

Notes on Two Acanthodriloid Earthworms from New Zealand.

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With Plates XV and XVI.

In the summer of last year (1890) I received, through the kindness of Professor Jeffrey Bell, of the British Museum, some earthworms for identification. They were collected by Mr. Vaughan Jennings in New Zealand, at Mangatua, south of Dunedin, who generously allowed me to retain them for further examination. I regret that so much delay has occurred in preparing my report for publication, for I almost completed my observations on them during last summer vacation, but continuous work since September last prevented me putting certain finishing touches to the descriptions and figures till August of the present year (1891).

I found in the bottle three worms and some fragments. One of these worms turns out to be Beddard's *Neodrilus monocystis*; the other two belong to a new genus.

Neodrilus monocystis, Beddard.

A single specimen¹ of a worm, found by Mr. Beddard amongst species of *Acanthodrilus* from New Zealand, differed from

¹ It is a curious thing that in so many cases only one specimen of a worm is found, which serves as a type of a new genus; and it has occurred to me, sometimes, that some of these may be hybrids or abnormalities, which from some weakness have failed to reach their burrows, just as we find the common earthworm on the surface of the ground after rains, &c., in a weakly or drying condition.

this genus mainly in the possession of only one pair of spermathecae, and one pair of male pores (atriopores) on Segment XVII, instead of the usual two pairs of each of these structures. Beddard¹ himself appears to have had some doubts as to the generic value of these features, for he states that "it is possible that this supposed new genus *Neodrilus* is really an *Acanthodrilus* in which the posterior pair of male generative pores (atriopores), together with their glands, have not yet been developed." In my recent contribution in this Journal, "An Attempt to classify Earthworms," I placed *Neodrilus* as a "doubtful genus."

I am now, however, in a position to confirm and extend Mr. Beddard's brief description, although, like him, I had but one specimen, the anterior end of which after dissection I cut into a series of sections.

The general colour of the worm, in spirit, is sienna brown; its length about two and three quarter inches, with an average diameter of a quarter of an inch, but rather wider anteriorly to the clitellum. In shape it appears cylindrical, but is nearly square in transverse section, owing to the position of the four bundles of chætæ. There are 155 segments. The chætæ are in the usual four couples, which are equidistant, so that the outer couples lie on the dorsal surface (fig. 1). The clitellum, which is rather lighter in colour than the neighbouring region, occupies the Somites XIV to XIX. In addition, the dorsal surface of Somite XIII is also glandular, as is also the ventral surface of Somites XVIII and XIX where the glandular epidermis extends across the middle line.²

In Somite XVII, in a line with the ventral couple of chætæ on each side, is a conspicuous rounded papilla, the apex of which is distinctly lighter than the base. At the apex of each of these papillæ is the pore of the prostate (fig. 2, *prst. p.*).

On Somite XVIII, immediately behind those of Somite XVII, are two other papillæ, much less conspicuous and more depressed. These bear the apertures of the sperm-ducts. The

¹ 'Proc. Roy. Soc. Edinb.,' 1887, vol. xiv, p. 158.

² Beddard states that the clitellum occupies Somites XIII to XVII.

lips are tumid, and the pores are connected with those on Segment xvii by grooves (fig. 2).

Beddard describes much the same sort of arrangement, but states that the grooves from the pores on Somite xvii extend on to Somite xix. I do not find this extension of the grooves backwards. The chætæ appear to be absent on Segments xvii and xviii.

The prostomium is completely dovetailed into the buccal segment (fig. 1).

The most noticeable external feature, besides the position of the male pores, is the alternation of the nephridiopores (figs. 1 and 2), a fact which Beddard mentioned, and which is known in *Acanthodrilus dissimilis*, and other species. This "alternation" is not quite regular, as will be seen from the following table, the pore being in front of sometimes the 4th, sometimes the 3rd or 2nd chætæ, counting the most ventral chætæ as the 1st:

Somite.		Left side.	Right side.
II.	Nephridiopore in front of . .	4th chætæ . .	4th chætæ.
III.	" "	3rd " . .	Worm injured.
IV.	" "	3rd " . .	injured.
V.	" "	3rd " . .	3rd chætæ.
VI.	" "	3rd " . .	3rd "
VII.	" "	3rd " . .	2nd "
VIII.	" "	2nd " . .	?
IX.	" "	2nd " . .	2nd "
X.	" "	3rd " . .	3rd "
XI.	" "	? " . .	2nd "
XII.	" "	3rd " . .	3rd "
XIII.	" "	2nd " . .	2nd "
XIV.	" "	3rd " . .	3rd "

And so on in regular alternation. A similar alternation in the position of the nephridiopores exists in the new genus described below.

INTERNAL ANATOMY.

There are no specially strong septa (fig. 3). The pharynx is covered by masses of glandular cells, as in the common earthworm, and resembling those which I described and figured

in *Eminodrilus*.¹ The gizzard lies in Somite VI. There are no calciferous glands, no typhlosole, nor intestinal cæca. The tubular intestine is slightly dilated in Somites VII, VIII, and enters the sacculated intestine in Somite XV.

Lateral hearts occur in Somites XI, XII, XIII, XIV, the first three being moniliform.

In accordance with the variations in positions of their pores, the nephridia lie latero-ventrally or latero-dorsally (figs. 4, 5), and exhibit slight differences in the mode of convolution of the tube and in other points. The inner (ventral) nephridium has a large cæcal portion to the bladder directed dorsally, while that of the dorsal nephridium is but feebly developed, the nephridiopore being placed near the end of the bladder (fig. 5). There is no nephridial network nor communication between the nephridia.

THE GENITAL SYSTEM.

The testes and ovaries have the usual position. There are three pairs of sperm-sacs in Somites X, XI, XII, that of the left side in Somite XII being much smaller than the right one (fig. 3).

The prostates are enormous, and there is but one pair of them. Each consists of two parts (figs. 3 and 6),—a soft, more or less cylindrical portion, which is white, glandular, constricted, and convoluted (*prst.*); and a short, narrow, shining duct (*pe. d.*). The latter opens externally in Somite XVII, and passes backwards into Somite XIX, where it joins the glandular region; this passes still further back to the 24th somite, and then bends forwards on itself, its free end (*a*) lying in Somite XVII, at the side of the duct.²

Lying above the prostate is a sac containing a bundle of penial chætæ (*pe. s.*) nearly as long as the prostate—that is about a quarter of an inch (figs. 6, 7). This penial sac opens

¹ "Report on an Earthworm from Equatorial Africa," *Journ. Roy. Micr. Soc.*, 1891, Pl. 1V, fig. 12.

² The shading in fig. 3 does not indicate satisfactorily the convolutions of the prostate.

externally on Somite xvii (fig. 8), by a separate pore from that of the prostate duct. Its wall is muscular, and its posterior extremity appears to be fixed to the body-wall by muscles. The sac contains four long, delicate penial chætæ, of which two are much longer than the others (fig. 9). The longer chætæ are sharply bent near their free ends, and this bent part is gracefully curved to a very fine point (fig. 9, *b.*). The shorter chætæ are not bent. The ends of all the chætæ are beset by numerous minute spines or asperities (fig. 10), and there appears to be a groove along one side, so that they are somewhat triangular in section.

When the prostate is removed or turned aside the sperm-duct can be traced along the body-wall to its pore in Somite xviii (fig. 7). There is no trace of a prostate in Segment xix.

The microscopic structure of the prostate is similar to that in *Acanthodrilus*, *Deinodrilus*, and other genera. The wall is formed of pyriform "clitellar" cells, amongst which a few blood-vessels occur. The whole is surrounded by a flat cœlomic epithelium (fig. 11, *a.*). The penial duct is lined by short columnar cells, surrounded by a very thick muscular coat (fig. 12), around which are blood-vessels and cœlomic epithelium.

There is only one pair of spermathecae in Somite viii; at first sight, however, there appears to be two pairs of these organs (fig. 3); but the structures lying in Somite vii are in reality the appendices or diverticula of the spermathecae, so common amongst earthworms. Mr. Beddard has already remarked upon the large size of the diverticulum in this species. On one side it is actually larger than the body of the spermatheca itself.

The spermatheca (fig. 13, *s.*) is ovoid, with rather a thick wall, as can be seen in the left sac in fig. 3, where its dorsal wall has been removed. The sac communicates with the exterior by a short, thick, muscular duct, which resembles in its structure that of the prostate. This duct opens in the anterior region of the segment, and is joined close to the body-wall by the diverticulum. This is a sac of smaller or larger size than the main sac, roughly cylindrical and truncated, and contains spermatozoa.

Such is the coarse anatomy of *Neodrillus monocystis*; and though I have done little more than confirm Mr. Beddard, I have thought it worth while to illustrate its anatomy.

The present specimen was found by Mr. Jennings among "rotten wood and mould."

Plagiochæta punctata, n. gen., n. sp.

The other worms have a very distinctive shape and colouring, and have numerous chætæ arranged in a nearly complete circle.¹ The generic name² refers to the fact that the chætæ are always seen crossing the body, whether this is looked at above, below, or laterally. At a first glance, indeed, one might mistake them for species of *Perichæta* (or *Megascolex*); but the possession of two pairs of tubular prostates, amongst other anatomical characters, removes them from that genus.

Of this worm there were two complete and mature (?) specimens, and two halves of a third, but immature, worm.

The size and shape of the worm are rather characteristic (fig. 14); it is 1.6 inches long by 0.5 inch across its widest part, which is posterior to the clitellum, so that it is, compared to its length, very broad; it is composed of eighty-nine segments.

As will be seen from the sketch, which is twice the size of a spirit specimen, the anterior and posterior extremities are nearly similar, tapering gradually to the mouth and anus respectively. The clitellum forms, so to speak, a waist; but that it is in life narrower than the neighbouring anterior and posterior regions is, I think, doubtful.

The body is depressed, so that the dorso-ventral diameter is only about half the lateral breadth (Pl. XVI, fig. 17). A groove runs along the dorsal and ventral mid-line, which is probably due to shrinkage.

The general colour reminds one somewhat of Michaelsen's

¹ This suggested the name *Cyclochæta* for the genus, but Mr. Hatcher Jackson has employed the term for a genus of ciliate Protozoa.

² 'Jahrb. d. Hamburg wissenschaft. Anstalten,' vi, 1889.

Acanthodrilus (Mandane) pictus,¹ but is a richer chocolate-brown, with rows of white spots² (hence the specific name), which are more noticeable dorsally than ventrally.

A narrow dark band (fig. 14), due to absence of spots, extends along the whole length of the body in the middle line dorsally and ventrally, but becomes rather less marked towards the hinder end of the worm, and less noticeable ventrally. This dark band occupies the groove above mentioned.

The spots, which, though white in the spirit specimens, are perhaps only "light" in life, are very regularly arranged, forming transverse and longitudinal rows; and in each spot is embedded a couple of chætæ (Pl. XVI, fig. 18). On the majority of segments there are twenty-five to twenty-seven of these white spots, diminishing in the anterior segments to fifteen.

The median unspotted grooves are about three times as wide as the distance between any two white spots of a circle. At the hinder end of the body, for about a quarter of the total length of the animal, the spots are much closer together, giving the appearance of a series of white rings. The ventral surface is much lighter than the dorsal and lateral surfaces, and the spots less noticeable.

The clitellum, though apparently not quite fully developed, is perfectly distinct; it occupies Somites XIV to XVII and part of XVIII. It is lighter in colour than the rest of the body, both dorsally and ventrally; and the white spots are quite distinct dorsally. As already mentioned, the body in the clitellar region is rather constricted.

The chætæ are numerous in each segment; they occur always in couples, each couple being embedded in a white spot (fig. 18). There are usually fifty to fifty-four chætæ in each somite, i. e. twenty-five to twenty-seven couples. They decrease in number in the more anterior somites, being forty-

¹ Πλαγιος, transverse.

² In a letter to me Mr. Jennings states that "while living they are lighter in colour than ordinary earthworms, and have a peculiar surface marking. Except contraction, they seem to undergo little change in spirit."

eight in Somite iv, forty-four in Somite III, and thirty in Somite II.

The chætæ are simple and sigmoid, without markings, and each is .036 mm. in length.

The prostomium is completely dovetailed (fig. 15) into Somite I. I can find no dorsal pores.

The pores of the two pairs of spermathecæ are fairly large, and provided with white lips. Each pair lies in a median ventral depression, which is situated on the anterior margin of Somite VIII and of Somite IX; each pore being in line with the ventralmost couple of chætæ (Pl. XVI, fig. 16, *splh.*).

The spermiducal pores are not to be seen externally, but by means of sections I find them situated in Somite XVIII, in front of the ventralmost couple of chætæ.

There is an oval depression on the ventral surface of Somites XVII, XVIII, and XIX, bounded laterally by a distinct ridge. Within this depression, on each of the Somites XVII and XIX, is a pair of small transverse slit-like pores—those of the prostates—which lie in a line with the other genital pores (fig. 16, *prst.*).

The chætæ of these two segments appear to be absent, but in reality they are especially long, and are retracted into the body-cavity—in fact, have become modified for copulatory purposes.

The oviducal pores have the usual position on Segment XIV, though they are not visible externally.

The nephridiopores (*ne. o.*) are very distinct, even on the clitellum; they appear as light spots, which are larger than those around the couples of chætæ. These pores alternate in position (fig. 16), as in *Neodrillus*, &c.; this alternation being nearly but not quite regular, and sometimes not symmetrical. In the following table the position of these pores in regard to the chætiferous spots is shown. The first spot is the ventralmost, so that the fourth spot is latero-ventral (fig. 17⁴), the tenth is latero-dorsal—in fact, lies on the dorsal surface, and is the fourth spot from the mid-dorsal line (fig. 17¹⁰).

Specimen A.

No. of Somite.		Right side.	Left side.
III.	Nephridiopore in front of . .	10th spot . .	10th spot.
IV.	" " " . .	10th " " . .	10th "
V.	" " " . .	5th " " . .	10th "
VI.	" " " . .	5th " " . .	10th "
VII.	" " " . .	4th " " . .	10th "
VIII.	" " " . .	10th " " . .	4th "
IX.	" " " . .	11th " " . .	10th "
X.	" " " . .	4th " " . .	4th "
XI.	" " " . .	10th " " . .	10th "
XII.	" " " . .	4th " " . .	4th "

And so on, in a regular way, with a few exceptions, i. e. on the even-numbered somites the nephridiopores are dorsal, on the odd-numbered they are ventral till the twenty-third somite, when there are the following divergences from the rule.

No. of Somite.		Right side.	Left side.
XXIII.	Nephridiopore in front of . .	10th spot . .	9th spot.
XXVIII.	" " " . .	5th " " . .	4th "
XXX.	" " " . .	4th " " . .	4th "
XXXI.	" " " . .	9th " " . .	4th "
XXXII.	" " " . .	5th " " . .	4th "
XXXIV.	" " " . .	5th " " . .	4th "
XXXVI.	" " " . .	5th " " . .	4th "
XXXVIII.	" " " . .	5th " " . .	4th "
XL.	" " " . .	5th " " . .	4th "
XLIII.	" " " . .	10th " " . .	9th "
XLIV.	" " " . .	5th " " . .	4th "
LIV.	" " " . .	5th " " . .	4th "
LIX & LX.	" " " . .	9th " " . .	9th "

In Specimen B.

No. of Somite.		Right.	Left.
III, IV, & V.	Nephridiopore in line with	10th spot . .	10th spot.
VI.	" "	9th " . .	9th "
VII.	" "	10th " . .	10th "
VIII.	" "	4th " . .	4th "
IX.	" "	9th " . .	4th "
X.	" "	4th " . .	4th "
XI.	" "	10th " . .	4th "
XII. }	" "	10th " . .	10th "
XIV, &c. }	" "		
XIII.	" "	9th "	
XV. }	" "	10th "	
XVII, &c. }	" "		

In this specimen the variations from the normal position are fewer in the posterior region of the body than in specimen A.

The distances between the pores when normally situated are equal; that is to say, the space between right dorsal and left dorsal pores = space between dorsal and ventral pores = space between right ventral and left ventral pores. See fig. 17, where the position of the couples of chætæ are indicated by numerals.

It is so very generally taken for granted that the nephridiopores in any genus or species have a fixed relation to one of the couple of chætæ, that it is worth while to carefully note such deviations from the rule, as exhibited in this table, and in that for *Neodrillus*, and to bear in mind that even in *Lumbricus* and *Allolotophora* this pore is not invariably situated anteriorly to the ventral couple of chætæ. Claparède and Hering pointed this out some years back, and Borelli, in 1887, recurred to the matter,¹ and examined some half dozen of the common species of the family *Lumbricidæ* (*s. s.*) from this point of view. His results, which are not very detailed, show, however, that in some species, *L. herculeus*, for instance, nearly as many nephridiopores have not the "normal" position as have. In *L. rubellus* there are more

¹ 'Boll. d. Mus. Zool. ed Anat. Comp. Torino,' vol. ii, No. 27.

pores in an "abnormal" position than in the normal, i. e. in front of the ventral chætæ. The "abnormal" position is itself variable, the pore sometimes occurring in front of the dorsal chætæ, sometimes dorsal of these, and even near the mid-dorsal line. Borelli does not state whether there is any approach to an "alternation," or whether the variability is more marked posteriorly than anteriorly.

There is little doubt that this sort of irregularity is of more frequent occurrence in other genera than we are apt to think. We have, amongst recorded cases (besides *Plutellus*), Beddard's description of *Acanthodrilus dissimilis*¹ and *Ac. rosæ*,² &c., where the alternation is not regular; Bourne's *Perionyx saltans*,³ where there are two rows of nephridiopores, usually regularly alternating, though he mentions certain variations; Fletcher's⁴ "*Cupptodrilus*" *mediterreus*, with an irregular alternation, and *Megascolides tasmanicus*, where the pores are in a sinuous series.

The deviation from any fixed positions is especially interesting in these genera, such as *Acanthodrilus*, *Megascolides*, and *Cryptodrilus*, in which some species are in a plectonephric condition, for it seems to support the theory of Beddard and Baldwin Spencer that this condition is primitive, and that the network communicated with extensively many scattered pores, as in *Perichæta*, &c.; when the meganephric condition supervened, by aggregation and enlargement of some portion of the network, the pores enlarged, and the nephridia now opened, not at some fixed point, as has usually been presumed to be the case, but at any point on the surface of the segment, the relatively fixed portions being probably a later phenomenon, and its relation to the bundles of chætæ being due to some secondary causes, with which at present we are unacquainted.

¹ 'Proc. Zool. Soc.,' 1885, p. 822.

² This Journal, vol. xxx, p. 434.

³ 'Proc. Zool. Soc.,' 1886.

⁴ 'Proc. Linn. Soc.,' N.S.W., 1887, p. 601.

INTERNAL ANATOMY, Pl. XVI, fig. 19.

There are no especially strong septa (though those of XIII/XIV, XIV/XV, and XV/XVI are slightly thicker than the rest), nor any great displacement of organs.

The Alimentary Canal.—The pharynx, which occupies the Somites III, IV, and part of V, is partially concealed by two pairs of lobulated masses, or “salivary glands” (*Sal.*), lying dorsally and laterally in Somites IV and V, the gland in the latter being bilobed. These are not modified nephridia, but consist of groups of large granular cells, deeply stained in borax carmine, and closely resembling the “salivary glands” of *Eminodrilus*,¹ &c.

The pharynx is internally divisible into a ventral cuticulated region, and a dorsally placed flattened diverticulum, laterally produced, and lined by tall ciliated cells, as in many other, perhaps all earthworms.

The œsophagus, which is not ciliated, is narrow and tubular: it passes backwards to the large sacculated intestine, which commences in Somite XVI.

The hinder region of the œsophagus in Somites X to XIII is highly vascular, and its wall thrown into folds; these become more definite in Somite XIV and give rise to a well-marked pair of calciferous glands. Each is a large sac, laterally placed, but extending dorsally and ventrally, so that the pair almost surround the œsophagus (Pl. XVI, fig. 20, *cal.*). Its structure calls for no remark.

There is no gizzard to be detected on dissection, but in Somite VI the wall of the gut is slightly more muscular than elsewhere, the coat being about twice the thickness of that of the neighbouring tract, instead of eight to ten times as thick, as in the case of the functional gizzard in most earthworms. The sacculated intestine commences in Somite XVI, where it suddenly dilates, to become about three times the width of the œsophagus. This character it retains in Somites XVII, XVIII, and XIX, beyond which it is spirally coiled (Pl. XVI, figs. 19, 21). This condition has been described in *Didy-*

¹ Benham, ‘*Journ. R. Micr. Soc.*,’ 1891, pl. iv, fig. 12.

mogaster by Fletcher;¹ and when I first examined the present worm I believed that the spiral appearance was merely due to contraction, causing the gut to bulge, first on one side and then on the other. But it is a true spiral, as can be seen by dividing the worm either longitudinally or transversely (Pl. XVI, figs. 17, 21). There is no typhlosole, nor are there any cæca, such as are found in most species of *Perichæta*.

The nephridia are large, conspicuous (Pl. XVI, fig. 19), and alternate in position in correspondence with the position of the nephridiopores; the funnels, however, are always placed below the gut, and in line; they do not share in the alternation. The nephridium (Pl. XVI, fig. 22) presents the usual regions described by me for *Lumbricus* and other genera;² the coils are arranged somewhat differently in the dorsal and ventral series, and there is a dilated cæcal bladder, which is longer in the dorsal nephridia than in those of the ventral series.

The funnel has the same general structure as in *Perichæta malamaniensis*—that is to say, there are no centripetal marginal cells; but whereas in that species all the eight cells are of the same size, in the present worm there is a difference in size, and an increase in number of the marginals, as in *P. aspergillum*. I append two figures (fig. 23, *a, b*) representing two consecutive sections through a funnel; and from it there appears to be about sixteen marginals, which decrease in size on each side of the funnel. I am doubtful as to the presence here of a "central cell,"² and can readily believe that this is absent, as is the case in some *Perichæta*.

The first full-sized nephridium in the second segment is in Somite III; but there is a pair of rudimentary structures which are, I believe, degenerate nephridia.

That on the left is a fairly typical though very small nephridium; the one on the right is much less developed.

This very minute organ only occupies some four or five

¹ 'Proc. Linn. Soc.,' N.S.W., 1886.

² This Journal, vol. xxxii, p. 293.

sections in a longitudinal series; these are represented in Pl. XVI, fig. 24, *a, b, c, d*.

A small pore on the anterior margin of Somite 11, just outside the peripharyngeal nerve commissure, leads by a short duct with a narrow lumen into a dilated portion (fig. 24, *b.*), which is filled with a coagulum (*coag.*); from this "bladder" a tract of cells (fig. 24, *c.*) leads backwards to a small coiled tubule which appears to end blindly (fig. 24, *d.*). I am unable to detect a lumen in the tract of cells lying between this coil and the "bladder."

On the opposite side of the body, occupying the same position as this minute structure, which is absent on this side, I find the small nephridium above mentioned; so that I think there can be little doubt as to the correctness of my interpretation of this minute organ as a "vestigial" nephridium. I expected that these two small nephridial pores and ducts would lead to "peptonephridia," but such is not the case; there is no modification of the anterior nephridia other than degeneration.

GENITAL SYSTEM.

The two pairs of testes, and of spermiducal funnels, the pair of ovaries and oviducts, are placed in the usual segments. The ovary (Pl. XVI, fig. 25) is rather remarkable, in that the ripe ova are not confined to the tip of the organ, but are present along the whole of one side. The ovary is attached to the septum by only a small peduncle; it is not pear-shaped, as in *Lumbricus*, but slightly lobed, and more closely resembling the testes in shape than is usually the case. I am not acquainted with any ovary amongst the *Oligochæta* with exactly this form, though Horst has figured some curiously shaped ones in *Benhamia Schegelii*,¹ where it is rosette-shaped; *B. Buttikiferi*,² where it is somewhat like the parent ovary. The oviducts open close to ventralmost *chætæ* of their respective sides, at the tip of very slight papillæ.

¹ 'Notes from the Leyden Museum,' 1887, pl. iv, fig. 7.

² Ditto, pl. v, fig. 6.

There are four pairs of lateral sperm-sacs (fig. 19, *sps.*), almost filling the Somites IX, X, XI, and XII, and hiding the œsophagus and the two median sperm-sacs which lie below the gut in Somites X, XI, and enclose the testes and ciliated rosettes.

There are two pairs of prostates, in Somites XVII and XIX respectively. Each prostate (figs. 19 and 26, *pro.*) is a soft, irregular body, but roughly cylindrical, terminating in a free, blunt point, placed dorsally. The free end is sharply curled upon itself; the prostate then gradually widens, and is slightly convoluted as it passes downwards at the side of the intestine towards the ventral wall of the body, just before reaching which its character suddenly changes, both in appearance and in structure. This "penial duct" (fig. 26), as I will call it, is much narrower than the glandular part or prostate, and is slightly curved as it penetrates the body-wall to open by the pores seen externally. In appearance, instead of the dull, whitish, uneven character presented by the prostate, the penial duct is smooth and glistening, due to the fairly thick layer of circular muscles which forms its wall (fig. 28). The histological structure of the prostate is similar to that of *Neodrilus*. In fact, these prostates are closely similar to those of *Acanthodrilus* and its allies, but are less compact in appearance.

In front of each prostate is a sac containing long penial chætæ (figs. 26, 29). Each sac enters the body-wall immediately in front of the penial duct, but, as can be seen in section (Pl. XVI, fig. 29), crosses the duct in the thickness of the body-wall, and opens independently to the exterior just behind, and rather to the outer side of it. Each sac is in reality double, and each subdivision contains a couple of chætæ, of which one is small (*b*) and no doubt in reserve, the other being longer (*a*). There appears to be no particular marking or other peculiarity about these penial chætæ. The ordinary chætæ are absent in these somites, and the penial chætæ occupy their places, as is usually the case in *Acanthodrilidæ*.

There are two pairs of spermathecæ (figs. 19, 30), each consisting of two parts, as is so generally the case in the

prostatiferous worms, viz. (1) a subglobular sac with a short, thick, muscular duct opening externally on the anterior edge of the segment; and (2) a conspicuous, curved, cylindrical, glistening diverticulum or appendix, which lies in the segment in front of that containing the main sac, with the neck of which it communicates. The spermathecæ lie in Somites VIII and IX, so that the appendices are in Somites VII and VIII respectively.

Repeated observations have shown that in spermathecæ formed on this plan the sac does not contain spermatozoa, which are, as Beddard was the first to point out, found only in the diverticulum. This is, on the whole, true in this case too, although in sections through the organs I detected a few spermatozoa in the neck of one of the spermathecæ (Pl. XVI, fig. 31).

The microscopic structure of the spermatheca is illustrated by figs. 31 and 32. The former, which is combined from two or three of a series of longitudinal sections, represents the general relation of sac to appendix, and the position of the cells which are shown enlarged in fig. 32. The lining cells of the sac itself are very much taller than those of the appendix, and of slightly different structure when fully developed.

The appendix has, outside the epithelium, a thick muscular coat (*mus.*). This is absent in the wall of sac, except around the neck. The muscle fibres are continuous with the circular coat (*c. mus.*) of the body-wall, which is here very strongly developed.

The cavity of the sac contains some granular matter (*x*), which is produced by the epithelial cells (fig. 32 *b*), together with a few spermatozoa (*spra.*). Each cell is columnar, with an oval nucleus near its inner end. The rest of the cell is occupied by a finely spherular or granular secretion (*x*). It appears that when the cells have reached a maximum of activity the free end projects into the lumen of the sac and discharges its contents, leaving then a vacuole or space near this free end (as at *m.*). It then probably shrinks, and gradually elongates again as renewed activity commences. The nucleus is only

feebly stained, and the contents of the cell remain unstained in borax carmine.

The epithelium of the appendix (figs. 31 and 32 *c*) consists of tall columnar cells, not quite so high as those of the sac. The outer free end of each cell is flat, and the inner end of all the cells in my sections is bent at a slight angle to the body of the cells, and at this point lies the nucleus. This is smaller than that in the epithelium of the sac, and stains much more deeply: it is surrounded by a deep staining almost homogeneous protoplasm. The rest of the cell is occupied by similar granules to those found in the epithelial cells of the sac.

The appendix is filled with spermatozoa, which are to some extent regularly arranged, with the heads towards the walls, and the tails directed centrally. The heads appear embedded in or attached to the epithelium (figs. 31, 32, *d*). The cells in these regions are much shorter, less than half the length of those just described; and have no definite outer surface: otherwise they resemble the above-mentioned cells. Intermediate conditions between *c* and *d* can be seen in the sections.

It is probable that the cells of the appendix do not simply discharge their product, but disintegrate, leaving only the nucleus and homogeneous protoplasm behind, which will come into renewed activity, and give rise to more secretion during the next breeding season.

The spermatozoa, as seen in the section, are arranged as if they formed a sperm-rope, but the heads and tails are reversed when compared with sperm-rope of *Tubificidæ*, &c., which may perhaps be due to the fact that there would be no opportunity for the use of the tails for locomotion of the sperm-rope in earthworms.

We are totally ignorant of the purpose of this sperm-rope in earthworms, and it is a matter of some uncertainty as to where they are formed in *Lumbricus*, &c.; but it seems, from the above observations and others made by Beddard that, in those genera which have "an appendix" to the spermatheca, the sperm-ropes or spermatophores are formed in that portion of the organ

Among the bases of these cells are a few roundish nuclei without any stained protoplasm. These perhaps help in the renewal of the epithelium.

The duct (at *a.*, fig. 31), common to the sac and the appendix, is lined by a layer containing two sorts of cells, the nuclei of which differ in shape, size, and capacity for stains, and in position in the cell. In sections two rows of nuclei are evident, a deeper and a more superficial series. The nuclei nearer the base of the epithelium are more deeply stained, and about half the length of those of the outer row, which themselves are so placed that their outer ends are at about the middle of the cells (see fig. 32 *a.*). The latter, longer nuclei belong to narrow cells filled with granules similar to those in other parts of the spermatheca. The shorter nuclei, which alternate with and lie more deeply than the others, belong to clear cells without any very definite contents. The alternation of the cells is quite evident with a high power, and is very regular. The spaces between the granular cells are not artificial, as the figure might suggest, but are occupied by excessively fine protoplasmic(?) contents. These two sorts of cells are, no doubt, modifications of the ordinary columnar and goblet cells of the epidermis.

Locality.—These worms were found, with the specimen of *Neodrilus*, amongst mould and decaying wood at Manngatua, south of Dunedin.

AFFINITIES OF *PLAGIOCHÆTA*.

This new genus apparently has affinities in two directions viz. with *Perichæta* and with *Acanthodrilus*. The circle of chætæ is known in *Perionyx* and *Perichæta* (including *Megascolex* and *Beddard's* sub-genera); but in no form do I find any mention of the chætæ being in couples, in the way in which they are arranged in the present genus. Again, the position of the genital pores marks it off from *Perichæta*, where both spermiducal and spermathecal pores are much further removed from the ventral mid-line than is here the case, while the male pores are usually on papillæ.

These pores in *Perionyx* are, relatively to the chætæ, in about the same position as in *Plagiochæta*, but the male pores and oviducal pores are in depressions.

The position of the clitellum and its appearance are more *Perichætous* than *Acanthodriloid*.

With *Perichæta Stuarti* it is in agreement in the position of the genital pores and in the character of the prostates; but this species has no appendix to its spermatheca, and differs from *Plagiochæta* in other points.

The alternation of the nephridiopores calls to mind *Perionyx saltans* of Bourne, *Acanthodrilus novæ-zealandiæ*, and other species, and *Plutellus* of Perrier; but with none of these does it agree in the essential generic characters.

The genus differs considerably in its internal anatomy from *Perichæta*, viz. in the character of the nephridium, in the shape of the prostates, in the position of these, and the possession of two pairs of them; in the presence of calciferous glands, in the absence of gizzard and of intestinal cæca; in the arrangement of sperm-sacs, in the shape of the ovary, &c.¹

With *Acanthodrilus* it agrees in the position of the male pores and in the character of the prostates, and with some species in the arrangement of the nephridia, and in the presence of sacs containing penial chætæ. But *Plagiochæta* differs from *Acanthodrilus*, and its allies *Trigaster*, *Benhamia*, and *Deinodrilus*, in the form of the clitellum, in the arrangement of the chætæ, in the absence of a gizzard (cf., however, *Ac. Georgianus*, Mich.).

Mr. Beddard has pointed out that the interesting genus *Deinodrilus* presents a somewhat similar mixture of *Perichætoid* and *Acanthodriloid* characters; and it seems to me that *Plagiochæta* more closely resembles in certain points each of these genera. In its locomotor organs it is closely

¹ *P. intermedia*, Beddard, and *P. Bakeri*, Fletcher, however, possess two pairs of prostates, which are cylindrical or "acanthodriloid" in the former species.

connected apparently with *Perichæta*, while its genital and alimentary systems are on the *Acanthodriloid* plan.

The genus appears to support the view as to a *Perichætatus* condition which I have put forward in my recent paper on the "Classification of Earthworms" (p. 275), viz. that it is not primitive, but secondary, and hence may be developed in any family.

It seems evident, too, that the meganephric and plectonephric condition may occur within the same genus, as we see to be the case in *Acanthodrilus*, and that this condition of the nephridium is not of itself sufficient to decide to which series of families a genus belongs. The sum of the characters of *Plagiochæta* places it amongst the *Plectonephrica*, *mihi*, or *Acanthodrilini* of Beddard.

The general features of its internal anatomy point to its close affinity with the family *Acanthodrilidæ*, *mihi*, rather than with the *Perichætidæ*.

Beddard forms two families, *Deinodrilidæ* and *Acanthodrilidæ*, to contain the genera which I have grouped in one family. I think that we shall do well to wait awhile before we subdivide the families too much; and I would still retain *Deinodrilus* in the same family as *Acanthodrilus*, *Trigaster*, and *Benhamia*, for it differs from these only in the possession of twelve chætæ; the extent of clitellum not being even a generic distinction, since it varies in different species of *Acanthodrilus*.

I therefore place *Plagiochæta* as a fifth genus in the family *Acanthodrilidæ*, *mihi*, with the following characters:—The chætæ are numerous, and arranged in couples, so as to form nearly a complete circle in each somite. The clitellum is short. There are four sperm-sacs; the spermathecæ have diverticula; penial chætæ replace the ventral chætæ of Somites xvii, xix; a pair of calciferous glands is present. There are no peptonophridia; no dorsal pores. Some of these characters are shared by some one or more of the other genera of the family.

It is possible that Bourne's *P. Stuarti* may belong to this

family, but it is to be regretted that we have received no detailed account of the anatomy of this and the other interesting forms which have been briefly described by him.¹

¹ 'Proc. Zool. Soc.,' 1886.

EXPLANATION OF PLATES XV and XVI,

Illustrating Mr. W. Blaxland Benham's "Notes on Two Acanthodriloid Earthworms from New Zealand."

Neodrilus monocystis.—FIGS. 1 to 13.

FIG. 1.—Dorsal view of anterior end of body, showing the character of the prostomium (*pr.*), arrangement of chætæ (*d. ch.*), and position of the nephridiopores (*ne. o.*) in these somites.

FIG. 2.—Ventral view of the somites in the neighbourhood of the genital pores. *ne. o.* Nephridiopores. *prst. p.* Pore of the prostate. *sp. p.* Spermiducal pore. *v. ch.* Ventral chætæ.

FIG. 3.—General anatomy, as seen when the worm is opened in the usual way; from the dorsal surface. *app.* Appendix of spermatheca. *d. v.* Dorsal vessel. *giz.* Gizzard. *l. h.* One of the lateral hearts. *ne.* Nephridium. *pe. d.* Penial duct. *ps. s.* Sac with penial chætæ. *prst.* Prostate. *sp. s¹.* Anterior sperm-sac. *sp. s³.* The most posterior (third) sperm-sac. *splh.* The main sac of the spermatheca.

FIG. 4.—A transverse section of the worm behind Somite xxx, showing the general squareness of the worm, the position of chætæ, and of the nephridia. It would be unusual to find the asymmetry of the last structures as represented in the figure. *a.* Separation of dorsal muscle bundle into two lateral halves. *b.* Lateral muscle bundle. *c.* Ventral muscle bundle. *d.* Accessory muscle bundle, separated from *c* by penetration of a nerve into the body-wall. *d. ch.* Dorsal chætæ. *d. n.* Dorsal nephridium. *d. v.* Dorsal blood-vessel. *m.* Band of muscle passing from the dorsal to the ventral bundle of chætæ, and acting as their retractor. *N.* Nerve-cord. *v. ch.* Ventral chætæ. *v. n.* Ventral nephridium. *v. v.* Ventral blood-vessel.

FIG. 5.—The inner surface of body-wall (rather more than half the worm is represented), to show position of the nephridia in consecutive segments. Letters as in Fig. 4.

FIG. 6.—A portion of Fig. 3, more enlarged ($\times 8$). It represents the prostate of the eighth side; the numbers are placed nearly in the mid-ventral line. *Prst.* Prostate. *a.* Its free extremity. *pe. d.* Penial duct. *pe. s.* Sac with penial chætæ.

FIG. 7.—The sac of the penial chætæ, which protrude from its cut end which is turned forwards, and the prostate are cut away to show the sperm-duct (*sp. d.*) entering the body-wall in Somite XVIII.

FIG. 8.—A diagrammatic longitudinal section through this region of the body-wall, to show the pores of the penial duct of the sac with penial chætæ, and of the sperm-duct. [It is compiled from a series of sections.] *ci.* Circular muscles of the body-wall. *ep.* Epidermis. *lg.* Longitudinal muscles of the body-wall. *pe. ch.* One penial chætæ in the sac (*pe. s.*). *pe. d.* Penial duct opening to the exterior, independently of the sac of penial chætæ. *pores.* Aperture common to the prostate duct and penial sac. *Prst.* Prostate. *pr. pap.* Papilla carrying the pore of the prostate and penial sac. *sp. d.* Sperm-ducts. *sp. p.* Spermiducal pore. *v. ch.* Ventral chætæ.

FIG. 9.—The sac with penial chætæ; it was broken in removing it from the body, and the two portions *a* and *b* are really continuous at *x*.

FIG. 10.—A portion of one of the long penial chætæ, very highly magnified to show the notched ridges and the triangular section. It is surrounded by the cuticular membrane (*m.*) which lines the sac.

FIG. 11.—Transverse section through the prostate. *a* is the colomic epithelium surrounding it. *bv.* Blood-vessels in the wall. Only a few cells are represented in detail, the rest in outline.

FIG. 12.—Transverse section of the penial duct. *ep.* Its epithelium. *m.* Its muscular coat. *v.* Blood-vessels.

FIG. 13.—The spermatheca of the right side. *s.* The chief sac. *app.* The appendix or diverticulum. *d.* The duct penetrating the body-wall.

Plagiochæta punctata.—FIGS. 14 to 32.

FIG. 14.—Dorsal view of the worm ($\times 2$), to show the characteristic marking (from a spirit specimen). *cl.* Clitellum. *pr.* Prostomium.

FIG. 15.—Dorsal view of anterior end of worm, showing the shape of the prostomium.

FIG. 16.—Ventral view of the anterior 23 somites, showing the characteristic arrangement of the chætæ (represented by dots) in couples, the position of the nephridiopores (*ne. o.*), the pores of spermathecae (*sph.*) in depressions, the prostate pores (*prst.*¹, *prst.*²) also in a depression. *clit.* Clitellum. *m.* Mouth. *pro.* Prostomium.

FIG. 17.—A transverse section of the worm behind the clitellum, showing the way in which the longitudinal muscular coat (*lg.*) of the body-wall is

broken up by the chætæ; these are not represented, but occur in couples at the spots marked with numerals; the position of the nephridia (*n. v.*, *n. d.*) is also shown. *D. v.* Dorsal blood-vessel. *Int.* Intestine, spirally coiled, a part of it showing through the septum (*sep.*). *N.* Nerve-cord.

FIG. 18.—About half of a segment (drawn to scale), showing the couples of chætæ inserted in light areas, the pigmented part being represented diagrammatically.

FIG. 19.—A general view of the internal anatomy, as seen when the dorsal portion of the body-wall is cut away. *app.* Appendix of the anterior spermatheca. *cal. gl.* Calciferous gland. *d. v.* Dorsal vessel. *int.* Intestine. *no. ne.* Nephridia. *pro.¹*, *pro.²* The two prostates. *sal.* Salivary glands. *sp. s.¹*, *sp. s.²* The most anterior and most posterior sperm-sacs. *sph.* The main sac of the spermatheca.

FIG. 20.—Transverse section of œsophagus and calciferous gland, represented diagrammatically.

FIG. 21.—A longitudinal section of the intestine, to show its spiral coils. *sep.* Septa.

FIG. 22.—One of the ventral nephridia (the funnel is not shown). *a.* The convoluted large and middle tubes. *b.* The coil of small tubes. [These are only represented diagrammatically; it is not intended to show the exact arrangement of *a*, *b*.] *c.* The cæcal portion of the bladder. *p.* Portion leading to the nephridiopore.

FIG. 23.—Two consecutive sections (*a*, *b*) through a nephridial funnel (from a series of transverse sections). *c. ep.* Cœlomic epithelium. *m.* Marginal cells.

FIGS. 24, *a*, *b*, *c*, *d.*—Four consecutive sections through the degenerate nephridium of the second segment. In *a* one edge of the nephridiopore and a part of the dilated bladder is seen. *b* goes through the nephridiopore. *coag.* Coagulum in bladder. *m.* Muscle. I, II. Portion of wall of the 1st and 2nd segments: *c* shows the tract of cells leading to the convoluted tube, a portion of which (*l*) is present. *m* is the position occupied in the next section by the coil *d*. *l* shows the position occupied by the tract of cells represented in *c*. *b. v.* Blood-vessels.

FIG. 25.—An ovary attached to septum (*spl.*).

FIG. 26.—View of the prostates, &c., after removal of the gut. *pe. s.¹*, *pe. s.²*. The two sacs containing penial chætæ. *pro.¹*, *pro.²*. The two prostates. *sp. d.* Sperm-duct. *pe. d.* Penial duct.

FIG. 27.—Transverse section of a sperm-duct, showing the oval nuclei with long axis at right angles to the axis of the duct. *b.* Blood-vessel.

FIG. 28.—Transverse section of penial duct. Here the nuclei of the epithelium have their long axes radially placed. *c. m.* Circular muscular coat. *lg. m.* Longitudinal muscles.

FIG. 29.—Diagrammatic obliquely longitudinal section through the aperture of prostate, combined from a series of sections. *Pe. d.* Penial duct. *pr. p.* Prostate pore. *pe. s.* Sac with penial chætæ. *a.* The longer; *b.* the reserve penial chætæ. *p. s. p.* Pore of this sac.

FIG. 30.—A spermatheca, showing its various parts.

FIG. 31.—A longitudinal section through a spermatheca (combined from a series of sections). *a, b, c, d* point to the regions which are represented more highly magnified in Fig. 32. *a.* The duct of spermatheca. *app.* The diverticulum. *b.* Wall of the sac. *c. m.* Circular muscle of the body-wall. *c. d.* Epithelium of appendix. *lg. m.* Longitudinal muscle of the body-wall. *mus.* Muscular coat of the diverticulum. *sept.* Septum VIII/IX. *spoa.* Spermatozoa in the diverticulum, and a few in the sac. *v. ch.* Ventral chætæ. *æ.* Granular secretion in the sac.

FIG. 32.—Portions of epithelium of the spermatheca from different regions. *a.* From duct. *g.* Glandular cells. *p.* Nuclei of non-glandular cells. *b.* From the wall of the sac. *m.* Cells which have probably just discharged their contents (*x*). *n.* Cells not quite fully developed. *c.* From the diverticulum. *k.* Nucleus of the interstitial cell. *d.* Also from the diverticulum, showing spermatozoa attached to the cells by (*h.*) their heads. *t.* Tails of spermatozoa.

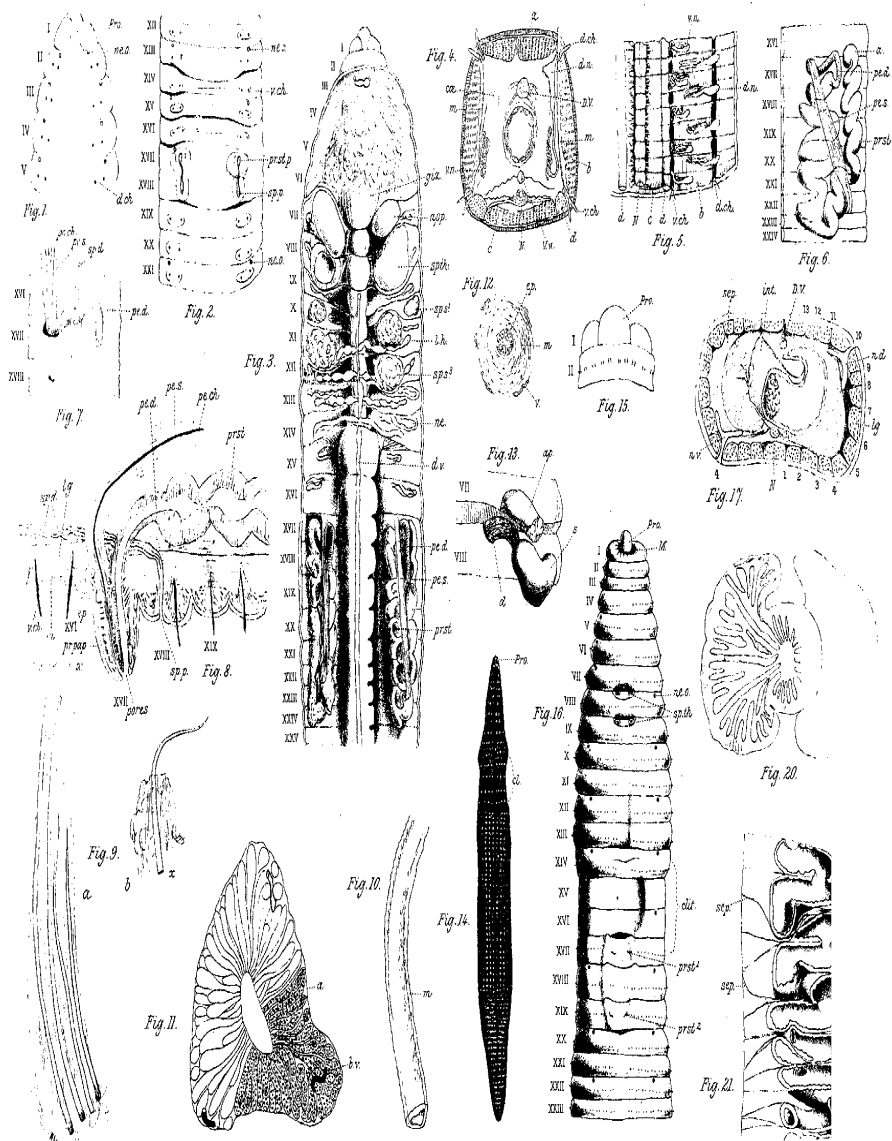


Fig. 18.



Fig. 19. V

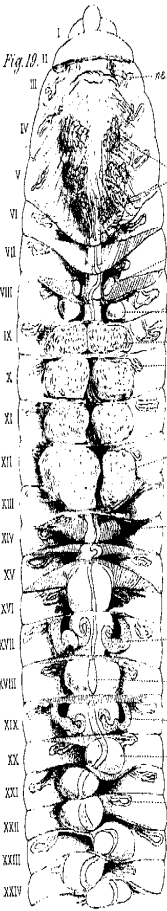


Fig. 24a.



Fig. 24b

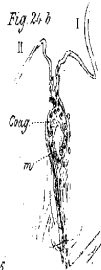


Fig. 24c.

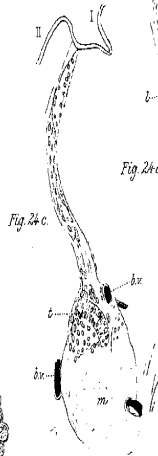


Fig. 24d.

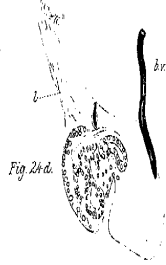


Fig. 27.



Fig. 25.



Fig. 28.

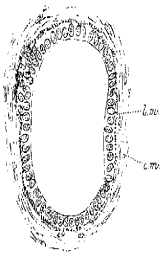


Fig. 26.

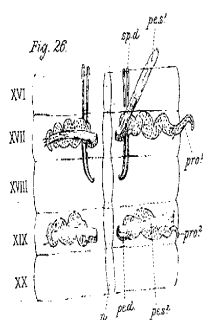


Fig. 30.

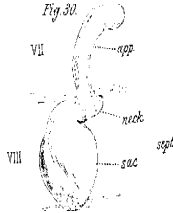


Fig. 32.



Fig. 31.

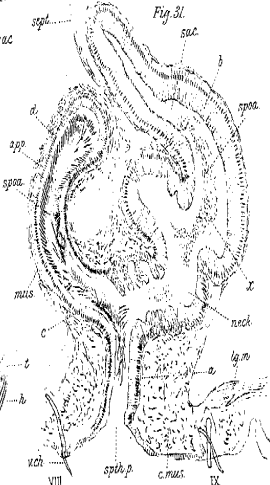


Fig. 22.

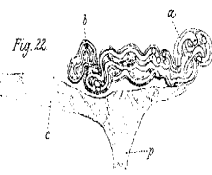


Fig. 29.

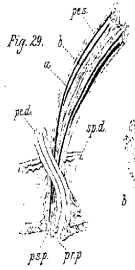


Fig. 23.

