7.—ON THE ANATOMY OF THYSANOCEPHALUM CRISPUM, LINTON, A PARASITE OF THE TIGER SHARK.

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I.—HISTORICAL.

The first notice of this species was published in the author's "Notes on the Entozoa of Marine Fishes of New England," U. S. Fish Commission Report for 1886, pages 464–468, plate II, figs. 1 to 12. It was there described under the name *Phyllobothrium thysanocephalum* sp. nov. Subsequently it was discovered that it had been referred to the genus *Phyllobothrium* improperly. A new generic name was needed to accommodate it, and the species was therefore renamed as above in the author's "Notes on Entozoa, Part II," U. S. Fish Commission Report for 1887, pages 823, 824. Notice of the change of name was given in a brief abstract of the latter paper in the American Journal of Science for March, 1889, page 240. The position to which the genus is assigned in the second paper is in the family *Tetrabothriidæ*, subfamily *Philacanthinæ*.

II.—HABITAT AND DISTRIBUTION.

This parasite has been found by the author thus far only in the tiger shark (*Galeocerdo maculatus*), and there only on three occasions, viz, July 23, 1885, August 3, and August 14, 1889, all at Wood's Holl, Massachusetts. In each case young, half-grown, and adult specimens were found together in the spiral valve, showing that the source of infection is distributed throughout a considerable portion of the year. In each instance, also, the parasites were numerous, and, in addition to the strobiles, the chyle was teeming with free proglottides, which were contracting and elongating in the most active fashion, and achieving a kind of progressive motion by means of a sucker-like use of the hilum at the anterior end.

The host, according to Jordan and Gilbert, has a range from Cape Cod to the Indian Ocean. It would be too much, of course, to infer that the parasite is coextensive in geographical distribution with its host. This depends upon the range of individuals of the final host, and of the distribution of the intermediate host or hosts, rather than on the distribution of the species to which the host belongs. No mention

is made of entozoa from this host either in the compilations of Diesing and Von Linstow or in the memoirs of Van Beneden, Molin, Oerley, Zschokke, etc., who have investigated the entozoa of the Selachians.

In the first two finds this parasite was the sole occupant of the spiral valve. In the last there were associated with it in the same organ several small cestods apparently identical with *Orygmatobothrium angustum* Lt. There were also a few scolices of a *Tetrarhynchus* attached to the walls of the stomach. A few large nematods were found in the stomach of each host. In the first and third finds there were a few long, slender, free proglottides not belonging to this species. These have not yet been satisfactorily accounted for. In the third lot they may belong to the Tetrarhynchi found in the stomach.

The character of the stomach contents throws but little light on the nature of the intermediate host. The stomach of the first was probably empty, at least there is no record of any stomach contents in the notes made at the time of collecting. In the second case, a half-grown female, the stomach was filled with half-digested menhaden (*Brevoortia tyrannus*). The third host, which measured about 7 feet in length, had in its stomach a bonito (*Sarda sarda*), the operculum of a large fulgur, and a large quantity of sandy mud. There were several hundred *Thysanocephala* in the spiral valve of this shark.

III.—DESCRIPTION OF THE SPECIES; EMENDATIONS.

The original description, while, in the light of more recent and careful investigations, faulty in some particulars, is sufficiently accurate to make identification of the species reasonably satisfactory. A revised description is given in the U. S. Fish Commission Report for 1887. A brief, systematic description of the species is, therefore, all that is necessary in this paper.

Scolex very small, about the same size in large as in small individuals, thus appearing minute when compared with the large cervical ruff or pseudoscolex of an adult; quadrangular in outline and provided with four oblong bothria, each armed with two short, straightish hooks, and with a single anterior loculus in front of the hooks. Each bothrium is thus divided into two pits or loculi by a transverse partition, which also bears the hooks at its extremities. During life the bothria are very versatile, moving backward and forward singly or in either parallel or diagonally opposite pairs. The anterior loculus is somewhat circular in living specimens, semicircular or crescentic in alcoholic specimens (figs. 4 and 6). The posterior pit is oblong-elliptical in living, somewhat shorter and broader in alcoholic specimens. The borders of the bothrial loculi are thin, but supported at the edges by a band of dense epithelial tissue. The neck immediately behind the scolex is slender, short, and cylindrical, usually in living and always in alcoholic specimens contracted and concealed within the voluminous cervical folds.

The latter constitute an abrupt expansion into a large, lobed, crisped, and folded mass, which, in alcoholic specimens, is more or less globose or disciform, but in living specimens may be spread out into a flat suctorial disk with fimbriated edges. This organ is so conspicuous and takes the place of bothria so effectually as an organ of adhesion that it may be called with some degree of propriety the pseudoscolex. The diameter of this organ may be from five times, in small specimens, to thirty or more times in adult specimens the diameter of the scolex.

Behind the pseudoscolex the body is broad, somewhat flattened, traversed by deep longitudinal rugæ, covered by fine transverse striæ. The unjointed part of the body is long and nearly linear. The segments begin remote from the head, at first as transverse wrinkles; subsequently they decrease slightly in breadth and increase gradually in length. Near the posterior end they are squarish and at the extreme posterior end two or three times as long as broad. The free proglottides, are oblong, truncate posteriorly, anterior angles rounded, and usually appressed and surmounted by a rounded tip at the anterior end, often breaking away before ova are developed, ultimately becoming much elongated.

Genital aperture a marginal cloaca. Cirrus long with spinose base. Length of strobile as much as 1 metre.

Varieties.—There are two types of the adult specimens based on the character of the pseudoscolex. In one there are several, six or eight, primary folds radiating from the scolex, each primary fold being made up of a number of smaller secondary folds. This type is rather poorly represented by the specimen sketched in fig. 1, which is from a small specimen where the distinction is not so strong in this particular as in the adult. A better example is figured in the author's Notes on Entozoa, U. S. F. C. Report, 1886, plate II, fig. 1.

The second type has a much more compact pseudoscolex, and the radiating folds are illy defined, fig. 7. These types are probably due to different degrees of contraction of the strong longitudinal muscles, many of which enter the pseudoscolex direct from the body without passing through the neck proper.

Emendation of original description.—The specimens which were obtained in the first find did not exhibit any movements of the scolex. The scolex was observed only in the smaller specimens, where it appeared to be a rigid body of chitinous structure and in some instances became detached during the examination of the fresh specimens. The scolex was not observed in the larger specimens, though doubtless present in all, the neck being contracted and the scolex buried among the small folds of the apex of the pseudoscolex. Furthermore the specimens were among the first of this difficult group which the author attempted to identify. Hence an inexcusable, though not unnatural, mistake was made in regarding the scolex as a hooked rostellum, characteristic of young specimens, but an evanescent character lost in the

adult, and therefore not to be given undue weight in a systematic description.

The resemblance between the pseudoscolex of these specimens and the scolex of *Phyllobothrium lactuca* was quite striking and naturally suggested a generic relation. This was borne out also by a decided resemblance between the mature proglottides of the two forms.

When, in the summer of 1889, the opportunity of studying a fresh lot of these parasites was afforded the author, the discovery was speedily made that the organ at first thought to be a rostellum is in reality a true scolex with hooks. The relationship of the species to genera of the *Tetrabothriidæ* with armed bothria, such as *Calliobothrium*, *Acanthobothrium* and the like, was thus established.

IV.—ANATOMY.

Method of study.—No special preparation was made of the first lot other than to kill in weak alcohol and pass the specimens through different grades of the same of increasing strength. In the other lots more care was taken in preparing the material for study. Specimens were hardened in Perenyi's fluid, picro-sulphuric acid, osmic acid, and hot corrosive sublimate. The most satisfactory series of sections were obtained from the picro-sulphuric preparations of some small individuals stained *in toto* in a dilute solution of Beale's ammonia carmine in glycerine. The specimens were allowed to remain in the staining fluid for several days. Preparations almost equally good were obtained from Perenyi's fluid, followed by borax carmine (Grenacher's). Corrosive sublimate and Perenyi preparations stained with hæmatoxylon (Bömer's) were also quite satisfactory. The stained specimens were imbedded in paraffin, serial sections cut with the Ryder microtome, the sections fastened with Schällibaum's fixative (clove oil and collodion), and mounted permanently in Canada balsam.

In order to make out the structure of proglottides with least perplexity it is necessary to have sections made in three directions—transverse, longitudinal parallel with a lateral face, and longitudinal at right angles to a lateral face.

The structure can be understood better from the sketches than from a written description.

The following remarks are based on the same series of sections from which selections were made for the illustrations, and will probably make the latter more intelligible.

Cuticle.—In the scolex the framework is made up of closely packed, short, parallel fibers which appear to be epithelial cells. This tissue is very resistant, withstanding the action of cold, and yielding very slowly to the action of hot, caustic potash.

In transverse sections and in longitudinal sections made perpendicular to the face of a bothrium, the fibers are seen in their long dimensions

lying parallel with each other. In longitudinal sections made parallel with the face of a bothrium, some of them are seen in cross section.

The cuticle of the body is a very remarkable structure. In superficial view, especially in a stained specimen, it appears to be scaly or, more properly speaking, minutely and irregularly tessellated, since the pieces do not break joint (figs. 24*c* and 33*a*).

In section the cuticle is seen, when highly magnified, to be made up of three distinct layers. These may be described as an outer epidermal layer, an inner epidermal layer, and a third limiting layer, the cutis (figs. 21*a*, 27, and 31).

The outer epidermal layer under high magnifying power shows a densely striated structure, the striæ being at right angles to the superficial extent of the layer. The inner epidermal layer appears very finely granular and usually almost homogeneous. In some especially good sections, however, fine striæ were seen in it. These also lie at right angles to the layer, but are not close together as in the external layer, and the interstices are filled with fine granular material. The epidermis rises in folds from a very thin limiting membrane, the cutis, to which the fine radial fibers of the subcuticular granulo-fibrous layer are attached (fig. 21*a*).

The outer epidermal layer is uniform in thickness; the inner layer is irregular in thickness, rising from a comparatively uniform base, where it touches the cutis, into papillæ which conform to the folded structure of the outer layer.

A few small granular patches, of glandular appearance but of unknown significance, were observed in this layer (fig. 31*a*).

The epithelial origin of the hooks of the scolex is shown in fig. 13. In unstained specimens treated with caustic potash the hooks appear transparent and homogeneous.

The hooks in this species differ from the chitinous hooks of such genera as *Calliobothrium* in that they are solid and not characterized by having an internal cavity. The epidermal layers of the body do not extend, at least unmodified, into the pseudoscolex.

The external folds of the pseudoscolex appear in section as fimbriæ, about 0.02^{mm} in diameter. The folds are seen to be limited on each side by a thin, uniform layer, apparently structureless and about 0.002^{mm} thick. This layer appears to be continuous with the cutis of the body. In the deeper parts of the folds, that is, toward the center of the pseudoscolex, this cuticular layer becomes somewhat thickened and is irregular or broken on the surface. In some cases it was seen to bear on its outer surface what appeared to be a dense coat of epithelial hairs.

This cuticular layer is in close connection with the longitudinal muscles of the body, which extend, mostly as radial fibers, into the pseudoscolex. It is itself apparently contractile. Indeed, it and the cutis of the body may subsequently be shown to belong to the subcuticular layer.

Internally the external folds of the pseudoscolex are composed of

granular tissue. In both transverse and longitudinal sections of the pseudoscolex this granular material is seen, along with a faint indication of an incipient striated arrangement of the granular material.

Musculature.—The muscular system is not complicated. Viewed in transverse section near the anterior end, the body is seen to be made up of three principal layers, each of which is more or less muscular. These are disposed between a central core and the cuticle in the following manner: The inner layer immediately surrounding the central core is composed of circular muscle fibers. The fibers are rather strong, but the layer is not thick. The circular layer is surrounded by a layer of strong longitudinal fibers. In the anterior regions of the body this layer is very prominent and the fibers are large and strong. Outside of this layer is the subcuticular layer, which contains both longitudinal and radiating fibers along with an abundance of granular material. The fibers in this layer are very slender. The layer itself is a prominent one, and in the posterior parts of the body is proportionally thicker than the other layers.

Longitudinal muscles.—These are the most prominent muscles of the anterior part of the body (fig. 20). In a specimen measuring over 30 centimetres in length the longitudinal fibers were found to be collected into a comparatively small area at a distance of 6 centimetres from the head, presenting, in fact, much the same aspect as shown in fig. 35. The disposition of this layer in the posterior regions of the body is made sufficiently clear in figs. 26, 27, 29, 30, 31, and 35. By a reference to figs. 10, 11, 17, 18 to 22, 24, and 25, it will be seen that the longitudinal muscles play a very important part in the structure of the head, and particularly of the pseudoscolex. Longitudinal fibers extend up through the slender neck and communicate with the bothria. Dense fascicles of these fibers enter the cervical folds in outgrowths which form the pseudoscolex, where many of them appear as radiating or transverse fibers. The longitudinal fibers which supply the bothria lie in the superficial area of the neck (figs. 11, 17, 18, and 22). A short distance back of the scolex four processes or outgrowths are given off from the neck. Each process contains an abundance of strong muscles which appear to radiate from the neck. Some of them are fibers which are radial or transverse throughout, and may be traced from one process or fold to another. Others are continuous with the longitudinal muscles of the body, which are here deflected nearly at a right angle from an axial direction. In the angles between the cervical processes longitudinal fibers may be seen in transverse sections, and may be traced from the longitudinal system of muscles in the body to the base of the bothria, where they communicate with those organs by a kind of frenum. In succeeding sections back from the head the cervical outgrowths are seen to increase rapidly in size and to become variously divided.

Interlacing muscular fibers running from one process to each adja-

cent one make up the principal mass of the neck as it passes through the pseudoscolex, of which organ it is the axial center (figs. 17, 18, and 22). The outer extremities of the massive parts of the cervical outgrowths receive muscular fibers from the longitudinal body layer. These extend to the base of the fine outer folds, where they seem to blend with the cuticular limiting layer, in which the contractile power, which the outer folds undoubtedly possess, apparently in large measure, resides (figs. 17*a*, also figs. 19 and 24).

Near the base of the pseudoscolex the neck enlarges very rapidly (figs. 19, 20, and 24). The last cervical outgrowths to disappear are the two lateral ones. In fig. 20, *d*, *d* indicate the position of the last cervical process to disappear. The longitudinal muscle layer is here seen to approach the cuticular layer. In the section immediately preceding this a few longitudinal fibers extend outward as radial fibers from these points. Figs. 19 and 24 give views of longitudinal sections of the head and pseudoscolex, but do not give a correct idea of the cervical processes in their entirety. The sections are made parallel to the lateral face of the body and pass through intervals between the cervical outgrowths. From the diagrammatic sketch, fig. 25, a somewhat better idea may be obtained. Figs. 17 and 22, which are from camera-lucida drawings of transverse sections, give a correct representation of these peculiar organs.

The very powerful longitudinal muscles of the anterior part of the body and their continuation into the cervical processes and folds, where they are further supplemented by another powerful set of interlacing transverse muscles, all indicate this to be a most efficient suctorial organ. This view is further substantiated by the fact that the structure of the external folds of the pseudoscolex is such that they may act as so many sucking disks.

Here then is a very curious instance of the development of a special organ for a special purpose, instead of the modification of an organ already possessed; or rather the development of an unusual part to perform a function which is normally performed by an organ which the animal already possesses. In kindred Cestods the organs of attachment are the bothria or cupping disks which are homologues of the sucking disks of the common Tænia. These may be supplemented by various contrivances in the shape of secondary disks as in *Orygmatobothrium*, by partitions dividing the bothria into loculi as in *Echeneibothrium*, by hooks as in *Calliobothrium*, by hooks and spines as in *Echinobothrium*, etc.

The pseudoscolex of *Thysanocephalum* is probably a no more remarkable organ than the proboscis of *Tetrarhynchus*, but it appears to be unique in having become such a conspicuous and manifestly essential organ, while the true scolex and slender neck would be wholly inadequate of themselves to sustain the strain of supporting the adult body.

That the head, though so minute, still retains the supremacy, however, is shown by the fact that the nervous system has its chief devel-

opment there. How long a strobile would continue to live in its proper habitat if the scolex were removed is an interesting though not very practical question.

While the pseudoscolex appears to be principally an organ for adhesion and absorption, as well designed for the former function perhaps as for the latter, the true scolex, though no doubt necessary as an organ of adhesion in very young individuals, must be of little use for this purpose in the adult.

In the mature segments the longitudinal system of muscles is reduced to a narrow and inconspicuous layer.

Circular muscles.—The layer of circular fibers is at first clearly defined at the base of the pseudoscolex. Anterior to that point they either do not exist or are obscured by the numerous interlacing fibers of the cervical outgrowths. It constitutes a conspicuous layer in the anterior part of the body. In the median regions of the body it consists of but a few fibers, and in those segments in which the genital organs are mature it has almost entirely disappeared, being there represented by a few fine fibers which, with the attenuated layer of longitudinal fibers, surround the inner core of the strobile.

Subcuticular granulo-fibrous layer.—This layer is first discernible at the base of the pseudoscolex. Anterior to that point the longitudinal layer lies next to the cuticular layer. It becomes one of the most prominent of the layers of the body a short distance back of the pseudoscolex. It consists of both longitudinal and radial-fibers, and at its extreme outer edge there is a layer which appears to consist of fine circular fibers placed very close together, appearing as a thin structureless membrane in transverse sections, but presenting the appearance of a row of fine dots in longitudinal, marginal sections. It furnishes a place of insertion for the radial fibers and has been interpreted as the cutis, and so named in the figures and in the description of the cuticle. The subcuticular layer in the median region of the body occupies more than one-half the area from surface to center of transverse sections. Its prominence in the mature segments is shown in figures 26, 27, 29, 30, 31. It furnishes the material from which the vitelline glands develop.

Inner core of the strobile.—In the anterior region of the body this contains, beside the longitudinal and nerve vessels, more or less granular or nuclear material in the loose and open meshes, formed by fibers which cross from side to side and others approximately at right angles to them. In the neck this space is quadrangular and poorly defined. Immediately behind the pseudoscolex it is elongated and lenticular in transverse sections. This general character is preserved throughout until distorted by the genitalia, which develop within and from its substance.

Water-vascular system.—Four longitudinal aquiferous vessels traverse the anterior part of the body. They are situated in pairs towards the margin of the central core. Each marginal pair consists of a large

and a small vessel, the latter nearer the margin. The course of the larger one is very tortuous, so that in moderately thin transverse sections it often appears as a double vessel (figs. 20, 21). The tortuous course of one of the large vessels is shown in fig. 23. The course of the smaller vessels is sinuous. Branches of the water-vascular system extend to the apex of the scolex (fig. 14). Lateral branches enter and ramify through the primary folds of the pseudoscolex (fig. 17*l'*). Towards the base of the scolex the neck is traversed by four vessels (fig. 10). A little further back, at the beginning of the cervical outgrowths, they are poorly defined (fig. 11). The interior of the neck at this point is made up of spongy tissue composed of interlacing fibers, and lateral vessels may be seen entering the cervical outgrowth. Fig. 11, *l'*, shows the first indication of one such lateral branch, which becomes quite evident a few sections farther on in the series. Towards the base of the pseudoscolex the lateral branches again unite with the central longitudinal vessels of the neck (figs. 17 and 22). At the point where the neck begins to broaden abruptly the aquiferous vessels are larger and appear to form a kind of plexus of vessels (fig. 19, *l'*). The exact disposition of the aquiferous vessels in the neck, pseudoscolex, and scolex have not been made out satisfactorily. Fig. 25 is a diagrammatic representation of what appears to be their general disposition. Near the anterior end of the body the smaller of the marginal vessels are from one-third to two-thirds the diameter of the larger vessels. As the vessels proceed towards the posterior end the large vessels increase in size very much, while the small vessels are relatively much smaller than they are near the head.

In sections made about the middle of a large specimen, a large aquiferous vessel measured 0.135^{mm} by 0.162^{mm} in its two diameters; the smaller vessel of the same pair measured only 0.022^{mm} by 0.030^{mm} in its two diameters. Nearer the posterior end a large vessel measured 0.162^{mm} in diameter; its small companion only 0.016^{mm}, or but one-tenth as much. In segments in which the sexual organs are mature only the large vessels persist, and they, too, are merged in the general body cavity in ripe segments. The aquiferous vessels are surrounded by a proper wall which is quite thin, with a few nuclei surrounding it.

Nervous system.—A cluster of nucleated cells, the largest of which measured 0.06^{mm} in diameter, in a finely granular mass and lying centrally in the scolex about on a level with the anterior loculi, has been interpreted as the anterior development of the nervous system (figs. 8, 14, and 15). This mass is traversed by exceedingly fine transverse and by coarser longitudinal fibers. Toward the base of the scolex the nerve tissue is collected into two marginal areas, in which there are a few nucleated cells on the peripheral side of the aquiferous vessels (fig. 10). In the neck their course can be traced as two cords or vessels of spongy, granular tissue, when seen in cross-section, or of finely striated spongy and granular tissue when seen in longitudinal section

(figs. 11, 17 to 22). Under high magnifying power occasional nucleated cells are visible. The nerve vessels extend back through the body, one near each margin of the central core (figs. 19, 20, 32). They were observed in sections made near the middle of the strobile, where the genitalia had already begun to develop. No nucleated cells were observed in the posterior extension of the nerve vessels, where they appear to consist of spongy tissue alone. These vessels are without proper walls in any part of their course.

Genitalia.—Along one of the lateral faces of each mature segment there is a depression, which is called in the explanation of the figures the lateral furrow (figs. 26, 27, 29, 30, 31). For convenience of description, the face which bears the lateral furrow is called ventral and its opposite dorsal.

The mature segments contain both sets of sexual organs. The external aperture is a genital cloaca. It is marginal and situated in the elongated mature segments a little in front of the middle. The cirrus is long and apparently smooth, except at the base, where it is beset with short curved spines (fig. 42). The male genital organs consist in general of the cirrus, which, when invaginated, is coiled into several folds in the cirrus pouch. The latter, together with the voluminous folds of the vas deferens, lies towards the median region of the segment in the sinus formed by the vagina. The testes develop within the central core of the strobile. They consist of spheroidal, granulo-nuclear bodies, often appearing as nests of nuclei, which occupy the whole inner core of the segment back to the germ glands, thus, in part, surrounding the cirrus pouch, vas deferens, vagina, and uterus, all of which lie in the central space, *i. e.*, the space which is inclosed by the thin layer of longitudinal and circular muscles.

The fine ducts which lead from the testes to the vas deferens have not yet been traced satisfactorily. A duct which is continuous with the voluminous folds of the vas deferens at the base of the cirrus pouch lies along the median line near the dorsal side of the segment (figs. 27, 29, *v. d.*).

The testicular lobes apparently communicate with this by means of fine tubules, but their disposition is not clearly shown in any of the sections. One of the lobes of the testis, in which there are spermatic cells and spermatozoa, is shown in fig. 39.

The following points on the arrangement of the female genitalia have been elucidated: The vagina opens in front of the cirrus in a common cloaca (figs. 34 and 35). Its course is thence forward and inward to the median line near the anterior end of the segment, thence posteriorly along the median line on the dorsal side of the uterus. Throughout its course it presents in sections a rugose interior surface (fig. 43). There are two enlargements of the cylindrical vaginal tube, one near the genital cloaca, from which the sketch shown in fig. 43 was made, the other near the posterior end of the segment in the midst of

the folds of the germ gland (see fig. 41). The vagina passes close to the shell gland (figs. 36 and 37) and continues in its course a short distance beyond that organ. Posterior to the shell gland it unites with the duct from the germ gland, and the common duct turns anteriorly to enter the posterior part of the shell gland. At the shell gland the common duct receives the duct from the vitelline gland. The vagina, thus reinforced, enters the shell gland at its posterior side and emerges from its anterior side as the oviduct. The latter proceeds forward for a short distance, then crosses from the dorsal to the ventral side of the segment, passing the vagina in its course and soon debouching into the uterus.

The uterus is a conspicuous oblong organ, lying along the median line on the ventral side of the segment, and extending nearly to the anterior end of the segment. Its course and structure are shown in figs. 26, 27, 29, 30, 31, 40, and 41. The vitelline glands develop from the subcutaneous granulo-fibrous layer and consist of granulo-nuclear bodies, smaller than the lobes of the testis and lying mainly between the aquiferous vessels and the margins of the segment. The vitelline duct, which enters the duct leading to the shell gland, is made by the junction of two principal branches, one from each of the vitelline glands.

The relative positions of the various female sexual organs are shown in the diagrammatic sketch, fig. 41; some details of structure are shown in figs. 36, 37, 38, 42, and 43.

Along the ventral furrow the epidermis and cuticle are discontinuous and the uterus here lies near the surface. The furrow is probably a line of dehiscence through which, in ripe proglottides, the ova are discharged. Only the following observations have been made on the ova: Those which appear in the series of sections of a ripe proglottis prepared for this paper are small, about .014^{mm} in diameter, and without other shell than a thin, much shrunken membrane. Furthermore they seem to be held together in a common mesh of fibers which appear to be continuous with the membranous covering of the ova. In some of the sections of mature, not ripe, segments, the uterus contains numerous small, rounded, and fusiform masses of deeply stained granulo-nuclear materials, having the same general characters as the ova in the ripe proglottis (fig. 27).

The elongated unidentified proglottides mentioned above (p. 544) contain large ova which are long, oval, and have a definite resistant shell. They therefore evidently do not belong to this species.

EXPLANATION OF THE PLATES.

The following letters have the same significance in all figures:

c. m. circular muscles.
g. c. duct of germ gland.
g. g. germ gland.
l. longitudinal aquiferous vessel.
m. longitudinal muscles.
n. c. marginal nerve chord or vessel.
n. g. nerve cells.
o. v. oviduct.
p. cirrus.
s. c. subcuticular fibro-granular layer.
s. g. shell gland.
t. testis.
u. uterus.
v. vagina.
v. c. duct of vitelline gland.
v. d. vas deferens.
v. g. vitelline gland.

The figures are all from drawings by the author.

PLATE I.

FIG. 1. Scolex and pseudoscolex; *a*, scolex; *b*, pseudoscolex; *c*, anterior part of strobile; × about 14. From a stained alcoholic specimen.
FIG. 2. Detail of pseudoscolex, superficial view, × 27.
FIG. 3. View of another portion of same, × 27.
FIG. 4. Face of bothrium, viewed from the front so that the posterior part is slightly foreshortened; from alcoholic specimen, × about 60.
FIG. 5. Scolex and pseudoscolex of small specimen, from life, much enlarged; *a*, anterior loculus; *b*, hooks; *c*, posterior loculus; *d*, neck; *e*, pseudoscolex; *f*, anterior part of strobile.
FIG. 6. Front view of bothrium, from life, much enlarged.
FIG. 7. View of top of scolex and pseudoscolex, of large specimen, about one-half of the latter shown in sketch. Outline of pseudoscolex, × about 14 diameters; scolex, × 15. From stained alcoholic specimen; *a*, scolex.

PLATE II.

FIG. 8. Transverse section of scolex near apex through anterior loculi, × about 225. Picro-sulphuric preparation stained with Beale's carmine; *b*, loculus of bothrium; *m*, cut ends of longitudinal muscles. Nerve cells mainly central.
FIG. 9. Detail of transverse section through wall of bothrium, × 750.
FIG. 10. Transverse section through posterior loculi of bothria, × about 200 +; *l*, longitudinal vessels of water-vascular system, nerve cells no longer central as in fig. 8.
FIG. 11. Transverse section immediately back of scolex, × about 225. *l'*, branch of longitudinal aquiferous vessel entering cervical outgrowth of pseudoscolex; *m*, cut ends of longitudinal muscles. The nerves are here collected into the two marginal chords or vessels, *n. c*, *n. c.*
FIG. 12. Longitudinal section of bothrium, × about 225. *b*, anterior, *b'*, posterior loculus.
FIG. 12*a*. Bothrium treated with caustic potash, × 80. Front view.
FIG. 12*b*. Bothrium treated with caustic potash, × 80. Side view.
FIG. 13. Hook, optical section, showing the closely packed epithelial cells of which it is composed, from longitudinal section of bothrium, × 450.
FIG. 14. Longitudinal section of apex of scolex, showing central nerve mass, and vessels of water-vascular system; *b*, *b*, anterior loculi, × 450.
FIG. 15. Longitudinal section of apex of head showing nerve cells and longitudinal vessel of water-vascular system, section more nearly central than fig. 14, × 450.

All the figures of plate II, with the exception of 12*a* and 12*b*, made from picrosulphuric preparations stained with Beale's carmine (ammonia).

The plates here numbered I to VII follow page 556 and are there numbered LXI to LXVII.

PLATE III.

FIG. 16. Side view of scolex, from life, much enlarged.

FIG. 17. Transverse section of neck and pseudoscolex of small specimen, × about 50; *l*, longitudinal aquiferous vessels; *l'*, lateral branches of same in pseudoscolex; *a*, cervical outgrowth of pseudoscolex.

FIG. 18. Transverse section a little below middle of neck, × 200 +; *v*, transverse muscle fibers; other letters as in previous figures.

FIG. 19. Section made nearly longitudinally through anterior part of body, pseudoscolex and scolex of small specimen more nearly central than fig. 24. *a*, folds of pseudoscolex; *b*, anterior, *b'*, posterior loculus; × about 30.

FIG. 20. Transverse section of anterior part of body immediately back of pseudoscolex of small specimen, × about 32. In section from which this sketch was made pieces of the pseudoscolex folds surrounded the section of the body but were not attached to it; *c*, epidermis and cuticle; *d*, *d*, points where the longitudinal muscle layer *m* touches the cuticle. In the sections preceding this the longitudinal muscle fibers entered the cervical outgrowth of the pseudoscolex at these places; *s. c.*, subcuticular granulofibrous layer; *m*, longitudinal and *c. m.*, circular muscle layer; *l*, larger inner, *l'*, smaller outer aquiferous vessel; *n. c.*, nerve vessels lying near marginal extremities of central core.

All the figures on plate III with the exception of fig. 16, made from picro-sulphuric preparations stained with Beale's ammoniacal carmine.

PLATE IV.

FIG. 21. Details of Fig. 22: Transverse section immediately behind pseudoscolex of small specimen; *c*, epidermis; *c'*, cutis; *s. c.*, cuticular fibro-granular layer; *m.*, longitudinal muscles; *l*, larger aquiferous vessel, section through an abrupt fold of vessel; *l'*, smaller aquiferous vessel; *c. m.*, circular muscles; *n. c.*, nerve vessels. × about 225.

FIG. 21*a*. Details of epidermis: *e*, outer; *e'*, inner layer of epidermis; *c*, cutis; *s. c.*, subcuticular layer.

FIG. 22. Transverse section approaching posterior of pseudoscolex; small specimen, × about 50; *m'*, muscle fibers of the pseudoscolex continuous with the longitudinal muscles of the body.

FIG. 23. Longitudinal marginal section from middle of small specimen through larger aquiferous vessel. × 54. The longitudinal fibers of the subcutaneous layer are here visible.

FIG. 24. Longitudinal section a little inclined to the lateral face of the strobile through scolex and pseudoscolex; × about 30; *a*, cervical outgrowth of pseudoscolex near base; *b*, same near scolex; *l'*, aquiferous vessel; *c*, epidermis.

Fig. 23. From corrosive sublimate preparation stained in borax carmine; others, picro-sulph., Beale's carmine.

PLATE V.

FIG. 25. Diagrammatic sketch showing general plan of scolex and pseudoscolex of small specimen in section; l', lateral branch of aquiferous vessel; l'', plexus of aquiferous vessels; *aa*, sections of superficial folds of pseudoscolex; other letters as previously explained.

FIG. 26. Transverse section of posterior segment in which the sexual organs are mature, on level with posterior of genital cloaca; *l. f.*, lateral furrow; *p*, invaginated base of cirrus; p', cirrus bulb with sections of coils of cirrus; other letters as previously explained; × about 36.

FIG. 27. Details of same in region of uterus and lateral fold; *c* inner, c' outer layer of epidermis; c'', cutis; *u*, uterus containing ova; other letters as previously explained; × 225.

FIG. 28. Details of fig. 26: Cirrus pouch; *e*, wall of cirrus pouch; *a* to *d*, different layers of invaginated cirrus; *m.*, longitudinal muscles, × 225.

FIG. 29. Transverse section of posterior segment with mature sexual organs, slightly more advanced than the one represented in fig. 30. Section made anterior to genital cloaca, × 45.

Figs. 26, 27, and 28, Perenyi's fluid preparation, Beale's carmine stain.
Fig. 29, Perenyi's fluid, Bömer's hæmatoxylon stain.

PLATE VI.

FIG. 30. Transverse section of posterior mature segment, near anterior end of segment, at extreme anterior end of uterus; *s*, portion of voluminous folds of vas deferens; other letters as in figs. 26, 29; × 45.

FIG. 31. Details of fig. 30; *u*, nuclear aggregation, first indication of the uterus; *s*, portion of folds of vas deferens with spermatozoa; *a*, epethelial glands, × 225.

FIG. 32. Longitudinal lateral section of small specimen, near anterior end through aquiferous and nerve vessels, × about 225.

FIG. 33. Superficial view of segments near posterior end. The apparent enlargement posteriorly is accidental, and would not appear in a longer portion of the strobile. As a rule the maturing segments become narrower; *a*, *a*, segments shaded to show characteristic roughened epidermis. From a stained alcoholic specimen.

FIG. 34. Longitudinal lateral section through genital cloaca, × 60.

FIG. 35. Longitudinal marginal section, posterior but not mature segment, × 260.

Figs. 30, 31, and 32, Picro-sulphuric, Beale's carmine.
Figs. 34 and 35, Perenyi's fluid, Bömer's hæmatoxylon.

PLATE VII.

FIG. 36. From transverse section of posterior segment with mature genital organs; posterior end of segment; germ gland, shell gland, etc.; × 112.

FIG. 37. Details of fig. 36, × 225.

FIG. 38. Transverse section of oviduct near the shell gland, from longitudinal section of posterior segment, × 475.

FIG. 39. Testicular body, with sperm cells, *a*, and spermatozoa, *b*, × 475.

FIG. 40. Partly diagrammatic sketch of segment near posterior end of strobile, × 30

FIG. 41. Partly diagrammatic sketch showing female genitalia in mature segment, × 30.

FIG. 42. Longitudinal section of invaginated cirrus, near base; the upper part of the figure is the marginal end; *a*, spines, × 225.

FIG. 43. Longitudinal section of vagina near genital cloaca; *a*, rugæ on wall of lumen, × 225.

Figs. 36, 37, 38, 39, and 41, Perenyi's fluid, Bömer's hæmatoxylon.
Figs. 40, 42, and 43, corrosive sublimate, borax-carmine preparations.


a
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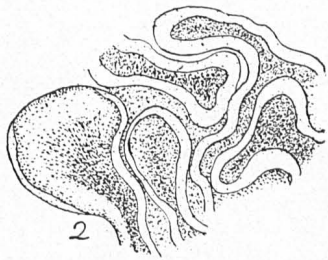
c
1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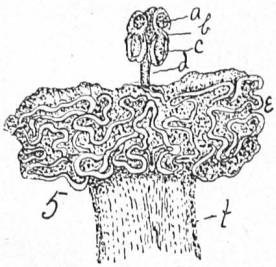
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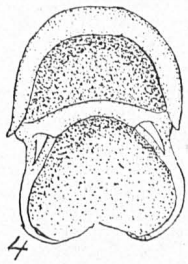
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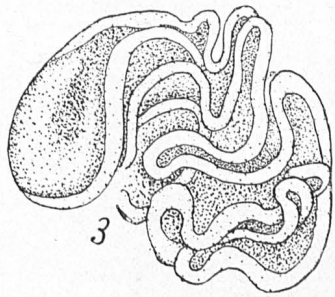
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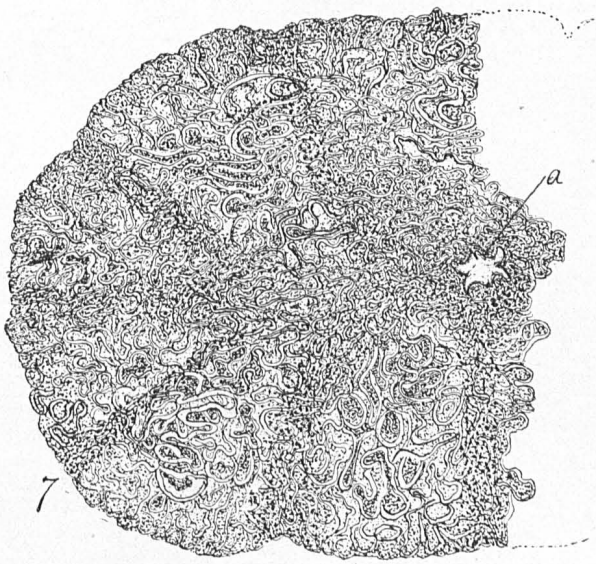
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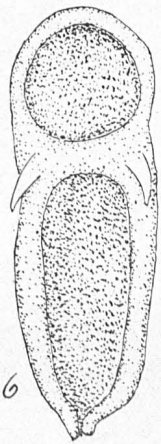
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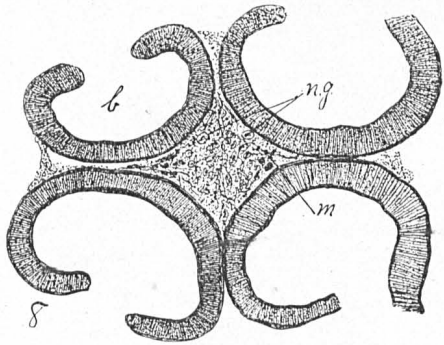
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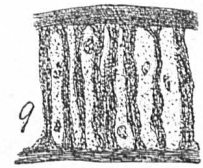
12a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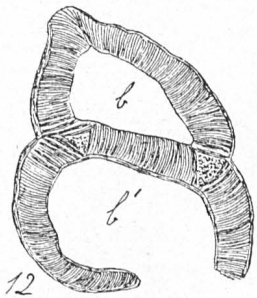
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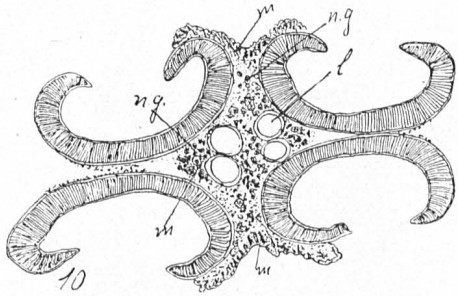
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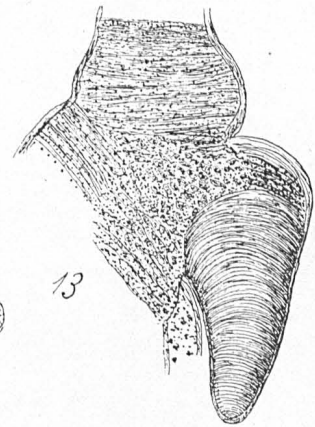
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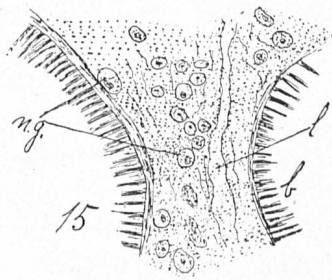
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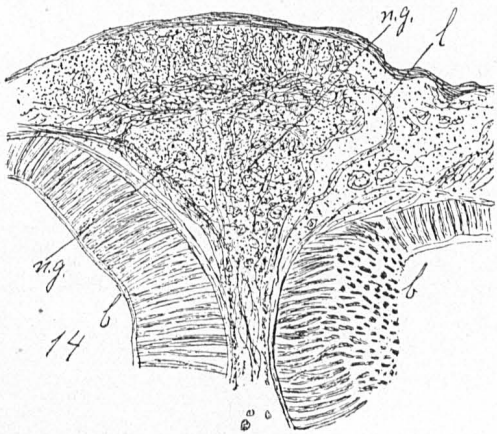
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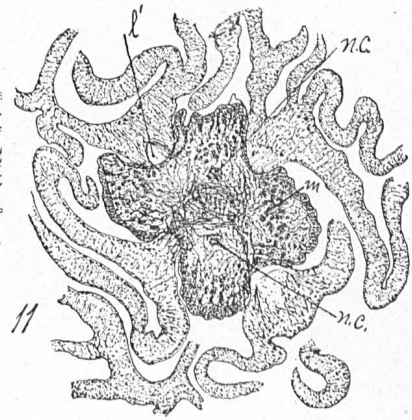
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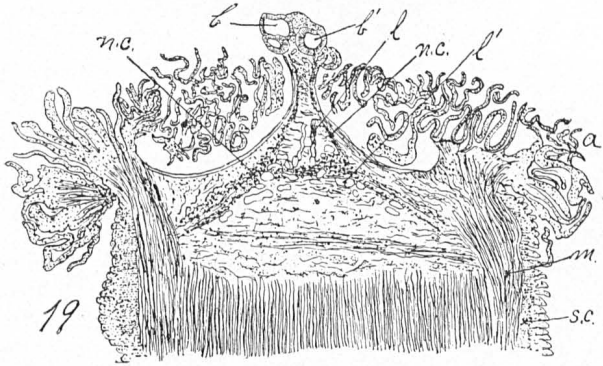
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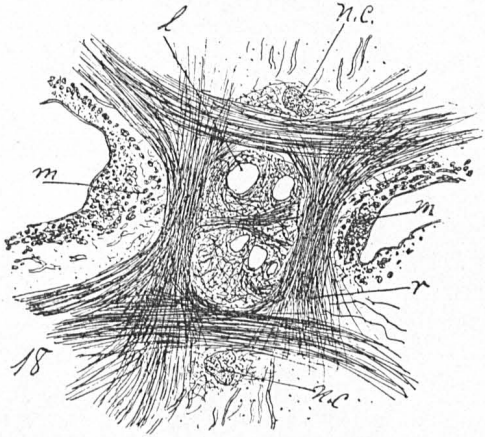
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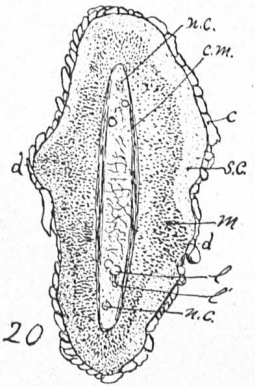
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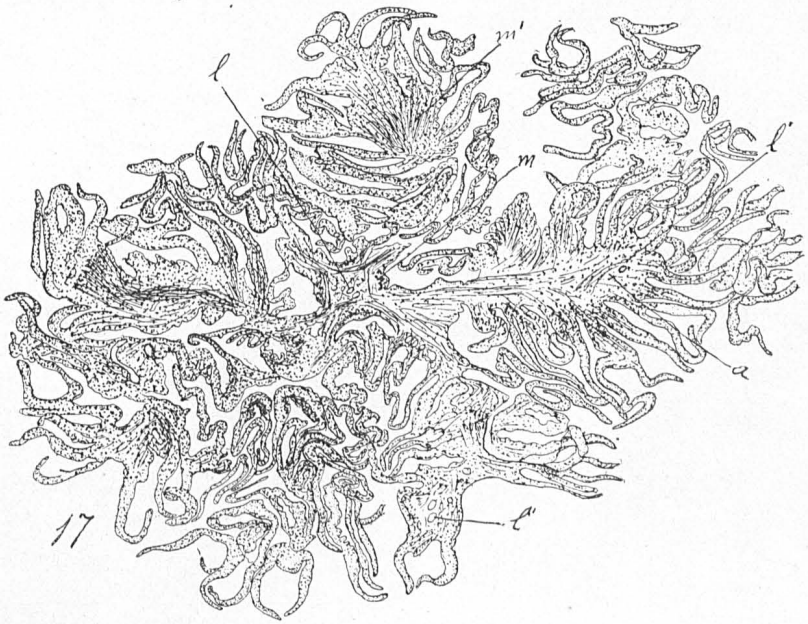
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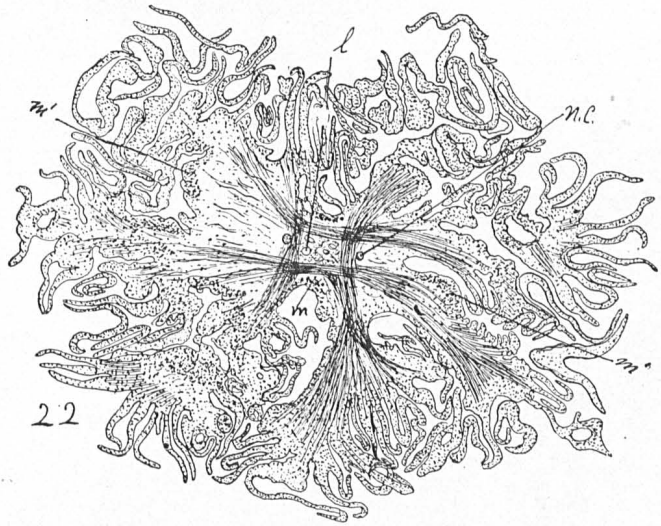
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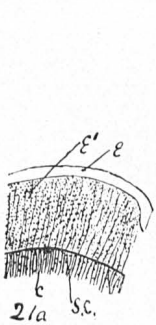
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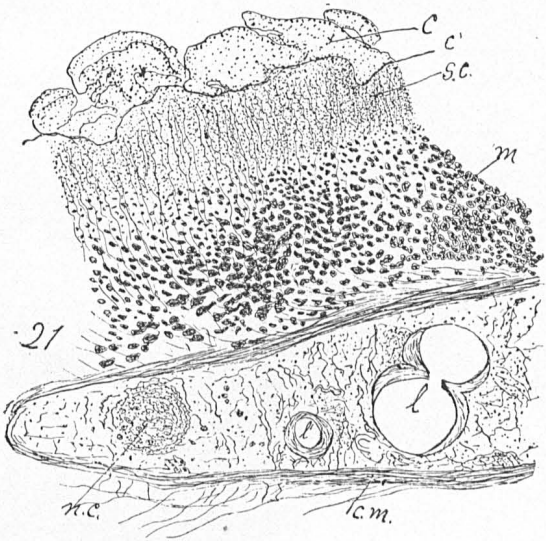
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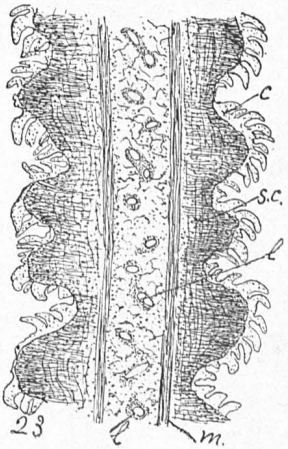
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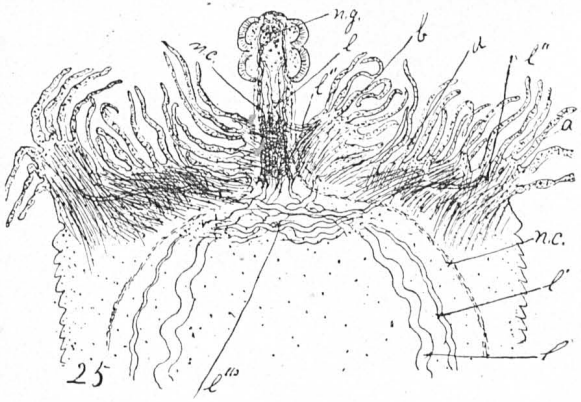
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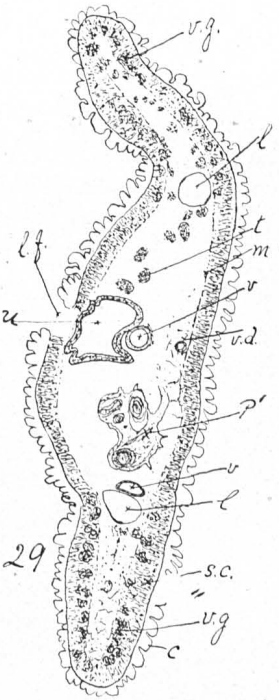
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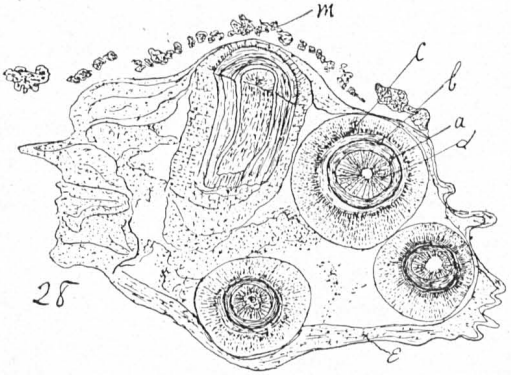
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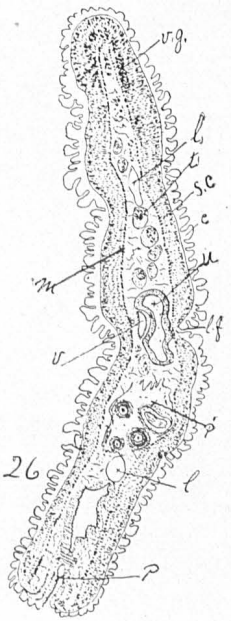
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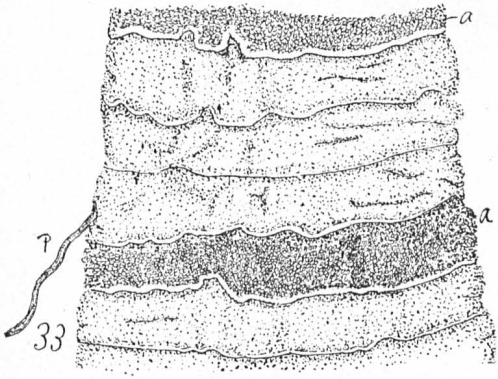
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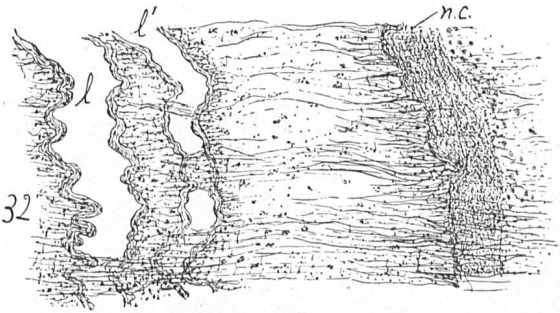
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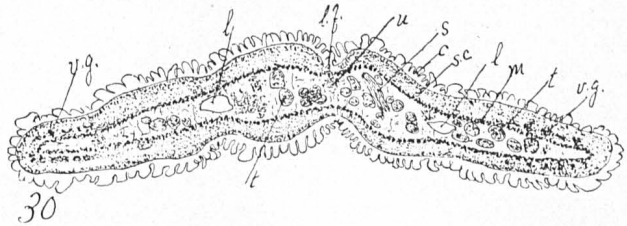
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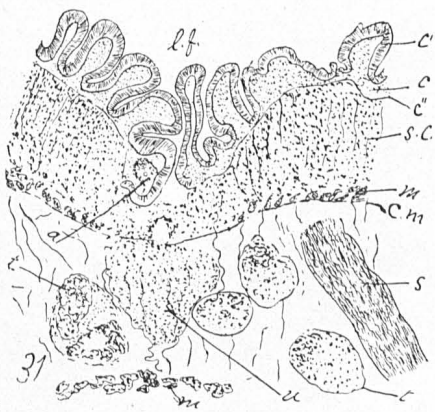
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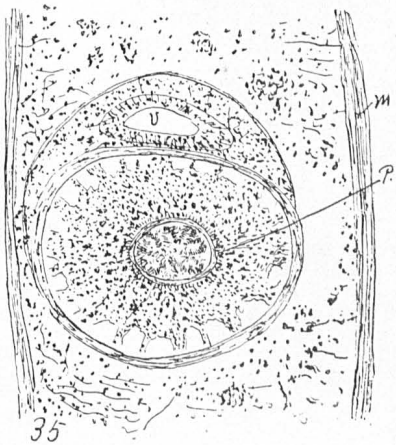
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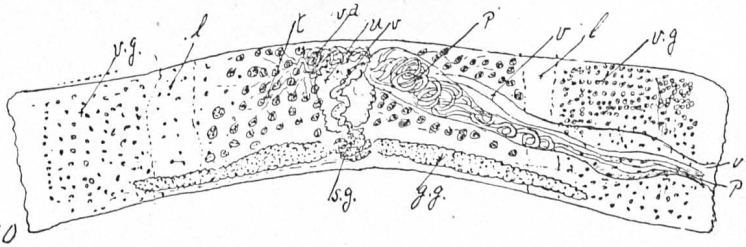
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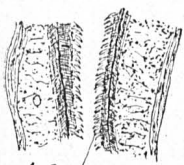
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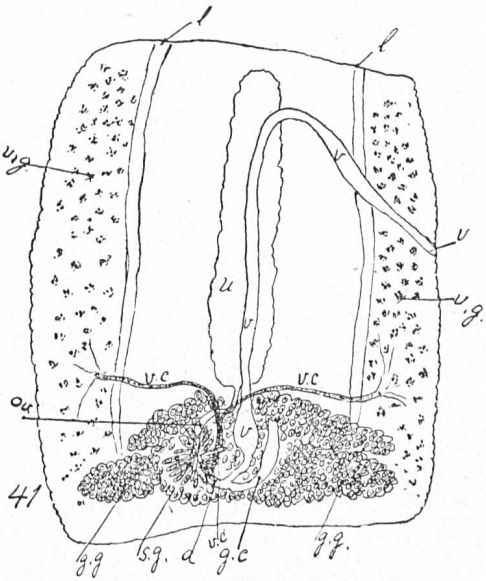
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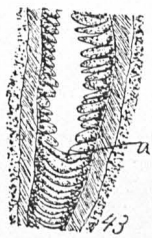
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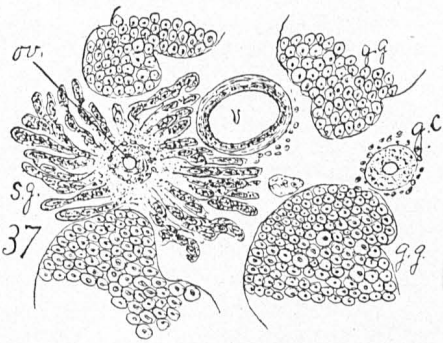
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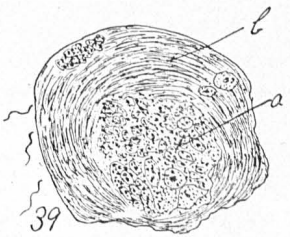
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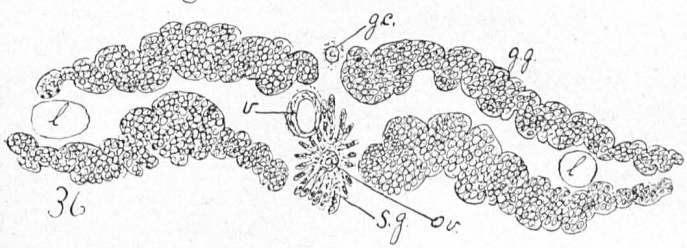
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