On the Structure of Vermiculus pilosus.

By

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With Plates 26—28.

In 1892 (3a) I published a short description of an interesting new Oligochæte I had found on the sea-shore near Weymouth. Since then I have obtained more material, which I have worked at in Professor Lankester's laboratory at Oxford, and am now able to give a more complete and accurate account of its anatomy.

The worm, which I have called Vermiculus pilosus, was discovered in the rich black mud underlying the sandy surface of the shore about halfway between Weymouth and Portland. It lives there in considerable numbers with various species of Pachydrilus and Tubificids, especially Heterochæta costata, Clap., from which it is quite indistinguishable to the naked eye. Unlike the Enchytræids, it does not seem to venture to the surface amongst the decaying seaweed and in the tidal pools, nor is it so often found underneath large half-buried stones as other Tubificids, Heterochæta for example. Fig. 1 represents it natural size; it is from about 4 to 6 cm. long, and of a dull reddish tinge. The body is soft, and its movements are slow. Under a low power of the microscope it can be distinguished at once, after a little practice, being much less transparent than any of its associates. This opaqueness, caused chiefly by the structure of the body-wall, the network of blood-vessels, and the enormous number of cœlomic

corpuscles, renders it very difficult to make out the details of its anatomy in the living animal.

The prostomium (figs. 2 and 6, *pr.*) is rather large and conical. Each segment, from the second, is provided with two dorsal and two ventral bundles of setæ (fig. 2, *l. d. s.* and *l. v. s.*), placed in a transverse section nearly at the four corners of a square. Each bundle contains from two to five setæ, generally three. All the setæ, both dorsal and ventral, are alike S-shaped in outline, with a thickening about one third of the way from the distal end, which is bifurcate (fig. 3); they are of the ordinary Tubificid furcate type.

On close examination in a favourable light it is seen that the whole worm is clothed from head to tail in a more or less dense furry covering of hair-like processes, closely set, extremely fine, and apparently of cuticular origin (fig. 4, *pcl.*). These hair-like structures are not cilia; they do not move, and are not protoplasmic. Resembling the so-called "sense-hairs" or palpocils found on the prostomium and first segments of most aquatic Oligochætes, they are probably homologous with these, but developed to an extraordinary degree. The cuticle itself (fig. 4, *c.*) presents no peculiarity. The epidermis (figs. 4 and 7, *ep.*) is formed of regular more or less cubical cells, with large oval or round nuclei. Below the epidermis is a narrow layer of circular muscles (fig. 7, *c. m.*) within which are the longitudinal muscles (fig. 7, *l. m.*). In the transverse section the contractile fibrils are of different heights, being cut through at various distances from the middle of the cells which bear them. Along each side, about halfway between the dorsal and ventral bundles of setæ, the layer of longitudinal muscles is interrupted by a row of cells forming the lateral line (fig. 7, *l. l.*). Dr. Hesse has recently shown (4) that these are the cells to which belong the circular muscular fibres; my preparations support this view. Lining the inside of the body-wall is the cœlomic epithelium, composed for the most part of large vesicular cells (fig. 7, *c. ep.*).

The cœlomic corpuscles, which as above stated are very numerous, are spherical and coarsely granular (fig. 28, *c. c.*).

The vascular system is very peculiar. In fig. 5 the main blood-vessels have been represented somewhat diagrammatically, omitting for the sake of clearness the complex fine network found all over the first ten segments. A large longitudinal dorsal vessel (fig. 5, *d. v.*), reaching from the brain to the last segment, gives off on either side in front of each septum from the 2nd to the 10th segment a lateral dorsal vessel (fig. 5, *l. d. v.*), which soon branches out over the body-wall, reuniting below into two lateral ventral vessels which enter the longitudinal ventral vessel (fig. 5, *v. v.*). One of the lateral ventral vessels, the smaller, enters the ventral vessel about the middle of the segment (fig. 5, *m. l. v. v.*); the other, and larger, runs into it towards the hinder end of the segment (fig. 5, *p. l. v. v.*). In my preliminary note I stated that there were a pair of "hearts" in the 10th segment; this was a mistake. Indeed, the fact that there is no direct communication between the longitudinal dorsal and ventral vessels is the most striking thing about the blood-system of Vermiculus. The manner in which the lateral dorsal communicate with the lateral ventral vessels by means of the cutaneous network is shown in fig. 9. In the post-genital region only small vessels are given off at each segment to the body-wall and to the intestine.

The dorsal longitudinal vessel from the third to the last segment is dilated in front of the region where each pair of lateral vessels is given off into a small bulb or swelling, round the posterior constricted edge of which are ranged large cells (often as many as eight or nine), forming a system of valves (figs. 8 and 10, *v.*). Each cell is attached at its posterior end only, while its main body can swing backwards and forwards; it contains a number of bright fatty granules and a small spherical nucleus (figs. 8 and 10). The lateral dorsal vessels increase in size from the 2nd to the 10th segments; from the 3rd segment to the 10th they have an increasing number of dilatations and constrictions, each provided with valves similar to those in the longitudinal vessel (figs. 5 and 10). The vessel in the 10th segment, which is by far the largest, has as

many as five such sets of valves; the number of cells round each constriction diminishes the farther it is from the longitudinal vessel. It is this vessel (of the 10th segment) which supplies the blood to the ovisac, into which it passes directly from the 11th segment. Both the longitudinal and these lateral dorsal vessels are contractile.

The non-contractile longitudinal ventral vessel runs straight up to the 3rd segment, where it divides and joins again, forming a ring. From the anterior border of this ring are given off three vessels, which join the terminal dorsal branches under the brain (fig. 5). The ventral system has no valves.

The circulation of the blood (which is red) and the action of the valves are as follows: The blood is propelled forward in the dorsal longitudinal vessel by the contraction of its walls; it is helped in its course by the position of the valves, which prevent its returning, for when the flow is forwards they assume the position *a'* (fig. 11), leaving a clear passage; when the blood tries to return they take up the position *b'* (fig. 11), meeting in the middle and closing the way. Occasionally the return flow is too strong, and the valves are forced right back to the position *c'* (fig. 11), when they more or less completely shut off the communication with the side branches. The course of the blood-stream in these branches is from the longitudinal vessels outwards to the body-wall. As already mentioned, coming off from the lateral branches there is over the whole surface of the body-wall of the first 10 segments underlying the cœlomic epithelium a fine network of blood-vessels, which must form a very efficient respiratory system. Thus we see that, in the main, the course of the blood is up the longitudinal dorsal vessel, down the anterior lateral vessels, spreading over the body-wall to be aërated, and returning to the ventral vessel, in which it will flow backwards. Thence it probably reaches the dorsal vessel again by means of the small branches given off to the intestine, where nourishment is no doubt absorbed, and so brought into the general circulation. As will be seen later, excretion probably takes place from the ventral vessel by means of the nephridia which cling closely to it.

The alimentary canal is simple, and quite similar to that of Tubifex. A short way behind the mouth (fig. 2, *m.*) is a muscular pharynx in the 2nd segment (fig. 6, *ph.*), followed by a slender œsophagus stretching through the 3rd and 4th segments (fig. 6, *œs.*), and from the 5th segment backwards a straight intestine covered with brown chloragogen cells (fig. 6, *int.*). The anus is terminal. The pharynx is provided with irregular masses of glandular cells. From the pharynx backwards the alimentary canal is lined by ciliated columnar epithelium, outside which is a thin layer of circular and longitudinal muscles. In the wall of the intestine is a system of blood-capillaries forming a plexus similar to that described in the Enchytræids and other Tubificids.

The cerebral ganglia form a bilobed brain, deeply cleft in front and situated in the 1st segment (fig. 6, *br.*). The structure of the ventral nerve-cord is somewhat exceptional. On examining a transverse section taken between the ganglia (fig. 16), it is seen to consist of an outer covering of cœlomic epithelium (fig. 16, *c. ep.*) enclosing the nerve-cord proper and three strands of muscular fibres, of which the middle one (fig. 16, *m. n. c. m.*) is the most important. The nerve-cord itself is formed of two circular strands of ordinary nerve-fibres, on the dorsal surface of which run three neurochordal fibres. Owing to their delicate structure, these enlarged fibres are so difficult to see in specimens preserved in corrosive and stained with borax-carmine that at first I thought they were altogether absent. They are, however, plainly visible in sections of specimens preserved in Lindsay-Johnson fluid and stained with paracarmine (fig. 15). A transverse section taken through a ganglion (fig. 15) shows that the ganglionic cells extend on the under surface of the cord, and rise up at the sides, actually overlapping the muscular strands (fig. 15, *g. c.*). In a section taken at the point where the nerve-cord is passing through the septum (fig. 14), we see that muscle-fibres pass from the septum underneath the median muscular strand overlying the cord (fig. 14, *m. s.*), while the lateral strands communicate with those which descend on either side to the body-wall.

The nephridia of Vermiculus are no less peculiar than are its other organs; they are situated in Segments 6 to 9 inclusive, and all the segments behind the 11th till near the tail end. It is interesting to observe a nephridium opening into the 11th segment in the adult. The general shape of the nephridium is shown in fig. 25. Stretching back from the funnel (fig. 25, *n. f.*) we have a narrow duct which passes through the septum, and gradually swells into a pear-shaped mass (figs. 25 and 28, *p. s. m.*), which is slightly pigmented, contains a large number of granules, and in which the canal is much convoluted (fig. 28, *nph. c.*). The main body of the nephridium (fig. 25, *b. n.*) is a more or less irregularly lobed mass lying by the side of, and spreading over the ventral blood-vessel, to which it closely adheres (fig. 32). Although the right and left nephridia in the same segment mingle over the blood-vessel, their canals do not communicate. From the main body starts a canal to the exterior (fig. 25, *c. ext.*), which opens on the surface in front of the ventral setæ by a minute pore (fig. 25, *nph. p.*). The internal funnel is small and somewhat flattened, but has its dorsal lip expanded into a large, flat, ciliated process of oval shape (figs. 26—29, *c. p.*) Delicate waving cilia are set round the edge of the funnel and its process (figs. 26 and 27, *ex. ci.*); on the lower or inner surface of the flat process alone arise numerous long cilia, forming a flame-like structure with its free end pointing into the canal (figs. 26, 27, and 29, *fl.*). These long cilia beat together with a peculiar quick motion, forming rapidly moving undulations which, starting from the rim of the process and travelling towards the tip of the flame, give the whole structure, with its transverse waves, somewhat the appearance of a tennis racket with its cross strings. The nephridiostome is formed of two cells with oval nuclei (fig. 29, *n. f.*); the rest of the organ consists of a mass of cells with roundish nuclei, and without distinct cell-outlines, pierced through and through by the delicate nephridial canal (fig. 30). Except for the few short blind diverticula given off, especially from that part of the canal which leads to the exterior (fig. 25, *c. ext.*), it does not branch,

and although much convoluted, appears to be continuous throughout. Here and there this canal enlarges into an ampulla, in which waves a flame-like bunch of cilia pointing towards the external aperture (figs. 28, 31, and 32, *c. a.*). No cilia are found anywhere else but in these ampullæ, which are not very numerous.

The gonads consist of a pair of testes on the anterior wall of the 10th segment (fig. 12, *t.*), and a pair of ovaries on the anterior wall of the 11th segment (fig. 12, *ov.*). The sperm-ducts are rather short tubes opening by means of widely opened shallow ciliated funnels into the 10th segment (fig. 12, *sp. f.*). A short narrow duct passes from behind the funnel through the 11th septum, rapidly changes into a thick tube for about half its course, then narrows again and opens into a median chamber below the nerve-cord (fig. 12, *sp. ch.*). This cavity, which may be called the median spermiducal chamber, opens to the exterior towards the posterior end of the 11th segment (fig. 2, *m. p. sp.*) by an irregular longitudinal aperture. The openings of the sperm-ducts into the chamber are situated very near together, close to the nerve-cord (fig. 22, *sp. p.*)

Fig. 24 represents a median longitudinal section through the spermiducal chamber; it shows how the nerve-cord (*n. c.*) and the ventral blood-vessel (*v. v.*) pass over it. From the structure of its wall with the cuticle, the epidermal cells (*ep.*), the longitudinal and circular muscle-fibres (*c. m.* and *l. m.*), the median chamber is obviously a direct invagination of the body-wall. Moreover, that this is really the case is proved by the fact that in the young worm the sperm-ducts come separately to the surface (fig. 23, *sp.*), and there is then no sign of a median pore. The gradual formation of the median chamber can be traced from its earliest beginning.

The sperm-duct, except the narrow terminal region, is ciliated. The structure of the wide region is shown in a longitudinal section in fig. 17, where it is seen that its large size is chiefly due to the covering of cœlomic epithelium cells (*c. ep.*), which have become modified into long columnar cells

with granular protoplasmic contents. Under this is a thin layer of circular and a few longitudinal muscles (*c. m.*), followed by the ciliated lining epithelium of the duct (*w. of sp.*) composed of small granular cells. In the narrow region of the sperm-duct the cœlomic epithelium is not modified (fig. 18, *c. ep.*), while the lumen is bounded by columnar epithelium, the cells of which are very deep when the duct is not expanded (fig. 18, *w. of sp.*). There is no special penial apparatus, and no prostate.

The oviducts appear to be reduced to a mere depression on each side of the ventral edge of the 12th septum (fig. 12, *ovd.*).

The spermathecæ are two pear-shaped sacs (fig. 12, *spth.*), opening in the median ventral line by means of a common median pore immediately below the nerve-cord at the anterior end of the 10th segment (fig. 2, *spth. p.*). Fig. 20 shows a transverse section of an adult worm in this region passing through the median pore (*spth. p.*), at which open both the right and the left spermathecæ (*spth.*). It is interesting to note that in the young worm a similar transverse section (fig. 21) shows that here the two spermathecæ (which have all the appearance of being direct invaginations of the epidermis) arise distinctly from right and left points some distance from each other (fig. 21, *spth. p.*); it is only later that the necks of the two organs approximate and finally open by a common aperture. This may easily be confirmed by surface views of the living worm. The structure of the wall of mature spermathecæ is shown in fig. 19. Outside is the ordinary cœlomic epithelium (*c. ep.*), followed by a layer of scattered longitudinal and circular muscles; finally we have lining the interior of the organ a thick epithelium, with large oval nuclei ranged with their long axis parallel to the surface. The lumen of the neck of the spermathecæ has a pronounced constriction and enlargement (fig. 12), as in many Tubificidæ. Spermatophores have not been observed.

In the mature worm there are two large sperm-sacs and one

of varying ages the development of these organs can be traced, and the result has been diagrammatically represented in fig. 13. The spermatozoa are shed at an early stage of development into segment 10, and the anterior septum of this segment soon bulges out, forming a sac—the anterior sperm-sac (fig. 13, *a. sp. s.*). Later on this sperm-sac pushes its way across segment 9, through its anterior septum into segment 8. The hinder wall of segment 10 also bulges out, forming the posterior sperm-sac (fig. 13, *p. sp. s.*) The ova are shed into segment 11. The hinder septum of this segment forms the ovisac (fig. 13, *ov. s.*), which ultimately pierces as many as seven or eight septa behind it.[1] The posterior sperm-sac also enlarges, enters the ovisac, and grows back through five or six segments. It is within the space between the wall of the ovisac on the outside and the wall of the posterior sperm-sac within, that the blood-vessels run which supply nourishment to the ova (fig. 5, *v. ov.*); it is also, no doubt, through this space that the ova escape back again to the 11th segment when ripe.

The clitellum extends over segments 10—12, and part of segment 13.

Summary and Conclusions.

The chief characters of Vermiculus pilosus are therefore the following:

Four bundles to each segment of furcate setæ, generally three per bundle.

A dense covering of hair-like processes.

A vascular system, containing red blood, and composed of a dorsal and a ventral longitudinal vessel communicating by means of lateral vessels which branch on to the body-wall. The absence of hearts or commissural vessels. An elaborate system of unicellular valves in the longitudinal and transverse dorsal vessels.

[1] The ovisac pierces the septa at a point nearer to the dorsal blood-vessel than is represented in the diagram.

A brain deeply cleft in front, and a nerve-cord bearing muscular strands of considerable size.

A compact nephridium, the funnel of which is peculiarly modified.

A pair of testes in the 10th, and a pair of ovaries in the 11th segment.

Two short sperm-ducts, without prostate, opening into a median chamber, which itself opens to the exterior on the 11th segment by a large median pore. Oviducts rudimentary.

Two pear-shaped spermathecæ, opening by a common median ventral pore on the 10th segment.

An anterior and a posterior sperm-sac, and an ovisac.

A clitellum extending over the 10th, 11th, 12th, and part of the 13th segments.

Many of these characters place this little worm in a very isolated position. The dense covering of "sense-hairs," although perhaps of no great morphological importance, is quite unique amongst the Oligochæta. The absence of commissural vessels again distinguishes it, I believe, from all its allies, except the smallest and lowest, such as Æolosoma; nor is it usual among the Tubificidæ, to which Vermiculus is doubtless related, to find strong muscular strands on the nerve-cord.

As for the nephridium, the ciliated process of the funnel is no doubt of the same nature as the long ciliated processes on the nephridiostome of Nereis (3);[1] all such structures appear to be specialised processes of the funnel-cells themselves. The presence of cilia in special ampullæ, and their absence in the rest of the nephridial canal, is a character which may, I think, prove to be common to all the so-called Microdrili. Such ampullæ are certainly present in other Tubificids I have examined, and in the Enchytræids, to the nephridium of which latter the compact excretory organ of Vermiculus bears no little resemblance. Professor Vejdovsky (6) has described a Planarian, Microplana humicola, in which the nephridia

[1] I once observed in an Enchytræid long ciliated processes on the nephridiostome, exactly like those of Nereis above referred to.

terminate in flame-cells, while the canal itself is provided with "flames" at intervals along its course; it seems not improbable that the flame-like cilia of the nephridiostome of Vermiculus represent the "flame" of the terminal cell, and the cilia of the ampullæ represent the "flames" distributed along the course of the canal in the Planarian. Possibly the arrangement found in the large nephridia of the Earthworms, described by Benham (1), in which whole tracts are ciliated, is derived from some such system as we find in Vermiculus and the lower Oligochætes by the extension of the cilia over a great length of the canal.[1]

The late development of the median spermiducal chamber is another of those characters quite peculiar to our worm. What the function of this chamber may be it is difficult to conjecture; perhaps it acts as a sucker during copulation; the disposition of the muscles would favour this supposition. However, it must be noticed that besides the formation of the spermiducal chamber, the apertures of the genital organs themselves show a distinct tendency, as it were, to unite in the middle line. This is clearly seen in the case of the male pores, which come close to each other; but more especially in the case of the spermathecal pores, which become actually confluent. As a striking contrast, we may compare such a form as Heterochæta, in which, as described by Benham (2), the sperm-ducts and spermathecæ open above the ventral setæ!

The fact that Bothrioneuron, described by Stolc (5), possesses a median male pore might suggest a close relationship between the two worms, but they differ in other particulars most markedly from each other. The setæ, nervous system, and nephridia of Bothrioneuron are all very different from those of Vermiculus; it possesses commissural vessels, a prostate, a complicated system of genital setæ, and no spermathecæ.

On the whole, it must be concluded that Vermiculus stands

[1] Since this was written, Professor A. G. Bourne has in this Journal (vol. xxxvi, 1894, "On Moniligaster grandis") described somewhat similar undulating bundles of cilia, which, however, are attached at both ends, not hanging freely in the canal as the cilia do in the ampullæ described above.

very much by itself; the shape of its setæ, and above all the situation of its gonads, place it in the family Tubificidæ, but its more intimate relationships remain obscure for the present.

March 30th, 1894.

List of Works referred to.

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2. Benham, Dr. W. B. B.—"Notes on some Aquatic Oligochæta," 'Quart. Journ. Micr. Sci.,' xxxiii, 1891.

3. Goodrich, E. S.—"On a New Organ in the Lycoridea, &c.," 'Quart. Journ. Micr. Sci.,' xxxiv, 1893.

3a. Goodrich, E. S.—"Note on a New Oligochæte," 'Zool. Anz.,' xv, 1892.

4. Hesse, Dr. R.—"Beiträge zur Kenntniss des Baues der Enchytræiden," 'Zeitschr. f. wiss. Zool.,' vol. lvii, 1894.

5. Stolc, Dr. A.—"Monografie Ceskych Tubificidu," 'Abh. k. Böhm. Ges.,' 1888.

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EXPLANATION OF PLATES 26—28,

Illustrating Mr. E. S. Goodrich's paper, "On the Structure of Vermiculus pilosus."

List of Reference Letters.

a. sp. s. Anterior sperm-sac. *b. n.* Main body of the nephridium. *br.* Brain. *b. v.* Blood-vessel. *b. w.* Body-wall. *c.* Cuticle. *c. a.* Ciliated ampulla. *c. c.* Cœlomic corpuscle. *c. ep.* Cœlomic epithelium. *c. ext.* Canal to the exterior. *ci.* Cilia. *cl.* Clitellum. *c. m.* Circular muscles. *c. n.* Cell of the nephridium. *c. p.* Ciliated process. *cœl.* Cœlom. *d. v.* Dorsal longitudinal vessel. *ep.* Epidermis. *ep. cl.* Epidermis of clitellum. *ep. spth.* Internal lining of the spermatheca. *ex. ci.* External cilia. *fl.* Flame-like cilia. *g. c.* Ganglionic cell. *int.* Intestine. *l. d. s.* Left dorsal bundle of setæ. *l. d. v.* Lateral dorsal vessel. *l. l.* Lateral line. *l. m.* Longitudinal muscles. *l. v. s.* Left ventral bundle of setæ. *l. v. v.* Lateral ventral vessel. *m.* Mouth. *m. l. v. v.* Middle lateral ventral vessel. *m. n. c.* Muscles on the nerve-cord. *m. n. c. l.* Lateral strand of muscles. *m. n. c. m.* Median strand of muscles. *m. p. sp.* Median pore of the spermiducal chamber. *m. s.* Muscles of the septum. *n. c.* Nerve-cord. *n. f.* Nephridiostome. *nph. c.* Nephridial canal. *nph. p.* Nephridiopore. *œs.* Œsophagus. *ov.* Ovary. *ovd.* Oviduct. *ovs.* Ovisac. *pcl.* Palpocil or sense-hair. *p. l. v. v.* posterior lateral ventral vessel. *ph.* Pharynx. *pr.* Prostomium. *p. s. c.* Post-septal canal. *p. s. m.* Post-septal mass. *p. sp. s.* Posterior sperm-sac. *r. v. s.* Right ventral body of setæ. *set.* Seta. *sept.* Septum. *sp. p.* Spermiducal pore. *sp. ch.* Median spermiducal chamber. *sp. f.* Spermiducal funnel. *spth.* Spermatheca. *spth. p.* Spermathecal pore. *t.* Testis. *v.* Valve. *v. ov.* Vessel to ovisac. *v. v.* Ventral longitudinal vessel. *w. of sp.* Wall of sperm-duct. *w. of v.* Wall of blood-vessel.

Fig. 1.—Adult Vermiculus pilosus, drawn natural size.

Fig. 2.—View of the anterior part of the body, slightly twisted so as to display the dorsal and ventral setæ and the median genital apertures.

Fig. 3.—Enlarged view of a seta. Z. apoch. 4 mm., oc. 4, camera.

Fig. 4.—Small portion of the body-wall, drawn from the living to show the covering of hair-like processes. Z. apoch. 4 mm., oc. 4.

Fig. 5.—Semi-diagrammatic view of the vascular system from the dorsal surface; from the living.

Fig. 6.—View of the brain and anterior part of the alimentary canal; from the living.

FIG. 7.—Portion of a transverse section of the body-wall in the region of the lateral line. Z. apoch. 4 mm., oc. 4, camera.

FIG. 8.—Longitudinal section through the longitudinal dorsal vessel, passing rather to the side, so that the lumen does not appear continuous. Z., ob. D, oc. 4, camera.

FIG. 9.—Portion of the vascular system, showing the manner of communication between the lateral dorsal and the lateral ventral vessels; from the living.

FIG. 10.—Small portion of the dorsal blood system in the region of the 10th and 11th segments, greatly enlarged to show the valves; from the living. Z., oil imm. 2 mm., 4 oc.

FIG. 11.—Diagram of the three positions taken up by the valves: *a'*, when the flow is forwards; *b'*, to stop the flow backwards; and *c'*, when they are forced back.

FIG. 12.—Diagram representing the genital organs in situ; from the living and sections.

FIG. 13.—Diagram representing the development of the sperm-sacs and ovisac in an immature specimen, as seen in a solid longitudinal section; chiefly from sections.

FIG. 14.—Transverse section of the nerve-cord passing through a septum. Z., ob. D., oc. 3, camera.

FIG. 15.—Transverse section through a ganglionic region of the nerve-cord. Z., ob. D, oc. 3, camera.

FIG. 16.—Transverse section of the nerve-cord between two ganglia. Z., ob. D, oc. 3, camera.

FIG. 17.—Longitudinal section of the thick region of the sperm-duct. Z., ob. D, oc. 4, camera.

FIG. 18.—Longitudinal section of the narrow region of the sperm-duct. Z., ob. D, oc. 4, camera.

FIG. 19.—Section through the wall of the spermatheca. Z. apoch. 4 mm., oc. 4.

FIG. 20.—Transverse section of an adult worm passing through the median spermathecal pore. Z., ob. A, oc. 3, camera.

FIG. 21.—Tranverse section of a young worm passing through the spermathecæ. It has been necessary to combine two sections to show this clearly. Z., ob. A, oc. 3, camera.

FIG. 22.—Transverse section of an adult worm passing through the median spermiducal chamber and its pore. Z., ob. A., oc. 3, camera.

FIG. 23.—Transverse section of a young worm in the same region, showing the absence of a median chamber. It has been necessary to combine two sections. Z., ob. A, oc. 3, camera.

FIG. 24.—Longitudinal section through the median spermiducal chamber.

FIG. 25.—General view of a nephridium, seen from below; from the living. Z., ob. D, oc. 4.

FIG. 26.—View of the nephridial funnel from below; optical section from the living. Z. apoch. 4 mm., oc. 8.

FIG. 27.—View of the nephridial funnel from the side; optical section from the living.

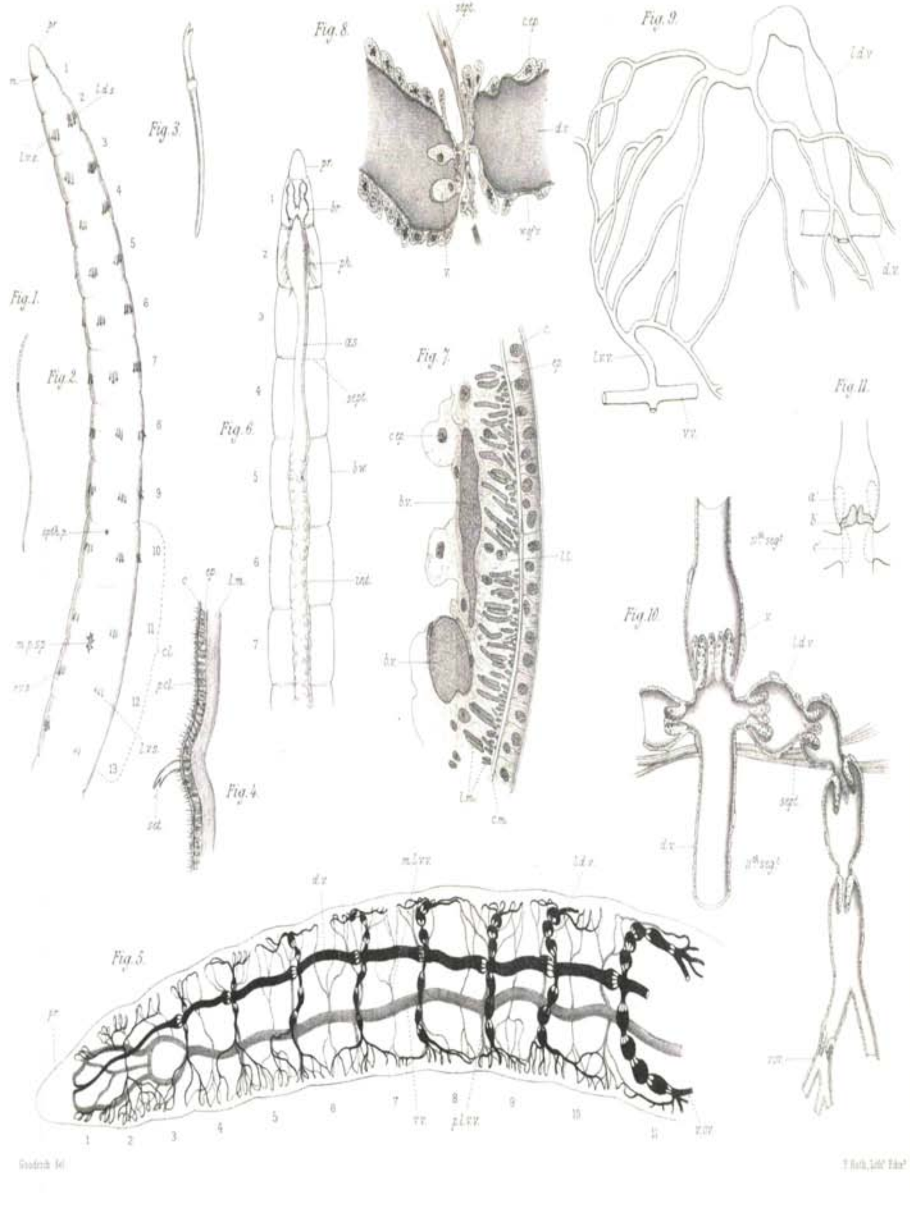
FIG. 28.—View of the post-septal mass of the nephridium, reaching through the septum to the funnel; from the living. So far diagrammatic that the whole course of the canal is represented, although it could not be followed out for certain in all its parts. Z., ob. D, oc. 8.

FIG. 29.—Section through the nephridiostome and post-septal canal, showing the nuclei of the funnel cells. Z. apoch. 4 mm. oc. 4, camera.

FIG. 30.—Small portion of section through the body of the nephridium, showing the canal and the nuclei of the nephridial cells. Z. apoch. 4 mm., oc. 4, camera.

FIG. 31.—Small portion of the living nephridium, showing the ciliated ampullæ. Z., oil imm. 2 mm. oc. 4.

FIG. 32.—Main body of the nephridium attached to the ventral longitudinal blood-vessel; from the living. Z. apoch. 4 mm., oc. 4.



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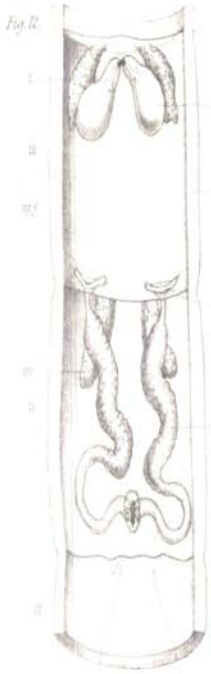
Fig. 12.


Fig. 14.


Fig. 20.


Fig. 21.


Fig. 22.


Fig. 15.


Fig. 23.


Fig. 16.


Fig. 17.


Fig. 24.


Fig. 18.

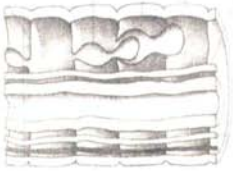
Fig. 13.


Fig. 19.

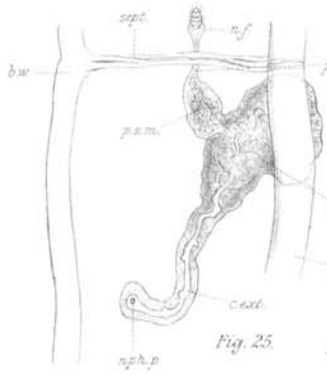

Fig. 25.

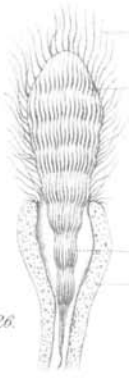

Fig. 26.

Fig. 28.

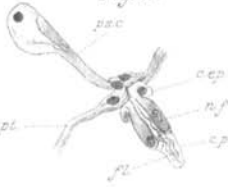

Fig. 29.

Fig. 27.

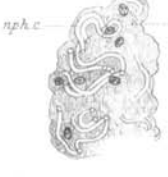

Fig. 30.

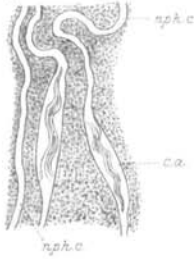

Fig. 31.

Fig. 32.