Notes on the Anatomy of Dinophilus.

By

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With Plates IX and X.

The anatomy of *Dinophilus,* a genus established by Oscar Schmidt in 1848, has formed the subject of several memoirs, amongst which attention must be specially called to the recent papers of Korschelt (6), Repiachoff (12), and Weldon (13). A complete account of the synonymy of the genus was given by v. Graff* in 1882, whilst Korschelt (7) has, within the last year or two, published a review of the facts known with regard to the anatomy of the various species of *Dinophilus.* Full references to the literature of the subject will be found in v. Graff's monograph (loc. cit.) as well as in the memoirs of Weldon (13) and Korschelt (6 and 7). In view of the recent appearance of the above-mentioned papers, it is unnecessary for me either to give a complete list of references or to attempt any historical account of our knowledge of the genus.

The animal which forms the subject of the present paper was found at Plymouth†, and has been described as a new species, under the name *Dinophilus tæniatus,* at a meeting of the Cambridge Philosophical Society.‡

D. tæniatus was found, in very great numbers, in rock-pools far above low-water mark, during the latter end of March and the first half of April. It was unfortunately necessary to interrupt the observations on April 18th, a day or two before which time it was noticed that the eggs which were being produced by the females were rapidly developing. On returning to Plymouth on June 26th no trace of the animal was discovered. Other observers, as Hallez (4) and Weldon (13) have recorded the fact that the species of *Dinophilus* which they have respectively described are only to be found during the spring.

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* v. Graff, L., Monographie der Turbellarien. I. Rhabdocœlida. Leipzig, 1882, p. 1.

† The study of the anatomy of *Dinophilus* was greatly facilitated by the excellence of the arrangements of the Laboratory of the Marine Biological Association, to the Director of which, Mr. G. C. Bourne, I desire to express my best thanks for the courtesy with which I have been treated during my visits to Plymouth.

‡ Proc. Camb. Philosoph. Soc., vol. vi, 1889.

It will not be superfluous to call attention to the fact that the bright orange colour which is so conspicuous a feature of *D. tæniatus* (as of certain other species of *Dinophilus*) cannot easily be regarded as a protective colouration. The rock-pools inhabited by this species of *Dinophilus* contain numerous bright green Algæ, and there is not the slightest difficulty in detecting with the naked eye individuals of *D. tæniatus*, whether crawling on this green background or on the mud or rocks which occur at the bottom of the tide-pool.

With regard to the habits of the animal, it may be noted that, so far as I am aware, it never performs those gyrations round a centre formed by the attachment of the tail to a foreign body, which have been described as of frequent occurrence in *D. metameroides*, for instance (4). The animal crawls (no doubt by means of its cilia) with considerable rapidity, but it is able to swim freely in the water; the latter method of progression appears to be specially characteristic of young individuals.

Specific Characters.—*Dinophilus tæniatus* is characterised as follows: Head with two circlets of præoral cilia. Body composed of five segments and a tail. Segments sharply marked off from one another in young individuals, each encircled by two rings of cilia, incomplete ventrally, where they are interrupted by the uniform ciliation of the ventral surface. Anus placed dorsally to the base of the conical unsegmented tail, surrounded by a ring of cilia, incomplete ventrally. Skin containing large numbers of transparent glandular bodies. Sexes not dimorphic. Maximum length, in either sex, about 2 mm. Colour bright orange, usually brighter in the male than in the female. Testes in the male extending nearly the whole length of the body, on the ventral and lateral sides of the alimentary canal; spermatozoa very long and undulating. Vesicula seminalis formed by the modification of the fifth nephridum on each side, opening into a median copulatory organ, whose external aperture is ventral and slightly posterior to the anus. Ovaries in the female four-lobed. Nephridia ten in number (five pairs), the fifth pair modified as a vesicula seminalis in the male. Ventral nervous system segmented.

As characters recognisable in living specimens, and which are sufficient to distinguish this species from all others at present known may be mentioned the following:

(1) The existence of five body-segments (in addition to the tail), each encircled dorsally and laterally by *two* rings of cilia; the segmentation being sharply marked in immature individuals.

(2) The four-lobed condition of the ovaries in the female.

(3) The existence, in the male, of a median penis and of lateral

vesiculæ seminales (in which respect, however, *D. vorticoides* may possibly be found to agree with *D. tæniatus*).

The characters above given appear to be amply sufficient to justify the formation of a new species. The species which most resembles *D. tæniatus* is probably *D. gigas*, Weldon, which, however, differs from it in such important features as the number of the segments, the arrangement of the ciliated rings, the general character of the reproductive organs, and more particularly the absence of a copulatory organ in the male sex.

External Features.—The form of the body is shown in Pl. IX, fig. 1, which represents a rather young individual (the distinctness of the cilia having been somewhat exaggerated). In an old animal, distended with ripe generative products, the external segmentation is not nearly so conspicuous as in the specimen figured. The arrangement of the cilia is often difficult to make out in living specimens, but may be very easily observed after treatment with hot corrosive sublimate, and before the extraction of the orange pigment by means of alcohol. In specimens thus treated, the cilia appear as white bands running over an orange background; when seen from the dorsal surface, the two rings of each segment together give rise to the impression that the middle region of the segment is encircled by a broad band; this appearance has suggested the specific name *tæniatus*.

The ciliation of the head is best studied in a sublimate specimen, seen from the anterior pole (fig. 8). The general surface of the head is not ciliated, the cilia occurring, on the contrary, as two definite præoral rings, between which are situated the eyes, near the dorsal surface. The anterior ring is more or less triangular, the apex of the triangle being directed dorsally.

In looking at the animal from above, it is seen that the posterior cephalic ring passes dorsally across the equator of each of the eyes (fig. 1). This ring, unlike all the other ciliated rings of the animal, is composed of several circlets of cilia. Of these, the first consists of long cilia directed forwards, and the third or last of somewhat shorter, backwardly-directed cilia. Between the two circlets occurs an intermediate series of very minute cilia (figs. 1, 15). It follows from this description that in structure, as in position, the second cephalic ring resembles the præoral ciliated band of a Trochosphere larva. No ciliated pits were observed. The head bears long, stiff sense-hairs arranged in two groups, situated within the area circumscribed by the anterior ciliated ring (fig. 1). Similar sense-hairs occur on various parts of the body and tail.

The study of longitudinal sections, in which, however, the cilia were not very well preserved, appeared to show that the second præoral ring becomes much broader in approaching the ventral surface, and that it becomes indistinguishable from an investment of cilia which clothes the ventral surface of the head and which passes continuously into the ciliated lining of the œsophagus (cf. fig. 3). The examination of the ciliation of the ventral surface of the head is always difficult in fresh specimens, but at the time when these were accessible to me, I believed that I could convince myself that the anterior circlet of the second præoral ring passed completely round the head, as shown in fig. 15. The most satisfactory way, it appears to me, of reconciling the apparent discrepancy between fig. 3 and fig. 15, is to assume that, whilst the anterior circlet of the second præoral ring does really pass continuously round the ventral surface of the head, the middle and posterior circlets become, ventrally, an extensive ciliated area which is continuous with the ciliated lining of the œsophagus.

The arrangement of the five pairs of ciliated rings which occur on the body and of the perianal ring is sufficiently explained by fig. 1. All these rings are interrupted by the cilia which cover, in a uniform sheet, the entire ventral surface of the body and of the tail.

Alimentary Canal.—The mouth occurs on the ventral surface, at the limit between the head and the first segment of the body. The aperture of the œsophagus is guarded by two lip-like structures, an outer and an inner. Of these, the former constitutes the outer wall of a triangular space (fig. 15) which includes in front the aperture into the œsophagus, and behind the end of the tongue-like structure formed by the muscular appendage of the œsophagus. The arrangement of this organ is well seen in the longitudinal section figured (fig. 3), where it will be noticed that the end of the muscular appendage (which is covered by a modified, probably hardened epidermis) projects into the space enclosed by the outer lip. A similar arrangement is figured by Repiachoff (No. 12, pl. iv, fig. 1) in *D. gyrociliatus*, whilst the disposition of the organ appears, from Weldon's description (13), to be somewhat different in *D. gigas*.

In front of the tongue-like structure is seen the aperture into the œsophagus (fig. 15). This aperture is subtriangular, and is bounded by the two richly ciliated inner lips.

The course of the alimentary canal is shown in fig. 3. The œsophagus ascends obliquely towards the dorsal surface, the lateral walls of its first part being thickened (*v.* fig. 10), and passing continuously into the inner lips. The posterior section of the œsophagus lies very near the dorsal skin, and is lined by cells which have a more glandular appearance, and which bear longer cilia than those which line the anterior two thirds of the œsophagus. The posterior division corresponds to the proventriculus ("Vormagen") described by Korschelt in *D. apatris*.

As in other species of *Dinophilus,* racemose salivary glands open into the anterior division of the œsophagus.

The stomach (which, during life, is of a rich orange colour) is ciliated throughout: it ends cæcally on the dorsal side of the commencement of the intestine, as in *D. gigas.*

The intestine, like the rest of the alimentary canal, is ciliated. It opens into the stomach by a narrow aperture situated on the ventral side of the latter.

As will be seen by reference to fig. 1, the œsophagus and its muscular appendage belong to the first segment of the body, the stomach occupying the second, third, and fourth segments, whilst the intestine is found in the fifth and posterior part of the fourth segment.

Nervous System.—Although Korschelt (6) and Repiachoff (12) succeeded in finding the brain of *D. gyrociliatus,* our knowledge of the nervous system of *Dinophilus* is in the main due to Weldon (13), who has not only described the brain, but has shown that this structure is connected with ventral cords, whose arrangement resembles that found in *Protodrilus* (*v.* Hatschek, No. 5).

The nervous system of *D. tæniatus* exhibits a feature which has not hitherto been described in any species of *Dinophilus.* The ventral cords are distinctly segmented, the number of ganglionic enlargements—five—corresponding with that of the segments of the body.

The ventral cords (figs. 3, 10 and 11) are situated outside the basement-membrane of the skin, and lie, widely separated from one another immediately, on the median side of the longitudinal muscles (as in *D. gigas*). The cords seem to be provided with an external investment of ganglion-cells along their whole length. The ganglionic swellings (fig. 3) appear to be shifted backwards, relatively to the segment to which they respectively belong, so that the middle of the segment on the dorsal side (as indicated by the ciliated rings) is in front of the corresponding ganglion.

In transverse section (fig. 10) it may be seen that each pair of ganglia is connected by a transverse commissure. I could not satisfy myself of the existence of ganglion-cells in connection with this commissure, although, as the whole ventral nervous system lies in the ectoderm, it is possible that some of the nuclei which are adjacent to the commissures may really belong to ganglion-cells, and not to the epithelial portion of the skin. No transverse commissures were discovered other than those which pass between the ganglia.

The brain is very large, and fills up nearly the whole of the præoral lobe (figs. 3, 9). It consists internally of fibres, and externally of numerous ganglion-cells arranged in groups. The structure of the brain is very complicated; its surface appears lobulated, owing to the arrangement of the ganglion-cells. A similar arrangement is figured by Repiachoff (12, pl. ii, fig. 10).

The brain gives off a pair of strong œsophageal commissures (fig. 9), which pass round the sides of the mouth to become connected with the ventral cords, as has been described by Weldon in *D. gigas*. The brain itself is, for the most part, separated from the skin by the basement membrane of the latter. The œsophageal commissures at first lie inside the basement-membrane, but perforate the latter shortly before they become continuous with the ventral cords.

On the ventral side, in front and on the median side of the origin of the œsophageal commissures, the brain becomes continuous with the ectoderm at two points, one on each side of the middle line (cf. fig. 6). It is probable that the tactile organs of the head itself receive their nerve-supply from this region of the brain, which, however, sends off at the same point an œsophageal nerve (figs. 6, 9, and 10) which may be traced, on each side of the œsophagus, as far as the end of the latter; these nerves were not observed to occur in the proventriculus. The œsophageal nerve supplies the wall of the œsophagus itself, and gives off a branch which can be traced as far as the surface of the muscular appendage.

The eyes, which are of a bright red colour, lie on the dorsal surface of the brain, immediately below the basement-membrane of the skin (fig. 9). Each consists of a double pigmented sac, filled with a clear substance, which no doubt functions as a lens. In surface view (fig. 1) the cavity of the eye is not seen, but it is shown in the horizontal section, fig. 7. Remembering that the plane of the section, fig. 9, is at right angles to that of the section, fig. 7, the difference between the two eyes in the former is readily accounted for by the obliquity of the section.

The ventral part of the head is provided with a pair of small sacs, each of which has an extremely fine lumen opening to the exterior at one side of the anterior portion of the mouth (fig. 9). These bodies are presumably sense-organs, since they are supplied by the above-mentioned œsophageal nerves. Similar organs are described by Repiachoff (12, pl. iv, figs. 1, 3, *y*) in *D. gyrociliatus*, in which species it must be noticed that they occur in addition to lateral, cephalic, ciliated pits.

Body-cavity.—The body-cavity is represented partly by irregular spaces in the loose connective tissue, as described by Weldon in *D. gigas*, and by Repiachoff in *D. gyrociliatus*, partly by more definite spaces, which seem to be specially connected with the internal ends of the nephridia. In males which are sexually mature, by far the greater part of the space between the alimentary canal and the skin is taken up by the very largely developed generative organs (*v.*

fig. 13). The further relations of the body-cavity may be conveniently considered in connection with the excretory and reproductive systems.

Nephridia.—Like *D. gyrociliatus*, as figured by Ed. Meyer (11, and as described, on Meyer's authority, in Lang's Polycladen, p. 678), *D. tæniatus* possesses five pairs of nephridia, whose arrangement is in some respects different from that of the same organs in *D. gyrociliatus*. It may be at once noted that the occurrence, in two species so distinct as *D. gyrociliatus* and *D. tæniatus*, of five pairs of nephridia, raises the question whether the body may not possibly consist of five metameres throughout the genus *Dinophilus*, in spite of variations in the number of the ciliated rings. Thus, according to Korschelt (6), Repiachoff (12)* and Meyer (11), *D. gyrociliatus* is characterised by the possession of seven post-oral ciliated rings (one of which is perianal), in spite of which fact there only five pairs of nephridia. It may, however, be noted that Korschelt figures (pl. xxii, fig. 43) a recently hatched (female) individual, in which the body consists of six segments, sharply marked off from one another, in addition to the tail.

In the female *D. tæniatus* the five pairs of nephridia are all alike, whilst in the male the fifth pair is modified as a part of the generative apparatus. The fifth nephridia of the female occur in the fifth segment of the body, on the ventral side of the intestine (behind the cæcal end of the stomach). The fourth nephridium has exactly the same position with regard to the stomach as the fourth nephridium of the male; it lies behind the posterior ovarian lobe. The third nephridium is situated between the two lobes of the ovary, whilst the second and first nephridia are in the same position as in the male sex.

The following, more detailed description refers entirely to the male, in which the nephridia can be more easily investigated than in the female. The general arrangement of the system may be understood from fig. 15, which illustrates the anatomy of a male *D. tæniatus* as seen from the ventral surface under a compressorium. The figure of course represents the combined results of a long series of observations, but it must be premised that the opacity of the animal was sufficient to prevent any complete elucidation of the structure of the nephridia.

The first four pairs of nephridia may be considered together. Each nephridium opens to the exterior on the ventral side of the body, and probably not far from the longitudinal nerve-cords. The observation of the exact point where the nephridium pierces the skin

the above-mentioned pigmented connective-tissue cells.

The internal end of the nephridium is composed of a triangular, ciliated appendage, the apex of which is inserted into the excretory portion of the tube. This insertion, in the case of the second, third, and fourth nephridia, takes place at some little distance from the proximal end of the excretory portion. The appendage is ciliated, the cilia together giving the appearance of a pointed flame-like structure which projects obliquely into the excretory portion of the organ. In certain conditions of the nephridium the ciliated appendage has exactly the appearance of a flame-cell, although as the animal dies and the cilia become more sluggish in their movements, the flame-like appearance is lost. I am inclined to believe, as the result of a long series of observations, that the appendage is provided with a number of cilia, which, working together, produce the optical illusion of a vibratile flame. This is almost certainly true of the portion of the tube described above as the duct, this region being undoubtedly lined by cilia, which, under certain conditions, give rise to a very flame-like effect.

In spite of having devoted a large amount of time to the observation of the ciliated appendages, I am unable to say whether or not

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* Repiachoff is strongly of opinion that there is no specific difference between Korschelt's *D. apatris* and the earlier described *D. gyrociliatus*.

* The form of each nephridium representing the result of one or more actual observations, made at different times.

was extremely difficult, but it may be taken as probable that the external aperture, in each case, is at a level between the two rings of cilia possessed by the segment to which a given nephridium belongs. The inner end of the first nephridium is very slightly behind the principal (second) præoral ring of cilia; this nephridium opens to the exterior on the first body-segment, and may be regarded as the equivalent of the head-kidney of a Trochosphere larva. The second nephridium commences at the anterior end of the stomach, runs at first dorsal to the testis, then bending round to open to the exterior on the ventral surface of the second segment. The third nephridium lies at the level of the middle segment, and, like the second, has its excretory portion situated on the dorsal surface of the testis, its duct curving round to open ventrally on the third segment. The fourth nephridium lies, in the fourth segment, on the ventral surface of the stomach, its internal end occurring close to the aperture from the stomach into the intestine. Its duct, unlike the ducts of the second and third nephridia, runs entirely ventral to the testis.

The internal end of each of the above nephridia lies in a perfectly definite space, which contains an orange fluid and which is probably merely a specialised portion of the general body-cavity. It is almost certainly the case that the spaces which surround the internal ends of the nephridia are continuous with one another, as shown on the right side of fig. 15. In the case of the first three nephridia, the space in question lies on either side of the alimentary canal, and in living specimens was usually most readily distinguishable in the region of the third nephridium, as a distinct cavity, apparently without proper walls, between the stomach and the membrane of the testis. In transverse sections it could usually be seen that this part of the body-cavity extended to the ventral side of the stomach (*v.* fig. 13), whilst in the region of the fourth nephridia, the median portion of the cavity was, in most specimens, observed to pass down ventrally as far as the skin, thus dividing the testis, in this region, into two symmetrical, right and left lobes. In the median space thus formed are situated the internal ends of the fourth nephridia.

The remainder of the general body-cavity consists of a meshwork of spaces, filling up the intervals between the various organs and the skin. These spaces are, like those described by Weldon in *D. gigas*, devoid of an epithelial lining. Many of the cells which bound these lacunæ are large, branching connective-tissue cells, which contain an orange pigment. The pigmented cells are usually more numerous in the male than in the female, their pigment in the female being often markedly paler in colour than in the male, whilst (in the female) their tint tends to be yellow rather than orange. The difference in the colouration of the two sexes, above alluded to in the description of the specific characters, is dependent on the condition of the connective-tissue cells.

Each nephridium (of the first four pairs) consists of three portions: (i) the ciliated appendage; (ii) the excretory portion; (iii) the duct. The entire nephridium is almost certainly composed of a small number of perforated cells, although no nuclei were discovered: it forms a moderately short tube, without convolutions, the curvature of the tube, as actually observed, doubtless depending to some extent on the position of the animal in the compressorium. Thus the differences between the nephridia of the two sides in fig. 15* probably imply nothing more than that the direction of the compression was not the same in all the observations made.

The excretory portion of the nephridium is of a distinct greenish-yellow or orange colour, the walls of this portion of the tube containing numerous colourless vacuoles, and granules of various sizes. One or two of the granules are very frequently large and deep orange in colour. The excretory portion is pear-shaped, the narrow end shading off insensibly, by gradual loss of the vacuoles and granules, into the duct. The first nephridia seem to be usually provided with two swollen portions, whose walls contain excretory granules and vacuoles, instead of with one only, as in the case of the remaining excretory organs. The nephridium is often suspended in a cord of the above-mentioned pigmented connective-tissue cells.

The internal end of the nephridium is composed of a triangular, ciliated appendage, the apex of which is inserted into the excretory portion of the tube. This insertion, in the case of the second, third, and fourth nephridia, takes place at some little distance from the proximal end of the excretory portion. The appendage is ciliated, the cilia together giving the appearance of a pointed flame-like structure which projects obliquely into the excretory portion of the organ. In certain conditions of the nephridium the ciliated appendage has exactly the appearance of a flame-cell, although as the animal dies and the cilia become more sluggish in their movements, the flame-like appearance is lost. I am inclined to believe, as the result of a long series of observations, that the appendage is provided with a number of cilia, which, working together, produce the optical illusion of a vibratile flame. This is almost certainly true of the portion of the tube described above as the duct, this region being undoubtedly lined by cilia, which, under certain conditions, give rise to a very flame-like effect.

In spite of having devoted a large amount of time to the observation of the ciliated appendages, I am unable to say whether or not

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* The form of each nephridium representing the result of one or more actual observations, made at different times.

these structures open into the portion of the body-cavity which undoubtedly surrounds them. In some cases the appendage appeared distinctly bifid (fig. 15), whilst in others it had a fimbriated appearance, and seemed to be composed of a large number of minute, elongated, pear-shaped bodies, each attached by its narrow end to the point where the appendage as a whole passed into the excretory portion of the tube. These minute bodies vibrated individually (*i. e.* not in connection with their neighbours) in the body-cavity space in which they were situated. These observations do not appear to favour the view that the ciliated appendage contains a single vibratile flame, nor indeed to render it easy to suppose that the appendage opens into the body-cavity.

At the same time, it must be noted that the ciliated appendages of the first nephridia are somewhat larger than those of the other nephridia, and that several observations were made which seemed to show that the appendage did really open into the body-cavity. In one of these cases I believed that I could see the individual cilia of the appendage projecting into the body-cavity. It is not impossible that the anterior nephridia have attained a somewhat higher degree of differentiation than the remainder.

The proximal end of the excretory portion, into which the cilia of the appendage project, as above described, does not seem to be ciliated, whilst the lumen of this region of the nephridium appears to be often in the condition of a series of isolated vacuoles rather than of a single passage continuous with the cavity of the rest of the organ. Cilia make their appearance towards the end of the pigmented portion, and can be followed uninterruptedly, from that point, as far as the external aperture. The "duct" has extremely delicate, colourless walls, and, as just stated, is richly ciliated internally.

Generative Organs.—A. *Male.*—The testes consist at first (as is shown by the examination of young individuals) of minute, paired, linear cords of cells (fig. 11), lying on the ventral side of the stomach in the general connective-tissue of the body.* It appeared probable that the testicular cells were simply differentiated connective-tissue cells. Owing to an injury to the tail end of the individual from which fig. 11 was drawn, it could not be ascertained whether or not a penis was already developed.

At a slightly later stage the cords of cells which constitute the young testes are found to have become slightly expanded in a lateral

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* It is not impossible that this and the next stage described may really be young conditions of the *female* generative organs, and that, for instance, the structure described as the penis may be the unpaired oviduct. I believe, however, that I am right in identifying the animals in question as young males.

direction, so as to form a pair of narrow, horizontally placed plates of cells, still separate from one another. The penis is already developed as a hollow mass of cells attached in its definitive position by a narrow stalk to the ventral ectoderm of the body. There is no connection between the testes and penis, nor could any vesiculæ seminales be identified with certainty in the sections on which the observation of this stage was made. As development proceeds, the lateral extension of the testes goes on increasing, and the two originally separate rudiments fuse from place to place across the middle line. The testis now consists of a solid plate, composed of a few layers of cells, extending along the ventral side of the stomach, and still showing obvious traces of its double origin. The testis next extends laterally round the stomach, still composed of a solid mass of cells. In the final condition, some of these sperm mother-cells are found in groups in various parts of the testis, whilst ripe and half-ripe spermatozoa are found moving about freely in the indefinite cavity which is by this time excavated in the interior of the organ. The testis is separated from the body-cavity by a distinct membrane.

Although, in the adult condition, the testis is constantly continuous across the middle line in its anterior and posterior regions, it is usually divided into two lateral halves, in the region of the aperture from the stomach into the intestine, by a median extension of the body-cavity, which, as already explained, contains the internal ends of the fourth nephridia. The testis, in its most fully-developed form, extends from the region of the muscular appendage of the œsophagus nearly as far as the anus, as shown in fig. 15.

Unripe spermatozoa are found, attached together in sperm-morulæ, in the cavity of the testis. The fully developed spermatozoon (fig. 4) is an extremely long, actively moving, undulating fibre. It hence closely resembles in form the spermatozoon of *D. vorticoides* as described by van Beneden (1) and Mereschkowsky (10) excepting that Mereschkowsky describes and figures a swollen head in the spermatozoon of *D. vorticoides*. I believe that no such structure occurs in *D. tæniatus*, although at the time when fresh material was accessible to me I was not familiar with Mereschkowsky's paper.

Although ripe spermatozoa may be found in any part of the adult testis, they are always present at its posterior end, if they have anywhere reached their mature condition. As has been already explained, the testes are fused together across the middle line in the region of the fifth body-segment, and the ripe spermatozoa which accumulate in this part of the organ are taken into the interior of a pair of vesiculæ seminales (*v.* fig. 15). In their most fully developed condition these structures are much larger than in the figure

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that while, for instance, fertilization was being effected near the posterior end of the body, a great mass of spermatozoa (obviously obtained on a previous occasion) was visible at the anterior end of the body. In many cases the females were enormously distended with spermatozoa, which could hardly have been all received at one time.

The common occurrence of great numbers of spermatozoa in the body of the supposed female might suggest that *D. tæniatus* was hermaphrodite. Such a supposition is rendered sufficiently improbable

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[*] Korschelt (6) has probably seen something of this process in *D. gyrociliatus*.

just alluded to (cf. fig. 3), and occupy a large proportion of the cavity of the fifth segment.

The connection between the testis and the vesiculæ seminales is by no means easy to discover in sections, but can be best made out by careful compression of the living animal. Under these conditions, it may be observed that the anterior end of the vesicula seminalis is quite closed, and that the communication with the testis is effected by the agency of a ciliated funnel, which passes forwards from the posterior end of the vesicula, and somewhat from its ventral surface, to open into the posterior median region of the testis (fig. 15). This region is reduced to a narrow space between the two vesiculæ seminales (and therefore ventral to the intestine) during the condition of full distension of these structures by spermatozoa.

The funnel and the adjoining part of the inner wall of the vesicula are ciliated, but I believe that cilia do not occur in all parts of the latter. The vesiculæ seminales never contain unripe spermatozoa, although mature, actively moving spermatozoa are to be found in the cavity of very young and small vesiculæ, even when no such spermatozoa could be seen in the testis itself. This implies that the spermatozoa tend to make their way to the posterior part of the testis as soon as they become ripe.

It is perhaps worth while to mention that the above account of the communication between the testis and the vesicula seminalis has been confirmed, in its general features, by the study of sections.

The fully developed vesiculæ seminales are regularly ovoid in form, with their principal axes parallel to the main axis of the body of the animal. The posterior pole of each vesicula passes into a very obvious duct, which opens laterally into the sheath of the copulatory organ.

The generative pore is a median structure, situated on the ventral side of the base of the tail, a little posterior to the level of the anus (figs. 3, 15). The pore opens into a vestibule, into which projects the extremity of the penis. This organ is embedded anteriorly in a solid glandular mass of cells, and consists of two parts. The first of these is composed of very distinct cells, of a glandular appearance, and staining very deeply with carmine or hæmatoxylin. These cells radiate in a single layer from the internal cavity of the organ. The second part of the penis projects into the generative vestibule, and consists of a series of narrow, spike-like rods (in which nuclei could be distinguished), which, lying side by side, form a truncated cone, open at its extremity, and continuous with the cavity of the penis.

A copulatory organ of the same general character as that above described is well known to occur in the dwarf males of *D. gyrociliatus* (Korschelt, Repiachoff, &c.), whilst from a figure (plate viii, fig. 7) given by M'Intosh (9) of *D. vorticoides* it appears probable that the entire male generative apparatus of this latter species closely resembles that of *D. tæniatus*.

So far as I am aware, copulation has not hitherto been actually proved to take place in any species of *Dinophilus*.* The proof that such a process takes place in *D. tæniatus* is very readily obtained by merely placing a considerable number of individuals of both sexes in a small quantity of sea-water, as in a watch-glass. Under these circumstances, it is noticed, even a very short time after the animals have been placed together, that here and there a male is attached, by means of its penis, to the body of a female. In these cases, the terminal, conical portion of the penis is protruded through the generative pore, and is passed into the skin of the female; spermatozoa are then seen to have passed from the vesiculæ seminales, through the skin of the female, and to be accumulating themselves into a mass immediately beneath the perforation made by the penis.

There seems to be no localisation of the spot at which spermatozoa can be introduced into the female. The penis can obviously be inserted into the skin at any point, as is shown by the fact that, in the cases actually observed, the point selected was sometimes in the region of the neck, in other cases far back in the body of the female, and in other cases near the middle of the body.

The act of copulation has no relation to the maturity of the ova of the female, nor is it prevented by the fact that the female has already received an ample supply of spermatozoa by a preceding operation. It was extremely difficult to discover any female, in which ovaries were recognisably developed, which did not contain large numbers of spermatozoa in its body-cavity. These were observed in almost any part of the body of the animal, their position being probably partly dependent on the manner in which fertilization had been previously effected. The spermatozoa show, however, a great tendency to accumulate into a large compact mass, situated in a space on the ventral side of the stomach (*v.* fig. 14, and description of the female generative organs). In some cases it was observed that the female was receiving spermatozoa simultaneously from two males, in others that while, for instance, fertilization was being effected near the posterior end of the body, a great mass of spermatozoa (obviously obtained on a previous occasion) was visible at the anterior end of the body. In many cases the females were enormously distended with spermatozoa, which could hardly have been all received at one time.

The common occurrence of great numbers of spermatozoa in the body of the supposed female might suggest that *D. tæniatus* was hermaphrodite. Such a supposition is rendered sufficiently improbable

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* Korschelt (6) has probably seen something of this process in *D. gyrociliatus*.

by the following considerations: (i) That no other species of *Dinophilus* is known to be hermaphrodite; (ii) that the process of fertilization was frequently observed in *D. tæniatus;* (iii) that the spermatozoa so constantly seen in the female of the same species were, without exception, ripe and actively moving, no trace of spermmorulæ or unripe spermatozoa being discernible. Such stages in the development of the spermatozoa were never missed in any adult male individual.

It will be noticed that the above-described process of copulation in *D. tæniatus* exactly resembles the processes which have been described by Lang (8, p. 231) in certain *Polyclada* (*Anonymus*, &c.)

The morphology of the vesiculæ seminales is one of the most interesting features of *D. tæniatus,* since there is reason to believe that these structures are the modified fifth nephridia of the male. The reasons for this conclusion are two:

(i) Five pairs of ordinary nephridia occur in the female *D. tæniatus* (as in the female *D. gyrociliatus*), whilst the most careful examination, often repeated, of the males of the same animal failed to show any trace, in that sex, of the existence of a fifth pair of undifferentiated nephridia.

(ii) The consideration of young stages of the vesiculæ seminales.

Fig. 5 represents the earliest of these stages which was observed. The vesiculæ seminales were in their definitive position in the fifth body-segment, and their indentification as vesiculæ was rendered sufficiently certain by the fact that they contained ripe spermatozoa. The vesiculæ were arranged in an obliquely transverse position, their outer portions ending blindly at a level between the two ciliated rings of the fifth segment, their inner ends opening into the cavity of the testis. A part of the vesicula immediately succeeding the internal aperture was lined with long cilia; the next part of the tube contained a small mass of spermatozoa. The penis was well developed, and obscure indications of a duct leading from the vesicula to the penis were observed; the existence of this duct was not, however, completely proved. The resemblance of the young vesicula seminalis to an ordinary nephridium was manifested, not only in its shape and position, but still more conspicuously by the fact that its walls contained an orange pigment, exactly resembling that so commonly found in the walls of the excretory tubes.

Stages intermediate between that represented in fig. 5 and the mature form of the vesicula seminalis were frequently observed. The final form is acquired by the gradual distension of the originally subcylindrical tube by spermatozoa, this distension being accompanied by an alteration in the direction of its axis, the result of which processes is that the end which, in the young vesicula, is external, is situated, in the adult condition, in front, the whole organ having now acquired an antero-posterior direction. The funnel, during the above changes, will naturally come to be situated near the posterior end of the organ.

There seems, therefore, fair reason to assume that the young vesicula seminalis shown in fig. 5 is morphologically the fifth nephridium; it must be especially noted that the funnel of the vesicula is in a position corresponding with that of the ciliated appendage of an ordinary nephridium, and that the original external aperture of the modified nephridium was probably (in the phylogenetic history of the organ) at the opposite end of the tube, which ultimately becomes the blind anterior end of the vesicula. The relations of the outer end of the young vesicula to the ciliated rings of the fifth segment further support this conclusion. The connection of the vesicula seminalis with the penis would, in this case, have to be regarded as having been acquired secondarily. Should the above account of the vesiculæ seminales of *D. tæniatus* be confirmed, the structure and mode of origin of these organs might be held to have an important bearing on the question of the phylogeny of the differentiated Chætopod nephridium. The structure of the first four nephridia in the male *D. tæniatus*, or of all five nephridia in the female, is obviously comparable with that of the head-kidney of a Chætopod larva. In this connection the figures given by Ed. Meyer (11) of the larval excretory organs of *Nereis* (Taf. xxvii, figs. 2, 3) and of *Polymnia* (Taf. xxvii, fig. 11) may be especially alluded to. The possibility of the conversion of the internal end of a head-kidney-like nephridium into a ciliated funnel, and of the entire nephridium into a vesicula seminalis, is a fact (if it be a fact) of some morphological interest.

Whilst the excretory nephridia of the male *D. tæniatus* open into a space which has been described above as a part of the body-cavity, the vesiculæ seminales open into the cavity of the testis. In certain other Archiannelids (*Protodrilus, Polygordius*), the space which is partially lined by generative cells, is certainly part of the body-cavity. From the analogy of these forms, it may perhaps be concluded that, in *Dinophilus*, the hardly differentiated space which occurs in the interior of the ripe testis is also a part of the body-cavity. In this case we could assume that whilst the excretory nephridia open into the general body-cavity, the vesiculæ seminales of *D. tæniatus* have acquired an opening into a special generative division of the cavity. Attention may be called to the similarity between the young generative organs shown in fig. 11 and the mesoblastic bands of a Chætopod larva, and also to the similarity between the subsequent history of the testis of *D. tæniatus* and of the body-cavity of the developing Chætopod. Although I make this suggestion with all reserve, it is perhaps possible* that in the connective-tissue lacunæ of the body of *Dinophilus* we have the representative of the so-called "primary body-cavity," whilst in the fully-developed male (fig. 13), the "secondary body-cavity" is represented by the cavity of the testis, with which the funnels of the vesiculæ seminales are connected.

B. *Female.*—The generative organs in the female *D. tæniatus* differ considerably from those of other known species of the genus, in the fact that the ovaries are four-lobed. The general arrangement of the ovaries will be understood by referring to fig. 2, where it will be seen that the ovaries, like the testes, are paired bodies, but that each half is subdivided into two lobes. Each lobe consists partly of small primordial ova and (in a moderately mature condition) partly of larger eggs which have already acquired the orange colour which characterises the ripe eggs. The ovaries are covered by a cellular investment, which is readily seen in fresh specimens to be continuous from lobe to lobe on each side of the body. The ovaries, as in *D. gigas*, are found on the ventral side of the stomach. No ducts could be discovered in the living animal. Spermatozoa, received during the process of copulation, occurred in almost every individual in which the ovaries were at this stage or more highly developed. In specimens in which the ova had become still further developed, the eggs were no longer confined to the four ovaries. As many as fourteen large spherical eggs of a distinct orange colour may, in such cases, occur on the ventral side of the stomach or intestine, and the two ovarian lobes of each side are then usually pushed apart from one another by the occurrence of ripe eggs between them.

Fig. 14 represents a transverse section through the region between the anterior and posterior ovaries of a female with numerous and fully-developed ova. On the ventral side of the stomach is a large space, containing a great mass of ripe spermatozoa, which appears to have no proper wall on its dorsal side at least, being in this region merely roofed in by the stomach. Laterally its walls are formed by the cellular investment of the ovaries, this investment passing across the middle line of the body on the ventral side of the space. In a section which passed through one of the ovaries on each side, the ovarian lobes would simply take the place of the ripe eggs shown in fig. 14. The cellular investment of the ovaries already noticed in fig. 2 would be seen to surround each lobe completely, and to be further continuous across the middle line on the ventral side of the interovarian space, exactly as in fig. 14.

Fig. 12 represents a longitudinal section through the two ovaries

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* As has previously been suggested, for other animals, by the Hertwigs.

of the same side at a much earlier stage of development, at a period, indeed, when the entire ovary is composed of a mass of small, uniform, primordial ova. The relations of the investment of the ovaries are further explained by this figure, in which it is seen that the space between the anterior and posterior lobes is, as in the later stage, devoid of any epithelium on its dorsal side. Ventrally, the space is floored by a single layer of cells, separated from the skin by loose connective tissue; the space itself contains (as was occasionally observed in older stages) a few free cells of unknown function.

In the absence of any developmental evidence it is not easy to say what is the nature of the interovarian cavity. From the analogy of the male, as well as from a consideration of the general arrangement of the ovaries, it would appear that the ovaries are primitively paired bodies, and not merely lateral thickenings of a median cavity. The interovarian cavity would thus be a specialised portion of the general body-cavity, which conclusion would be supported by the absence of any proper wall, the space being bounded partly by the investment of the ovaries and partly by the wall of the stomach. The conclusion is further strengthened by distinct evidence obtained from sections, that the internal ends of the fourth nephridia project into the space.

In most females observed in section there was found to be a mass of spermatozoa at the sides of the stomach and dorsal to the ovaries, these masses of spermatozoa usually passing continuously into the large central mass which is nearly always present in the interovarian cavity. The spaces in which these lateral masses of spermatozoa lie appear to be parts of the general body-cavity, which is hence continuous with the interovarian cavity at those points where the spermatozoa enter the latter. This continuity does not necessarily prove that the ventral space is really part of the body-cavity, as, from the method in which the spermatozoa are introduced into the female, they must probably often have to make their way through various obstructions in order to reach the ventral space.

The layer of cells connecting the two ovaries (figs. 12 and 14) across the middle ventral line of the body may thus be provisionally interpreted as resulting from the median fusion of two originally separate organs, and this process probably takes place at an early stage of development, as in the case of the testes of the male.

The interovarian cavity extends along the middle line of the body throughout the whole of the region of the stomach, and therefore occurs, not only between the ovaries themselves, but also behind and in front of the ovaries, which are lateral thickenings of the walls of the cavity, projecting into it. In consequence of this projection, the posterior part of the cavity in fig. 12 is separated (in the particular section in question) from that part which occurs between the anterior and posterior lobes; the posterior part of the cavity is of course continuous with the anterior part. It will be noticed from fig. 12 that the posterior part of the interovarian cavity has an epithelial wall on its dorsal side as well as on its ventral side, and the same is true of the anterior end of the cavity (not involved by the section shown in fig. 12). The complete conversion of the interovarian cavity into a tube which runs backwards below the intestine takes place at the level of the posterior ovarian lobes, and appears to be due to the fusion across the middle line of the investments of the ovaries of opposite sides. The tube thus formed runs backwards, becoming much smaller as it approaches the end of the body. In one specimen examined, the tube was distinguishable almost as far back as the anus, although very minute in the hinder part of its course.

In fig. 14, the eggs which are cut by the section are still outside the interovarian cavity. Most of the large eggs in this individual possessed two nuclei, as shown in one of those figured. They were further provided with a somewhat shrivelled membrane, which is probably the vitelline membrane. In the fresh condition, the only case noticed in which the vitelline membrane was acquired before the eggs reached the exterior was in a dead female, most of the tissues of which were beginning to break up into fragments.

In other sections of the series from which fig. 14 is taken, eggs are found in the interovarian space. The posterior, tubular continuation of this space may probably be regarded as an oviduct, although the process of egg-laying was not directly observed. It does not appear to me probable that the eggs are liberated by the death of the female, as Weldon (13) supposes to be the case in *D. gigas*.

In *D. vorticoides* (van Beneden, No. 1) and in the species described by Korschelt (6) as *D. apatris* (probably identical with *D. gyrociliatus*), the eggs are known to pass to the exterior by means of a minute pore situated on the ventral side of the animal, at the base of the tail. This pore is said not to be recognisable except when the eggs are being laid; the eggs completely lose their shape in passing through the aperture, but regain their spherical form on arriving in the water.

In *Protodrilus*, an animal to which *Dinophilus* is probably allied, the eggs are said by Uljanin and Repiachoff (*v.* Repiachoff, No. 12, p. 29) to escape from the body in the same way as in the above-mentioned species of *Dinophilus*. According to the observations of Uljanin, quoted and confirmed by Repiachoff, the ripe eggs of *Protodrilus* move about freely in the meshes of the network of connective tissue which fills the general body-cavity, passing from segment to segment through apertures which remain between the interlacing muscle-fibres constituting the dissepiments, and finally escape from the body on the ventral side of the last segment.

The above description shows that in *Protodrilus* the eggs fall into the general body-cavity, whilst the same is true of *D. gyrociliatus,* where the body-cavity opens to the exterior by means of a ventral pore situated near the base of the tail. The fact that in *D. tæniatus* the interovarian cavity has been above shown to be continued ventrally almost as far as the anus, taken in conjunction with the admitted difficulty of discovering the actual generative pore except when eggs are being laid, is distinctly in favour of the view that the eggs of *D. tæniatus* are laid in the same manner as that which has been already described in other species of *Dinophilus.* The analogy of *D. gyrociliatus,* in which the eggs undoubtedly fall into the general body-cavity, further suggests that the interovarian cavity, into which the ova fall in *D. tæniatus,* and which is continuous with a passage which leads towards the exterior, is similarly a part of the general body-cavity.

On the Affinities of Dinophilus.—It has been repeatedly pointed out, by Metschnikoff, Lang, Repiachoff, and Korschelt, that *Dinophilus* has affinities with the Annelids, and more particularly with the Archiannelids. Weldon (13) expresses himself even more definitely in favour of the Archiannelid relationships of this form, supporting his conclusions by referring to the muscular œsophageal organ, to the ciliated ventral surface, associated with lateral nerve-cords, and to the character of the excretory organs, as described by Meyer.

The similarities between *Dinophilus* and the admitted Archiannelids are so numerous and so striking that it can hardly be doubted that the above conclusion is amply justified by the facts. It may, however, be worth while to call attention to the special resemblances shown by *D. tæniatus* to admitted Archiannelids, and to one or two considerations which are suggested by the study of this animal.

1. *External ciliation.*—The existence of two rings of cilia on each segment, a feature which appears to be so characteristic of *D. tæniatus* is common to this species and to *Protodrilus Leuckartii* (Hatschek, No. 5). In the latter animal, each segment is provided with two rings, interrupted, as in *Dinophilus,* by the uniform cilia which cover the ventral surface (ventral groove in *Protodrilus*). Two præoral rings of cilia exist in *Protodrilus,* which, however, differs from *Dinophilus* in possessing an elongated "postoral region of the head" (containing the muscular appendage of the œsophagus, and hence probably identical with the first body-segment of *Dinophilus*) which bears five rings of cilia.

2. *Nervous system.*—In *Protodrilus*, as in *Dinophilus*, ventral nerve-cords run along the sides of the ciliated ventral region of the body. In both cases, these cords are connected with the brain by œsophageal commissures running round the sides of the mouth. Further, the œsophageal commissures in *Protodrilus* acquire a relation to the longitudinal muscles which is precisely similar to that which obtains, not only in the same region, but throughout the body, in *Dinophilus*. *Protodrilus* is well known to possess an almost continuous layer of longitudinal muscles, which are separated by small interspaces into two ventral and two dorsal groups. In the region of the head (*v.* Hatschek) the four groups of muscles become widely separated; by referring to Hatschek's fig. 14 (Taf. ii), representing a section passing through the region of the mouth, it will be seen that the ventral longitudinal muscles, in their relative size and in their relations to the œsophageal commissures, are exactly similar to the longitudinal muscles of *Dinophilus*. Still further forwards in *Protodrilus*, the dorsal muscles (which do not seem to be represented in *Dinophilus*) disappear altogether.

The ventral nervous system of *Protodrilus* is not known to be segmented, and Hatschek describes only one transverse commissure between the two cords, occurring at the junction of the "head" and body.

The researches of Foettinger (2) have shown that *Histriobdella* is to be regarded as an Archiannelid. Foettinger re-names this animal *Histriodrilus*, in order to mark its removal from the group of the Leeches to that of the Archiannelids.

In one respect, the nervous system of *Histriodrilus* shows a closer resemblance to that of *Dinophilus tæniatus* than is manifested by that of any other Archiannelid. The ventral nervous system has been shown by Foettinger to be definitely segmented, in correspondence with the external segmentation indicated by metameric constrictions of the skin. *Histriodrilus* possesses about eight ventral ganglia, which, however, differ from those of *Dinophilus* in being continuous across the middle ventral line. In the intersegmental regions alone, the ventral nervous system consists of separated ventro-lateral cords. Paired œsophageal nerves, similar to those of *Dinophilus*, are described and figured by Foettinger (pl. xxv, figs. 10, 11).

3. *Excretory and generative organs.*—The nephridia of *D. tæniatus* closely resemble those of *Protodrilus*, as described by Hatschek. According to this observer, each nephridium of *Protodrilus* commences with a small funnel, opening into the body-cavity, and bearing internally a single, very long cilium. The difficulty of the investigation of nephridia of this type makes it possible that the difference between the funnel in *Protodrilus* and the ciliated appendage in

Dinophilus is really less considerable that would appear from a comparison of Hatschek's figures with my own.

In many of its features, *Polygordius* differs from *Dinophilus* far more than does *Protodrilus*. This is sufficiently obvious by such characters of *Polygordius* as the fusion of the ventral nerve-cords, the absence of a muscular œsophageal appendage, the form of the nephridia, the greater development of the longitudinal muscles, &c. (cf. Fraipont, No. 3). All these facts justify us in concluding that *Polygordius* is less closely related to *Dinophilus* than is *Protodrilus*.

Histriodrilus (*Histriobdella*), on the contrary, is probably more closely related to *Dinophilus* than is *Protodrilus*. The similarity in the nervous systems of the two genera has been already alluded to, and the same general resemblances characterise the excretory and generative systems.

The arrangement of the excretory system in *Histriodrilus* is said to differ in the two sexes. The nephridia are somewhat S-shaped, intracellular tubes (unfortunately not figured by Foettinger in much detail); it is stated that five (or perhaps six) pairs are found in the male, and four pairs in the female; their relations to the segments are shown by means of woodcuts on p. 469 of Foettinger's Memoir. The second nephridium was observed on two occasions to end internally in a ciliated ampulla.

In the existence of structures connected with the generative apparatus, and which may possibly be regarded as modified nephridia, *Histriodrilus* again shows evidences of affinity to *Dinophilus*.

In the female *Histriodrilus* there are two ovaries, which are more or less fused posteriorly (as in *D. gigas*). These ovaries are situated, as in *Dinophilus*, on the ventral side of the alimentary canal. The ripe ova fall into the body-cavity, whence they are taken up by the ciliated funnels of a pair of tubes which open to the exterior laterally. These funnels (woodcut, p. 481 of Foettinger's paper) are large, and open into the body-cavity on the ventral side of the ovaries. The tubes into which the funnels lead possess a dilatation, containing spermatozoa which have been presumably derived from a male individual. The resemblance of these structures to the vesiculæ seminales of the male *D. tæniatus* (in which evidence has been brought forward above to show that the vesicula is a modified nephridium) suggests that they too are possibly modified nephridia.

The male generative organs of *Histriodrilus* appear to be very complicated, and their structure and functions were not thoroughly understood by Foettinger. The testes are placed on the ventral side of the alimentary canal, and are more or less paired in front, whilst they are fused posteriorly. At the posterior end of the generative segment are a pair of vesicles containing spermatozoa (Foettinger, pl. xxix, fig. 3) and obviously comparable with the vesiculæ seminales of *Dinophilus*. As in the latter animal, the vesicles open by ducts into a median organ, supposed by Foettinger to be copulatory, and of very complicated structure. No communication between the vesicles and the body-cavity or testis is described. Anteriorly the generative segment has a pair of lateral eversible penes. The existence of three separate copulatory organs in *Histriodrilus* recalls the condition met with in some Polyclads (*Anonymus, Thysanozoon*), where more than a single penis is found.

The above facts, together with other well-known and striking resemblances between *Dinophilus* on the one hand and *Protodrilus, Polygordius*, or *Histriodrilus* on the other, make it in the highest degree probable that *Dinophilus* is a true Archiannelid, as has been insisted on by so many of the more recent writers on the subject. In the number of segments, in the segmentation of the ventral nervous system, and in the arrangement of the muscular system, of the nephridia, and of the generative organs, *Dinophilus* more nearly approaches *Histriodrilus* than any of the remaining Archiannelids. On the other hand, in the character of the muscular appendage of the œsophagus, in the wide separation of the ventral nerve-cords, and in the method adopted by the female for laying its eggs, *Dinophilus* most closely resembles *Protodrilus*. Although *Dinophilus* seems so clearly an Archiannelid, it is nevertheless possible to hold with Korschelt, Weldon, and others that it gives evidence of having been derived from Platyhelminth-like ancestors.

Weldon (13) has called special attention to the significance of the muscular œsophageal appendage as a representative of the pharynx of a Planarian. The median position of the generative pore, and the method of fertilization adopted by the male *Dinophilus tæniatus*, further support the view of the Platyhelminth origin of the Archiannelids. The median penis of *D. tæniatus* and *D. gyrociliatus* is strictly comparable with the same structure in a Planarian, although it is probably a highly significant fact (if this is really the case) that this organ has entered into relations with a pair of modified nephridia which receive the spermatozoa from the testes.

Korschelt (6) and others have drawn attention to the remarkable fact that, whilst the female of one species of *Dinophilus* differs comparatively little from that of any other species, there are very great differences between the males of the various species. In *D. gyrociliatus* (including *D. apatris*) (and possibly in *D. metameroides*, in which the male is not known), there is very striking sexual dimorphism, the female being many times larger than the male. In *D. vorticoides, D. gigas*, and *D. tæniatus*, on the contrary, the males do not differ appreciably in size from the females. Whilst in *D. gigas* the male is said to have neither penis nor vesiculæ seminales, these structures are found in *D. tæniatus*, which is probably closely allied to *D. gigas*.

I have no observations which explain the disappearance of *D. tæniatus* during the summer. It is, however, important to notice that the eggs develop immediately after being laid. Small individuals were of common occurrence during the early part of April, although I did not succeed in finding the segmenting eggs till April 16th; the termination of my visit to Plymouth occurring a day or two after that date, I have no observations worth recording on the development. The eggs may be easily obtained by looking through mud drawn by means of a siphon from the bottom of a rock-pool which is inhabited by *D. tæniatus*. The general course of the development is apparently similar to that which has been described by Korschelt in *D. gyrociliatus* (*D. apatris*), the embryo, as in this species, acquiring most of its adult characters while still enclosed in its vitelline membrane. The absence of any metamorphosis in *Dinophilus* appears to me a noteworthy fact. It is perhaps a legitimate inference, from the facts known with regard to *Dinophilus*, that a Trochosphere stage is not to be expected in the ontogeny of this animal, since in the persistence of the præoral ring of cilia, and probably of the head-kidneys, and in the general characters of the alimentary canal, the adult *Dinophilus* may be considered to remain in a condition which is practically that of a Trochosphere.

Postscript.—I owe to the kindness of Dr. Norman the opportunity of referring to the description which has been given by G. N. R. Levinsen of *Dinophilus caudatus*, published in a paper which had previously been inaccessible to me (*Bidrag til Kundskab om Grönlands Turbellarienfauna*, Vidensk. Meddel. fra den naturh. Foren. i, Kjöbenhavn, 1879—1880).

D. caudatus is identified by Levinsen with the *Planaria caudata* of Fabricius (Fauna Groenlandica, 1780) and of O. F. Müller (Zool. Danica), and, in the words of Fabricius, "Habitat stupenda multitudine in confervis, et ulvis littoralibus, sæpe illas tegens."

It resembles the species above described as *D. tæniatus* in the division of the body into segments by deep constrictions of the skin, in the form of the testes, and in the existence of a penis and of vesiculæ seminales, but is stated to be so well known that detailed description is unnecessary; it is, moreover, unfortunate that Levinsen has published no figure of the species described by him.

It appears to me quite possible that "*D. tæniatus*" is identical with *D. caudatus*, but as the evidence on this point is quite inconclusive, I do not propose to withdraw, for the present at least, the specific name, which has already been published in the Proceedings of the Cambridge Philosophical Society (vol. vi). According to Levinsen, *D. caudatus* is the species which has been described by other writers as *D. vorticoides;* its colour is stated to be red, whilst no mention is made of the existence of four-lobed ovaries or of segmental ciliated rings.

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DESCRIPTION OF PLATES IX AND X.

Illustrating Mr. S. F. Harmer's paper, "Notes on the Anatomy of Dinophilus."

N.B.—All the figures refer to Dinophilus tæniatus.

Fig. 1.—Dorsal view of a young individual; the mouth, which is ventral, is represented as being visible through the semitransparent tissues of the head.

Fig. 2.—Ventral view of an adult female, somewhat compressed.

Fig. 3.—Longitudinal section of an adult male (combined from several sections). Most of the organs are shown as they appear in a median section; *i. e.* the brain, alimentary canal, testis, penis, and generative pore. The eye, ventral ganglia (the distinctness of which is slightly exaggerated), and vesicula seminalis, being laterally placed, would not

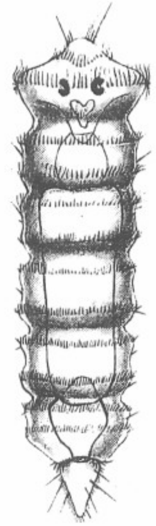


Fig. 1.

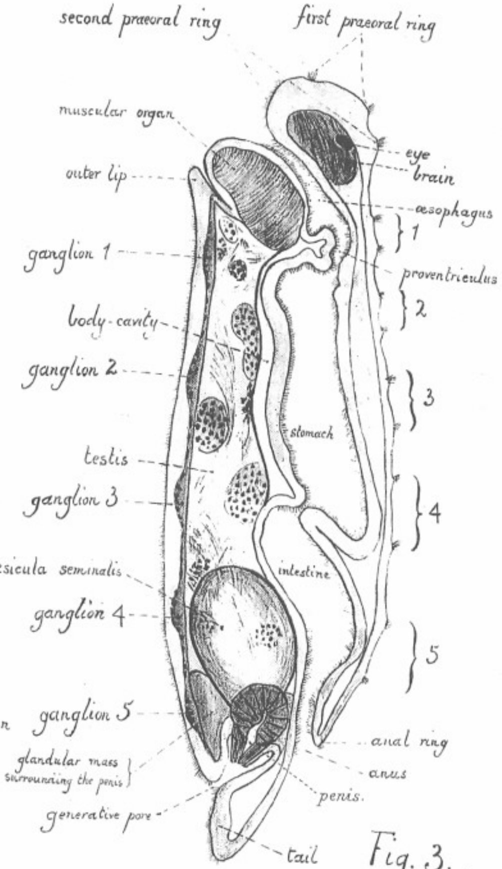


Fig. 3.

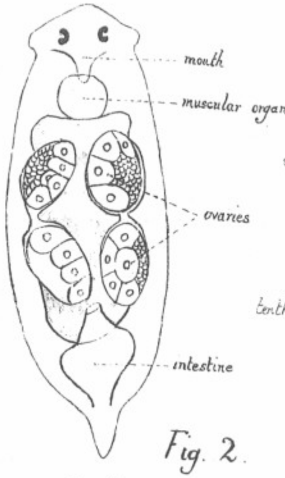


Fig. 2.

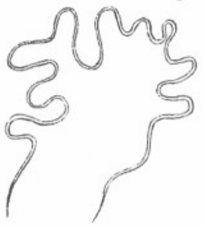


Fig. 4.

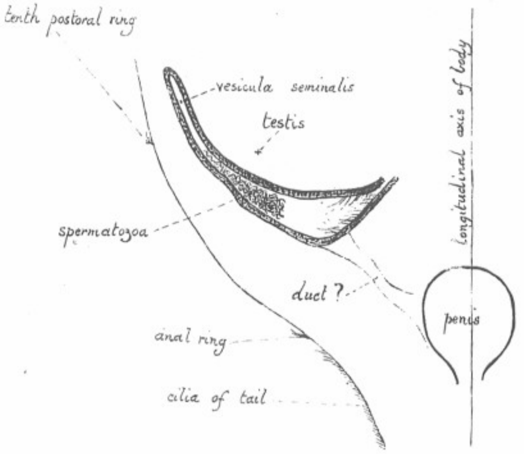


Fig. 5.

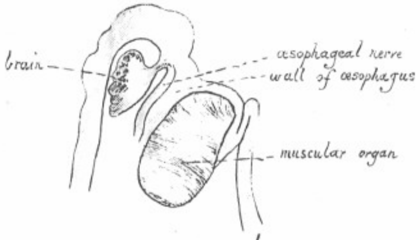
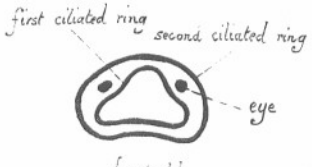


Fig. 6.

Fig. 7.



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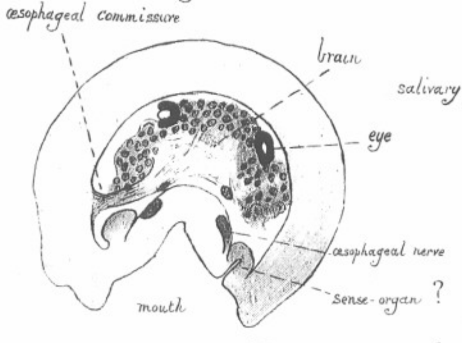

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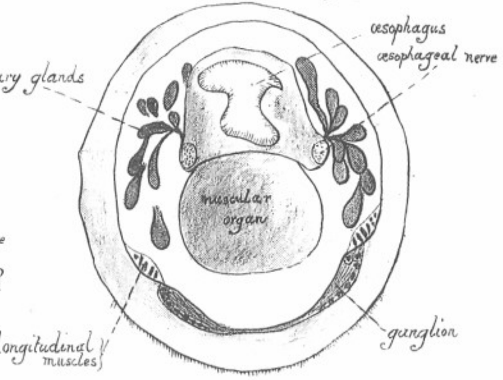


Fig. 10.

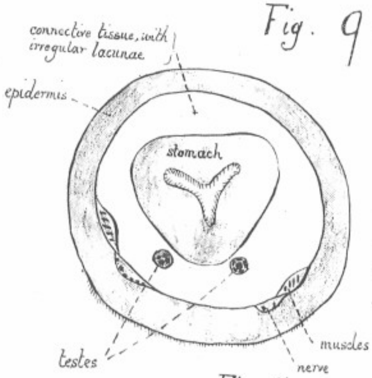
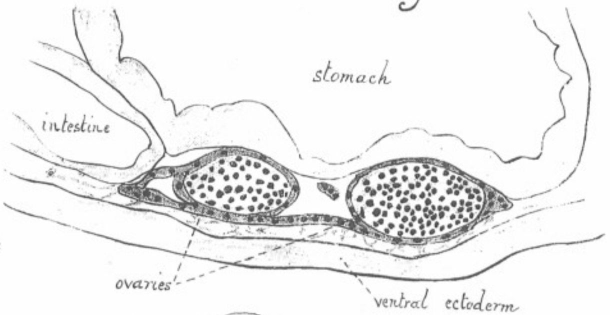


Fig. 11.



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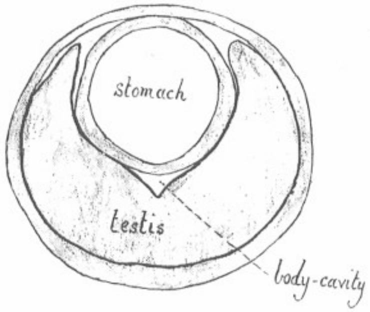

Fig. 13.

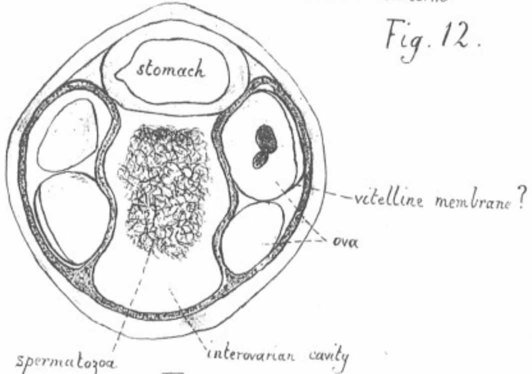

Fig. 14.

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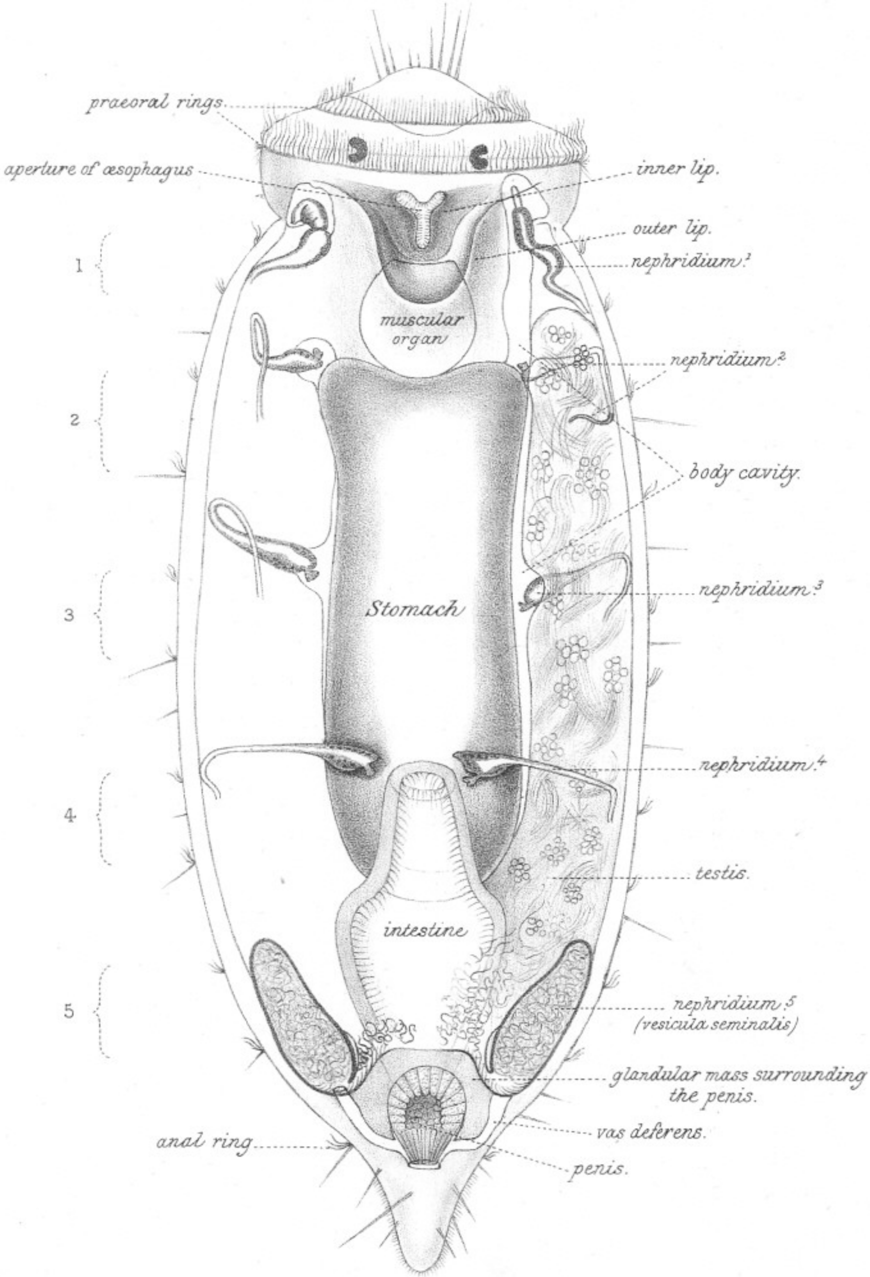

Fig. 15.

S. F. Harmer del. F. Huth, Lithr Edinr

appear in a strictly median section. The two ciliated rings of each of the five segments of the body are indicated by one of the brackets to which the numbers 1, 2, 3, 4, 5 refer.

FIG. 4.—Spermatozoon.

FIG. 5.—Ventral view of part of the posterior end of a young male, as seen in a compressorium. The vesicula seminalis is still very young and nephridum-like, opening at its internal end into the cavity of the testis. The existence of the structure marked "duct?" was not established with certainty.

FIG. 6.—Longitudinal section of head, almost median, showing one of the œsophageal nerves.

FIG. 7.—Horizontal section of eye.

FIG. 8.—View, seen from the front, of the surface of the head of an individual killed with hot corrosive sublimate.

FIG. 9.—Transverse section through the head, passing through the origin of one of the œsophageal commissures.

FIG. 10.—Transverse section through the region of the first postoral pair of ganglia.

FIG. 11.—Transverse section through the middle region of the body of a young individual (probably a male).

FIG. 12.—Longitudinal vertical section, not median, passing through the two ovaries of one side of the body, of a young female.

FIG. 13.—Transverse section through the middle region of the body of an adult male.

FIG. 14.—Transverse section through the region of the interval between the anterior and posterior ovaries of an adult female.

FIG. 15.—Ventral view of an adult male, as seen under strong compression in a compressorium. The figure represents the results of a long series of observations. The vesiculæ seminales have been drawn at a rather young stage of development; at their period of maximum development they would appear very much swollen, and would extend forwards as far as the posterior end of the stomach. The double ciliated rings of the five segments are indicated, as in fig. 3, by the numbers 1, 2, 3, 4, 5. The testis is not shown on the left side of the figure.