XI.—*Anatomical Description of Two New Genera of Aquatic Oligochæta.*

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At present our knowledge of the exotic genera of the aquatic Oligochæta is not very far advanced. During the last twenty years there has been a considerable accumulation of descriptions of exotic Earthworms, but the lower Oligochæta have been much less studied. The principal investigations into this group have been carried on by EISEN, who has made us acquainted with a number of interesting forms, belonging to the families Tubificidæ and Lumbriculidæ, from North America. Other naturalists, such as LEIDY, have also dealt with the Oligochætous fauna of that country; but their papers have chiefly had for their object the discrimination of genera and species, and are not so much concerned with the description and delineation of anatomical structure. Beyond the series of papers published by the above-mentioned authors, we have only a few scattered memoirs by other writers upon exotic species of "*Limicolous*" Oligochæta.

Having recently been awarded, by the Government Grant Committee of the Royal Society, a sum of money to assist me in the investigation of the Oligochæta, I have been anxious not to limit myself to Earthworms, but to obtain as many specimens of the aquatic forms as possible. In the following pages I describe two new genera from New Zealand, and I hope to be able to offer to this Society later an account of the genus *Ocnerodrilus*, of which I have received living examples from British Guiana.

DESCRIPTION OF *PHREODRILUS SUBTERRANEUS*, nov. gen. n.sp.

Concerning the locality and habits of this worm, Mr W. W. SMITH of Ashburton, New Zealand, to whom I am much indebted for two specimens, writes as follows:—

"The two examples of the subterranean species came up in the water of a well near here. They are occasionally pumped up from various depths, according to the depth the pipe is driven to reach the 'flow.' Their habits at great depths in the shingle of the Canterbury Plains must be very remarkable, as all their motions are peculiarly snake-like, and they are extremely nimble and rapid in moving through the water."

The worms are described by Mr SMITH as being of a "fleshy red" colour during life. Each measures about 2 inches in length; even when preserved they have a graceful appearance, due to the delicate, almost transparent, body walls, and to the projection of the long setæ of the dorsal rows.

§ *External Characters.*

The characters of the *setæ* alone show that this Annelid conforms to no genus of which we have any adequate description. As in the majority of the Tubificidæ and the Naidomorpha, the dorsal setæ are capilliform; but in *Phreodrilus* there is only a single dorsal seta on each side of the body in the posterior segments. These setæ have the form which is illustrated in fig. 1, *a*. The portion implanted in the body is straight and of some thickness; the free portion is slightly curved and tapers gradually towards its extremity. Each of these setæ was invariably accompanied by two reserve setæ of the same form, one on each side. In no instance did I observe more than a single mature seta belonging to each of the two dorsal series. On the other hand, the ventral setæ were as invariably paired. The setæ of the ventral series (see fig. 1, *b*) are of two kinds, a single seta of each kind are found in every pair. In both cases the setæ approximate in shape to those of the Lumbriculidæ and of Earthworms; the extremity is not bifid, and shows no traces of having been worn down. The embedded portion of the seta is nearly straight, but the free portion is much curved—more so than in the setæ of the two groups referred to. This, however, only applies to the larger of the two setæ in each pair; the smaller seta has a less marked curvature. I could observe no difference in the setæ in the different regions of the body; but as the worm was not fully mature, it does not follow that such differences may not be developed later.

In every case the setæ protruded from the apices of well-marked papillæ.

The *prostomium* is obtuse, ending in a wide truncated anterior margin.

The *clitellum* was visible in neither of the two specimens.

The *male genital apertures* are paired, and lie on segment XII, in front of the ventral setæ.

The *oviducal* pores occupy a corresponding position in the interval between segments XII/XIII.

The *spermathecal pores* lie in front of the dorsal setæ of segment XIII.

§ *Integument.*

The integument had the same structure throughout. In neither of the specimens which I examined was the clitellum developed, nor was there the very least indication of the position of this organ, such as is sometimes afforded in immature Oligochæta. It is evident therefore, that *Phreodrilus*, like some other genera, may reach a considerable degree of sexual maturity of the internal organs without a corresponding development of the clitellum. As Mr Smith has very kindly promised me to look out for some more specimens of this very interesting Annelid, I may be able at some future time to fill up this and other blanks in the present Memoir. The integument is covered externally by the usual chitinous layer, and the epidermis presents no specially noteworthy differences from other *Oligochæta*. The glandular cells were, however, remarkably clear and free

from granules, and the interstitial cells seemed to be fewer in number than is ordinarily the case.

The transverse muscular layer is only about two fibres wide. The longitudinal muscles consist, as in other of the lower Oligochæta, of a row of muscle-plates, indicated in fig. 14. These show in transverse sections a disposition to curl up at the free edge. Isolated fragments of the longitudinal muscle lamellæ are illustrated in fig. 15. They are darkly stained and show no recognisable fibrillation.

§ *Nephridia.*

These organs commence only in the XIVth segment (in the worm with sexual organs); the whole organ is furnished with the large vesicular cells so commonly found attached to the nephridia of the lower Oligochæta. The funnel opens into the segment in front of that in which the organ lies; it is small, and is placed to the side of the nerve cord.

§ *Alimentary Tract.*

As no known genus of the aquatic Oligochæta possesses a gizzard,* it is almost unnecessary to state that *Phreodrilus*, which would certainly have been included by Claparède in his *Oligochæta Limicolæ*, has no trace of such a structure. The alimentary canal of *Phreodrilus* has in other respects the usual simple structure of the lower Oligochæta. It is also, as in the Naidomorpha and Enchytræidæ, ciliated throughout, with the exception only of the buccal cavity. The cilia of the pharynx and œsophagus are shorter than those of the intestine, but not less obvious. The buccal cavity is distinguished by the short columnar cells by which it is lined. It is abruptly marked off from the pharynx, particularly on the dorsal side; the obvious demarcation between the two structures is not, however, due to a sudden change in the character of the cells, but to their very rapid increase in length; the dorsal wall of the pharynx is lined by very tall cells, which in the space of three or four cells, change their character to the comparatively flattened epithelium of the buccal cavity. The posterior limits of the pharynx are not at all clearly marked; the epithelium very gradually decreases in height, and it is impossible to fix upon any point which might be termed the junction of the pharynx with the œsophagus. The calibre of the intestine is greater than that of the œsophagus, and its walls are in the same way highly vascular. The transition between œsophagus and intestine is not very abrupt; the intestine seems to commence in segment XIII.

§ *Vascular System.*

The vascular system in these smaller Annelids is most conveniently studied by examining the living worm. As, however, I am not ever likely to have an oppor-

* The so-called gizzard of the Naidomorpha seems to be hardly comparable to the gizzard of Earthworms.

tunity of doing this, I do not hesitate to set down the facts that I have been able to gather from an inspection of one individual mounted in Canada balsam, and of a complete series of longitudinal sections of another.

Previously to receiving, through the kindness of the author, Dr Štolc's beautifully illustrated Memoir upon the Tubificidæ of Bohemia [5], I should have been disposed to consider that the presence or absence of a supra-intestinal vessel was characteristic of Claparède's two divisions of the *Oligochæta Limicolæ* and *Oligochæta Terricolæ*. The vessel in question occurs in so many of the former, and had not been noted in the latter. However, Štolc figures such a vessel in his genera *Lophochæta* and *Bothrioneuron* [5, pl. ii. figs. 5 and 6]. In both genera it is closely applied to the dorsal œsophageal wall from segment VI.–IX.; it is furthermore very interesting to note that, as in some Earthworms,* the supra-intestinal vessel is directly connected with the ventral vessel by hearts (one pair in *Lophochæta*, two in *Bothrioneuron*).

In longitudinal sections of *Phreodrilus* two perfectly separate vessels may be observed running along the dorsal wall of the œsophagus. Their course is fairly straight, as the worm had been fortunately killed in an extended condition. The two vessels are different from each other in structure, and cannot therefore be confounded in sections, where sometimes only one of the two was visible in a particular segment.

The vessel, which is closely applied to the dorsal wall of the œsophagus, is extremely thin walled and completely filled with coagulated blood. It resembles in these particulars the ventral blood-vessel.

The other dorsal vessel, which is separated by some little distance from the supra-intestinal trunk is largely—in some places quite—empty of blood; it has rather thicker walls, and is of less calibre. This latter fact is probably due to the contraction of the muscular fibres forming the walls of the tube. There is a certain parallelism here to the arteries and veins of the vertebrata. The thick-walled tube less full of blood after death is the artery, and the two thin-walled vessels full of blood are the veins. The thick-walled vessel appears to be the homologue of the dorsal vessel in Earthworms, while the thin wall intimately connected with the dorsal wall of the œsophagus, and giving off branches to it, is clearly the homologue of the supra-intestinal vessel in that group of worms. The dorsal vessel is lined with a layer of cells of some thickness, and its muscular fibres run for the most part in a circular direction.

I have traced the dorsal vessel from the VIth segment in front to the XVth segment posteriorly. I am not able to make an accurate statement as to the segment in which it disappears; but it does not exist for some distance in front of the tail end, as I have been able to prove by transverse sections through some of the posterior segments.

Another difference which distinguishes the dorsal from the supra-intestinal vessel is the fact that the latter is coated with chloragogen cells; the peritoneal cells of the dorsal vessel are flattened, and have no yellowish-green granules in their interior.

* I state the facts with due reservation. It seems to me far from improbable that the "intestinal heart" may ultimately prove to be connected, as they are in Eudrilidæ, for example, with both dorsal and supra-intestinal trunk in all worms which possess the latter.

In both vessels, particularly in the supra-intestinal, it is easy to see that the blood is a corpusculated fluid ; here and there oval bodies, which have in every respect the appearance of the nuclei in the endothelial lining, may be seen embedded in the coagulated yellow blood. There is little doubt that LANKESTER's description of corpuscles in the Earthworm's blood will be extended to other, to perhaps all the groups of Oligochæta, in many of which they have been observed by VEJDOVSKY.

Here and there the endothelium lining the blood-vessels—particularly at the points where they traverse the intersegmental septa—is thickened to form valve-like structures ; VEJDOVSKY has described and figured something of the same kind [7] in many other Oligochæta. These agglomerations of cells may be the localities where the blood corpuscles take their origin through the rapid proliferation of the lining membrane, as VEJDOVSKY has suggested. On the other hand, the mechanical function of these valve-like structures, which occur in all Oligochæta that I have examined, both terrestrial and aquatic, must not be left out of consideration. The supra-intestinal vessel is connected with the blood-supply of the intestines, and it gives off from the lower side numerous branches which at once break up and form a plexus lying within the œsophageal or intestinal walls. The supra-intestinal vessel is also connected in the XIIth segment directly with the ventral vessel. This connection is effected by a pair of great coiled vessels, which I describe later as blood-glands. Further forward the supra-intestinal vessel appears to have no direct connection with the ventral vessel ; there are, however, a number of a perivisceral trunks, thin and coiled, which surround the œsophagus and communicate with the ventral trunk. These take their origin from the dorsal blood-vessel. We thus have in *Phreodrilus*, as in *Lophochæta* and *Bothrioneuron*, a double system of perivisceral trunks—one set connected with the dorsal and the other with the supra-intestinal vessel. As in *Lophochæta* there is only one pair of vessels belonging to the latter set.

The arrangement of the dorsal and supra-intestinal trunks in *Phreodrilus* is shown in fig. 34 of Pl. III. The drawing, however, only illustrates a few segments, since I am at present uncertain as to the exact segment where the dorsal vessel terminates posteriorly. I have found that in front of the VIth segment it is the only dorsally placed blood-vessel. In the VIth segment the supra-intestinal finally disappears, becoming gradually of less and less calibre towards its termination.

It seems to me, however, to be far from certain that the dorsal vessel of *Phreodrilus* is the homologue of the dorsal vessel in *Tubifex* and some of the lower forms. Professor ŠTOLC's important investigations evidently show the need for a more detailed study of the vascular system of *Tubifex* and other Tubificidæ ; it may prove that they are not without the supra-intestinal vessel of *Lophochæta* and *Bothrioneuron*. I make this suggestion in entire ignorance of the text of ŠTOLC's paper, which, being in the Bohemian language, is absolutely inaccessible to me. In *Pelodrilus*, however, a new genus of Phreoryctidæ, of which I give some account further on in the present paper, there certainly appears to be no trace of more than *one* dorsal vessel.

The question then arises, to which of the two vessels of *Phreodrilus* does the dorsal vessel

of *Pelodrilus* and other of the lower Oligochæta correspond? The relations of the single dorsal vessel, which is present in the posterior segments of *Phreodrilus*, to the intestinal, suggests that *it* is the equivalent of the single dorsal vessel of other Oligochæta; in this case the vessel which I have termed "dorsal vessel" in the anterior segments will be unrepresented in these Oligochæta. There can, I think, be little doubt that the two dorsally placed blood-vessels of *Phreodrilus* are the equivalents of the two in *Perichæta*, *Acanthodrilus*, and a large number of Earthworms. In the simpler forms of Oligochæta, then, the dorsal vessel in most cases has disappeared, while the persistent supra-intestinal takes on its functions as well as its own.

§ *Blood-Glands.*

Many of the Lumbriculidæ are provided with peculiar cæcal diverticula of the dorsal vessel. These have been recently compared by GROBBEN to the "pericardial glands" of the Mollusca. I have myself described in *Perichæta* a series of "blood-glands" formed by a network of capillaries, with frequent dilatations crowded with corpuscles and surrounded by a layer of chloragogen cells, which appeared to me to be referable to the same category. In *Phreodrilus* there is a structure which is more plainly of a glandular nature than the vascular appendices of the Lumbriculidæ or the blood-gland of *Perichæta*. In the XIIth and XIIIth segments is a wide, irregularly coiled tube of which a portion is illustrated in fig. 34, *b.gl.* I cannot be certain of its exact shape, as the bending and twisting was so complicated that I have hesitated to attempt a re-construction from my sections; this tube exists on both sides of the gut, and appears to connect the supra-intestinal and ventral blood-vessels. It is the morphological equivalent, I believe, of the perienteric vascular loop of its segment. But it evidently has a quite different function.

The vessel in question has the comparatively thick muscular coat of the dorsal blood-vessel. Its interior is almost entirely solid, but here and there were conspicuous blood-clots, about the nature of which there could be no doubt; these clots are coloured pink in my figure (Pl. I. fig. 6, *bl.*).

The solid mass, which occupies the greater portion of the lumen of the tube, is made up of cells. The arrangement of these cells seems to indicate that they are simply the lining of the vessel which has, for the most part, become so thick as to occlude the lumen, or nearly so. The cells are large and vesicular; they are almost unstained, only the nucleus having been acted upon after a fairly long immersion in borax carmine; the cells contain a number of granules. They resemble most nearly the tall cells which form the valvular structures in the blood-vessels of the Oligochæta, and like them are probably to be looked upon as a local proliferation of the lining membrane of the vessel. I am not aware whether there is any special development of the lining epithelium of the lateral appendages of the dorsal vessel in *Lumbriculus;* but I am inclined to believe that the two structures correspond very closely. The immensely larger size of the blood-gland in *Phreodrilus* than in the Lumbriculidæ is, perhaps,

related to the fact that there are not a large number of such bodies in the former genus.

It appears to me also possible that these blood-glands are the physiological equivalents of the "Herzkörper" of the Enchytræidæ and some Polychæta. The cardiac body in the former group is seen in two conditions—(1) a distinct, tubular, paired outgrowth from the alimentary tract lying on its dorsal side in *Buchholzia appendiculata;* (2) a solid rod in *Mesenchytræus* extending through the greater portion of the dorsal vessel. MICHAELSEN, who discovered the body in question in *Mesenchytræus* [15], describes and figures it as being attached to the ventral median line of the dorsal blood-vessel. He makes no definite statement as to its continuity with the intestinal epithelium, but considers that "it must be looked upon as an outgrowth of the intestinal epithelium into the dorsal vessel, and, therefore, as homologous with certain organs in certain other Enchytræidæ, for example, the diverticulum of *Buchholzia*." In a later paper MICHAELSEN [14] noted the presence of a similar body in the dorsal vessel of *Stercutus niveus*. These discoveries of MICHAELSEN are of great interest, as they confirm the suggestion of HORST [23] that the cardiac body in certain Polychæta is the homologue of the dorsal diverticulum of *Buchholzia appendiculata*. The structure of the cardiac body in *Mesenchytræus* is evidently much like that of *Pectinaria belgica*. MICHAELSEN at first [14] inclined to the view that the solid cardiac body served the purpose of "purifying the blood from useless, perhaps injurious, substances." This was also, as MICHAELSEN has pointed out, the opinion of CLAPARÈDE.

A later suggestion of MICHAELSEN'S, although highly ingenious, does not commend itself to me as an improvement upon the earlier view. He says [14, p. 485]:—"Concerning the meaning of the cardiac body I have lately formed an opinion which I will take this opportunity of detailing. It is clear that undulatory contractions of a tube will drive forward the fluid contained in that tube with a vigour proportionate to the narrowing of the tube during each pulsation. If the lumen is fairly wide at the maximum of contraction, a portion of the fluid contents will find a way out in the opposite direction; this backward flow will be completely hindered if the lumen is absolutely obliterated during contraction. On the other hand, it is clear that long before this point is reached the capability of contraction possessed by the tube will have found its limits. To remove this difficulty dependent upon the limitation of contractility and preventing a complete pulsation, a compact rod is formed in the tube. By this means the walls of the tube, by closing round the rod, can obliterate the lumen of the tube without reaching the limits of their power of contracting."

This argument might, of course, be applied to the explanation of the lateral cardiac bodies (or blood-glands, as I prefer to term them) of *Phreodrilus;* but the unequal distribution of granules, and the large size of the cells, and their apparently vesicular nature, is against a purely mechanical interpretation of their function.

Mr CUNNINGHAM has objected [22] to HORST'S identification of the "cardiac body" in the Chlorhæmidæ with the gut diverticulum of the Enchytræid, on the ground that there

is demonstrably no connection between the "cardiac body" and the gut wall in the former. This can, I think, be hardly regarded as an objection, though it has, of course, to be proved that this connection does exist at some time or other in *Mesenchytræus* and *Stercutus*.

It seems to me by no means impossible that the paired blood-glands of *Phreodrilus* may have been originally paired diverticula—like the calciferous glands—and connected like the latter with a dorsal and ventral vessel. The change of structure has obviously been followed by some change of function, and I should consider that both the cardiac body, and the structures which I describe in the present paper, have some relation to the blood, as CLAPARÈDE suggested. In relation to this matter I may refer to a highly interesting paper by WELDON on the supra-renal bodies of *Bdellostoma* [18]. The connection of a portion of the pronephros in that animal with the blood system, and its almost complete separation from the rest of the renal organ, is a parallel instance of great interest; but a better analogy with the vascular glands of these Annelids is perhaps to be found in the thymus gland which, originally a diverticulum of the gut, is converted to some function in relation to the vascular system, and entirely loses its connection with the gut. The vertebrate spleen is another organ which may be possibly foreshadowed in these Annelid structures.

§ *Nervous System.*

The *supra-œsophageal* ganglia lie between the first and second segments above the dorsal vessel; a strong nerve leads from the fore part of the brain to a patch of modified epithelium upon the dorsal wall of the buccal cavity, just in the angle where it becomes continuous with the epidermis of the prostomium. In my description of the integument, I have not referred to this organ, which appears to be of a sensory nature.

The ventral chain commences in the IInd segment. In each segment three pairs of nerves are given off at approximately equidistant intervals, which at once perforate the integument, into which they can only be followed for a very short distance; besides these, separate branches supply the dissepiments. The branches of the nerve cord furnish characters which appear to be of a certain value for systematic purposes.

Three equidistant pairs of nerves have been stated to be given off in each segment of *Tubifex rivulorum* [see D'UDEKEM, pl. i. fig. 8], and the same number in several of the genera of Tubificidæ described by ŠTOLC [5] with the addition of dissepimental nerves which were overlooked by D'UDEKEM in *Tubifex*, as VEJDOVSKY has pointed out [7, see pl. viii. fig. 4]. In Lumbriculæ, on the other hand, VEJDOVSKY could only discover a single pair of nerves in each segment.

EISEN has mentioned [3] the very anomalous fact of the absence of any branches at all from the ventral cord of *Eclipidrilus*, and has lately made the same statement with regard to *Sutroa* [4].

I believe that the reason why EISEN discovered no lateral branches of the ventral cord is simply due to the fact that the worms were dissected, and not studied by the section method. A dissection of *Phreodrilus* would certainly reveal no lateral nerves, for these arise from the ventral surface of the cord, and at once become lost in the subjacent body-wall. In longitudinal sections they are easy enough to see.

Perhaps some of the other nerves of *Lumbriculus* escaped VEJDOVSKY'S notice for the same reason. In any case, it is noteworthy that it is in the Lumbriculidæ only where observers have partially (?) or entirely failed to find the lateral branches; and as in the remaining families they have been figured as projecting some way from the ventral cord [*cf.* for *Chætogaster*, VEJDOVSKY [7], pl. v. fig. 4, and for *Dero*, ŠTOLC, [6], pl. i. fig. 6], this fact is so far an indication of affinity to certain Lumbriculidæ.

As to the minute structure of the ventral nerve cord, I may mention that the "neurochord" is a single tube which I traced for a considerable distance forwards.

The connection of the neurochords in *Lumbricus* with the processes of nerve cells, and the demonstration of their nervous nature, has been recently the subject of some admirable investigations by FRIEDLÄNDER. I am not aware that these discoveries have, as yet, been extended to the lower Oligochæta, and I may, therefore, direct attention to fig. 8 of Plate I., which illustrates a branch of the neurochord passing down at right angles to the axis of the chord. I have not, however, traced these branches into ganglion cells, and they seem to occur at the points where nerves are given off.

§ *Testes.*

The testes of *Phreodrilus* lie partly in segment X, but chiefly in segment XI. In the semidiagrammatic sketch of the genitalia (fig. 5), the testis of each side is represented as perforating the intersegmental septum between segments X and XI. In longitudinal sections I have found a perfect continuity between the portions of the testis which lie in front of and behind this septum. When a section is examined that passes considerably to one side of the median axis of the testis, an appearance is presented of two distinct testes, such as CLAPARÈDE described in *Pachydrilus* [1], depending into the cœlom from opposite sides of the same septum. There is, however, no doubt that in *Phreodrilus* the germinal tissue is perfectly continuous through the septum. At both extremities each testis is frayed out into irregularly shaped processes, which contain the germinal cells in the most advanced stage of development. The body cavity in the neighbourhood of the gonad is occupied by a quantity of developing and fully developed spermatozoa. I did not observe anything remarkable about the spermatozoa or their development, except the important fact that all stages of this development are found in the general body cavity. There was no trace of a sperm sac, which is a nearly universal structure among the Oligochæta. As ripe spermatozoa were abundant in the body cavity and in the circumatrial sac (see below, p. 263), I think it probable that no sperm sac other than the circumatrial space is ever developed. However, as the worm possessed no recognisable

clitellum,* it is not possible to be certain about this point, though the male organs had every appearance of having arrived at full maturity.

§ *Vas Deferens.*

Phreodrilus is furnished with only a single pair of vas deferens funnels situated in segment XI. The funnel of one side is illustrated in fig. 2. It is comparatively small and markedly cup-shaped. The funnel is lined by a single layer of epithelial cells, which are furnished with particularly long cilia. The length of the cilia is only paralleled in the case of *Chætogaster*. The funnel on each side of the body is connected with the vas deferens, which is a narrow tube lined by comparatively few cells (see fig. 2). In each case the vas deferens passes back from the funnel, and then bends round towards the septum separating segments XI and XII; from this point it runs obliquely backwards, and then is bent upon itself and runs forwards along the side of the sac surrounding the atrium; near to the ventral side of the body (see fig. 7), where the atrial sac terminates, the vas deferens perforates the muscular sac of the atrium; in the atrial sac it becomes greatly convoluted, and I have found it impossible to make an accurate diagram of these convolutions. Near to the opening of the vas deferens into the atrium the cilia disappear, and the cells become slightly different in character. This portion of the vas deferens is illustrated in figs. 11, 12.

In longitudinal sections, a large portion of the XIth segment lying anterior to the circumatrial sac, is occupied by a highly convoluted tube of a different histological structure from the vas deferens. This tube is, in the first place, of considerably greater calibre than the vas deferens, and cannot, therefore, be confounded with it; its diameter is perhaps three times that of the vas deferens. The structure of the tube is as follows:— The outer coat is formed by a layer of muscles arranged in a circular direction, and covered externally by a peritoneal layer, or at least by a number of nuclei, which in all probability belong to peritoneal cells; inside is a single layer of epithelium, which is so thick as to leave for the most part only a very restricted lumen. The width of the lumen was found to vary in different parts of the tube. The epithelial cells are very granular, and thus contrast with the epithelium of the vas deferens, which is not at all granular. This tube ends blindly in the neighbourhood of the vas deferens funnel; not, however, in the XIth segment, but in the XIIth, just behind the septum. It is a little dilated at the blind extremity, and the cells are here a little more unevenly granular. The tube is entirely confined to the XIIth segment. When followed out it is seen to approach the ventral extremity of the circumatrial sac. At this point it becomes narrower, and the epithelium lower; it perforates the sac, and becomes continuous with the vas deferens, lying in the interior of the sac close to the junction of the latter with the part that lies outside the sac. Here and there the interior of this blind sac contains a small mass of darkly stained refracting substance, which is probably the excretion of the epithelium.

* See, however, p. 290, footnote.

The structure of this diverticulum of the sperm duct is precisely that of the spermathecæ, which lie in the following segment—the XIIIth. It is, however, of somewhat less calibre, otherwise it might have been supposed to be a second pair of spermathecæ lying in the XIIIth segment.

§ *Atria.*

The transition between the vas deferens and the atria is quite abrupt as regards the character of the epithelium lining the two tubes. But the diameter of the atrium is at first exactly equal to that of the vas deferens; it becomes gradually wider, and then narrows again towards its external aperture, which is situated upon the XIIth segment. The external pores of each side of the body are quite evident in the specimen, which was mounted entire in Canada balsam, lying in front of the ventral pair of setæ of the XIIth segment. One remarkable point about the atrium of *Phreodrilus* is its great length; but instead of extending through a large number of segments, as in *Sutroa* [EISEN, 4], the entire atrium is contained in the XIIth segment. It is, however, coiled upon itself several times, and is thus able to be stowed away in one segment. The structure of the atrium is the same throughout. It is illustrated in fig. 4 of Plate I.; the atrial epithelium is apparently composed of columnar cells, the boundaries of which were not visible in my preparations. The individual cells could only be separated by the nuclei, which were much more darkly stained than the surrounding protoplasm. The epithelium of the whole atrium was thrown into folds. I could detect no trace of cilia anywhere; and, as the cilia of the vas deferens and other organs were beautifully preserved, I am disposed to think that the atrium of this genus is not ciliated during life. At the external pore the atrial epithelium passes without any break into the epidermis. There was no trace of a penis, or any specialisation in the distal section of the atrium. As has been already remarked, the only difference between the distal and middle region of the atrium is the less calibre of the former.

The distal section of the atrium, which passes obliquely backwards from the external pore, in addition to its epithelial lining, is covered externally with a layer of muscular fibres and a thin layer of peritoneum outside of this. The muscular fibres run in a circular direction; inside of them is a recognisable membrane by which they are separated from the epithelium. The peritoneal layer which covers the muscular layer is extremely thin. In sections this layer can be only detected by the nuclei, which are quite as large as the nuclei of the epithelium.

At some distance from the external orifice of the atrium the muscular and peritoneal coats become widely separated from the epithelial layer. At this point the lumen of the atrium becomes suddenly contracted, as is shown in fig. 30 of Plate II. The muscular layer, and the peritoneum which covers it externally, becomes completely detached from the epithelium, and a wide space is thus left (see fig. 30, *sp.*, and 9, *sp.*), which is filled with spermatozoa. Besides spermatozoa, which lie separately, and are not in any way aggregated into bundles, this space contained numerous free nuclei, which appear to have

no connection whatever with the spermatozoa. These nuclei (fig. 16, *n.*) bear the closest possible resemblance to the nuclei of the peritoneal cells, but how they have managed to get into the sac in question is unintelligible to me. There is, of course, no lining of peritoneum to the circumatrial space, since it is simply caused by the separation between the muscular layer and the epithelium. There is no doubt, however, that they are merely nuclei, and not cells. The muscular coat surrounds the convoluted portion of the atrium and the greater part of the vas deferens, which lies coiled up in the same cavity. Fig. 32 represents a longitudinal section through the space which surrounds the atrium, near to the periphery. The section, therefore, does not show the convolutions of the atrium or the vas deferens. The space is seen to be filled with spermatozoa and the mysterious nuclei already referred to. The section happens to have been cut rather obliquely, and in consequence the muscular coat is partly shown in longitudinal section. A more highly magnified section through the muscular layer is illustrated in fig. 33, which shows the single layer of circular muscular fibres in the membrane which separates them from the space.

In many Oligochæta the vas deferens is enclosed for a greater or less extent within the sperm sac—for example, in *Pelodrilus*, to be described presently. But in *Phreodrilus* there appears to be no question of a sperm sac surrounding the vas deferens. The space which I have described is simply due to the separation between the muscular coat of the atrium and its epithelial lining. The only other type which I can compare with *Phreodrilus* is *Eclipidrilus*—a most remarkable genus of Lumbriculidæ which has been made known by EISEN. EISEN'S description of the organs in question runs as follows [**3**, p. 6]:—"The *efferent ducts* are two, of enormous size, occupying the segments IX–XIV. The exterior porus of the duct is situated in the IXth segment, just behind the ventral spines. Each efferent duct consists of two large, rather cylindrical, saclike ducts of nearly equal size, which at the extremities are connected by a narrow, short tube of the same general structure as the rest of the organ, except being surrounded by spiral muscles. The interior extremity of the ducts is free, suspended in the perigastric cavity of the body, but the exterior extremity is, as usual, attached to the body wall, and a part of it projects beyond the same, forming a retractile exterior penis proper. The longest of the two bags, which constitute the efferent duct, is the one directly connected with the body wall, and is nearer its interior end, furnished with three very minute circular openings, through which the spermatozoa evidently enter.

"Inside, and freely suspended within this exterior duct, we find another interior one, of very much the same form and size as the former, only it is somewhat shorter, its exterior extremity being free and not attached to the body wall, nor being able to be projected through the same. This extremity is furnished with a large circular opening. The inner extremity of this interior duct ends blindly, and is always full of spermatozoa, and serves accordingly as a true seminal vesicle, in which the spermatozoa are stored before they are ejected through the sexual porus.

"The exterior duct consists of at least three different layers—one exterior epithelial layer; one middle layer, much thicker than the others, consisting of heavy longitudinal

muscles; and one interior membranous layer, which at the exterior extremity is separated from the two former ones, and forms by itself a pellucid membranous penis at times found projected through the sexual porus. The two exterior ones of these layers connect directly with the body wall, of which they seem to be a mere continuation. This structure of the exterior duct is the same throughout the organ, except at the narrow tube, which connects the two sacs (the seminal vesicle and the atrium), which former is surrounded by numerous spiral muscles very similar to those found in *Camptodrilus*.

"If we therefore consider the course a spermatozoon can take, after having escaped from the testes, we find that the efferent duct is most admirably adapted to the purpose of transmitting and storing spermatozoa. A spermatozoon after having entered the efferent duct, through one of the three small circular openings, passes down the exterior duct towards the sexual porus, but is on its way intercepted by the exterior opening of the inner duct, and attracted by the ciliated epithelium of its inner surface, ascends through the exterior part of the duct up through the narrow tube, and is finally lodged in the seminal vesicle, and is here stored until of future use. The spiral muscles round the narrow tube, which can easily be contracted, serve evidently to keep the spermatozoa in the seminal vesicle, and prevent them from escaping in undue time. From the form and free suspension of the inner duct, it may easily be seen that its free exterior extremity can be considerably extended clear down to the penis proper at the moment of copulation."

The account given by EISEN is in some respects incomplete, owing to the fact that his investigations were made upon the living worm. It appears, however, that in *Eclipidrilus* the vas deferens and atrium is entirely surrounded by a sac, which is of a muscular nature, and may possibly be the exact equivalent of the sac which has been described in this paper in *Phreodrilus*.

But EISEN has not described in *Eclipidrilus* any funnel such as I have described in *Phreodrilus;* on the other hand, he has figured three ciliated apertures leading directly from the body cavity into the circumatrial space. Since making myself acquainted with EISEN'S very interesting paper, I have carefully examined my sections, with a view to discovering if any apertures of this nature exist in *Phreodrilus*. I cannot, however, find anything of the kind, and the difficulty of understanding how the spermatozoa get into the space which surrounds the atrium, and how the spermatozoa get to the exterior, is still for me unsolved.

The male efferent apparatus of *Phreodrilus* thus differs in many details from that of any other genus of Oligochæta. It may present points of agreement with *Eclipidrilus*, but I am inclined to agree with VEJDOVSKY when he says that the data given by EISEN require confirmation, as the facts described are so very extraordinary. Nevertheless the account given by EISEN, and quoted in full above, is clear and agrees plainly with his figures. As to *Phreodrilus*, in the first place, the great length of the atrium coiled up itself several times is peculiar, at any rate among the aquatic Oligochæta. The absence of any structure comparable to a penis removes *Phreodrilus*

from the neighbourhood of the Tubificidæ and brings it nearer to the Lumbriculidæ, or the Naidomorpha and some of the lowest groups.

The presence of a diverticulum of the vas deferens is a perfectly unique character among the Oligochæta. I am inclined to suspect that it may serve as a sperm reservoir; but this is only conjecture, as no trace of spermatozoa were discovered in the tube.

The fact that this diverticulum is connected with the vas deferens suggests that it may be possibly the representative of the second vas deferens, present in the Lumbriculidæ and most Earthworms, converted to another function.

In some Oligochæta, for example in *Perichæta*, *Pontodrilus*, &c., the atrium is a diverticulum of the vas deferens, but there can be no question of any such condition in *Phreodrilus*, since a structure evidently corresponding to the atrium is present in addition to this diverticulum.

The coiling of the diverticulum is just as striking as the coiling of the vas deferens, but it does not extend into the following segment as the second vas deferens of a Lumbriculid would. However, *Sutroa*, which is clearly a member of the latter group, though a somewhat aberrant one, has two pairs of vasa deferentia, which all open into the same segment.

This interpretation of the diverticulum acquires a fresh significance when its resemblance in structure to the spermathecæ is borne in mind; a separation from the vas deferens and the acquirement of an independent opening would result in the formation of a structure which would be undoubtedly regarded as a spermatheca. There is not, however, at present any Oligochæt known in which the spermatheca opens into the same segment as the atrium.

The development of spermathecæ as appendages of the male and female ducts seems to be a reasonable conception of their origin, but a great many more facts are required before they can be satisfactorily connected with these ducts. In the meantime I would again emphasise the peculiarities of the vasa deferentia in *Phreodrilus*, which seem to offer a hint that this is the direction in which the explanation of the origin of the spermatheca is to be sought.

One of the most remarkable features about the atrium is the development of a special sac round the junction of the atrium and the vas deferens, including the greater part of both tubes. The structure in question does not appear to me to be a cœlomic sac, but simply a space caused by the separation of the muscular wall from the atrium, which has then undergone an increase in length resulting in the coiling of the tube within the muscular sac. Apart from *Eclipidrilus*, which I have already mentioned, there is no other Oligochæt which shows anything analogous to this very extraordinary state of affairs. If my interpretation of the nature of the circumatrial sac be correct, it is clear that there are no grounds for comparing it with the cœlomic spaces surrounding the genitalia in certain Eudrilids, notably in *Hyperiodrilus* and *Heliodrilus* [BEDDARD, **11**]. For in these cases there can be no doubt whatever that the sacs which enclose the spermathecæ and other organs are cœlomic spaces which have been differentiated round them.

The numerous free nuclei which lie in the circumatrial sac are very remarkable. They agree very closely in general appearance with the nuclei of the peritoneal cells which cover the sac externally; but I have not found any such a layer of nuclei lining the internal wall of the sac. Although the nuclei lie among the spermatozoa, it has not appeared to me that there is any connection between the two. And as the spermatozoa, which I found abundantly in all stages of development in the Xth and XIth segments, develop in the usual way in which the spermatozoa of Earthworms and other Oligochæta have been shown to develop, I cannot see how any such nuclei can be traced to the germinal cells. Moreover, I could detect no such nuclei among the sperm polyplasts so abundantly present in segments X and XI.

Another noteworthy point about the atrium of this Annelid is the total absence of cilia from its lining epithelium; the vas deferens is of course ciliated, but not the atrium or the appendix of the vas deferens. The ciliation of the atrium is so constant a feature of the lower Oligochæta that it is remarkable to find an exception to the rule in a form like *Phreodrilus*, which perhaps comes nearer to the Naidomorpha than to any other group.

§ *Ovaries.*

These gonads (fig. 5, *ov.*) are paired, and arise from the intersegmental septum between segments XI/XII in a position corresponding to that of the testes; they lie therefore in the XIIth segment below the funnel of the vas deferens; but they do not also extend into the segment in front as the testes do. The ovaries are limited to the XIIth segment.

I have been able to observe certain stages in the development of the ova, which shows a remarkable parallelism to the development of the spermatozoa.

Towards the attachment of the ovary, the cell outlines were indistinguishable, and the nuclei alone indicated the separate cells; the rest of the ovary was made up of spherical groups of cells presenting the structure shown in fig. 37, *a*; each of the cells is pear-shaped, the nucleus being in every case embedded in the wide end of the cell; the apices of the cells nearly meet in the centre of each sphere, where there is a minute portion of non-nucleated protoplasm, more plainly to be seen in the later stages of development. These spherules become detached from the ovary, and undergo their further development in the body cavity.

Many clumps of developing ova were to be seen lying in various parts of the cœlom of segment XII. I found others (not so many) in segment XI among the developing spermatozoa. This may possibly be due to the presence of an additional pair of ovaries belonging to the XIth segment, but I have no other evidence which points to such a conclusion.

There was no trace of any egg sac other than a pushing out of the intersegmental septum between segments XII and XIII, and this is illustrated in fig. 31. Later, it may be that this pushing out of the septum results in the formation of a nearly closed egg sac. But in my specimen it opened by a very wide mouth into the cavity of segment XII. The interior of this sac was nearly full of groups of developing ova.

The further stages in the development of the ova are as follows :—The central mass of protoplasm is always without a nucleus, but soon comes to be clearly separated from the cells surrounding it; it assumes a polygonal form, which is illustrated in fig. 37, *b*, *c*. The surrounding cells, which form a complete investment for the centre mass, lose their pear-shaped outline, and become angular when they are in contact with the neighbouring cells and with the central mass of protoplasm. The outer surface is rounded and convex.

The nuclei of the cells are very large and unstained, except for a number of rounded granules, of which one is markedly larger than the rest, and corresponds in all probability to the nucleolus. The protoplasm of the cells is, on the contrary, deeply and uniformly stained.

One of the cells then (see fig. 37, *c*) begins to enlarge, and eventually becomes larger (*d*) than the entire mass of the remaining cells with which it rests in contact. I presume that all of the cells become ova in time, but only one (rarely two) was developed at the same time. I have no facts relating to the further development of the ova, which probably become a good deal larger, and filled with yolk.

Each sphere of developing germinal cells is covered externally by a few nuclei (*n*, fig. 37), which form a kind of follicle.

In the early and middle stages, the resemblance of the sphere to a sperm polyplast is extremely close. In both we have a central mass of non-nucleated protoplasm surrounded by a single layer of germinal cells, which become ova or spermatozoa, as the case may be.

The mode of development of the egg in the Oligochæta is treated of by VEJDOVSKY [7] in his Monograph, chiefly from his own observations, which are the most important in this subject. The development of the ova in *Phreodrilus* is in most respects similar to the development of the ova in certain Enchytræidæ, which is briefly referred to by VEJDOVSKY in the work mentioned, and more fully in his "*Monographie der Enchytræiden.*" The cells of the ovary in certain Enchytræids are arranged in groups exactly as they are in *Phreodrilus*, but there is only a single string of these groups of cells instead of a large mass, such as I describe in the present paper.

The development of the ova in the genus *Ilyodrilus* appears from the figures of ŠTOLC [5] to be very similar to *Phreodrilus*.

§ *Oviduct.*

The oviduct, as in the Lumbriculidæ and Tubificidæ, is very short, and consists of little more than the funnel; the duct leading to the exterior is very short. The oviduct funnel opens into the XIIth segment, and the external pore lies on the boundary line between this segment and the XIIIth. In the only specimen (see fig. 18) which I studied by means of sections, the oviduct was not ciliated, and the funnel also had evidently not arrived at maturity. It is interesting to note that the female organs of this worm are not fully mature at the same time as the male organs; there appears to be here, as in other hermaphrodite organisms, a dichogamy.

§ *Spermathecæ.*

There is only a single pair of spermathecæ in this genus, which are situated in the XIIIth segment (fig. 5, *sp.*); at least, their external orifice is placed in this segment, in front of the dorsal setæ. The pouches themselves are extraordinarily elongated, and extend into the XVth segment.

Each spermatheca is coiled upon itself once or twice; the lumen is at first tolerably wide and the external pore is large. At this point the epidermis can be seen to be continuous with the cellular lining of the spermatheca. One spermatheca had the form illustrated in figs. 5, 10. The former figure represents the genitalia of *Phreodrilus* as they would be seen on a dissection of the worm; it is, however, compiled from a single continuous series of longitudinal sections, of which not a single one was missing. Fig. 10 represents the spermatheca in longitudinal section. The wider portion of the spermatheca referred to passes back towards the posterior end of segment XIII; it is then bent upon itself, and runs back to a point about opposite to the external orifice. The spermatheca then passes down to the ventral side of the body with a gradually decreasing lumen; arrived at this point it comes to lie between the ventral blood-vessel and the nerve cord; the tube is then directed backwards, running still between the blood-vessel and the nerve, and perforates septum XIII/XIV; in the XIVth segment the spermatheca again becomes wider, and lies no longer beneath the ventral blood-vessel; its course is nearly perfectly straight, and after perforating intersegmental septum XIV/XV without any decrease of its width, it terminates blindly in the interior of the XVth segment at a little distance from the septum last traversed. The constriction of the spermatheca in the middle, which amounts to an actual occlusion of the lumen in the individual studied by me, recalls the spermatheca of *Anachæta Eiseni* figured by VEJDOVSKY [**8**, pl. vii. fig. 22].

I could not discover any spermatozoa in either of the two spermathecæ, and they present an appearance of immaturity, owing to the non-glandular character of the lining epithelium. The immaturity of the spermathecæ, therefore, corresponds to the immature condition of the ova and oviducts.

The minute structure of the spermatheca presents no character of any particular importance. It is covered externally by a circular layer of muscles, and has a lining of a single layer of cells. Its structure corresponds exactly to that of the diverticulum of the vas deferens.

The position of the spermathecæ is that of certain of the Lumbriculidæ. In all the lower groups of Oligochæta, as well as in all Earthworms excepting only *Microchæta*, *Brachydrilus*, and some of the Eudrilidæ, the spermathecæ lie in front of the ovarian segment.

Furthermore, the great length of the spermathecæ, and the fact that they extend through more than one segment, is a peculiarity almost confined to the genus *Phreodrilus*. The only other example that I can recall is the Eudrilid *Heliodrilus* [see BEDDARD, **11**], where the spermatheca extends through three or four segments.

AFFINITIES OF *PHREODRILUS*.

This very remarkable genus does not fit in perfectly with any single one of the known families of Oligochæta. The characters of the setæ remove it from any of these families, and are alone sufficient for the creation of a new family.

The elongated setæ of the dorsal rows agree fairly closely with the "Haarborsten" of the Tubificidæ, many Naids and *Aeolosoma*, but the ventral setæ have an altogether peculiar form.

Turning to internal characters, the same difficulty is met with in referring *Phreodrilus* to any of the seven well characterised families into which the aquatic Oligochæta fall.

The single pair of funnels opening into the XIth segment, recalls the Enchytræidæ; but, as MICHAELSEN has pointed out the variability of the position of these essential organs in closely allied forms, *Phreodrilus* may be also compared in these particulars to the Tubificidæ and the lower forms generally. The long atrium, apart from the curious sac in which it is enveloped, is perhaps more like that of the Tubificidæ, but it is not furnished with a prostate, nor with a penis.* However, in *Ilyodrilus* both these structures appear to be wanting. Although this latter genus is included by ŠTOLC in his recent Monograph of the Bohemian Tubificidæ [5], it is placed in a special sub-family. I imagine that if it were not for the *position* of the genitalia, the worm would be referred to the Naidomorpha.

The ciliation of the entire alimentary canal, with the exception only of the buccal cavity, is an important point of resemblance between *Phreodrilus* and the Naidomorpha, as well as other lower families of Oligochæta.

In short, it does not seem to me to be possible to refer this genus to any known family, without extending the definition of that family so as to include many of the peculiar characters of *Phreodrilus*.

I therefore propose the following definition of a new family, which is compiled on the same lines as VEJDOVSKY'S definitions of the remaining families of aquatic Oligochæta.

Fam. Phreodrilidæ, n. fam.

Setæ in four rows; the dorsal setæ long and capilliform, two to each bundle in the anterior segments; only one posteriorly. Ventral setæ of two kinds—one of each kind in each row—curved and S-shaped without notched extremity.

Testes in X and XI forming a continuous mass on each side, perforating septum X/XI; ovaries in XII; development of ova as in Enchytræidæ and *Ilyodrilus;* sperm duct much coiled, opening by an atrium also much coiled on to segment XII; atrium and the greater part of sperm duct inclosed in a muscular sac derived from

* Since the above was written, I have received a more fully adult specimen, in which one of the segments in the neighbourhood of the XIIIth was furnished with a pair of tubular processes. An unfortunate accident in the preparation of this specimen for section cutting prevented me from ascertaining whether these are merely the everted atria, as I believe, or are penes. The clitellum in this specimen apparently occupied about four segments, commencing at the XIIth or XIIIth.

muscular tunic of atrium; sperm duct furnished with a long convoluted diverticulum; oviducts opening on to intersegmental groove XII/XIII; alimentary tract ciliated throughout the entire length with the exception of the buccal cavity.

Genus **Phreodrilus**, nov. gen.

A single pair of very elongated and coiled spermathecæ, opening on to exterior in front of dorsal setæ of segment XIII. Septal glands present, connected with pharynx. Nephridia wanting in anterior segments. No special sperm sacs or egg sacs. (?)

Phreodrilus subterraneus, n.sp.

Long, slender worm about 2 inches long; chloragogen cells upon œsophagus commence towards end of segment VI. Habitat, New Zealand.

The above definitions must naturally be considered as very temporary; they will no doubt require revision in the event of the discovery of an allied form.

I should regard the Phreodrilidæ as a very low form of Oligochæta greatly specialised in certain directions. I should explain, however, that in using the expression "low," I do not mean that this genus is in any way near the ancestral form of the Oligochæta. The simplicity of structure in this and other aquatic genera is rather to be looked upon as evidence of degeneration. The almost complete ciliation of the alimentary tract is a feature that *Phreodrilus* shares with the simpler forms; so also is the very complete internal metamerism of the body; I mean as regards the intersegmental septa. Whether it actually propagates by the asexual method, is a question upon which I may possibly have the opportunity of reporting later; but I am in the meantime inclined to suspect that *Phreodrilus* will prove to be one of the "*Gemmipares*" of d'UDEKEM. Another character by which *Phreodrilus* shows its low position among the Oligochæta is the absence of spermsacs or ovisacs. There are some indications, to which I have duly referred above (p. 267), that an egg sac is formed by a dragging back of the septum bounding posteriorly segment XII. However, in the not fully mature *Stylaria lacustris*, VEJDOVSKY figures (**7**, pl. iv. fig 2, *v.*) an egg sac totally distinct from the septa, and apparently bearing no relation to them. On the other hand, in *Mesenchytræus* there is an impaired egg sac very like that of *Phreodrilus*, but longer. Whatever may be the case as regards the egg sac in specimens of *Phreodrilus* with more matured female sexual organs than my example, it appears highly probable that a sperm sac is never developed.

I should place the Phreodrilidæ nearer to the Naidomorpha than to any other group of Oligochæta, though I admit that the position of the genital organs suggests an affinity to the Enchytræidæ. But what their exact position with regard to these lower groups is, I regard as a matter which cannot be at present satisfactorily determined. There are, however, a few points in which *Phreodrilus* recalls the higher among the

aquatic Oligochæta; for instance, the ventral setæ, with their non-bifurcate extremity. At present setæ of this description are only met with in the Enchytræidæ among the lower forms. The form of the setæ in question in *Phreodrilus* is certainly different in some details from the setæ of the Lumbriculidæ, but they conform to the same general type. I have described in some detail (p. 258) the curious "blood gland" of *Phreodrilus*, and have compared it with the dilated branches of the dorsal vessel, which are so characteristic of the Lumbriculidæ. *Phreodrilus* also agrees with some members of that family in the position of the spermathecæ; and if I am right in my supposition that the cæcal appendage of the sperm duct is the metamorphosed equivalent of the second sperm duct of the *Lumbriculus*, there is an interesting point of affinity to that group. The non-ciliation of the atrium, however, removes *Phreodrilus* from the neighbourhood of the Lumbriculidæ no less than from the neighbourhood of the Tubificidæ and the lower forms; indeed this organ is altogether peculiar.

A survey of the structure of *Phreodrilus* leads me to the conclusion that it should be placed some way off the line leading from the more highly developed Lumbriculidæ to the lower Naidomorpha, but that its precise relationships require further study, and cannot be determined with any probability of success at the present time.

DESCRIPTION OF *PELODRILUS VIOLACEUS*, nov. gen. n.sp.

The Annelids which form the subject of the present communication, were, like the last, collected and preserved by Mr W. W. Smith of East Belt, Ashburton, New Zealand, to whose kindness I have been for some years past greatly indebted for specimens of New Zealand Oligochæta.

They were collected about a mile from Ashburton, in rich wet soil, at a little distance from a swamp. They are described by Mr Smith as "flesh-coloured" during life. The worms were fixed with corrosive sublimate and hardened in alcohol; their colour in the preserved state is bluish-grey, caused by the transparent walls and the opaque contents of the alimentary tract.

The length of the specimens varies from 1 to 2 inches; they are very slender, and resemble a *Phreoryctes* or *Lumbriculus*. Most of them have the clitellum well developed; and this fixes the period of maturity to the month of August, when they were collected.

I find that they belong to a distinct generic type, for which I propose the name *Pelodrilus*. They have affinities both to the Lumbriculidæ and Phreoryctidæ.

§ *External Characters.*

(1.) *Prostomium.*—The prostomium of *Pelodrilus* is short and blunt, and very inconspicuous in the preserved specimens; it has no resemblance to that of *Phreoryctes*, which is divided by a furrow into two portions.

(2.) *Setæ.*—The setæ exist upon all the segments of the body except the first. They are arranged in four couples, both of which are, in the anterior part of the body at any rate, rather lateral in position. I could detect no difference of size between the setæ of the more dorsal and of the more ventral couples, such as I have shown to occur in *Phreoryctes* [12].

The shape of the setæ is in no way distinctive; as shown in fig. 20, *s*, they agree with those of *Phreoryctes*, the Lumbriculidæ, and most Earthworms.

There is, furthermore, an agreement with the two first-mentioned families in the fact of there being no modification of the setæ upon the clitellum or of those in the neighbourhood of the spermathecal apertures. They are present, and are perfectly normal in shape, as well as in arrangement, upon all the segments of the clitellum.

It appears, therefore, that the setæ of *Pelodrilus* are more like those of the Lumbriculidæ than of any other family or group of Oligochæta.

(3.) *Clitellum.*—The data with regard to the number of segments occupied by the clitellum in the Lumbriculidæ are not very numerous. With regard to *Rhynchelmis*, VEJDOVSKY says (9, p. 34), "Ein solcher [wurm] ist in der Regel im Begriff einen cocon alzulegen, was sich aüsserlich nach einem weisslichen Auflage am 8-16 segmente kenntlich ist." I take this to imply that the VIIIth to the XVIth segments are occupied by the clitellum, as he has also said (7, p. 67), "Bei *Rhynchelmis* der Gürtel eine bedeutende Anzahl von segmenten einnimmt."

In *Phreoryctes* the clitellum is much more limited, and extends over four segments only, viz., from XI–XIV.

In *Pelodrilus* the clitellum occupies segments XI–XIII. It is only developed on the dorsal side of the body. In the region of the clitellum the body is much swollen, owing to the tension caused by the genital products.

So far, therefore, as can be said at present, *Pelodrilus* comes nearer to *Phreoryctes* than to the Lumbriculidæ. I shall refer to the minute structure of the clitellum under the heading "Integument."

(4.) *Nephridiopores.*—These are situated in front of the ventral pair of setæ.

§ *Integument.*

The most interesting fact relating to the structure of the body wall in *Pelodrilus* is its great thickness in the anterior, as compared with the posterior, segments. This is frequently met with among terrestrial Oligochæta (*cf.*, for example, figs. 4 and 3 in the plate illustrating my memoir upon *Moniligaster* [13]), where it appears to have an obvious relation to the density of the medium in which they live. Increased muscular power in the anterior segments is not so much needed by worms which swim in water, and is not developed. *Pelodrilus*, however, does not live in water, like most of its allies, but in marshy land; and its structure bears evidence of its mode of life, not only

in the thick longitudinal muscular coat of the anterior segments, but also in the greatly increased thickness of some of the anterior inter-segmental septa. These latter structures will be again referred to later (see p. 276).

The epidermis consists of the usual oval glandular cells, between which lie tall interstitial cells.

The circular muscular layer is not more than two fibres thick in the anterior thickened region of the body.

In connection with the epidermis I may mention the presence of two sucker-like structures, which lie, one behind the other, in the middle ventral line of segment X. These bodies seem to be possibly organs of sense connected with the generative function. I should compare them to the "Wollustorgane" described by MICHAELSEN [17] in *Acanthodrilus georgianus*.

One is shown in longitudinal section in fig. 20, *g*. The epidermal cells are here seen to be somewhat elongated, and to converge towards a point situated in the middle of the modified area. The cells are, some of them, very granular, and it may be that they have a glandular function. The integument was not sufficiently well preserved to permit of a more decisive opinion as to the nature of these bodies.

The clitellar epithelium is one cell thick. These cells are elongated and laden with granules. The glandular part of the clitellum is only developed dorsally; on the ventral side an area surrounding the generative openings appears quite different when the body wall of the worm is examined from below in a glycerine or Canada balsam preparation. A number of lines shown in fig. 22 radiate out from the male generative pores. These lines suggest muscles connected with the widening or narrowing of the genital pores. In sections I have found it difficult to make out the structure of the integument in this region; fig. 28, therefore, which illustrates the opening of the vasa deferentia as seen in longitudinal section, must be taken to be only very diagrammatic as regards the epidermis. In any case it is certain that the tall granular columnar cells present on the dorsal surface of the clitellum are here absent. A darkly-stained area divided into cubical blocks underlies the epidermis, which is not greatly developed. I take these structures to represent a series of muscular masses peculiar to this region of the integument, and concerned with the movements of the clitellar segments during coitus, and perhaps also with the closure or opening of the genital pores. The structure wants working out on material that has been specially preserved to this end.

§ *Alimentary Canal.*

This presents the characters that are usually met with in the lower Oligochæta, that is, there is no gizzard, and no glands appended to the canal. The buccal cavity occupies the first segment of the body. Its walls consist of little else than a layer of somewhat flattened cells. The pharynx also occupies a single segment—the second. It is chiefly

distinguished by the thickened epithelium, developed only on the dorsal side, which begins and ends abruptly. A few muscles attached to the pharynx connect it with the body wall. The œsophagus is narrow, but the commencement of the intestine is hardly wider. The latter is distinguished by its epithelium being ciliated.

The chloragogen cells commence in the Vth segment. It was CLAPARÈDE who first noticed that the commencement of the chloragogen layer covering the intestine was a fixed point often characteristic of the species.

§ *Nephridia.*

The nephridia, instead of being, as is the rule in the aquatic Annelids, absent in the genital segments, are present in all the segments of the body, commencing with the VIIth and excepting the XIth and XIIth.

At present the only instance of an Oligochæt, included by CLAPARÈDE in his group "Limicolæ," where the nephridia are not absent from the genital segments, is *Lumbriculus*. This fact has been recently discovered by VEJDOVSKY, who has, however, only stated that the nephridia persist in the spermathecal segments. A fuller account of this form is promised by Dr A. ŠTOLC. Now that two genera are known in which the nephridia persist in the genital segments after the worm has attained sexual maturity, it is obviously impossible any longer to retain a group "Limicolæ," distinguished by the absence of nephridia in those segments. VEJDOVSKY suggested that the disappearance of the nephridia in the genital segments of aquatic Oligochæta on the development of the sexual organs and ducts might be due simply to want of space in these small Annelids. In support of this suggestion it may be noted that both *Lumbriculus* and *Pelodrilus* are large worms as compared with the majority of the aquatic forms; but as they are equalled or exceeded in size by many Lumbriculidæ, and even by certain Tubificidæ, and a species of *Pachydrilus*, some other cause must be sought for the comparatively rare persistence of the nephridia in the aquatic Oligochæta, and their almost universal persistence in the generative segments of the terrestrial forms.

I should regard it myself as simply a further illustration of the structural simplification which is so frequently associated with smallness of bulk, and which DOHRN and LANKESTER regard as degeneration. On this view we should expect to meet with this simplification of structure less marked in those forms which approach nearest to the higher Oligochæta. And that is precisely the position occupied by the Lumbriculidæ and Phreoryctidæ, in the neighbourhood of which families *Pelodrilus* should undoubtedly be placed.

A very convenient method of studying the anatomy of this worm, which I found too small to dissect, is to cut the anterior end of the body in half by a longitudinal cut; the ventral and dorsal halves are then mounted in glycerine, and the relative position of the organs, as well as to a certain extent their minute structure, may then be very easily studied. This forms a good way of checking the results obtained by continuous series of longitudinal sections.

In such preparations the nephridia are seen to occupy a relatively small space in the body cavity of their segment; each lies coiled up closely approximated to the anterior septum; the duct to the exterior passes off from the ventral surface of the nephridium, and after a relatively long course opens on to the exterior in front of the ventral pair of setæ. This position *in front of* the ventral pair of setæ is also found in *Phreoryctes* [12], though apparently not in *Phreoryctes filiformis*, and in *Phreatothrix* among the Lumbriculidæ.

The nephridial funnel, as in all Oligochæta in which there are paired nephridia, except *Plutellus*, lies in the segment anterior to that in which the nephridia itself is placed. A single funnel depending into the IXth segment is shown in fig. 24; they lie near to the junction of the septum with the body wall, on a level with the ventral setæ.

A single nephridium *in situ* is illustrated in fig. 2. The coils of which it is composed are closely pressed together, and under a low power it looks almost as if the nephridium were simply formed by a comparatively short and broad tube bent a few times upon itself. A closer examination shows that each coil is really composed of a bundle of fine nephridial tubules closely pressed against each other, and occasionally anastomosing. They run for the most along or at right angles to the long axis of the mass. There is hardly any development of peritoneal cells round the nephridia; certainly the large vesicular cells, which are so often found in the aquatic Oligochæta, are absent.

§ *Body Cavity.*

The *septa* which separate the cœlom into a series of cavities corresponding to the external segments are replaced in the four anterior segments by irregularly-placed fibres and bundles of fibres passing between the alimentary tract and the parietes; after the Vth segment the regular septa begin. It is interesting to find that the first five of these are very thick, and consist of two distinct muscular coats, whose fibres run in opposite directions. The relative thickness of one of these anterior septa, as compared with one of those that immediately follow, will be seen by a comparison of figs. 25 and 26, which were drawn with the aid of a camera lucida. The septa are cup-shaped, with the concavity directed forwards, and in the segments which contain the sperm sacs and ovisacs this concavity is much emphasised by the stretching of the septa, caused by the growth of the sacs in question.

As far as I am aware, *Pelodrilus* is the only instance of an Oligochæt, which CLAPARÈDE would undoubtedly have referred to his group of Limicolæ, where this increase in thickness of the anterior intersegmental septa is met with. It may very possibly have a relation to the habitat of the worm in soil, and not in the softer mud at the bottom of a lake or river; and in any case it shows that no importance can be attached to the presence of these thickened septa in Earthworms as a character distinguishing them from the lower Oligochæta. In view, however, of other points in which *Pelodrilus* resembles the higher Oligochæta, this character, perhaps, gains an additional importance.

Septal Glands.—A few Oligochæta are provided with peculiar glandular structures attached to a certain number of the anterior intersegmental septa, which are usually regarded as glands appended to the œsophagus. They have been hitherto found in the Enchytræidæ, in some Naidomorpha, and in *Phreatothrix* among the Lumbriculidæ. They occur also, as I have already pointed out in this memoir, in my new genus *Phreodrilus*.

The septal glands are found in segments V–VII; they form a series of paired structures lying on the anterior face of the cup-shaped septæ which lie between these segments. I could not find any evidence of their possessing a central lumen such as has been described by various writers. In all my sections the septal glands were undoubtedly solid structures, though often furnished with a fibrous core. The cells which compose these glands appear to have no particular arrangement. They have a glandular appearance, and are pear-shaped. The extremity of the cell passes into a fine prolongation; the prolongations of all the cells unite to form solid strands, which are bound up in a darkly staining sheath, which is continuous with the sheath of the gland. The fibrous core that has been mentioned is simply produced by the processes of these cells. In fig. 36 I have sketched a portion of one of the septal glands showing the fibrous core, which is really a bundle of the ducts of the unicellular glands, which are associated together to constitute the septal glands. The fibrous core passes forward towards the pharynx, and then gives off branches of various sizes, which end in close contact with the basis of the epithelium of the pharynx on the dorsal side. The dorsal blood-vessel is also shown in the figure lying just above the "apertures" of the septal glands. The fibrous strands which connect the septal glands with the pharynx have a few nuclei interspersed. It appears to me that, at any rate in this Annelid, the septal glands are simply to be regarded as masses of unicellular gland-cells—each gland-cell being prolonged into a duct which reaches the pharyngeal epithelium.

The structure of these glands, in fact, is very much like that of the "capsulogenous" glands in *Perichæta*. In many species belonging to that genus—probably in most—there are little, white, pear-shaped, glandular bodies opening on the ventral side of the body in the neighbourhood of the reproductive apertures—both the vasa deferentia and the spermathecæ.* The structure of these bodies is very simple; they consist of groups of unicellular glands bound together in a common sheath, whose ducts can be traced through the epidermis to the exterior. In *Pelodrilus* I must confess to having been unable to trace the ducts of the septal glands through the pharyngeal epithelium. They appeared to end at these bases of these cells. I am, nevertheless, decidedly of opinion that the septal glands should be referred to the same category as the integumental glands of *Perichæta*, and that both structures are seen in their least specialised condition in the

* I notice that ROSA, in a recent paper, still speaks of the small second appendage of the spermatheca in *Perichæta Houlleti* (and *P. campanulata*) as a diverticulum of the spermatheca. If the structure of the body in question is the same in *Perichæta campanulata* as in the species which I investigated, and believed to be identical with PERRIER'S *P. Houlleti*, the term is hardly applicable.

single glandular cells which open on to the body surface in Leeches, and appear also, according to BENHAM [20, pl. xvi. *bis*, fig. 39], to occur in the Earthworm *Microchæta*; though here the numerous nuclei probably indicate that the glands in question are really multicellular. It is almost unnecessary to point out that there is every probability of the pharynx being in *Pelodrilus* of stomodæal origin.

§ *Testes.*

There are two pairs of testes placed in segments X and XI (see fig. 27), and attached to the anterior septa of their segments. They are of considerable size when fully developed, and are branched at their free extremities. In the mature worm the testes are nearly always incomplete in number, owing presumably to the fact that the germinal cells of one or more of the gonads have been transferred to the interior of the sperm sacs. Something of this kind possibly accounts for the statements that there are only a single pair of testes in certain genera of the Lumbriculidæ, whereas in these very forms there are two pairs of funnels, and two pairs of testes might therefore be expected to exist. In any case, a correspondence between the number of gonads and funnels is always met with among Earthworms. If there are only a single pair of funnels, the testes are reduced to a single pair, while in the vast majority two pairs of vasa deferentia correspond to two pairs of testes.

§ *Vasa Deferentia.*

The characters of the vasa deferentia are, so far as is known at present, very different in the Phreoryctidæ and in the Lumbriculidæ. From the Lumbriculidæ I exclude *Ocnerodrilus*, which, as I shall point out to this Society in a forthcoming paper, really shows no particular affinities to the family in which EISEN first placed it. *Eclipidrilus* also is a genus which requires further investigation before its claims to be placed with family Lumbriculidæ can be fully recognised. The family contains at present only seven well-marked genera, viz., *Rhynchelmis*, *Stylodrilus*, *Claparedilla*, *Lumbriculus*, *Trichodrilus*, *Phreatothrix*, and *Sutroa*.

In all of these, with the exceptions of *Lumbriculus* and *Sutroa*, the vasa deferentia have the following arrangement:—There are two pairs of funnels which open respectively into the IXth and Xth segments. The vasa deferentia open separately on each side of the body into the atrium, which lies in the Xth segment. It follows, therefore, that the vasa deferentia belonging to the second pair of funnels perforate the intersegmental septum X/XI twice.

As to *Lumbriculus*, our knowledge is at present confined to a very short note by VEJDOVSKY [7, p. 150, footnote], which runs as follows:—"Neuerdings aber erhielt ich eine grössere Anzahl der mit vollständigem Geschlechtsapparate angerüsteten Exemplare, an denen ich sichergestellt habe dass die vermeintlichen Samentaschen des 8 Segmentes voluminöse mit ausstülpbaren Penisröhren versehene Atrien vorstellen, in welche ungemein dünne Samengänge einmünden." It is not, therefore, at present quite clear

whether *Lumbriculus* does or does not agree with other Lumbriculidæ in the relations of the vasa deferentia.

Sutroa is a somewhat aberrant Lumbriculid, quite recently described by EISEN [**4**]. Each atrium is furnished with two vasa deferentia, the funnels of which both open into the XIth segment (? XIIth).

Phreoryctes shows no affinities with the Lumbriculidæ, except in possessing two pairs of vasa deferentia. The atrium is entirely absent, and the vasa deferentia open separately on to the XIth and XIIth segments [see No. **12**]. In *Pelodrilus* the conditions differ from both the Phreoryctidæ and the Lumbriculidæ, and approach to a certain extent the Lumbricidæ.

There are two pairs of funnels which open into segments X. and XI. The funnels are of large size, and the arrangement of the septa is such (see fig. 39) that they face upwards. In both cases the funnels are completely enclosed by the sperm sacs, which almost completely fill the segments in which they lie. The cilia are very long, as is usually the case with the Lumbriculidæ [*cf.* CLAPARÈDE, **1**, pl. iii. fig. 1, VEJDOVSKY, **7**]. The position of the funnels agrees with that of the Phreoryctidæ and most Earthworms. They are both a segment farther back than in most of the Lumbriculidæ.

The vasa deferentia are remarkably long and greatly coiled. Fig. 38 illustrates the coils of one of the second pair of vasa deferentia, which are, like those of the first pair, almost entirely included within the sperm sac. The vas deferens is for the most part extremely thin, though it widens out just before joining the funnel, and also for some little distance in front of the external orifice.

In the extremely thin and much coiled vasa deferentia, *Pelodrilus* differs from all the Oligochæta, to which it presents other points of affinity. In both the Lumbriculidæ and Phreoryctidæ the vasa deferentia are almost straight, or at most slightly sinuous. The Enchytræidæ are more like *Pelodrilus* in this particular than any other family. The structure of the vasa deferentia is not in any way peculiar; they are, as is always the case, composed of a single layer of ciliated cubical cells, and are covered by a delicate layer of peritoneum.

The communication of the vasa deferentia with the exterior is effected in a way which is unique among the Oligochæta.

There is, in the first place, no trace of an atrium—a structure which is present in all the Lumbriculidæ. The vasa deferentia open directly on to the exterior, as in *Phreoryctes* and the Lumbricidæ.

The male apertures are situated within the clitellum, and are conspicuous when this region of the body is examined in a specimen mounted entire. The cells of the clitellar epidermis are seen to have an arrangement which is illustrated in fig. 35. They radiate outwards from a conspicuous orifice placed upon the XIIth segment. In such preparations I have been able to recognise two pairs of orifices upon the XIIth segment corresponding in position to the orifices of the spermathecæ upon the VIIIth segment. In longitudinal sections (fig. 28), two distinct male apertures are to be found upon each side of the body, placed one in front of the other and on a line with the oviducal pores, as well as with the

apertures of the spermathecæ. The two male pores of each side of the body are very much nearer to each other than the posterior of the two is to the oviducal pore.

It follows, therefore, that, while the posterior of the two funnels is connected with a vas deferens which opens upon the following segment, the anterior vas deferens traverses *two* segments before it communicates with the exterior. This is the only instance known to me of an Annelid which would obviously belong to CLAPARÈDE's division of the *Limicolæ*, in which the aperture of the vas deferens is situated further behind its funnel than the following segment; and this genus forms an unique instance of the vasa deferentia of each side opening on to the same segment, but by separate orifices.

In the position of the funnel and male orifices this genus appears to be intermediate between *Phreoryctes*, on the one hand, and *Eisenia* (= *Tetragonurus*) on the other. In *Phreoryctes*, each vas deferens opens separately on the segment behind that which contains the funnel. In *Pelodrilus*, the anterior male pore has receded until it has come to lie in the same segment with the posterior pore. In *Eisenia*—probably, we cannot say certainly, for the worm has never been studied anatomically—both vasa deferentia open by a common pore on segment XII.

§ *Ovaries.*

There are a single pair of ovaries (fig. 27, *ov*) in segment XII. Each is attached close to one side of the ventral nerve cord. The ovary, as shown in fig. 41, *a*, is of an oval, somewhat pear-shaped form; it is for the most part made up of small germinal cells, and contains one or two ova in advanced stages of development. The ova, however, do not undergo their entire development in the ovary; masses of cells consisting of developing ova are apparently from time to time broken off, and undergo their further development in the egg sac. The fully mature ova (see fig. 41, *a*) are laden with yolk granules, and are of very large size; a single ovum will extend through two or three segments. I never observed (in three specimens investigated by longitudinal sections) more than two or three mature ova in a given worm.

§ *Oviducts.*

The two oviducts open on to the intersegmental groove XII/XIII. One of these is illustrated in longitudinal section in fig. 40. What strikes one about the oviducts of this and other "*Limicolæ*" is the small size, as compared with the gigantic ova which have to find their way out of the body cavity through them. The epithelium is of course ciliated—the cilia being short; the funnel is, as in the Lumbriculidæ, "sessile" upon the ventral body wall just in front of the septum separating segments XII and XIII. The duct is thus reduced to the smallest dimensions.

§ *Spermathecæ.*

Pelodrilus is furnished with a single pair of spermathecæ in segment VIII.

Each spermatheca opens close to the boundary line between segments VII and VIII, at a spot corresponding to the male apertures, *i.e.*, between the dorsal and ventral setæ, though nearer to the latter.

The spermathecæ are very large, and each is doubled upon itself (see fig. 14). The portion which lies nearest to the external aperture is long and narrow, and lined with a columnar epithelium of a non-glandular character, which is shown by its being readily stained by borax carmine; further back (fig. 23) the spermatheca widens out, and the epithelium becomes laden with secreted granules, and have not been stained to any extent by the same colouring reagent. I usually found clumps of small spherical granular cells, each with a minute but darkly staining nucleus near to the blind extremity of the spermatheca. I am uncertain whether or not to regard these as parasites.

AFFINITIES OF *PELODRILUS*.

This Annelid my be characterised as follows:—

Genus **Pelodrilus**, nov. gen.

Moderately long, thin worms, inhabiting marshy soil. Setæ simple in shape and strictly paired; absent only from the XIIth segment in the sexually ripe individuals. Clitellum extending over segments XI–XIII (inclusive). Testes, two pairs in X and XI. Vasa deferentia opening by two distinct pores on each side, placed one in front of the other upon the XIIth segment, greatly coiled, with funnels in the Xth and XIth segments. No atria. Sperm sacs occupying segments IX–XII. Ovaries in XIII; oviducts consisting of little more than a funnel opening immediately on to the exterior in groove between segments XII/XIII. Ova large and few, enclosed in thin-walled egg sac. Spermathecæ, a single pair in VIII. Septal glands present. Nephridia in all segments after the VIth with the exception of XI and XII. Some of anterior septà thickened.

Species **Pelodrilus violaceus**, n.sp.

Prostomium short. Nephridiopores in front of ventral setæ. Habitat, New Zealand.

In the above description I cannot, of course, pretend to distinguish between generic and specific characters; I select as a specific character the position of the nephridiopores, for the reason that that appears to be a specific character in *Phreoryctes*—the most nearly allied genus.

There can be, I think, little doubt that *Pelodrilus* should be included in the family Phreoryctidæ.

It agrees with *Phreoryctes* in the following assemblage of characters:—

1. Testes in X and XI.
2. Sperm ducts, two pairs opening separately.
3. Atrium absent.
4. Spermathecæ anterior to testes.
5. Hearts long, thin, and much convoluted,

as well as in a number of minor points which need hardly be recapitulated, as they are found in many of the aquatic Oligochæta. I refer to such points as the shape and arrangement of the setæ, the absence of gizzard, &c. The five points of agreement between *Pelodrilus* and *Phreoryctes* enumerated above are stated in such a way as to refer only to the families of aquatic Oligochæta ("*Limicolæ*" in the sense of CLAPARÈDE), which I consider alone for the present. The more important points of difference between *Pelodrilus* and *Phreoryctes* are these:—

1. Sperm ducts greatly coiled; both on each side opening upon the XIIth segment, though separately.

2. Only one pair of ovaries in XII, and one pair of oviducts opening between XII/XIII.

3. The presence of septal glands.

4. Nephridia present in some of the genital segments.

5. Clitellum occupying only three segments (XI–XIII), and developed only ventrally; setæ of segment XII absent.

6. Some of anterior septa thickened.

These structural characters of *Pelodrilus* do not indicate much affinity to any other group of the lower Oligochæta. The Lumbriculidæ are the only other group with which any comparisons suggest themselves, and these are really limited to the characters of the setæ, and of the oviduct, which has pretty much the same form. It is true that *Lumbriculus* is the only other genus of aquatic Oligochæta where the nephridia persist in the genital segments; but this fact, though important enough in another aspect, is, perhaps, hardly one upon which considerations of affinity can be based.

The greatly coiled sperm ducts recall those of the Tubificidæ and Enchytræidæ, but other characters do not permit of the establishment of any close relationship between *Pelodrilus* and either of these two families.

On the other hand, it does seem possible to indicate some relationship between *Pelodrilus* and the higher Oligochæta (earthworms), though these are not sufficiently pronounced to admit of a comparison between *Pelodrilus* and any particular family or families of that group.

The general resemblances to the higher forms, other than those shared by *Phreoryctes*, are as follows:—

1. Persistence of nephridia in certain of the genital segments. (This is shared by *Lumbriculus*.)

2. Several of anterior intersegmental septa greatly thickened.

3. One of the pairs of vasa deferentia traverses two segments between the internal and external orifice.

Phreoryctes itself comes nearer to Earthworms than does any other genus among the lower Oligochæta, and *Pelodrilus* serves to increase the closeness of the family Phreoryctidæ to the higher Oligochæta.

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DESCRIPTION OF PLATES.

PLATE I.

Phreodrilus subterraneus.

Fig. 1. Setæ, *a*, dorsal; *b*, ventral.
Fig. 2. Funnel of vas deferens.
Fig. 3. Transverse section of narrow part of atrium.
Fig. 4. Longitudinal section through atrium where lumen is wider.
Fig. 5. Semidiagrammatic view of genitalia. *te*, testis; *f*, funnel of vas deferens; *eff*, efferent canal; *s*, setæ; *od*, oviduct; *ov*, ovary; *sp*, spermatheca.
Fig. 6. "Bloodgland." *bl*, blood-clots.
Fig. 7. Male efferent apparatus. *f*, funnel; *spt.*, septum; *v.d*, vas deferens; *sp'*, blind appendix of vas deferens; *j*, their junction within periatrial sac (*sac*); ♂, external orifice.
Fig. 8. Longitudinal section through nerve-cord. *nc*, neurochord branching where nerve is given off.
Fig. 9. Longitudinal section through external aperture of atrium, showing adjacent parts of efferent duct. ♂, external pore; *at*, distal section of atrium; *at'*, portion of atrium lying within periatrial space (*p.sp*); *v.d*, vas deferens; *sp'*, appendix of vas deferens.
Fig. 10. Longitudinal section through spermatheca.
Figs. 11, 12. Longitudinal and transverse section through appendix of vas deferens. *a*, secreted matter in lumen of tube.
Fig. 13. External ventral view of genital segments which are numbered and show position of orifices. ♂, male apertures; *od*, oviduct pores; *sp*, spermathecal pores; the nerve-cord is indicated as showing through the body walls, and the setæ are shown.
Fig. 14. Transverse section through body wall. *s*, seta sac; *ep*, epidermis; *tm*, transverse muscles; *lm*, longitudinal muscles.
Fig. 15. Separate lamellæ of longitudinal muscular coat.

PLATE II.

Fig. 16. *Phreodrilus subterraneus*, a portion of the contents of periatrial sac. *vd*, vas deferens in transverse and longitudinal section; *sperm*, spermatozoa; *n*, nuclei lying between them.
Fig. 17. *Pelodrilus violaceus*, natural size, showing clitellum (*cl*).
Fig. 18. *Phreodrilus subterraneus*, oviduct.
Fig. 19. „ „ longitudinal section of body wall.
Fig. 20. *Pelodrilus violaceus*, section of epidermis to show glandular papilla (*g*). *s*, setæ.
Fig. 21. „ „ nephridium as seen on dissection. *f*, funnel; *spt.*, septum; *o*, external orifice; *s*, setæ.
Fig. 22. „ „ ventral view of genital segments which are numbered. *sp*, spermathecal pore; ♂, male pores; ♀, oviducal pore. The extent of the clitellum is indicated by the dotted portion.
Fig. 23. „ „ spermatheca transverse section. *n*, nucleus of glandular cells; *a*, parasites (?).
Fig. 24. „ „ nephridial funnel. *bl*, blood capillary.
Figs. 25, 26. „ „ septa to show relative thickness of specially thickened anterior septa (fig. 26) and posterior septa (fig. 25).
Fig. 27. „ „ dissection to show genitalia, semidiagrammatic. *sp*, spermathecæ; *sps*, sperm sacs; these are cut open in segments X and XI to show the testes and vasa deferentia lying within them; *t*, testes; *f*, funnel of vasa deferentia; *ov*, ovary; *od*, oviduct.
Fig. 28. „ „ longitudinal section through external orifices of vasa deferentia of one side of the body.
Fig. 28*a*. „ „ spermatheca.
Fig. 29. „ „ supra-œsophageal ganglia, lateral view. *dv*, dorsal blood-vessel; *com*, peri-œsophageal commissure.

Fig. 30. *Phreodrilus subterraneus*, longitudinal section through atrium at region lettered *a* in fig. 7, to show commencement of periatrial sac. *sp*, space, filled with spermatozoa, produced by the splitting off of the muscular coat of the atrium.

Fig. 31. „ „ egg-sac containing developing ova. *s*, walls of sac, which are simply formed by a pushing back of the septum ; *o*, clumps of developing ova.

Fig. 32. „ „ periatrial space containing spermatozoa and nuclei.

Fig. 33. „ „ muscular wall of periatrial space in transverse section.

Plate III.

Fig. 34. *Phreodrilus subterraneus*, chief vascular trunks in four of the anterior segments. *d*, dorsal vessel; *h*, hearts ; *bgl*, blood-gland ; *v*, ventral vessel ; *si*, supra-intestinal ; *n*, network upon œsophagus.

Fig. 35. *Pelodrilus violaceus*, dissection showing apertures of vasa deferentia of one side, opening by separate pores, δ^1, δ^2. *s*, setæ.

Fig. 36. „ „ section through commencement of œsophagus to show septal glands (*sg*), and their ducts (*d*) ; *bl*, dorsal blood-vessel ; *sp*, septum.

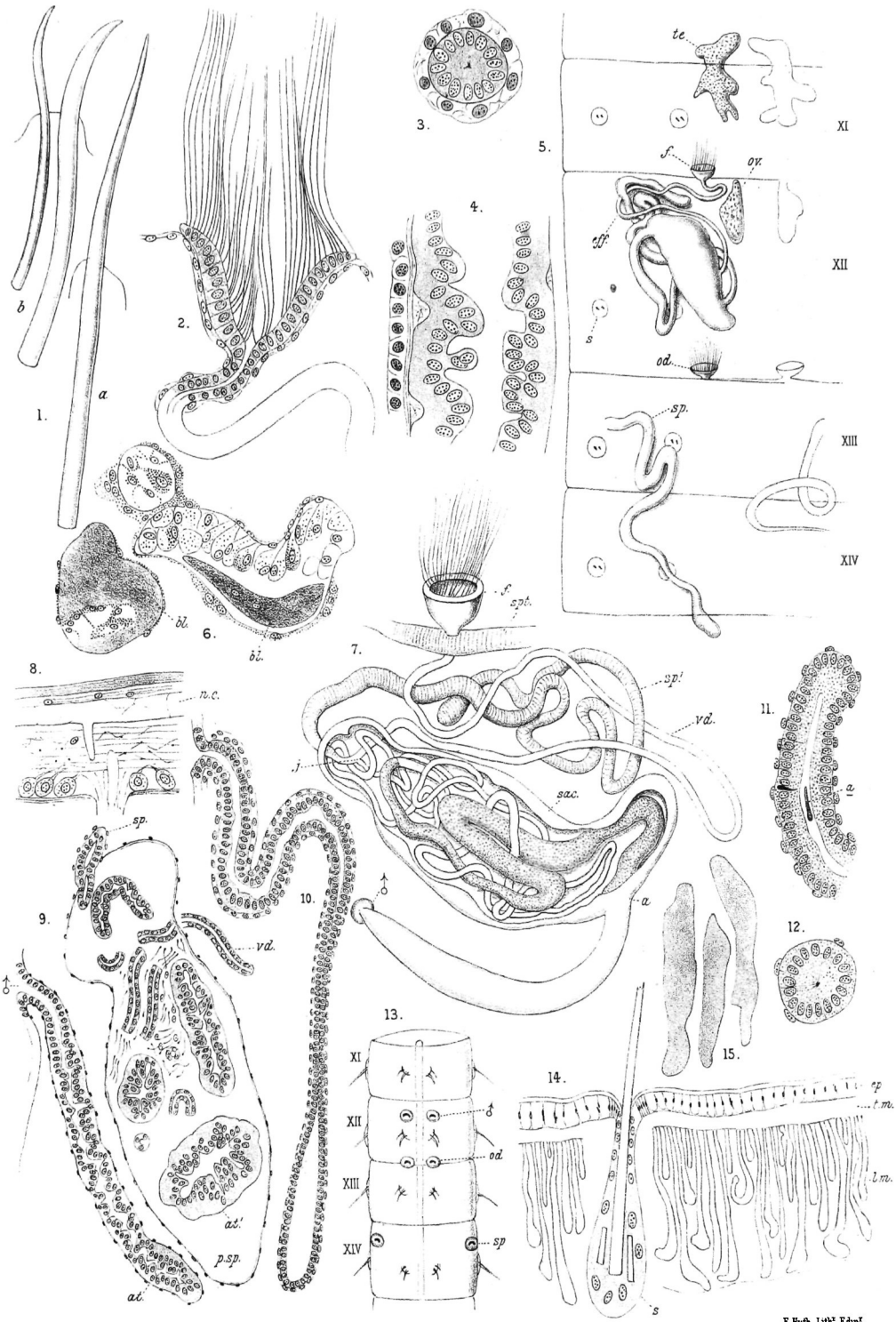
Fig. 37. *Phreodrilus subterraneus*, developing ova at different stages.

Fig. 38. *Pelodrilus violaceus*, interior of portion of sperm sac to show the coiling of the vas deferens (*v.d*) within the sac ; bundles of developing spermatozoa (*sp*) are also shown ; *sps*, wall of sperm-sac.

Fig. 39. „ „ dissection to show vasa deferentia and oviduct. *f*, funnels of vasa deferentia ; δ, external orifices ; *spt*, septum ; *od*, oviduct ; *s*, setæ.

Fig. 40. „ „ oviduct in longitudinal section.

Fig. 41. „ „ *a*, ovary ; *b*, nearly mature ovum ; *c*, fully mature ovum.



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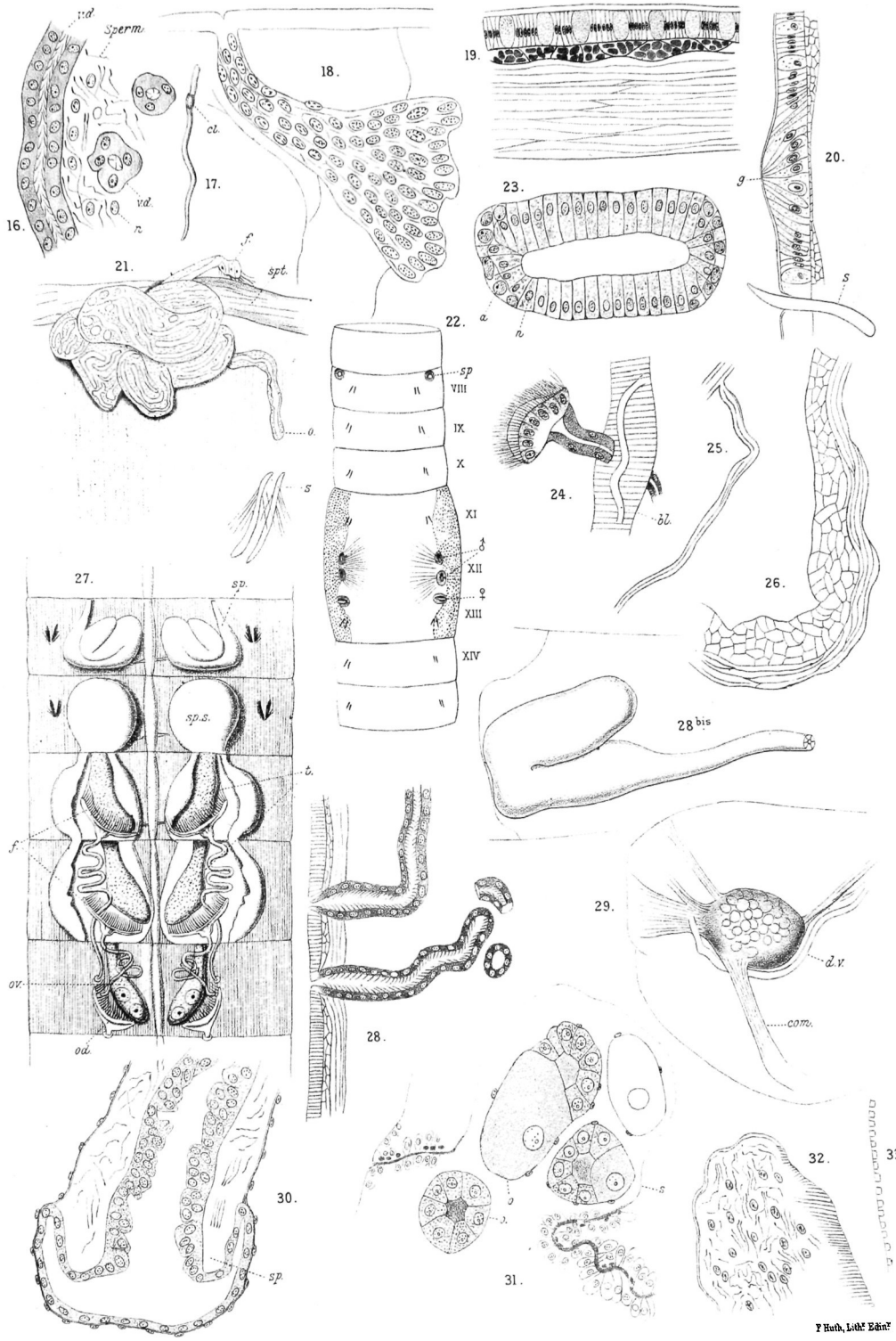

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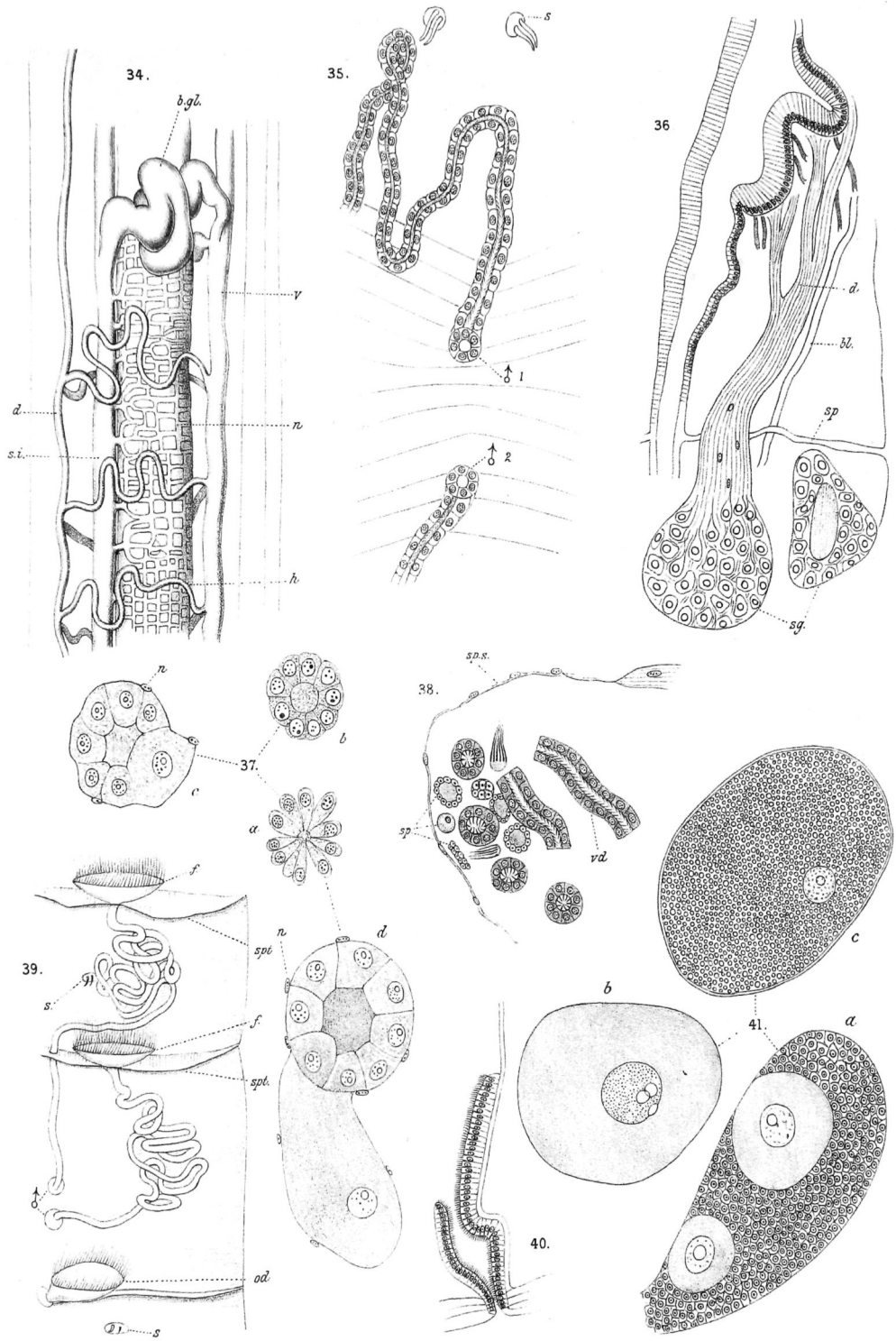

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