A THESIS

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[From the Department of Zoology.]

"PARASITES from FRESH-WATER FISHES and MOLLUSCA;
a new species of CAPILLARIA from the MINNOW and
five new CERCARIAE from LIMNAEA".

by

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INTRODUCTION.

Since the discovery of sporocysts and rediae by Steenstrup in 1842, the study of the life histories of different Trematodes has received much attention by investigators, for instance Wagener in 1857, Leuckart in 1882, Thomas in 1883, Heckert in 1889, Creutzberg in 1890 and Looss in recent times. It was from the observations of these workers that the life cycle of Trematodes was put on a firm basis. But no real importance was attached to the study of miracidia, sporocysts, rediaeand cercariae until after the classical work of Thomas in 1883, which resulted in a thorough explanation of the life history of the liver fluke and its transmission from sheep to sheep.

Since 1883 numerous investigations have been carried out from the economical and medical point of view, and the bulk of the contributions to the knowledge of cercariae consists of the results of observations and experiments on the cercariae of the Trematodes infecting man and the domestic animals Particular/

Particular attention was paid to the different intermediate hosts and the conditions under which they are capable of causing the infection of the definitive hosts.

A serious study of the organisation of cercariae was long neglected and in spite of the numerous cercariae described by many investigators, it is impossible to identify many of the species correctly. It was only after the study of the cercariae of the Schistosomidae infecting man that the study of the morphology and histology of other cercariae was adequately undertaken, and authors began to attach importance to features of the internal organisation, which may throw light on the structure of the adult. The systems which have been carefully studied are the alimentary tract, the excretory and genital systems, and specific differences were observed even among cercariae closely resembling one another. Certain glands in the body have also been observed, and have proved in many cases to play an important part in the process of infection of the definitive host.

If the external and internal structures of a cercaria be considered, we may divide the characters into/

into two sets.

(A) Those structures such as the suckers, the alimentary tract, the excretory system, the genital system, and some parenchymatous cells which form the basis or are the miniatures of the corresponding adult structures.

(B) Those structures such as tails, spines, processes, stylets, eye spots, salivary glands, cystogenous cells and parenchymatous cells, which are purely larval structures and are not carried over to the adult. The structures belonging to the former group are relatively well known but in the case of the larval structures there is much yet to be explained.

What are termed salivary glands may have the same structure but different functions in different cases. The cystogenous cells are distinguishable from parenchymatous cells by possessing larger nuclei poor in chromatin, and cytoplasm which may contain obvious granules or may be faintly granular, but their function is not always demonstrable. Lastly the parenchymatous cells are indistinguishable from other cells such as those surrounding the nerve ganglia, those under the cuticle, which have received the name of cuticular cells and from cells which are destined to give rise to other structures such as vitelline glands. Looss emphasized the fact that these cells/

cells are at first indistinguishable cytologically and maintained that many of these mesodermal cells remain undifferentiated for a considerable time. There is also reason to believe that some cells in the parenchyma form the basis of other structures such as the excretory system, for the collecting ducts are not bounded by cellular walls, but are merely lumina among certain cells. Certain other parenchymatous cells both in the body and in the tail of some cercariae are more vacuolated and distended and their function appears to be that of buoyancy.

SOURCE AND DISCUSSION OF CERCARIAE.

This paper is an attempt to describe the cercariae infecting the genus Limnaea and particularly Limnaea peregra and Limnaea auricularia in three localities in Scotland. The work was begun during a survey of the fresh water molluscs of Lochs Lubnaig and Vennacher. While Dr. Annandale was collecting Limnaeas from these two lochs an opportunity was afforded me of making a careful study of the cercariae infecting Limnaea peregra during the summer month of July. In August Dr. Annandale visited the Inner Hebrides and especially the islands of Ulva and Mull, and kindly/

kindly sent me some specimens of Limnaea peregra and Limnaea truncatula. During the same month I collected Limnaea stagnalis and Limnaea auricularia from Duddingston Loch near Edinburgh.

An examination revealed the fact that Limnaea peregra from Lochs Lubnaig and Vennacher was heavily infected with two species of cercariae, a furcocercous form and a xiphidiocercaria. The specimens of Limnaea peregra from Ulva and Mull were infected with two species of xiphidiocercaria, while none of the specimens of Limnaea truncatula were infected in spite of the fact that Ulva sheep are sometimes infected with Fasciola hepatica. Only the Limnaea auricularia was infected from the Duddingston Loch.

Of the five species of cercariae described in this paper, two species were found to infect the Limnaeas under fluviatile conditions and three species under lacustrine conditions. The different environmental conditions to which Limnaea peregra is submitted render it specific for different species of cercariae, the adults of which are parasitic in definitive hosts more or less restricted to such regions.

A/

A local modification of the Limnaea is also a result of such conditions but infection with cercariae in this case seems to depend not so much upon the variation of the Limnaea as upon the local conditions to which it is adapted. In Loch Lubnaig two forms of Limnaea peregra are found, a large infected form inhabiting the bays and still pools along the shore line and a small uninfected form more common in running water, especially where the River Leny flows out off the loch and in small streams flowing into the loch.

According to Dr. Annandale three different forms of Limnaea peregra are found in the streams of the Ross of Mull and Ulva. In the little Tarn Loch Pot I. as it is called on the Ross of Mull the small short spired phase sometimes called Gulnaria lacustris occurs in abundance. A second form with larger and broader shells than lacustris is also found on Mull. In the hill streams of Ulva the third form is found, which resembles lacustris but is smaller with a narrower body whorl and with a more exserted spire. All of these forms were infected with the Xiphidiocercaria

B/

B to be described. The other xiphidiocercaria was only observed once in the same collection, but its cysts were present on the shells of all the forms. Limnaea peregra was not found in Duddingston Loch and Limnaea auricularia was not common, only five specimens of the latter having been obtained of which one was infected with the furcocercaria to be described.

The Limnaeas sent by Dr. Annandale from the islands were collected in pools and bodies of still water along the streams. A pool or a body of still water appears to be favourable to miracidia and cercariae and unless this condition is present the Limnaeasif present are not infected. Limnaea peregra collected in a swiftly flowing stream in the South of France during October showed no infection, but in a hill stream containing many pools of still water with numerous Limnaeas the infection with Cercaria gibba Fil. was heavy.

An interesting point is the fact that the small forms of Limnaea peregra collected in hill streams flowing into Loch Lubnaig were found uninfected in spite of their presence in pools, while those from the hill streams of Ulva and Mull were comparatively/

comparatively heavily infected. If the definitive host and its distribution were known this isolation of cercariae could be explained, for there is no doubt that the infection of the same mollusc in different places with different species of cercariae could be explained on the grounds of the distribution of the respective definitive hosts. Thus the Limnaea peregra in the South of France, which is infected with Cercaria gibba is also under fluviatile conditions, but the definitive host of the cercaria is probably confined to the southern parts of Europe, for this species of cercaria has only been reported from that region.

The specificity of molluscan hosts for a definite species of cercaria has at least in some cases been disproved by the discovery of different gastropod hosts in widely different geographical regions for the liver fluke Fasciola hepatica and some human flukes. There is reason to believe that different species of molluscs may become adapted to the parasitism of the same cercaria, when the real host is absent. These facts point to the conclusion that the distribution of cercariae depends largely upon/.

upon the geographical distribution of their definitive hosts.

Another point to be taken into consideration is the relation of infection to the temperature and the season. In the description of the two cercariae from Loch Lubnaig the fact is mentioned that the furcocercous form is common in July, but its liberation declines in August, and as the investigations were carried out during July and August only those cercariae prevalent during these two months have been studied. There is no definite reason to assume that other species of cercariae are liberated during other months of the year, but the apparent absence of infection during a month in Spring or Autumn does not prove that a certain gastropod is not a host. Some land snails from Southern France examined in October were infected with sporocysts containing undifferentiated embryos and there were no signs by which the future organism could be recognised. In this case the development of the cercariae is probably completed in the winter or delayed till the Spring of the following year.

METHOD/

METHOD OF STUDY.

The infected Limnaeas in all cases were kept in aquaria and the study was carried out on free swimming and living cercariae where possible. The livers of infected Limnaeas were also teased out in order to examine the sporocysts. Liberated cercariae as well as pieces of the liver were fixed in corrosive acetic and preserved in alcohol. The genital system and alimentary tract, especially the former were studied in stained whole mounts or in sections.

The nematode and the encysted larvae were obtained from the minnow Leuciscus phoxinus Linn. About fifty minnows were caught in Loch Lubnaig and examined. Only two specimens were found to be infected with the nematode, one with a single female and the other with two females and a male. The worms were found in the mucus of the posterior part of the intestine. The material was preserved in formalin (one part of a 40% solution in 19 parts of water). The encysted larvae were found in the intestinal wall of one minnow and were preserved in alcohol.

In/

In connection with this paper my thanks are due to Prof. J.H. Ashworth without whose kind interest and advice the work would not have been carried through; and to Dr. N. Annandale for the kind assistance he gave me in procuring the material for the scientific names of the molluscs and the fish, and for general observations in connection with the distribution of Limnaea peregra in the localities cited.

DESCRIPTION of FURCOCERCARIA. A. and XIPHIDIOCERCARIA. B. from LIMNAEA PEREGRA MÜL. from LOCHS LUBNAIG and VENNACHER.

FURCOCERCOUS CERCARIA A.

From Sporocysts in liver of Limnaea peregra var burnetti (MÜLLER) from Lochs LUBNAIG and VENNACHER.

THE SPOROCYSTS.

The sporocysts are long worm-like structures, and in all the Limnaeas examined, they were so numerous and involved, that it was difficult to separate them or to obtain an undamaged one. They arise in or near the ovo-testis, and as development proceeds they extend into the liver and finally destroy the entire organ.

The individual sporocyst presents to the naked eye the appearance of a piece of thin cotton. It may reach a length of 1 cm. with a maximum thickness of .15mm. The entire sporocyst is active, its pointed anterior end especially so as it continually oscillates from side to side. The sporocyst is usually uniform in diameter, but in some cases has become constricted at certain points and resembles a string of sausages. The constrictions are probably due either to points of maximum resistance of the liver/

liver tissue, or to incipient transverse division of the sporocyst.

The sporocyst is white, sometimes slightly tinged with yellow or brown; the extreme anterior end is yellow. It is closed at its posterior end, but about .1mm. from the anterior end (Fig.1,BP) is a definite birth-pore. About .08 mm. from the anterior end is a ridge, which is not a constant character, but is subject to variation, according to the state of contraction.

Externally the sporocyst is covered with flat epithelial cells (Fig.2,E.C.), the spaces between which are filled with a granular material.

In some parts of the external layer cell outlines are not visible. Internal to the epithelial layer is a muscular layer, below which is a layer of cells, from which the cercariae arise (Fig.1,C_g & Fig.10,C_g). Anterior to the birth pore, the sporocyst is completely filled with a mass of cells, and this region marks the locality of primary cell-proliferation (Fig.1,C_g). Behind the birth pore the sporocyst exhibits a cavity bounded by a thin cuticular membrane. The cercariae arise from germinal elements, and as the cells increase in number, each

group/

group or cluster becomes constricted off from the internal lining to which, however, it remains attached by a thin homogeneous non-cellular strand. In some instances similar strands connect adjacent embryos (Fig.10,S.). These strands probably restrain the movements of developing individuals to a certain extent. More anteriorly, that is towards the birth pore, the cercariae are mature and free, but in the rest of the cavity they occur in all stages of development. The wall of the sporocyst exhibits peristaltic movements and thecontained cercariae of various ages - the younger ones still connected to the wall - are kept in movement. Every movement brings a mature cercaria nearer to the birth pore. All the cercariae are, however, not directed forwards; some are directed backwards and move over and under other individuals. Ordinarily they are passed out regularly at the birth pore, but rupture of the wall may occur when the sporocyst is overcrowded with mature cercariae.

THE CERCARIA (FIG. 3. & 4.).

The cercaria which is translucent is furcocercous, having a slender body and a stout tail with two lanceolate forks. The shape of the body is variable, depending upon the state of contraction. The oral region is very contractile, and the walls of the buccal cavity are protrusible.

The body is concave ventrally and convex dorsally. The tail is inserted terminally, in a small pocket, the margins of which are slightly overhung by the posterior margin of the body.

The anterior end of the body is covered with transverse rows of minute recurved spines. The extreme anterior rows are close together and enter the buccal cavity. Posteriorly the rows become further apart and soon disappear on the dorsal surface, but scattered spines are present on the ventral surface, as far back as the ventral sucker. The remainder of the body is smooth, and bears no processes except laterally on each side, and .01mm. from the posterior end, two backwardly directed bristles.

There are two suckers, a powerful oral sucker surrounding the mouth, and a ventral sucker /FIGS./

(FIGS. 4 & 5), bearing three rows of spines. The first row situated on the rim, consists of long spines, each with a stouter basal part, embedded in the muscles, and a needle-like distal part about .008mm. long, fixed at an angle with the basal part. The spines are movable, and their orientation depends upon the state of retraction or extrusion of the sucker. The spines of the second row are blunt and knob-like, and alternate more or less with the basal elements of the first row. Deeper down in the cavity of the sucker is a third series, but these are mere tubercles.

The tail (FIG.7) is thick and powerful, and transversely striated. It bears stiff hairs, reaching a length of .013-.02 mm., but these are few and far apart. The two forks of the tail are about as long or rather longer than the basal part, and are flattened from side to side. No hairs could be seen on the forks, but the dorsal and ventral edges, especially posteriorly, have a serrated appearance (FIGS. 7 & 8).

MEASUREMENTS/

MEASUREMENTS of LIVING CERCARIAE.

(The figures in brackets which follow, are the corresponding measurements from specimens fixed in sublimate acetic and examined in alcohol).

Length of body	.14-.16mm.	(.12-.15mm.)
Breadth of body anteriorly	.025mm.	(.02mm.)
Breadth of body posteriorly	.04mm.	(.025-.04mm)
Breadth of body in middle region (maximum)	.05mm.	(.04-.05mm.)
Thickness of body in the region of the ventral sucker about	.043mm.	(.035mm.)
Thickness of body in posterior region	.023mm.	(.023mm.)
Length of tail	.19-.2mm.	(.16mm.-.19mm.)
Length of fork	.2-.22mm.	(.17mm.-.2mm.)
Breadth of tail	.03-.035mm.	(.03mm.)
Breadth of fork at base.	.015-.019mm.	(.012-.014mm.)
Length of ovate oral sucker about	.05mm.	(.04-.05mm.)
Maximum breadth of oral sucker about	.025mm.	(.025mm.)
Diameter of ventral sucker (uncontracted)	.03mm.	(.03mm.)
Diameter of ventral sucker(contracted)	.018-.024mm.	(.02mm.)

The anterior margin of the ventral sucker is about .084-.09mm (.06-.08 mm.) from the anterior end.

INTERNAL ORGANISATION.

ALIMENTARY TRACT (FIG. 4.)

The mouth is situated terminally and the neighbouring wall of the buccal cavity is introvertible. The dilated posterior part of this cavity, still surrounded by the oral sucker, leads into the tubular oesophagus, which bifurcates immediately anterior to the ventral sucker. Each fork can be seen as a string of about six clear, transparent cells situated in the dorsal region of the cercaria. A little posterior to the oral sucker is a cluster of cells opening into the oesophagus and simulating a pharynx (FIGS. 4 & 9.), but there are no muscle layers here, such as there would be in a true pharynx. The salivary glands are four large coarsely granular cells, two on each side, having a diameter of about .01mm. situated ventrally and behind the ventral sucker. They are sometimes placed obliquely, one behind the other. The salivary ducts are lateral and run anteriorly, passing through the walls of the oral sucker to their external openings, one on each side of the mouth. During their course through the wall of the oral sucker, they become dilated.

EXCRETORY SYSTEM (Fig. 6, & Fig. 7,)

There are 14 flame cells - seven pairs - in the body; The part anterior to the acetabulum has 2 flame cells. The first one is situated lateral to the oral sucker and opens into a duct running posteriorly almost parallel to the lateral margin of the body. The second flame cell is situated in the oesophageal region, and opens into a duct running medial to the first duct, but lateral to the ventral sucker. Both ducts unite posteriorly to the ventral sucker to form a single vessel, opening into the antero-lateral angle of the excretory vesicle. The five remaining flame cells lie posterior to the ventral sucker. The third one is lateral, and directed anteriorly. The fourth one is almost in the median line and a short distance posterior to the sucker, and opens into a duct, which unites with that of the third flame cell to form a tributary of the outer lateral duct from the anterior region. The fifth one is situated transversely near the coalescence of the main ducts, and is connected with the inner lateral duct. The sixth one is lateral, directed posteriorly and its duct opens into the main canal near the union of the main ducts. The seventh one is/

is lateral to the vesicle and directed laterally, and its duct runs anteriorly and leads into the main outer lateral duct.

The excretory vesicle is T shaped, and is situated at the posterior end of the body. It has a length of about .01 mm. and a breadth of about .007 mm. The excretory system in the tail is highly developed. There are four flame cells each of them opening by a short duct into the main caudal vessel. One of these flame cells is situated anterior to each of the last four pairs of large caudal cells.

There are six large caudal cells on each side of the main vessel. They are not always opposite to each other and sometimes an extra one occurs on one side, so that the total number is thirteen. These cells are large, about .025 mm. long and .012 mm. broad. They contain large hyaline nuclei, and the cytoplasm is clear and fluid. They collapse when fixed. Some of these cells are connected to cells in the wall of the tail by a thin strand. It cannot be definitely concluded that these cells have an excretory function, but as their inner walls bound the caudal canal, this function is suggested. The main caudal vessel is median in position, and it receives a duct from each fork. It opens into the posterior arm of the excretory vesicle.

GLANDS /

GLANDS & CELLS. (Figs. 4 & 9.)

The region between the alimentary canal and the body wall is filled with parenchymatous tissue, many of the cells of which are distended. There are numerous cells posterior to the oral sucker, and in the oesophageal region. Many cells are found under the cuticle, and are flask shaped. In the living cercaria some cells are faintly granular.

In no case was there any sign of gonadial tissue. The gonads have not yet been differentiated.

The wall of the tail is constituted of a layer of small cells. The tail is very muscular, longitudinal and circular fibres being visible under the cuticle.

MOTIONS of the CERCARIAE in WATER.

These cercariae do not emerge from the Limnaea in "puffs" or swarms, but pass out one by one, at the rate of about four or five per minute. They swim rapidly, and rise towards the surface, by lashing movements of the tail, and by rapid opening and closing of the forks. As the tail is moved from side to side, the caudal cells together with the flame cells and duct move, within a limited range, up and down the cavity of the tail.

The cercariae are heavier than the water and tend to sink, but after sinking a little distance they rise again towards the surface film by rapid movements of the tail. Their methods of locomotion remind one of those of Culex larvae. They are positively phototropic, collecting on the illuminated side of a tube. They swim obliquely upwards, tail directed forwards and body downwards, and come to to rest with the body turned symmetrically to the rays of light. If the tube is now slowly turned round the cercariae become active again, and migrate towards the light.

The main effort of the cercariae seems to be to get rid of the tail. The tail, after it is detached, performs independent lashing movements for some time.

The large caudal cells of the tail seem to give buoyancy to the cercaria.

The tailless cercariae creep leech-like, moving their mobile and contractile anterior ends from side to side. There seems to be a tendency to intrude into cavities. The cercaria was not observed to encyst, and probably has to gain entrance into the final host by penetration. The spines on the ventral sucker together with the spiny anterior extremity/

extremity, probably help the animal to penetrate the epidermis of the host. The function of the four salivary glands is not known, but probably their secretion aids in the act of penetration. The liberated cercariae were observed to live in water for 48 to 72 hours. After that they died and disintegrated. The definitive host of this cercaria is unknown.

TABLE/

X I P H I D I O C E R C A R I A A.

From sporocysts in liver of Limnaea peregra var burnetti (Müller) from Lochs Lubnaig and Vennacher.

THE SPOROCYSTS :-

The sporocysts are situated in the liver, and sometimes form knob-like projections on its surface. They are blunt, thick and short, and in the living condition are opaque and white, but empty sporocysts have a definite tinge of yellow. They are not straight but bent upon themselves and show no movement. They may reach a length of 1.5 mm. to 3 mm. and a breadth of .2 mm. to .5 mm.

The external layer is cellular and granular. Traces of a black pigment are found on the surface. Internal to the epithelial layer is a layer of cells from which the embryos arise. It is difficult to localise a definite centre of origin of the embryos as these are scattered throughout the sporocyst cavity. Early embryos are attached to the wall of the sporocyst by thin strands.

CERCARIA /

CERCARIA (fig. 1 and 2)

The cercariae arise from the germ balls, which constitute the contents of the sporocyst cavity. The mature cercariae creep in all directions as soon as the sporocyst is exposed or disturbed, there being no definite concentration of mature individuals at any special point.

The cercaria is oval in shape, and its anterior end is truncated. The body, especially the anterior extremity, is contractile and is capable of great modification, assuming either a more elongated or a more globular form. The normal form, while the animal is in suspension in the water is oval with the maximum breadth anterior to the ventral sucker. The anterior third is more or less transparent, but the posterior part is opaque. When examined alive and suspended in water the body is convex dorsally and concave ventrally, and the lateral margins of the body in lateral aspect tend to hide the ventral sucker. The anterior and posterior extremities are both directed downwards, the oral sucker and caudal pocket being subterminal. The posterior margin of the body projects rim-like over the base of the tail. The lateral extensions of the posterior margin are a little longer than the dorsal rim./

rim. In the normal condition the tail gives the impression of being inserted almost at right angles to the body. The walls of the caudal pocket are muscular and contractile, and the pocket has a cuticular lining, the surface of which is slightly thicker opposite the lateral extensions of the body. This thickened part is beset with minute bristles directed towards the base of the tail.

The cuticle of the body is thick and strong and muscle fibres can be seen below it. The cuticle is covered with rows of minute bosses or tubercles, which are better developed anteriorly and also posteriorly in the region of the caudal pocket. They are arranged in intersecting rows, and form a "diamond pattern". The cuticle of the tail is smooth, but transversely striated. Besides the tubercles the body is covered with fine hairs or bristles •01 to •02 mm. in length. These are scattered over the posterior three-fourths of the body at intervals of •02 to •04 mm. The arrangement of these hairs was difficult to determine as they are easily broken off. In most of the specimens there were nine transverse rows as evidenced by the nine bristles on each side of the body (fig. 2,H,). The first two rows are close together and their position is fairly characteristic of this cercaria;/

cercaria; the remaining seven rows of hairs on the body are by no means regular in position but the figure shows their usual arrangement. Six characteristic bristles project forward on each side of the stylet. One of these - the fifth from the stylet - is much longer than the others. These anterior bristles have been found in all the specimens examined, and may be considered as characteristic for this Xiphidiocercaria.

The tail possesses no hairs or bristles, but the cuticle is often seen to be raised into membranous extensions, which seem to be due to the effect of the water, for freshly liberated cercariae do not possess them. The cuticle of the tail may be transversely wrinkled, due to contraction.

The oral sucker is powerful and larger than the ventral sucker. In the dorsal part of the oral sucker is a stylet (fig. 2,St. and fig. 3), cylindrical proximally but with a nib-like distal part. The average length of the stylet is ·034 to ·037 mm., the diameter at the base is ·005 - ·006 mm., and at the base of the "nib" is ·009 - ·01 mm. At the base of the "nib" on the ventral surface, is a band-like reinforcement, which extends from the ventral onto the lateral surface and is about ·003 mm. in/

in thickness. The length of the "nib", measuring from the distal edge of the rim, is about •01 mm. The stylet is subject to slight variations in form in different individuals, e.g., the reinforcement may be present only on one of the lateral surfaces. The main body of the stylet is hollow, but the "nib" is solid. The distal point is situated in a slight invagination at the anterior end of the cercaria, but it does not project to the exterior. A lateral view of the cercaria shows that the stylet is situated obliquely, and dorsal to the mouth, and also that the reinforcement does not extend on to its dorsal surface, so that in profile the dorsal surface of the stylet is a straight line.

The ventral sucker is slightly smaller than the oral sucker, and its aperture is directed backwards.

MEASUREMENTS/

MEASUREMENTS OF LIVING CERCARIAE.

(The figures in brackets which follow are the corresponding measurements from specimens fixed in sublimate acetic and examined in alcohol)

Length of body about.	·14–·25 mm. (·12–·25 mm.)
Breadth of body anteriorly.	·08 mm.
Breadth of body (maximum).	·1–·17 mm. (·12–·135 mm.)
Thickness of body anterior to the ventral sucker.	·053 mm. (·09 mm.)
Thickness of body posterior to the ventral sucker.	·035 mm.
Length of tail, depending on its state of contraction, or extension.	·11–·35 mm. (·15–·2 mm.)
Breadth of tail at base.	·035 mm. (·03–·05 mm.)
Diameter of the oral sucker.	·05–·06 mm. (·04–·05 mm.)
Diameter of the pharynx.	·023 mm. (·023 mm.)
Diameter of the ventral sucker.	·04 mm. (·04 mm.)
The ventral sucker may protrude.	·02 mm.

The anterior margin of the ventral sucker is about ·134 mm. (·1 mm.) distant from the anterior margin of the body.

ALIMENTARY/

ALIMENTARY TRACT. (Fig. 2)

The mouth is situated ventrally and is crescentic in shape, the corners being directed forwards. There is a small pharynx with muscular walls. An oesophagus is absent, the two forks of the intestine seem to arise from the pharynx, and may be traced each as a single curved row of cells to the posterior lateral region of the body. The interval between bifurcation and the ventral sucker is comparatively large.

EXCRETORY SYSTEM. (Fig. 4.)

The excretory system consists of flame cells, collecting ducts and an excretory vesicle. Eight flame cells were observed in the body, two of which are preacetabular and six postacetabular.

The anterior part of the body is drained by two ducts one on each side of the body, which run posteriorly. Each duct arises in the lateral region of the oral sucker and receives a small duct from the region of the pharynx, and another from a flame cell close to the anterior margin of the ventral sucker. The posterior region is drained by two ducts one on each side of the body, which run anteriorly. Each of these ducts receives tributaries from three flame cells, and a duct from the postero lateral/

lateral region of the body. The most posterior flame cell is situated at the posterior corner of the vesicle, and its duct is continuous with the main duct. Another flame cell is lateral to the vesicle, and a third is near the anterior margin of the contractile part of the vesicle.

Both the anterior and posterior main ducts on each side of the body unite to form a coiled lateral vessel which opens into an arm of the excretory reservoir. The posterior end of the vesicle receives a single duct, which traverses the tail. No flame cells were visible in the tail, and no external opening of this duct was observed.

The excretory reservoir lined with large cells is situated at the posterior end of the body. It is Y shaped having two noncontractile antero-lateral arms, each about ·03-·04 mm. long, and a median posteriorly directed contractile vesicle about ·04 mm. wide. The posterior part of this vesicle is more contractile than the anterior part. Frequently there is a correlation between the contraction and expansion of the vesicle, and the leech like creeping movements of the tailless individual. Thus, when the anterior end moves forwards, and the posterior end is at rest, the vesicle is expanded, but when the anterior end is fixed, and the posterior/

posterior part moved forward, the vesicle contracts, This is, however, not constant, and the reverse reaction was also observed. The contractility of the vesicle decreases after the tail has been cast off, and the caudal pocket has been contracted.

GENITAL SYSTEM. (Fig. 2, 7, and 8.)

The gonads are represented as masses of germ cells, and are as yet feebly differentiated. The testes occur as two masses at the level of the excretory vesicle, near the ventral surface. They are not exactly connubial for the left one is situated a little in front of the anterior margin of the vesicle. No ducts were visible. The ovary is median and situated near the dorsal surface above the posterior edge of the ventral sucker. From it passes forwards a semicircular string of cells situated dorsally and to the left margin of the ventral sucker. At the level of the anterior margin of the sucker the string of cells extends ventrally in an oblique direction towards the preacetabular field. There is no doubt that these structures, which stain deeply are the "anlagen" of the oviduct and uterus. The genital pore in the adult must be situated anterior to the ventral sucker.

GLANDS /

GLANDS and CELLS (Fig. 2,6,7, and 8.)

On each side of the animal and lateral to the ventral sucker there are six granular cells with large nuclei. They are divided into two groups. The posterior group on each side consists of two transversely placed gland cells, with a diameter of about ·01–·013 mm., situated close together and lateral to the ventral sucker. From each pair there extends anteriorly a small duct which is sinuous in the contracted condition of the cercaria. Anterior to these and also situated transversely is a cluster of four glands on each side. Two of each group extend into the median field anterior to the ventral sucker. From these anterior groups ducts pass anteriorly, extend laterally round the oral sucker, and open by pores into the slight invagination, on each side of the stylet. The ducts often show slight dilatations along their course.

The space between the alimentary tract and the body wall is filled with parenchyma and other cellular elements. Some of the latter, situated close under the cuticle, are small and correspond to dermal glands. Certain others, flask shaped and slightly granular with fairly large nuclei, correspond in character with those designated as cystogenous/

cystogenous glands by authors. They are most abundant laterally and posterior to the ventral sucker. Some of the parenchyma cells of the body and the tail are much distended, (Fig. 6, Cd.) and in most cases they collapse on fixation. Besides the cells, granules and globules are visible in living specimens. The tail is filled with a vacuolated parenchymatous mass.

NERVOUS SYSTEM. (Fig. 2, N.C.)

Posterior to the oral sucker and dorsal to the short prepharynx is a fibrous commissure resting like a saddle on the prepharynx. It connects the two laterally situated ganglionic masses, from which pass two ventral posterior cords, and two anterior cords. The ganglia, commissure and cords are surrounded by cells which constitute the nerve sheath.

GENERAL OBSERVATIONS.

The cercariae do not escape regularly one by one as in the case of the furcocercous form previously described from the same mollusc. They come out in great numbers and slowly swim away, rising towards the surface film. The locomotion is entirely different from that of a furcocercous cercaria. The caudal pocket is the centre of activity, the tail/

tail being moved vigorously in this socket from side to side.

The cercariae are exceedingly active, but their progress is slow, and they remain within a limited area for a long time.

This cercaria encysts on the shell of Limnaea peregra preferably on that of a young Limnaea. On reaching a young Limnaea the cercaria becomes very active and creeps leech-like over the shell, the tail is eventually cast off by active movements of the body, and the tailless individual closely resembles a leech both in form, and in its locomotion. The cercariae concentrate along the edge of the peristome of the shell and on the ventral surfaces of the whorls, and there as well as on the dorsal surface, they encyst. The encystment of cercariae was observed under the microscope. The body becomes hemispherical, concave ventrally and convex dorsally, drops of fluid can be seen exuding through the cuticle, and a mucous layer is formed. The encysting cercaria is not quiescent, but continually moves its anterior extremity through an angle of about 180°.

Frequently the whole body exhibits undulatory movements which appear to be essential for the/

the production of a uniform cyst. The stylet glands probably cooperate in the formation of the cyst wall. Drops of a secretion can frequently be seen exuding even in unencysted forms. The cyst wall consists of concentric layers. (Fig. 5). The inner ones being especially well seen. The cyst when hard seems to be composed of material allied to chitin. The whole of the cyst is opaque and dark in appearance owing to the dark brown cercaria inside. The completed cyst is concavo-convex when viewed laterally, and circular when viewed from the dorsal surface. It adheres by means of the ventral surface.

The diameter of the cyst is about ·22-·23 mm. and the thickness of its wall is ·03-·04 mm.

Unencysted cercariae may survive for 24 hours in an aquarium, but unless a Limnaea is reached within that time, they die and decompose. A few were observed to encyst on the walls of the glass dish. All the cercariae do not encyst even when Limnaeas are present. The percentage of encysting individuals is small in comparison with the large numbers liberated. The finding of a Limnaea seems to depend upon chance. A special vitality or activity is however shown when the cercariae reach the Limnaea/

Limnaea. When several Limnaeas are present, relatively more cysts are formed on the shells of the smaller examples. The definitive host no doubt is one that preys upon Limnaea.

The cercariae were studied in July and August, and on specially warm days of the former month their liberation was frequent, and at laboratory temperature there was a continual supply available. The warm summer months seem to favour their liberation. The cercariae are liberated in quiet bodies of water such as little bays and pools. Their chance of finding a suitable place for encystment depends upon the presence of Limnaeas on weeds and grasses within a certain limited radius.

GENERAL REMARKS about the 2 SPECIES of CERCARIAE of LOCHS LUBNAIG and VENNACHER and about the HOST LIMNAEA PEREGRA VAR. BURNETTI. (MÜLLER)

LIMNAEA PEREGRA was fairly common in July in these Lochs. There were two forms, a large and a small. The large form generally frequented the shore line, attached to stones, algae, grasses and weeds. The small form on the contrary was more abundant in situations where the movement of the water was rapid, e.g. round the outflow of the River Leny, but is not strictly confined to such conditions, and occurs together with the larger form in the still pools and bays along the shore line.

Every large Limnaea examined was heavily infected with sporocysts of either of the 2 species, but it was rare to find the two kinds of sporocysts in the same individual. The furcocercous cercaria was the more common, and was found in at least eight out of every ten Limnaeas. A heavily infected individual may be recognised by the dull white appearance of its shell, through which the liver and sporocysts/

sporocysts may be seen. The colour is due not to the shell, but to the underlying liver and sporocysts. The different kinds of infection may be distinguished externally through the shell by the appearance of the sporocysts.

In the Xiphidiocercariae sporocysts are white or yellowish and, plump in appearance; in the furcocercous form they are yellowish, but thread like and thin. Infected Limnaeas are very sluggish in their movements, whereas the smaller and uninfected Limnaeas are active.

The furcocercous cercariae were continually liberated, but the discharge reached its maximum at the end of July and the beginning of August. Molluscs opened in the middle of August had empty sporocysts, containing comparatively few undeveloped cercariae. The Xiphidiocercariae were liberated in swarms only during certain very warm days in July. They were common at the beginning of August, and at laboratory temperature during the first three weeks of August, their liberation was continual. The number set free declined at the end of August. This holds good for both the species described from L. Lubnaig and L. Vennacher under observation during July and August.

The/

.The Limnaeas in the aquaria died off at the end of August. There may be several reasons for this, firstly that naturally at this period of the year the molluscs die off, secondly that the heavy infection disturbs physiological and metabolic processes and causes death, and thirdly insufficient food or lack of proper food may have been the cause of death. The evidence seems to incline towards the second assumption, and death seems to be caused not by the living sporocysts, but by the disintegration of empty sporocysts. Some dead molluscs examined had a mass of empty sporocysts in the liver tissue. The latter organ was atrophied, and had a yellow colour.

There is no definite proof that parasitism deprives the Limnaeas of reproductive activity. However in an aquarium containing about 30 specimens only two or three clusters of eggs were produced during the whole month of July. An examination of the ovotestes revealed active spermatozoa and ova, even in heavily infected individuals. The small forms of Limnaea also had active spermatozoa, and in no single case was there any sign of infection.

Infection by miracidia probably occurs early in the summer or in spring, and very young Limnaeas/

Limnaeas are infected. The molluscs grow and develop, and at a certain period are able to reproduce. In the meantime the sporocyst or sporocysts multiply and develop, and when the infected snail reaches the average size of a Limnaea peregra, it becomes so heavily parasitised, that reproduction is arrested. The apparent incapability of reproduction is not due to the atrophy of the gonads, but to change in physiological activity.

There may be other reasons why infected Limnaeas do not deposit eggs. The maximum deposit may be in early summer or in spring; and that in mid-summer at the climax of the liberation of cercaria, no eggs are deposited. The fact that all the large individuals in the Lochs are infected, and that the species is capable of persisting would lead to the conclusion that in spite of infection reproduction is still possible.

The effects of infection are probably more chemical than mechanical. Individual cells in a section of infected liver tissue show degeneration. As the sporocysts increase in size and multiply, very little of the liver ultimately remains./

remains. Cells between sporocysts are broken down and others again increase in size. The liver envelope is often broken through and the sporocysts project. Foreign material such as grit and fine sand gains entrance. A certain amount of pigment of a dark nature probably a result of disintegrated liver tissue, and excretory matter of the sporocysts, is sometimes visible between contiguous sporocysts.

DESCRIPTION of FURCOCERCARIA. B. from LIMNAEA AURICULARIA. LINN. from DUDDINGSTON LOCH.

FURCOCERCARIA. B.

From SPOROCYSTS in the LIVER of

LIMNAEA AURICULARIA LINN

From DUDDINGSTON LOCH, EDINBURGH.

SPOROCYSTS.

The sporocysts are slender, long, and threadlike, and difficult to remove without damage. There is no mobile anterior end or birth-pore, and the breadth varies from .1 - .15 mm. The outer layer is tough, containing large flat epithelial cells, and circular muscle fibres are visible under this layer. There appears to be no definite internal layer, but some parts of the thin wall of the sporocyst are thickened, numerous granular cells being visible. A sporocyst frequently has constrictions, and the lumen is not continuous. The walls of the sausage-like constricted regions are thicker, owing to the internal masses of granular cells, and their cavities contain embryos/

embryos in all stages of development, but no mature cercariae. In older sporocysts, where few embryos are present, the wall is thin, and the granular masses of cells are entirely absent.

THE CERCARIA. (Fig. 1 & 4)

The cercaria has an elongated, cylindrical and translucent body with a mobile anterior end, which does not extend posterior to the oral sucker. The cuticle is covered with transverse rows of tubercles, giving it a striated appearance. The tail is inserted terminally in a small caudal pocket, and is powerful, with longitudinal muscle fibres, which appear as parallel lines. The forks are leaflike and flattened laterally with a narrow wavy membrane on the dorsal and ventral edges. Each fork ends in a clear cuticular point about .013 mm. long at the base of which is an opening (Fig. 8, E.P.)

There is a muscular, pouch-like oral sucker the extreme anterior part of which is introvertible and when this is everted the mouth is seen to be surrounded by a raised lip-like structure, which sometimes/

sometimes assumes the form of three ridges (Fig. 2 & 4). The sucker is ovoid,, and in the living animal longitudinal muscle bands can be seen in its wall. The posterior part of the sucker is especially muscular, and resembles a pharynx, the muscle fibres giving it a transversely striated appearance.

About .13 - .14 mm. from the anterior margin, and on the dorsal surface are situated two eye spots,, which in the living cercaria contain a black pigment. The eyes are about .01 - .03 mm. apart,, and .008 mm. in diameter. Under a high power each eye appears to be made up of numerous clear refractive cells, which are embedded in the black pigment. The eye,, when viewed from the dorsal surface is circular, but in some specimens it is slightly concave laterally and convex medially.

The muscular ventral sucker is a characteristic structure of this furcocercaria. It can be extruded for about .03 - .04 mm. and retracted into a/

a pouch, which is simply the depressed ventral surface of the body (Fig. 3.). The retracted sucker appears as a circular disc,. surrounded by the rim of the pouch. When extruded the sucker is tubular and projects slightly posteriorly (Fig. 5 & 7.) The retraction and extrusion are brought about by lateral muscle fibres, radiating out from the walls of the sucker, and attached to the body wall (Fig. 3) The sucker can also be moved from side to side, and backwards and forwards..

MEASUREMENTS of LIVING CERCARIAE. (The figures in brackets,. which follow are the corresponding measurements from specimens fixed in corrosive acetic, and examined in alcohol..)

Length of body	.34 – .4 mm.	(.3 – .4 mm.)
Maximum breadth of body	.06 – .1 mm.	(.06 mm.)
Breadth at anterior region		(.03 – .04 mm.)
Breadth at posterior region	.04 mm.	(.04 mm.)
Depth of body anterior to the ventral sucker and in the region of the oral sucker.		(.04 – .05 mm.)
Depth of body posterior		(.03 – .04 mm.)

posterior to the ventral sucker		
Depth of body plus the extruded ventral sucker	.....16 mm.	(.1 mm.)
Length of tail	.38 - .4 mm.	(.38mm.)
Breadth of tail	.04 mm.	(.04 - .05 mm.)
Depth of tail	.04 mm.	(.04 mm.)
Length of fork	.26 - ,3 mm.	(.2 - .3 mm.)
Maximum breadth of fork	.02 mm.	(,023 mm.)
Length of oral sucker	.11 - .12 mm.	(.11 mm.)
Maximum breadth of oral sucker	.04 mm.	(.03 - .04 mm.)
Diameter of ventral sucker	.03 mm.	(.02 - .03 mm.)
Ventral sucker is distant from the anterior margin of the body	.2 - .23 mm.	(.15 - .22 mm.)

INTERNAL ORGANISATION.

ALIMENTARY TRACT (Fig. 4).

The mouth is slightly ventral, and leads into a large cavity occupying most of the oral sucker. The rest of the alimentary tract is vestigial, and is in the form of a straight tube extending a little posterior to the eyes, where it ends, there being no bifurcation into two forks. No indications of a pharynx, or a mass of cells simulating a pharynx were observed./

observed.

EXCRETORY SYSTEM (Figs. 6 & 7)

The excretory system consists of fourteen flame cells, four flame tracts, collecting ducts, and an excretory vesicle. The anterior region is drained by two ducts, one on each side of the body and arising in the region of the oral sucker. Each duct receives tributaries from three flame cells, the first flame cell is lateral and in the posterior region of the oral sucker, the second is behind the eye, and the third is lateral and anterior to the ventral sucker. The posterior region is drained by two main ducts, one on each side of the body, and each arising as a flame cell in the base of the tail. Three small ducts from three flame cells in the posterior region of the body open into this main duct. The first flame cell is lateral and posterior, the second is about midway between the posterior end and the ventral sucker, and the third is lateral and in the region of the ventral sucker and its duct runs posteriorly to join the main posterior duct.

The main anterior and posterior ducts, on each side of the body unite to form a sinuous lateral vessel, which extends anteriorly and ventrally , and bending round it runs posteriorly, opening into a short antero-lateral arm of the excretory vesicle. The characteristic feature of this lateral vessel is the presence of two flame tracts, consisting of two bundles of cilia beating in the direction of the excretory vesicle, and attached to the wall of the lateral vessel. A lateral view shows the position of these two bundles of cilia to be in the first loop of the vessel (Fig. 7, F.L.Tr.). Besides the flame cells and their ducts, there is a small sinuous duct, on each side of the body, arising near the base of the ventral sucker, and opening into the ascending part of the lateral vessel. The excretory vesicle is noncontractile, and bicornuate. Into the posterior part of the vesicle opens a caudal vessel, which traverses the main part of the tail, and divides into/

into two branches, each of which passes down a fork, and after giving off a short diverticulum opens to the exterior at the base of the clear cuticular tip (Fig. 8, E.P.).

NERVOUS SYSTEM (Fig. 4, N.G.)

The nervous system consists of two ganglia situated laterally and opposite the two eyes near the dorsal surface. A fibrous commissure connects the two ganglia and passes dorsally over the vestigial alimentary tract.

GENITAL SYSTEM (Fig. 4 & 5, 6)

The gonads are in a undifferentiated condition, and are found as a triangular mass of deeply staining cells near the ventral surface, immediately posterior to the ventral sucker.

GLANDS and CELLS. (Figs. 4 & 5)

The salivary glands are divided into two groups of five glands on each side of the body. Each group consists of two clusters of glands, a posterior cluster of three coarsely granular cells about .04 mm. long, and situated in the form of a triangle/

triangle, one dorsal and lateral,, and two posterior to the ventral sucker, and of an anterior cluster of two vesicular cells,, situated anteriorly to the ventral sucker. Each group of glands on each side of the body gives off a bundle of five sinuous ducts which pass anteriorly and laterally to the oral sucker, opening by five pores situated on five processes at the side of the mouth within the lip-like ridge,

The ten salivary glands occupy most of the posterior three-fourths of the body, and the parenchymatous cells are few, being found chiefly in the region between the oral sucker, and the anterior clusters of salivary glands. The commissure and nerve ganglia are surrounded by numerous cells, which do not differ from parenchymatous cells. Parenchymatous cells are also present in the posterior region of the body, where some cells under the cuticle correspond to cuticular cells. Besides parenchymatous cells, ten cells, which are of the nature of cystogenous cells were observed on each side of the body. These cells possess hyaline nuclei/

nuclei, and cytoplasm which is often granular. In all the cercariae examined these cells were arranged in a definite pattern as shown in (Fig. 5. Cy.), one anterior to the eye, three behind it, three in the region of the ventral sucker, and three posterior to the ventral sucker.

The parenchymatous tissue of the tail surrounds the caudal vessel, and contains cells, which are situated nearer the cuticle. The forks contain comparatively few cells, and many of these resemble mesenchyme cells, sending out processes, which often connect them to other cells (Fig. 8). The delicate and wavy membrane more or less confined to the posterior part of the forks is non-cellular.

GENERAL/

GENERAL REMARKS.

The cercariae are extremely active when they emerge from the limnaea, and by rapid movements of the tail swim towards the surface film of the water. The tail is the chief organ of propulsion, and at short intervals is lashed from side to side; the oral end of the cercaria being always directed forwards. Frequently the cercaria becomes quiescent and appears to sink down, when suddenly the forks are rapidly opened and closed, while the tail is lashed vigorously, causing the animal once more to rise towards the surface.

The cercariae are positive phototropic collecting on the illuminated side of the test tube, but if such a tube be now slowly turned round the animals actively migrate towards the illuminated side. Attachment to a surface is effected by the muscular ventral sucker, as a result of which the attached cercaria takes up a characteristic position the anterior end is slightly bent ventrally, and the tail is directed obliquely upwards. The oral sucker appears/

appears to take no prominent part in the attachment, but tests the surface by repeated attempts at adhesion.

The tail is not easily cast off, and when detached performs independent movements. Freshly liberated cercariae were able to survive three or four days in a test tube of water, but after that they all died, and no encystment was observed.

The secretion of the salivary glands is copious, and can easily be demonstrated by introducing a few drops of formalin under the coverslip, where some cercariae are swimming about. The effects are in most cases instantaneous, the cercariae becoming rigid and ejecting fine threads of mucus, which solidifies in the surrounding medium, and often exceeding the cercariae in length.

EXPLANATION/

DESCRIPTION of XIPHIDIOCERCARIA. B. and XIPHIDIOCERCARIA. C. from LIMNAEA PEREGRA MÜL. from the ISLANDS of MULL and ULVA.

XIPHIDIOCERCARIA. B.

From SPOROCYSTS in the LIVER of

LIMNAEA PEREGRA (MULLER.)

From the hill streams of ULVA and the mainland of MULL.

SPOROCYSTS (Fig. 1.)

Most of the Limnaeas sent by Dr. Annandale from the hill streams of Ulva and the mainland of Mull were infected with this cercaria. The sporocysts are plump, having a length of about 1.6-2 mm. and a breadth of about .1-.3 mm, and are often bent upon themselves. They are white or yellowish, and in most cases found along the part of the intestine, coiling in the liver. Some sporocysts are constricted at certain regions, giving rise to dumb-bell shaped structures, but frequently only the inner layer becomes constricted off into oblong sacs. The external surface is covered with masses of a granular black pigment, which often render the sporocyst opaque. The wall of the sporocyst is comparatively thick, consisting of two definite layers of cells, an outer epithelial layer, and a well defined internal layer, from which the cercariae arise, and which often/

often becomes separated from the epithelial layer, The internal layer surrounds the embryos like an envelope, and it differs from the outer layer in the nature of the nuclei, which are larger, but poorer in chromatin. By rupturing a sporocyst and applying a gentle pressure the internal envelope can be pressed out with its contents, and some parts of the layer are found to be cuticular; nuclei and cell boundaries being absent. No true muscle layer was observed in the wall of the sporocyst.

THE CERCARIA (Figs. 2,3, & 4)

The mature cercariae are more common in the larger sacs of the sporocyst, and creep in all directions as soon as the sporocyst is disturbed. The cercaria is oval in shape, and the anterior end is truncated. The body in suspension in water is concavo-convex, the oral sucker being subterminal, and the mouth ventral. In lateral aspect the lateral margins of the body tend to hide the ventral sucker, so much so that from a ventral view there appears to be a definite rim on each side of the body (fig. 4.) The anterior end in the region of the oral sucker is contractile.

The cuticle is tough, and covered with inter-

intersecting rows of minute tubercles, which are more prominent anteriorly and also posteriorly in the region of the caudal pocket. On the ventral surface of the body the cuticle is often raised into bosses, which are well developed in the cavity of the ventral sucker. There is a well developed caudal pocket with a thickened cuticular lining, the surface of which, on each side, is covered with stiff bristles, directed towards the base of the tail. There are no hairs on the body, but five small papilla-like structures are found in the anterior region, on each side, and dorsal to the stylet (figs. 3 & 4, pap.)

The oral sucker is well developed, and is often transversely elongated. In the dorsal part of the oral sucker is an opaque, solid and cylindrical stylet, which has a slight reinforcement on the ventral and lateral surfaces at the base of the "nib". The length of the stylet is about .03 - .033 mm., the diameter at the base is .005 mm., and at the base of the "nib" is .006 mm.; the "nib" being .008 mm. long.

The muscular ventral sucker is slightly smaller than the oral sucker, and is either circular or transversely elongated, with its opening directed either/

either anteriorly or posteriorly. The tail is about as long as the body or often longer; the length depending on its contraction and extension. In suspension in water the convex dorsal surface of the cercaria projects over the caudal pocket, the tail being inserted ventrally (figs. 2 & 4), and often directed anteriorly for a short distance before bending downwards. The entire cercaria is granular and feebly translucent, presenting to the naked eye the appearance of being greyish in colour.

MEASUREMENTS of LIVING CERCARIA. (The figures in brackets which follow are the corresponding measurements from specimens fixed in corrosive acetic and examined in alcohol.)

Length of body .....25 - .35 mm. (.25 - .3 mm.)
Maximum breadth of body .....15 - .16 mm. (.14 - .16 mm.)
Length of tail ..... 2 - .35 mm. (.16 - .28 mm.)
Breadth of tail at base .....04 - .05 mm. (.033 - .04 mm.)
Diameter of oral sucker .....07 - .08 mm. (.07 mm.)
Transversely elongated oral sucker ..(.063 mm. by .08 mm.)
Diameter of ventral sucker .....06 - .07 mm. (.05 - 06 mm.)
Transversely elongated ventral sucker ....(.06 mm. by .05 mm.)
The ventral sucker is .16 - .17 mm. (.14 - .16 mm.) distant from the anterior margin of the body.

INTERNAL/

INTERNAL ORGANISATION.

Alimentary Tract (figs. 3 & 4.)

The mouth is situated ventrally and is crescentic in shape, the corners being directed forwards. There is a muscular and well developed pharynx about .03 mm. long and .025 mm. broad. From the pharynx there extends a tubular and cuticular oesophagus, which bifurcates about .025 - .03 mm. from the pharynx into two forks. The forks of the intestine are peculiar in that the proximal part of each is non-cellular and cuticular like the oesophagus(fig.4); the rest of the fork is cellular, and extends to the posterior region.

Excretory System (fig. 4)

Owing to the opacity of the cercariae no flame cells were observed, but the collecting ducts and excretory reservoir were visible. The anterior region of the body is drained by two main ducts one on each side of the body, which run posteriorly. Each duct arises in the lateral region of the oral sucker. The posterior region is drained by two main ducts one on each side of the body, which run anteriorly. Each

of/

of these ducts receives three tributaries, one from the lateral region of the excretory vesicle, a second from the region of the anterolateral arm, and a third from the lateral region of the body. Both the anterior and posterior main ducts on each side of the body unite to form a short vessel, which opens into the antero-lateral arm of the excretory reservoir.

The excretory reservoir is Y shaped, and its wall consists of a single layer of cells, the posterior part or vesicle about .05 mm. long, and .025 mm. broad is contractile, while the antero-lateral arms about .05 - .06 mm. long are feebly contractile. The posterior end of the vesicle receives a single duct, which traverses the tail.

GENITAL SYSTEM (figs.3 & 4, G.)

The rudiments of the genital system consist of a mass of deeply staining cells, situated near the dorsal surface, and opposite the ventral sucker. No definite structures are visible and the only parts observed were a posterior mass of cells connected by a string of cells, which curve round opposite the left margin of the ventral sucker to an anterior mass/

mass of cells, which extend downwards for a short distance.

GLANDS and CELLS.(fig.2 & 3)

There are seven large, granular, salivary glands on each side of the body. Each group is often divided into two clusters, a posterior cluster of four glands situated close together and lateral to the ventral sucker, and an anterior cluster of three glands situated laterally and transversely. The glands are easily visible and extremely granular having a length of about .04 mm. and a breadth of about .02 mm. From each gland there extends anteriorly a small sinuous duct, and the seven ducts together form a bundle, which extends anteriorly, opening by seven pores situated on processes on each side of the stylet (fig.4, S.D.O.)

The parenchymatous tissue between the alimentary tract and the body wall contains numerous cystogenous cells, which are situated near the cuticle. These cells are large and granular with large nuclei. The cells are more numerous posteriorly and give the cercaria a mottled appearance(fig.2, & 3, Cy.) thus rendering it opaque, and obscuring the internal/

internal structures. The ordinary parenchymatous cells are more numerous in the region of the pharynx and nerve commissure, where they surround the ganglia forming a sheath. Many cells which are not distinguishable from ordinary parenchymatous cells are found under the cuticle. The tail contains a parenchymatous tissue between the caudal duct and the wall, and the cells are vacuolated. Besides the cells the parenchyma of the body also contains numerous inclusions such as granules and globules, which increase the opacity of the cercaria.

NERVOUS SYSTEM (fig. 3).

The nervous system is in the form of a commissure, which rests like a saddle on the anterior and dorsal part of the pharynx, and connecting together two lateral ganglionic masses. The beginnings of two posterior ventral and two anterior cords could be made out.

REMARKS.

These cercariae emerge in swarms and the motion is typical of most of the Xiphidiocercariae, the caudal pocket being the centre of locomotion, and the/

the tail lashed from side to side. The movements are active, but the progress is comparatively slow. Freshly liberated cercariae were able to survive in water for about two days, but after that they died without encystment. The definitive host is unknown.

EXPLANATION of the FIGURES of XIPHIDIOCERCARIA B.

FIG. 1. An entire sporocyst showing the two layers of cells, and the constrictions. X 120.

FIG. 2. Two cercariae. X 120.

FIG. 3. The body of a cercaria showing the position of the salivary glands, and the cystogenous cells. X 550.

Fig. 4. A ventral view of the body, showing the ventral concavity, the alimentary tract, gonads, and excretory system. X 550.

XIPHIDIOCERCARIA C.

From SPOROCYSTS in the LIVER of LIMNAEA PEREGRA (MÜLLER.) From the hill streams of ULVA and the mainland of MULL.

While studying Xiphidiocercaria B. another xiphidiocercaria appeared in the aquarium one morning and as there were not many of them they were at once carefully examined. The aquarium contained about sixty Limnaeas from streams of Ulva and Mull and as the Limnaeas were kept for the study of Xiphidiocercaria B., none were sacrificed to find the sporocysts of this new cercaria, and neither were there any more fresh cercariae liberated. The infected Limnaea or Limnaeas were never found in spite of a careful examination.

THE CERCARIA (figs. 1 & 2.)

The cercaria was easily distinguished by its white appearance from Xiphidiocercaria B. which is greyish. It is oval in shape and the anterior end is truncated. The body, especially the anterior extremity/

extremity is contractile, and is capable of great modification, assuming either a more elongated or a more globular form. The body is translucent and the internal organs are easily recognised. When examined alive in water the cercaria is convex dorsally and concave ventrally and the lateral margins of the body in lateral aspect tend to hide the ventral sucker. The anterior and posterior extremities are both directed downwards, the oral sucker and caudal pocket being subterminal. The posterior margin of the body projects over the base of the tail and there is a well developed and prominent caudal pocket about .047 mm. broad, and .03 mm. deep. The walls of the pocket are cuticular and on each side there is a circular patch about .02 mm. in diameter, on which are situated stiff bristles, which are directed towards the base of the tail (figs. 2 & 4.)

The cuticle of the body is thick and strong, and is covered with rows of minute tubercles, which are better developed anteriorly in the region of the oral sucker and also posteriorly in the region of the caudal pocket. The cuticle of the tail is smooth but the muscle fibres below it give it a striated appear-

ance/

appearance. Besides the tubercles the posterior three-fourths of the body is covered with nine transverse, irregular rows of hairs. The anterior end is without hairs, but on each side of the stylet and on the dorsal surface is a row of four papillae (fig. 2, Pap.)

The oral sucker is comparatively large and subterminal in position. In the dorsal part of the oral sucker is a clear stylet (figs. 1,2,& 3, St.) cylindrical proximally but with a nib-like distal part. The average length of the stylet is .035 mm., the diameter at the base is .01 mm., and at the base of the "nib" is .011 mm.; the "nib" being .01 mm. in length. The base of the stylet as well as the base of the "nib" in this xiphidiocercaria has a ventral reinforcement, which extends from the ventral on to the lateral surface. The main body of the stylet is hollow, but the nib is solid. A lateral view of the cercaria shows that the stylet is situated obliquely, and dorsal to the mouth, and also that in profile the dorsal surface of the stylet is a straight line.

The ventral sucker is circular in outline or transversely elongated and is as large as the oral sucker or in some specimens is slightly larger. The/

The opening is directed backwards and the anterior rim is often raised a little above the level of the body.

MEASUREMENTS of LIVING CERCARIAE. (The figures in brackets which follow are the corresponding measurements from specimens fixed in corrosive acetic and examined in alcohol.)

Length of body	.26 - .3 mm.	(.22 - .3 mm.)
Maximum breadth of body anterior to the ventral sucker	.15 - .16 mm.	(.15 - .2 mm.)
Depth of body		(.08 - .1 mm.)
Length of tail	.15 - .23 mm.	(.14 - .23 mm.)
Breadth of tail at the base	.034 - .04 mm.	(.03 - .04 mm.)
Thickness of tail		(.03 mm.)
Diameter of oral sucker	.06 - .07 mm.	(.06 mm.)
Transversely elongated oral sucker		(.08 by .06 mm.)
Diameter of ventral sucker	.06 - .09 mm.	(.05 - .07 mm.)
Transversely elongated ventral sucker		(.08 by .07 mm.)

The anterior margin of the ventral sucker is .15 mm. (.12 - .15 mm.) distant from the anterior margin of the body.

INTERNAL ORGANISATION.

ALIMENTARY TRACT (fig. 2.)

The mouth is situated ventrally and is crescentic/

crescentic in shape, the corners being directed forwards. There is a well-developed pharynx about .03 - .036 mm. long, and .025 - .03 mm. broad, with a muscular wall about .007 mm. in thickness. An oesophagus is absent, and the two forks of the intestine about .01 mm. in diameter arise from the pharynx and extend to the posterior region. There is a definite lumen and the wall of the fork consists of a single layer of cells.

EXCRETORY SYSTEM. (fig. 5.)

The excretory system consists of eighteen flame cells, collecting ducts and an excretory reservoir. The anterior part of the body is drained by two large ducts one on each side of the body. Each duct arises in the lateral region of the oral sucker, and receives two small ducts from two flame cells in the pharyngeal region, a third duct formed by the union of two small ducts from two flame cells in the lateral region of the ventral sucker, and a fourth duct formed by the union of two minute ducts from two flame cells anterior to the ventral sucker.

The posterior region is drained by two main ducts one on each side of the body, which run anteriorly. Each of these ducts beginsposteriorly as a minute/

minute duct, and receives the ducts of three flame cells situated laterally to the excretory vesicle, and a small sinuous duct from the lateral region. The anterior and posterior main ducts on each side of the body unite to form a thick coiled vessel, which opens into the antero-lateral arm of the excretory reservoir.

The excretory reservoir is a Y shaped structure lined with a single layer of large cells, and situated at the posterior end. The two antero-lateral arms about .07 mm. long are non-contractile, but the median posteriorly directed vesicle about .06 mm. long and .03 mm. broad is contractile. The posterior part of the contractile vesicle receives a single caudal duct, which traverses the tail. No flame cells were visible in the tail, and no external excretory openings were observed either on the tail or on the body.

GENITAL SYSTEM (fig. 2, T. & Ov.)

The testes consist of two deeply staining masses of cells, one on each side of the median contractile part of the excretory reservoir. The testes are situated near the ventral surface, and as yet there is no indication of ducts leading from them./

them. The ovary, oviduct and uterus are represented as a deeply staining semi-circular mass of cells situated near the dorsal surface and opposite the left margin of the ventral sucker. The mass of cells at the posterior end of the semi-circular string of cells represents the "anlagen" of the ovary, while the thickened anterior end of the string of cells represents the uterus, which bends downwards for a short distance. The genital pore in the adult fluke probably opens anterior to the ventral sucker.

GLANDS and CELLS. (fig. 2, S.G., Cy., Cp., & Cn.)

On each side of the body and lateral to the ventral sucker there is a cluster of seven salivary glands. From each gland there extends anteriorly a small sinuous duct, and the seven ducts together form a bundle, which extends laterally round the oral sucker, opening by seven pores on each side of the stylet. The parenchymatous tissue between the alimentary tract and the body wall contains two kinds of cells, the cystogenous cells (Cy.) with granular cytoplasm and large nuclei poor in chromatin, and parenchymatous cells (Cp.) with deeply staining nuclei rich in chromatin. The cystogenous cells are situated nearer the cuticle, but many parenchymatous cells are also found/

found immediately below the cuticle. The parenchymatous cells are not distinguishable from those cells, which surround the ganglia and commissure and constitute a sheath. The tail contains a vacuolated parenchymatous mass.

NERVOUS SYSTEM. (fig. 2, N. G.)

Posterior to the oral sucker and dorsal to the pharynx is a fibrous commissure resting like a saddle on the short prepharynx. It connects the two laterally situated ganglionic masses, from which pass two ventral posterior and two anterior cords.

REMARKS.

The locomotion of this cercaria does not differ from that of other Xiphidiocercariae. The centre of movement is situated in the well-developed caudal pocket. The cercariae are very active and tend to remain near the surface film of the water. Some of the free swimming cercariae were isolated in a dish of water to which were added two Limnaeas, the shells of which had previously been scraped and cleaned. After a few hours the cercariae had disappeared, and a few cysts/

cysts were found on the shells of the Limnaeas. The Limnaeas continually liberated Xiphidiocercariae belonging to the previously described Xiphidiocercaria B. which was proved not to encyst on the shell of Limnaea peregra.

~~LIMNAEA PEREGRA.~~

A cyst was scraped off from the shell of one of the Limnaeas and examined. Externally it was identical both in size and shape with the cyst of Xiphidiocercaria. A. from Loch Lubnaig. On the application of pressure a cyst was broken and the stylet of the damaged cercaria was found to be identical with that of Xiphidiocercaria C. There is no doubt that Xiphidiocercaria C. encysts on the shell of Limnaea peregra and that the cyst is indistinguishable externally from that of Xiphidiocercaria A. from Loch Lubnaig. The cyst is opaque, dark in appearance, and concavo- convex when viewed laterally. The wall of the cyst consists of concentric layers of a substance allied to chitin and probably secreted by the salivary glands and cystogenous cells of the cercaria. The average diameter of the cyst is .23 mm. and the thickness of the wall is .025 mm.

The discovery that this cercaria encysted on the shell of Limnaea peregra explained the problem of the cysts found on some Limnaeas sent by Dr. Annandale from the hill streams of Ulva. The cysts were found to be identical both in size and structure with those formed by Xiphidiocercaria C. in the experiment. The question arises whether Xiphidiocercaria A. from Loch Lubnaig and Xiphidiocercaria C. from the hill streams of Ulva are not the same species. A comparison of the two cercariae proves Xiphidiocercaria C. to be slightly larger, more transparent, with no hairs on the anterior region and with comparatively larger suckers. The stylet is broader and with an extra reinforcement at the base. The caudal pocket is better developed and the bristles are stouter. The internal organisation shows marked differences, the pharynx is larger, and the fork of the intestine consists of a layer of cells surrounding a lumen. The most distinguishing internal character is the excretory system which consists of eighteen flame cells with their ducts, and a comparatively larger excretory reservoir.

EXPLANATION/

DESCRIPTION of CAPILLARIA LEUCISCI n. sp.

from the INTESTINE of LEUCISCUS PHOXINUS. LINN.

and also

a DESCRIPTION of the ENCYSTED "GORDIUS" and NEMATODE

LARVAE from the INTESTINAL WALL of

LEUCISCUS PHOXINUS. LINN.

HISTORICAL

The genus Capillaria was established in 1800 by ZEDER on material from poultry. The type species is Capillaria (Trichocephalus) anatis (Schrank 1790) from ducks. In 1819 RUDOLPHI catalogued 22 species of Capillaria from birds and mammals, but not a single one from fish. RUDOLPHI substituted the name "Trichosoma" for Capillaria and subsequent writers adopted this synonym.

CREPLIN in 1831 mentioned one from a Cyprinoid fish in his "Observationes des Entozois". No description however was given.

DUJARDIN in 1843 described several Trichosomes from mammals and birds. Among others he described the female of a new species, Trichosoma tomentosum from the intestine of Scardinius erythrophthalmus Linn., and Idus melanotus Heck. DUJARDIN believed CREPLIN'S specimen from the Cyprinoid fish to have belonged to this species.

O. BELLINGHAM in 1844 gave a list of Trichosomes in his "Irish Entozoa" and proposed the name of Trichosomum gracile for a Capillaria he found in/

in the hake Merlucius vulgaris Cuv.

In 1873 VON LINSTOW described a new species from Blicca bjoerkna Linn., and Lota vulgaris Cuv. The females were immature but he was able to establish that they belonged to a distinct species which he named Trichosoma brevispiculum..

In 1886 G. FRITSCH described another species Trichosoma papillosum from Malapterurus electricus Lac. This specific name was changed to fritischi by TRAVASSOS, in 1914.

The last Capillaria described from a fish was Trichosoma tuberculatum from a ganoid fish Acipenser ruthenus Linn. by O. VON LINSTOW in 1914.

The five species of Capillaria from fish thus far described are:-

NEMATODE.	HOST:-
1 Capillaria tomentosa DUJ. 1843.	Scardinius erythrophthalmus L. Idus melanotus. Heck.
2 Capillaria gracile BELLINGH 1844.	Merlucius vulgaris Cuv.
3 Capillaria brevispicula O. VON LINST 1873	Blicca bjoerkna Linn.
4 Capillaria fritischi. FRITSCH 1886 TRAV.1914.	Malapterurus electricus Linn.
5 Capillaria tuberculata O. VON LINST 1914	Acipenser ruthenus Linn.

DESCRIPTION OF CAPILLARIA LEUCISCI N.SP. FOUND IN THE INTESTINE OF LEUCISCUS PHOXINUS LINN.

GENERAL CHARACTERS.

The nematodes are threadlike, and possess the characteristic form of Capillaria, increasing gradually in diameter from the anterior end to the posterior end. There is no marked increase in the postvulvar region as is found in Trichuris. The oesophageal region is shorter than the postvulvar region. Taking the anus and vulva as ventral there passes down on each side of the nematode a band, which is darker and more granular than the rest of the body. The bands begin about .1mm behind the mouth, and extend to the posterior end. The breadth of the band, in the ♀ is about .017mm in the anterior region, and .028mm in the post-vulvar region, and .013-.015mm in the ♂.

Small wartlike tubercles are situated on these bands (fig.1 tub), and especially in the case of the ♀ increase in prominence posteriorly in the region of the vulva, where they become very coarse. Further back they gradually decrease in size and become/

become wider apart, and disappear altogether a short distance behind the vagina; the band only persisting as a dark strand. Some of the tubercles are in rows, but others are irregularly situated. If the nematode, especially the ♀, be rolled so that it lies on its ventral surface, the tubercles are seen as small projections. The cuticle of the body is smooth and no traces of striation were observed.

ALIMENTARY TRACT. (FIGS. 2, 6 and 7)

The mouth leads into an inconspicuous buccal capsule, the wall of which is chitinous. No papillae were observed. The lumen of the capsule leads into a wavy tube, about .3 - .4 mm. long in the ♀, which is not surrounded by cells. The tube is continuous with the lumen of the oesophagus, which lined with chitin passes through a string of vacuolated oesophageal cells. The cells are comparatively large with crenulated margins and their large nuclei contain refringent bodies. The length of the cells varies from .07 - ,12 mm., and their breadth from .027 mm.- .04 mm. The diameter of their nuclei varies from .02 - .05 mm. the oesophageal region is about 3 mm. long in the ♀ and 1.5 mm. in the ♂. At the beginning of the post-vulvar part of the body, the oesophagus passes into the dilated anterior part of the intestine, which consists of a single layer of cells, roughly hexagonal in form when viewed from the dorsal surface. The intestine takes an almost straight course, and passes into a muscular rectum, which opens by the anus subterminally. In the living condition the nematode is whitish and/

and resembles a fine piece of cotton. In the natural medium, the mucus of the intestine, the male was spirally coiled and difficult to remove, and the three females were sinuous in form. The oesophageal region of the female was generally loosely coiled, and the extreme posterior end straight or only slightly bent.

MALE (fig.3)

The ♂ is much smaller than the ♀, having a length of about 3.38mm. and a breadth of about .047mm. in the testicular region, and about .04mm. at the posterior extremity in the region of the spicule. The posterior extremity is slightly bent ventrally.

There is a single coiled testis, which is bulky, occupying most of the posterior region. A single blunt spicule (Fig.4,Sp.) is present. The head of the spicule is about .013mm. broad, and the lenghh of the entire spicule is .26mm., and the maximum breadth is .01mm. The spicule is surrounded by a sheath, about .013-.014mm. broad, which is finely striated transversely. The sheath was not observed in an evaginated condition. The rectum is situated ventrally to the sheath and spicule, and opens by the same cloacal opening subterminally between the posterior lobes.

There are two posterior lobes(figs.4 & 5,PL2) supporting a feebly developed membranous expansion. Anterior to these lobes are 2 smaller supporting lobes one on each side of the cloaca. Under a high power 4 round structures are visible on one side (fig.5 x), and these are probably nuclei.

FEMALE.

The ♀ is only slightly coiled and longer than the ♂. It has a length of about 8-9 mm., and a breadth of about ·013 mm. anteriorly, and a maximum breadth of ·06-·07 mm. posteriorly. The posterior extremity is blunt and straight or only slightly bent (Fig. 7).

There is a single ovary, which begins in the rectal region and extends anteriorly; it suddenly thins out and becomes bent on itself for a short distance and then continues anteriorly again as a broad uterus filled with eggs. The uterus passes into a muscular vagina (Fig. 6,Mus. Va.), which opens by the vulva on a slight elevation about 1/3 of the length of the body from the anterior end. The junction of the oesophagus and the intestine is a little anterior to the vulva, and at this junction are situated the "pyriform glands". The intestine passes into a muscular rectum ·065-·07 mm. long, which opens by the anus subterminally about ·013-·02 mm. from the posterior end.

THE EGG (FIG. 8).

The eggs are of Trichinelloid type ie. more or less lemon shaped with flattened poles. The outer shell is radially striated. The surface of the egg has a pitted appearance due to little depressions. The shape of the eggs varies from a lemon shape to an oblong lozenge shape. Some are slightly constricted in the middle region, but not characteristically so. The eggs in the distal part of the uterus show no embryos and are probably deposited in an early stage of clearage. The eggs in utero measure .06-.064 mm. in length, and .028-.03 mm. in breadth; the shell is about .003 mm. in thickness.

TABLE SHOWING DIFFERENTIAL CHARACTERS OF THE SPECIES OF CAPILLARIA FROM FISHES.

	CUTICLE & SURFACE	LATERAL BANDS	OESOPHAGUS & CELLS	♂	♀	EGG	HOST
C.LEUCISCI.N.SP.	Cuticle Smooth.	Two lateral bands; with small tubercles prominent in vulvar region. Band is to breadth of body in ♀as 2:5., in ♂ as 3: 9.4.	Oesophagus of ♀ about 3 mm. long or 1/3 length of the body. Oesophagus of ♂ is about 1.5 mm. long. Cells large longer than wide. Length of cells from .07-.12 mm. Breadth from .02-.04 mm.	Length 3.38 mm. Breadth posteriorly .04mm. Breadth in region of testis .047mm. Spicule .26 mm. long & .01mm broad. Sheath finely striated and .013-.014mm. broad. Two posterior lobes and 2 smaller anterior lobes at level of cloaca, present.	Length about 8-9mm. Breadth anteriorly .013mm. Breadth posteriorly .06-.07mm. Posterior extremity blunt & straight. Anus subterminal .013-.02mm. from posterior end. Vulva about 3mm. from anterior end.	Surface of egg is pitted. It is lemon shaped with flattened poles. Length. 06-.064 mm. Breadth .028-.03 mm. Shell is .003mm. thick.	Leuciscus phoxinus
C.TOMENTOSA DUJ.	Striated posteriorly	One longitudinal band with tubercles anteriorly and hairs posteriorly.	?	Unknown.	Head .009mm broad. Length 8-9 .15 mm. Breadth .075 mm. Vulva 4 mm. from anterior end. Tail obtuse.	Granular & characteristically constricted in the middle. Length .06-.064 mm.	Scardinius erythrophthalmus, and Idus melanotus.
C. GRACILE (Bellingh)	?	?	?	?	About 1 inch long.	?	Merluccius vulgaris.

C.BREVISPICULA (Von Linst)	?	Two lateral bands and transverse folds in many places. Band is to breadth of body as 1:2.5	Oesophagus in ♀ 2/3 of body length. In ♂ 22:21. Cells short and wider than long.	Length 3.3 mm. Max. breadth .06mm. Spicule .25mm. long. Sheath smooth. Two posterior round lobes present.	Length 7.8 mm. Max. breadth .1mm. Posterior end round.	Unknown.	Blicca bjoerkna and Lota vulgaris.
C. FRITISCHI (FRITSCH 1886) TRAVAS 1914	Papillae scattered over body. Head possesses collar-like dilatation	?	?	Unknown	Length 15 mm. Posterior extremity obtuse. Annus terminal.	Large and more developed than is usual for a Capillaria (Fritsch) Constricted in the middle. (hour glass shaped)	Malapterurus electricus.
C.TUBERCULATA (Von Linst)	Head round with two small papillae.	No bands.	Oesophagus in ♂ is to posterior part of body as 13: 14. In ♀ as 14:19.	Length 5.81mm. Breadth at anterior end .026 mm., at middle .066mm., and at posterior end .036mm. Spicule .44mm. long & .0052mm. broad. Sheath smooth and projects slightly over the spicule, when evaginated. Two posterior lobes are present.	Length 8.71mm. Breadth at anterior end is .035mm., at middle .092mm, and at the posterior end .07mm.	Shell is thick. Length of egg .083 mm. Breadth .026 mm.	Acipenser ruthenus.

CONCLUSION.

By a comparison of the six species of Capillaria from fish it will be seen that there are six main points, which distinguish the different species from one another.

These are :-

a. The nature of the cuticle.

b. The presence or absence of bands, and of the structures on them.

c. The length of the oesophagus, and the nature, and size of the oesophageal cells.

d. The length and shape of the spicule, and the nature of the sheath.

e. The shape, nature, and size of the egg.

f. The different hosts.

By comparing the dimensions, it is evident that the females of C. leucisci and C. tomentosa practically correspond in size.

The points of difference which separate C. leucisci from C. tomentosa are :-

a. The unstriated cuticle.

b. The presence of two lateral bands with tubercles only.

c. The size of the oesophageal cells (in comparison with Dujardin's drawing, where the cells are wider than long).

d. The distance of the vulva from the anterior end.

e. The absence of a distinct and characteristic constriction in the middle of the egg.

f. The different host.

ENCYSTED LARVAE in the WALL of the INTESTINE of LEUCISCUS PHOXINUS LINN.

While examining the alimentary tract of Leuciscus phoxinus a number of encysted larvae were observed in the wall of the intestine of one specimen. A microscopic examination revealed the presence of two kinds of encysted worms, minute Gordius larvae and nematode larvae.

THE GORDIUS LARVAE. (Figs. 1,2,3 & 4.).

The larvae are minute and surrounded by a thin membranous cyst wall. They may reach a length of .04 - .14 mm. and a maximum breadth of .01 - .02 mm. The larvae generally assume a hook-shaped or a horse-shoe shaped outline in the cyst (figs.1,3 & 4.) The anterior end is armed with hooks and is usually thicker than the rest of the body. The armature consists of chitinous, thorn-shaped hooks about .005-.007 mm. long, and these are situated in three transverse rows of six hooks in each row. Frontal and lateral views show the hooks to be directed backwards, and those of one row to alternate with those of another (figs. 1 & 2.).

The/

The anterior armed part is introvertible and the hooks are only clearly visible, when this part is completely everted. Besides the hooks there are three rod-like stylets .013 - .015 mm. long, which are situated in the wall of the proboscis. The proboscis is also capable of being everted and the anterior points of the three stylets can be pressed against a surface. The cuticle of the body is thick and covered with transverse grooves, which are more prominent in the middle region of the body, where the margins often present a serrated appearance. The posterior extremity rapidly diminishes in thickness and ends in a sharp chitinous point about .005 mm. long.

INTERNAL ORGANISATION.

Posterior to the proboscis there is a short tubular structure, which appears to be an oesophagus. No internal structures are as yet differentiated and the string of cells in the posterior region of the body may represent the intestine. These cells are connected with the cuticle about .005 mm. from the base of the posterior spine and this connection probably represents the anus.

REMARKS/

REMARKS.

There is no doubt that these Gordius larvae find their way into the tissues of their hosts by penetration and that the stylets and hooks play an important part in the process. Gordius larvae are generally found in Coleoptera, Orthoptera, in larvae of Diptera and in many other groups of insects. They have also been found in Arachnids, Molluscs, Crustacea and in fishes belonging to the genera Cobitus, Petromyzon, Thymallus, Aspius, Coregonus and Salmo. Encysted larvae have even been found in Amphibia, Aves and in man. The vertebrate hosts in these cases are probably infected accidentally as a result of feeding on infected insects and their larvae.

The above described Gordius larva resembles the drawings of Gordius aquaticus (Dujardin) made by A. Villot in his "Monographie des Dragonnaux". The species found in Leuciscus phoxinus belongs to the "Gordius aquaticus" group, characterised by a single posterior spine and three transverse rows of hooks in the anterior introvertible region.

THE/

THE NEMATODE LARVAE. (Figs.1,2 & 3.).

Numerous encysted nematode larvae were found in certain parts of the intestinal wall of the infected minnow. The cysts are oval or globular about .07 - .08 mm. long and .04 - .06 mm. broad; the wall being about .005 mm. thick. The larvae are usually in a coiled condition as shown in figs. 1,2 & 3, about .2 - .3 mm. long and .015 - .017 mm. broad. The anterior end is armed with a chitinous, boring spine about .014 - .02 mm. long of which .005 - .01 mm. project forwards outside the body. The body gradually tapers to a blunt and coiled tail. The cuticle is comparatively thick and smooth without any trace of striation.

The internal organs are not yet differentiated and in stained mounts a cuticular tube about .03 mm. long can be seen in the anterior region, and this may represent an oesophagus. The rest of the body contains numerous cells as shown in fig. 3. A characteristic feature of all the stained specimens is the compact mass of cells immediately posterior to the oesophagus. There is another mass of cells in the posterior region. The intervening space contains scattered cells which probably represent/

represent the intestine, but no definite structures were observed.

EXPLANATIONS/

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THE FOLLOWING LETTERS APPLY TO ALL THE FIGURES OF THE CERCARIAE.

A.B. Anterior Bristles.

A.E.D. Anterior Excretory duct.

A.L.A. Antero-lateral Arm of Excretory Vesicle.

A.L.V. Antero-lateral Vessel.

A.V.' Anterior part of Excretory Vesicle.

B.P. Birth Pore of Sporocyst.

C.C. Caudal cell of tail.

C.D. Caudal Duct.

Cg. Cells from which Cercariae arise.

Cn. Nerve Sheath cell.

Cp. Cell of parenchyma.

Cpd. Distended parenchymatous cell.

Cu. Cuticular cell.

Cut. Cuticle.

Cy. Cystogenous Cell.

Div. Diverticulum.

E. Eye.

E.C. Epithelial Cell.

E.L. Epithelial Layer.

E.P. Excretory Pore.

E.V. Excretory Vesicle.

F.L. Flame Cell.

Fl. tr. Flame Tract.

G. Gonad.

H. Hair on body or tail.

I.F. Fork of Intestine.

M. Mouth.

Mem. /

THE FOLLOWING LETTERS APPLY TO ALL THE FIGURES OF THE CERCARIAE. (Contd.)

Mem. Membrane lining cavity of sporocyst containing the cercariae.

M.L. Muscle Layer of body, tail or sporocyst.

N. "Nib" of stylet.

N.G. Nerve Ganglion.

Oes. Oesophagus.

O.S. Oral Sucker.

Ov. Ovary.

Pap. Papillae.

P.B. Pocket Bristles.

P.E.D. Posterior Excretory Duct.

Ph. Pharynx or cells simulating a pharynx.

P.V. Posterior part of Excretory Vesicle.

R. Ridge of sporocyst.

S. Strand connecting embryos to wall of sporocyst.

S.D. Salivary Duct.

S.D.O. Salivary Duct Openings.

Ser. Serrations of posterior part of fork of tail.

S.G. Salivary Gland.

Sp. Spine of ventral sucker and cuticle.

St. Stylet.

T. Testes.

V.S. Ventral Sucker.

W. Wall of cyst

EXPLANATION OF THE FIGURES OF THE FURCOCERCOUS CERCARIA. A.

FIG. 1 The anterior part of a sporocyst to show the ridge, birth pore and the mass of cells (Cg.) from which cercariae arise. x200.

FIG. 2 A portion of the epithelial layer of a sporocyst.

FIG. 3 The cercaria. x120.

FIG. 4 The body of the cercaria. x800.

FIG. 5 The ventral sucker with the 3 rows of spines. x1000.

FIG. 6 The outline of the body, showing the position of the flame cells, ducts, and the excretory vesicle. x800.

FIG. 7 The tail, to show the hairs, the large caudal cells, the four flame cells, the ducts in the forks, and the main caudal duct. x800.

FIG. 8 The posterior part of a fork of the tail to show the dorsal and ventral serrations.

FIG. 9 Transverse section through the pharyngeal region of the body, showing the cells grouped round the oesophagus, and simulating a pharynx, and also the position of some of the cells under the cuticle and in the parenchyma,

FIG. 10 Transverse section of the body made posterior to the birth pore to show the layer of cells (Cg) from which the cercariae arise the internal lining membrane, two embryos, and the strands joining them together and to the membrane.

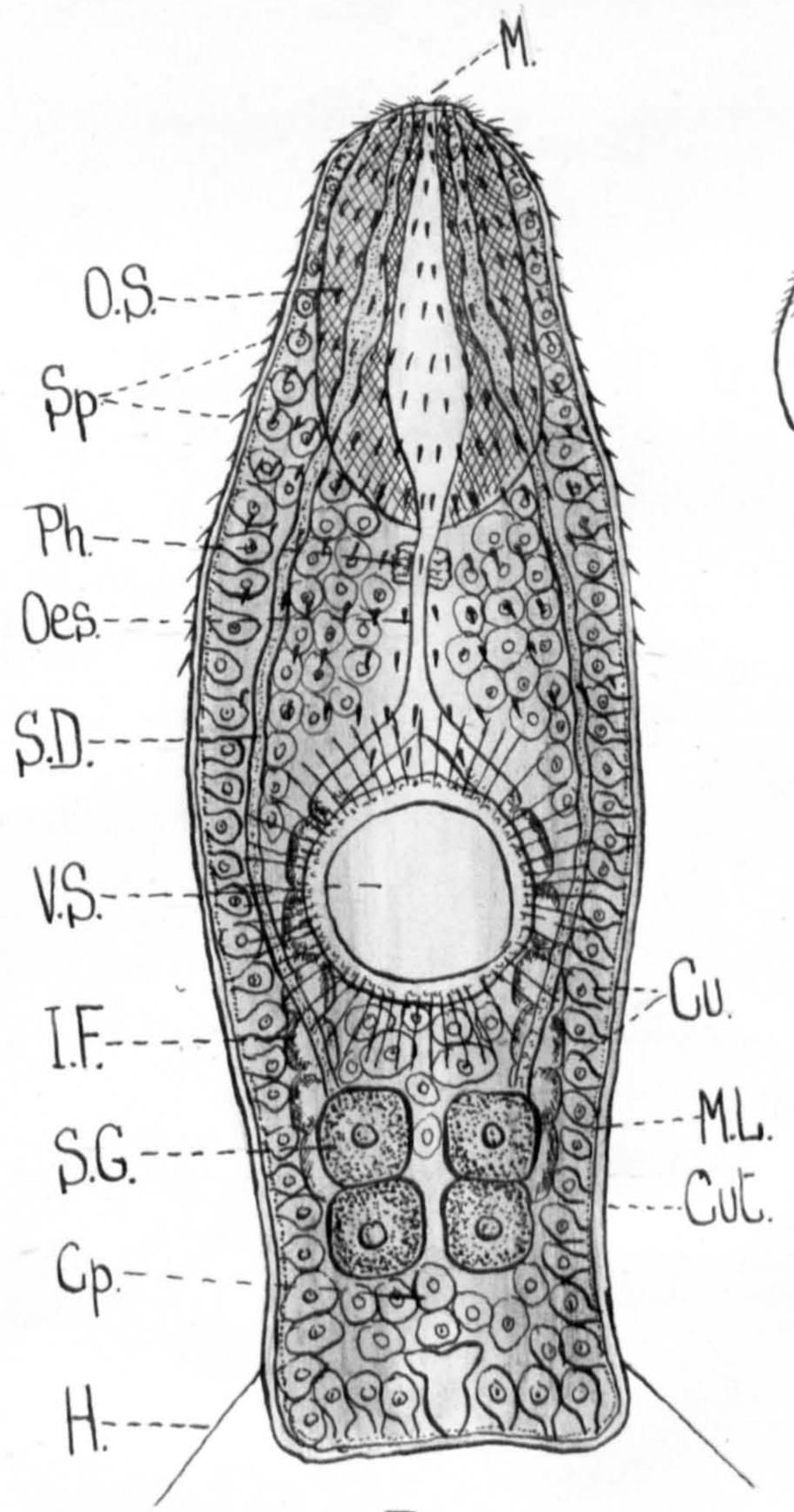
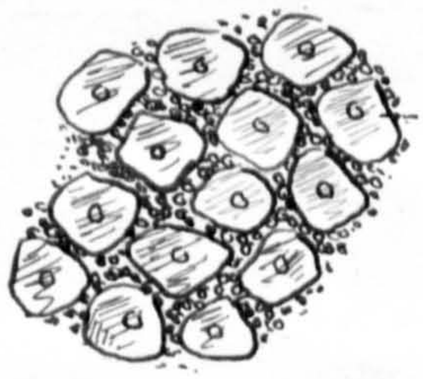
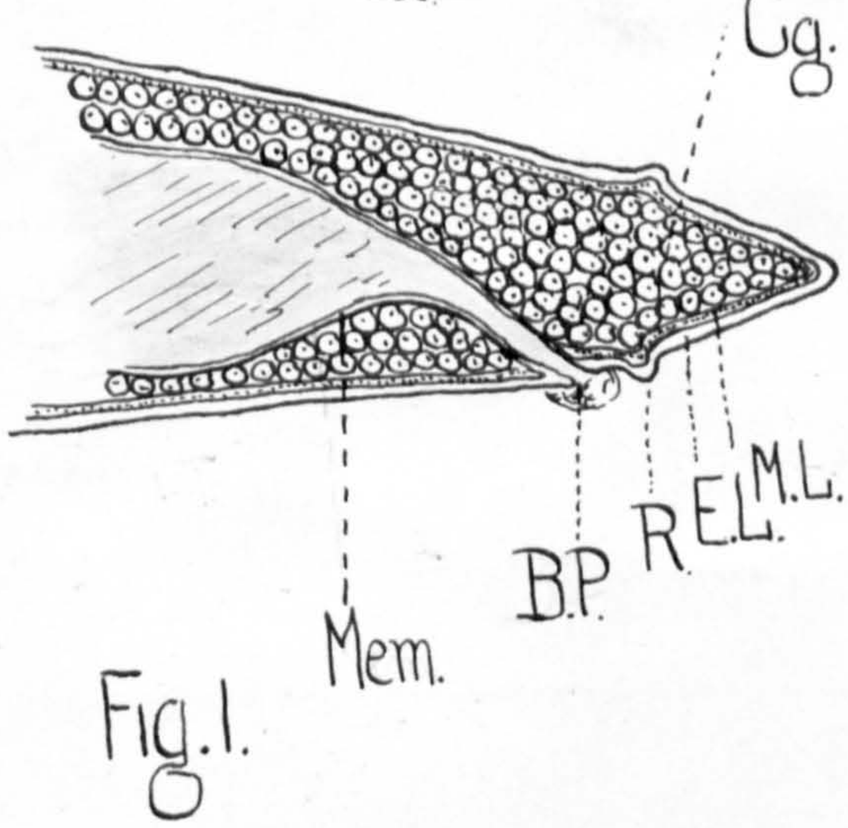


Fig. 3.

Fig. 4.

Fig. 2.





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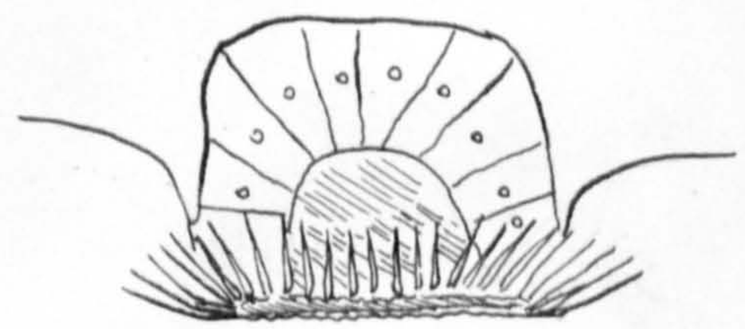

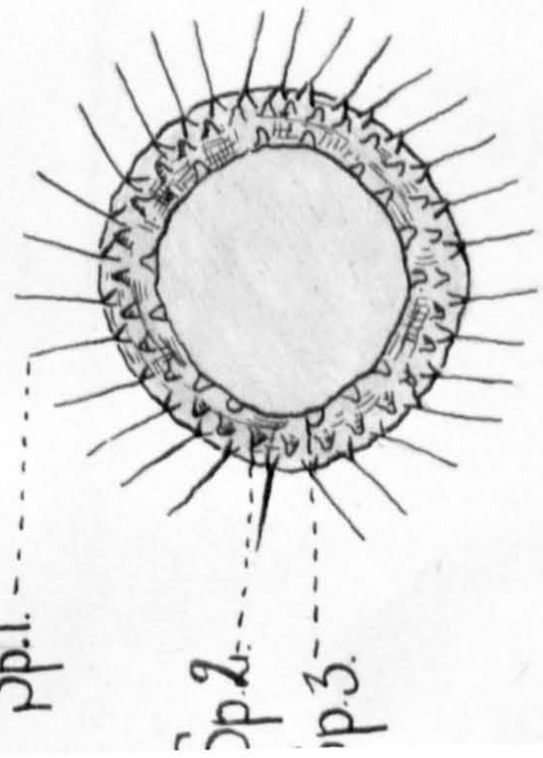

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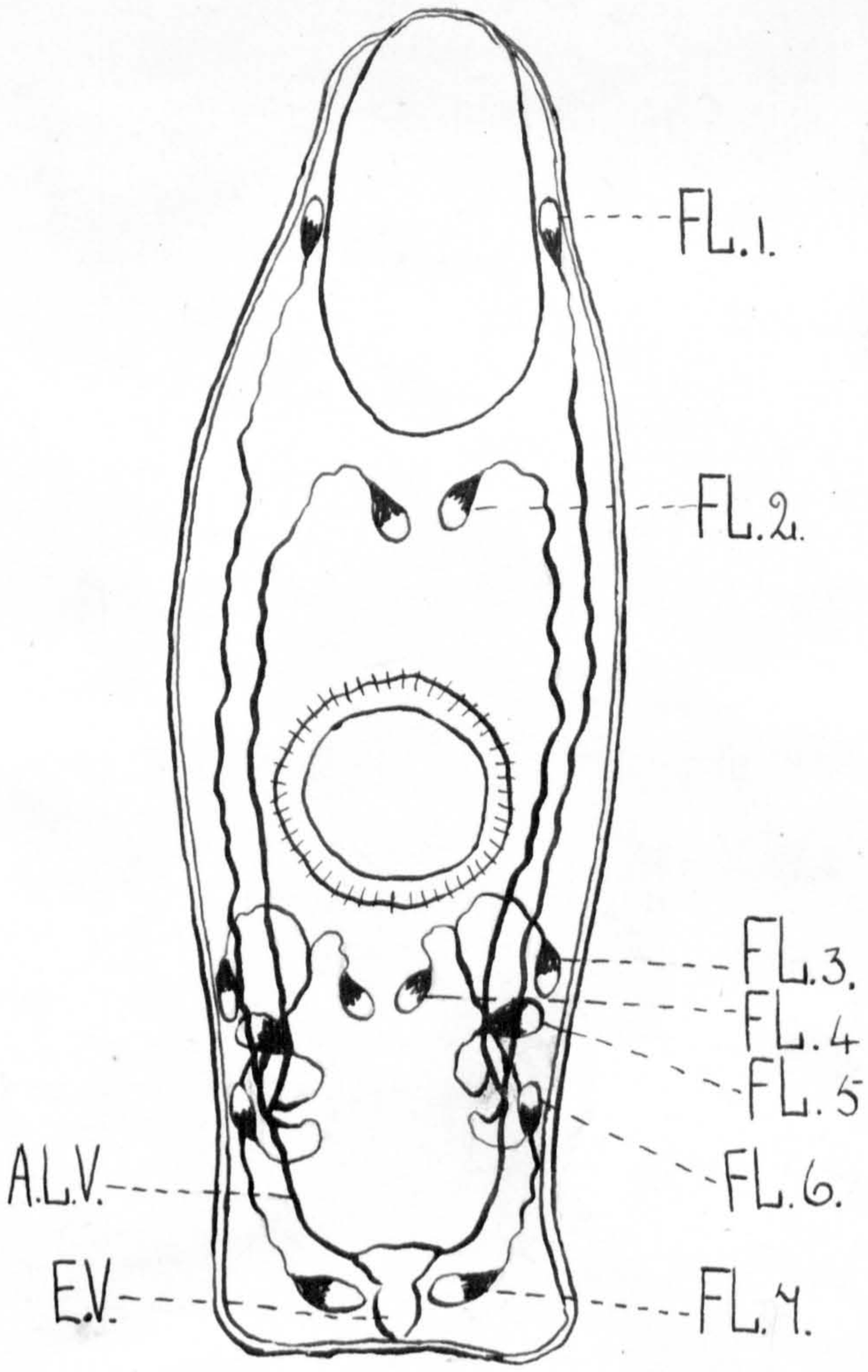

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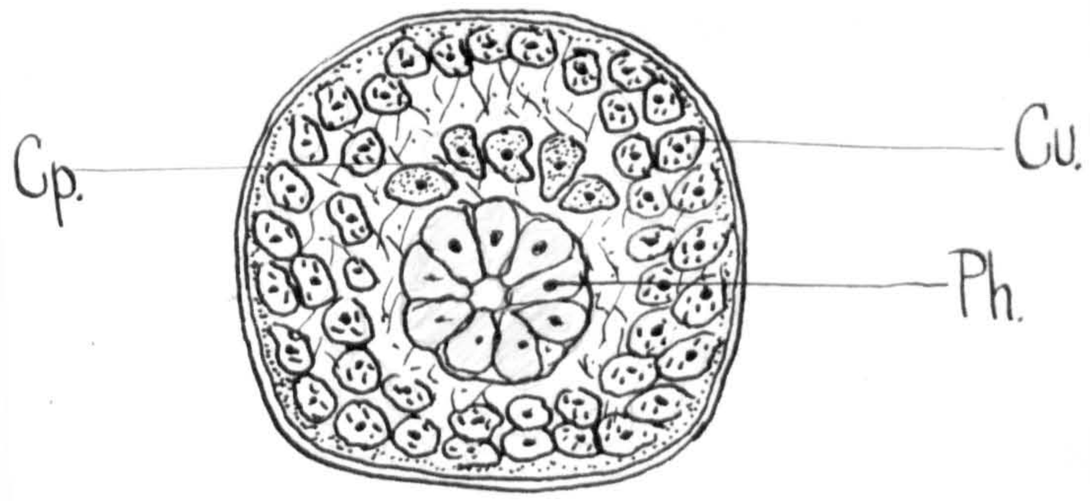

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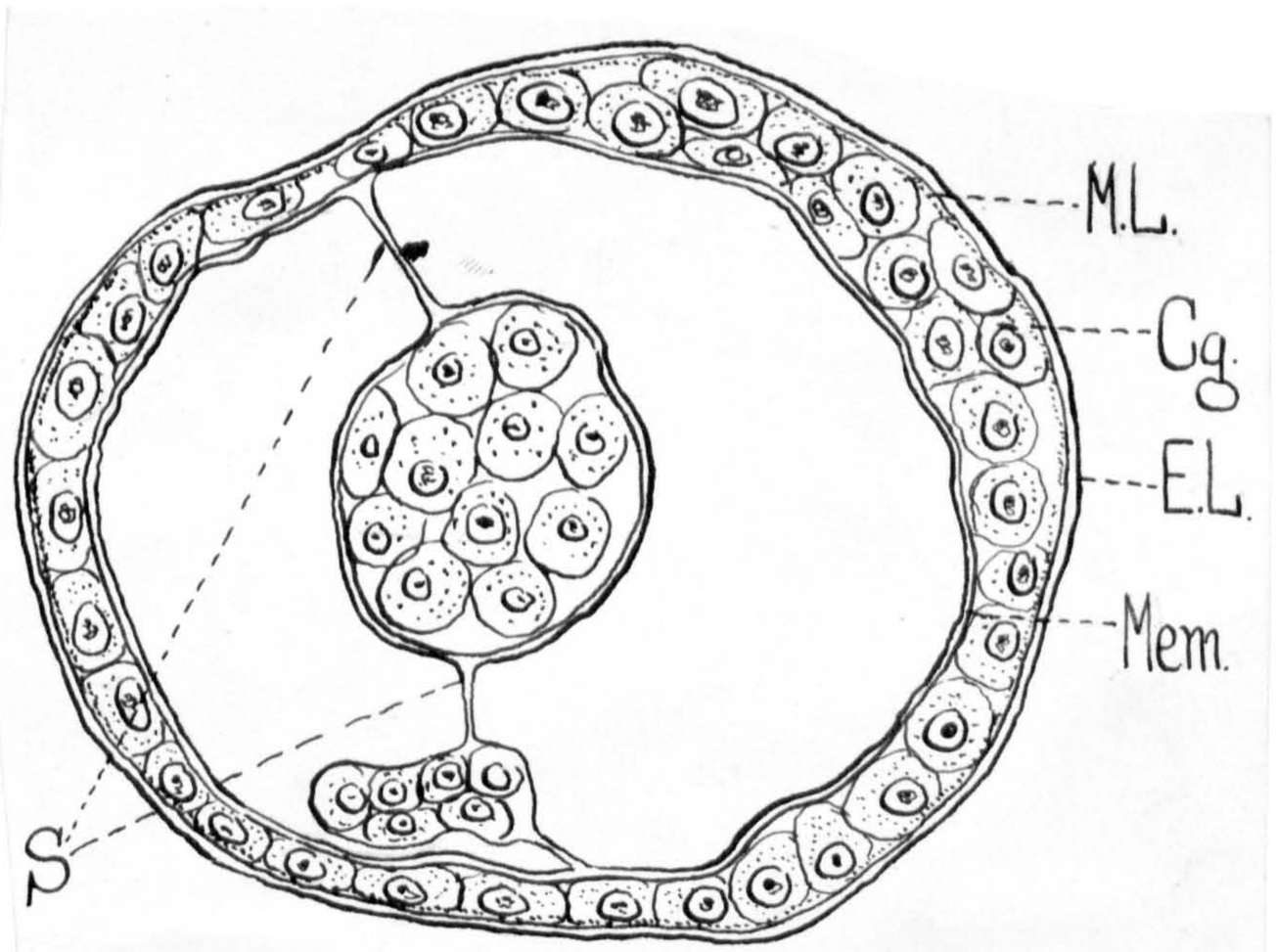

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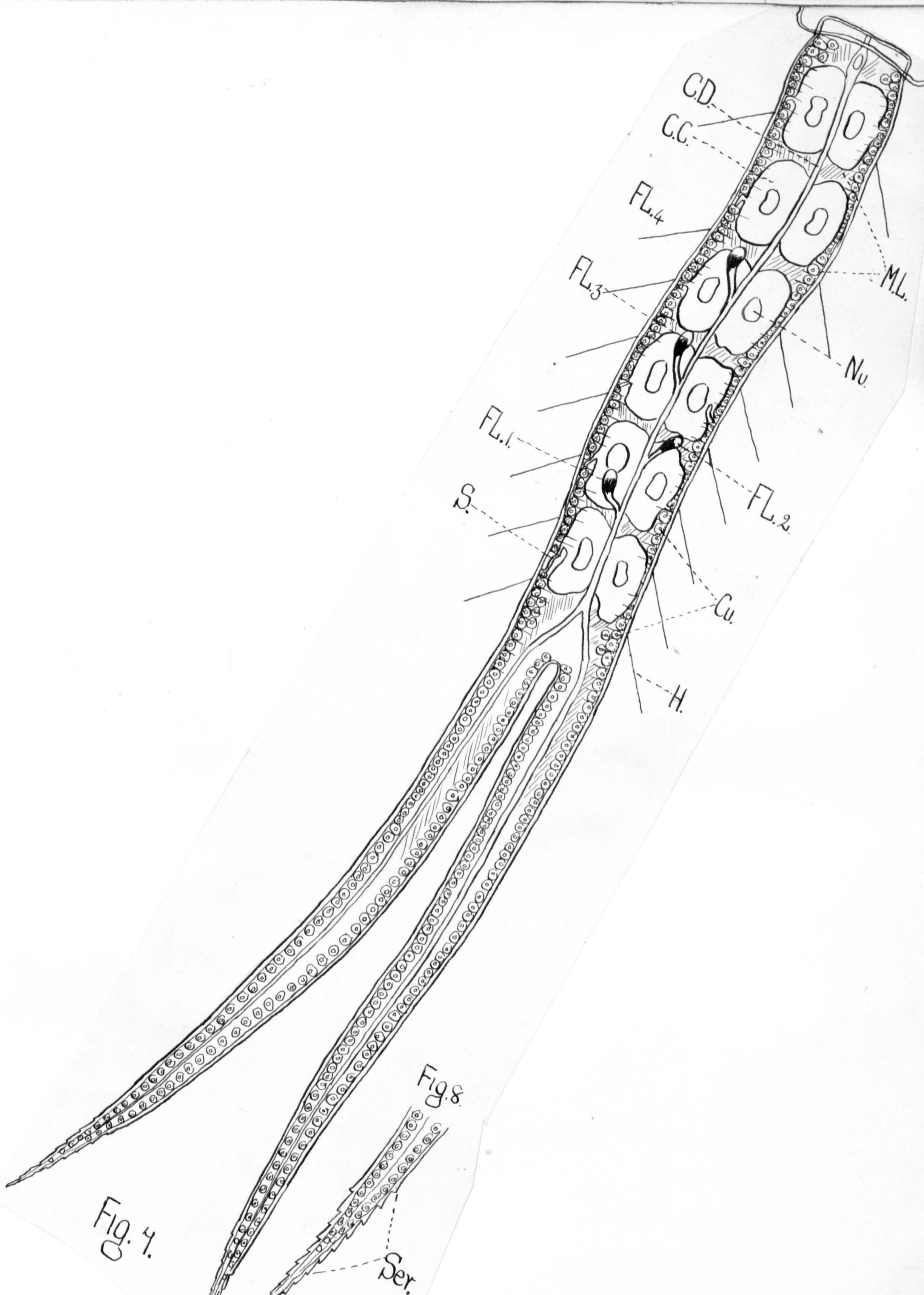


FIG. 7.

FIG. 8.

EXPLANATION OF THE FIGURES OF THE XIPHIDIOCERCARIA. A.

FIG. 1. The outlines of 2 cercariae. x120.

FIG. 2 The body of the cercaria. x800.

FIG. 3 Dorsal and lateral views of a stylet. x1000.

FIG. 4 The outline of the body showing the position of the flame cells, the ducts and the excretory reservoir.

FIG. 5 An encysted Xiphidiocercaria. x120.

FIG. 6 Transverse section of the body through the pharyngeal region, showing the nerve ganglia, the pharynx, the nerve sheath cells, cystogenous cells, cuticular cells, parenchymatous cells and two distended parenchymatous cells. (Cp.d)

FIG. 7 Transverse section of the body through the anterior margin of the ventral sucker showing the ovary, salivary glands, cystogenous cells, parenchymatous cells and cuticular cells.

FIG. 8 Transverse section of the body through the antero-lateral arms of the excretory reservoir showing the ovary cystogenous cells, parenchymatous cells and cuticular cells.

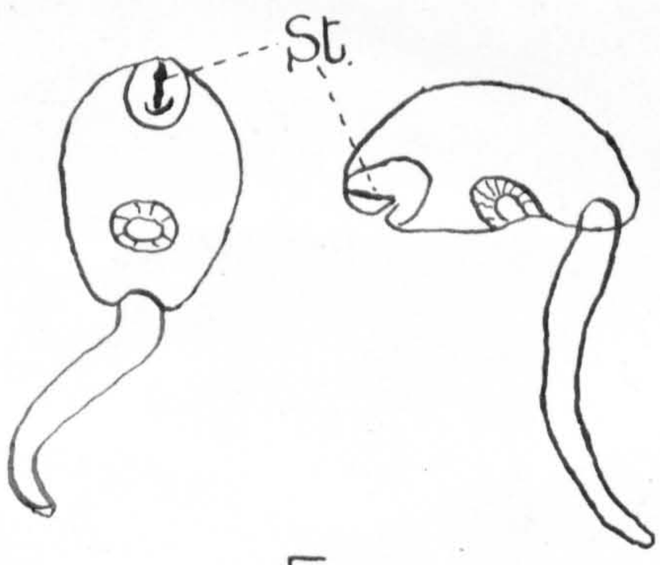
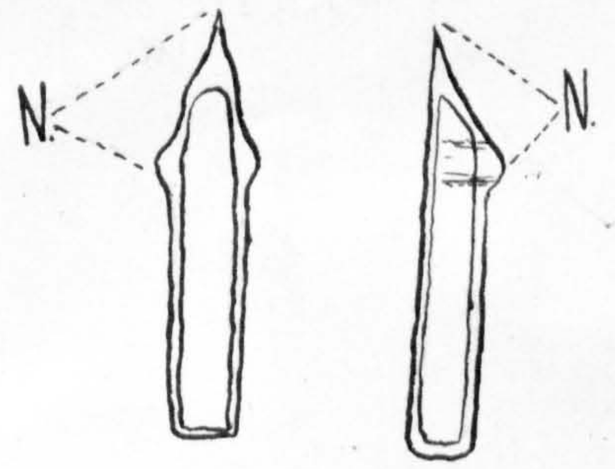


Fig. 1.



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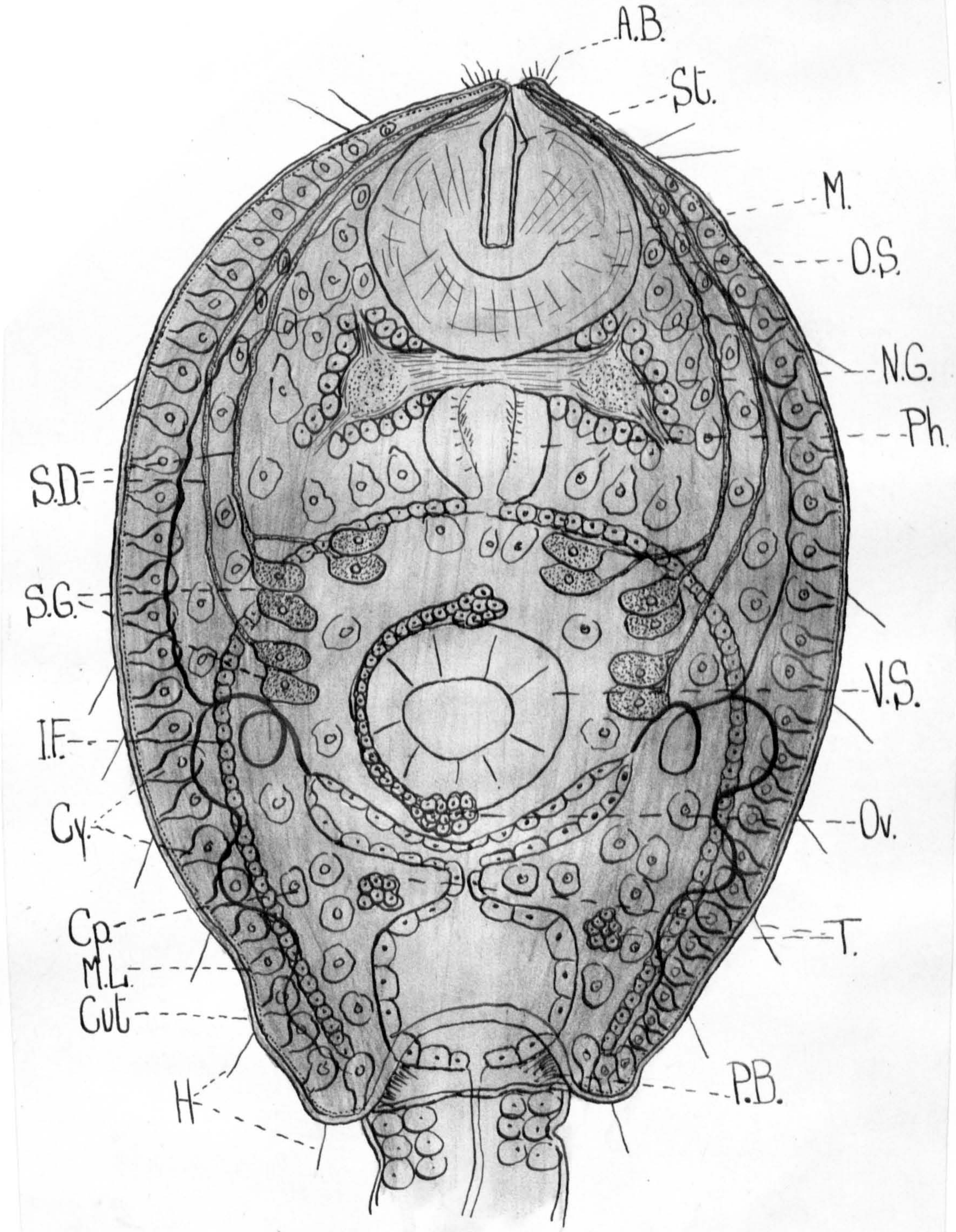
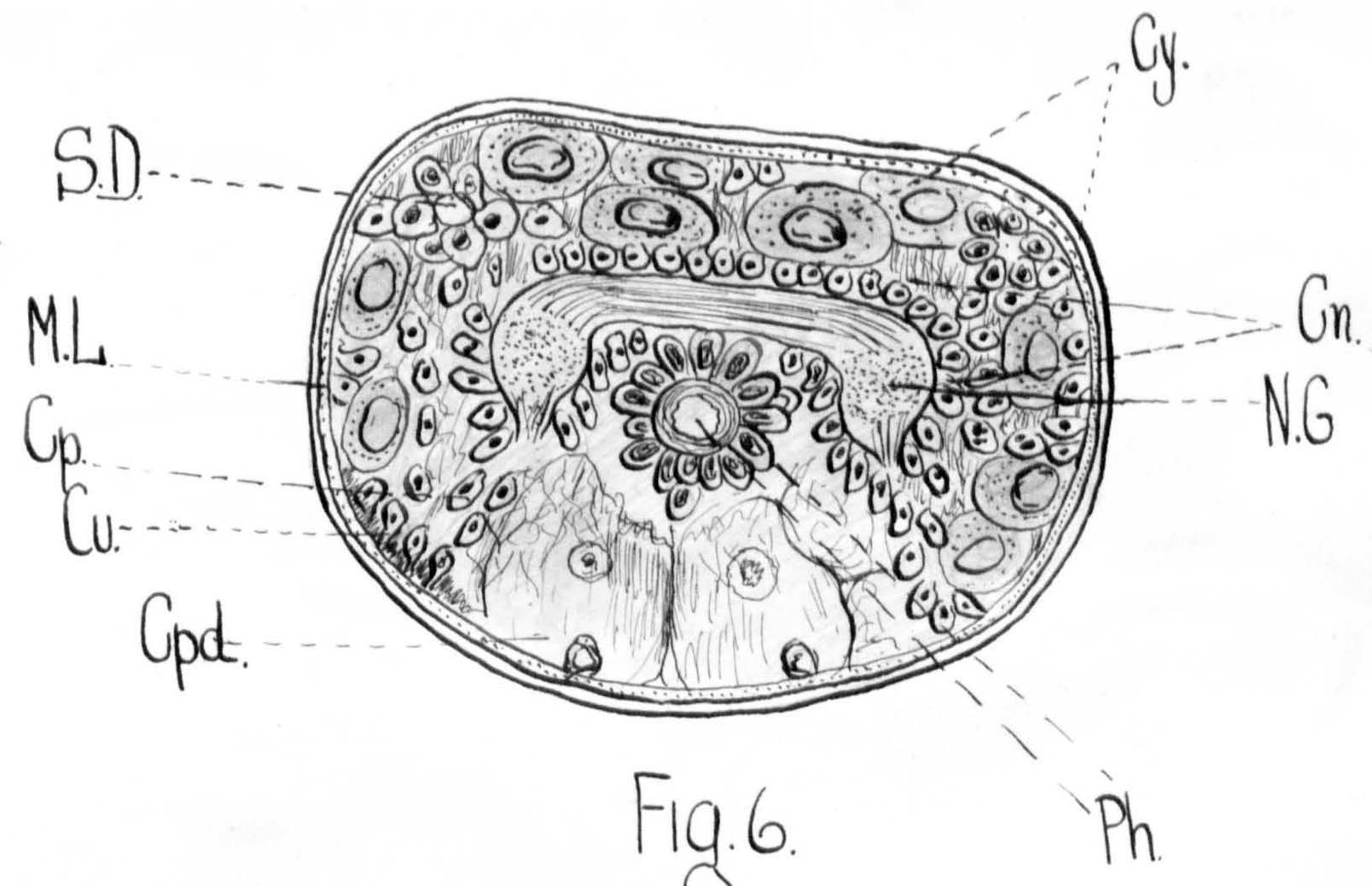


Fig. 2.

Fig. 5.

Fig. 4.



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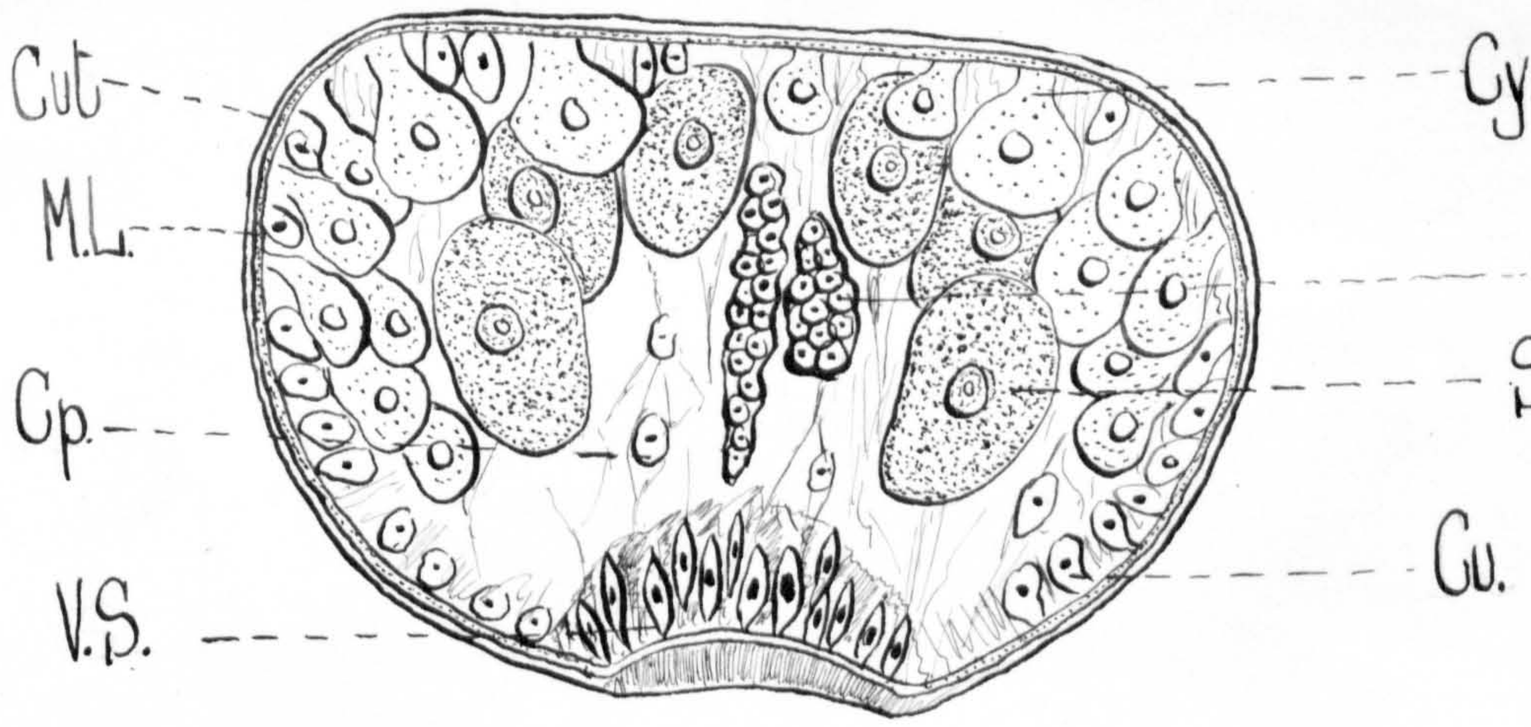

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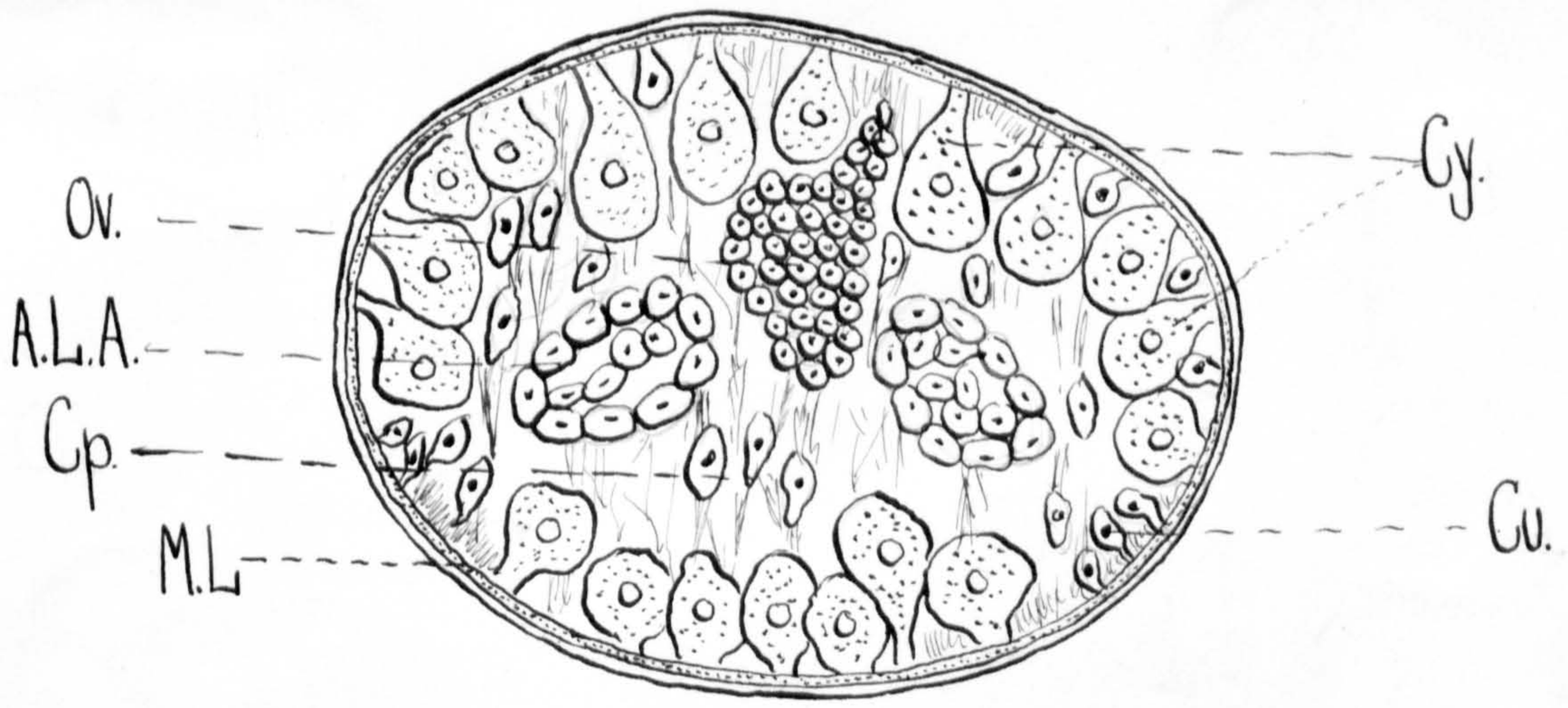


Fig. 8.

EXPLANATION of the FIGURES of FURCOCERCARIA B.

FIG.. 1 — The cercariae. X 120.

FIG.. 2. — The anterior end of a cercaria, showing the lip-like structure, and the five pores of the salivary ducts on each side of the mouth. X 800..

FIG.. 3.. — The retracted ventral sucker. X 800.

FIG.. 4. — The body of the cercaria. X 550.

FIG.. 5.. — A lateral view of the body showing the position of the salivary glands. The ten lateral glands, and the extruded ventral sucker. X 550..

FIG.. 6. — A ventral view of the body,. showing the excretory system. X 550.

FIG. 7. — A lateral view of the body, showing the excretory system X 550.

FIG.. 8. — The posterior ends of two forks, showing the clear cuticular tip,. the membrane, the duct with the short diverticulum, the external opening at the base of the tip, and the cells with processes X 800.

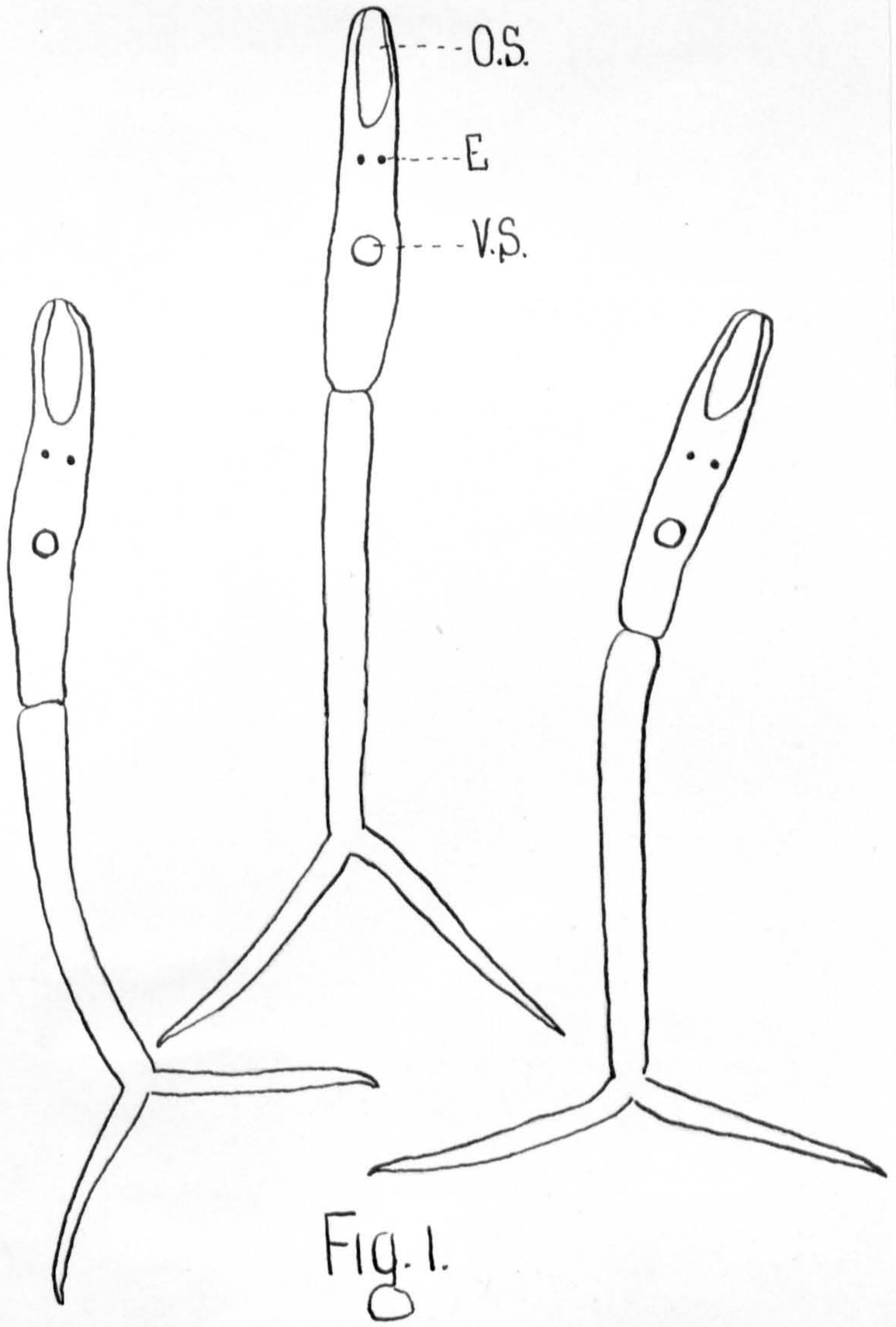
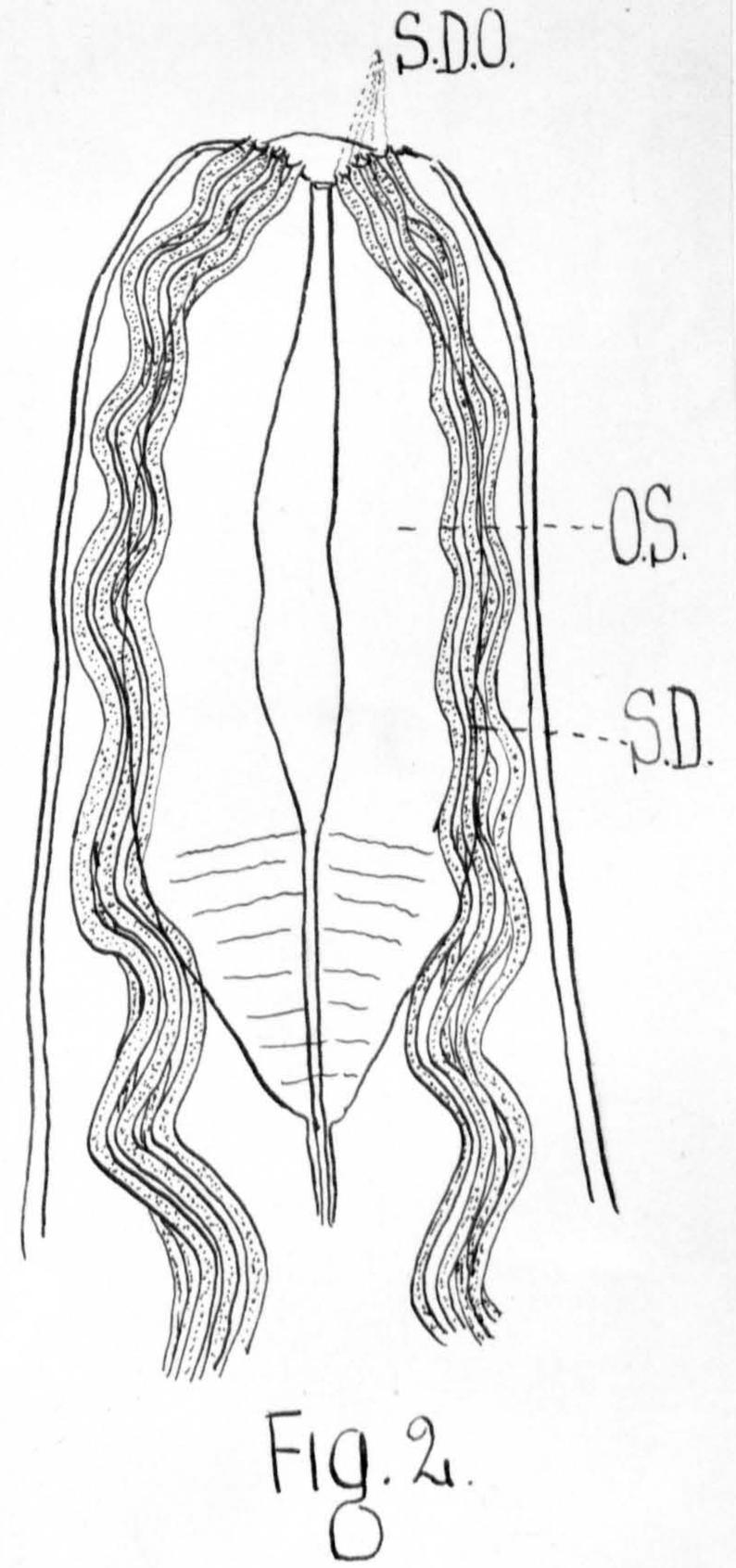


Fig. 1.



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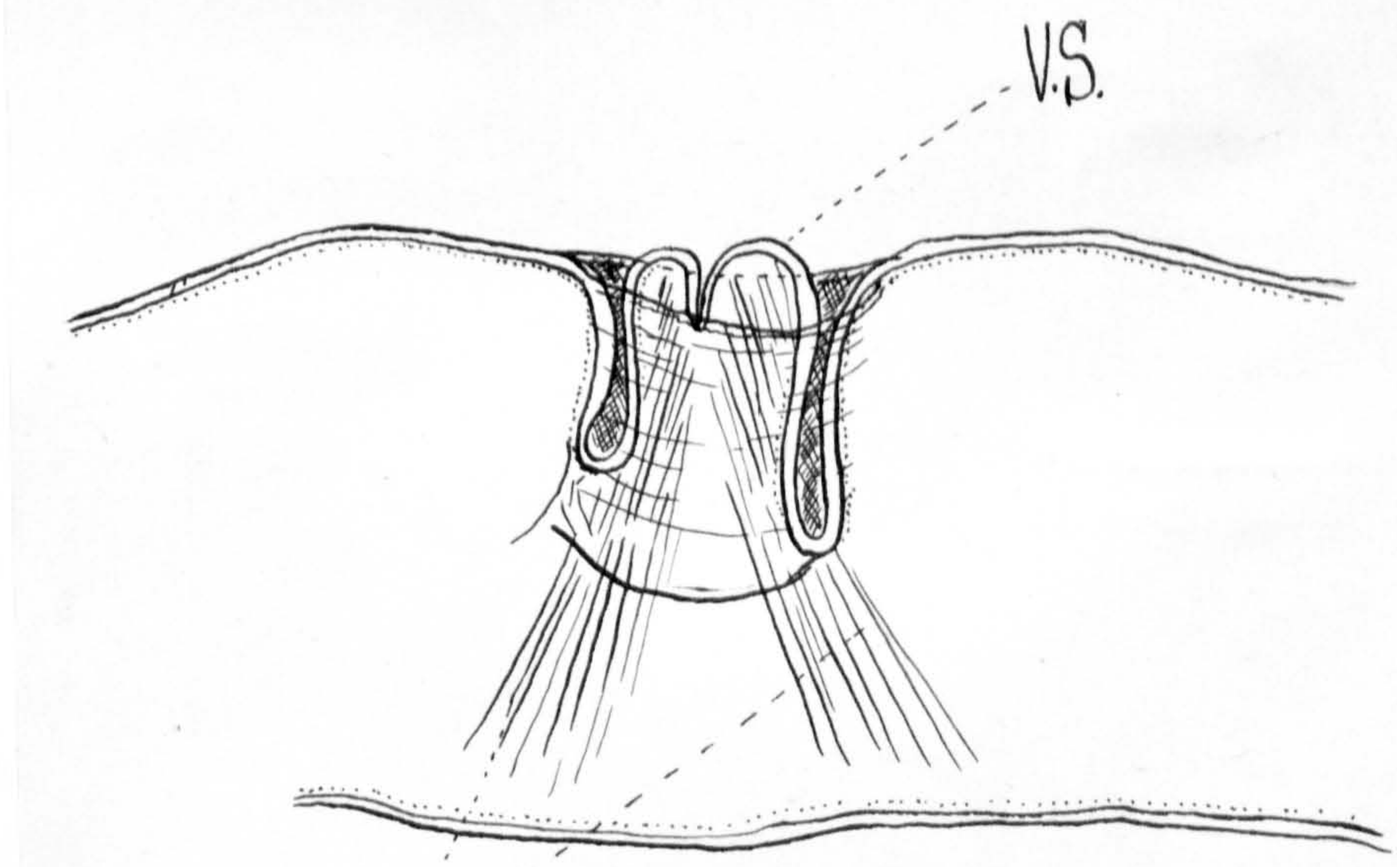

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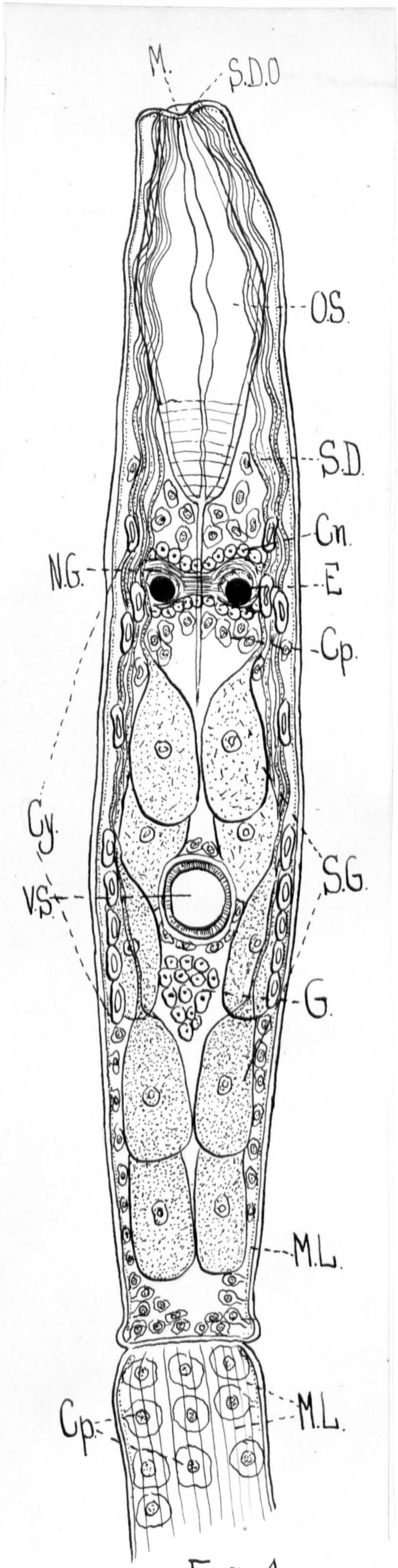

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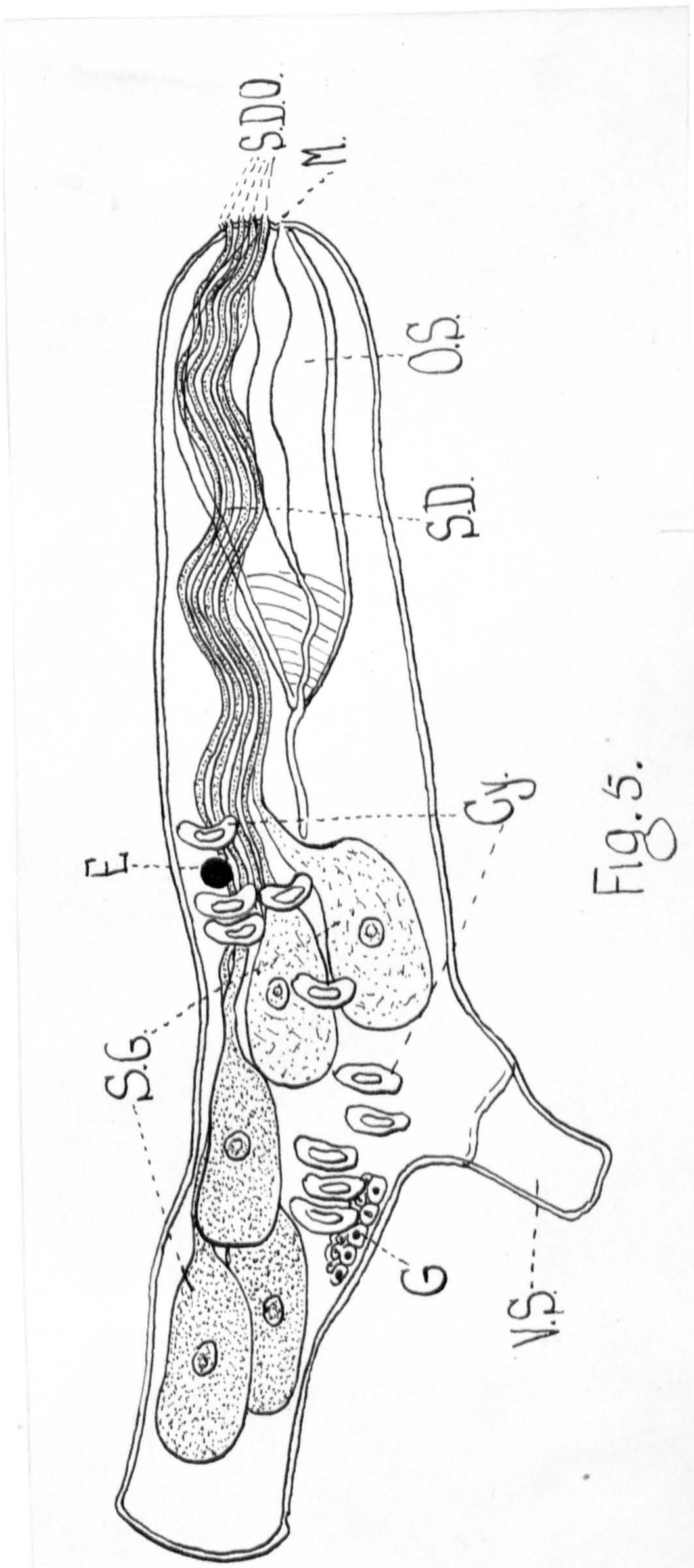
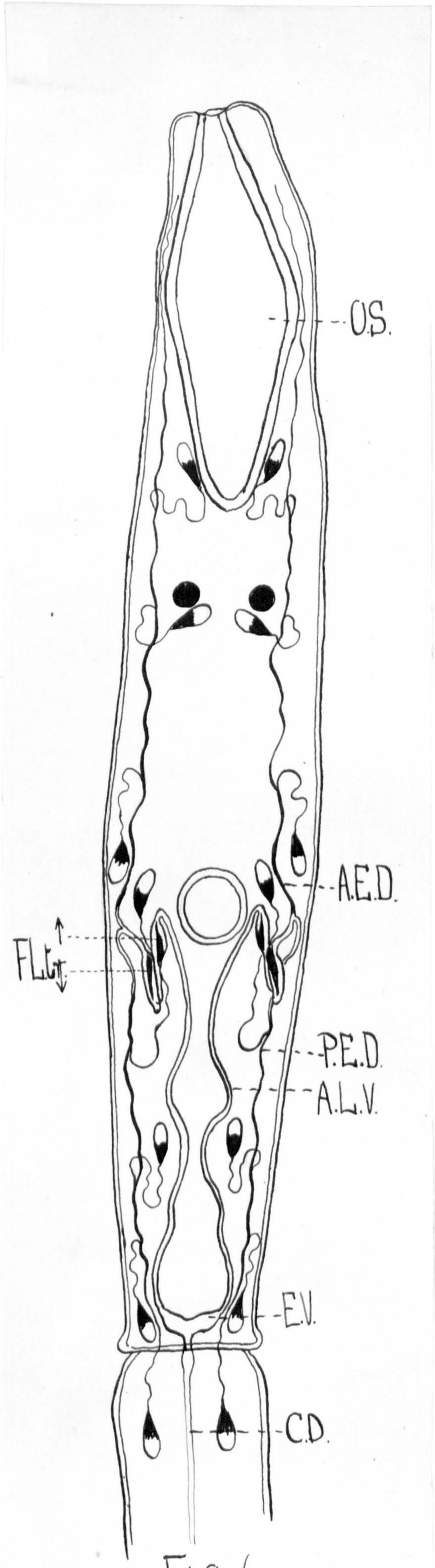


Fig. 5.



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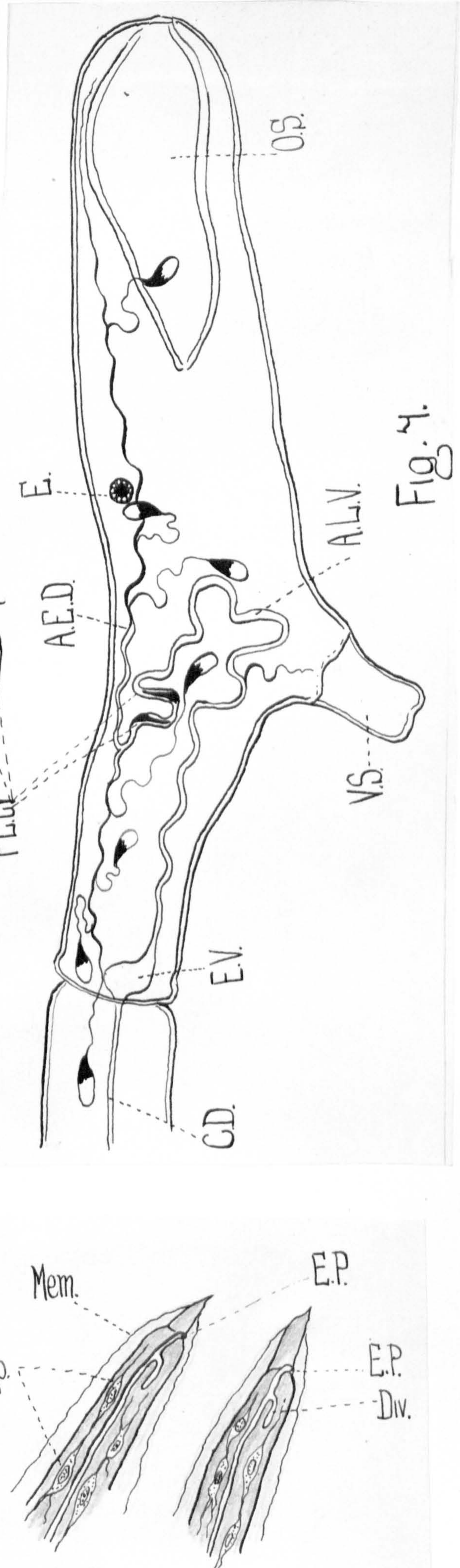


Fig. 7.

Fig. 8.

EXPLANATION of the FIGURES of XIPHIDIOCERCARIA. B.

FIG. 1. An entire sporocyst showing the two layers of cells, and the constrictions. X120.

FIG. 2. Two cercariae. X120.

FIG. 3. The body of a cercaria showing the position of the salivary glands, and the cystogenous cells. X550.

FIG. 4. A ventral view of the body, showing the ventral concavity, the alimentary tract, gonads, and excretory system. X550.

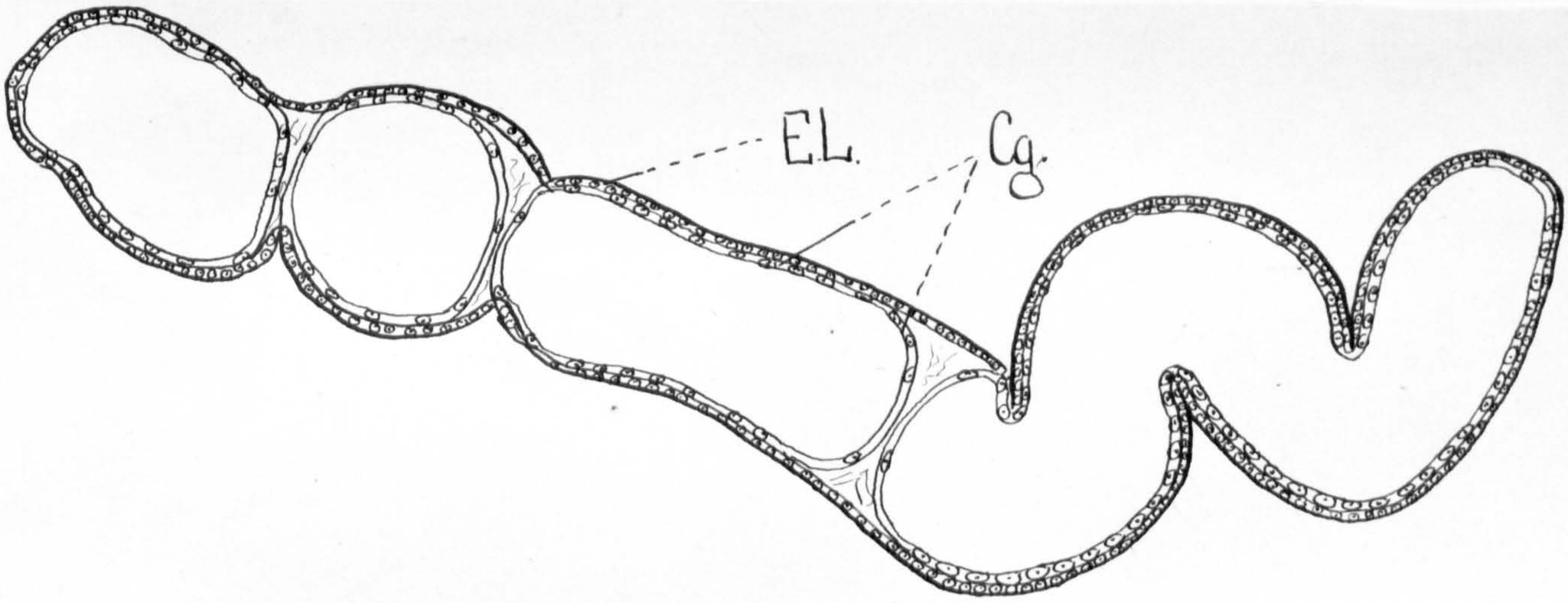
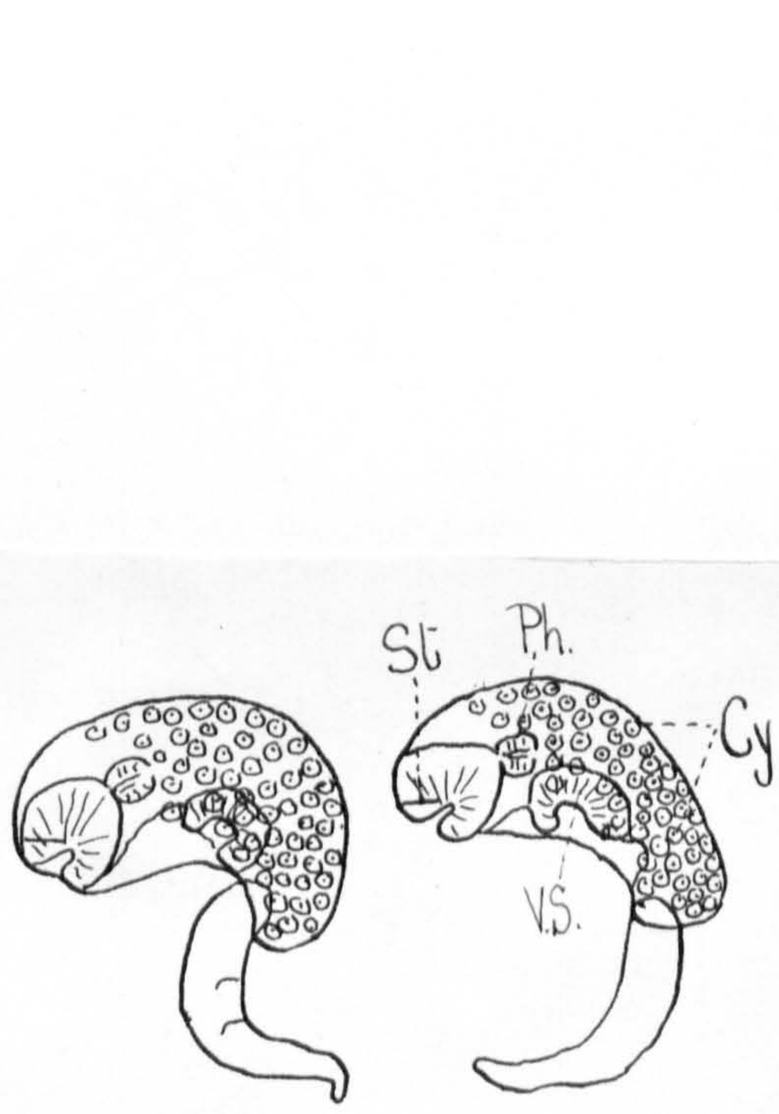


Fig. 1.



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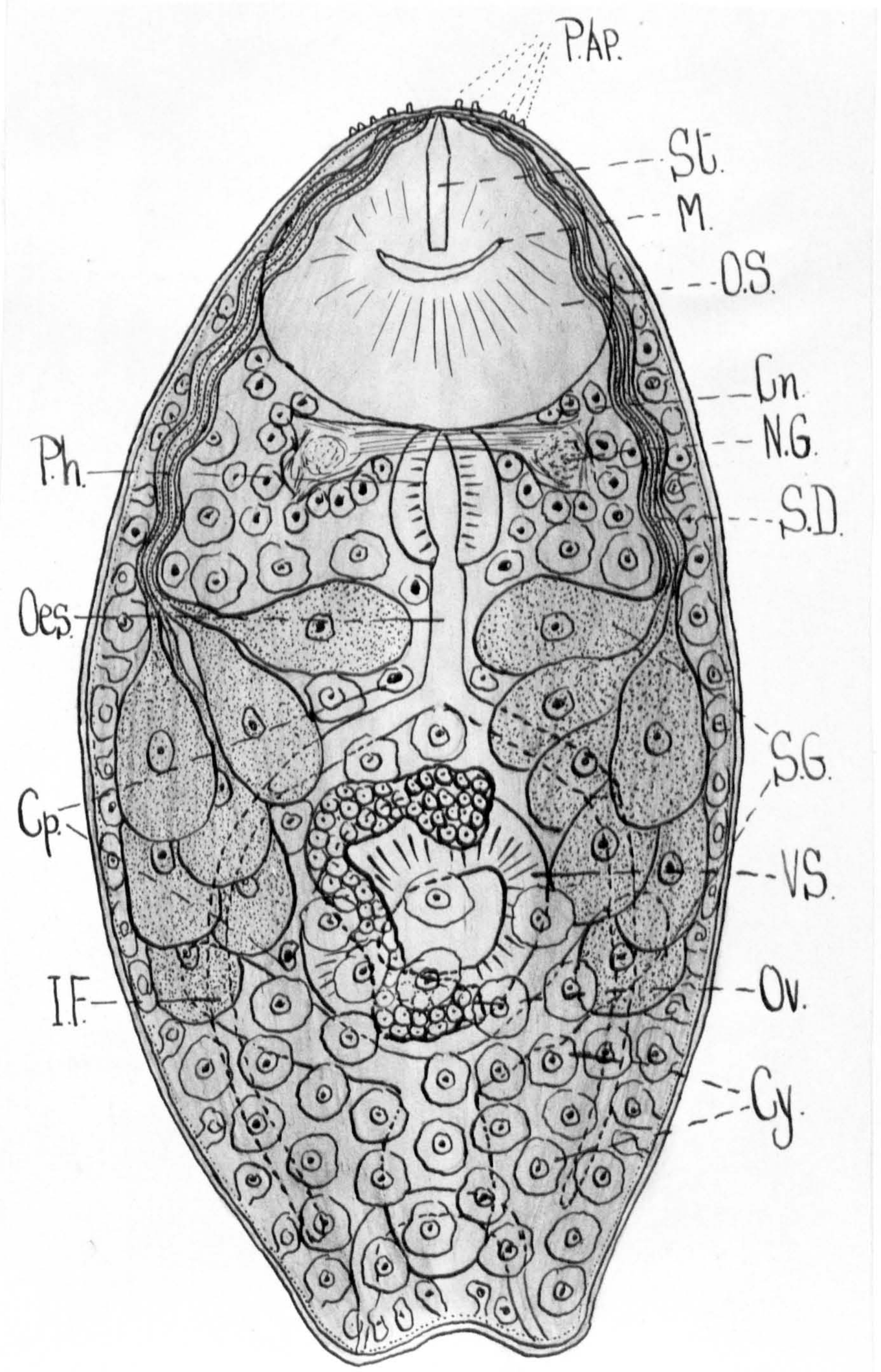

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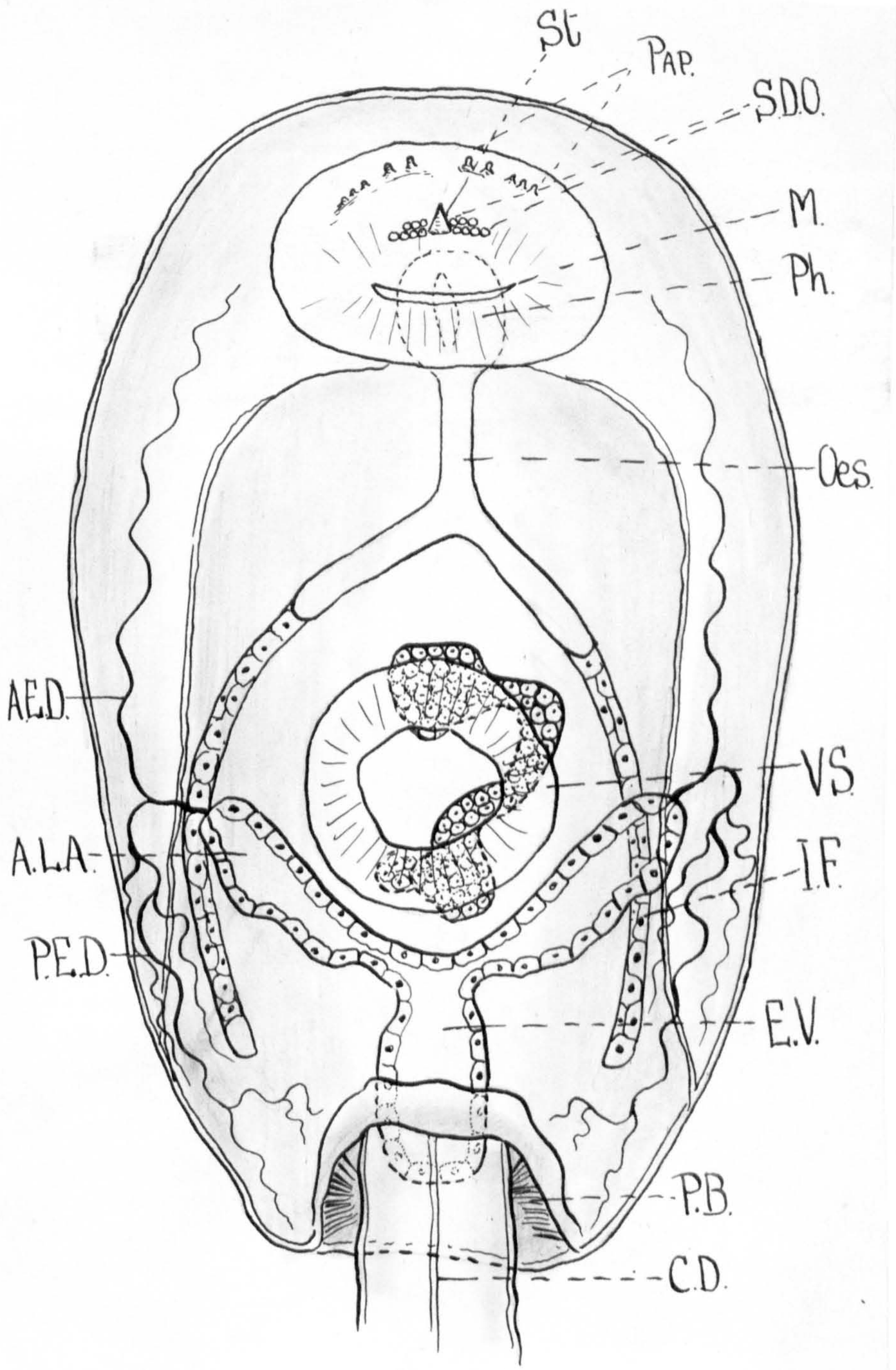


Fig. 4.

EXPLANATION of the FIGURES of XIPHIDIOCERCARIA C.

Fig. 1. The cercariae X 120.

Fig. 2. The body of a cercaria showing internal organisation X 550.

Fig. 3. Dorsal and lateral view of the stylet X 1000.

Fig. 4. A ventral view of the caudal pocket showing the patches of bristles on each side of the pocket.

Fig. 5. The body of a cercaria showing the excretory system X 550.

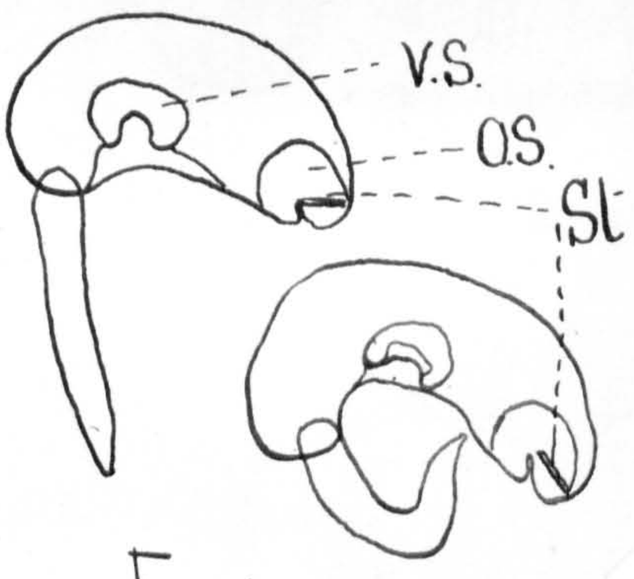
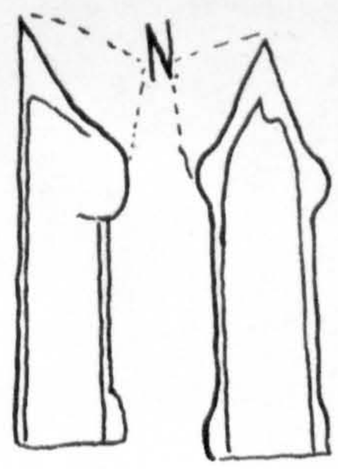


Fig. 1.



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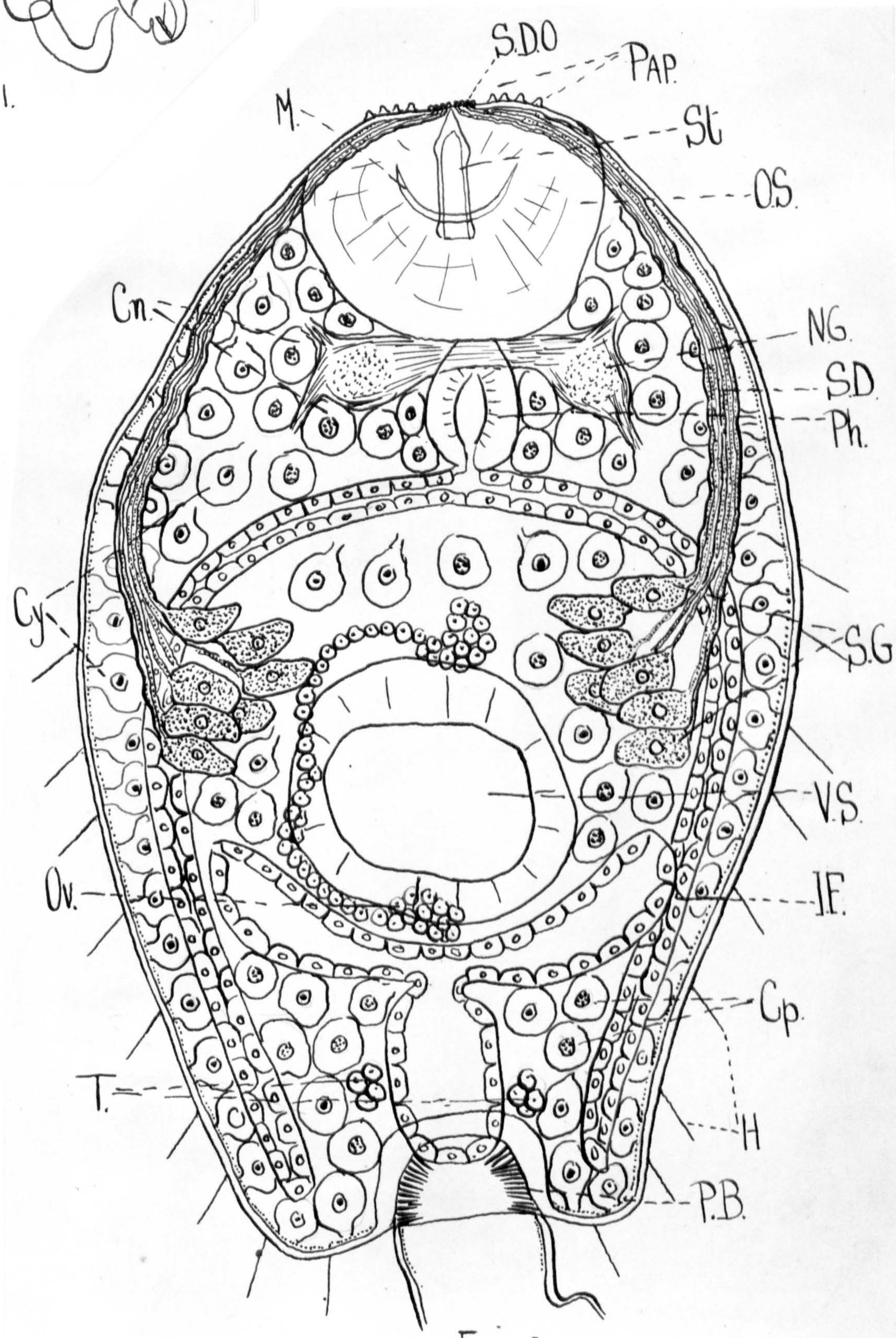

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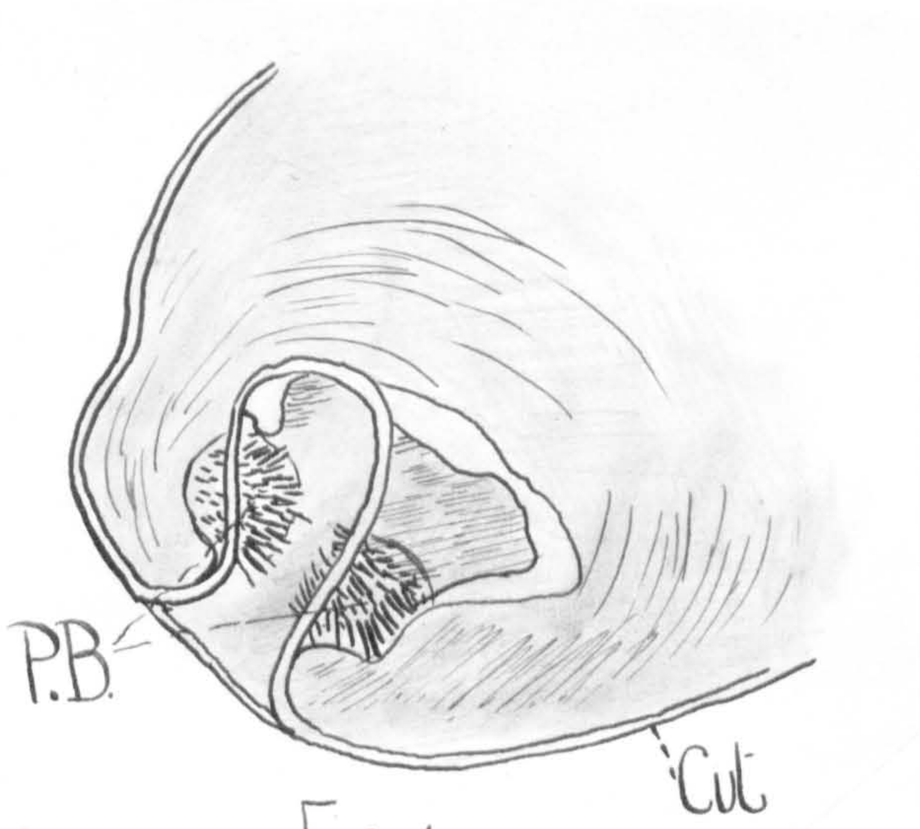

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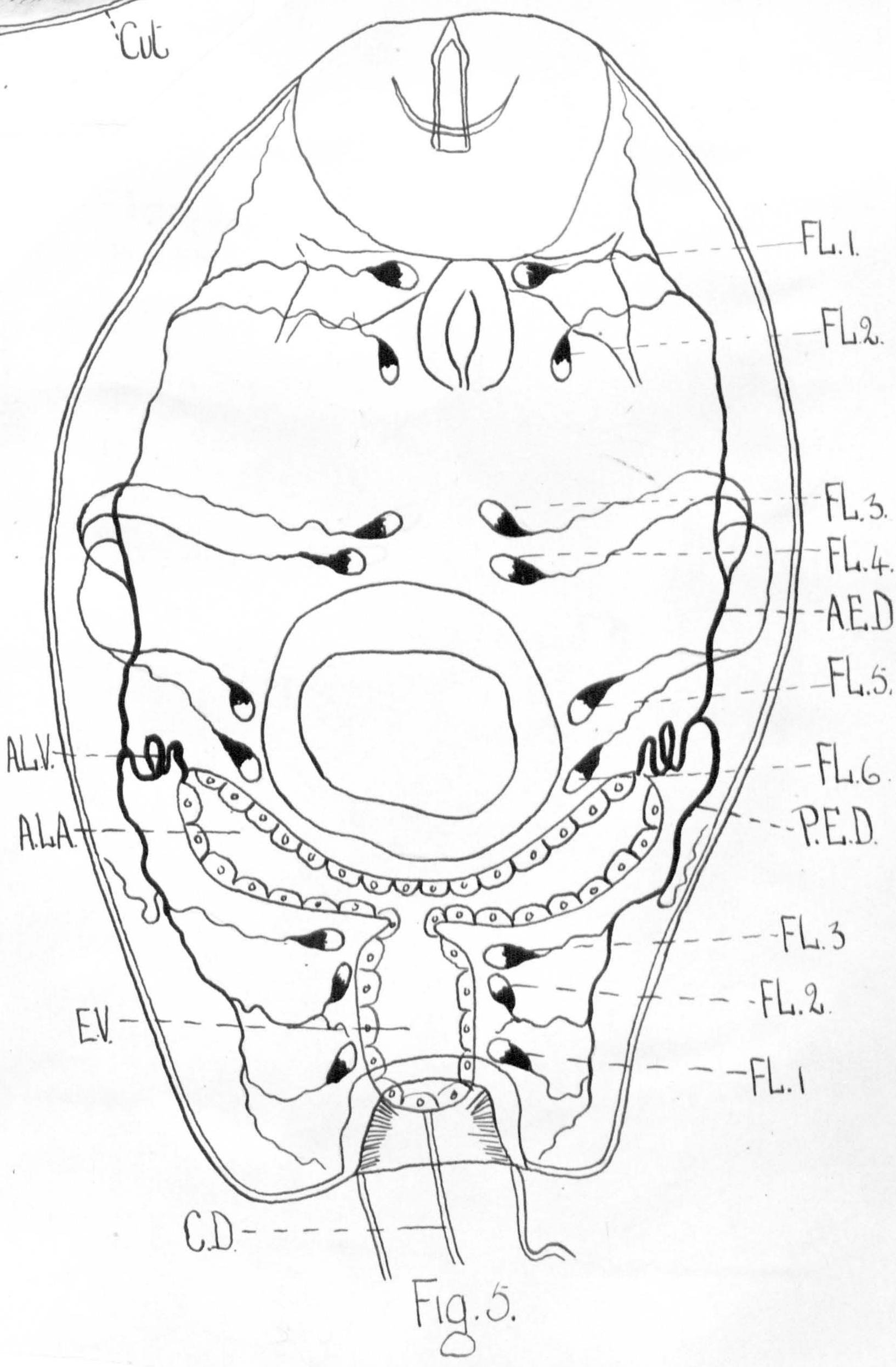


Fig. 5.

The following letters apply to all the figures of:- Capillaria leucisci,
the Gordius Larva and
the Nematode Larva.

A.	Anus.
Ba.	Band.
B. Sp.	Boring Spine.
Cl.	Cloacal opening.
C. Sp.	Caudal Spine.
Cut.	Cuticle.
Hks.	Hooks.
I. C.	Intestinal Cell.
I. Dil.	Intestinal Dilatation.
Int.	Intestine.
M.	Mouth.
Mem.	Cuticular expansion of the tail of the male.
Mus.	Muscles.
Nu.	Nucleus.
Oes.	Oesophagus.
Oes. c.	Oesophageal cell.
Oes. t.	Oesophageal tube.
Ov.	Ovary.
P. G./	

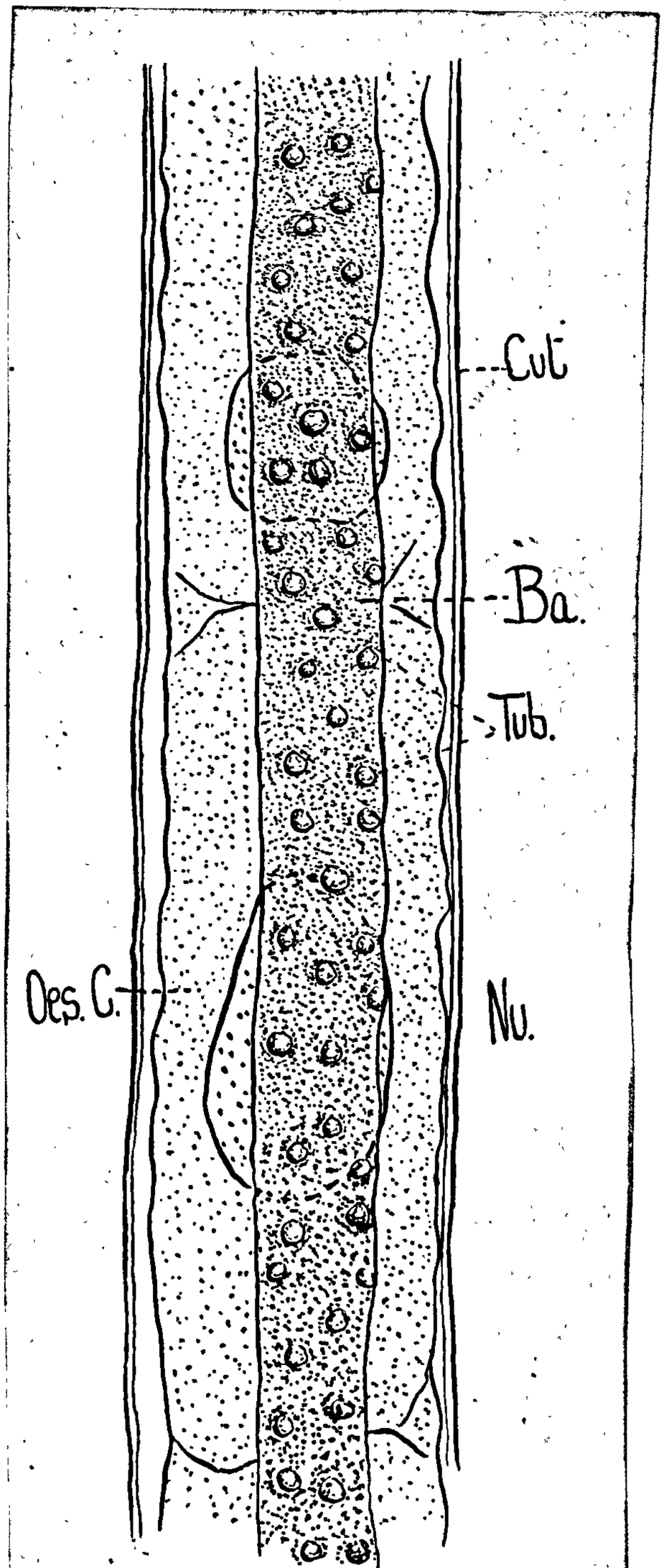
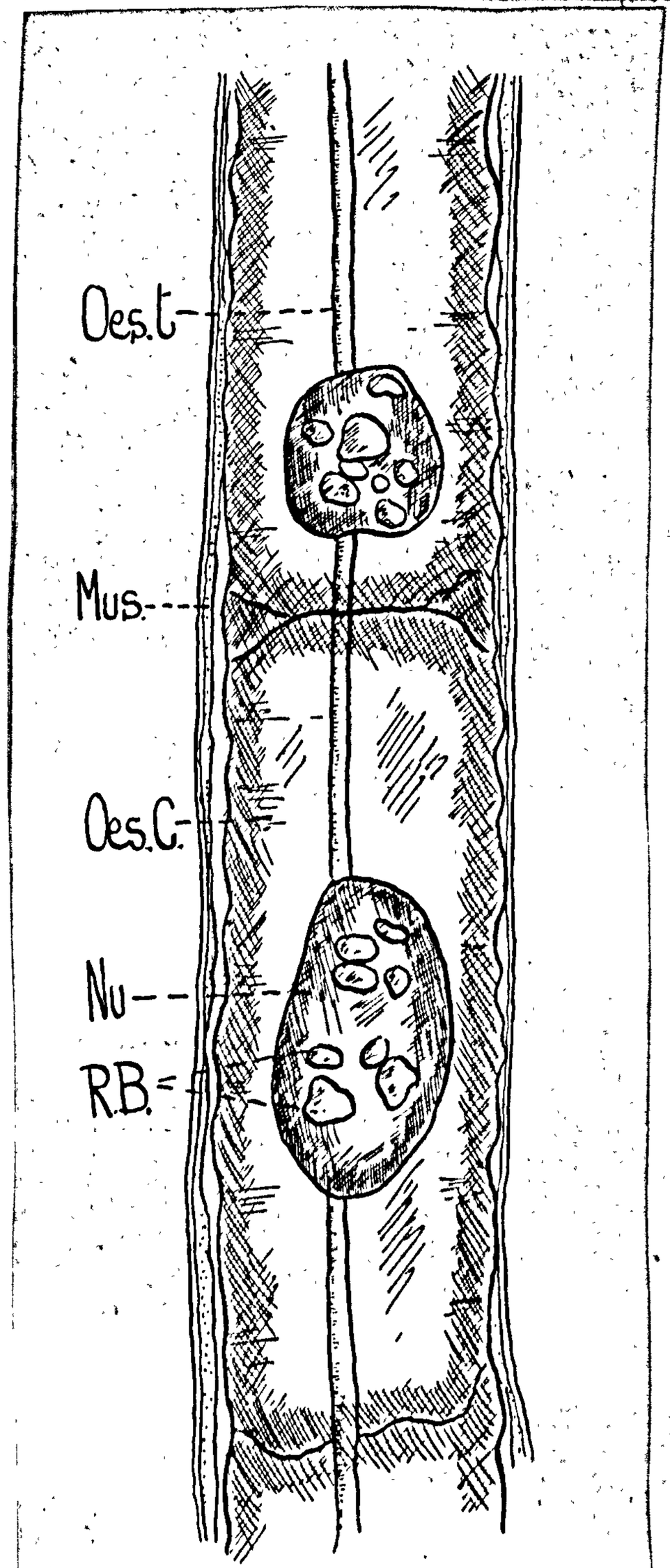


Fig. 1.



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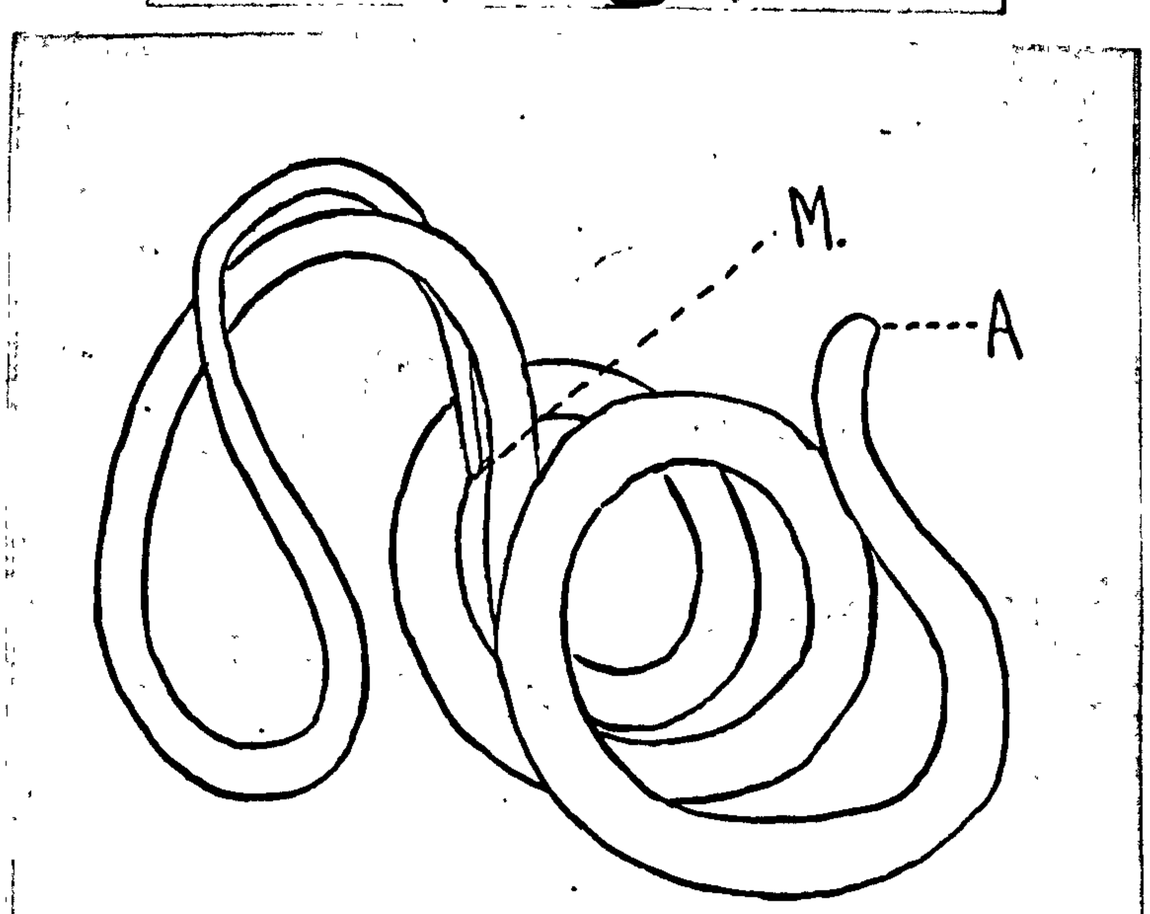
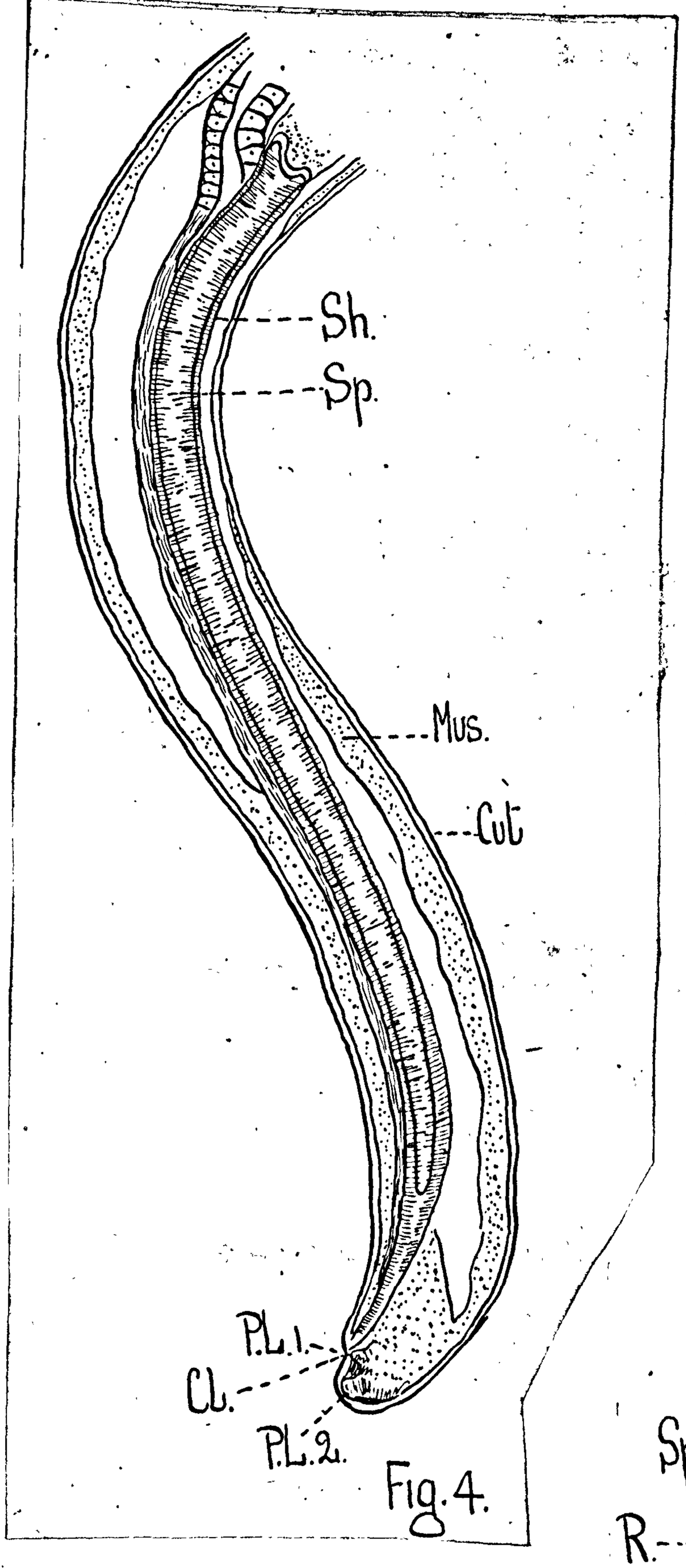


Fig. 3.



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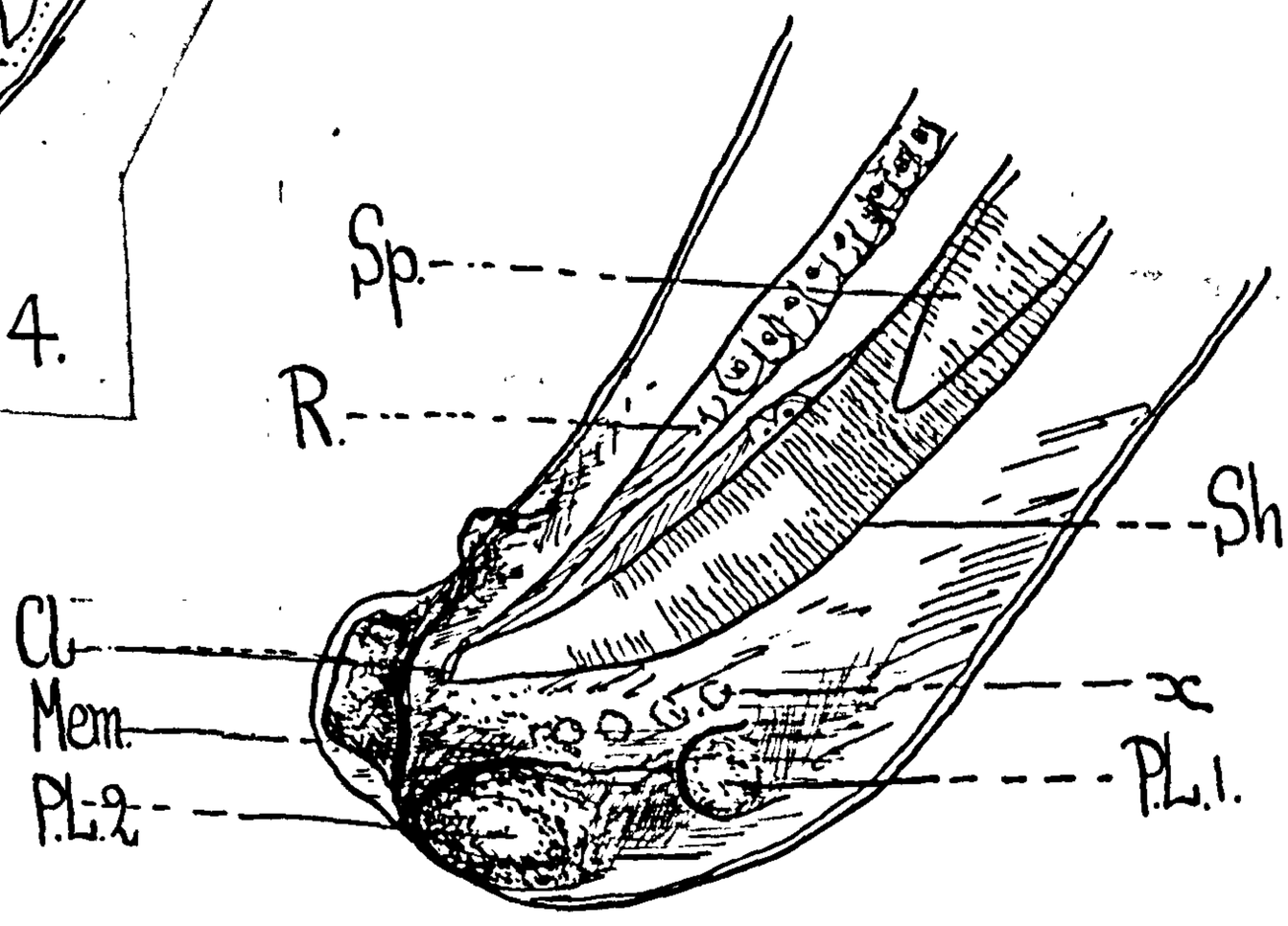

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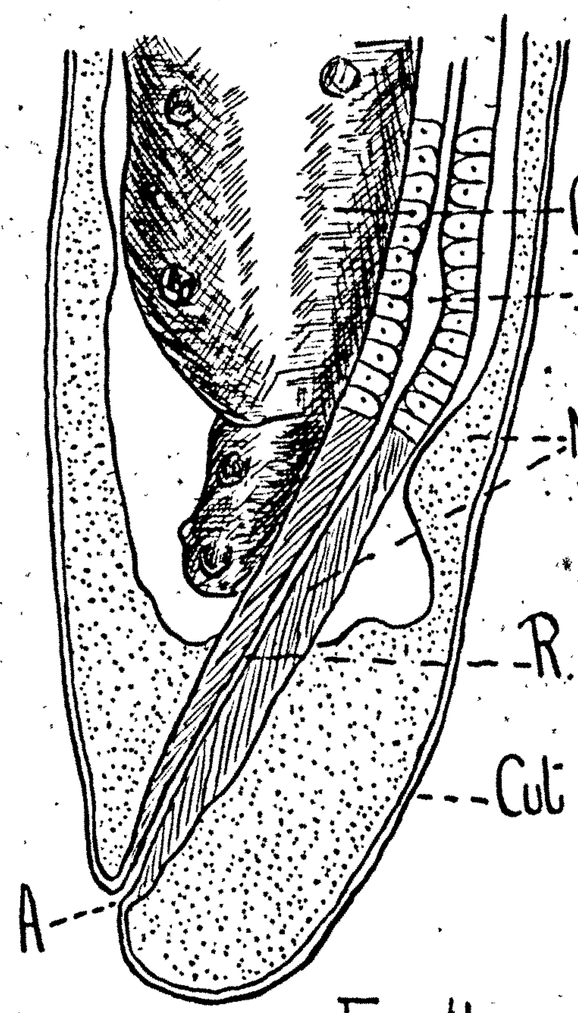

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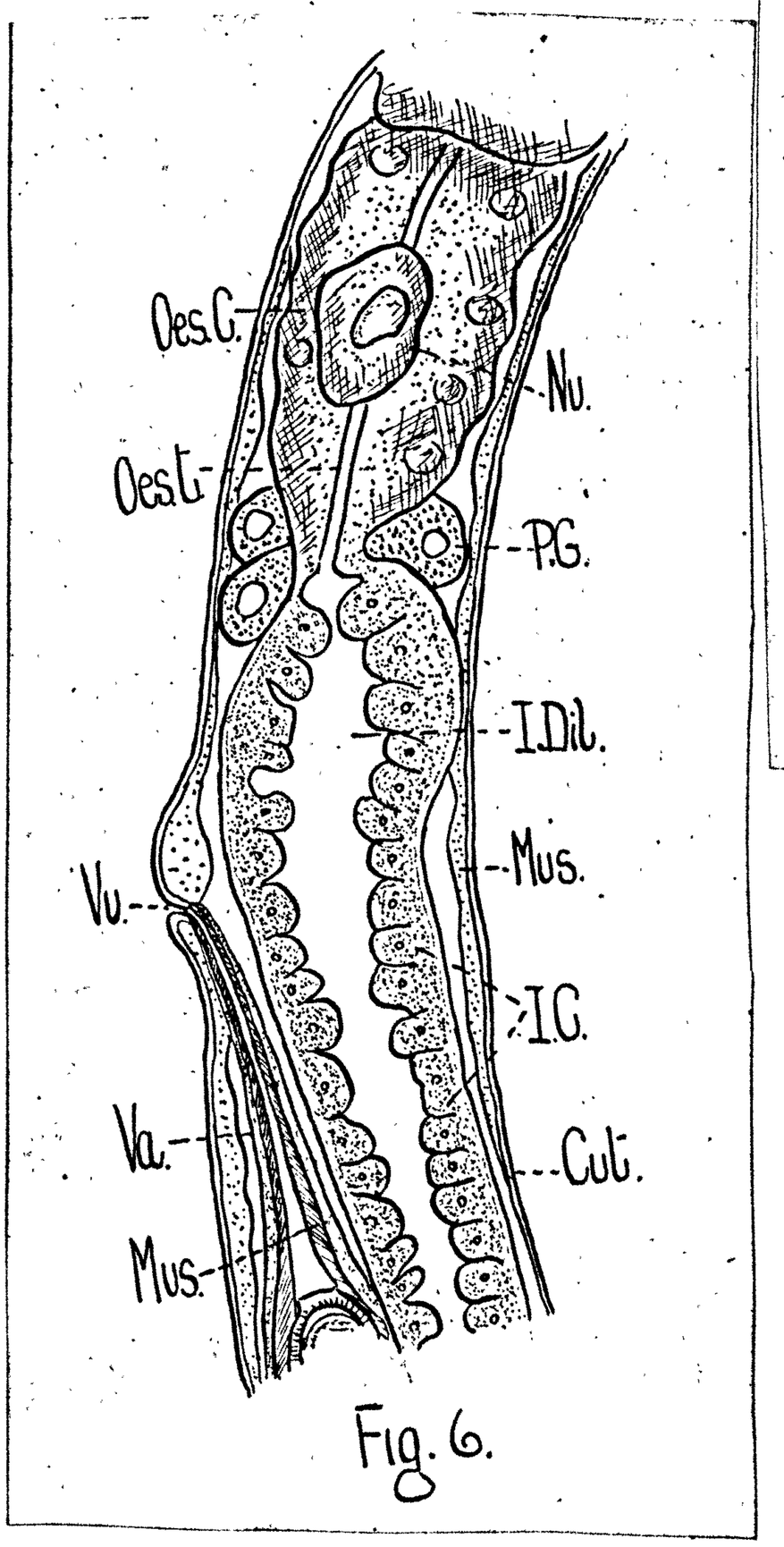

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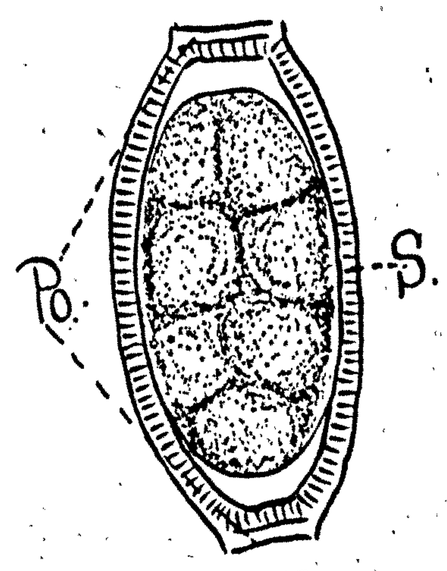


Fig. 8.

EXPLANATION of the FIGURES of the GORDIUS LARVA.

FIG. 1. A larva showing the everted anterior end with the three rows of hooks, the proboscis with the three stylets (St.) and the grooves on the cuticle. X800.

FIG. 2. A frontal view of the anterior end of a larva. X800.

FIG. 3. Another larva. X800.

FIG. 4. A larva with partially everted anterior end showing only a single row of hooks. X800.

EXPLANATION of the FIGURES of the NEMATODE LARVA.

FIG. 1. An entire larva showing the coiled condition and the boring spine (B. Sp.). X800.

FIG. 2. Another larva. X800.

FIG. 3. A larva showing the oesophagus (oes.) and the numerous cells in the body. X800.

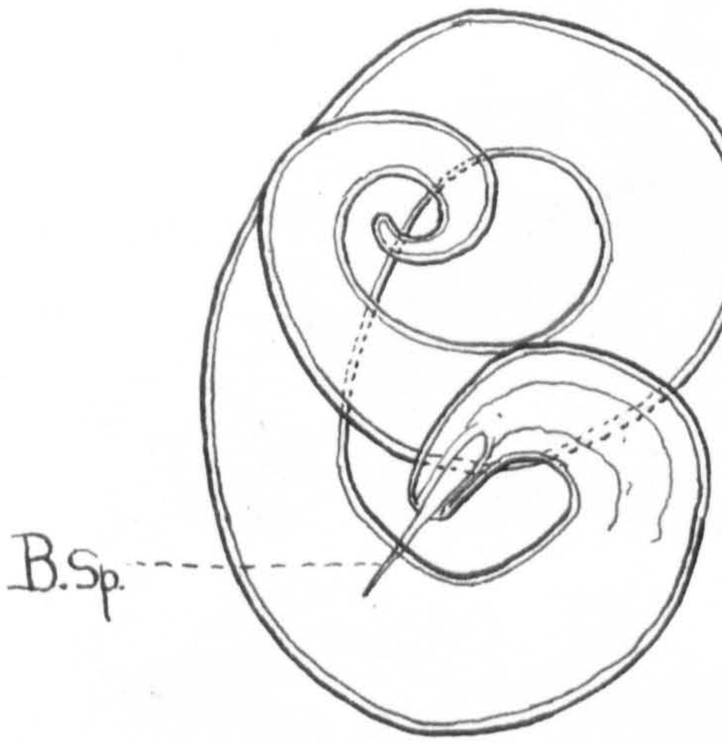
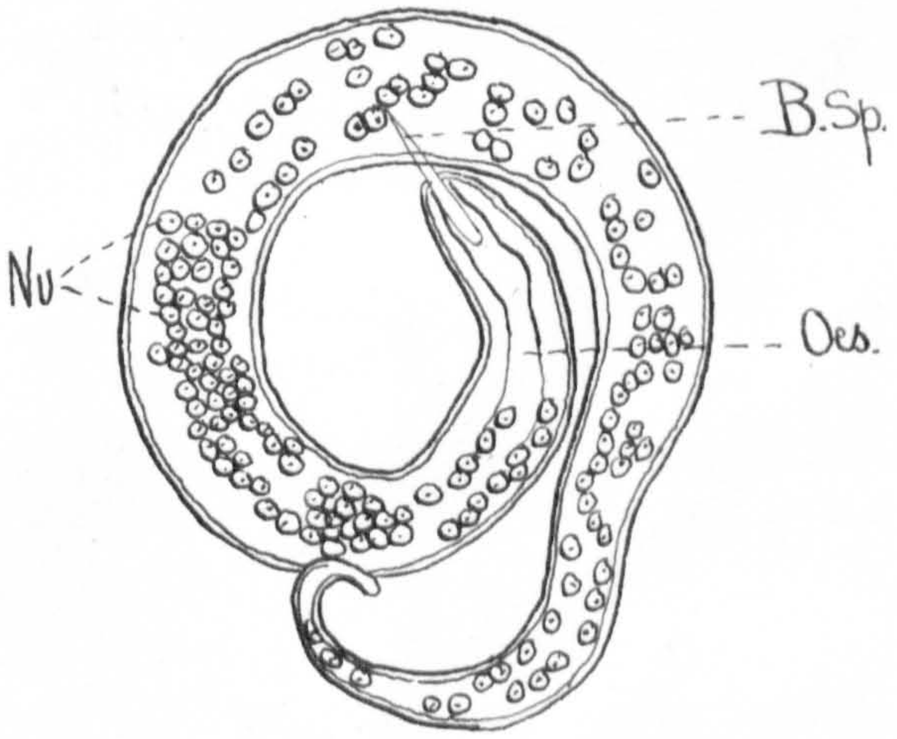


Fig.1



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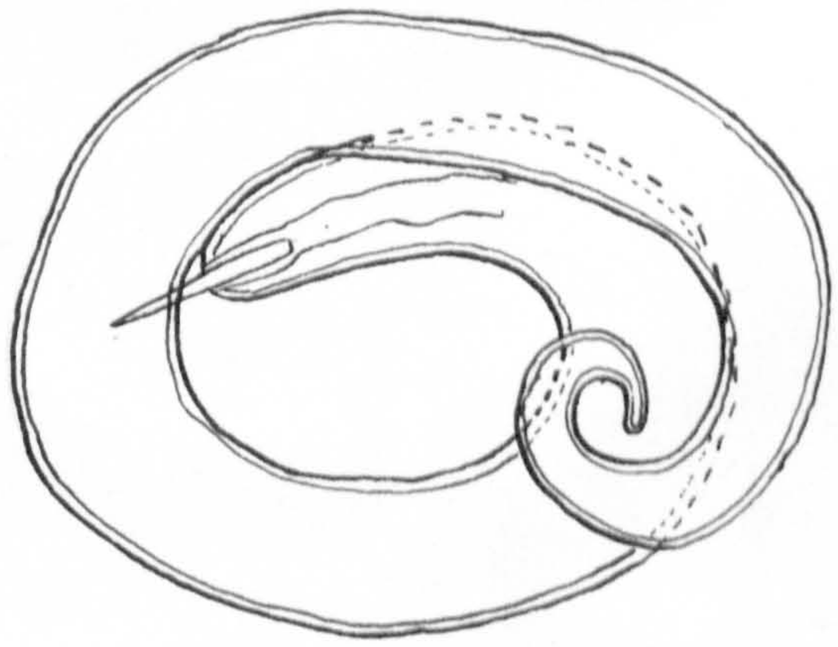

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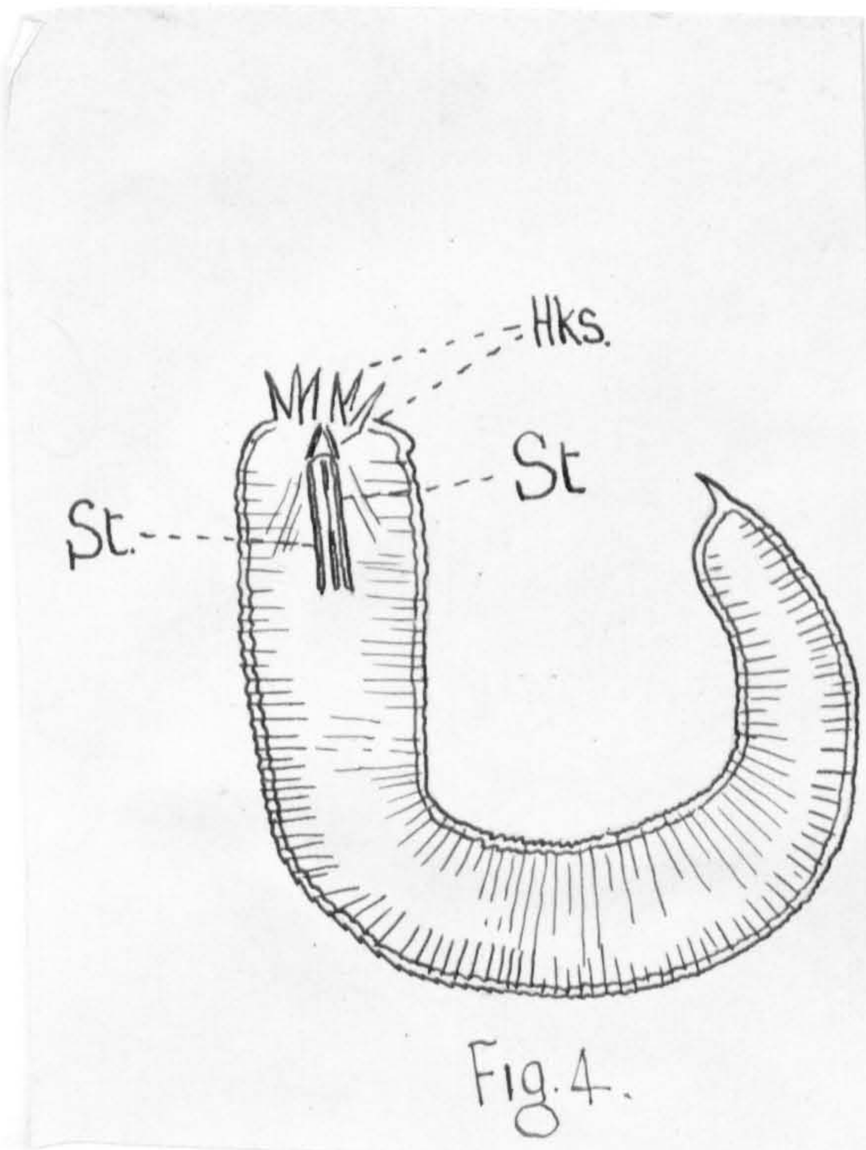

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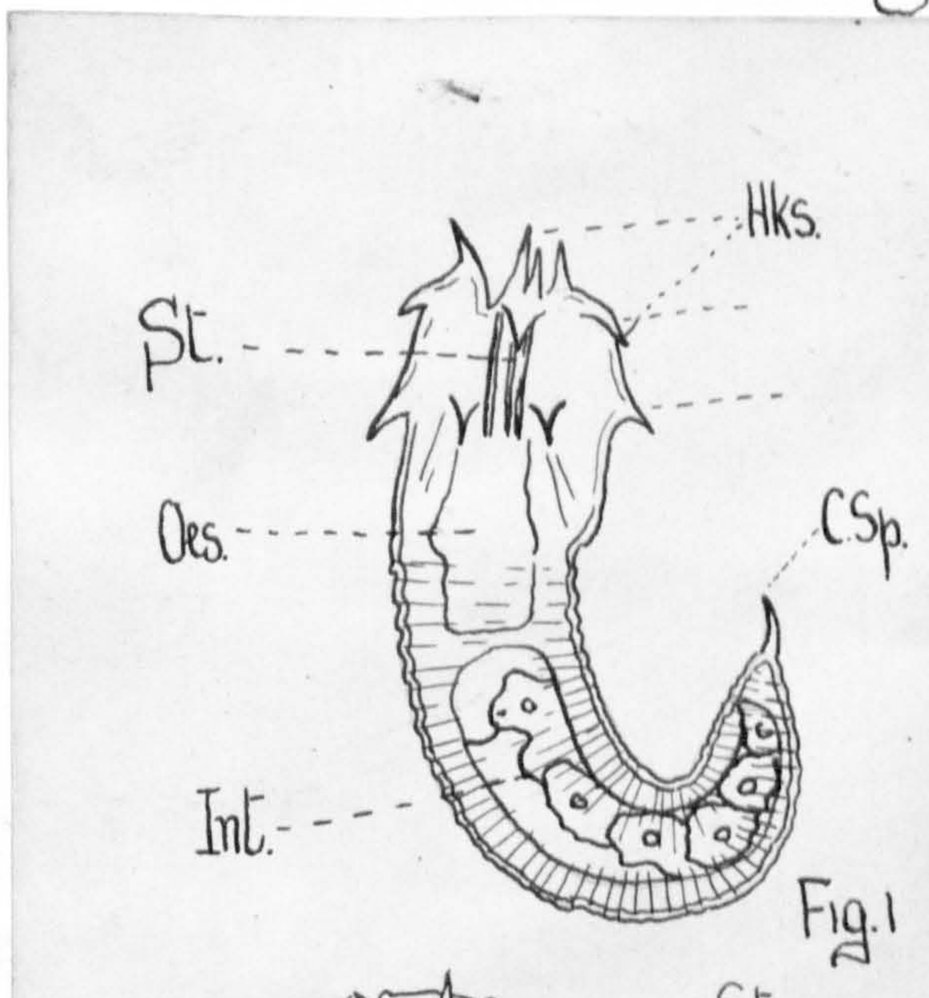
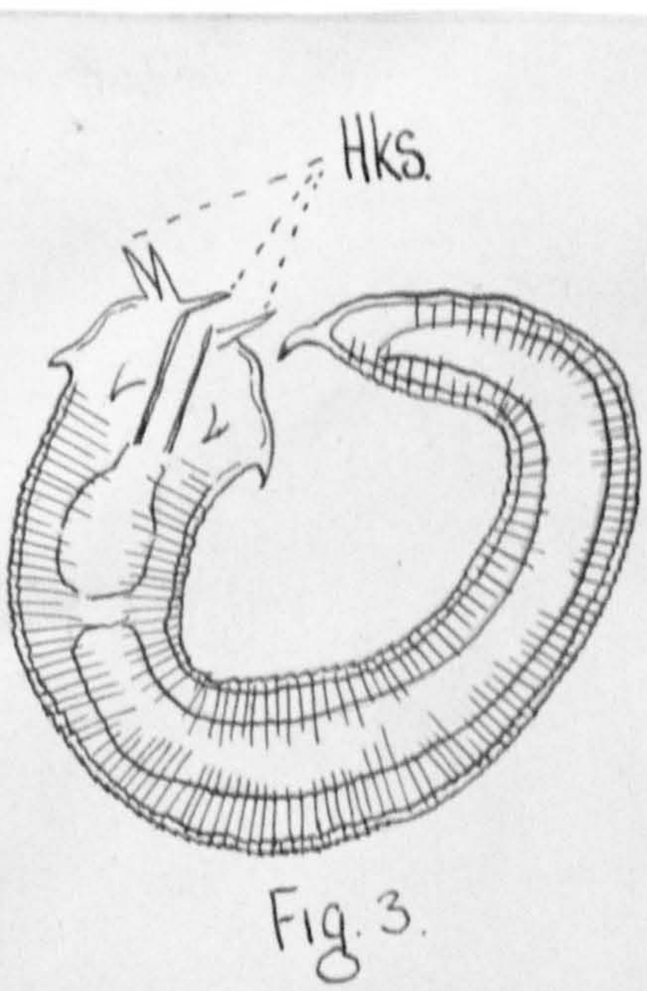


Fig.1



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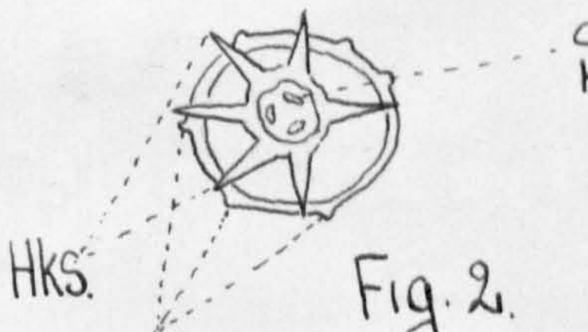

Fig.2.