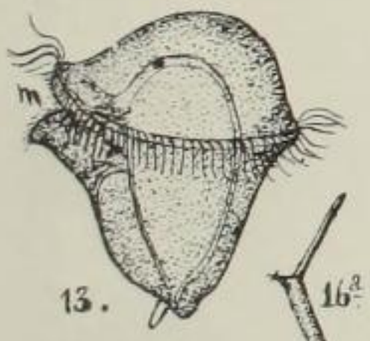
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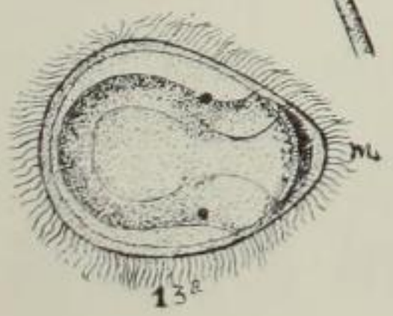
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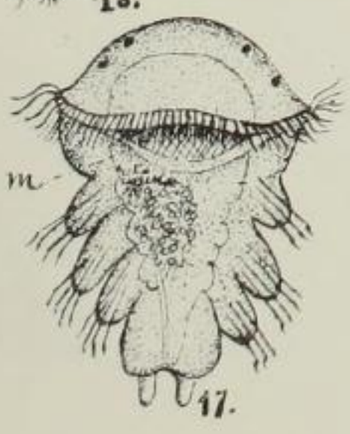
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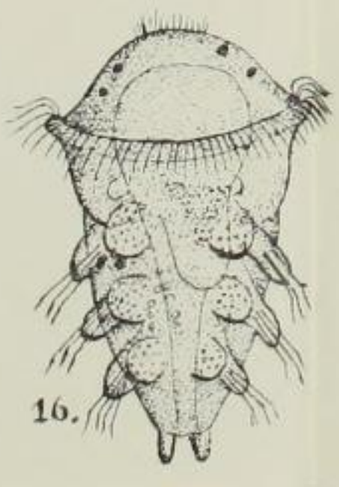
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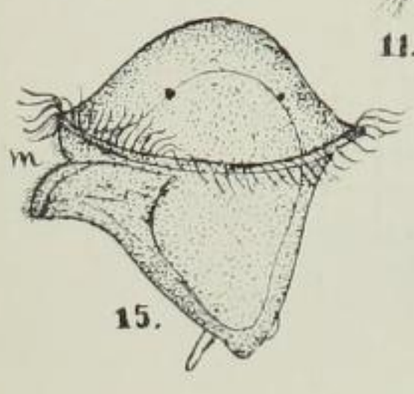
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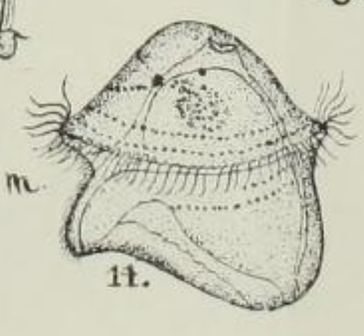
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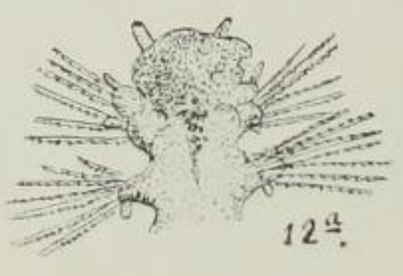
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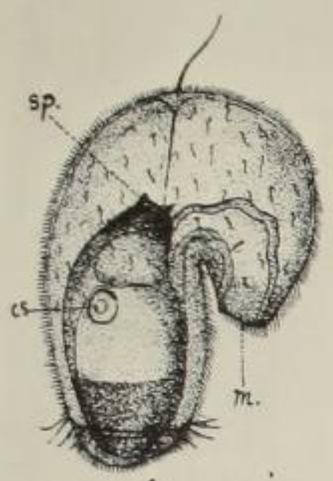

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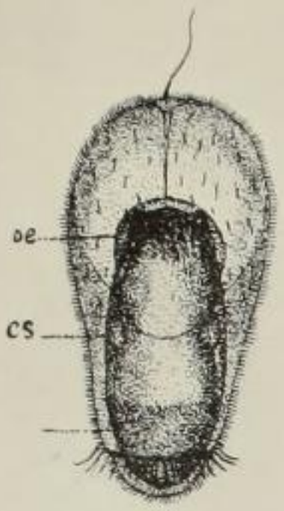

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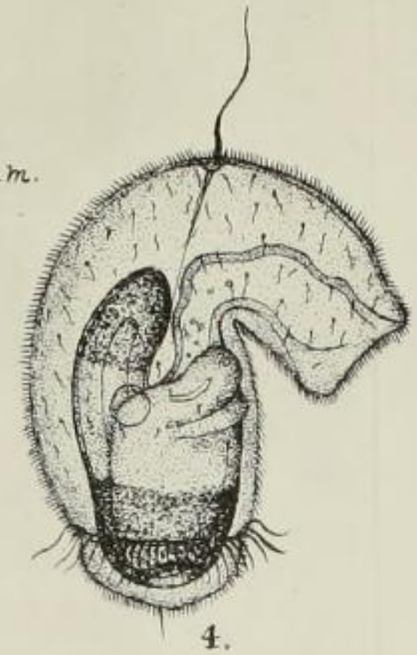
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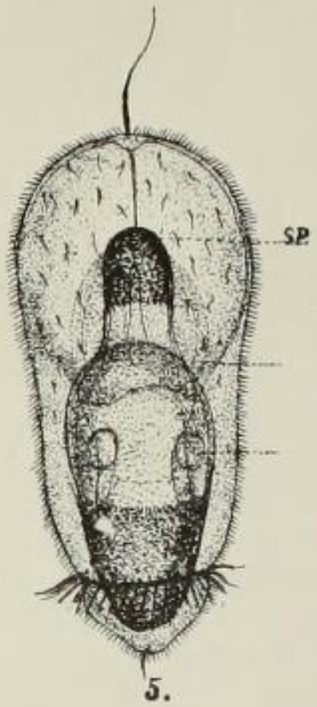

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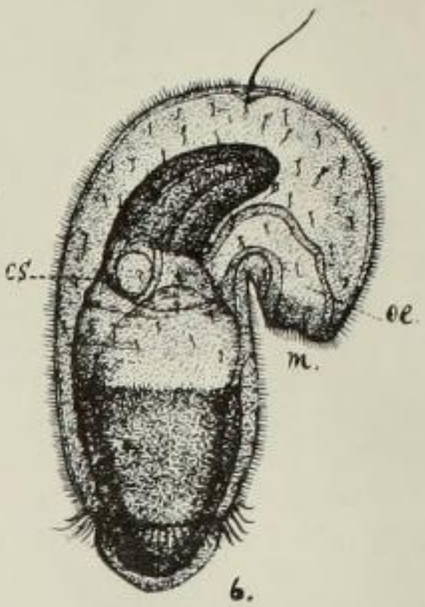

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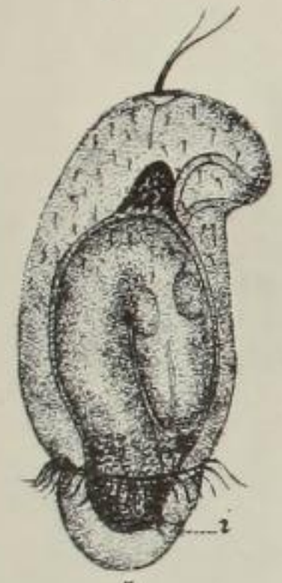

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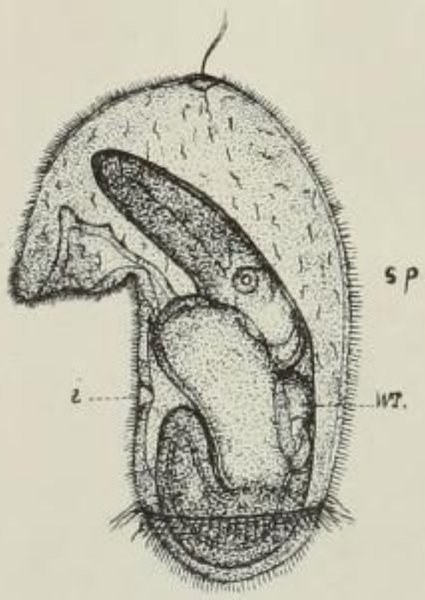

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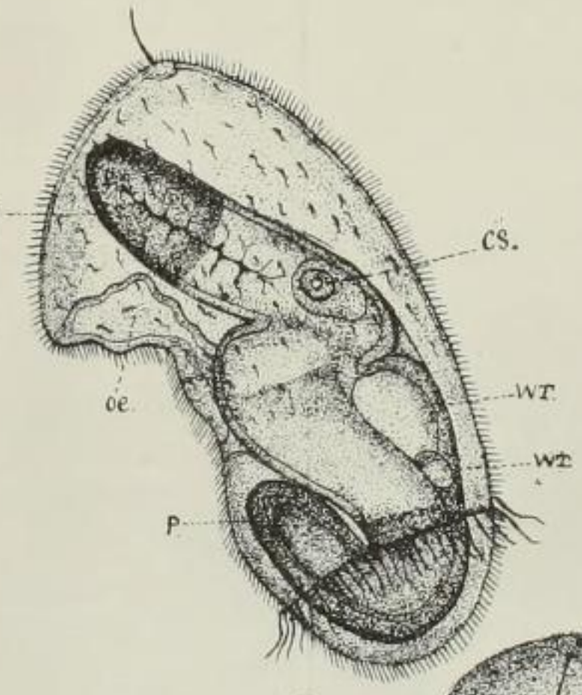

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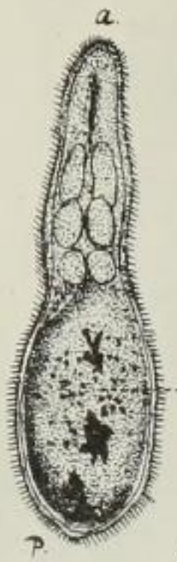

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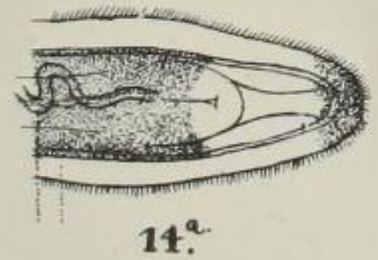
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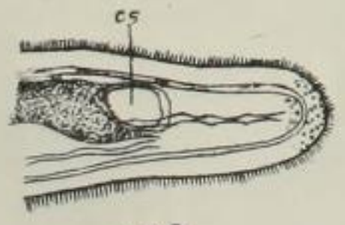

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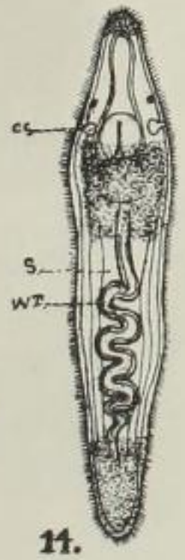

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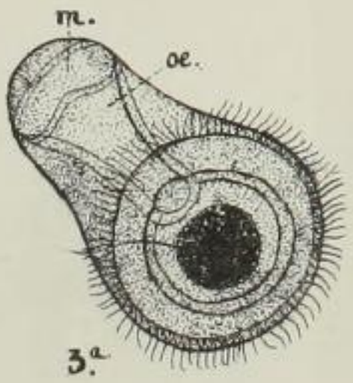

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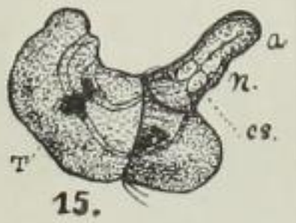

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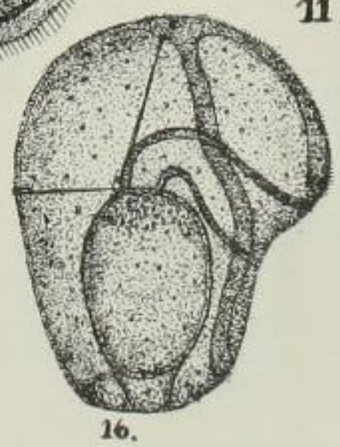
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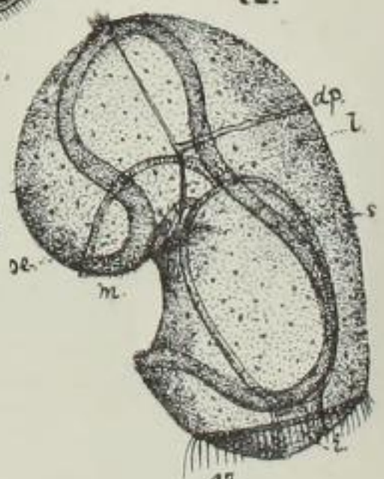

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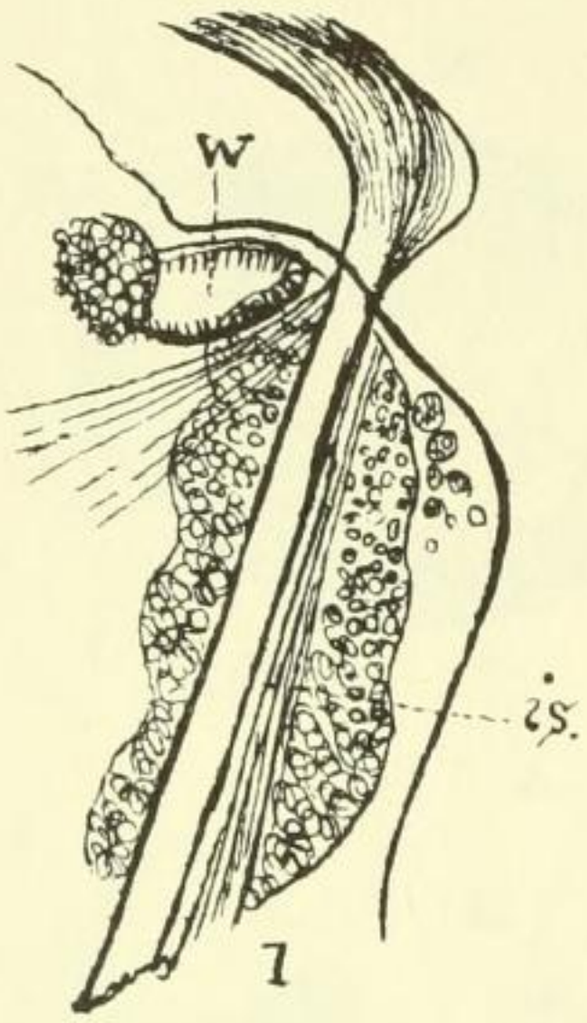

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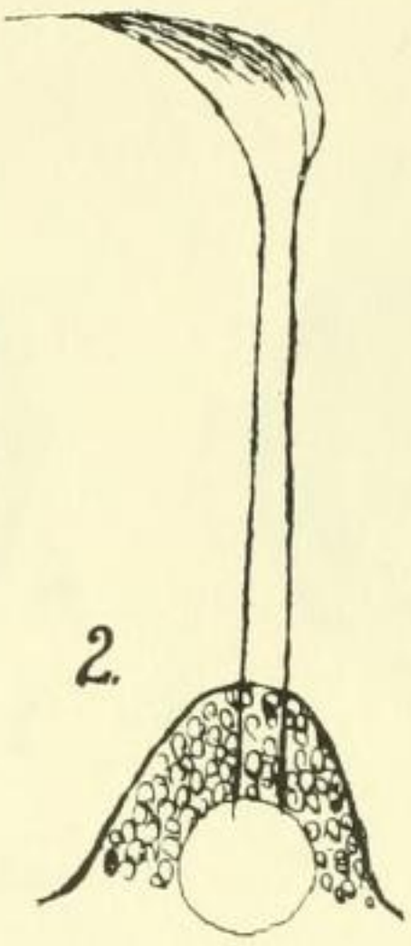

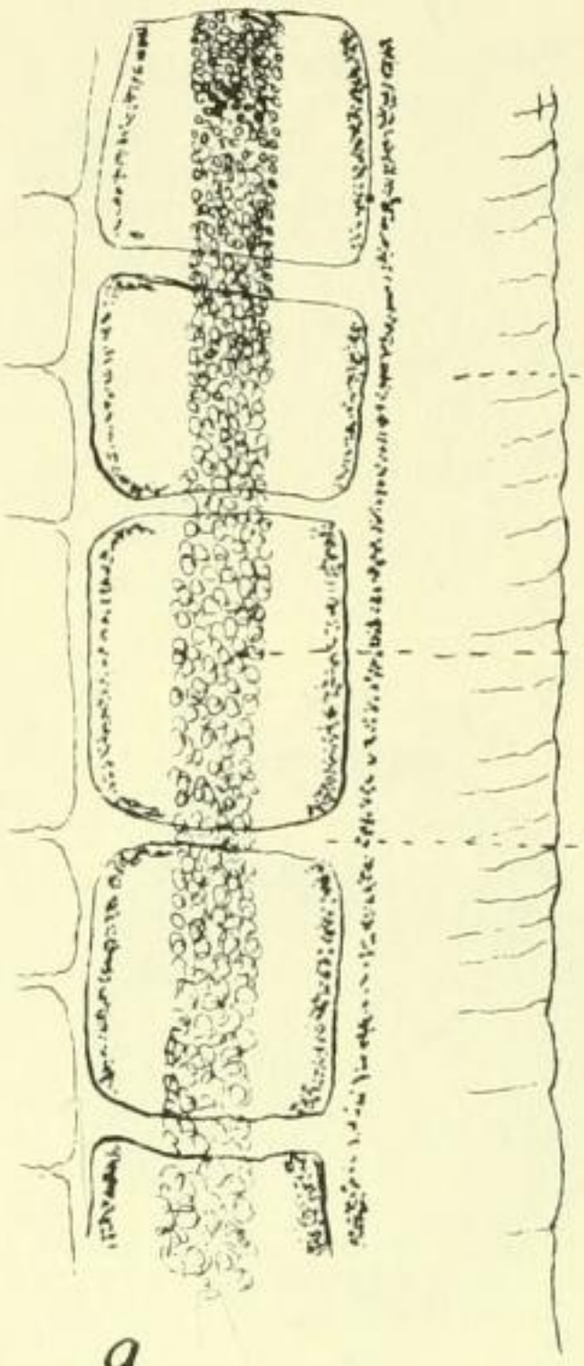

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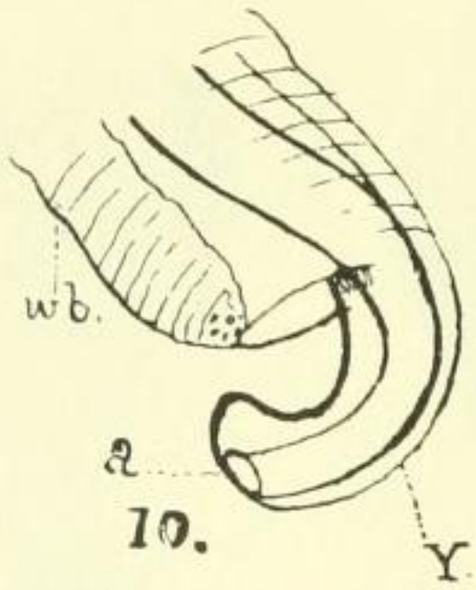

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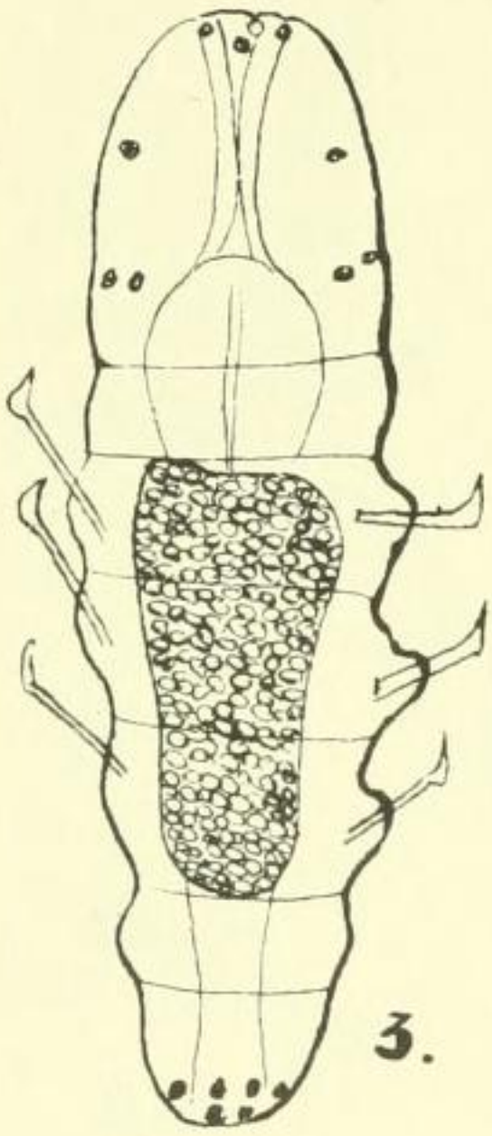
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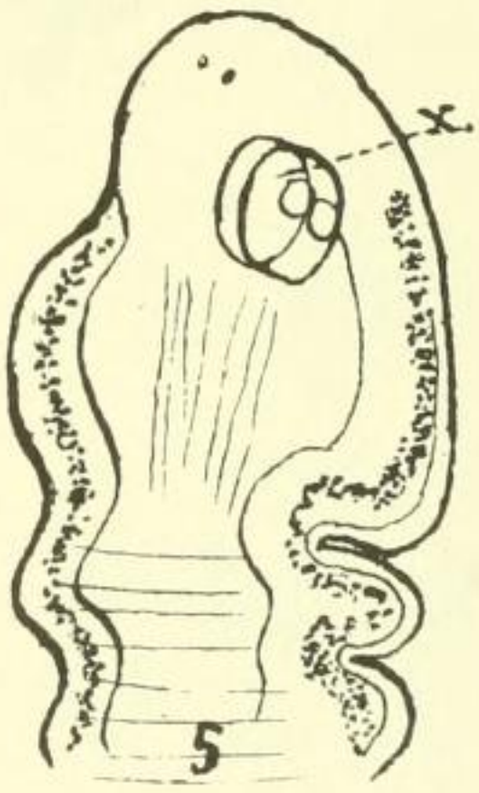

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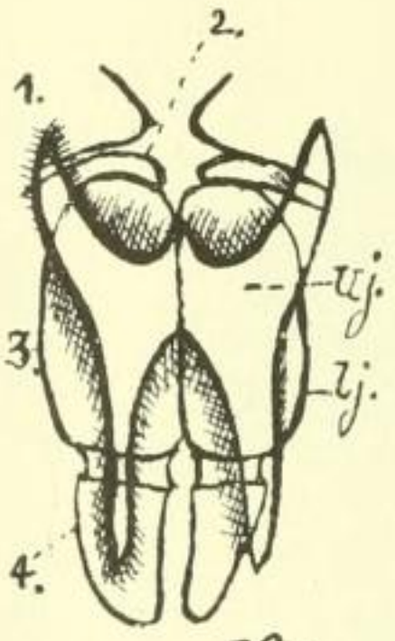

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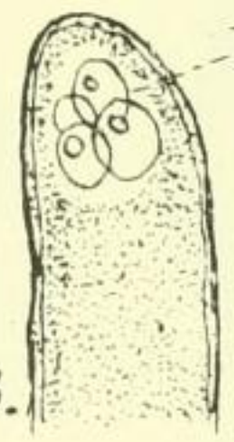

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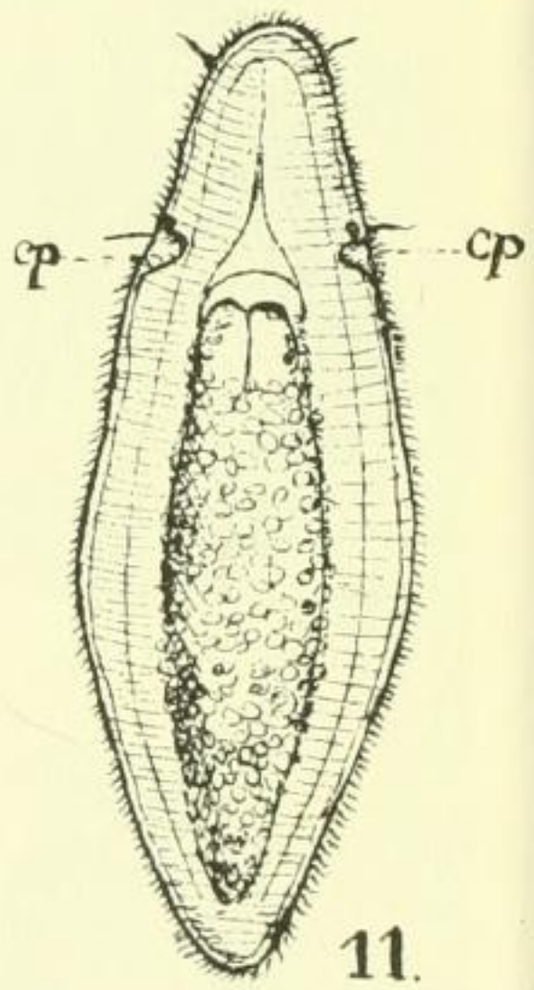

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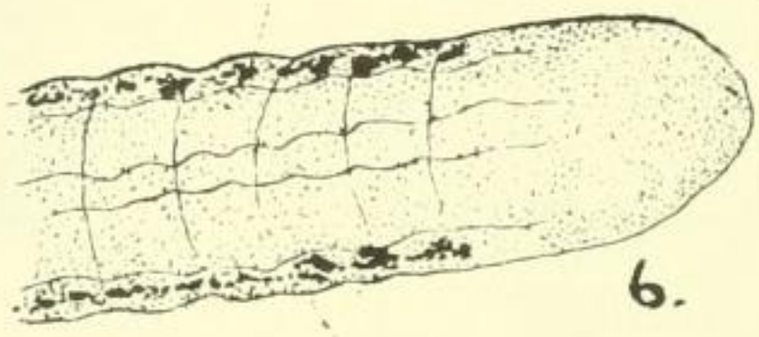
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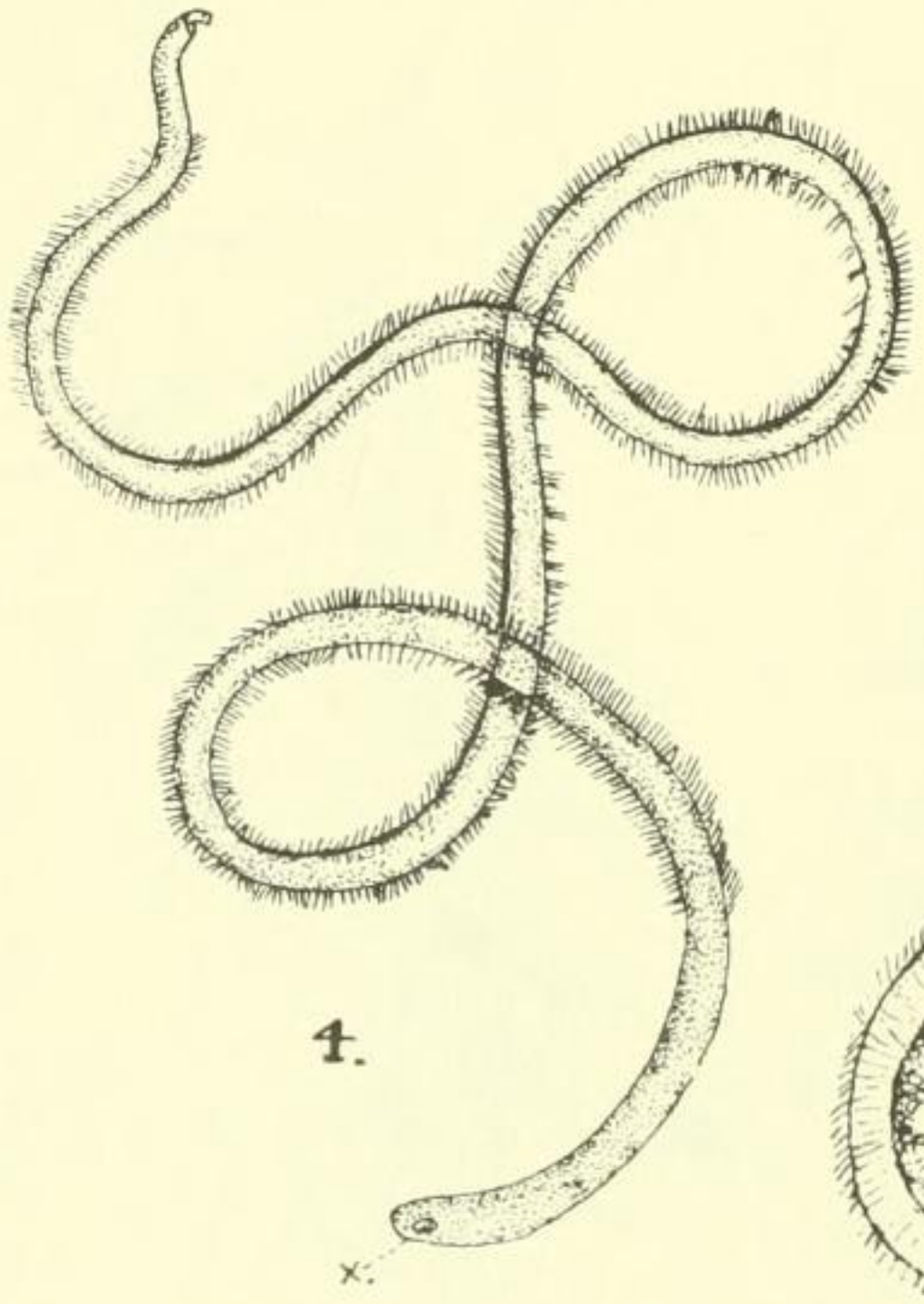
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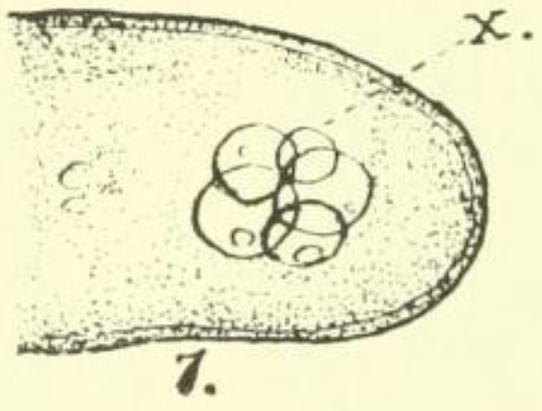

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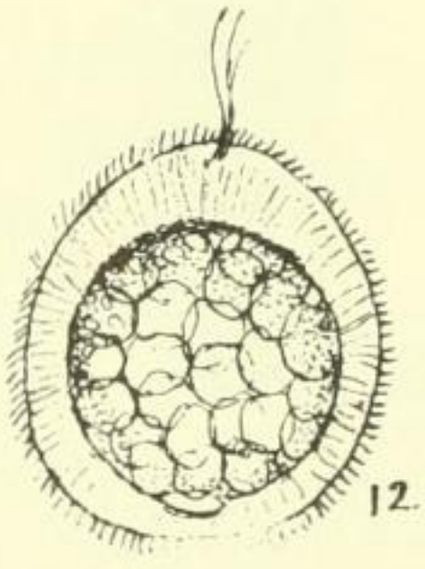
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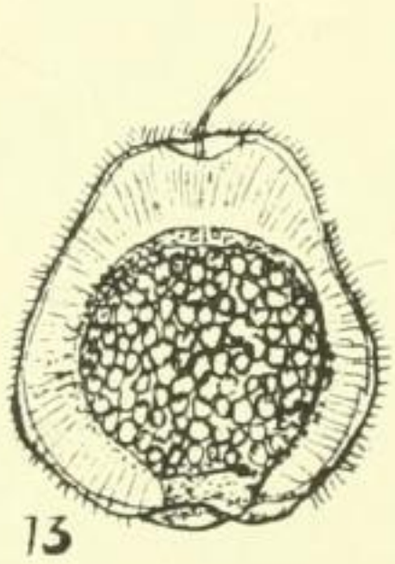
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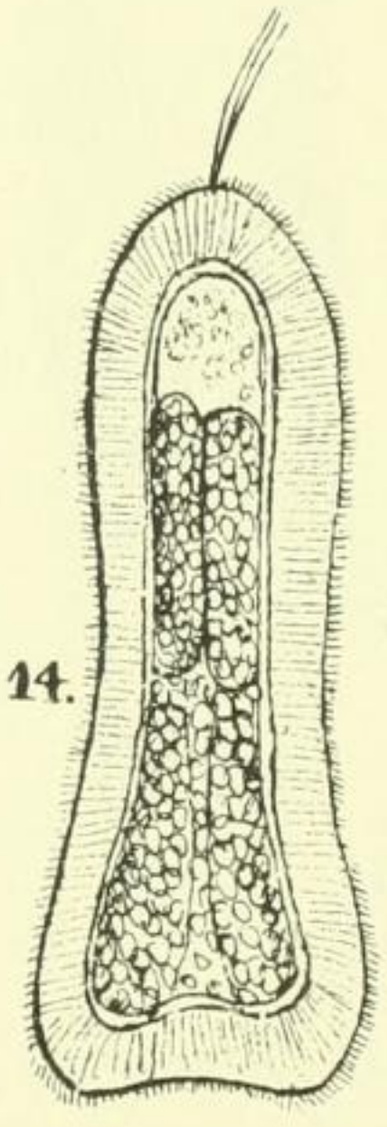
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