The Anatomy of Oncholaimus vulgaris, Bast., with Notes on two Parasitic Nematodes.

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With Plates 7—9.

I BEGAN this work with the intention of trying to ascertain if any light could be thrown on the comparative morphology of the cœlom and Nephridia by the study of Nematodes. The uncertainty as to the true nature of the body-spaces in this class is well known. No one has been sufficiently daring to identify any space in Nematodes with the cœlom. The space between the body wall and the gut is generally admitted to be a schizœle.

Ray Lankester (**11**, p. 9) writes: "In some few groups of Cœlomocœla the cœloms have remained small, and limited to the character of simple gonocœls. This seems to be the case in the Nemertina, the Planarians, and other Platyhelmia." The Nematodes are not mentioned, since nothing is definitely known in regard to them.

Thanks largely to the work of Jägerskiöld (**9**), we know that the excretory organs of Nematodes are unicellular, with intra-cellular canals, and, physiologically at least, interchangeable with skin glands, but they have not yet been homologised with Nephridia. Ray Lankester, in the same article (**11**, p. 14), writes: "True Nephridia are only found in the

Platyhelmia, Nemertines, Rotifers, Chætopods, and embryonic Mollusca."

In all text-books the Nematodes are placed in a very isolated position, and no attempt is made to compare them with other groups. This, I believe, is largely due to the fact that most work has been done on parasitic forms, and that these have been held up as the types of the group. But even although the great majority of a group were parasitic, it is to the free-living minority we should go for the type, and not to the secondarily modified majority.

I therefore selected for study a free form Oncholaimus vulgaris (Bast.), a parasitic form Ascaris clavata (Rud.) to compare with it, and an embryo of a parasite to connect the two, if possible.

No member of the genus Oncholaimus has been investigated by modern methods. I therefore have gone thoroughly into its anatomy.

In regard to A. clavata the alimentary and excretory systems have been fully described by Jägerskiöld (**9**). I have, therefore, limited my work to the reproductive system, while in the embryo I have confined myself to the excretory organs.

The specimens were all obtained at St. Andrews, and a large part of the practical work was done at the Gatty Marine Laboratory there. My thanks are due to Professor McIntosh for the use of the laboratory and for his kind assistance in many other respects.

Oncholaimus Vulgaris (Bast.)[1].

Measurements:

Male	Length	10—15 mm.
,,	Breadth (max.)	·135—·221 mm.
Female	Length	12—15 mm.
,,	Breadth	·18—·225 mm.

The body is elongated and cylindrical, tapering very slightly and slowly to the anterior extremity (Pl. 7, figs. 1

[1] Bastian (**2**).

and 2), which is square in profile, rapidly to the posterior, which forms a rounded and rather blunt cone (Pl. 7, fig. 5).

The animal is quite translucent; the only pigment present is in the intestinal wall, golden-brown granules arranged in patterns, which produce a tesselated appearance, and are sometimes sufficiently abundant to cause the animal to appear of a brown colour, even to the naked eye.

The mouth is terminal, and is surrounded by three very flat papillæ (Pl. 7, fig. 2, *a*).

Immediately behind the latter is a ring of short setæ (ibid., *b*), while smaller hairs are scattered over the anterior portion of the body, and arranged along the dorsal (*c*) and ventral lines.

The anus (Pl. 7, fig. 5, *cl. ap.*) is subterminal, ·153 mm. from the tail, in the midventral line.

The cellular character of the longitudinal lines (Pl. 7, fig. 1, MDL, LC, MVL) and the striation of the muscle fields (Pl. 7, fig. 5) are obvious. Prominent objects also are the cup-shaped pharynx, with its three teeth (Pl. 7, fig. 2); the œsophagus (Pl. 7, fig. 1); surrounded by the œsophageal ring and collar of ganglion-cells (Pl. 7, fig. 1); the pigmented intestine; the hyaline ducts of the tail glands filling up the post-anal region (Pl. 7, fig. 5); the ventral gland in the male, opening ·112 mm. in front of the nerve-ring; and the large cells of the body space which generally lie in the submedian lines (Pl. 7, fig. 1, *a*).

The gonads occupy a large part of the body in either sex, but are more conspicuous in the female; the large chalk-white ova (text-fig. 2, *ov.*, p. 124) in the uterus can be distinguished even with the naked eye. Under a low power the central vulva(*vu.*) surrounded by the cellular mass of vulvar and vaginal glands and the elongated ovaries (*ovr.*) running alongside the uteri can be seen.

In the male the gonads appear as a fairly uniform cellular cylinder opening posteriorly in common with the gut. Here also are to be found the sabre-shaped spicules (Pl. 7, fig. 5, *sp.*) with their central accessory piece.

It is convenient in describing the animal to divide the body according to the regions of the alimentary canal. I shall, therefore, frequently refer to pharyngeal, œsophageal, intestinal, rectal, and post-anal regions. The œsophageal region it is convenient to divide into anterior œsophageal in front of the nerve-ring, posterior œsophageal behind it.

Habitat.—Oncholaimus vulgaris is very common under stones between tide-marks. It is essentially a sociable animal, twenty to thirty being often found together under one stone; it is not usual to find individuals isolated.

The Cuticle.

The cuticle forms a continuous layer over the whole body, as in all Nematodes, and passes in through all the apertures, mouth, anus, cloacal opening, and vulva to become continuous with the cuticular linings of the cavities into which these apertures open.

It is a structureless membrane ·00215 mm. thick, and with certain stains shows a division into two layers (Pl. 7, fig. 15). Hairs occur in certain localities: (1) in a circle round the head at the base of the lips; (2) scattered over the anterior œsophageal region, and (3) arranged along the mid-dorsal and mid-ventral lines (Pl. 7, figs. 1 and 2). They are more abundant in the dorsal than in the ventral line, and in the œsophageal than in other regions of the body. The numbers vary considerably in different individuals, but an average would give about forty for the dorsal and twenty for the ventral line. In the female several occur in front of and behind the vulva.

Each hair is formed by a projection of cuticle, while at the base the cuticle is perforated by a minute canal containing a core of protoplasm passing out from the epidermis. The hairs along the median lines spring from the centre of shallow depressions in the cuticle.

The canals at the roots are, as pointed out by Jägerskiöld (**10**), identical with the integumental pores of Bastian (**2**).

In prepared specimens the hairs are very frequently broken off.

The cuticle is also perforated by the openings of the ventral and tail glands (Pl. 7, fig. 5, *tg.ap.*) and of the glands of the lateral lines.

From the base of the lips four flattened pouches (Pl. 7, fig. 2, *e*) extend outward and backward in the substance of the cuticle as far as the oral circlet of hairs. They are semicircular in shape, the base directed toward the mouth, the arc away from it. At the base of the lips the pouches are continuous with each other, and here the four pore-like openings to the exterior are situated.

The pouches contain a number of coarse granules with amphophil staining reaction. I have not been able to trace any connection between these granules and the epidermal protoplasm.

From the nature of the contents I believe the function of these structures to be glandular. They appear to correspond, not with the "Seitenorgane" of other forms, but with the circumoral "patterns" and glands described by De Man in O. fuscus (**12**).

The Epidermis and Nervous System.

It is hardly possible to separate these two. The only structure which is definitely specialised as nervous is the circumœsophageal ring; other structures which are nervous in function, such as the ganglionic mass which surrounds the ring and the anal ganglion, shade off into the general epidermis. I shall, however, describe the latter first.

The epidermis consists of four lines of cells—the longitudinal lines (Pl. 7, fig. 3, MDL, MVL, LL), which run from one end of the body to the other, and which project into and divide the muscular layer of the body wall, and of a thin layer of protoplasm—the subcuticula or hypodermis (Pl. 7, fig. 3, *sc.*), which connects these four lines, and lies between the cuticle and the muscular layer. This consists merely of an outgrowth of protoplasm from the cells of the longitudinal lines and contains no nuclei. The longitudinal lines are, in fact, situations where the epidermal nuclei are aggregated, and where the nutrition and general government of the entire epidermis is carried on.

I have described the lines as cellular, but although cell-walls do occur, they are often not complete, the protoplasm of one cell being at one point continuous with that of another, or several nuclei may appear in one mass of protoplasm, and as no cell-walls are to be found in the subcuticula, all the cells whose protoplasm is continuous therewith are presumably in this way continuous with one another, although this layer is so thin that divisions might exist in it but be undemonstrable.

The four longitudinal lines lie, as usual, one mid-dorsal, one mid-ventral, and two lateral, dividing a transverse section of the body-wall into four quadrants. They extend, as I have stated, from one end of the body to the other. Their absolute and relative breadth varies in the different regions. In the œsophageal regions all four lines are of fairly equal breadth, and occupy each about one fourteenth of the circumference, each showing about four cells in transverse section.

In the intestinal region (Pl. 8, fig. 24) the median lines decrease in size, showing only one or two cells in section; the lateral lines, on the other hand, are considerably broader and occupy each about one eighth of the circumference. Opposite the gonads the lines are very much flattened from pressure. Behind the anus they are of approximately equal breadth, and each occupies one eighth of the circumference.

Two types of cells occur—viz. (1) cells whose shape varies from square to oval, and whose greatest diameter varies from 0·0086 to 0·0107 mm. The protoplasm is fairly abundant and is non-granular. The nucleus, spherical or oval, measures from 0·0043 to 0·00538 mm., and has a well-marked nuclear membrane containing numerous minute chromatin granules and a nucleolus (Pl. 7, fig. 9). (2) Rather smaller cells, 0·0043 mm., varying in shape, but more generally circular in sections, the protoplasm scanty, nucleus spherical or oval, 0·0032 mm., and staining diffusely with basic dyes (Pl. 7, fig. 8, T_2). In addition the lateral lines contain gland-cells, but these will be described separately. Type 1 is most common.

Where there is not much pressure from the bulk of internal organs, as in the œsophageal and post-anal regions, the cells project into the space between the body-wall and gut. Opposite the gonads, however, they are very much flattened. In the posterior œsophageal region Type 1 cells often show vacuolation; while in the median lines in the intestinal region they are generally triangular on section, the apex directed to the cuticle, and the protoplasm shows fibrillæ passing in from the subcuticula to surround the nucleus.

The submedian lines (Pl. 7, fig. 13, *s.m.l.*) are not epidermal, but are merely mesodermal partitions between groups of muscle-cells.

Jägerskiöld (**10**) describes epidermal sub-median lines in neighbourhood of the nerve-ring in Cylicolaimus magnus; nothing corresponding is present in our animal. In Thoracostoma acuticaudatum he mentions sub-median lines, but does not make it clear whether they are cellular. The subcuticula is an excessively fine sheet of protoplasm; in fact, in places it is so fine that it is impossible to demonstrate it. It is continuous with protoplasm of the cells at the margin of the longitudinal lines.

De Man (**12**) in reference to the genus Oncholaimus and more particularly to the species O. fuscus, describes the subcuticula as richly cellular and granular. Neither of these statements applies to O. vulgaris.

I have used the term "epidermis" freely. I see no reason why this structure in Nematodes should be veiled under terms such as "hypodermis," etc., Wandolleck (**15**), Jammes (**7**), and Hamann (**4**), are agreed as to its ectodermal origin. The only authority who maintains its meso-dermal nature is Zur Strassen (**14**).

The nervous system consists of the circumœsophageal ring and ganglionic collar and of the ganglion in the wall of the rectum or cloaca. These are the only structures which are in any way separated from the general epidermis.

The nerve-ring (Pl. 7, fig. 4, *nr*) lies at the junction of the first and second thirds of the œsophagus, and consists of fine fibrillæ united into a bundle. It contains a few nuclei, 4 to 6, which resemble those of the Type 1 cells of the epiderm, but are somewhat smaller. A sheath of fine connective tissue derived from the fibrillar stroma which here fills the space between the body-wall and the gut encloses the ring. The sheath stains more deeply than the nerve-fibrils. Processes which in places can be shown to be hollow pass off from the sheath, and join the connective tissue surrounding the cells of the collar and the muscle-cells. I have in a few instances found nerve-fibrils in these hollow processes, but they are so fine that it is not possible to follow them for any distance. They probably connect the ring with the collar-cells and the longitudinal lines.

The circumœsophageal collar (Pl. 7, figs. 1 and 3) extends from nearly the commencement of the œsophagus to a short distance behind the nerve-ring, and is composed of cells growing in from the longitudinal lines. It completely fills the space between the body-wall and œsophagus. In preparations of the entire animal it can be clearly seen as a compact cylinder of cells.

The cells are of three types, viz. cells of the same character as Types 1 and 2 of the longitudinal lines, and in addition large oval cells (Pl. 7, fig. 3, bc^1) ·016 mm. in diameter, with abundant protoplasm which may show very faint, irregular, basophile markings, the nucleus ·0064 mm. with a definite nuclear membrane, finely granular acidophil contents, the chromatin aggregated into a large spherical pseudo nucleolus. These cells are, I believe, identical with the basophil cells which occur in the space between the body-wall and the gut in other regions of the body; they differ from them, however, in some points, and as I can only speculate in regard to their functions, I shall discuss them under the section dealing with this space and its contents, rather than include them in the nervous system, to which they may not belong.

Yet another type of cell, the coarsely granular acidophil, occurs among the collar-cells as well as elsewhere, but is certainly not nervous.

The fibrillar groundwork binds together all these various units.

De Man (**12**) for the genus Oncholaimus describes numerous cells lying in the body cavity in front of and behind the nerve-ring.

Bastian (**2**) also mentions their presence.

Jägerskiöld (**10**) for Cylicolaimus magnus and Thoracostoma acuticaudatum describes and figures what is evidently an œsophageal collar; the cells shown in his drawings are, however, not so numerous as those in our subject. He frankly states that he has not examined the matter fully, and he does not connect them in any way with the nervous system, but considers them to be the same as the phagocytic "büschelförmige organ" described by himself, Nassonow (**13**), and others in parasitic forms. This opinion, which I believe to be an error, accounts for the fact that he also considers them to be identical with the "floating gland-cells" of Bastian and the "fat cells" of De Man. These cells occur isolated in the "body cavity" through all regions of the body, and are entirely different from this localised compact structure.

In parasitic Nematodes also a cellular investment to the nerve-ring is found; *e. g.* Hamann describes and figures it in Lecanocephalus (**5**) as connected with all four longitudinal lines, and the same holds good for the embryo (A. capsularia) which I shall describe later.

The anal and cloacal ganglia (Pl. 7, fig. 6, *ag.*) are also formed by ingrowths of cells from all four longitudinal lines. Shortly before reaching the level of the anus in the female, or of the cloacal opening in the male, cells begin to project inwards from the dorsal and the two lateral lines, passing towards the dorsal wall of the anal canal or cloaca. Here they form a layer one cell deep, lying on the cuticular lining of the space, and continuous at the sides with the protoplasmic wall. Since the latter is continuous with the cells of the ventral line, this line may also be presumed to take part in the formation of the ganglion. The cells are of Type 1.

The only sensory organs to be found are the hairs above described. They are, as above noted, specially aggregated on the head and in front of and behind the genital apertures.

To sum up, the nervous system is very imperfectly differentiated. The circumœsophageal ring and collar form the brain of the animal; the longitudinal lines, and possibly the subcuticula as well, form the conducting paths, both motor and sensory, in the latter capacity receiving stimuli from the sensory hairs. I have not found processes from the muscle-cells to the lines such as occur in other forms; the motor mechanism is, therefore, obscure. The anal and cloacal ganglia doubtless control defæcation and copulation.

The Excretory and Glandular Apparatus.

Three sets of glands are included in this system:

(1) The single excretory ventral gland.

(2) The series of glands of the lateral lines.

(3) The three tail glands.

These glands resemble each other in being all unicellular. The ventral and tail glands have ducts of considerable length, formed by outgrowths of the protoplasm of the cells; the glands of the lateral lines have no ducts but open directly through the cuticle.

The ventral gland[1] occurs in males and immature females; it is absent in mature members of the latter sex. It is composed of one large cell, which lies in the body cavity immediately ventral to one of the lateral lines, in males on

[1] Golowin (3) has described this gland in O. vulgaris. I have not been able to procure a copy of his paper, which is, I presume, in Russian. He regards the three "Keimdrüsen" of the tail as of the same nature as this gland.

the right side, in immature females on the left. The cell body, which forms the secreting portion of the gland, is found at a level a little behind the commencement of the intestine; from it a duct runs forward to the level of the nerve-ring, and bending towards the midline, opens by a minute pore in the median ventral line, ·112 mm. in front of the ring.

The cell (Pl. 7, fig. 12) is of a flattened oval shape. The nucleus is central, and contains one large pseudo-nucleolus. The protoplasm is hollowed out by large vacuoles, which in some of the specimens contain numerous large basophil granules arranged round their periphery.

The duct (Pl. 7, fig. 4, *vgd.*; Pl. 7, fig. 13) is narrow and cylindrical. It has a fine protoplasmic wall, which is apparently an outgrowth from the gland-cell. The contents are homogeneous, and stain with basic dyes. Near its termination the wall of the duct becomes continuous with the cells of the median ventral line, which separate, continuing the lumen to the pore in the cuticle.

The glands of the lateral lines lie in series at the margins of the lateral lines. They are found as far forward as the posterior limit of the œsophageal collar and as far backward as the commencement of the rectum.

They consist of large, pear-shaped cells (Pl. 7, fig. 7), with the pointed ends directed to the cuticle. The outlines are sharply marked off from the other cells of the lateral lines.

Each cell is filled with large rounded granules, with amphophil staining reaction. The nucleus lies toward the rounded extremity, has a nuclear membrane, chromatin granules, and true nucleolus. From the pointed end a minute duct leads through the cuticle, filled with a hyaline substance which frequently projects beyond the surface as a small spike. The glands are identical with those described by Jägerskiöld (**10**) in Cylicolaimus magnus.

The tail glands are three in number. In preparations of the entire animal they are exceedingly conspicuous as hyaline, club-shaped masses, extending from the extremity to some distance in front of the anus (Pl. 7, fig. 5, *tgd.*;

Pl. 7, fig. 6), the middle gland extending further forward than the other two.

In the posterior intestinal region they lie ventral to the intestine, in males in the grooves between the intestine and the ductus. They pass on either side of the rectum, and behind the level of the anus occupy almost the entire space within the muscular wall. They open by a single pore on the tip of the tail. On section, the protoplasm shows a highly vacuolated appearance, the contents of the vacuoles staining very uniformly, suggesting a colloid. The nucleus resembles that of the ventral gland.

The duct has a very fine membranous wall; the contents are basophil, sometimes acidophil. The three ducts remain separate until a point immediately before the external pore. There is, however, only a single such pore.

Muscle of the Body Wall.

The muscular layer is the thickest part of the body wall. The cells which compose it are arranged in eight longitudinal fields, four on each side, dorsal, dorsolateral, ventrolateral, and ventral (Pl. 7, fig. 3, DM, DLM, VLM, VM), separated from each other by the four epidermal longitudinal lines and by the four submedian lines. The latter, as I have stated above, are not epidermal in O. vulgaris, but are merely mesodermal partitions.

The entire eight fields extend forward to the anterior extremity; only four, the two dorsolateral and the two ventrolateral, reach the posterior, the two dorsal and the two ventral ending at the level of the anus. In transverse section the fields at the different levels show on the average the following number of cells:

	Buccal Region.	Œsophageal.	Intestinal.	Post Anal.
Dorsal	1	2	1–2	0
Dorsolateral	4	7	13	7
Ventrolateral	6	7	14	6
Ventral	2–4	6	6	0

The muscle-cells are of the usual Nematode type. I have not been able to detect any of those fibre-like projections from the undifferentiated portions of the cells to the longitudinal lines which occur in other forms, and no doubt act as nerves.

The Body Space.

The interval between the body-wall and the gut is, in sections, found to be occupied by a substance the characters of which vary in different regions. The gonads, glands, etc., are imbedded in it.

As the subject is a somewhat contentious one, I shall first describe the substance in question and then discuss its nature.

It extends through almost the entire length of the body; the only regions in which it is impossible to prove its presence are at the level of the pharynx and behind the anus. It naturally varies in development according to the space to be filled, is most abundant around the termination of the œsophagus (Pl. 7, fig. 13) and around the rectum, where a considerable interval occurs between the alimentary tract and the body wall. It is also fairly abundant where a large organ such as the ovarian cæcum or testis ends.

In that part of the œsophageal region which lies behind the nerve-collar it forms a fibrillar network (Pl. 7, figs. 8, 10, and 13 *m.*) The fibrillæ are tortuous, but their general direction is from the muscular layer inward to the œsophagus. In places the meshes between the fibrils are circular, as if they had been occupied by globules of some substance. Over the outer surface of the œsophagus the fibrils interlace, forming an irregular membrane, while the same occurs over the internal surface of the cells of the body-wall, muscular and epidermal, the interwoven fibrils applying themselves closely to these cells, or passing in between the muscle fields at the submedian lines, and to a lesser extent between individual muscle-cells. At the submedian lines, indeed, they reach the epidermis.

They stain intensely with nigrosin, and also take up eosin, but with less avidity.

Nuclei occur in the tissue (Pl. 7, fig. 8, *mn.*), but are not common. They generally lie opposite the longitudinal lines, but also occur opposite the muscle fields. They resemble the nuclei of the Type 2 epidermal cells, staining diffusely with basic dyes, measure ·00215 to ·00322 mm. in diameter—that is, rather smaller than the nuclei of Type 2. I have not been able to find any protoplasm surrounding. They are completely isolated from the epidermis by the fibrils.

In the region of the collar, owing to the presence of the ganglionic cells, the tissue is not so much developed (Pl. 7, figs. 3 and 4). Its characteristics are the same as already described, but as it forms a stroma for the collar cells, the general direction of the fibrils is rather parallel with the body-surface than radial, since these cells are growing in from the epidermal lines across the muscle fields.

In front of the collar the tissue is still less developed, but other tissues, such as the body-wall, are also somewhat meagre as they approach the pharyngeal region.

I believe that this fibrillar network has a very definite function—viz. that of connecting the outer surface of the œsophagus with the body-wall and affording a surface of origin for the œsophageal muscle, so that when this contracts the entire value of the contraction is devoted to widening the lumen. In parasitic forms a similar surface is provided by the thick cuticle which surrounds the œsophagus.

Throughout the greater part of the intestinal region, owing to the close approximation of the gut and body-wall, and to the presence of the gonads, the space is narrow. The substance filling it is best studied in the interval, triangular in cross section, between the gut, body-wall, and gonad tube, or where the gonad tubes end, but it must not be imagined that it is confined to these regions, since it forms a complete, although narrow, cylindrical covering for the gut.

In sections through this region stained with thionin and eosin (Pl. 7, figs. 14, 15) a dull-pink hyaline ground-work occurs with a very fine, more intense pink, granulation. The very fine, obscure fibrillation which is found in the protoplasm of the epidermis or of the gonad tube-wall is not present.

In sections stained with nigrosin and in some stained with eosin a few fibrillæ can be detected. They are, however, much finer than those of the œsophageal region, and strongly resemble fibrin filaments.

Nuclei (ibid., *mn.*) occur in this matrix identical with the nuclei in the œsophageal region—·00215 to ·00322 mm. in diameter. Around them is sometimes a thin film of protoplasm which stains more distinctly than the matrix, but which has not a sharp line of demarcation from it. It can be demonstrated that these nuclei have no connection with either epidermal or muscular cells, with gut or gonads, or with either of the types of cell which will be described later which lie in the body-space. They are often to be found lying completely isolated and free in the matrix.

At the commencement of the intestine the œsophageal fibrillar network does not end abruptly, but the fibrillæ become gradually more and more scanty.

In this situation, and near the termination of the intestine, muscular fibres traverse the space, running almost longitudinally. They are passing very obliquely from the body-wall to the gut.

The interval between the narrow rectum and the body-wall is considerable, but here the connective tissue is largely replaced by muscular fibres and by the ingrowth of epidermal cells to form the anal ganglion. There is, however, a basis of fine fibrils.

In the post-anal region also the epidermal cells project inward to such an extent that it is difficult to say how much of the fine tissue surrounding the duct of the tail glands is epidermal and how much, if any, is mesodermal.

Two types of cell occur imbedded in this substance:

(1) The coarsely granular acidophil cell (Pl. 7, fig. 3), oval in outline, maximum diameter ·01076 mm. with a distinct cellular membrane. The protoplasm does not stain, but contains numerous large spherical acidophil granules. The nucleus is central, and stains rather diffusely, although it shows some granulation (chromatin). These cells occur most

frequently opposite the epidermal and submedian lines, but also opposite the muscle fields. They are to be found throughout the entire length of the body with the exception of the pharyngeal region.

(2) Rather flattened cells (Pl. 7, fig. 10, *bc*²) generally crescent-shaped in transverse sections of the animal, owing to compression between the gut and the body-wall. Maximum diameter, ·02152 mm. The protoplasm contains a basophil substance. The nucleus is more or less spherical, has a nuclear membrane, and finely granular acidophil contents. The chromatin is aggregated into a large spherical pseudo-nucleolus.

These are the cells referred to above as possibly identical with the third type of cell in the collar. They differ from this type, however, in the fact that the basophil markings in the protoplasm are much more extensive and constant, and that the material filling the nucleus is definitely acidophil, not amphophil.

They occur most commonly opposite the submedian lines, but also opposite the muscle fields. Commencing at the posterior limit of the collar, they are found as far back as the rectum. As to function, they do not appear to be phagocytic; they are possibly nervous.

The only previous reference to an organised tissue filling the body space in Nematodes is on the part of von Linstow (**11** *a*), who describes a "plasma cylinder" surrounding the gut in Thoracostoma denticaudatum (Schn.) and Enoplus edentatus (v. Linst.) "von dem dorsal und ventral je zwei Leisten ausstrahlen." His figures, however, show no nuclei in this "cylinder." Jägerskiöld (**10**) for Cylicolaimus magnus writes: "Hie und da findet sich zwischen dem Darme und der Muskulatur eine ganz homogene, bisweilen sich stärkfärbende Schicht. Ich kann sie nur als eine Art coagulierter Flussigkeit deuten, denn alle Kerne fehlen. Vielleicht ist es sogar nicht allzu gewagt zu vermuten dass diese Flüssigkeit, die, wie angedeutet wurde, nicht überall oder gar immer vorhanden ist, nur als folge kräftigen Ergreifens mit der Pincette oder dergleichen kleinerer Verletzungen exsudiert worden. Denn dass die Thiere normalerweise eine freiströmende Leibes flüssigkeit zeigen, habe ich, wie schon erwähnt, nie bemerkt." He suggests that v. Linstow's "plasma cylinder" is such a coagulated fluid, the "leisten" the submedian lines. As mentioned above, however, he describes the fibrillar stroma supporting the collar, but he apparently has not observed that it extends beyond the limits of the cellular collar—if it does so in Cylicolaimus magnus, or that there are any nuclei present apart from those of the collar cells. He does not attach any morphological importance to it.

To commence, then, I may repeat that there is no doubt that the body cavity in the œsophageal region is occupied by a nucleated fibrillar stroma.

The nature of the substance filling the rest of the body cavity is debatable.

There are three views which may be taken in regard to it—

(1) That it is a pathological exudate coagulated by the fixing fluid.

(2) That it is a physiological body cavity fluid, coagulated in the same way, and containing cells.

(3) That it is a mesenchyme tissue of rather low organisation.

(1) This is the view taken by Jägerskiöld, and his reasons for it have been quoted above. But in dealing with specimens preparing for sectioning I have never, until they were securely fixed, used any coarser instrument than a camel-hair brush, so that I can see no reason why a pathological exudate should be present.

It is, of course, not at all necessary to suppose that C. magnus and O. vulgaris are identical in this respect; but as they resemble each other very markedly in other points, it would be natural to expect that they should also resemble each other in this highly important morphological point.

Jägerskiöld states that the substance in question is only present in certain localities, and that it is non-nucleated. I have found it present in almost every region of the body and continuous, and it contains nuclei proper to itself.

(2 and 3) The substance when stained with eosin has a

certain resemblance to a coagulated albuminous fluid, but it should be contrasted with, e. g., the cœlomic fluid of annelids, as seen in section. The latter, if stained with nigrosin, appears as an exceedingly loose reticulum of very fine fibrils, which do not stain very intensely; the former, in some places, shows a very fine fibrillation, with a homogeneous background, in others stains intensely and evenly. I would not, however, lay much stress on this, since I know of no test which would enable us with the microscope to differentiate a coagulum from a lowly organised jelly. On the other hand, a coagulum formed in a fluid ought to contract, and not completely fill the space occupied by the fluid; the substance in question completely fills the space, while the thickness of the walls lining the space forbids the idea that they might have contracted on a loose coagulum.

The presence of nuclei and their character is the strongest argument in favour of the third view. Any nuclei occurring in a fluid must belong to floating cells. Such cells would probably be amœboid, and would almost certainly have a reasonable amount of protoplasm and definite cell outlines. The nuclei which I have found, on the contrary, are either entirely naked or have a very fine pellicle of protoplasm, which shades off into the surrounding matrix. This, I think, suggests that they are connective-tissue nuclei rather than the nuclei of wandering cells. They are also identical with the nuclei of the stroma in the œsophageal region.

For these reasons I would put forward the view that the body cavity is filled by a mesenchyne, which in the œsophageal region takes the form of a nucleated fibrillar network in the regions behind the œsophagus of a jelly-like substance, also nucleated. The reason for the difference in character of the tissue in the œsophageal and other regions is, that in the former it has a special function, which I have explained above. At the same time, I put this view forward only tentatively. It would be rash to speak dogmatically on so important a point without having thoroughly investigated a number of allied forms.

ALIMENTARY SYSTEM.

The alimentary system is divided into pharynx or buccal cavity, œsophagus, intestine, rectum, and cloaca in the male, anal canal in the female.

The pharynx (Pl. 7 , fig. 2, *ph.*) is cup-shaped, narrowing at its hinder extremity ·085 mm. long, ·034 mm. in diameter.

The mouth is surrounded by the diaphragm-like ring of the lips. In life the lips are in constant motion.

The cavity of the pharynx is shamrock-shaped in transverse section. It has a cuticular lining, and from this lining there project into it three large teeth (ibid., *d.*) composed of the same substance, one lying in the dorsal line, the other two subventral. At the tips of these teeth are situated the openings of the œsophageal glands. Outside the cuticle is a fine membrane connected with the cells of the longitudinal lines.

The œsophagus (Pl. 7, fig. 1, *oes.*) is 1·3 mm. in length. Its general shape is that of an heraldic club. In diameter it measures, at its commencement, ·0525 mm., at the level of the nerve-ring the same, and at its broadest part posteriorly ·0862 mm.

The walls are thick and muscular, the direction of the fibres radial. When at rest the internal surfaces are in apposition and the lumen appears in cross section triradiate—one radius in the midventral line, the other two subdorsal. There is a cuticular lining considerably finer than that of the pharynx.

The organ is essentially a strong suction pump, since the radial muscle-fibres in contracting must open out the lumen with considerable force. This appears a somewhat anomalous organ for a free-living form.

The œsophageal glands occur in the posterior quarter of the organ, as canals ramifying in the muscular substance. They unite to form the ducts, which run forward and open into the pharynx at the tips of the teeth.

The only evidence of a secreting epithelium is to be found in the presence of cells with finely granular protoplasm in the lumen of the ramifying canals. The lumen also contains numerous sharp spherical granules which stain intensely with acid dyes.

The ducts (Pl. 7, figs. 3–4, *oes. d.*) also lie in the muscular wall, alternating with the radii of the œsophageal lumen, one dorsal, two sub-ventral. They are elliptical in cross section, and have a very fine protoplasmic lining. They also contain the same granular material.

On leaving the œsophagus, the ducts lie along the pharynx, external to the cuticle, between two layers of the membrane referred to above. This membrane also supplies them with a lining as they pass up the centre of the teeth to their openings.

The intestine is about 11·5 mm. in length, cylindrical, except where it is compressed by the reproductive organs. In the living animal it has a tesselated appearance from the patterns formed by numerous golden-brown globules contained in its wall.

The wall is formed of columnar epithelium, from twenty-four to thirty cells occurring in a transverse section. The cells vary in depth from 0·015 mm. near the commencement, to 0·008 mm. near the termination. Their protoplasm does not stain, and contains the golden-brown globules referred to above. In certain of the cells numerous coarse acidophil granules occur, strongly resembling those of the coarsely granular acidophil cells of the body space, but, on the average, slightly smaller. The cells containing these granules are distributed in what appears to be an entirely capricious manner, generally wedged in between cells entirely free from granules.

I attempted to discover if there was any relation between these cells and the granular cells of the body space, but was unable to find any. The two kinds of cells do not occur in apposition, or even, as a rule, in close proximity, and there is no correspondence between the frequency of occurrence of the two in different animals or in different regions of the same animal. As to the nature of the granules there is no clear evidence. If they represented digested food in the process of absorption, a more uniform distribution should occur. They are probably either a digestive secretion produced in cells which, although specialised, show no other signs of specialisation, or excretory. There is no sign of a basement membrane external to the epithelium.

The contents are very meagre, apparently portions of small Algæ, but one fact is very striking—viz. the presence in the adult female of large masses of spermatozoa, which have found their way in through the gonenteric canals.

The rectum is a short tube leading from the intestine to the anal canal or cloaca. Its width, including walls, is 0·016 mm. The wall has an outer layer of circular muscle-fibre and an internal epithelium, while ganglion-cells which have grown in from the longitudinal lines are to be found on the dorsal surface. It terminates abruptly on joining the cloaca or anal canal. The former I shall describe with the male reproductive organs; the latter is a very short invagination of epidermis with cuticle, in the dorsal wall of which the anal ganglion lies.

Male Reproductive Organs.

The male reproductive organs (text-fig. 1) consist of two testes (*at.*, *pt.*), an anterior and a posterior, lying in two cavities, the testicular regions of the reproductive tubes (*atr.*, *ptr.*). The testicular regions open into a single ductus ejaculatorius (*de.*), which unites with the rectum to form the cloaca (*cl.*). The anterior testicular region runs in a straight line backward into the ductus; the posterior, on the other hand, lies along the side of this structure, and it is at its anterior extremity that it opens into it.

The symmetry, it may be assumed, was originally bilateral, the reproductive tract consisting of a pair of cavities with a common duct, and that, as the result of the narrow form of the body, one of the cavities has been turned through an angle of 180°. The entire system lies ventral to the alimentary canal.

Each testicular region with its contents forms an elongated mass, tapering at either extremity. In cross sections the outline varies from semicircular to triangular in adaptation to the other internal organs. The anterior mass is the larger; where it attains its greatest breadth it occupies as much as two thirds of the body cavity.

In preparations of the entire animal the richly cellular character of the testis and the mass of developing sperms can be readily distinguished.

On examination by serial sections, the testicular region is found to consist of a tube with epithelial walls, the commencement occupied and closed by the germinal syncytium, the termination becoming continuous with the epithelial lining of the ductus.

The epithelium of the wall is, throughout the greater part of the length, very fine and flattened (Pl. 7, fig. 17, *gw.*). It is only possible to demonstrate the protoplasm in places where the contained sperms have been artificially separated, but the flattened nuclei (ib., *ngw.*) are always readily detected. Toward the junction with the ductus the epithelium increases in depth, forming a well-marked layer still without cell limits, but with fairly large oval nuclei. A fine layer of muscular fibre appears on the outside. This portion is analogous or, possibly, homologous with the vas deferens described by Jägerskiöld (**10**) in Cylicolaimus magnus and Thoracostoma acuticaudatum.

The germinal syncytium (Pl. 7, fig. 16) which occupies the fundus consists of a mass of nucleated protoplasm, which is in continuity with the protoplasm of the wall: in other words, it is a specialised portion of the epithelium lining the gonocœl. From this syncytium the sperm mother-cells are developed, growing down and filling the lumen of the tube, multiplying and undergoing development as they pass down.

The nuclei of the syncytium at the commencement are spherical, or oval, ·0043 mm. in greatest diameter, have clearly marked chromatin granules, and one or two pseudo-nucleoli. On passing further from the fundus, the nuclei increase in size, the protoplasm becomes relatively less, then cell outlines appear; the nuclei have increased to ·00645–·00753 mm., and the chromatin takes the form of a network (Pl. 7, fig. 17, *sg.*). About the commencement of the last quarter of the region the sperm mother-cells begin to divide, the chromatin is aggregated in larger granules, the nuclear membrane disappears; still further on the chromatin takes on a star-shape. The cells (mature spermatozoa) are here more numerous and smaller, ·0043 mm. in diameter, are not so closely packed, and are surrounded by some residual protoplasm. Spermatozoa are found in the anterior portion of the ductus. The rest of this organ is generally found to be empty.

The ductus ejaculatorius is a straight cylindrical tube, although at its commencement slightly flattened. The posterior testicular region opens into it a short distance behind its origin from the anterior.

Its wall consists of two layers—internal epithelial, external muscular (Pl. 7, fig. 17, DE.). The epithelium is cubical, becoming columnar towards the termination of the tube. The cells are highly vacuolated, and the free surfaces present a frayed-out appearance, as if a secretion had been discharged. In places this secretion can be made out as numerous acidophil granules.

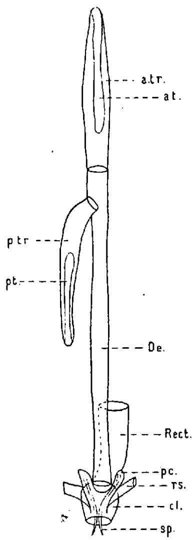
The muscular wall consists at first only of a layer of circular fibres. Flattened nuclei with a fine film of protoplasm can be made out on the outer surface, no doubt the nuclei of this layer. In the posterior quarter there is also an external layer of longitudinal fibres.

At its termination the ductus unites with the rectum to form the cloaca (text-fig. 1, *cl.*). As this latter structure is intimately connected with the copulatory apparatus, I shall describe it here rather than under "The Alimentary System."

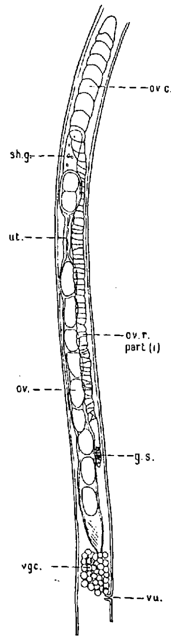
It is a short chamber, at its commencement roughly cylindrical in section, but becoming flattened towards its external opening, which is slit-like.

The wall (Pl. 7, fig. 6, *cl.*) is continuous with the epithelium of the ductus and rectum, and with the epidermis in the ventral line. It consists of protoplasm, which shows a circular striation as if it might fulfil a muscular function. Nuclei are

TEXT-FIG. 1.



TEXT-FIG. 2.



fairly numerous. Cells from the dorsal and the two lateral lines extend inward through the body-space towards the cloaca and form a layer of cubical epithelium on its dorsal wall, the cloacal ganglion (ibid., *cl., ag.*). There is a cuticular lining continuous with the external cuticle.

The accessory sexual apparatus consists of the two spicules

(Pl. 7, fig. 5, *sp.*) with their accessory piece, with the musculature which governs them and assists in expelling the sperm. Lying dorsal to the cloaca a muscular mass (Pl. 7, fig. 6, *ps.*) is to be found, imbedded in which are the spicules and accessory piece. The fibres run in the same direction as the long axis of the body and parallel with the spicules. In front they envelop the anterior ends of the spicules, behind they are attached to the wall of the cloaca. This muscle obviously acts as protractor of the spicules.

A second set of muscles (ibid., RS) passes from the body-wall to the posterior portion of the ductus, to the cloaca, and to the protractor muscle. It consists of a series of muscular bundles lying in the coronal plane of the animal and on the side of the body-wall attached mainly to the lateral lines. By enclosing the posterior portion of the ductus it assists in expelling the sperm; by the attachment to the protractor it is enabled to act as retractor of the spicules, and by its attachment to the cloacal wall as dilator of the cloaca.

The spicules are curved, pointed at their free ends, ·13 mm. long. They consist apparently of a chitinous material, are hollow at their upper portions, containing protoplasm. The accessory piece is triangular, grooved at the sides, the spicules fitting into the grooves.

Female Reproductive System.

The female reproductive organs (text-fig. 2) consist, as is usual in Nematodes of two tubes, uniting before reaching the external aperture. The tubes do not lie side by side, but one is found in front of, the other behind, the external aperture. This aperture is situated in the middle of the mid-ventral line of the body, the entire gonads being included in the middle two quarters of the body.

Each tube consists of ovarian region (text-fig. 2, *ov. r.*), including an ovarian cæcum (*ov. c.*), uterus (*ut.*), and vagina. The ovarian cæcum lies furthest from the external aperture, the rest of the ovarian region being bent back on the oviduct.

The first part of the ovarian region (*ov. r.*)—that is, that part which is not ovarian cæcum—has the form of an elongated cone, the base being continuous with the ovarian cæcum. It measures 1·87 mm. in length. It is completely filled by the ovary and by the mass of developing ova.

The ovarian cæcum, or second part of the ovarian region, is a blind prolongation of the first part. The openings into it of the first part and of the uterus lie side by side. It is oval in shape, with a truncated end at its junction with the first part and the uterus. It measures ·85 mm. in length, ·221 mm. in breadth.

The ovarian cæcum is the original gonad cavity, as will be shown when describing the immature female organs. The first part is a secondary outgrowth from it.

The wall of the ovarian region (Pl. 8, figs. 19 and 20) is formed of excessively fine flat epithelium. Indeed, so fine is this epithelium, that except near the termination of the organ, the only evidence of its existence consists in the presence of very much flattened nuclei (*ngw.*) closely apposed to the sides of the ovary and of the column of ova. The protoplasm of this epithelium cannot be distinguished even with a magnification of 1000 diameters. The state of matters in the immature female which I shall describe later, and the fact that this layer of flattened nuclei can be traced into the epithelium lining the ovarian cæcum, leave no doubt, however, as to the real existence of a wall.

The wall of the ovarian cæcum (Pl. 8, fig. 18, *gw.*) is composed of flattened epithelium, in which no cell outlines are discernible. The nuclei are flattened oval. The transition from the first part to the cæcum is, of course, gradual, not abrupt.

The germinal syncytium (Pl. 8, fig. 20, *gs.*) occupies the fundus of the tube, and doubtless springs from the epithelial lining. It consists of a protoplasmic mass, which shows an affinity for basic stains. Nuclei are imbedded irregularly in it, at the commencement 4 to 8 in a transverse section, increasing up to 12, and then again decreasing until at the end of the syncytium not more than two occur in any section. The nuclei are oval, have a nuclear membrane, distinct chromatin granules, and nucleolus. At the commencement of the syncytium they measure ·0136 mm. in their greatest diameter, at the termination ·0477 mm. There is a narrow, more condensed, ring of protoplasm round each nucleus.

The syncytium occupies about one eighth of the length of the ovarian region. It is followed by a column of disc-shaped ova (Pl. 8, fig. 19, *ov.*), which have become separated from it. These ova increase in size as they pass toward the ovarian cæcum, and become cylindrical rather than disc-like in shape. About the middle of the column the ova measures ·0484 mm. in diameter.

The ovarian cæcum contains about eight ova. A space is left between the ova and the dorsal wall, through which the ovum which occupies the fundus, and which is the most mature, can pass to reach the oviduct. This mature ovum is richly supplied with yolk-granules (Pl. 8, fig. 18, *ov.*).

The next division of the gonad tube is, in O. vulgaris, physiologically merely an oviduct, but morphologically it is identical with the subdivision which functions as an uterus and receptaculum seminis in other free Nematodes—e. g. Cylicolaimus magnus and Thoracostoma acuticaudatum. As this division has been described as an uterus by Jägerskiöld, I shall retain the name for the sake of uniformity. The uterus measures 2·5 mm. in length. Its calibre and shape vary according to its contents. It may be distended by a series of large ova or entirely empty. The latter condition is the exception. Generally from four to twelve opaque white ova can be seen in each uterus (text-fig. 2, *ov.*) lying end to end like a short chain of beads. The uterus then adapts itself, of course, to the shape of the ova. When empty it is collapsed and flat.

At its commencement a glandular mass, ·204 mm. in length, projects into and fills the lumen. This is the shell-gland (text-fig. 2, *shg.*, Pl. 8, fig. 19, *shg.*). Ova, after passing it, are found to have acquired their shells. Its shape is very much that of the ovarian cæcum, resembling a conical bullet, the pointed end directed towards the cæcum. The base is concave, and receives into its concavity one end of the first uterine ovum. The gland is attached to the right wall of the uterus, except at the base; here it projects freely into the lumen.

The gland is interesting histologically. It is formed of protoplasm continuous with the wall of the uterus. Cell outlines are not present. At the apex the nuclei are large and spherical, have a very prominent pseudo-nucleolus and a nuclear membrane; at the base, however, the nuclear membrane has disappeared, and the nuclear substance is diffused into the protoplasm. Contiguous nuclei thus become continuous, and, as the nuclei are arranged at the periphery of the mass, a basophil circle, in transverse sections, results. In this basophil circle the pseudo-nucleoli stand out, and might easily be mistaken for the nuclei themselves.

The wall of the uterus (Pl. 8, fig. 20, *ut.*) for the greater part of its length is composed of a cubical epithelium. This is, of course, considerably flattened where the uterus is distended by the ova. Near the junction with the ovarian cæcum the outlines of the cells become indistinct. When, as sometimes happens, there is no ovum in contact with the base of the shell-gland, the wall is here thick and the epithelium has a glandular appearance.

The ova in the uterus (ib., *ov.*) are oval in shape and measure ·27 mm. in length. The protoplasm is obscured by the mass of yolk-granules. A single nucleus occurs in each ovum, and this is invariably undergoing karyokinetic division, presumably in preparation for the extrusion of the polar body, although I have not observed this body. The shell is ·001 mm. thick and is sculptured, narrow ridges running over its outer surface.

Spermatozoa do not occur in the uterus.

The vagina (Pl. 8, figs. 22, 23, 24, *vag.*) is a glandular and muscular tube ·595 mm. in length. The glands surrounding it (*vgc.*), with those which lie around the vulva, give it a richly cellular appearance in preparations of the entire animal. At its origin from the uterus it is tightly constricted, but it soon opens out although its lumen is not so wide as that of the uterus. Shortly after its commencement, where the lumen begins again to widen out, a narrow canal passes through its dorsal wall and opens into the intestine. This is the gon-enteric canal.

The wall of the vagina consists of three layers—an internal epithelium, a middle muscular, and an outer glandular layer.

The epithelium is composed of cubical cells, the walls of which are thick and consist of specially condensed protoplasm. Within these walls the protoplasm does not stain, so that the nucleus appears to lie in a vacuole. The muscular layer is thick, the fibres circular. Where the two vaginæ meet (Pl. 8, fig. 24) the fibres pass outwards to the body-wall, forming a longitudinal layer around the short common terminal portion of the tube. It is difficult to distinguish any definite epithelial lining in this portion, but a fine film of cuticle is invaginated through the external aperture. The aperture is surrounded by a sphincter internal to the longitudinal fibres.

The vaginal and vulvar glands consist of cells lying in the body space. Around the first half of the vagina they form a single layer, and as they are pear-shaped give the appearance of a rosette in transverse section. I have not been able to demonstrate any openings from these cells into the lumen of the vagina, but from the definiteness of their arrangement it seems natural to suppose that their secretion is discharged into the vagina. Beyond the middle of the vagina the cells begin to arrange themselves around the vulva, and processes pass from them to a circle of minute pores surrounding this aperture (Pl. 8, fig. 24, *vag. ap.*).

The vagina always contains masses of spermatozoa (ibid., *s.*). Near the vulva these are spherical, with stellate nuclei, but higher up at the uterine end they become elongated and the nucleus almost thread-like.

Fertilisation must presumably take place in the vagina during the passage of the ova. It is somewhat peculiar that spermatozoa do not find their way up to a level at which the ova are without their shell, as occurs in the forms described by Jägerskiöld. I have not detected any opening through the shell, but such an opening would no doubt be very minute, and it is difficult to obtain a complete series of sections of the ova without some slight tearing of the tough shell.

The vulvar aperture is slit-like, the greatest diameter transverse to the long axis of the body.

The gonenteric canal.—This is a minute duct which, as stated above, opens into the vagina close to its commencement (Pl. 8, fig. 23, *gec.*)—in fact, just below the sphincter at the junction of uterus and vagina. It traverses the dorsal wall, passing vertically through the muscular layer. In this part of its course a few minute nuclei indicate the presence of an exceedingly fine lining of epithelial nature. Emerging from the vaginal wall, it lies in the body-space (Pl. 8, fig. 22, *gec.*) with nucleated protoplasmic walls which conduct the canal to the gut in the midventral line (Pl. 8, fig. 21, *gec.*) and becomes continuous with the alimentary epithelium. Passing from the vagina to the gut, the canal inclines slightly away from the mid-point of the body—*i.e.* the anterior canal inclines slightly towards the head, the posterior slightly towards the tail.

The function of this canal is to carry off superfluous spermatozoa. Spermatozoa are found in it and one of my sections shows a sperm passing from it into the gut. The gut in the adult female contains large masses of sperms.

No such canal has been described previously in any nematode. Its comparative morphology will be discussed later.

Reproductive Organs in the Immature Female.

I was fortunate enough to secure a specimen which was full grown, but in which the reproductive organs were undeveloped. In this specimen the gonads occur in from one fifth to one fourth of the length of the body. The vulva lies somewhat behind the centre.

They consist, as in the adult, of two tubes, an interior and a posterior, uniting to open by a single aperture to the outside. The tubes are straight, not bent back upon themselves as in the adult, but, as will be explained further on, the fundus does not correspond with the commencement of the first part of the ovarian region in the adult, but with the fundus of the ovarium cæcum.

The tubes are only potentially tubes; towards the fundus, where the oogonia occur, these cells completely fill the lumen; in that part destined to become vagina the lumen is occupied by a solid core of cuticle, and between these two regions the "tubes" consist of solid rods of protoplasm, which show their tubular nature only by the arrangement of the nuclei in a single layer around the periphery.

If each tube were divided into five parts, the first part, counting from the fundus, would contain the oogonia (Pl. 8, fig. 25). Here the wall (*gw*) is of flattened epithelium, not showing cell outlines, the nuclei flattened oval, with chromatin granules and nucleolus.

At the junction of the first and second fifths in the ventral wall the germinal portion of the epithelium is situated. Here the protoplasm of the wall grows into the lumen, the nuclei, still retaining the same characters, become larger and more spherical. The oogonia (*og*) as they develop from this protoplasmic projection pass, not towards the external aperture, but towards the fundus. The youngest nuclei which can be definitely recognised as oogonial resemble the nuclei of the germinal projection, but are more oval, and are larger, measuring 0·0016 mm. in diameter, and the chromatin granules are smaller and fewer in number. A transverse section at this point shows about eight such nuclei. The protoplasm is scanty, shows no cell outlines, and stains with basic dyes.

In the later stage of development the nuclei have become still larger, 0·0161 mm., and consequently there are fewer in a transverse section. The chromatin granules have disappeared, the nuclear vesicle being filled by a finely granular material which does not stain, the nucleolus is large. The protoplasm is relatively greater in amount. The immature ovum which occupies the fundus has a nucleus of the same character, but still larger, 0·0172 mm.

Comparing this with the adult, it is obvious that the projection of germinal epithelium corresponds with the commencement of the ovary, and the fundus of the tube with the ovarian cæcum. In development to maturity the germinal syncytium and the oogonial mass grow in the direction of the external aperture, evaginating the epithelial wall, and forming the reflected portion of the adult gonads.

Of the remaining four fifths of the tube, three fifths consist of a solid protoplasmic rod, with nuclei arranged around the periphery. In the last fifth the epithelium becomes columnar (Pl. 8, fig. 25). The cuticle of the body-wall passes into the lumen of the gonads as a solid core, but extends only a very short distance beyond the union of the two tubes. Gonenteric canals do not occur.

The last quarter of each tube and the united portion are surrounded by gland-cells (*vgc.*) lying in the body space. Processes pass in the direction of the vulva, but I have not been able to detect any openings through the cuticle.

Ascaris clavata (Rud.).

Female Reproductive Organs.

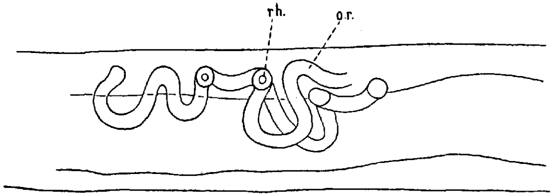
The female reproductive organs of A. clavata occupy one half of the length of the body. If the body is divided into ten parts, they extend from the end of the third to the end of the eighth part. The external aperture lies at the end of the third part.

They conform to the general Nematode type, consisting of two germinal masses lying at the fundi of two tubes, the two tubes uniting before reaching the external aperture.

Physiologically each tube may be divided into two regions—viz. one in which the ova develop from the germinal syncytium, and undergo maturation, the other strictly a passage to the exterior, but in which fertilisation and a certain degree of development also take place.

The first portion is, as usual, termed "ovary," although this term should strictly be applied only to the germinal syncytium, and to the rhachis with the oogonia attached to it.

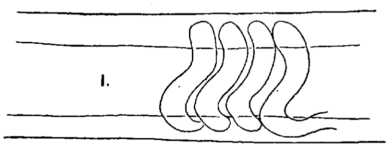
TEXT-FIG. 3.



The second part is divided into oviduct, receptaculum seminis, and uterus. The common portion is formed by the union of the two tubes in the vagina.

The ovarian region (text-figs. 3, 4, 5, 6, *ov. r.*) is by far the largest; it extends from the end of the eighth to the tenth part

TEXT-FIG. 4.



of the body forward to the end of the fourth—i.e. it extends through almost the entire reproductive region. It is, in addition, highly convoluted; in a specimen rendered transparent with, e.g., cedar-wood oil the tightly-packed coils form a most conspicuous object. The commencement is slightly conical, the diameter increasing as we pass down, but after a comparatively short distance the diameter ceases to increase, the tube being for the greatest portion of its length perfectly cylindrical.

The wall (Pl. 8, fig. 26 A, *gw.*) is excessively thin, consisting of a layer of flattened epithelial cells. At the fundus this layer becomes continuous with the germinal syncytium; in other words, the germinal syncytium is a specialised portion of the epithelium lining the gonocœl.

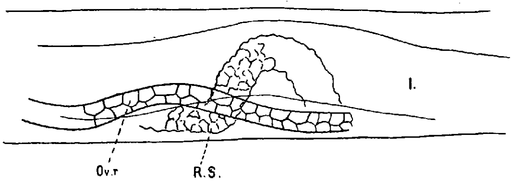
The germinal syncytium and the ova developing from it extend from the fundus down the tube as an unbroken column, completely filling the lumen, and this mass is, of course, the true ovary. In the germinal syncytium numerous nuclei occur, imbedded rather irregularly in the relatively scanty protoplasm. As we pass down the tube the nuclei begin to arrange themselves in a single layer at the periphery of the column; the central, non-nucleated protoplasm is the rhachis. Next, cell outlines appear around the nuclei, and the rhachis becomes smaller with the increasing size of the developing ova. Finally the rhachis ceases, the ova are arranged in successive tiers, closely packed against each other (Pl. 8, fig. 26 A, *ov.*) The protoplasm of the ova at this point consists of a meshwork. Before the ova becomes separated from this continuous column and pass into the oviduct eosinophil granules (yolk) make their appearance.

The division of the remaining portion of the genital tract into regions is necessarily somewhat arbitrary. Each region shades off into the one preceding and the one following it, and in different individuals the appearances at the same level vary. The same portion morphologically may be empty and constricted, or distended with ova or spermatozoa. In the following description I have divided it, according to the characters of the wall, into oviduct, receptaculum seminis, and uterus; the vagina is the single terminal portion.

The oviduct and receptaculum (text-fig. 5, R.S.) follow the ovarian region. They extend from about the middle of the body backward to the end of the sixth to tenth, then turn forward again for a short distance, and become continuous with the uterus. Their course is slightly tortuous, only slightly when compared with the ovarian region. The appearance of the tube varies with the contents; at its commencement it contains at most a few single ova and spermatozoa, and here it is fairly narrow, viz. ·102 mm. This portion is the oviduct (Pl. 8, fig. 27). Further on it widens out somewhat, to become the receptaculum, measuring ·255 mm. in diameter.

The wall of both oviduct and receptaculum consists of an epithelium with an external basement membrane (ibid., *bm.*). In the oviduct the epithelial cells are rounded, the lamina

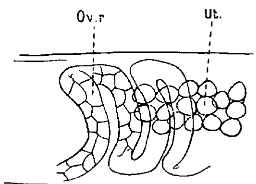
TEXT-FIG. 5.



poorly marked. The outer portions of the epithelial cells show indistinct circular fibrillation, as if they might act as a sphincter.

On passing to the receptaculum the lumen widens out, and

TEXT-FIG. 6.



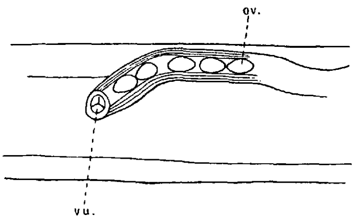
the epithelia cells become less spherical, although they still project into the lumen. Their protoplasm is reticular. The basement membrane becomes thick and distinct. The contents consist of spermatozoa, which frequently form a single layer on the surface of the epithelium, and of ova in small groups. Fertilisation takes place here.

The uterus (text-fig. 6, UT.) extends from about the end of the sixth tenth forward to the middle of the body, where it unites with its fellow to form the vagina. It is the widest and most distended portion of the tract. In a transparent specimen the mass of ova which fills it is very prominent. Its course is fairly straight, with the exception of an S-shaped bend at one point, where it is constricted. Its wall (Pl. 8, fig. 28) is three-layered, consisting of epithelium and basement membrane as in the oviduct and receptaculum, with the addition on the outside of a layer of flattened epithelioid cells.

The epithelium is more flat than in the oviduct. On the internal surface the protoplasm is differentiated into a more dense, almost cuticular, layer.

The outer epithelioid layer (*ml.*) is exceedingly fine, and it

TEXT-FIG. 7.



is difficult to demonstrate it except where the nuclei cause a slight bulging. Its function I believe to be muscular. It is continuous with the muscular layer of the vagina. Hamann describes a similar layer in Lecanocephalus as muscular.

The uterus is always distended with masses of spermatozoa and segmenting ova. Spermatozoa predominate towards the commencement, ova toward the termination. Toward the commencement the spermatozoa produce a remarkable appearance, arranging themselves on the surface of the epithelium in a closely-packed single layer, the nuclei lying at the free ends (ibid., *s.*). It is very easy to mistake them for a tall columnar epithelium.

The vagina (text-fig. 7) extends from the junction of the two uteri at the level of the middle of the body to the external aperture which lies in the mid-ventral line at the end of the third tenth of the body.

In preparations of the entire animal the appearance of this portion varies according to whether it is distended or not. At its commencement it contains large quantities of ova, and is not to be distinguished from the uterus. Further on, however, it contracts, and forms a fairly thick walled muscular tube, with here and there a single ovum in its lumen.

In sections this division is also clear, the upper portion thin walled, the lower thick and muscular. Histologically, indeed, for about the first quarter the wall is identical with that of the uterus. Then it begins to change, the epithelium becomes more and more columnar, the basement membrane more and more indistinct, merging on the one hand with the outer wall of the epithelial cells and with the partitions between them and on the other with the outer muscular layer. This outer muscular layer is continuous with the outer epithelioid layer of the uterus; it consists of circular muscular fibres.

Towards the termination there is also an internal cuticular lining, continnous with the cuticle of the body wall.

The external aperture is puckered, and, if open, would be circular. Around the aperture the epithelium of the vagina becomes continuous with the subcuticular layer of epidermis.

Male Reproductive Organs.

The male reproductive organs consist of a single tube, in contrast to the double female tubes. In other respects analogies, if not homologies, are easily demonstrable. The germinal mass again is attached to the fundus, and projects down the lumen. The tube is divided into a portion in which development and maturation of germs take place and into a portion serving merely as a passage to the exterior, the former consisting of a region containing the testis corresponding with the ovarian region, the latter of a vas deferens corresponding with the oviduct, a seminal vessel corresponding with the receptaculum and uterus, and a ductus ejaculatorius corresponding with the vagina.

The testicular region occupies two thirds of the reproductive division of the body. It is, in addition, highly tortuous. The wall is identical with that of the ovarian region, consisting of an excessively flat epithelium (Pl. 8, fig. 29, *gw.*). The germinal syncytium again arises from this epithelium at the fundus. The vesicular nuclei of the syncytium are at first scattered through the protoplasm. They soon arrange themselves around the rhachis, however, measuring ·003 mm. in diameter.

Further down, they invade the rhachis (Pl. 8, fig. 29), running in lines through it (·0043 mm.). Cell outlines begin to appear in the protoplasm, leaving some residual protoplasm between the cells. The rhachis ceases, and the cells lie free in the lumen, packed against each other. The nuclei continue to increase in size (·0064 mm.), the protoplasm is scanty. In the lower reaches the protoplasm again increases. The spermatogonia divide by karyokinesis and form the spermatozoa, spherical bodies, ·0053 mm. in diameter, showing fine amœboid processes, the nucleus represented by a single chromatin granule (Pl. 8, fig. 30, *s.*).

The vas deferens (Pl. 8, fig. 30, v.*d.*) is a short muscular passage from the foregoing division to the seminal vesicle. Its length is about ·34 mm. It is exceedingly narrow, ·068 mm. compared with ·41 mm. of the vesicle. The wall consists of a cubical epithelium with an outer muscular layer.

The seminal vesicle (ibid., s.v.) extends through rather less than one third of the reproductive region of the body. Its course is straight. It is the widest portion of the genital tract, ·41 in diameter, the lumen distended with spermatozoa. It is often constricted near the middle of its course. The wall consists of an epithelial layer, which does not show cell-outlines. Where the tube is distended the epithelium is flat; where it is contracted the epithelium is thrown into ridges. The muscular layer consists of circular fibres.

The ductus ejaculatorius (Pl. 8, fig. 31) is the shorter, terminal portion. Its lumen is narrow, but this is due to the thickness of the walls, as the diameter over all measures ·306 mm. The epithelium is the thickest layer; it is columnar, and shows a remarkable intra-cellular structure. The protoplasm is differentiated into two layers, an outer which stains with hæmatoxylin, and an inner which stains with eosin. The former projects into the body of the cell in a fingerlike process which surrounds the nucleus.

The muscular layer is well developed, and consists, as usual, of circular fibres. Muscular trabeculæ pass from the body-wall in the neighbourhood of the lateral lines, and converge toward the midventral line; they are attached to the outer surface of the ductus.

The ductus opens into the cloaca. This is formed by an invagination of epidermis, the wall consisting of cuticle, and a protoplasmic layer continuous on the one hand with the epithelium of the ductus and on the other with the epidermis (subcuticular).

The spiculæ are attached to the dorsal wall of the cloaca, and pierce this wall to project through the external aperture.

Ascaris capsularia (Rud. ?).

Excretory Gland.

In almost every cod numerous nematode embryos are to be found encysted under the peritoneum. They occur in largest numbers on the surface of the liver and among the pyloric cæca, but are also common in the mesentery. They certainly belong to an Ascaris, but to what species I am unable to say. As usual with Nematode embryos, they occur coiled up like a watch spring and surrounded by a capsule of badly-formed fibrous tissue. They measure 22 to 28 mm. in length. The head is blunt, with three papillæ—one dorsal, two subventral—around the triangular mouth. The body tapers more gradually toward the head than toward the tail. There are no lateral membranes. The anus is subterminal. There is no diverticulum at the junction of œsophagus and intestine. The nerve-ring lies shortly behind the mouth and is surrounded by a ganglionic collar. Generative organs indistinguishable as such. One of the most prominent internal organs is the gland which will be described below.

I believe that this form is identical with A. capsularia (Rud.) found in salmon and Gadidæ, but as there are very few points to distinguish Nematode larvæ from one another, this may not be the case, or several distinct embryos may be included under the one name. Dujardin (**2 a**) gives the length as 27 mm., von Linstow (**11 a**) 19 mm. I have therefore given the above description.

In addition, A. capsularia is, of course, merely an embryo; it should therefore not have a separate specific name, except for convenience, until the adult form is identified.

The gland which I propose to describe is interesting from the fact that it is homologous with the ventral gland of free Nematodes, and with, e.g., the poison glands of Strongylus filaria (Rud.).

It extends through the anterior six tenths of the body, lying ventral to the alimentary canal (Pl. 8, fig. 32, *vg.*), and its duct, after a short course, opens in the midventral line between the two subventral oral papillæ and immediately in front of the ganglionic collar which surrounds the nerve-ring.

The body of the gland (Pl. 8, fig. 32 *a*) is composed of a single gigantic cell, 15 mm. in length, ·255 mm. in greatest breadth, somewhat flattened between the body-wall and the alimentary tract, tapering to the posterior extremity, and rather blunt at the anterior.

The body of the cell is composed of finely granular acidophil protoplasm, the outer layer of which appears somewhat more condensed, and stains with hæmatoxylin.

The nucleus (*n.*) is a remarkable structure lying in the anterior half of the cell. It is 6 to 7 mm. in length. In transverse section its outline varies from linear to circular or biconcave. It has a wall identical in appearance with the outer wall of the cell; this encloses a vacuole containing a finely granular substance which stains intensely—almost black—with hæmatoxylin.

A fine canal (*can.*), 0·0075 mm. in diameter, traverses the entire length of the cell, and becomes continuous with the duct. Its course is in places slightly tortuous. It receives numerous smaller canaliculi which traverse the protoplasm. Its walls are also composed of condensed protoplasm; its contents when fixed are very finely granular and acidophil.

The short duct (Pl. 8, fig. 33) runs from the anterior pole of the cell to the midventral line, and in the substance of this line to the external aperture. Its wall is composed of protoplasm continuous with the protoplasm of the cell; one or two small nuclei occur in it. There is a very fine cuticular lining continuous with the external cuticle.

Hamann describes a similar organ in the embryos found in Zeus faber. It again consists of a single cell, in front thread-like, at its greatest breadth extending from one lateral line to the other, is always in connection with the *dorsal* median line, contains a canal lined by a "glashelles membran," which opens *dorsally* behind the lips. [The italics are mine.]

Cells occur in the body cavity identical with the basophil cells of Oncholaimus vulgaris.

Lying between the ventral gland and the right lateral line is a solid cellular mass, possibly the rudiments of the gonads.

Comparative Morphology of the Excretory Glands in Nematodes.

This subject has been very fully worked up by Jägerskiöld in a masterly paper (**9**). I have, however, a few points to add. I shall commence with a brief summary of his results.

He finds that the excretory organs of Nematodes can be classified into four groups:

(1) The ventral gland of the most free living forms (Pl. 9, fig. 35).

(2) The unilateral asymmetrical excretory organ, in its anterior part flattened and band-shaped, and with a highly modified nucleus, as in A. decipiens (Pl. 9, fig. 37).

(3) A similar organ, but without the band-like enlargement, as in A. clavata (Pl. 9, fig. 38).

(4) The bilateral organ of, e. g., A. megalocephala (Pl. 9, fig. 40).

In all these types the organ consists of a single large cell, with an intra-cellular system of canals, and with a duct formed in many cases by an invagination of epidermis. All four are homologous, an intermediate type between (2) and (4) being found in A. rotundata, in which a small limb crosses from the main stem of the gland on the left side to the right (Pl. 9, fig. 39). The cause of the change in type from (1) through (2) and (3) to (4) is to be found in an increase of work thrown on the gland, probably by change of habits in the animal. The gland is compelled to enlarge, and adapts itself to the narrow body-form by elongating, and following the line of least resistance, applies itself first to one and then to both lateral lines.

Bastian (1) had previously (and he is quoted by Jägerskiöld) stated the same opinion, that the ventral gland of free Nematodes was homologous with the excretory organ of parasitic forms.

The results given above supply another link in the chain. The excretory gland in the embryo above described (Pl. 9, fig. 36) is a typical ventral gland, inasmuch as its opening, although situated close to the mouth, is also immediately in front of the nerve-ring (corresponding with the situation in Oncholaimus vulgaris), and as it lies free in the body space, comes into contact only with the left lateral line, never being in continuity with it.

On the other hand, in many points it resembles the excretory organ of A. decipiens. Its duct is formed by an ingrowth of cells from the ventral line; its anterior portion is broad, almost band-like, and contains the nucleus; its posterior portion is narrow and thread-like. It contains a central canal with branches ramifying through the protoplasm. The nucleus is highly elongated, in places band-like, and its structure very strongly resembles that of A. decipiens and allied forms.

We should expect in the embryo of a parasitic form to find a transition between the type found in the free-living forms and that in the adult parasite. As I have shown, our expectations are fulfilled.

A step further can be taken in pointing out homologies; it appears probable that the excretory organ of Nematodes, in whatever form it occurs, is a nephridium homologous with the nephridia of, e. g., Platyhelmia or Chætopods.

A nephridium is defined by Ray Lankester (**11**) as follows: "Nephridia are distinguished by their independent origin, each from a single superficially placed cell, which often is seen to be derived from ectoderm, and probably must be traced to that layer even when it appears as part of the mesoblast. They are also distinguished by their structure, which is primarily that of a number of perforated or drain-pipe cells placed, as it were, end to end."

The excretory organ of Nematodes is a cell perforated by an intra-cellular canal. That it consists of a single cell and not of a number placed end to end does not militate against the homology suggested, since the chains of cells originate from a single cell.

Jammes (**7**) and Jägerskiöld (**9**) agree that it is ectodermal in origin. The condition as found in the ventral gland of free-living forms by many observers, and as described for Oncholaimus vulgaris by myself, certainly suggests an ectodermal origin.

Hamann (**5**) is the only modern authority who regards it as mesodermal.

We are accustomed to think of nephridia as paired organs, but a single organ arising from the midline is as much bilateral as two arising one on each side of the midline.

If the excretory organ when specialised resembles a nephridium, in its most simple form, it bears a strong resemblance to an unmodified skin-gland. Jägerskiöld (**10**) has pointed this out also, stating that physiologically at least the ventral gland and the skin-glands are interchangeable. The results given above agree with this; in the female of Oncholaimus vulgaris the functions of the ventral gland are taken over presumably by the vulvar and lateral line glands, as the animal reaches maturity.

It is hardly necessary to insist on the structural resemblance between the ventral gland on the one hand and the tail-glands and glands of the lateral lines on the other.

The Cœlom.

It seems probable that the chief reason why a cœlom has not been recognised in Nematodes is to be found in the manner in which the reproductive organs have been described. The terms "testis" and "ovary" have been made to cover, not only these organs themselves but also the spaces which contain them, and although the spaces have of course been recognised, sufficient morphological importance has not been attached to them.

The condition may be summarised as follows: In all Nematodes hitherto described there is to be found either a single median space or two bilateral spaces, lined by a characteristic flat epithelium. These spaces with their walls I have described as testicular and ovarian regions. A specialised patch of this epithelium forms the testis or ovary. From the space, or spaces, a duct, or ducts, leads to the exterior: where there are two ducts they unite before reaching the exterior. In regard to origin, the cavity and, no doubt, the ducts as well are mesodermal. This is the view of Jammes (**7**), and in Hallez's (**6**) figures it can be seen that the gonad tubes arise from two groups of cells which in the early embryo lie in the blastocœle, one on either side of the gut.

The cavities are, then, typical gonocœls or protocœloms (**11**, pp. 35, 36), and the ducts (unless they should prove to be formed by ingrowth of epidermis, which there is no reason to expect) are typical gonoducts or cœlomoducts.

The fact that in parasitic Nematodes the cavities form highly convoluted tubes of great length should not be allowed to obscure this truth. In the forms which I have described we have a series. It commences with the simple gonocœl found in the immature female or mature male of Oncholaimus vulgaris; next, in the mature female the gonocœl is slightly more complex; there is a narrow conical outgrowth from the original cavity, which is represented by the ovarian cæcum; finally, in A. clavata the entire gonocœl has become enormously elongated and convoluted.

The cause for this latter development is obvious—viz. the call for an enormous increase in the reproductive products on changing from a free to a parasitic life.

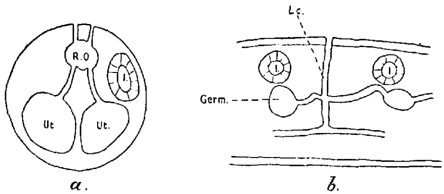
In the description of Oncholaimus vulgaris and Ascaris clavata above I have refrained from the use of the terms "gonocœl" and "gonoduct," since I did not wish unnecessarily to bring theory into the strictly descriptive part of my article. I wish now, however, to repeat that I believe that the "testicular" and "ovarian regions" correspond accurately with the male and female gonocœls respectively, and that the remaining portions of the genital tracts (uterus and vagina and ductus ejaculatorius in Oncholaimus vulgaris; oviduct, receptaculum seminis, uterus and vagina, vas deferens, vesicle, and ductus in Ascaris clavata) correspond with the gonoducts. The wall of the former consists of an exceedingly fine squamous epithelium only; in the wall of the latter the epithelium is cubical or columnar (except when the duct is much distended), and there are other coats.

Comparative Morphology of the Gonenteric Canals.

The only organ in any way similar which has been previously described in Nematodes is the remarkable "Röhrenförmige organ" with its ducts, found by De Man (**12**) in Oncholaimus fuscus. This consists of a tube lined by epithelium, lying dorsally in the body-space, communicating by two canals with the exterior and by two canals with the two uteri.

This condition and that found in O. vulgaris suggest at once a comparison with Trematodes. The former reminds us

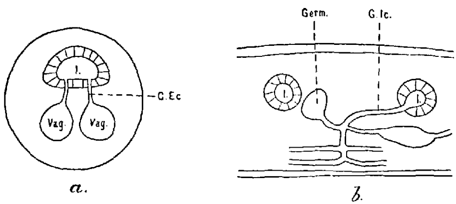
TEXT-FIG. 8.



of Laurer's canal as it occurs in Malacocotyleans, the latter of the genito-intestinal canal of Heterocotyleans. The diagrams (text-figs. 8, 9) illustrate the point better than much writing. The diagrams of the Trematodes are copied from the article in Ray Lankester's 'Treatise on Zoology,' Pt. IV, p. 87.

Text-fig. 8 *a* represents diagrammatically a transverse sec-

TEXT-FIG. 9.



tion through O. fuscus. The "Röhrenförmige Organ" (R. O.), with its ducts, is shown. Text-fig. 8 *b* represents a Malacocotylean. *Germ* is the germarium, *L. c.* Laurier's canal. Text-fig. 9 *a* represents O. vulgaris, and shows the gonenteric canals, to be compared with the genito-intestinal canal (*g. i. c.*) of the Heterocotylean (text-fig. 9 *b*).

In text-figs. 8 *a* and 9 *a* the two uteri and vaginæ are, for fairness of comparison, represented as if they lay side by side.

Literature referred to.

1. Bastian.—"Anatomy and Physiology of Nematoids, Parasitic and Free," 'Phil. Trans. Roy. Soc.,' 1866.
2. Bastian.—"Monograph of the Anguillulidæ," 'Trans. Linn. Soc.,' vol. xxv, 1866.
2 a. Dujardin.—'Systema Helminthum.'
3. Golowin.—"Beobachtungen an Nematoden," II, 'Excretorishes Apparat.,' Kasan, 1902. (Summary, 'Zool. Centralblatt,' ix, p. 449.)
4. Hamann.—'Centralblatt f. Bakteriologie,' vol. xi, p. 501.
5. Hamann.—"Die Nemathelminthen," II, 'Die Nematoden,' Jena, 1895.
6. Hallez.—"Developpement de quelques Nematodes," 'Recherches sur l'Embryogenie,' Paris, 1885.
7. Jammes.—'Ann. des Sciences Natur.,' t. xiii, p. 321.
8. Jammes.—'Recherches sur l'Organisation et Developpement des Nematodes,' Thesis, Paris, 1894. (Summary, 'Zool. Centralbl.,' Jahrg. ii, p. 398.)
9. Jägerskiöld.—"Beiträge zur Kentniss d. Nematoden," 'Zool. Jahrb. Abtheil. Anat. u. Ontog.,' Bd. vii, p. 449.
10. Jägerskiöld.—'Weitere Beiträge z. Kentniss der Nematoden,' Stockholm, 1901.
11. Ray Lankester.—'Treatise on Zoology,' part ii.
11a. von Linstow.—'Fauna Arctica' (Schaudinn and Römer), Bd. i, p. 119.
12. de Man.—'Anat. Untersuchungen über Freilebende Nordsee-Nematoden,' Leipzig, 1886.
13. Nassonow.—'Zool. Anz.,' xx, p. 203.
14. Zur Strassen.—'Zeitschr. f. wiss. Zool.,' vol. liv.
15. Wandollek.—'Arch. f. Naturgeschichte Jahrg.,' lviii, Bd. i, 1892.

EXPLANATION OF PLATES 7—9,

Illustrating Dr. F. H. Stewart's paper, "The Anatomy of Oncholaimus vulgaris, Bast., with Notes on two Parasitic Nematodes."

Reference Letters.

a. c. Acidophil cell. *a. g.* Anal ganglion. *a. t.* Anterior testis. *a. t. r.* Anterior testicular region. *b. c.*[1] Basophil cell in ganglionic collar. *b. c.*[2] Basophil cell behind collar. *b. m.* Basement membrane. *Can.* Canal, excretory. *Cl.* Cloaca. *Cl. ap.* Cloacal aperture. *cut.* Cuticle. *D. E.* Ductus ejaculatorius. *D. L. M.* Dorso-lateral muscle-field. *D. M.* Dorsal muscle-field. *ex. ap.* Excretory aperture. *g. c.* Ganglionic collar. *G. Ec.* Gonenteric canal. *g. s.* Germinal syncytium. *g. w.* Gonocœl wall. *I.* Intestine. *L. L.* Lateral line. *L. L. g.* Lateral line gland. *M. D. L.* Median dorsal line. *M. V. L.* Median ventral line. *m.* 'Mesoglœa.' *m. c.* muscle cell. *m. l.* muscular layer. *m. n.* 'Mesoglœa' nucleus. *n.* Nucleus. *n. g. w.* Nucleus of gonocœl wall. *n. r.* Circumœsophageal nerve-ring. *œs.* Œsophagus. *œs. d.* Œsophageal gland-duct. *og.* Oogonium. *ov. c.* Ovarian cæcum. *ov. r.* Ovarian region. *ph.* Pharynx. *P. S.* Protractor spiculorum muscle. *p. t.* Posterior testis. *p. t. r.* Posterior testicular region. *rh.* Rhachis. *Rec.* Rectum. *R. S.* Retractor muscle. *s.* Spermatozoön. *sc.* Subcuticle. *sg.* Spermatogonium. *shg.* Shell-gland. *sm. l.* Submedian line. *sp.* Spicule. *S. V.* Seminal vesicle. $T.^1$ Epidermal cell or nerve-cell, type 1. $T.^2$ ditto, type 2. *tg. ap.* Tail-gland aperture. *tg. d.* Duct of tail-gland. *T. R.* Testicular region. *ut.* Uterus. *vag.* Vagina. *v. d.* Vas deferens. *v. g.* Ventral gland. *v. g. c.* Vaginal or vulvar gland-cell. *v. g. d.* Duct of ventral gland. *V. L. M.* Ventro-lateral muscle-field. *V. M.* Ventral muscle field. *Vu.* Vulva. *Vu g. ap.* Aperture of vulvar gland.

PLATE 7.

Fig. 1.—Anterior extremity, O. vulgaris. Adult female. × 80. (*a*) A large cell of the body space.

Fig. 2.—Head, O. vulgaris. × 350. (*a*) Circumoral papilla; (*b*) circumoral ring of hair; (*c*) dorsal row of hair; (*d*) dorsal tooth.

Fig. 3.—Transverse section, O. vulgaris, male, shortly in front of nerve-ring. × 350. Stain: Safranin, picronigrosin.

Fig. 4.—Transverse section, O. vulgaris, male, through the nerve-ring. × 350. Stain: Safranin, picronigrosin.

Fig. 5.—Tail, O. vulgaris, male. × 350.

Fig. 6.—Transverse section, male, through cloaca. × 350. Stain: Thionin, eosin.

Fig. 7.—Gland-cell of lateral line. × 800. Stain: Safranin picronigrosin.

Fig. 8.—Part of a transverse section in posterior œsophageal region. × 800. Stain: Safranin, picronigrosin.

Fig. 9.—Type 1, epidermal cell. × 800.

Fig. 10.—Part of a transverse section in posterior œsophageal region. × 800. Stain: Safranin, picronigrosin.

Fig. 11.—Coarsely granular acidophil cell of the body space. × 800. Stain: Safranin, picronigrosin.

FIG. 12.—Transverse section through ventral gland, showing nucleus. × 350. Stain: Thionin, eosin.

FIG. 13.—Transverse section at the level of the termination of the œsophagus. Immature female. × 350. Stain: Safranin, picronigrosin.

FIG. 14.—Part of a transverse section in intestinal region. Mature female. × 800. Stain: Thionin, eosin.

FIG. 15.—Part of a transverse section, same as 14.

FIG. 16.—Transverse section through anterior testicular region, showing the germinal syncytium. × 350. Stain: Thionin, eosin.

FIG. 17.—Transverse section through posterior testicular region, ductus ejaculatorius, and intestine. × 350. Stain: Safranin, picronigrosin.

PLATE 8.

FIG. 18.—Transverse section through ovarian cæcum, containing ripe ovum with yolk granules. × 350. Stain: Thionin, eosin.

FIG. 19.—Transverse section through ovarian region (first part) and shell-gland. × 350. Stain: Thionin, eosin.

FIG. 20.—Transverse section through ovarian region (first part), and uterus. × 350. Stain: Hæmatin, picronigrosin.

FIG. 21.—Transverse section, showing gonenteric canal opening into intestine. × 350. Stain: Borax-carmine, picronigrosin.

FIG. 22.—Gonenteric canal (between the sections represented in figs. 21 and 23). × 350.

FIG. 23.—Gonenteric canal opening into vagina. × 350.

FIG. 24.—Transverse section through vulva. × 350. Stain: Borax-carmine, picronigrosin.

FIG. 25.—Immature female. Transverse section through gonocœl. × 350. Stain: Thionin, eosin.

FIG. 26.—Immature female. Transverse section through gonoduct not far from vulva. × 350. Stain: Safranin, picronigrosin.

Ascaris clavata.

FIG. 26 *a*.—Transverse section, ovarian region. × 350. Stain: Hæmatoxylin, eosin.

FIG. 27.—Transverse section, oviduct. × 350. Stain: Hæmatoxylin, eosin.

FIG. 28.—Transverse section, uterus. × 350. Stain: Hæmatoxylin, eosin.

FIG. 29.—Transverse section, testicular region. × 350. Stain: Hæmatoxylin, eosin.

FIG. 30.—Transverse section through vas deferens at its opening into seminal vesicle; portion of wall of latter shown. × 350. Stain: Hæmatoxylin, eosin.

FIG. 31.—Portion of transverse section, ductus ejaculatorius. × 350. Stain: Hæmatoxylin, eosin.

Ascaris capsularia.

FIG. 32.—Transverse section, showing ventral gland. × 80. Stain: Hæmatoxylin, eosin.

FIG. 32*a*.—Transverse section through ventral gland, anterior portion. × 350. Stain: Hæmatoxylin, eosin.

FIG. 33.—Oblique section through duct of ventral gland. × 350. Stain: Hæmatoxylin, eosin.

PLATE 9.

Diagrams illustrating the development of the excretory apparatus in Nematodes.

(FIGS. 37–40 are based on the descriptions given by Jägerskiöld [**9**]).

FIG. 34.—Skin-gland of lateral line.

FIG. 35.—Ventral gland of eg., Oncholaimus vulgaris.

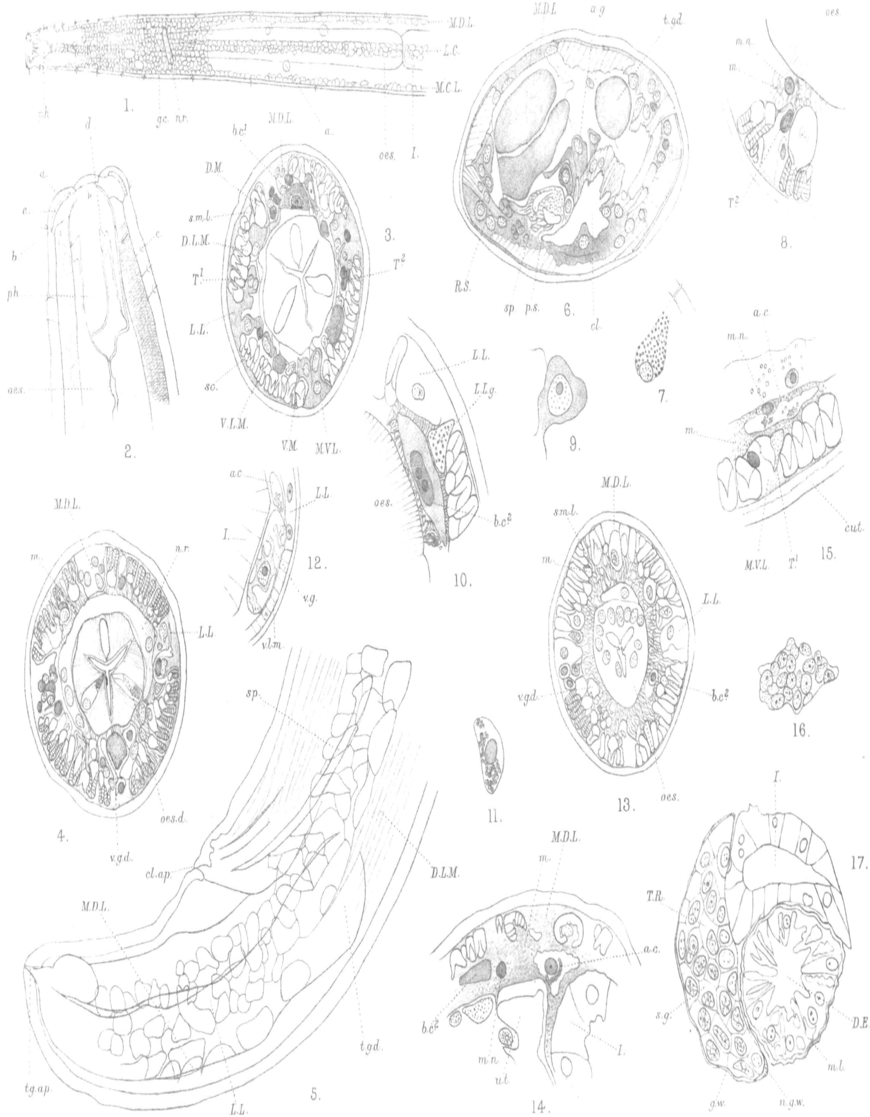
FIG. 36.—Ventral gland of Ascaris capsularia.

FIG. 37.—Excretory organ of A. decipiens.

FIG. 38.—Excretory organ of A. rotundata.

FIG. 39.—Excretory organ of A. clavata.

FIG. 40.—Excretory organ of A. megalocephala.



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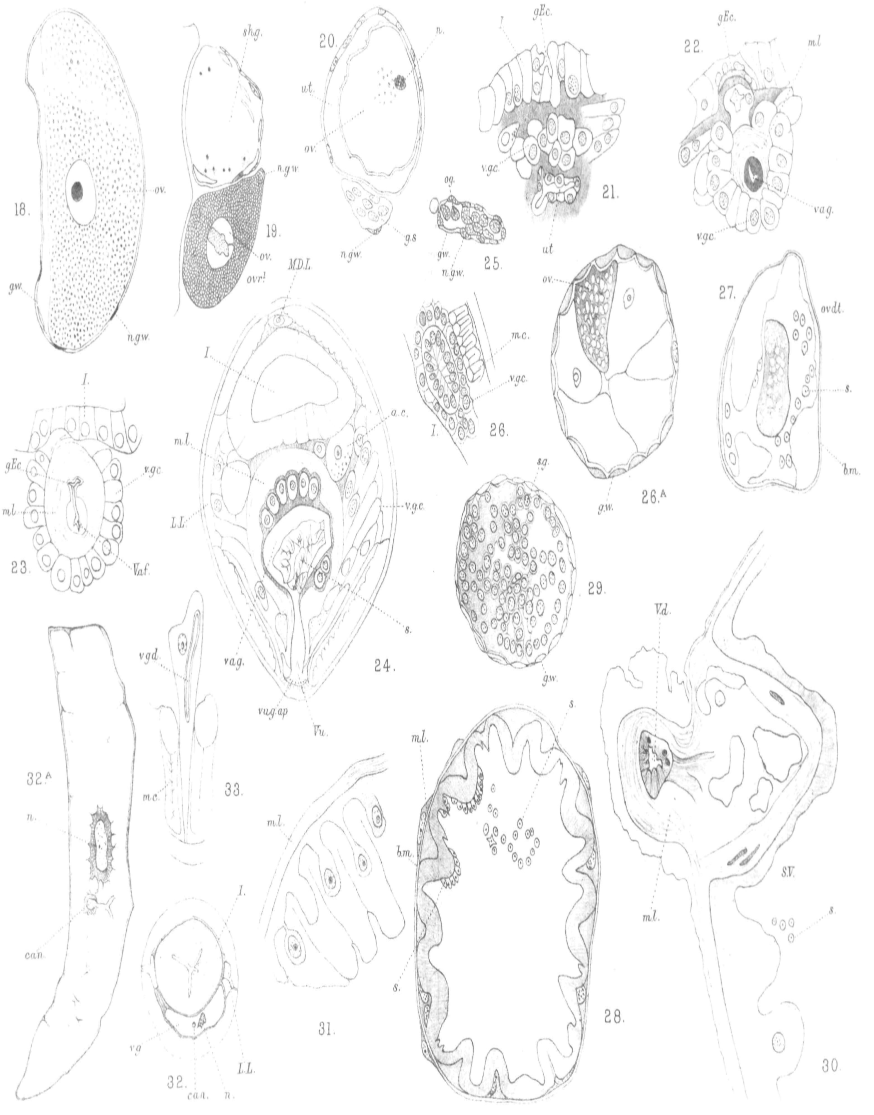
18.
ov.
gw.
n.gw.
19.
sh.g.
n.g.w.
ov.
ovr!
20.
n.
ut.
ov.
g.s
n.gw.
21.
gEc.
v.gc.
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22.
gEc.
ml.
v.a.g.
v.gc.
25.
og.
gw.
n.gw.
23.
I.
gEc.
ml.
v.gc.
Vaf.
24.
M.D.L.
I.
m.l.
a.c.
L.L.
v.g.c.
v.a.g.
s.
vu.g.ap
Vu.
26.
m.c.
v.gc.
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26.A
ov.
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27.
ovdt.
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29.
sg.
g.w.
32.A
n.
can.
33.
v.g.d.
m.c.
31.
m.l.
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I.
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S.V.
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s.

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Fig. 34.

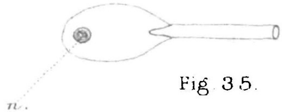

Fig. 35.

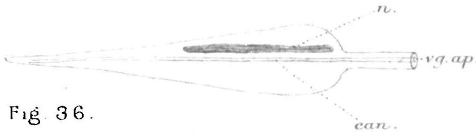

Fig. 36.

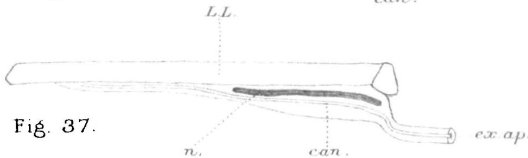

Fig. 37.

Fig. 38.

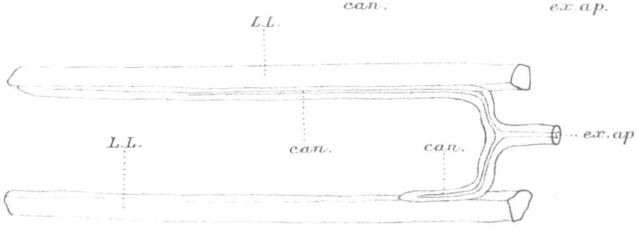

Fig. 39.

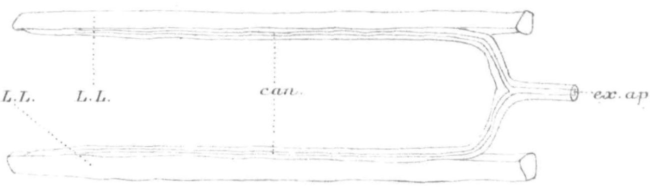

Fig. 40.

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