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A Contribution to our Knowledge of the Oligochæta of Tropical Eastern Africa.

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With Plates 16 and 17.

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1. Introductory.

There seems to be no doubt that at present tropical Africa furnishes the most remarkable and interesting representatives of the terrestrial Oligochæta. The family Eudrilidæ have their headquarters there; indeed, with the exception of the almost cosmopolitan genus Eudrilus, the family is confined to the Ethiopian region, not even extending, so far as we know at present, into the more northern part of the continent.

Eudrilidæ are already known from both the west and from the east side of Africa; they appear to abound principally in the equatorial region, though by no means unknown from

more southerly districts. The forms from the east have been mainly described by Dr. Michaelsen[1]; those from the western side of the continent by myself.[2] It has been shown by these investigations that, as a rule, the east and west of tropical Africa are inhabited by different genera, and always by different species. It also appears that, on the whole, the number of worms belonging to this family is greater on the east coast than on the west.

The peculiar interest attaching to this group of Oligochæta, independently of their distribution, concerns the structure of the reproductive organs; in most of the members of the group there are no spermatothecæ homologous with those of other Oligochæta; the place of these organs is taken by cœlomic sacs which acquire an opening to the exterior; rarely are there true spermatothecæ in addition to these cœlomic sacs; when such spermatothecæ are present they are partially or entirely enclosed by the sacs in question. In the more specialised members of the family the ovaries are also enclosed in sacs which communicate with the egg sacs and sometimes also with the spermatothecal sac. The Eudrilidæ, in fact, are an altogether remarkable family of Oligochæta, and it is desirable that our knowledge of them should be perfected. I am therefore glad to be able to contribute towards that end by the following account of a number of new forms collected in Zanzibar and Mombasa. I was enabled to acquire this material through the liberality of the Government Grant Committee of the Royal Society, who awarded me £100, with which I paid the costs of a collector; I was so fortunate as to secure the assistance of Mr. Frank Finn, to whom I am indebted for the careful way in which he carried out my instructions in the matter of preservation, &c.

[1] "Beschreibung der von Herrn Dr. F. Stuhlmann im Müirdungs gebiet des Sambesi gesammelten Terricolen," 'J. B. Hamb. wiss. Anat.,' vii. "Beschreibung der von Herrn Dr. F. Stuhlmann auf Sansibar und dem gegenüberliegenden Festlande gesammelten Terricolen," ibid., ix.

[2] "On the Structure of Two New Genera of Earthworms, &c.," 'Quart. Journ. Micr. Sci.,' vol. xxxii. "On the Structure of an Earthworm allied to Nemertodrilus, &c.," ibid.

I received from him a very large number of Oligochæta belonging to thirteen species at least; of these I describe eight in the present paper as new. The eight new species are the following:

Eudriloides Cotterilli, n. sp.
Eudriloides brunneus, n. sp.
Polytoreutus violaceus, n. sp.
Polytoreutus Finni, n. sp.
Polytoreutus kilindinensis, n. sp.
Pareudrilus stagnalis, n. gen., n. sp.
Gordiodrilus zanzibaricus, n. sp.
Alluroides Pordagei, n. sp.

In addition to these there were numerous examples in the collection of species apparently identical with Michaelsen's Stuhlmannia variabilis. This species is indeed to all appearance the most abundant form of Eudrilid in the regions visited by Mr. Finn. Besides the specimens preserved by Mr. Finn, he brought me a large number of living Oligochæta; the bulk of these were of this species.

Another species abundant in the gatherings was a Benhamia of small size, which I have not minutely studied as it showed no noteworthy differences from the smaller species described by Michaelsen.

In the mud from swamps brought home there was an abundant supply of a Dero with two long processes in addition to the four "gills;" this species seems to be identical with that named Dero Mülleri by Bousfield; in the same mud I found a Nais and an Enchytræid, neither of which have I identified; these two species, however, were immature, and they did not exhibit any characters of particular interest.

The worms were all of them, with the exception of the species of Eudriloides, the Benhamia, and the Polytoreutus, found in, or at the margin of swamps. The aquatic character of these Eudrilids is perhaps to be noted in connection with the total absence of dorsal pores, a character already known to distinguish the Eudrilidæ from the majority of "earthworms." The other forms were collected in soil outside a bungalow,

which was kept continually moist with the "slops" of the household. In no other situations were any Oligochæta to be found even after or during rain. It seems probable that in the dry season they retire deep within the ground or take refuge in swampy ground. As to the former suggestion, it is only supported by the presence of the worms in moist ground, for Mr. Finn informs me that he examined a deep trench in the course of its digging, and did not come upon any traces of these animals at all. It is possible that the comparative rarity of terrestrial Oligochæta in other tropical countries is to be accounted for by the fact that they lurk in swamps, and only come forth when the ground is thoroughly soaked, and fit for them to traverse. On the west coast of Africa the earthworms seem to be more purely terrestrial in habit. I hear from Mr. Finn that I am indirectly indebted to the kindness of General Mathews, principal minister of His Highness the Sultan of Zanzibar, to Mr. Pordage, to Mr. Macalister, and to Mr. Cotterill, for some of the material. To these gentlemen I beg to tender my thanks.

2. Description of New Species.

Eudriloides Cotterilli, n. sp. (figs. 1, 15, 16, 18—20).

A considerable number of examples of this species were collected by Mr. Cotterill outside a house at Kilindini. I have studied the species partly by the section method, and partly by dissection, and subsequent examination in glycerine.

The species is a small one—an inch or so when preserved.

The specimens were preserved with Perenyi's fluid and had, after preservation, hardly any definable colour, but the paired nephridia were very conspicuous as white masses shining through the transparent skin.

The prostomium of the worm is not large, nor does it appear to be continued by grooves on to the buccal segment. In longitudinal sections the prostomium seemed to be divided by a transverse fissure, a character which is known to distinguish Phreoryctes but has not been met with elsewhere in

this group. The setæ begin on the 2nd segment; they are strictly paired, and rather small in size, of the usual form, without any ornamentation. The two ventral pairs are rather further apart from each other than is either of them from the lateral pair of its side, but all the setæ are distinctly upon the ventral surface of the body. They appear to be absent from a few segments of the body. I did not find the ventral pair on the 13th segment on either side of the body, nor were there any traces to be discovered on any of the clitellar segments of either ventral or lateral pairs. They re-commence just on a level with the posterior boundary of the male papilla.

The clitellum is saddle-shaped. It occupies the Segments XIV—XVII. The median ventral area which is not part of the clitellum is chiefly occupied by the prominent pores of the reproductive organs. The whole area is hour-glass-shaped, being narrower in the middle than at either of the two ends. Independently of the very prominent papillæ which bear the reproductive orifices, there is a single papilla upon the 11th segment of an oval form. It lies on the posterior half of the segment, just causing a slight convexity of the boundary line between this segment and the 12th. The papilla lies entirely between the ventral setæ. It ends on each side just on a level with the inner of the two setæ of that pair. The transverse diameter of the papilla is greater than its antero-posterior diameter. The median spermatothecal pore lies on the line between Segments XIII/XIV. The actual orifice itself is circular and not large, not so large as the male pore. It is borne upon a very prominent swelling of the body-wall, which may extend as far forwards as the posterior boundary of Segment XII. In some specimens the terminal section of the spermatothecal sac is protruded from the aperture.

The oviducal pores are not conspicuous until the worm is carefully examined with a tolerably high power of the microscope; they are invisible under a low power; each aperture is on the 14th segment; it lies in a position exactly corresponding to the lateral setæ.

The single median male pore is a transversely elongated

aperture on the boundary line between Segments xvii/xviii; it is curved, the concavity being forwards; the two ends of the orifice are wider than the middle part—like the mouth of an Actinozoon; out of this orifice protrude the penial setæ; the aperture is upon a conspicuous papilla, which is larger than that which bears the spermatothecal pore; there are two small supplementary papillæ at the posterior angles of the cushion.

The external characters distinguish this species from the three others, viz. Eudriloides parvus, E. gypsatus, and E. titanotus.

In the first of these species there is a median papilla upon the 19th segment, but none is mentioned by Michaelsen upon the 11th. No papillæ are mentioned in the remaining two species; Eudriloides Cotterilli has not, as have the other species, a complete clitellum.

Vascular System.—There is at present no information as to the vascular system of this genus. Michaelsen's two papers,[1] which deal with the only species of Eudriloides known previously to the publication of this memoir, contain not a syllable about the blood-vessels. My own notes upon the subject, though few, will therefore be of some use. The dorsal vessel has a thick coating of peritoneal cells, and its walls are of some thickness; in this it contrasts with the supra-intestinal vessel, which, although of greater calibre, has thin walls; the ventral vessel has also a covering of quite conspicuous cells. In the 10th and 11th segments there are a pair of perivisceral vessels which arise from the supra-intestinal vessel alone. I have ascertained that they have no connection at all with the dorsal vessel. These "hearts" have thick muscular walls, which commence abruptly at their origin from the supra-intestinal trunk; they are furnished along their course with frequent valves, and the opening into the ventral vessel is guarded with valves, as is also that into the supra-intestinal; in front of these are a series of perivisceral trunks of less calibre which arise from the dorsal vessel only, and have no connection with the supra-intestinal. The dorsal

[1] Loc. cit. (on p. 201).

vessel has valves at the points where it perforates each septum.

The alimentary canal has a gizzard in Segment VI; the œsophagus has a number of pairs of peculiar glands, which are separately described in connection with those of other Eudrilids below. The intestine begins in Segment XV. The œsophagus is very vascular.

The first septum separates Segments IV/V; it is very delicate; behind this are five very thick septa, and then follow two others which are somewhat thicker than those which follow them.

The nephridia commence in Segment IV. They appear to open in front of the ventral setæ; in any case their duct was traced into the body-wall on a level with the ventral setæ; but whether it expands into a plexus like that of Libyodrilus, or opens at once on to the exterior, I am unable to say; the nephridial duct is not a conspicuous sac, as in some other Eudrilidæ, but a tube having an intra-cellular duct.

Reproductive organs.—This species has, as have the other species of the genus, only a single pair of testes; as is customary when there is but a single pair of these gonads, they lie in the 11th segment. Each testis is attached to the front wall of Segment XI; its shape is a little unusual. The testis is a curved rod of narrow dimensions, only a little broader than elsewhere near to its origin from the septum; if it were to lie in a perfectly straight line in its segment, as the testes usually do, it would reach as far as the funnels of the sperm ducts; it therefore has to be coiled in order to get it out of the way. The cells of which the testis are composed are not very distinct; the nuclei, however, are; these nuclei are larger and clearer at the base of the gonad.

The sperm-sacs lie in Segment XII; they depend from the anterior septum of this segment; they are fused together at their origin, and the question therefore arises as to whether we are to consider that there are two sacs or only a single bifid sac. The latter view would bring the sperm-sacs into correspondence with other parts of the generative apparatus; in any case they are not to be distinguished at their actual

origin. The sperm-sacs have a slightly racemose appearance; they are attached to the septum by a stalk; this stalk is hollow, and seems to open into the cavity of the 11th segment; it is of course lined by peritoneum, which is especially thick on that part of septum near to the origin of the sacs. The walls of the sacs are muscular and thin; there are also trabeculæ of muscular fibres which divide the interior of the sacs into compartments; these spaces are full of developing sperm. Michaelsen has described in Eudriloides gypsatus, in addition to these sacs, a sac in the 11th segment. I have looked carefully for this, but can only find a mass of sperm in that segment. This mass of sperm is not enclosed by any walls, and there are no blood-vessels for the supply of any sac, such as are abundantly obvious in the case of the sperm-sacs of the 12th segment.

The sperm duct runs along the body-wall just at the line of implantation of the ventral setæ; it is accompanied in its course by a blood-vessel. Near to the external orifice of the atria the sperm-duct perforates the outer coat of the atrium of its own side, and comes to lie where it is represented in fig. 1. Anteriorly the sperm-duct of each side opens into the cavity of the 11th segment by a large and much folded funnel; the two funnels together occupy a great deal of the space in the 11th segment; above the nerve cord the two funnels become fused together. The atria extend through three or four segments; they lie side by side, and are never coiled; this coiling, which is often seen in the long atria of other species, is rendered impossible in the present case by the thick muscular coat which forms the outer layer of the atria. This muscular layer consists of longitudinal and circular fibres; the circular fibres are internal. The epithelium lining the atrium appears to consist of two layers, but these are not by any means so thick as in other Eudrilidæ; in transverse sections of the atrium the lumen is seen to be crescentic; the convexity of the crescent is dorsal; below this lies the sperm-duct, which, as already stated, lies within the atrium: the sperm-duct passes just between the epithelium and the muscular layers; it is accompanied by a blood-vessel. Towards the external pore of the

two atria the lumen of each gets to be more and more oval in outline. As in other species of the genus Eudriloides, the aperture of the atria is furnished with penial setæ; there are two of these, one on each side; the penial seta is curved into an S-shape; the curvature is much more pronounced than that of the ordinary setæ; the free tip of the seta appears to be bifid; it is ornamented with a series of minute denticulations; these occupy a restricted area just in front of the actual tip of the seta; their shape can be understood by an inspection of the accompanying figure (fig. 20).

There is in connection with the male efferent apparatus a very complicated arrangement of muscles, recalling in many particulars the corresponding structures in Eudriloides brunneus. These structures are best elucidated in glycerine preparations of the worm from which the alimentary tract has been removed. In such a preparation the two penial setæ will be seen on either side of the male pore lying somewhat obliquely; near to the distal end of each seta a strong bundle of muscles is attached; the actual attachment is not extensive, but the muscles rapidly fan out, and where they are inserted on to the body-wall form a bundle of considerable dimensions. The muscular fibres forming these two bundles are bound up into separate muscles, as is shown in the figure illustrating this copulatory apparatus (fig. 18). On the opposite side of each seta there is another strip of muscles which runs obliquely almost in the same straight line as the first mentioned set; this bundle of muscles is, however, of equal diameter throughout, and is not nearly so wide as the first. It seems clear that these two sets of muscles have an opposite effect, moving the penial seta in different directions. We now come to the muscles of the bursa copulatrix. The two atria join to form a tube, which is much narrower than either of themselves; this unpaired tube is covered by a layer of muscles which runs transversely across the body, being attached to the body-wall in the immediate neighbourhood of the penial seta on each side. From the same point of origin arise a few fibres which are inserted upon the tube itself, and a still more slender

bundle which is inserted upon each of the two atria just in front of the point where they become fused. On the opposite side of the male pore is a bundle of muscular fibres running longitudinally. The total effect of the contraction of all these muscles, as it appears to me, would be the protrusion of the terminal apparatus of the male organs. I think that any of these muscles could play the part of retractors when the terminal sac is protruded; they could, I should imagine, serve both as retractors and protractors, according to the position of the organ.

The ovaries are in the 13th segment; they are unenclosed by any sac; the oviducts opposite to them open partly into the cavity of the 13th segment and partly into the egg-sac. In the independence of the ovaries, egg-sacs, and spermatothecal sac, the present species agrees with other Eudriloides.

The spermatothecal sac is much like that of Eudriloides brunneus; it opens on to the 13th segment and extends a little way in front of its external pore and reaches for some way behind it—as far as the 17th segment. I have studied the minute structure in a nearly mature specimen (quite mature except as regards the clitellum), and in a much younger specimen. The part of the spermatothecal sac lying in front of the aperture is not in any way different in structure from the rest. The walls of the sac are much thinner posteriorly than anteriorly; they are lined by a layer of large cells which are covered externally by a muscular coat; at the pore the structure is a little difficult to understand; it is shown in fig. 16. I could find no actual orifice, perhaps to be accounted for by the worm not being fully mature. The epidermis is thin just below the pouch and the muscular layers of the body-wall have disappeared. The spermatotheca is lined by the thick layer of cells referred to. These get so close together where the lumen narrows towards the pore that the lumen is entirely obliterated. It may be that this arrangement of the cells means that the protrusible termination of the male efferent apparatus can be thrust into the spermatotheca, but that the sperm cannot escape from the sac. The ventral half

of the pouch is encircled by a cup-shaped layer of epithelium whose cells are of an altogether different character. These cells are regular columnar cells with the nucleus at about the middle. They have every appearance of being epidermic cells invaginated, but I could not find that they were at any point continuous with the epidermis; there was a slight break on either side. This, however, is not fatal to the view that they are invaginated epidermic cells. These cells, so easily distinguishable by their characters from the thick mass of cells occupying the inner surface of the spermatothecal sac, do not immediately abut upon the latter; the two layers are separated by a thick, non-staining membrane which has every appearance of being of a chitinous natnre; it is homogeneous and of a faint horn colour; it completely divides the two layers of cells spoken of. This species has, like Eudriloides brunneus, glands at the sides of the spermatothecal sac (see fig. 19). These have, apparently, precisely the same structure as in that species, and need not therefore be particularly described; there is, however, but a single pair of them. The ducts of these glands open partly on the exterior direct, and partly through the layer of cells already spoken of and presumed to be formed by an invagination of the epidermis. This is additional evidence of the justice of this interpretation of the cells in question.

In a younger specimen of the species the spermatothecal sac was less fully developed; the posterior part of the sac is very thin-walled, and lies to one side of the nerve-cord; it looks like a piece of a septum detached, and has a roughly circular contour. Following the course of the sac in a series of sections, it is seen to get beneath the nerve-cord and to lose its lumen; at the same time it decreases in diameter; at the external aperture there is a protuberance of the body-wall in which there is a slit-like crescentic lumen bordered by tall columnar cells; a lumen also suddenly appears in the dorsal part of the sac which is quite independent of the crescentic lumen referred to; this, indeed, is merely the border line between the tall columnar cells, which I believe to be an invagination of the epidermis,

and the cells lining the spermatothecal sac. This specimen was remarkable for a plug of cells filling the lumen of the sac just where it narrows towards the pore. The plug of cells projects a little way into the lumen, as shown in the figure (fig. 16), and is furthermore rendered obvious by its less staining and by a fibrous appearance with scattered nuclei. In the more mature worm I could distinguish no such plug. Underneath the epidermis the mass of cells forming this plug spreads out into a more extensive layer.

One of the three individuals which I examined by longitudinal sections showed a difference from the typical structure of the genus in the presence of two pairs of sperm-duct funnels. To these corresponded two pairs of testes. The additional pair was in Segment x. This segment, like the following, was filled with a mass of developing sperm not contained in a sperm-sac or sperm reservoir. In other particulars I could detect no differences from other specimens. It should be stated, however, that the penial setæ could not be studied. These setæ are, of course, frequently most useful in distinguishing species. It must, therefore, be left undecided as to whether this worm is a distinct species of Eudriloides or is only a variety of Eudriloides Cotterilli.

Eudriloides brunneus, n. sp. (figs. 2, 10, 21—23).

Of this new species of Eudriloides I have examined four examples; two were dissected and two examined by means of transverse sections.

As compared with the first species of Eudriloides described in the present communication, this is large; it is not, however, quite so large as Michaelsen's Eudriloides gypsatus.

The colour of the species was of a uniform greyish brown (after preservation in alcohol); the setæ are exceedingly minute, so as to be quite invisible when the worm is examined by a hand lens alone. Michaelsen has commented upon the minute setæ of Eudriloides gypsatus.

The clitellum was not very distinct; it appears to occupy the greater part of Segments XIV—XVII; the clitellum is not

developed upon the ventral surface of the body; the segments of which it is composed are a little difficult to map on account of the fact that the segments are subdivided by numerous transverse furrows, which do not correspond to the actual segments themselves. The arrangement is shown in the accompanying figure (fig. 10). Behind the median spermatothecal pore, which lies upon the 13th segment, there is a furrow which is the boundary line of Segments XIII/XIV. This latter segment bears a median genital papilla of an oval form, the long axis of the papilla being disposed transversely; in front of and behind this papilla is a short furrow; then follow five other transverse furrows, the last of which marks the line between Segments XVI/XVII; the clitellum is developed laterally in the region which is occupied by the various furrows which have been described; on the 16th segment is a pair of genital papillæ, one on either side of the median line; behind the male pore is a single and median papilla upon the boundary line of Segments XIX/XX.

The spermatothecal pore is upon the 13th segment; it is very conspicuous, being borne upon a prominent projection, which is no doubt retractile. The male pore is even more conspicuous, and is of about the same area.

The nephridia of this species appear on a dissection to be paired structures like those of other Eudrilidæ. This is, indeed, the case, but the duct leading to the exterior forms a network within the integument, as in the genus Libyodrilus, where I have lately described it.[1] I have mainly studied the nephridial system of this worm in the anterior segments of the body; in transverse sections through one of the anterior segments—the ninth, I think—two longitudinal ducts are observable running just to the inside of the longitudinal muscular layer in the peritoneum on each side of the body. These ducts correspond in position with the pairs of setæ; the inner of the two on each side is the larger. Near to the septum dividing the segment from the one in front the inner duct

[1] "On the Structure of an Earthworm allied to Nemertodrilus, &c.," 'Quart. Journ. Micr. Sci.,' vol. xxxii, p. 553.

became continuous with the nephridium, and at that point gave off a duct which penetrated the body-wall and apparently opened on to the exterior, though I did not succeed in discovering the actual pore. Following the duct back, the longitudinal duct was found to vary in calibre from place to place; it was sometimes so reduced as to be very nearly invisible; at other times it became of much greater calibre than the average. In these places it seemed as if the duct formed a kind of rete. In the one segment I counted three or four of these retia; in the same segment three or four branches arose from the longitudinal duct to apparently reach the exterior. At the point where the septum was attached to the body-wall the nephridial duct penetrated still deeper within the longitudinal muscular coat. When the septum lifted away from the body-wall, the inner of the two longitudinal ducts was found to have resumed its original position. Immediately after the septum a branch was given off from the vessel which, penetrating into the body-wall, passed round the circumference of the body, ultimately joining the outer of the two longitudinal ducts. I confess that the actual junction was not observed, but the tube was traced up to a very minute distance away from the second of the two longitudinal vessels; in front of this there is a connection by way of the peritoneum—a duct, that is to say, runs from one longitudinal duct to the other in the peritoneum. Here, again, I was not able to find the actual opening at both ends; but I have no doubt, from the appearances presented, that this takes place. The second longitudinal duct—that running on a level with the outer pair of setæ—is not dilated, and shows no such retia as the inner duct; nor does it appear to give off any branches penetrating the integument and reaching the exterior; in other segments, and more particularly in the region of the body occupied by the clitellum, I could not find the connection of the nephridia from segment to segment, such as undoubtedly occurs in some, at any rate, of the anterior segments. The nephridial system of this species, therefore, is constructed on the plan of that which characterises the genus Libyodrilus, but is in a less differ-

entiated condition. The integumental plexus appears to be much less developed in Eudriloides than in Libyodrilus. After finding that this species of Eudriloides showed the above mentioned resemblances to Libyodrilus, I examined other species, with a view to discovering how far they agreed with the present. In Pareudrilus something of the same kind seems to occur (see below). In Stuhlmannia variabilis I traced the nephridial duct into the body-wall at the inner pair of setæ; instead of opening on to the exterior opposite to the point where it entered the body-wall, the tube passed along the body-wall below the circular muscular layer, and eventually opened on to the exterior on a level with the outer pair of setæ. In one instance, at any rate, I feel sure that the tube did not extend further than this point, but whether there was more than one opening on to the exterior for each nephridium I am not able to say with certainty. I think that in Eudriloides Cotterilli the same state of affairs is found. In the two latter cases the small size of the worms was a matter of difficulty; the corresponding fineness of the tubes rendered their discovery a matter of greater difficulty than in Eudriloides brunneus. I am almost inclined to think that all those species of Eudrilids in which Michaelsen has described ventral nephridiopores will be found to have a nephridial system like that of the species described here. One is tempted, in the instances brought forward here, to associate the complexity of the integumental plexus with the size of the worm. In Libyodrilus and in Eudriloides brunneus, which are the two largest species in which the nephridial system has been investigated, it is apparently the most complex; in Stuhlmannia, at any rate, it seems to be less complex. The only time that I was able to follow out the tube from the point where it entered the body-wall to its external pore, it seemed to me to pass straight from opposite the inner pair of setæ to the aperture on a level with the outer pair of setæ. In this connection Professor Hubrecht's[1] inter-

[1] "The Nephridiopores in the Earthworm," 'Tijdschr. Ned. Dierk. Ver.,' ser. 2, vol. iii, p. 226.

esting discovery of the course of the nephridial tube in certain species of Lumbricus (or Allolobophora) will occur to the reader. The facts discovered by Hubrecht, which I can confirm by my own experience, seem to be analogous to those described here. In those worms Hubrecht found that the nephridial duct, after entering the body-wall, passed along it between the two muscular layers to the opening, which is situated in some cases beyond the outer pair of setæ; there is, however, no question, in Lumbricus, of an integumental plexus. Still it is possible that there may be in this peculiar disposition of the nephridial duct in some Lumbricidæ a resemblance to the Eudrilidæ. We may have here a clue to the affinities of the Lumbricidæ, which has been hitherto wanting; but I do not propose to follow up this matter at present.

Reproductive Organs.—The sperm mass of the 11th segment is, like that of the next segment, apparently not enclosed in a sac. When the worm was dissected the mass of sperm could be easily disturbed by the dissecting needle. There was nothing to offer any resistance to the needle. There is, however, seemingly a functional equivalent of the missing sac. The septum which bound this segment posteriorly is comparatively thin, though thicker than the septa in the posterior region of the body. It is inserted on to the body-wall in the usual way. Just before its insertion a sheet of muscular tissue, of precisely the same thickness and general appearance as the septum, arises from the said septum and passes obliquely forwards, ultimately joining the anterior septum of the segment which encloses the mass of sperm. There is thus formed a chamber which encloses the mass of sperm, but which does not seem to be the exact equivalent of the sperm-sacs of other earthworms. It is well known that in many earthworms the successive septa are bound together by muscular bands running in various directions. This state of affairs is more especially characteristic of the anterior and often thickened septa. It is probable, therefore, that the materials for the formation of the septum above described already exist, and that the sheet of tissue which

bound the sperm mass of the 11th segment anteriorly is to be regarded as a development of these muscular threads. In another specimen, however, this peculiar disposition of the septa was absent.

The spermatothecal pouch of this species is single and median, extending from its opening on the border line of the 12th and 13th segments for three or four segments posteriorly. Anteriorly, also, it extends for a short distance beyond the external pore. This portion of the sac is conical in form, as is shown in the figure (fig. 22). The general appearance of the spermatotheca is closely similar to that figured by Michaelsen for Notykus emini (loc. cit. on p. 1, Taf. ii, fig. 8). The spermatothecal sac is also, as in that worm, without lateral branches, such as occur in Stuhlmannia and form a ring round the gut. There is, moreover, a further point of resemblance to Notykus illustrated in my figure, which may be compared with that of Michaelsen. Round the base of the sac in Notykus are represented in Michaelsen's drawing a pair of small glands lettered "*nt.*" It is described by Michaelsen as "ein kleines muskuloses Polster . . . . wahrscheinlich mit einem Hohlraum versehen, welcher durch die oben erwähnten spaltförmigen Öffnungen neben der Samentaschen-Öffnung ausmündet." I shall revert to the probable nature of these organs later. The anterior part of the spermatothecal pouch which lies in the 12th segment is histologically different from the region which it precedes. There is in this particular a remarkable analogy between these sacs which function as spermatothecæ and the true spermatothecæ of, for example, the Perichætidæ. In the latter the diverticula of the spermatothecæ have invariably a different structure from the pouches of which they are diverticula. This, it will be noticed, is also the case with the spermatothecal sac of the present worm. When the sac is examined by a series of transverse sections, from in front backwards, the first pair to appear in the series is of course the anterior diverticulum already referred to. This (fig. 23) is seen to have a circular form in section, and it presents a most curious resemblance to a

section through the œsophagus of a worm. Its walls are muscular and stout. They are lined within by a layer of darkly staining cells which have much the appearance of a low columnar epithelium; the lumen, however, is not simple. Numerous folds of the lining membrane are visible, which project far into the lumen, and nearly meet in the centre. These folds have a fairly regular arrangement. They are not only folds of the lining epithelium, but also of the strong muscular layer. This anterior diverticulum gradually passes into the bursa. The latter is a somewhat flattened sac, with strong muscular walls. It is lined by a regular columnar epithelium. This epithelium is markedly different in appearance from the epithelium lining the diverticulum of the spermatothecal sac; the two layers do not in any way pass into each other. In a series of sections the epithelium of the pouch terminates more or less abruptly; near to its end it gets to be covered by the cells of the diverticulum, which ultimately replace it. In a series of sections quite complete through the anterior of the two genital pores it was impossible to find any external aperture. This was also the case with a second series. Both worms, it should be said, were sexually mature. The epithelial lining of the pouch already referred to dips down towards the epidermis. Some little way above the epidermis it ends abruptly, and the lining of the sac is made up of cells of a quite different appearance. There is, however, no communication that I could discover between the inside of the bursa and the exterior of the body. A moderately thick layer, chiefly cellular, blocks the spot where the aperture should be. The principal part of the spermatothecal pouch lies behind the aperture. At first the pouch is lined with epidermic cells entirely similar to those which line the bursa. These cells form numerous folds in the interior of the sac. The folds, however, are not, as in the anterior diverticulum, supported by upgrowths of the muscular layer. Further back still the folds die away. At first, as already said, the pouch is lined by cells which resemble those of the bursa, and must be, I should imagine, formed by an ingrowth of the epidermis.

These cells are in places partly covered by isolated groups of cells much smaller than themselves. These cells lie to a great extent loose in the cavity of the spermatotheca; only here and there are they congregated into little heaps covering the epidermic lining of the pouch. Presently the covering of peritoneal cells gets to be closer, and coincidently with this the cells which they cover diminish in height, though they are still clearly separated from each other; indeed, the separation is usually marked by a darkly staining but structureless layer, which seems to be thrown off by the epidermic cells. The peritoneal cells which cover the subjacent epidermis are long and filamentous cells, which proliferate freely at their free extremity. The whole structure of the spermatothecal sac of this species seems, as in the case of Eudriloides Cotterilli, which it greatly resembles, to indicate that it is formed out of a peritoneal sac into which an epidermic invagination has grown. The fact that there seems to be no external pore is very remarkable and unintelligible. It is a further point of agreement with the other species of this genus described in the present paper, and also with Stuhlmannia. All the worms that I examined were sexually mature, but in no one of them were there any bodies of any sort within the spermatothecal sac, except the detached cells evidently derived from the lining peritoneal epithelium. In no one of them was there any pore leading to the exterior. It is, of course, possible that at stated seasons there is a pore which is at other times blocked; but this is only supposition, and I have no facts which suggest any interpretation of the use of these sacs. In front of and behind the point where the external aperture of the spermatothecæ ought to be, were it visible, is a glandular mass lying upon the bursa. This mass reaches down on either side, thus forming two rings, one anterior and one posterior, nearly enclosing the spermatothecal sac. These two ring-shaped glands are composed of small nucleated cells, which above the spermatotheca are arranged in a continuous mass. As the gland comes to lie at the sides of the sac its cells become arranged in a series of columns, which anastomose here and

there. In transverse section these columns are seen to be formed of about eight or ten cells whose nuclei lie peripherally. I could not detect any lumen for the most part. In places a lumen appeared to exist. Each disc of cells (as seen in transverse sections) is enclosed in a delicate sheath not closely adherent to the cells. These rows of glandular cells appeared to open on to the exterior, but their external apertures were not very evident. They were plainer in Eudriloides Cotterilli. Glands in the neighbourhood of the spermatothecal orifices are common in the Oligochæta; but the form of these glands in the present species is unlike that which I have seen in any other, excepting, of course, in the other species of the same genus described in the present paper. It may be that Michaelsen's Notykus is furnished with similar glands. The figure given by him seems to indicate a similarity.

The atrium (see fig. 2) differs in structure from that of Eudriloides Cotterilli in the fact that the muscular layers surrounding the glandular lining are thinner; but, though thin, both layers are there. The cellular lining of the atria resembles that of other Eudrilids and of nearly all other earthworms in being composed of two layers of cells. The layer immediately abutting upon the lumen is composed of columnar cells. In certain tracts of the atrium near to the external orifice this layer of cells is very plain, and resembles such columnar cells as line the sperm-duct and their funnel, &c. Elsewhere the inner lining of the atria consists of cells which are loaded with granules, and of which the nucleus has got obscured. The sharply marked layer of epithelium referred to is furthermore remarkable by the presence of cilia. Cilia are also visible in other parts of the atrium, but more obvious along this tract of unmodified epithelium referred to. I believe that this is the first record of ciliation of the atrium in any earthworm. The sperm-duct comes to lie within the muscular sheath of the atrium as in other Eudrilids, but I have not ascertained the exact spot at which it opens into the lumen.

The terminal pouch of the male efferent system is furnished

with a rather complicated arrangement of muscular bands. These are illustrated in the accompanying figure (fig. 21). Just behind the muscular bulbus arise by a common stalk the two atria. At the angle on either side of their entrance into the terminal bulbus is a bundle of muscular fibres running transversely to the longitudinal axis of the body. These muscular fibres appear to be mainly concerned with the penial seta, which is enclosed by them. From each of these bundles of fibres arises a flat strap-shaped band of muscles, which passes forwards obliquely and is inserted on to the body-wall just in front of the edge of the muscular bulbus. Besides these muscles, a number of delicate fibres pass from the parietes to be inserted round the periphery of the bulbus. The latter muscles are, I take it, retractors, while the single strap-shaped muscle on each side, perhaps, by its action when contracted, protrudes the bulbus by drawing back the body-wall just in front of it.

The penial seta of each side of the body lies, as already stated, in the mass of muscles lettered in my figure. These setæ are very strong and rather short, in fact very short if compared, for example, to those of Eudrilus Cotterilli. They are strongly curved into an S-shape, and are a deep yellow colour. The free extremity is not at all ornamented, but it thins off like the blade of a knife, and on this thin edge a few transverse striæ are to be noticed. The genital setæ of this species are decidedly peculiar in form and very characteristic of the species.

Pareudrilus stagnalis, n. g., n. sp. (fig. 9).

I have had for examination a considerable number of individuals of this worm, which is referred to a new genus. It presents upon a casual inspection all the characters of the genus Eudrilus, to which genus I was at first disposed to assign it. Not only are the colour and general appearance quite similar to those of that genus, which also appears to exist on the east coast of Africa, but the position of the reproductive pores are identical, and they are paired—a character which is

only known in the genus Eudrilus, and in the not very nearly allied Nemertodrilus. Nevertheless, a more detailed study of the worm has convinced me that it is an entirely distinct genus, showing, except for the paired apertures of the generative ducts, no particular likeness to any Eudrilus with which I am acquainted. It is probably true that the genus Eudrilus requires revision. It is possible that the individuals from Africa, America, New Zealand, &c., differ specifically among themselves. I confess that I have not been able to detect any such differences, and I am at a loss to understand by what characters Dr. Horst distinguishes his Eudrilus jullieni, though I admit that he only creates the new species in a very diffident manner. On the other hand, Michaelsen's Eudrilus pallidus is, in my opinion, unquestionably a distinct form. These two species of Eudrilus and Nemertodrilus griseus are at present the only Eudrilids with paired genital pores. These Michaelsen places in a distinct sub-family from the members of the family, the great majority of which have median unpaired pores. I shall attempt to show in the sequel that this character is not alone sufficient to distinguish two such groups; that the resemblances between the genus Pareudrilus and certain genera of the sub-family Teleudrilini is closer than that which obtains between Pareudrilus and Eudrilus.

The colour of this worm is a dark purplish brown upon the dorsal surface, becoming light below. The colour was not well preserved in specimens that had been treated with Perenyi's solution. In a single individual, which was brought home alive and preserved by myself in gradually increasing strengths of alcohol, the colour was very dark, as dark as during life; it was much bluer than the rest. All the specimens were found either in the mud at the edge of a pond on Mombasa Island or from a bog up country about four miles from the coast line opposite to Mombasa. The length of a worm selected for measurement was 63 mm., the breadth 4 mm.; this represents about the average size. The prostomium is continued for a short distance on to the peristomial segment by two grooves enclos-

ing a narrow space. The setæ are strictly paired, and ventral in position; the last segment of the body had four pairs just like those of any other segment. The only modification of the setæ that I could see was that the ventral setæ of Segment XVII were wanting, being here replaced by the large penial setæ.

The male pores are paired. They lie on the border line of Segments XVII/XVIII. In one or two specimens a round mass was protruded from the pore which I take to be the partially protruded bulbus atrii. The male pores are on a line with the ventral setæ.

The spermatothecal pore is on the border line of Segments XIV/XV. The clitellum I am unable to place. The only specially noteworthy matter to be recorded about the epidermis is that there is no trace whatever of the peculiar sense bodies, so like the Pacinian corpuscles of Vertebrates, and so commonly met with among the Eudrilidæ. The circular muscular layer can be seen in longitudinal sections to show a decidedly bipinnate arrangement of its fibres; these are grouped into narrowish tracts which are two to four fibres wide. The fibres of the circular muscular layer are laxer in their packing than the longitudinal layer. The interspaces are filled up by delicate strands of an appearance like that of connective tissue. The pigment is chiefly lodged in this outer layer of muscles. It is disposed in tracts that follow the direction of the fibres. Here and there threads of pigment pass down through the longitudinal layer following the course of the blood-vessels. These are so regular in their arrangement that the longitudinal muscular layer is divided up by them into a series of squarish blocks. The peritoneum lining the walls of the body is also pigmented, and pigment also occurs in the peritoneum covering the septa.

The body-cavity contains in parts numerous corpuscles.

The septa are, as in so many, if not in all, earthworms, not attached to the parietes entirely along the grooves which correspond to the external metamerism. The first septum divides Segments V/VI. It is very delicate. The next six are thick-

ened, but not so greatly as is so often the case. The next septum is also thicker than those which follow, but not so thick as those which precede it. All these thickened septa lie behind the gizzard. The anterior septa are cup-shaped.

The alimentary canal is differentiated into a gizzard which lies in the 6th segment. It is long and rather narrow. The œsophagus which follows extends as far as the 17th segment. It is very vascular throughout its whole length, and the lining membrane is so folded that in cross sections the edges look like a mass of tubes containing blood and cut across. The œsophagus is entirely unprovided with glands of any kind appended to it. The intestine has a very small typhlosole.

The nephridia are paired structures. Those of the posterior segments are, as is the general rule, much more obvious in dissections than the few most anterior. This is due to the development of the peritoneal cells which clothe them. These cells are often filled with quite large lumps of an amorphous secretion which stains darkly in borax carmine. It is these secretions which give the white colour and therefore the conspicuous appearance to the nephridia in the posterior segments. When the worm was examined with a hand lens, or even mounted in glycerine on a slide and studied with comparatively high powers of the microscope, there was no indication of nephridiopores. These are usually conspicuous in the Eudrilidæ, but they were absolutely invisible in Pareudrilus.

The reason for the apparent absence of nephridiopores was revealed by an examination of transverse sections. In such preparations the duct of the nephridium could be easily traced into the body-wall in the region of the ventral pair of setæ; the duct of the nephridium was quite obvious on account of its considerable width, and the fact that it has an intercellular lumen. Directly it penetrates the body-wall it becomes of less calibre, and instead of opening on to the exterior forms a duct which runs right round the body-wall on the boundary line between the two muscular layers, and in immediate proximity

to the principal nerve. I have in many cases followed out these ducts to the dorsal mid-line. I am inclined to believe that there is a connection between those belonging to the nephridia of opposite sides of the body. In any case the connection below the nerve cord seems to exist, the duct as it enters the circular muscular layer dividing into a right and left half. The arrangement of the nephridia of this worm is very similar to that which characterises the genus Libyodrilus, but in Libyodrilus there are not only numerous branches of the circular ducts which lead to the exterior, but numerous branches which lead in other directions, thus forming a plexus of tubes within the body-wall. In the present species I did not observe anything of the kind. In one case I found a branch apparently leading to the exterior. Such branches cannot, I am convinced, be very numerous or they would have been more obvious; on the other hand, fine tubes would be very difficult to detect without a special mode of demonstration, and it seems likely that the present species has more resemblance to Libyodrilus than I have at present been able to discover.

The vascular system has not been studied in great detail. In the intestinal region the dorsal vessel gives off three pairs of branches in each segment. The vessel itself lies upon the chloragogen cells, and is covered superiorly by a layer of thin cells, which are not continuous with those of the intestine. Here and there are delicate muscular strands, two or three fibres wide, attaching the dorsal vessel to the intestine; they pass from the muscular layer of one to the muscular layer of the other. There are six or seven of them on each side in each segment. The openings into the dorsal vessel of the branches are guarded by valves. Two pairs of vessels supply the intestinal walls, the third pair spread out over the septum.

Reproductive organs.—Unfortunately there was only a single specimen out of the ten or a dozen examples collected for me that was sexually mature. In this individual the generative organs were dissected, parts of them being investigated later by the section method.

The ovaries were not seen in this specimen, but I have found that they occupy the normal position in the 13th segment. Apparently they are enclosed in a large sac which extends from the septum bounding the 11th and 12th segments. This sac (see fig. 9) is somewhat pear-shaped; it gradually narrows to a fine tube which opens into the large spermatothecal sac. The latter opens on to the exterior between the Segments XIV/XV. The pear-shaped sac, which I believe involves the ovary, is the "ovarialblase" of Michaelsen. A narrow and short tube leads from it to the egg-sac, which occupies the usual position attached to the anterior wall of the 14th segment. From the egg-sac leads another tube, which appears to open into the ovarian sac. This tube, as I have ascertained from a continual series of sections through the entire apparatus, only lies within the ovarian sac; its lumen does not communicate with that of the ovarian sac; the tube soon issues again from the sac, and opens on to the exterior by the oviducal pore. The first tube mentioned which connects the egg-sac with the ovarian sac is really a portion of the funnel of the oviduct—that portion which in other Oligochæta does not open into the egg-sac, but freely into the cavity of the 13th segment. As in the present species, there is a sac developed which involves the ovary; it must happen that the funnel partly communicates with the sac in question. As the latter grows a stretch is put upon the funnel which grows out in the way that we see. The spermatothecal sac is a large pouch which is somewhat bilobed at its free extremity. This region lies posteriorly to the end which opens on to the exterior. In sections it is seen to be lined by an epithelium which is columnar in form, and shows no signs of that proliferation so frequently seen in the spermatothecal sacs of these Annelids. Its interior is folded.

The male organs of generation are as in many other Eudrilids. There are two pairs of testes situated in Segments X and XI; the sperm sacs are in Segments XI and XII, and, like the testes, are attached to the front walls of their segments. The sperm-ducts retain their distinctness until their point of

opening into the atrium. The atria lie perfectly straight on each side of the body; they are comparatively short, and are not twisted as is so frequently the case with the longer atria of other species. Each atrium consists of two parts; the external pore leads into a nearly spherical and very muscular bulbus; from this arises the atrium proper. This tube is quite as wide as the terminal bulbus, and has a nacreous appearance. This appearance is of course due to the stout muscular walls of the organ. In longitudinal sections the atrium is seen to be composed of four layers exclusive of the peritoneum; beneath the peritoneum is a layer of longitudinally disposed fibres; beneath this, again, a layer of circular fibres. These two layers are of about the same diameter. The lining membrane of the atrium is built up of two strata of epithelium; the innermost layer is composed of not very tall columnar cells, outside which are several layers of slightly staining pear-shaped glandular cells. The two layers of epithelium together are twice as thick as the muscular coats.

Each atrium is accompanied by a long, thin, muscular sac, which is nearly, if not quite, as long as the atrium itself. This sac is placed to the outside of the atrium, and is slightly curbed. Each of the two sacs contains a single very long penial seta. It is very thin, and curved more sharply at the free extremity. The free end of the seta expands at the actual extremity into a thin, flattened plate; just before this the seta is beset with a few short spinelets.

I have been able to study the female reproductive system in immature worms, and to ascertain that the spermathecal apparatus is formed from at least two sources. The spermatotheca appears to be formed by an epidermic invagination. Its lining epithelium is continuous with the epidermis. This sac is large and has very thick walls. It appears at first sight to be independent of any other part of the system and I believe that originally it is so. However, in all the specimens examined by me there is a strand of tissue, principally constructed of muscular fibres, which has in the immediate neighbourhood of the spermatotheca no lumen. This

solid strand joins the spermatotheca. Traced in the opposite direction it is seen to gradually develop a lumen, which gets wider and wider until it expands into a trumpet-shaped orifice which opens into the 13th segment. It seems in fact to be clear that this tube, which ultimately forms the communication between the ovary egg-sac and spermatotheca, is merely a backward growth of the septum separating Segments XIII/XIV. The oviducal funnel lies just above the mouth of this diverticulum of the septum, and is placed within the mouth of the egg-sac. The oviduct itself, shortly after it expands to form the funnel, projects into the interior of the septal sac; it does not open into it, but is enclosed by the walls of the said sac. At this stage the ovary is quite free, and is attached in the usual position to the anterior septum of the 13th segment.

The development of the corresponding regions of the female generative apparatus has been studied by myself in Libyodrilus violaceus; I was able to show that nearly the whole of the large spermatothecal sac originated from the cœlom, the septa being modified to form its walls; at most the merest trace of an invaginated part was to be found at the external orifice. I suggested that the large spermatothecal sacs of Eudrilus and Teleudrilus were also probably to be regarded as the homologues of the unpaired sac of Libyodrilus. The facts that I make known in the present paper do not lead me to adhere to that opinion. For in Pareudrilus it seems to be more than probable that the whole of the spermatothecal sac is an invagination, and that the egg-conducting apparatus only is of mesoblastic origin, and has a cavity which is an enclosed section of the cœlom. The nature of the spermatothecal sacs of the Eudrilidæ was first proved by myself to be different from that of other earthworms in the paper upon Libyodrilus referred to; at least it was rendered exceedingly probable that the conditions obtaining in Libyodrilus were not confined to that genus, but were characteristic of the whole gronp. Rosa, however, independently in point of observation, but subsequently to myself in date of

publication, arrived at the same results. His results, however, were not the outcome of a study of the young stages, but of a comparison of the structure of the several regions in the adult. He found that the epithelial lining of the sac stopped abruptly at a point not far removed from the external aperture, and gave place to a layer of cells of an entirely different character, and like the peritoneal epithelium. It may, I think, be regarded as certain that a great part of the complicated system of spaces surrounding the ovary, and communicating with the exterior, in the Eudrilidæ are derivatives of the cœlom, but it is also clear that a variable tract of what has been termed the spermatotheca is really an invagination of the epidermis, and is therefore comparable to the spermathecæ of other worms. I shall recur to this subject in describing the anatomy of some species of Eudriloides. The development of the sac *a* shows how the oviduct comes to be partly enveloped by it; as it is simply a part of the cœlom, there is nothing to be surprised at in the fact that the oviduct lies within it.

§ Affinities of Pareudrilus.

This genus evidently is referable to the second of the two sub-families into which I divide the Eudrilidæ (see below). It has no integumental sense-organs of the characteristic form found in Eudrilus and other allied genera. The sperm-ducts are not dilated at their junction with the funnels. There are no calciferous glands. It is the only genus in this sub-family besides Nemertodrilus which has paired reproductive apertures. A very marked peculiarity of the present genus is arrangement of the nephridia. This is only paralleled, so far as we know at the present time, in the West African genus Libyodrilus. In that genus there is a complex system of integumental nephridial tubes. Nevertheless it is not perhaps the only other genus in which this peculiarity occurs. In the description given by Michaelsen of Megachæta tenuis, it is stated that the nephridiopores could not be discovered; so, too, with Notykus and Metadrilus.

In the latter genus, however, Michaelsen was unable to see the nephridiopores, but found (by transverse sections) that the nephridiopores were placed in the neighbourhood of the ventral setæ. It seems to me to be possible that in these species there are nephridia of the type which characterise the genera Libyodrilus and Pareudrilus. When the nephridia are of the usual form, the orifices are so conspicuous that it is almost impossible to overlook them. In these three genera, moreover, as well as in Libyodrilus, the atria are comparatively short and have very muscular walls. These are additional points of resemblance to Pareudrilus. Pareudrilus differs from Libyodrilus mainly in the form of the female reproductive apparatus, and in the absence of the three posterior gizzards. With Metadrilus, the genus Pareudrilus agrees in the position of the spermatothecal orifice. But in Metadrilus the spermatothecæ are much reduced, and there are besides only the rudiments of penial setæ. The affinities of Pareudrilus are with the genera mentioned, but no one of them can be said to be much nearer than the others.

Polytoreutus violaceus, n. sp. (figs. 3, 7).

Two species of the genus Polytoreutus have been at present described. The type species of the genus, P. cœruleus, was described briefly by Michaelsen in a preliminary account of the earthworms of Zanzibar and the opposite mainland,[1] and subsequently re-described in a more thorough fashion.[1] A second form, P. magilensis, was afterwards described by myself from Magila, East Africa.[2] I have now to add a third species, which I name P. violaceus, on account of the colour of the worms.

There were four examples of this species in the collection; all of them were fortunately sexually mature, and all of them were about the same size. The length of one individual which was selected for measurement was 83 mm., its diameter 4 mm.

[1] Loc. cit. (on p. 201).

[2] "Some New Species and Two New Genera of Earthworms," 'Quart. Journ. Micr. Sci.,' vol. xxxiv.

The species is therefore fairly stout in build. This individual had 190 segments. The size of the species is therefore about the same as that of Polytoreutus cœruleus, and considerably less than that of P. magilensis.

The dorsal surface of the preserved specimens was of a reddish purple, bluer perhaps in some than in others; but there was nothing that could be fairly described as "leuchtend himmelblau," a term which Michaelsen uses in writing of Polytoreutus cœruleus. The under surface was yellowish. The clitellum also was readily distinguishable from the rest of the body by its yellowish coloration. The coloration of this species was indeed almost, if not exactly, that of the genus Eudrilus.

The prostomium is broad and does not indent in the least the buccal segment. This is a generic character, and not peculiar to the present species.

The clitellum occupies Segments XIV—XVIII or in some specimens XVII only. It is less developed on the ventral than on the dorsal or lateral surface, and it is here only that the boundaries of the segments, which compose it, are clearly visible. The clitellum may in fact be spoken of as "saddle-shaped," though there is really no distinction to be drawn between a clitellum of this kind and a "cingulum." In both the remaining species of the genus the clitellum has been described as complete, and consists of an additional segment, the 13th.

The nephridiopores are lateral in position.

The setæ are paired, and are nowhere deficient except upon Segment XII (see below). The two setæ of each of the ventral pairs are, however, further apart from each other than are those of the lateral pairs. This arrangement was apparent on the posterior as well as on the anterior segments of the body; it is not peculiar to the present species, but also characterises P. magilensis and P. cœruleus. Michaelsen found no setæ upon the clitellum of the last-mentioned species; they were certainly not absent from this region of the body in Polytoreutus violaceus.

The median genital pores lie, as in the other two species,

on Segments xvii—xix. The middle region of the 18th segment is occupied by a protuberant swelling of the body-wall, which also extends for a short distance on to the segment in front; this lies entirely between the ventral setæ. The posterior border of this projection appears to be the boundary line of Segments xviii/xix. Anteriorly, however, the border line of Segments xvii/xviii is seen to end on each side behind the anterior part of this protuberant pad. The anterior orifice therefore lies on the 17th segment, and not on the border line between this segment and the one which follows. On the other hand, the posterior aperture, which is that of the spermatothecal pouch, is distinctly on the border line of Segments xviii/xix. The latter orifice appears to be very much smaller than the male pore, which has slightly crenated lips. The ventralmost seta of Segment xvii is absent on both sides of the body. The present species is also remarkable for a median unpaired papilla situated upon Segments xxii and xxiii. This is oval in form, and is flattened with a raised margin. It commences at the level of the setæ of Segment xxii, and extends back as far as the end of the next segment, the border line of which convex backwards. The median region of this segment is, in fact, very much wider than that of the neighbouring segments. The ventralmost seta of Segment xxiii lies on the papilla on both sides of the body; on the 22nd segment that seta of the left side is upon the papilla.

Reproductive Organs.—As in other species of the genus, Polytoreutus violaceus has only a single pair of testes. These lie in the 11th segment; they are not, however, attached to the front wall of their segment, nor are they, as is sometimes—though rarely—the case with earthworms, attached to the posterior wall. They are attached to the wall of the sperm-sac, which commences in this segment. It can hardly be doubted that originally the testes were attached to the front septum of the 11th segment; but the growth of the sperm-sac appears to have cut them off from this position, and in the adult worm the heart lies between them and the septum in question. The testes lie in the proximal end of the sperm-

sac. The sperm-sacs are paired, and extend, as in Polytoreutus magilensis, through a large number of segments. Their commencement is in the 11th segment, and here they are somewhat dilated. The upper wall of the sperm-sac curves round, and is attached to the dilated part of the sperm-duct, the testes lying just in the angle formed by it and the wall of the sperm-duct dilatation. The lower wall of the sperm-sac is formed by the septum separating Segments XI/XII. The sperm-sac then perforates this septum, and becomes a very narrow tube not more than a quarter or less of its dimensions at first. These two fine tubes pass along the dorsal surface of the gut side by side, and in contact with each other. They are partially concealed from view by the bulky atria, which also lie—at least for the greater part of their course—upon the dorsal lateral aspect of the intestine. At about the 30th segment of the body the two elongated and narrow sacs appear to fuse together and form a much wider sac, which extends back for about ten segments, and is deeply constricted at the points where it passes through the intersegmental septa. The atria are circular in section. The lining epithelium is, as usual, composed of two kinds of cells; it is much folded. The muscular layers are excessively thin. On the lower surface of the atrium, but within the muscular coats, run two blood-vessels, between which is a distinct thickening of the longitudinal muscular coat. The two atria fuse together before opening on to the exterior. The exact point where the sperm-duct enters the atrium I have not discovered, but in any case it is not at a very great distance from the external pore.

The illustration (fig. 7) will give some idea of the very remarkable character of the spermatothecal sac. It extends through five segments—from its beginning in the 14th to its external aperture on the border line of Segments XVIII/XIX, and for two segments beyond this point—to the 21st segment, in fact. The spermatothecal sac is single, but shows unmistakable indications of being the result of a fusion between two originally separate sacs. Anteriorly it is in contact with the wall between Segments XIII/XIV. There are two diverging

horn-like processes which meet in the middle line of this segment. They end blindly in front. Just at the blind end the egg-sac is attached to each whence the oviduct passes outwards, as shown in the figure referred to. The median sac formed by the fusion of the two anterior sacs passes straight down the body-wall below the ventral blood-vessel and the nerve cord. It is a narrow tube, but is rendered conspicuous by the fact that it gives off on either side a series of diverticula. These diverticula are accurately symmetrical. They are narrower at their origin from the median sac, and become dilated at their free end, which is of course closed. Their shape reminds one of the Polian vesicles of the Holothurians. In another specimen, also mature, which I dissected, these lateral vesicles showed an asymmetry. Those of the left side were, with the exception of the fifth, much smaller than those of the right side. I regard this as an abnormal or perhaps, in spite of appearances, not a fully mature specimen. These lateral cæca of the spermatotheca bore a distinct relation to the metamerism of the body; there were, in fact, a pair of them to each segment. The atria pass between the fifth and sixth pairs. The two last pairs are beyond the aperture of the spermatotheca. The most anterior pair of diverticula—those which bear the egg-sacs—differ from all the rest in being a little longer and narrower. I have investigated the minute structure of the spermatothecal apparatus in this species by longitudinal sections. The first point of importance to be noted is that they contain spermatophores exactly like those of Polytoreutus magilensis, a species recently described by myself in this Journal.

These spermatophores do not for this reason need any particular description. Their distribution, however, is remarkable. They do not, as perhaps they might have been expected to do, occur in the entire spermatothecal sac. They are restricted to the end of the sac, which, as already mentioned, lies in the 13th segment. These two sacs at the end of the spermatothecal sacs are crowded with spermatophores. I have also seen spermatophores at the external pore of the spermato-

thecal sac, but never in between. I find it difficult to understand this. The spermatothecal apparatus is so large that it must, one would think, perform some function not performed by spermatothecæ which are smaller in size ; for instance, those of Eudrilus. The presence of spermatophores needs more room, supposing that there is about the same amount of sperm. But the restriction of the spermatophores to the anterior end of the spermatothecal apparatus is still unexplained. In Polytoreutus cœruleus and in Polytoreutus magilensis the oviduct is dilated near to the opening into the egg-sac. In this dilatation are lodged bundles of sperm. Michaelsen has suggested that this looks as if the ova were fertilised in the egg-conducting apparatus. The facts described in the present paper support this contention, but unfortunately throw no further light on the exact place where fertilisation takes place. The spermatothecal sac is lined throughout with a layer of very tall columnar cells, the nuclei of which are near to the attached base of the cells. In the anterior part of the spermatothecal sacs where the spermatophores are lodged these latter are seen to lie partly among the cells, having, as it were, thrust their way in between them. There were, however, no indications that the cells lining the sacs are in any way responsible for the formation of the spermatophores.

The ovaries of Polytoreutus cœruleus have been described by Michaelsen as lying in a spherical chamber which itself lies at the extreme end of each of the two branches in which the spermatothecal sac ends anteriorly. The epithelium lining this chamber is believed by Michaelsen to be the ovarian epithelium. This spherical pouch is attached to the Septum XII/XIII by a strand of connective tissue. In Polytoreutus violaceus the position of the ovarian chamber—if I am right in so calling it—is rather different. At the point where the large terminal chamber of the spermatothecal pouch comes nearest to the Septum XII/XIII there is a minute sac attached to its wall, and formed of a muscular coat with a lining of epithelium. Where this sac is in contact with the wall of the spermatothecal sac there is no development of muscles, so

that the epithelium of both pouches is in actual contact. This minute sac is attached to the Septum XII/XIII by a strand of fibrous tissue (muscular or connective tissue). It is situated on the opposite side of the spermatothecal sac to that on which is placed the orifice of the duct leading from the oviduct. The sac was filled with a few small rounded cells which might be immature germinal cells or might, indeed, be any kind of cellular tissue in an immature state. I have no evidence to bring forward that this tissue is really what is left of the ovary, except its position and the fact that it is enclosed in a special sac.

The egg-sac and the oviduct appear to have the same structure and relations as in Polytoreutus cœruleus. The only difference that I noted was the absence of any diverticula of the oviduct lodging sperm masses such as Michaelsen has figured and described in that species. The egg-sacs contained, besides ripe ova, germinal cells in various stages of growth.

In describing the structure of Polytoreutus kilindinensis I shall have some observations to offer about the development of the different parts of the female reproductive organs.

Polytoreutus kilindinensis, n. sp. (fig. 8).

The present species was represented by two individuals, both of which were collected at Kilindini, on Mombasa Island; they were found, together with another species to be presently described, in damp ground where the slops of a household were deposited.

This species cannot be confounded with the next, nor with either of the two remaining species of the genus. It is larger than the last; the larger of the two individuals measures 120 mm. in length by a diameter of 5 mm. This specimen consisted of 220 segments. The colour, too, is different; it is characterised by the same general coloration, but the violet is less deep and less extensive.

The prostomium is broad, and does not invade in the least the buccal segment; the latter segment has numerous wavy lines anteriorly.

The setæ seem to be as in other species of the genus. There seems to be a tendency for the ventral setæ to be defective upon the segments which bear the genital pores; I refrain, however, from giving any details, since I am not certain how far this deficiency may be normal.

The nephridiopores are lateral in position.

There is no median genital papilla such as occurs in P. violaceus.

The clitellum extends over Segments XIV—XVIII, being only developed upon the anterior half of the last segment. Behind the clitellum is a median area bounded by the ventral setæ, which looks like an extension of the clitellum; it has the same tumid appearance, and the boundary lines between the segments are there not apparent. This area reaches from the 18th to the 21st segments; when the worm is seen in profile it is seen to project somewhat. It is very possible that this area serves the purpose of the genital papilla in Polytoreutus violaceus.

The anterior of the two median and unpaired genital openings is situated on the border line between Segments XVII/XVIII; it is a widish aperture with crenated margins; behind it is a transverse groove which runs for a considerable distance right and left; this groove is not, as might be supposed, the boundary line of Segments XVII/XVIII; it can be easily seen that the furrow between these segments is anterior to it and bisects the genital pore already described. Immediately behind the groove referred to is the posterior genital aperture; this is much less conspicuous than the anterior pore, and has not crenated margins.

The internal structure of this species is very similar to that of the last, but there are certain recognisable differences. There are six specially thickened septa; the first of these lies behind the 5th segment, and the last behind the 11th segment. As appears to be usual in the family Eudrilidæ, these septa are not much connected together by threads.

The gizzard lies in the 5th segment, and is small; the calciferous glands, of a white colour, are in Segment XIII; the

unpaired calciferous pouches are in Segments IX—XI, and are reddish in colour.

Reproductive Organs.—The sperm-sacs are, as in the other species of the genus, long, but they are by no means so elongated as in Polytoreutus magilensis; they commence in the same way in the 11th segment, and are at first thin tubes; in the next segment, however, they attain their ultimate size, and extend back to about the 27th segment. The two sacs run close together on the dorsal surface of the intestine, but they do not become fused as is the case with Polytoreutus violaceus; the sacs are constricted where they pass through the segments; their whitish colour contrasts with the orange colour of the atria, which extend through the same segments that they do.

There is a single pair of sperm-ducts which open into the 11th segment; they show the usual dilatation before their opening; the atria present no noteworthy particulars; they extend as far back as do the sperm-sacs. It is in the disposition of the spermatothecal pouches that the present species is chiefly to be distinguished from its congeners.

Fig. 8 illustrates the arrangement of the sacs. From the point of opening on to the 17th segment a narrow median tubular sac passes forwards beneath the nerve-cord up to the 14th segment; here it divides into two sacs, each of which immediately becomes dilated into a wide pear-shaped pouch lying transversely to the longitudinal axis of the body; just where this pouch narrows into the stalk which connects it with the median spermatothecal sac a short tube arises, which very soon dilates into the funnel of the oviduct; the latter is a globular sac, as in other species of the genus, and is connected on the one hand with the oviduct, and on the other with the egg-sac, as is shown in the figure. I could find no spermatophores in the sac—not the least trace of the bundles of spermatozoa figured by Michaelsen (Taf. iv, fig. 30, sk.), and observed by myself in Polytoreutus magilensis, were to be seen in the present species.

The spermatothecal sac of the present species is the simplest that has yet been met with in the genus. The appendices of

the median sac, that occur in the remaining species, are here quite absent; the storage of the sperm is effected by a development, not met with in the other species, of the anterior end of the sac on each side.

I investigated the structure of the female reproductive organs in an immature example of this species. The spermatothecal sac was almost filled by small rounded cells, quite unlike the tall columnar cells which line the mature spermatothecal sac of Polytoreutus violaceus. So numerous were these cells that the lumen of the entire tube was almost completely obliterated. I had hoped to find some indication of the position of the ovary in this specimen; but, unless the epithelium lining the two end pouches into which the spermatothecal sac divides anteriorly is the germinal epithelium, I could find nothing at all. There is not, as there is in P. violaceus, a small sac attached to the main spermatothecal sac, set apart for the lodgment of the ovary. It is probable that the ovary is only free in very young specimens, and it is also possible that it has a very transitory existence. There is a precedent for this in Libyodrilus. In that genus the ovary appears to exist only for a short time, its contents being early transferred to the interior of the egg-sacs. In this young specimen of Polytoreutus kilindinensis the egg-sacs were quite fully developed as regards size, but they contained only quite immature cells; the germinal cells filling the egg-sacs were exactly like the cells in the immature ovary of other worms; it is evident, therefore, that the germinal tissue is transferred en masse to the egg-sac, and that the entire development of the ova goes on in those sacs. The spermatothecal sac seems not to be formed by an invagination from the epidermis; the epithelium lining it bears no resemblance at all to the epidermis; the structure of the sac is exactly like that of the developing sperm-sac which lies in the preceding segment; in the section of the worm the two could be very well compared, as they almost came into contact. Judging from structure only, no one would hesitate to regard the two structures as of the same nature.

§ Note upon an Immature Example of this Species.

From the same locality I have an example of a Polytoreutus which I regard as an immature specimen of P. kilindinensis. It measured 98 mm., and consisted of 158 segments. The external characters, except those afforded by the apertures of the reproductive organs, were as in the species P. kilindinensis. The reproductive openings were only represented by a pore upon the boundary line between Segments XVII/XVIII. This pore was, however, extremely conspicuous, and showed no indications of being in an immature condition. Behind the pore was a short transverse groove such as exists in the mature worm, but there were no signs of the second pore. The internal anatomy, apart from its immature state, showed one or two small differences from that of the species of which I presume the present example to be an immature one. There was a thick septum in front of the gizzard, which, therefore, separated Segments IV/V. The dorsal vessel also was double, a rare condition in this family. The dorsal vessel was formed of two tubes, at any rate in Segments VIII—XII. The two tubes became fused at the septa. There are other examples beside the present which appear to show that a double or a single dorsal vessel is not necessarily a diagnostic character of a species. Thus I described the dorsal vessel of Megascolex cœruleus as double, while Bourne saw no signs of any such doubling. Another point in which the present specimen differs from the type of the species is in the fact that the two sperm-sacs join together at their distal extremity. The median calciferous pouch of Segment XI was distinctly smaller than the two which precede it.

The sperm-sacs, it should be said, are of precisely the same form as in the mature examples; that is, they arise from the septum bounding posteriorly the 11th segment. At first each sac is thin, and this region extends through one segment only. It may, therefore, be pointed out that the probability of this shape of the sperm-sacs being characteristic of the species and distinguishing it from, for example, Polytoreutus magi-

lensis is increased by the fact that the immature worm exhibits the same condition. The funnels of the sperm-ducts were by no means so prominent as in the fully mature worm; they, of course, occupied the same position. The only other part of the male apparatus that was visible were two little sacs lying one on either side of the extremity of the spermatothecal sac. I do not think that these were the immature sacs of the penial setæ of a species of Polytoreutus provided with these structures. It seems, therefore, that the first rudiment of the terminal apparatus of the male ducts is double, which is so far a demonstration that originally this apparatus was double. Beyond these two minute sacs nothing was visible of the male efferent ducts. On the other hand, the spermatothecal sac was as well developed as in the mature worm. It showed no differences that I could detect from the structure already described. There was, however, no sperm in the sac.

We may, therefore, note that the female apparatus is developed before the male, and that the sperm-sacs are the first part of the male apparatus to reach maturity.

Polytoreutus Finni, n. sp. (figs. 6, 17).

I have unfortunately only a single specimen of this worm for examination. It is extraordinarily long and thin—perhaps I may say even for an Eudrilid. The preserved specimen measured 183 mm. by 3 mm. in breadth at the clitellum, which is distinctly broader than any other region of the body. The worm consisted of rather more than 500 segments, a most unusual number. The clitellum is exceedingly conspicuous, being raised above the level of the surrounding segments; it occupies Segments XIII—XVIII. It is quite complete except for the area which lies between the genital pores. The genital pores (fig. 17) are, as is usual with this genus, situated on the 17th, and on the boundary line between the 18th and the 19th segments respectively. These apertures are very large and prominent, and are surrounded by thick tumid lips. The integument at the actual orifice is marked by numerous slight furrows which have a radiate arrangement. These pores,

together with the modified integument immediately surrounding them, occupy nearly the whole of the ventral surface of the worm. Between the anterior and the posterior orifice is a tract of integument of the same character as that which immediately encircles the pores, and differing from the clitellar tissue.

The setæ are as in the other species of the genus.

The internal structure, no less than the external characters, distinguishes Polytoreutus elongatus from the remaining species of the genus Polytoreutus. These differences mainly concern the spermatothecal sacs, which are different in all the species of the genus. In other particulars there is less difference. The last specially thickened septum divides Segments XI and XII. The last pair of hearts are in Segment XI. There are the usual three median calciferous pouches in Segments IX, X, and XI. The calciferous glands are present, but have a very unusual form; they appear to lie in the 15th segment, but I am not able to be quite certain, as the segments just about this region were hard to fix. Not only are the calciferous glands unusual by reason of their position, they are also peculiar in shape. Each gland is situated at the sides of the œsophagus, and is curved up like a ram's horn.

As in the other species of the genus there is but a single pair of funnels; and I presume, though I have not actually verified the fact for the present species, they have only a single pair of testes. The funnels of the sperm-duct lie in the 11th segment, and the funnel itself is preceded by a dilated section of the sperm-duct, which has an opaque white appearance, and is of large size. It is directed obliquely backwards. I have not followed the course of the sperm-duct.

The atria are long; they open together into a terminal bulbus which is median in position, and again opens on to the exterior by the anterior of the two genital orifices already described. The atrium belonging to the right side of the body was extended at full length, while that of the opposite side was looped once or twice. The fully extended atrium reached

back to about the 25th segment behind the clitellum; a peculiarity about it was the fact that the last half or rather less of the gland was double, the two portions, however, running in close contact. Whether, as seems likely, this is a mere abnormality I am unable to say; but I may point out that in Eudrilus each atrium is normally divided into two separate tubes by a continuous longitudinal septum.

The sperm-sacs are very remarkable. On the dorso-lateral surface of the intestine I observed a pair of fine tubes running a fairly straight course, which I put down at first as being the sperm-ducts, thinking that they terminated in the atrium. They do as a matter of fact terminate close to the atria, but quite independently of them. These slender tubes are the sperm-sacs. One of them, that of the left side, was distinctly varicose, being dilated here and there into oval chambers. Traced forwards, they appeared to end in the immediate neighbourhood of the funnels. Each sperm-sac was accompanied by a blood-vessel. It is a pecularity of this genus to possess long sperm-sacs, which in Polytoreutus magilensis are of enormous extent, but in no other species are they of the extreme tenuity exhibited by Polytoreutus Finni. This state of affairs may be simply due to the fact that the sperm did not happen to be present in any great amount; but this is unlikely, as the worm was in all other respects fully mature. Besides, this is not the only case of a worm possessing such extraordinarily long and thin sperm-sacs. I have described elsewhere the sperm-sac of the Geoscolicid genus Trichochæta, which are of precisely the same character as those of the present species of Polytoreutus. On the other hand, it will be recollected that there are a number of different degrees in the development of the sperm-sacs in this genus which may perhaps be interpreted as different grades of development of the sacs. In Polytoreutus magilensis the sperm-sacs are at first extremely narrow, and later become much wider. In Polytoreutus kilindinensis, described on a preceding page of the present paper, the narrow region of the sperm-sacs is reduced greatly, nearly

the whole of the sacs being wide. Finally in the present species we have the other extreme. The entire sperm-sacs are formed by the slender tubes referred to.

The female reproductive organs present a fourth variety, all the species at present known being different in the form of these organs. They are most like those of Polytoreutus kilindinensis. P. Finni agrees most closely with P. kilindinensis in the general form of the spermatothecal sacs. As in the last-named species, there are only a single pair of diverticula of the median unpaired sac. The latter runs beneath the nerve cord until it reaches the anterior boundary of the bulbus of the male efferent apparatus. Arrived at this point it diverges to the left, and, forming a semicircle, again bends to the middle line, and opens by means of a dilated terminal sac behind the orifice of the atria. Anteriorly this median sac extends as far as the 13th segment. Just below the septum which divides this segment from the one in front, it divided into two. Each branch swells out as in P. kilindinensis and forms a largish oval sac. The two sacs are coiled to some extent round the intestine. From the base of each, not far from the point where it joins the median sac, a short tube is given off, which passes into the receptaculum ovorum and thence becomes continuous with the oviduct. The arrangement of these parts is, in fact, precisely as in Polytoreutus kilindinensis. They are illustrated in fig. 6.

Alluroides Pordagei, n. gen. (figs. 4, 5).

I shall describe this new form under the name of Alluroides Pordagei. It was collected along with a number of examples of Stuhlmannia variabilis in a swamp four miles up country, opposite to Mombasa Island. The species is represented by only two individuals, measuring in the preserved state about an inch in length. They had a delicate appearance owing to their small size and the thinnish body walls, and resemble somewhat, except in colour, an aquatic member of the family Phreoryctidæ which I have lately described from New Zealand under the name of Pelodrilus violaceus. In

fact, any one acquainted with this group of worms would probably assign the species from its general appearance to the Lumbriculidæ or perhaps to the Tubificidæ.

Reproductive organs.—The testes are a single pair only, which are placed in the 10th segment attached to the front wall of that segment. There appear to be no actual sperm-sacs, but the 10th and the 11th segments are filled with a mass of developing sperm. This is so compacted together that the appearance of a definite sac is produced, and the sperm is so abundant and occupies so much of the interior of the two segments in question that the septum dividing them, which is thinnish, is hardly visible without a very careful inspection.

The funnels of the sperm-ducts correspond in number to the testes, that is to say there is only a single pair, which lies opposite to the testes in the same segment. They are much folded.

The terminal apparatus of the male efferent duct is formed by an atrium.

The atria (fig. 5) extend through more than one segment, and are long enough to be coiled. They open on each side on the 13th segment, the aperture being lateral in position, showing therefore, which is remarkable, no relation to the pores of the spermatothecæ. The tubular atria have, however, not a close resemblance in structure to the tubular atria of such genera as Acanthodrilus. Their structure is as follows: —The internal lining of the tubes is formed by a single layer of cells, which have a clear appearance, as they were not stained by a long immersion in borax carmine. The cells were certainly in some places ciliated. Towards the external pore these lining cells got to be more and more like the epidermic cells, and were also ciliated, until at the actual orifice they became continuous with the epidermis. Outside the epithelium is a layer of muscular fibres of some thickness. These fibres are entirely circular in disposition. They do not form an absolutely continuous covering of the epithelium; here and there slight gaps are to be seen. These gaps correspond

to the exits of the ducts of a mass of glandular cells which form the outer covering of the organ. As in Moniligaster, the atrium is invested externally by a mass of pear-shaped cells, which are loosely compacted into separate masses.

The structure of the atrium, therefore, is like that of Moniligaster alone among "earthworms." In fact, it only differs from the atrium in that genus in its greater length. The external aperture of the atrium is placed upon a fan-shaped outgrowth of the body wall, which in all probability serves as a penis. Whether or not these penes are in- and evaginable I am unable to say. They were extruded in both the specimens at my disposal. I should imagine that they are protrusible.

The ovaries are in the 13th segment.[1] They are attached as usual to the front wall of this segment. From the 13th to about the 20th, there are ova and masses of ovarian cells apparently lying loose within the body cavity. In the most anterior of the segments in question, there are only egg masses consisting of immature ova surrounded by groups of small cells, but in the segments situated further back, there were only ripe ova visible. These ova are of special interest on account of their large size; they are also, like the ova of the aquatic Oligochæta, generally crowded with yolk. The ova are fully as large as those of such a genus as Rhynchelmis. In longitudinal sections of the body the ova reached across nearly from one side of the body to the other.

I could find no egg-sacs. There is a single pair of oviducts which open into the 13th segment. The tube remains very wide after it has entered the 14th segment, and has a much folded lumen; it narrows rapidly before the external pore.

The spermatothecæ are present to the number of a single pair, which are in the 8th segment. They are oval pouches without any diverticula, and with perhaps unusually thick

[1] The septum dividing Segments XIII/XIV was largely deficient, and masses of young egg-cells and non-differentiated germinal cells passed into the 14th from the 13th segment. I should not like to be certain that these were not developed in situ; younger specimens are required to clear up the matter. In the meantime there is only one pair of oviducts.

muscular walls. They open quite dorsally close to the median dorsal line of each side of the body. This is a remarkable but not unknown position for the spermatothecal pores. Another instance of a similar position, which occurs to me, is in the species Allolobophora fœtida.

Other facts in the anatomy of the worm which are of some little importance are the following.

The prostomium is, as is indeed usual, covered with a thick columnar epithelium. This thickened pad is prolonged for a very short distance into the mouth-cavity. This epithelium is very possibly of a sensory nature. The cœlom is, of course, divided up by transverse septa into a series of chambers. Some of the septa which divide these chambers are thicker than others. The first of these thickened septa divides Segments IV/V. The following seven septa are, with the exception of that which divides Segments X/XI, also thickened. The next septum to the last of the specially thickened septa is rather thicker than the excessively fine septa which separate the following segments. As in so many of the lower Oligochæta, there are septal glands present; these glands commence in the present species in the 5th segment, and the last pair were observed in the 9th. The brain lies in the 3rd segment. From the brain one among several nerves which pass forward ends in a medianly situated ganglion in close juxtaposition to the epithelium of the prostomium, which consists of but few cells. A median ganglion in this position has not, I believe, been described as existing in any earthworm, but it has been met with in certain aquatic Oligochæta belonging to the family Tubificidæ. In this family Stolc[1] has figured such a ganglion in Bothrioneuron and in Lophochæta.

The alimentary tract has no traces of a gizzard. The œsophagus does not appear to be at all vascular; it terminates in the 13th segment, in which segment begins the intestine. There are no glands of any description appended to the alimentary tract unless the septal glands can be referred to this category.

[1] "Monogr. Ceskych Tubificidu," 'Abh. böhm. ges.,' 1888.

The nephridia commence in the 16th segment. They open on to the exterior by the second seta. They are clothed with a thick layer of peritoneal cells.

The question now to be considered is the family into which this new type should be placed. That it is generically distinct there is in my opinion no doubt whatever. This genus Alluroides is one of those forms which render the distinction between the old groups of the "Limicolæ" and the "Terricolæ" untenable. In some respects it is even more perfectly intermediate than Moniligaster.

Aside from Moniligaster, the "waterworms," all of them, differ from any earthworm in the following characters:

1. Clitellum one cell thick.
2. Ova very large and full of yolk, few in number.
3. Genital aperture situated far forwards.
4. Egg-sacs occupy more than one segment.

These are positively all the distinguishing marks if we leave aside the genus Moniligaster. Moniligaster itself, as I have shown in several papers[1] dealing with the structure of this remarkable worm, breaks down the first, third, and fourth of the above distinctions. Moreover, it has eggs which, although they are not greatly above the average size of the eggs in earthworms, differ from those eggs in containing a great quantity of yolk in the form of large spherules. Moniligaster, in fact, is only an earthworm in having a gizzard or rather gizzards, and in the comparative thickness of the body-wall. This latter character, however, is seen in Phreoryctes, which is one of the genera assigned by Claparéde to his division Limicolæ. Besides the points enumerated in the above tabular statement, Moniligaster has various other resemblances to several Limicolous Oligochæta, which are not of first-rate importance from the present point of view, inasmuch as they also occur in other earthworms, though not to so marked a degree. The atrium, for example, is almost exactly like that of the Lumbriculidæ. The protrusible penis is constructed more on the lines

[1] For a list of literature see "Description of New or Little Known Earthworms from various localities," 'Proc. Zool. Soc.,' 1892, p. 690.

of the corresponding organ in the Tubificidæ than is the penis in the Eudrilidæ and other terrestrial Oligochæta which possess an organ of this kind. The atrium is lined by a single layer of cells, a feature which is also found in Ocnerodrilus and in some other genera. The sperm-duct has a very short course, opening on to the exterior in the next segment to that which contains the internal funnel. It is quite possible, however, that Tetragonurus shares this peculiarity with Moniligaster. So, too, with the oviducal pores. Moniligaster is not alone among earthworms in the fact that they are in front of the sperm-duct pores. In both Allurus and Tetragonurus the oviducal pores are nearly certainly (in Allurus quite certainly) in front of the sperm-duct pores. Dr. Rosa has rebuked me for laying much stress upon the fact that the male pores of Moniligaster are so far forward as the boundary line of Segments x/xi, a position which of course recalls the very anterior position of the corresponding apertures in the generality of the "Limicolæ." It is true that the difference between an opening upon the 10th and 11th segments and one upon the 12th segment is not a very great one, but the difference, such as it is, is in the direction of the lower Oligochæta, and not in the reverse direction.

So much, then, for Moniligaster. The only point in which it differs in an important way from the aquatic forms is in the relatively small size of the ova. The Annelid which forms the subject of the present communication is the only known example of an Annelid with marked affinities to the terrestrial Oligochæta which has that hitherto distinctive character of the lower Oligochæta—large ova filled with yolk.

It resembles the aquatic Oligochæta in the following points:

1. Clitellum consisting of a single layer of cells.

2. Ova very large and full of yolk, few in number, and occupying several segments.

3. Atrium lined by a single layer of epithelium, and covered by masses of pear-shaped cells; sperm-ducts open into it.

4. Longitudinal muscular layer of body-wall consists of a single row of plate-shaped fibres.

The above resemblances are in structures which are, with the sole exception of Moniligaster, confined to the aquatic Oligochæta. Besides these, the genus Alluroides departs from the usual structure of the terrestrial Oligochæta in a few other points, viz.:

1. There is no gizzard, no calciferous glands, and no typhlosole.
2. The nephridia are deficient in the anterior segments.
3. There is no subnervian vessel.

These points do not absolutely distinguish the terrestrial from the aquatic Oligochæta, but they occur in a few of the former while characteristic of the latter. For example, there is no gizzard in certain species of Microscolex; Pontodrilus has no calciferous glands, &c.

The points in which the present genus resembles the terrestrial Oligochæta are by no means numerous. They are as follows:

1. The segments occupied by the clitellum.
2. The position of the male pores, and the fact that the sperm-duct traverses several segments on its way to the external pore.
3. The situation of the ovaries in Segment XIII.

In addition to these, there are some points in which Alluroides agrees with earthworms to differ from the majority of the lower Oligochæta. The sperm masses in Alluroides are confined to the 10th and to the 11th segments; it is the rule among the lower forms for the sperm-sacs to extend much further back. The testes being limited to the 10th segment is rather unusual among earthworms. When there are but a single pair of these gonads they are, as a rule, in the following segment. Among the Lumbriculidæ the testes are in the 9th segment, or, as in Rhynchelmis—and possibly in other genera,—in the 9th and 10th. However, in Phreoryctes the testes are in Segments X and XI, but here the sperm-ducts open on to the exterior in the following segments. The same is the case with the nearly allied Pelodrilus.[1]

[1] "Anatomical Description of Two New Genera of Aquatic Oligochæta," 'Trans. Roy. Soc. Ed.,' 1890.

While we may, as it appears to me, term Moniligaster an earthworm with numerous points of affinity to the "waterworms," it is better to speak of Alluroides as a "waterworm" with affinities to the terrestrial worms. If an exchange could be effected between these two genera of various characters, we should get as a result either an obviously terrestrial genus or an equally obviously "Limicoline" genus. Thus Alluroides would be undoubtedly referable to the terrestrial section of the Oligochæta if it possessed the body-wall and the ova of Moniligaster; on the other hand, Moniligaster would be an undoubted "waterworm" if we could transfer to it the body-wall and the ova of Alluroides.

It is therefore, in my opinion, useless to attempt any comparison with any particular family of terrestrial Oligochæta; it is rather with some family of the aquatic Oligochæta that Alluroides should be compared; be it noticed, however, that, judged by external characters only, Alluroides would probably be referred to the immediate neighbourhood of Allurus.

The family of "waterworms" with which Alluroides has the closest affinities is that of the Lumbriculidæ. It agrees with that family in the following characters:

(1) Setæ paired and S-shaped.

(2) Atrium with thick peritoneal investment.[1]

(3) The great depth of the single layer of longitudinal muscular fibres.

These two characters are found together in the Lumbriculidæ alone among the aquatic Oligochæta; in other respects, however, there are not any striking resemblances between the genus Alluroides and the Lumbriculidæ.

Two of the most characteristic features of this family are wanting in Alluroides; these are (1) the absence (?) of the vascular contractile cæca, and (2) the absence of a second pair

[1] I have shown that in Moniligaster the cells enveloping the atrium are prolonged through the muscular layer and epithelium to open into its lumen; Vejdovsky's figure ('Zeitsch. wiss. Zool.,' Bd. xxvii, pl. xxiv, fig. 3) seems to show that this is also the case with Rhynchelmis.

of sperm-ducts. As to the latter point, I have discovered that in Sutroa the second pair of sperm-ducts are much thinner than the first pair, and that coincidently with commencing disappearance (?) of one of the two pairs of sperm-ducts the testes belonging to the vanishing pair are absent.[1] In my genus Phreodrilus[2] there is a cæcum of the sperm-duct, which is possibly a still further reduced condition of a second pair of sperm-ducts. Among the higher Oligochæta the absence of one pair of testes and of the corresponding sperm-duct is not a matter upon which great weight is usually laid. In any case it appears to me that Alluroides shows no marked affinities to any other family of worms.

Alluroides, gen. nov.

Setæ simple, S-shaped, arranged in pairs; clitellum occupying Segments XIII—XVI, consisting of a single layer only of cells; alimentary canal without a gizzard or any appended glands; some of anterior septa thickened; testes, one pair in X; sperm-ducts open on to exterior on XIII through a moderately long atrium, which has much the same structure as in the genus Moniligaster; above the apertures of the atria is a process of the body-wall (a penis?); ovaries in XI; ripe ova of large size, and filled with yolk, occupy five or six segments of the body; oviducts open on to Segment XIV; spermatothecæ, one pair, without diverticula, in VIII.

The genus contains one species, Alluroides Pordagei, of which I shall not attempt a definition.

1. Gordiodrilus zanzibaricus, n. sp.

A large number of specimens of this species were collected from damp mud at the edge of a pool. They are, when preserved, an inch or so in length. Their colour during life was red.

[1] "A Contribution to the Anatomy of Sutroa," 'Trans. Roy. Soc. Ed.,' vol. xxxvii, p. 195.

[2] "Anatomical Description of Two New Genera of Aquatic Oligochæta," 'Trans. Roy. Soc. Ed.,' vol. xxxvi.

The setæ are strictly paired, and are not in any way ornamented. The pairs are equidistant, and are all of them decidedly ventral in position. The only modification of the setæ occurred on the 17th and 18th segments. On both of these segments only one ventral seta was present on each side; the remaining seta appeared to be the outermost of each pair.

The atrial pores are two pairs, which open on both 17th and 18th segments. Each pore is situated in a groove with raised and somewhat folded margins, which connects the two pores of each side.

The oviducal pores lie a little to the outside of the outermost seta of each ventral pair.

The spermatothecal pores occupy a corresponding position between Segments VII/VIII, VIII/IX.

The clitellum occupies Segments XIV—XVIII, and is complete except over the area lying between the atrial pores.

The nephridiopores lie in front of the inner seta of the outer pair.

The alimentary canal shows the structure which is characteristic of this genus.

In Segment IX is the median ventral calciferous gland, which to describe would be merely to recapitulate my description of other species. From the 9th segment the walls of the œsophagus are highly vascular; the intestine begins in the 13th segment; the intestine is not at first so regularly constricted in successive segments as it is posteriorly, and appears to be of a rather wider calibre. The ciliation of the œsophagus commences just in front of the opening of the calciferous pouch.

The first distinct septum separates IV/V; this septum is thin, but the four following are thickened; the next three septa, though thinner than those which precede them, are thicker than those which follow.

As in other species, there are masses of unicellular glands in the neighbourhood of the pharynx, which have been termed by myself and others "septal glands," on the view that they

correspond to the septal glands in certain genera of aquatic Oligochæta. These glands extend back as far as the 7th segment.

The nephridia are paired structures. The first pair lie in the 5th segment; they are not absent in any of the genital segments; but in the 11th, 12th, and 14th segments the nephridia are more or less rudimentary. That they are present can be made out without any difficulty, for the large vesicular cells which clothe the nephridia from the 9th segment onwards can be readily seen.

The degeneration of the nephridia in these segments must, as it appears to me, be correlated with the development of the genital ducts, or rather their funnels; so complete is this degeneration in the case of the nephridia of Segment XIV that nothing is left but a mass of vesicular cells to tell of the former existence of a pair of nephridia in this segment.

As to the reproductive organs, the testes lie in Segments X and XI, in which are also to be found the funnels of the sperm-ducts; there is nothing unusual in either their structure or their position. The same segments, with the addition of the 12th, contain the sperm-sacs. The sperm-ducts and atria are precisely like those of the West African Gordiodrilus elegans, and call, therefore, for no particular remark. The ovaries are in Segment XIII, and there is nothing remarkable about them or their ducts. There are however, and I have not yet observed this in the genus, egg-sacs in Segment XIV. The spermatotheca are in Segments VIII and IX.

§ Calciferous Glands in the Eudrilidæ.

I have studied with care the calciferous glands in two of the species described in the present paper, viz. Eudriloides Finni and Stuhlmannia variabilis. These two species and another which I have lately described in a paper communicated to the Zoological Society, and named Eudriloides durbanensis, show a peculiar form of these glands which present various points of interest. I find also that Eudri-

loides brunneus has glands of a similar character, but I have not studied them in detail. Michaelsen has not mentioned the existence of these glands at all in the two genera referred to. In fact, he distinctly states them to be absent in the following genera:—Eudriloides, Notykus, Stuhlmannia, Megachæta, and Metadrilus. It is not the case that calciferous glands are absent from at any rate two of the genera mentioned in the above list. But the glands are so little like the usual form of these glands in the Eudrilidæ that it is not at all surprising that their existence has been overlooked.

In Eudrilus and in other genera there are a pair of calciferous glands in the 13th segment or thereabouts, which recall in every particular the calciferous glands of other earthworms. In addition to these there are in Eudrilus, Polytoreutus, Heliodrilus, and Hyperiodrilus unpaired median pouches which agree with the calciferous glands in structure, and are clearly to be referred to the same category. The only ways in which these glands differ from calciferous glands are—(1) their unpaired character—which I am not able to regard as of importance, and (2) the excessive complication of the folded interior of the organ, which is so developed in some forms that the lumen becomes partially intra-cellular. Of these "Chylus-Taschen," as Michaelsen terms them, there are never more than three. In longitudinal and transverse sections of Stuhlmannia, Segments VI—XII are largely occupied by whitish masses on either side of the intestine. These have a paired arrangement, there being a pair to each segment. The shape of these masses is more or less irregular. They are roughly oval with indented margin, as shown in fig. 12; they have in certain regions the form of a coiled tube, the individual coils being closely pressed together. The diameter of each gland varies at different points. The white colour of the glands appears to be due to the presence of innumerable rounded granules which make up the tissue. These granules suggest the yolk spherules of ova. Lying among them are a, comparatively speaking, limited number of small darkly stain-

ing bodies which I take to be nuclei. There is, however, no trace of cell limitations corresponding to the nuclei. The whole gland is covered with a darkly staining but thin sheath. Through the middle of the gland runs a stout blood-vessel, which I found to be nearly everywhere filled with coagulated blood. Its track through the gland was therefore not difficult to follow. The blood-vessel runs through the gland from end to end, but gives off very few branches; it is, however, of such great width as compared with the gland that any branching seems to be unnecessary for the adequate blood-supply of the surrounding tissue. The vessel belonging to each gland could be traced in three directions. Anteriorly it leaves the gland, and traversing the septum becomes the blood-vessel of the corresponding gland of the segment in front. Posteriorly the same thing happens. The successive glands of one side of the body are therefore, as it were, strung upon a continuous lateral vessel. In the middle of each gland a large branch arises from this which communicates with the plexus round the œsophagus. In the case of the last pair of glands, those belonging to the 12th segment, I observed two such branches communicating with the peri-œsophageal blood-plexus of which one was distinctly smaller than the other. Nearly the whole of the gland is made up of the peculiar tissue described and illustrated in figs. 12—15. In places where the gland was very slender in dimensions, this tissue has taken on a decided resemblance to columnar epithelium, faint lines of demarcation between the cells being apparent. Here the appearance presented is that of a tubular gland, but the lumen of the gland is filled with blood. Although these structures are solid, excepting for the blood-vessel which occupies so large a portion of their interior, they are not without communication with the gut. Transverse sections show the nature of their connection with the œsophagus better than longitudinal sections. A transverse section is illustrated in fig. 12. On the ventral surface of the œsophagus a pair of moderately long cellular tubes arise close together from the lining epithelium of the alimentary tract. These diverge, and each follows the

course of the blood-vessel destined for the supply of the gland. It terminates abruptly in the calciferous gland. I am not at all certain that these tubes really possess a lumen; it is at least very inconspicuous, and also the duct is not always so long as that represented in the figure quoted. The aperture into the gut of a second gland is shown in fig. 11. Here it will be seen the duct of the gland is excessively short, and it appears to become solid a very short distance from the point whence it arises from the gut.

Concerning the nature of the peculiar tissue which makes up the greater part of the calciferous gland it is very difficult to speak positively. In several preparations from specimens which had been preserved with Perenyi's solution, the layer of peritoneum surrounding the œsophagus appeared to pass without a break into the tissue of the gland. The appearance of this tissue is, indeed, more suggestive of peritoneal cells than of epithelial cells derived from the intestine. On the other hand, sections of a worm that had been killed and preserved in gradually increasing strengths of alcohol did not show any such gradual passage as has been indicated, for in these sections the peritoneum clothing the intestine was coloured of a greenish tint, and there was a sharp demarcation between this tissue and that forming the bulk of the calciferous glands. Notwithstanding this fact, the tissue in question has more likeness to peritoneal than to any other tissue in the worm's body. The only possible alternative, as it appears to me, is to assume that the cells have retained their embryonic state. In the embryo (not of this species, which is unknown, but of others) the cells of the mesenteron are charged with yolk spherules exactly like those in the gland tissue of the calciferous glands of the adult Stuhlmannia. The structure of the glands in this species is not very widely different from what I have described in Notykus (?) durbanensis in a paper recently published in the 'Zoological Society's Proceedings' (1892). It appeared to me, however, that the lumen of the glands in that worm were rather more developed than in Stuhlmannia. The lumen was quite obvious, though of little extent. The

glands, too, were of a more regular form, and showed no modification of the peculiar cells of the gland such as occurs in places in the gland of Stuhlmannia. I have now to record the structure of the corresponding glands of Eudriloides Finni. In this worm the glands are rather different in the details of their histology. There are pairs, but there is not always an absolute separation between the glands of adjacent segments. In a few cases I have found that there is a communication from segment to segment. The tissue composing the glands is for the most part exactly as in Stuhlmannia. The glands, however, are more irregular in form and the blood-vessel is much more coiled; where it (the blood-vessel) leaves the gland the tissue surrounding it is reduced to a comparatively thin layer. As the vessel with the surrounding tissue is much coiled, the appearances of a transverse section through a portion of the gland are much as is shown in fig. 15. This section presents a most curious resemblance to a section through the thyroid gland. It has every appearance of tubes of columnar epithelium surrounding a lumen which is filled with a homogeneous secretion; this "secretion" is nothing but blood. I have, of course, traced the supposed blood-vessels into connection with the vascular system. The modification of the tissue of the gland is not gradual; here and there it suddenly passes into the tissue illustrated at *c* in fig. 15. The tissue in question stains much more darkly than the rest of the gland, the granules in the cells which compose it are disposed in a radiate fashion, and the cells have acquired a columnar appearance, of which indications are observable in Stuhlmannia, as I have already pointed out. The specialisation of the cells is much more marked in the present species. It will be clear, at least from the figures which illustrate the foregoing description, that the glands which I call "calciferous" are not only different in the three genera referred to from those of other Eudrilids, but are also different—very different—from the corresponding glands of nearly all other earthworms. The only genus which at all approaches these Eudrilidæ in the structure of its calciferous glands is my genus Gordiodrilus. In all the species

of this genus there is a single calciferous gland or rarely a pair of these glands in the 9th segment ventral in position. The genus Gordiodrilus is mainly an African genus; it has been found in West Africa, and I describe in the present paper a species from Zanzibar. Gordiodrilus has no marked affinities to the Eudrilidæ, and for the present I place it in that unsatisfactory family the Cryptodrilidæ. The only point of resemblance to the Eudrilidæ is in the median and unpaired calciferous gland. This gland is a diverticulum of the œsophagus, which is surrounded by a mass of tissue exactly like that which makes up the greater part of the glands in Stuhlmannia and Eudriloides. The œsophageal diverticulum, however, passes from end to end of the gland, and expands at its blind extremity into a network of fine tubes having an intra-cellular lumen and bearing the strongest possible likeness to nephridial tubes. This genus is noteworthy from the present point of view as furnishing an intermediate condition between the calciferous glands of the more typical earthworms and those of the genera Stuhlmannia, Notykus, and Eudriloides. The lumen connected with the œsophagus is reduced in extent and is not folded, while at the same time the peritoneal covering is greatly increased in importance. The next stage is furnished by Notykus. Stuhlmannia seems to me to have a still more reduced œsophageal diverticulum. Finally, in Eudriloides I could not detect any diverticulum at all. In this species the walls of the œsophagus were much folded, so that a short diverticulum, if it exists, would be less conspicuous than in Stuhlmannia. As the extent of the epithelial diverticulum of the œsophagus is lessened there is a corresponding increase in the amount and also in the specialisation of the peritoneum-like tissue which surrounds it. Already in Stuhlmannia there is a commencing conversion of some of these cells into a definite layer bordering the blood-vessels in certain regions. In Eudriloides the amount of this specialised tissue is increased and the specialisation has gone further. It appears to me that this remarkable change in the histological characters of glands, which I cannot but consider to be the homologues

of the calciferous glands, must indicate a change in function.

In the present state of our knowledge, we can do no more than guess what this change of function can be. We are helped, however, by certain facts in the histology of the glands, and by the analogies offered in other animals. The structural change undergone by the calciferous glands is a reduction of the lumen, and presumably, therefore, a rapidly decreasing amount of secretion furnished to the œsophagus. I have never, it should be mentioned, seen the least trace of any calcareous particles in the calciferous glands in either Gordiodrilus, Stuhlmannia, Notykus, or Eudriloides. As the secreting tissues diminish, the tissues surrounding the glands increase in amount and in specialisation. They are supplied with blood from a large vessel which is dilated within the gland, and by its devious course must prolong the time that the blood is submitted to the action of the surrounding cells. The function of these glands must, I believe, have some relation to the blood. I regard them as analogous to the spleen of the Vertebrata; and in relation to this matter it may be pointed out that it has been stated that the spleen is originally formed as a diverticulum of the gut, thus indicating a conversion from a gland appended to the alimentary tract, and probably performing the function of a digestive gland to a "gland" concerned in some way with the blood. The instances described in the present paper are remarkably analogous. A series of glands undoubtedly related to the function of digestion are metamorphosed into glands which also appear to have some relation to the vascular system. In the family Enchytræidæ there is something of the same kind. The genera Buchholzia and Henlea are furnished with glandular appendages to the œsophagus, which can hardly be different in their nature from the calciferous glands of earthworms; from these glands (in most cases) the dorsal vessel arises. In the genus Mesenchytræus there are no such glands, but the dorsal vessel at its origin from the periœsophageal plexus (or sinus) contains a cellular rod which has been called the "cardiac

body." I agree with Michaelsen in considering this structure as the reduced equivalent of the œsophageal diverticulum, which, if it has any function at all, must perform some office in relation to the blood. In this connection, also, I may refer to my own description of an analogous organ in the fresh-water Oligochæte Phreodrilus. In that worm there are a pair of perienteric blood-vessels of larger size than the rest which contain in their interior masses of cells. These, too, may be the last stage in the conversion of an alimentary gland into a "blood gland." Of a different nature are probably the vascular tufts which arise from the dorsal vessel in many Lumbriculidæ; though here, too, the error of Grube in terming these vascular cæca diverticula of the intestine is not unsuggestive. Finally there are the "blood glands" of Perichæta, which I have described in a recent volume of this Journal. These are hardly referable to œsophageal diverticula which have lost their connection with the gut. Their existence is interesting as showing the possibility that in the Annelids we have a group of glands very suggestive of the spleen, supra-renal bodies, and perhaps some other of the "ductless glands" of the Vertebrata which are not all traceable to a common origin. Mr. Weldon has shown how the supra-renal body derived from the renal epithelium has lost its renal function and become converted to the interests of the vascular system. His description and figures of blood-clots lying in the lumen of the tubes is of particular interest to me in connection with the structures illustrated in fig. 15 of the present paper; but in making this comparison, it would be necessary to assume that the cells which I have regarded as peritoneal were in reality metamorphosed epithelium of the calciferous glands.

The only other Eudrilid in which calciferous glands, after the pattern of those described in the present paper in Stuhlmannia and Eudriloides, seems to be Megachæta tenuis. Michaelsen writes as follows about the matter:—"In den folgenden Segmenten erkennt man je ein Paar eigenartiger, Fettkörper-ähnliche Organe, die zu Seiten des Darmes liegen.

Die Zellen, aus denen diese Körper bestehen, sind grob granulirt und erhalten durch Einlagerung zahlreicher, schwarzer Korner ein Chloragogenzellen-artiger Aussehen. Ein starkes Blutgefäss geht mitten hindurch. Ich glaube erkannt zu haben, dass diese Körper mit den Segmentalorganen zusammenhangen, deren in je einem Segment ein Paar vorhanden ist. Es musste unentschieden bleiden, ob sie durch die ganze Lan ge des Körpers oder nur am Vorderkörper ausgebildet sind. Soweit ich das Tier untersuchte, bis zum 20. Segment, sind sie vorhanden." It seems to be possible that the structures which Michaelsen here describes (without any figures) are the same as the organs regarded by myself as the metamorphosed equivalents of the calciferous glands of other Eudrilids. The account of the minute anatomy which Michaelsen gives, though not very full, agrees so far as it goes with the organs in question. They have a kind of resemblance to a fat body, and the cells of which they are composed are distinctly "grob granulirt," but they do not, so far as my own observations go, contain any black pigment. Another difficulty, and the most serious one in the way of comparing the glands of Megachæta with those of Stuhlmannia, &c., is the fact that in the former genus they extend back as far as the 20th segment. This is too far, one would be inclined to suppose, for glands to extend which are homologous with calciferous glands, connected as they are in all earthworms with the œsophagus. The close proximity of the nephridia to the glands might easily give the impression that the two series of organs were connected. The fact that they are traversed by a strong blood-vessel is another point of resemblance to the calciferous gland of Stuhlmannia, &c.

§ Note on the Substitution of Organs as Illustrated by the Spermatothecæ in the Eudrilidæ.

I do not think that attention has been directed to the excellent instance which the spermatothecæ of the Eudrilidæ afford of the substitution of one organ for another (physio-

logically identical, but morphologicallly different). The principal feature of interest in the anatomy of the Eudrilidæ is the presence of cœlomic sacs which do duty as spermatothecæ. I have called these sacs consistently "spermatothecal sacs" to mark their difference in structure from, but their similarity in function to, the spermatothecæ of other Oligochæta. Michaelsen, it is true, has denied to the spermatothecal sac of the Eudrilidæ the function of storing sperm. They have, however, been proved to contain sperm in Nemertodrilus, Eudrilus, and Polytoreutus. That these sacs are not homologous with the spermatothecæ of other Oligochæta is shown by their development. I have pointed out that in Libyodrilus the sac is formed at the expense of the septa, and Rosa has arrived at the same conclusion by a consideration of the histological structure of the sac in Paradrilus. There is, however, at least one genus in which the spermatotheca appears to be of the type general in the Oligochæta. In Heliodrilus there is a single long and narrow sac which opens externally on to the 11th segment, and reaches back to the 13th. At the extreme end the spermatotheca is enclosed by a cœlomic sac continuous with the ovarian sac, &c. I have no facts of development to offer in support of my belief that the spermatotheca in this Annelid is comparable in origin to that of other earthworms; I rely upon its structure and relations. The sac in question is lined by a columnar epithelium, quite different in appearance from the cells which line the sac in which it lies, but quite like the cells which are found in the spermatothecæ of other worms, in which these organs are epidermic invaginations. This is, I hope, plainly shown in the figures illustrating my account of the anatomy of Heliodrilus. The next stage is seen in Hyperiodrilus. Here we have the true spermatotheca reduced to very small dimensions, and the sac involving it is greatly increased in size. In Paradrilus it is possible, whether it actually occurs or not, for sperm to reach the interior of the large cœlomic sac; for this sac communicates directly with the exterior by a short tube which seems to be an invagination of the epidermis, and

appears to be the equivalent of a part of the spermatotheca of Hyperiodrilus. The genus Eudriloides which I have dealt with in the present paper supplies the next stage. Here we have a cup-shaped layer of cells which, though they have lost their connection with the epidermis, are very possibly to be regarded as a derivative of it. They do not, however, line the cœlomic pouch, but have been, as it were, thrust aside by the growth of the cells lining the sac, which cells have forced their way to the exterior. Here, therefore, the original spermatotheca is entirely relieved of all share in the organ devoted to the storage of the sperm. Finally, Libyodrilus and perhaps Polytoreutus have no trace left of the original epidermic invagination except possibly at the very pore. I have shown in Libyodrilus that the sac which is formed out of the tissues of the septa, burrows its way into the thickness of the body-walls; it is quite likely that it actually reaches and perforates the epidermis by its own unaided efforts. The spermatotheca, therefore, of Heliodrilus gradually yields up its place to the sac developed out of the mesoblastic tissues, which grow as it diminishes, and finally entirely replace it. This instance is quite analogous, for example, to the replacement of the notochord by the vertebral column.

§ Classification of the Eudrilidæ.

This family comprises now so large a number of forms that it may be desirable to subdivide it. A subdivision has been attempted by Michaelsen (loc. cit.); but it seems to me that a further acquaintance with the structure of the various genera of the family does not tend to confirm the justice of dividing the family, as Michaelsen does, into two sub-families, Eudrilini and Teleudrilini. The diagnosis which Michaelsen gives of the Teleudrilini is as follows:

"Die Teleudrilinen sind meganephridische, mit 4 Borstenpaar-Reihen ausgestattete Terricolen, die eine einzige ventral-mediane männliche Geschlechtsöffnung auf oder am 17 Segment und eine einzige ventral-mediane Samentaschenöffnung hinter der Intersegmentalfurche 10/11 besitzen."

The two sub-families are, in fact, distinguished by the median or paired character of the generative apertures alone. In the absence of any other characters it appears to me that the paired or unpaired character of the apertures in question is by no means a difference of first-rate importance. Even if we follow Michaelsen in separating as a distinct genus the Cryptodrilid Fletcherodrilus on account of its median series of spermatothecæ, no one would in all probability consider that genus to be worthy of being placed in a separate sub-family, nor, indeed, does Michaelsen propose anything of the kind. The median spermatotheca of Sutroa does not disguise its likeness to other Lumbriculidæ. And in general there are so many instances in the group of the Oligochæta of structures which are paired in one genus and unpaired in another, that a division so pronounced as that which Michaelsen proposes does not commend itself to me.

There are two characters which seem to me to afford a more reliable means of subdividing this family into two sub-families, should such a step be regarded as necessary; as they both relate to structures which are highly characteristic of the genera in which they occur, more weight is to be attached to them. The genus Eudrilus, when it was the only Eudrilid known, was shown by myself to differ from all other earthworms by the possession of ventral median unpaired pouches, which Michaelsen termed "Chylustaschen." The fact that these structures are unpaired is not alone a fact that is greatly to be valued, though it may be pointed out that Gordiodrilus is at present the only other genus (not a Eudrilid) in which these so generally present, and with these exceptions paired, structures are to be found. The most remarkable fact about these unpaired pouches is that they coexist with one pair of paired pouches not lying in the same segment as any one of them; this is more remarkable than if all the calciferous glands were paired or unpaired, as the case might be. Another (at that time quite unique) character of Eudrilus is the existence in the epidermis, or rather just below it, of numerous integumental bodies, which Dr. Horst and I myself have compared to the Pacinian

bodies of the Vertebrata; their appearance, at least, is very like that of the structures mentioned. These same characters are found in a few other genera of Eudrilidæ; they occur in Teleudrilus, in Hyperiodrilus, and Heliodrilus (which two latter Michaelsen unites into a single genus), and finally in Polytoreutus. I am in a position to state that the integumental sense-organs—if I am justified in applying the term "sense-organs" to them—are absent in the following genera:—Eudriloides, Heliodrilus, Pareudrilus, Nemertodrilus, and Stuhlmannia. In none of these genera are there calciferous glands at all like those of the genera mentioned in the first list. Libyodrilus, Pareudrilus, Alvania, and Nemertodrilus have no calciferous glands at all—not a trace of them. In the remaining forms the calciferous glands have undergone the peculiar modification that has been described on a previous page. I think that these two characters serve to distinguish two groups of Eudrilidæ better than the paired or unpaired generative apertures. I would furthermore remark that the condition of the glands, which I believe to be the representatives of the calciferous glands of other Eudrilidæ—in the genus Eudriloides, for example—is not in accord with the low position among the "Teleudrilini" to which Michaelsen assigns it.

These genera are the only ones in which both the points used for the subdivision of the family are known; in some others the presence or absence of calciferous glands has been noted. Thus both Michaelsen and Rosa have shown the existence of a single pair of calciferous glands in the 12th segment in the genus Paradrilus. Preussia is said to have a pair of these glands in the 12th segment; but Michaelsen is doubtful about their nature, and has stated that they contained no calcareous particles. Platydrilus, Megachæta, and Metadrilus have, according to Michaelsen, no calciferous glands, and the remaining genera are not described in this respect. It will be noticed that in the two groups into which I have provisionally divided the family there is yet another character which divided them, and which may possibly be of

value. In Eudrilus and the genera which are placed with it, the sperm-ducts are dilated into a round or oval sac before they open into the funnel. Michaelsen terms these dilatations "Eiweisskapseln." These oval dilatations are absent in all the genera which I have placed in the second group. Paradrilus has them, and, as it also has at least one pair of calciferous glands, may perhaps be referred to the first group. Such dilatations appear to be absent in the genera Platydrilus, Megachæta, Metadrilus, and Notykus. These genera have, as has already been pointed out, no calciferous glands; it remains to be shown whether the integumental sense bodies are absent. Provisionally, therefore, I group the Eudrilidæ[1] into—

Sub-family 1. Eudrilinæ.—Calciferous glands present. Integumental sense organs generally present. Funnels of sperm-ducts dilated proximally.

Sub-family 2. Pareudrilinæ.—Calciferous glands absent or greatly modified. No integumental sense-organs.[2] No dilatation of sperm-ducts.

[1] It is very possible that the structure of the nephridia will prove to separate these two groups. I have to some extent dealt above with the excretory organs of a few types belonging to the sub-family Pareudrilinæ; in these there is either a well-developed integumental plexus of tubules or traces of such. On the other hand, nothing of this kind occurs in any of the Eudrilinæ.

[2] Except in Eudriloides (occasionally).

EXPLANATION OF PLATES 16 & 17,

Illustrating Mr. Frank E. Beddard's paper, "A Contribution to our Knowledge of the Oligochæta of Tropical Eastern Africa."

Fig. 1.—Transverse section through atrium of Eudriloides Cotterilli. *v. d.* Vas deferens, alongside of which runs a blood-vessel.

Fig. 2.—Transverse section through atrium of Eudriloides brunneus, just at the point where the two atria join. *v. d.* Vas deferens. *gl.* Glandular cells containing abundant secretion.

Fig. 3.—Transverse section through atrium of Polytoreutus violaceus. *bl.* Blood-vessel. *m.* Special thickenings of muscular coat.

Fig. 4.—Alluroides Pordagei; lateral view of anterior segments. *sp.* Spermatothecal pore. ♂. Penis. ♀. Oviducal pore. The clitellum is indicated by the absence of furrows dividing its segments.

Fig. 5.—Alluroides Pordagei; longitudinal section through atrium and adjacent structures. The segments are numbered. *Cl.* Anterior, *Cl'.* Posterior end of clitellum. ♂. Male pore. *p.* Penis. *o.* Ovary. *At.* Atrium. *od.* Oviduct. *ov.* A ripe ovum.

Fig. 6.—Polytoreutus Finni. Spermatothecal sacs and atria. *s.* Spermatothecal sacs. ♀. Oviducal pores. ♂. Terminal muscular sac in which atria (*At.*) open. *sp.* Terminal sac through which spermatothecal sacs open.

Fig. 7.—Polytoreutus violaceus. Spermatothecal sacs and atria. Lettering as in Fig. 6.

Fig. 8.—Polytoreutus kilindinensis. Spermatothecal sacs and atria. *v. d.* Sperm-duct. *v. d. f.* Its funnel, opening into interior of *s. s.*, sperm-sac.

Fig. 9.—Reproductive organs of Pareudrilus stagnalis, displayed by dissection and in sitû. *œs.* Œsophagus. *E. s.* Sac containing ovary, and connected with spermatothecal sac. *Sp.* Orifice of latter on to exterior. *Ro.* Egg-sac. ♀. Oviducal pore. ♂. Terminal sac of *At.*, atrium. *p. s.* Sac containing penial setæ.

Fig. 10.—Genital segments of Eudriloides brunneus, from beneath. ♀. Spermatothecal pore. ♂. Male pore. *Cl.*, *Cl'.* Anterior and posterior boundaries of clitellum.

Fig. 11.—Longitudinal section through a few segments of Stuhlmannia variabilis in œsophageal region. *Œs.* Œsophagus. *Ca.* Calciferous glands. *D. v.* Dorsal vessel. *S.* Septum. *Ep.* Epidermis. *m.* Muscular layers of body-wall.

Fig. 12.—Transverse section through œsophagus and one of calciferous glands of the same. *œs.* Œsophagus. *d.* Duct of gland opening into it. *a.* Extremity of gland where nuclei are arranged in irregular portions on each side of a blood-vessel.

Fig. 13.—A portion of a calciferous gland of same, more highly magnified to show the nuclei (*n.*), the boundaries of the cells (*l.*), and the secreted granules (*s.*).

Fig. 14.—Extremity of calciferous gland, lettered *a* in Fig. 12.

Fig. 15.—Section through a calciferous gland of Eudriloides Cotterilli. *c.* Modified cells of gland closely investing the blood-vessels.

Fig. 16.—Section through end of spermatothecal sac of Eudriloides Cotterilli. *Ep.* Epidermis. *Pl.* Plug of cells occluding lumen of sac. *m.* Mesoblastic cells lining it. *E.* Layer of epiblastic cells, apparently invaginated to form wall of sac.

Fig. 17.—Genital segments of Polytoreutus Finni. ♀. Spermatothecal pore. ♂. Male pore.

Fig. 18.—Terminal male apparatus of Eudriloides Cotterilli. *At.* Atria. ♂. Male pore. *s.* Penial seta. *a—e.* Muscles referred to in text.

Fig. 19.—Spermatothecal sac of the same. *gl.* Its glandular appendices.

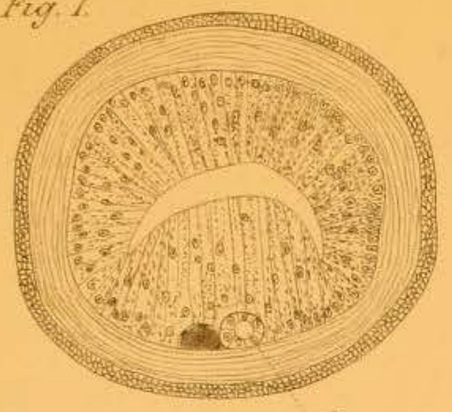
Fig. 20.—End of penial seta of the same.

Fig. 21.—Terminal male apparatus of Eudriloides brunneus. *v. d.* Sperm-duct. Other letters as in Fig. 18.

Fig. 22.—Spermatothecal sac of the same. *x.* End of sac lying in front of external pore. *gl.* Glandular appendices.

Fig. 23.—Transverse section through part of spermatothecal sac, lettered *x* in last figure.

Fig. 1.



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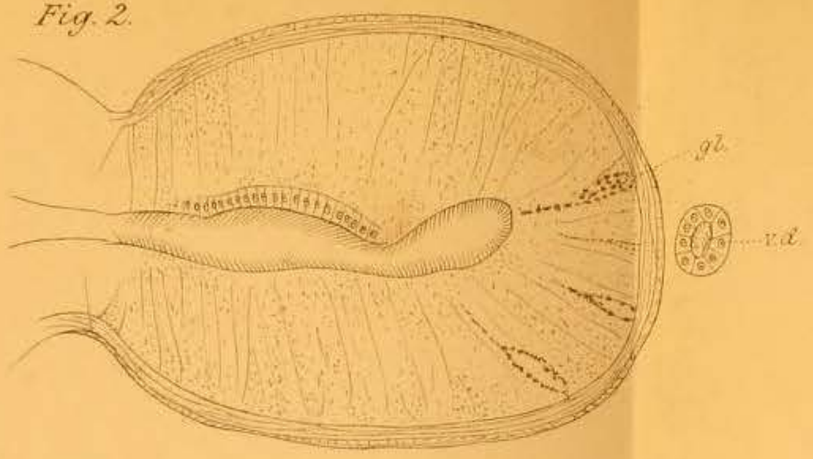

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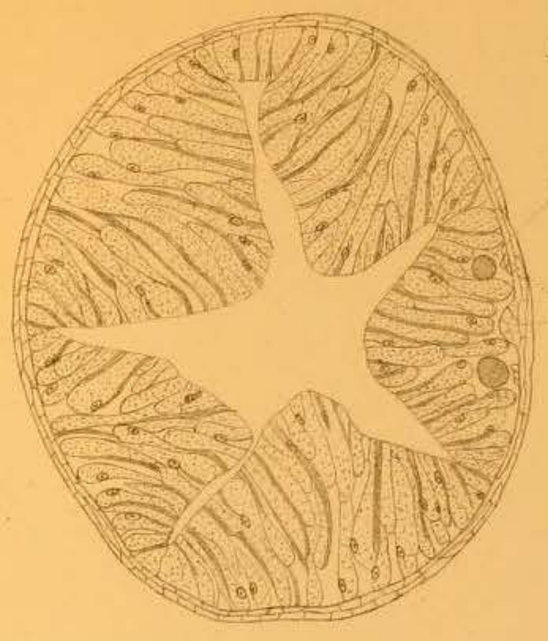

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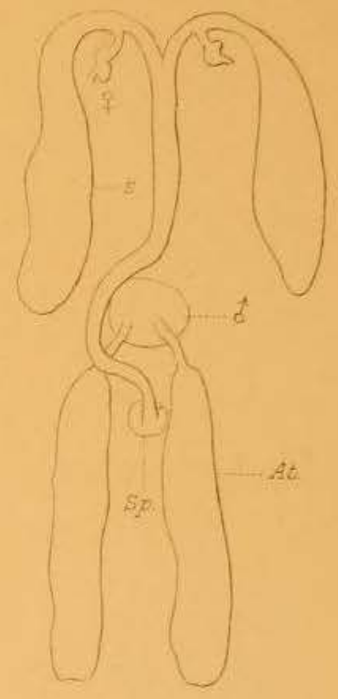

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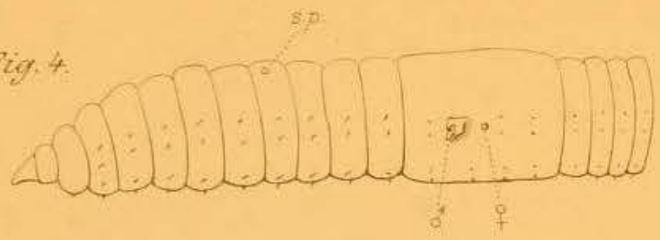

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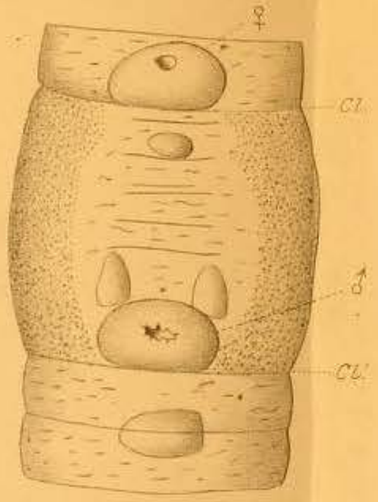

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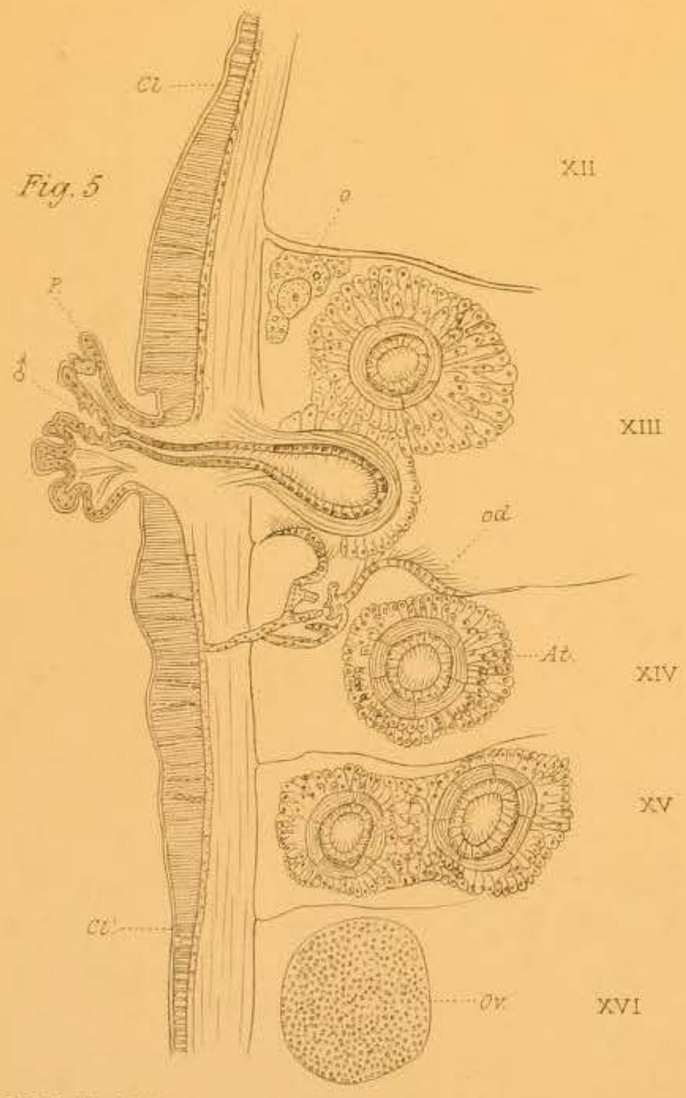

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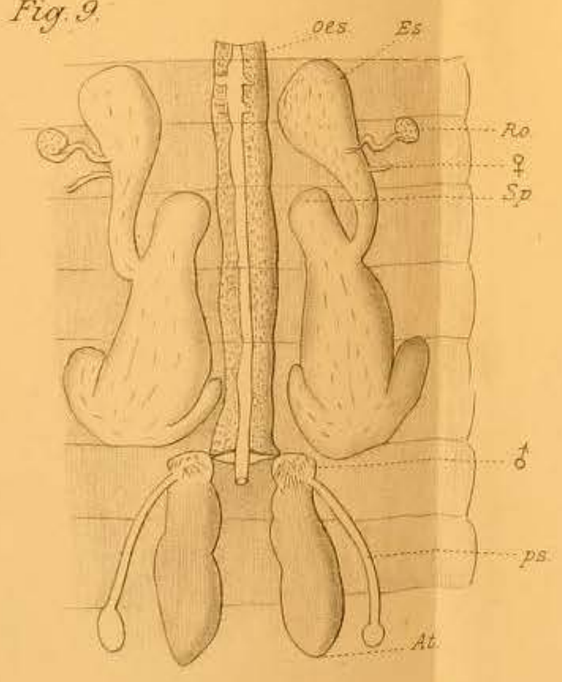

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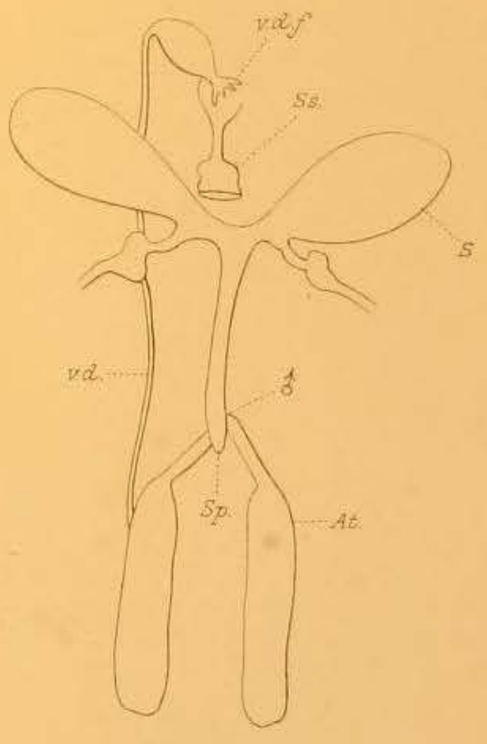

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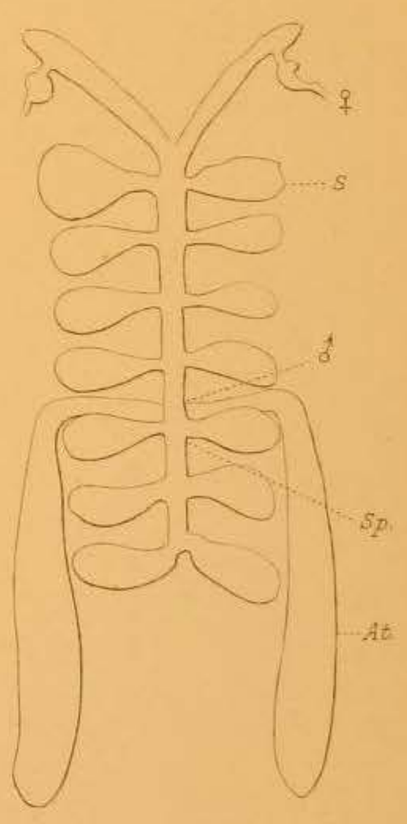

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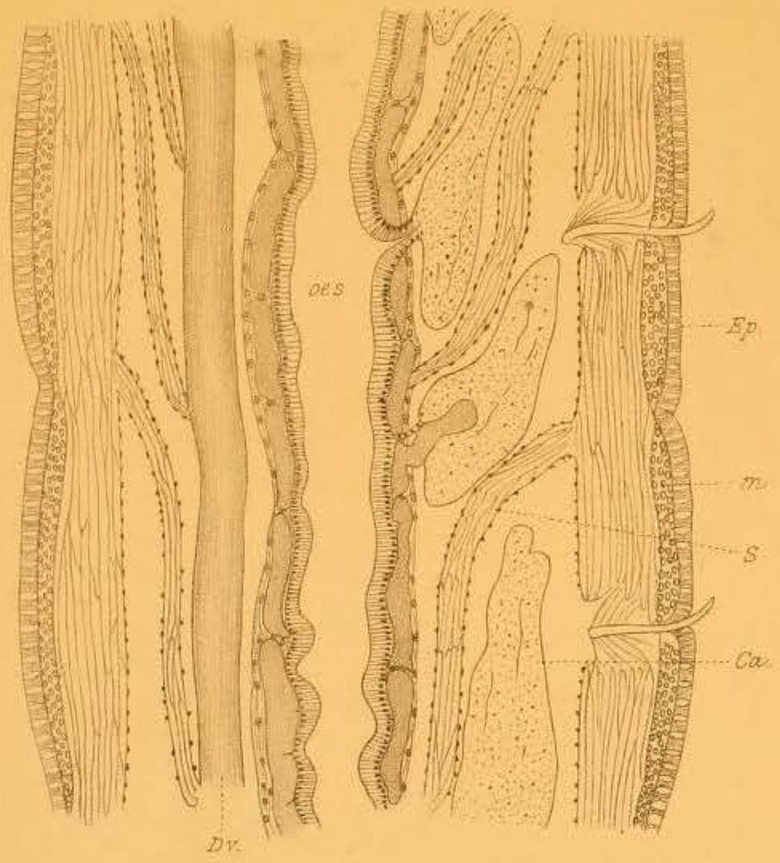
Fig. 11.



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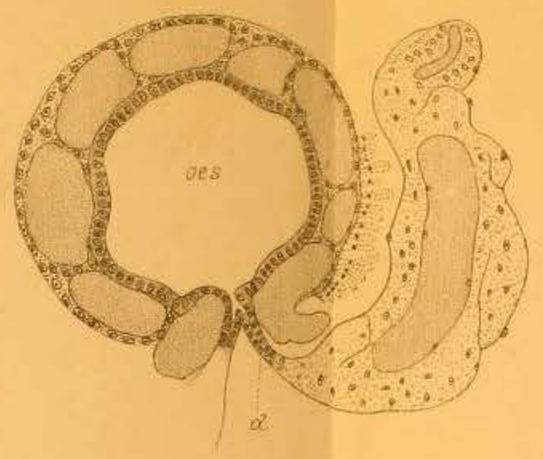

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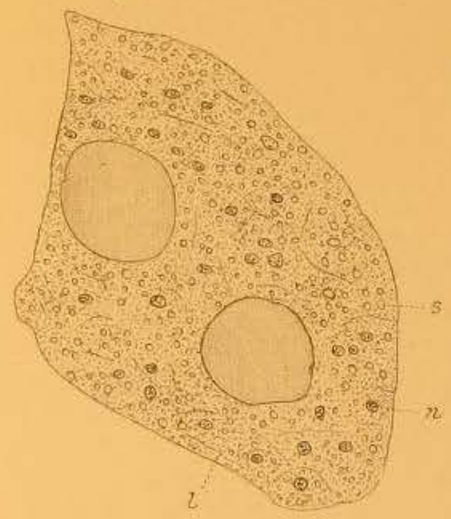

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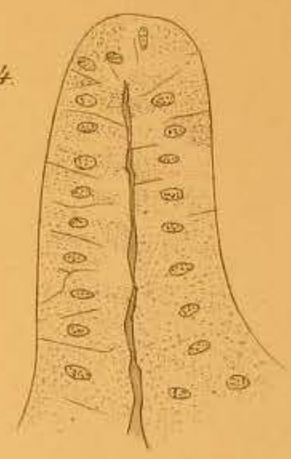

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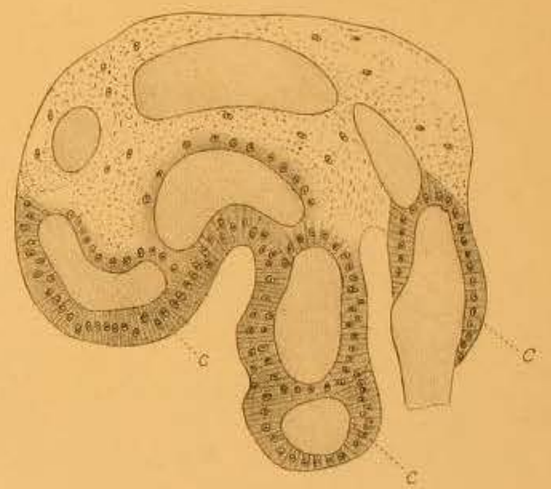

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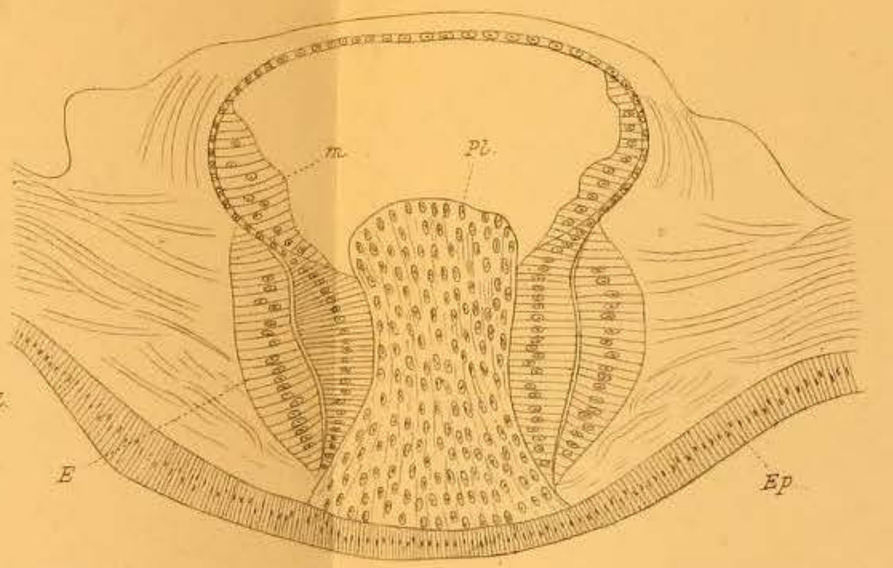

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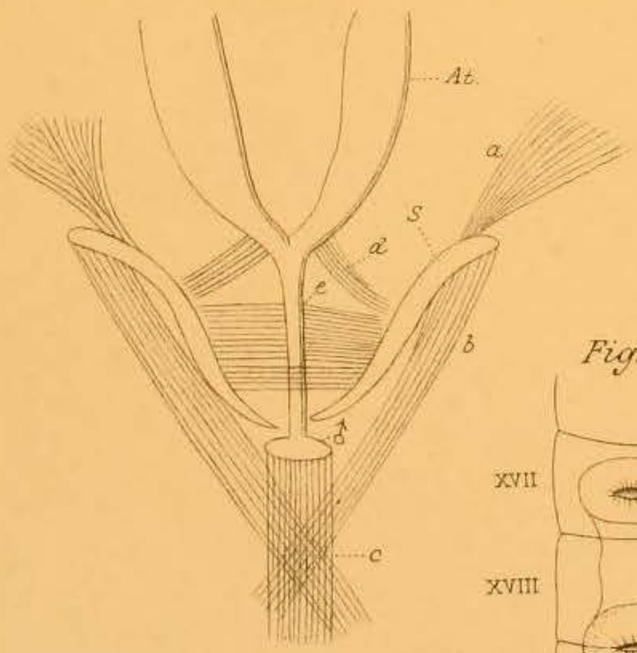

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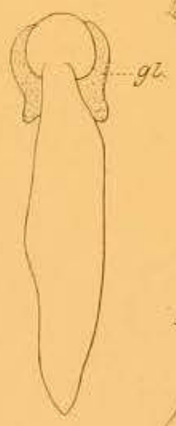

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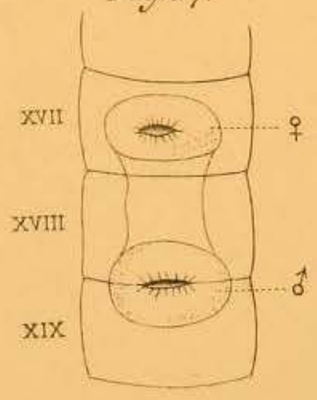
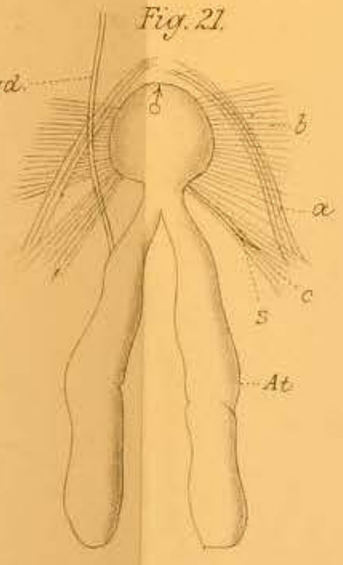


Fig. 20.

Fig. 21.



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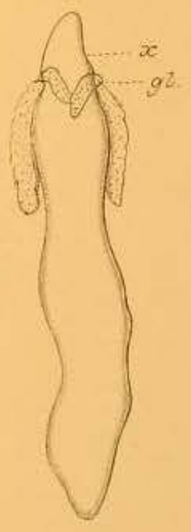

Fig. 23.