Notes on some Aquatic Oligochæta.

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With Plates V, VI, and VII.

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DURING the present spring (1891) I had under observation at various times a number of aquatic Oligochæta, for the purpose of illustrating my lectures to the students here who were working at the group; and I came across several interesting facts, some of which are worth recording in these pages.

Wishing to obtain examples of Oligochæta living on the sea-shore, I wrote to Mr. W. H. Shrubsole, of Sheerness, and he was good enough to obtain for me several gatherings from the neighbourhood. I wish to convey to him my best thanks for the energy and promptness which he displayed in acceding to my requests.

Amongst these gatherings, living in dark, smelling, decaying organic detritus, I found Hemitubifex ater, Paranais littoralis, Clitellio arenarius, and Pachydrilus sp., together with a worm originally diagnosed very briefly by Claparède about thirty years ago, which appears to have

escaped the notice of naturalists since that time. To it he gave the name Heterochæta costata; the generic name referring to the interesting arrangement of chætæ, and the specific to longitudinal ridges, or to the distinctly annulate character of the segments.

Of these worms I found abundant specimens in some of the earlier gatherings (in May); but more recently, in the latter end of June, I have been able to find only a few specimens, though I still find a few fully mature forms now in July.

Heterochæta costata, Claparède, 1863.

In his studies on Invertebrates from the coast of Normandy ('Beobach. u. Anat. und Entwickel. wirbellöser Thiere') Claparède gives (p. 25) a brief diagnosis of a new genus, of which the following is a translation:

"Heterochæta, n. gen.

"Chætæ bundles in two rows (on each side); those of the upper row, on Segments v to VIII, are hollowed out at the free end in the form of a cup. The remaining chætæ are all crotchet-shaped [hakenförmig].

"H. costata, n. sp., Taf. xiii, figs. 16 to 19.

"Body 16 mm. in length, $\frac{1}{2}$ mm. in breadth; skin ribbed by longitudinal grooves; each segment divided into rings by about four constrictions."

He further states, during a brief extension of the diagnosis, occupying only eight lines, that all his specimens were immature and without a clitellum; that the peculiar chætæ (which he figures) have a constriction just below the cup (or "becher"); that the ordinary chæta has a swelling (or "node," as I will call it) about midway along its length. The vascular system consists of a dorsal vessel, a ventral vessel, and a loop in each of the hinder segments.

This is essentially all that is known of this interesting worm;

and Vejdovsky makes no remarks upon it, merely giving Claparède's diagnosis almost textually ('System und Morph. d. Oligochæta,' p. 84). Vaillant, in the 'Hist. nat. d. Annélides,' has no more to say of it.

In the above diagnosis there is one error, which I will point out at once. The chætæ referred to as "becherförmig" are not cupped; they are what is known as fan-shaped (or palmate, as I shall call them), such as are characteristically found in Psammoryctes.

I have been able to extend our knowledge of this worm, and will now give my own observations on Heterochæta.

During life the worm is pink in colour, the sperm-sacs and ova in mature animals showing up white.

The length is about five eighths of an inch when fully mature, and exceptionally slightly longer; but I have seen none that attain a length of one inch. The white region which marks the position of the genital cells occupies about one eighth of an inch, commencing about the same distance from the anterior end (fig. 1). The number of segments is about forty.

In habit it resembles Hemitubifex, &c., amongst which it lives; and I found it sometimes by itself in the mud, with posterior end protruded therefrom, as is the habit of other members of the family, or twisted and coiled amongst the Hemitubifex in the "balls" which the latter form.

When disturbed, an individual will roll itself into a spiral, or twist itself into a knot (fig. 2).

It is not by any means easy to distinguish Heterochæta by the naked eye from such forms as Paranais littoralis, Pachydrilus, or even some paler forms of Hemitubifex. I have found it impossible to identify them without picking them out and using a low-power microscope for their examination; and even then, unless they happen to present their dorsal surface to view, it requires great practice to appreciate the exact shade of pink which serves to distinguish them from the other worms mentioned above.

If, however, the back is uppermost, then one can readily

recognise the fan-shaped bundles of dark palmate chætæ on Segments v to XIII[1] (fig. 3).

The ventral chætæ (figs. 12, 13) are practically all alike, to wit, crotchets or "furcate" chætæ; although the size of the prongs and the angle between may vary in different parts of the body. The dorsal chætæ, with the exception of those on Somites v to XIII (both inclusive), are similar to the ventral chætæ. These are shown in figs. 10, 11.

The dorsal chætæ of Segments II, III, IV, have the two prongs very nearly equal, the lower (or proximal) prong being slightly smaller than the upper or distal prong; the two prongs are not greatly divergent (fig. 10). The dorsal chætæ of the hinder segments are slightly stronger than the anterior ones; the proximal prong is shorter than the distal prong, and has a decided curve away from the latter, so that the angle between them is slightly more obtuse than that of the anterior dorsal chætæ (fig. 11).

The ventral chætæ present a similar difference according to their position—namely, those of the more anterior segments (fig. 12) have less divergent prongs than have those of the more posterior segments (fig. 13); and there is the same difference in size of the prongs as occurs in the dorsal bundles. These differences agree with those figured by Professor Lankester for Psammoryctes umbellifer ('Ann. Mag. Nat. Hist.,' 4th ser., vii, 1871, p. 92). Similar differences have been noticed in other members of the family Tubificidæ.

The dorsal chætæ of Segments v to XIII closely agree in appearance with those described and figured by Lankester as characteristic of Psammoryctes umbellifer; where they occur, however, in Segments II to X.

Each of these palmate chætæ has the appearance presented by fig. 4. The stalk or axis of the chæta is straight, swollen at the point where it passes through the skin in a protruded

[1] The numeration that I here adopt is that usually followed by recent writers on Oligochæte anatomy—namely, to regard the first chætigerous segment as the second [II] body-segment; the buccal or peristomial segment being the first [I] segment.

state; then narrows, as Claparède stated, before dilating to form the "head."

This "head" is flattened from in front backwards in the natural position of the chæta as seen in a living worm, and expanded laterally; it is not cup-shaped: this appearance is an optical illusion. When seen from in front this head is seen to be formed by seven or eight blunt teeth; and each is slightly curved forwards, so that the free edge of each "tooth" is marked by a thicker line. The "teeth" appear at first sight to be separated from one another by very fine spaces, but I believe these spaces are in reality occupied by an extremely thin transparent membrane, as in Psammoryctes and Tubifex.

I was at first inclined to regard the "teeth" as separate from one another; but, as Professor Lankester remarked to me, if this were so, the lines between the "teeth" would appear much more pronounced, owing to refraction along the edges, than is the case.

And further observation served to assure me that there is such a membrane; it can be distinguished by the use of Zeiss's homogeneous immersion, with compensating eye-piece 4. Moreover if the chætæ, during the movements of the bundles to and fro, be looked at from above (with a Zeiss' E, and No. 2 eye-piece), so that the free edge only of the structure be seen in focus, we get a curved beaded appearance (fig. 7); the thicker parts are the "teeth," the thinner are the intervening membranes. This interpretation is further confirmed by a very lucky find of an abnormal variety of the chæta, in which the "teeth" are scarcely differentiated, and we have a continuous membrane with extremely faint lines across it (fig. 9). This is not a young chæta, but occurred in middle of a bundle of palmate chætæ, and was of same size as these.

The whole of the "head" is curved at its sides, as shown in fig. 7, and at the same time is bent forwards, as in fig. 6. Hence the whole "head" can never be in focus at one and the same time under a high power. This leads to the appearance represented in fig. 5, where the two most laterally placed or outer teeth or ridges are in focus, whilst the remainder are

only imperfectly focussed; hence the outermost ridges appear more strongly defined than the rest (see Lankester's and Vejdovsky's figures of Psammoryctes), but by careful focussing it appears to me that all the ridges are equally developed.

Now, if one of these chætæ be observed from above during life, so that we look down it, we shall of course see the head foreshortened, and we have the appearance portrayed in fig. 8. This has somewhat the appearance of a cup, one side of the cup being formed by the free edge of the teeth, whilst the two outer ridges and the thick stalk immediately below the head form the curve which may be mistaken for the other side of the cup; and I believe this appearance deceived Claparède. These palmate chætæ vary in number on different segments, as the following table and fig. 3 show; there is also individual variability for each bundle.[1] The chætæ of a bundle, when in movement, diverge from one another in a fan-shaped manner, the edges of the various chætæ almost touch, and are so regularly arranged as to form part of a curve. The whole bundle is moved backwards and forwards—striking the water, that is to say, with the flat faces of the chætæ, which no doubt serve as oars. It is interesting to note that the furcate chætæ are freqnently rotated on their own axes, in addition to their to and fro movement; and that not unfrequently the angle between the prongs, which is normally directed downwards, is directed upwards. There appears to be a much greater freedom of movement in all directions in the furcate bundles than in the palmate bundles.

Although these facts can be to a very great extent observed in a living worm, slightly compressed by a cover-glass to prevent too active a movement, yet it is necessary, in order to properly ascertain the character of the chætæ, to treat them with caustic potash. This I did, and have mounted them in glycerine jelly, which, as Professor Lankester has observed, is a most useful mounting medium for chætæ.

When treated with KHO, however, the embedded ends of

[1] That is, the bundle of the corresponding somite in two or more worms does not always have the same number of chætæ.

the chætæ swell up to nearly twice their real diameter, so that this method alone would give a wrong impression as to their real shape; the terminal parts appear to be harder, and are not so affected.

Table of Arrangement of CHÆTÆ.

	Dorsal Bundles.		Ventral Bundles.	
Segment.	Right.	Left.	Right.	Left.
II.	2 or 3	2 or 3	3 or 4	3 or 4
III.	4 (+ 1)	4 (+ 1)	3 (+ 2)	3 (+ 1)
IV.	4 (+ 1)	4 (+ 1)	3 (+ 2)	4 (+ 1)
V.	**6** or **7** (+ 2 or 3)	**6** (+ 2 or 3)	3 (+ 1)	4 (+ 1)
VI.	**7** (+ 3)	**8** (+ 3)	3 (+ 1)	3 (+ 1)
VII.	**7** (+ 3)	**10** (+ 1)	3 (+ 1)	3 (+ 1)
VIII.	**9** (+ 3)	**11** (+ 3)	3 (+ 1)	3 (+ 1)
IX.	**11** (+ 2)	**11** (+ 1)	3 (+ 1)	3 (+ 1)
X.	**9** (+ 1)	**9** (+ 3)	2	2
XI.	**6** (+ 1)	**5** (+ 2)	2 (or 1)	2
XII.	**6** (+ 3)	**6** (+ 2)	2 (+ 1)	1 (+ 1)
XIII.	**4** (+ 2)	**6** (+ 1)	1 (+ 1)	1 (+ 1)
XIV.	3	3	1 (+ 1)	1 (+ 1)
XV.	2 or 3	2 or 3	2	2
XVI.	2	2	2	2
XVII.	2	2	2	1 or 2
XVIII.	2	2	2	2
XIX to XXIV.	2	2	2	2
XXV to end.	2	2	1	1

NOTE.—The strong figures represent the palmate chætæ; the (+ *x*) represents young chætæ, which do not protrude.

But I have found, not unfrequently, examples which show a slight difference in the position of the palmate bundles.

In two or three specimens the chætæ of Segment XIV were palmate, like those of XIII.

In another specimen the dorsal bundle of one side of Segment XIV consisted of four palmate and one furcate chætæ, that of the other side only of furcate chætæ.

In another a similar asymmetry of Segment XV occurred; i. e. on one side the bundle consisted of one furcate and two palmate chætæ, those of Segment XIV being all palmate.

Still further, in one specimen, whilst the chætæ of the dorsal bundles of Segment XIII were as usual palmate, those of Segment XII were furcate.

Seeing that in Psammoryctes and in Tubifex we get certain chætæ which are neither simple crotchets nor completely palmate (see Vejdovsky's figs. 11 and 4, pl. viii), I looked carefully for similar intermediate forms in Heterochæta, and for a long time I looked in vain, but ultimately I was successful in finding somewhat similar "intermediate" or "multidentate" chætæ. The one figured (fig. 15) was from one of the dorsal bundles of Segment XIV of one specimen; it occurred with three typical palmate forms, and there were no crotchets. Curiously enough it was not at the side of a bundle, but between the 2nd and 3rd palmate chætæ. These "intermediate" chætæ have one or two teeth between the prongs.

One specimen I noted, and here represent (fig. 16), in which a great amount of divergence from the typical arrangement was accompanied by intermediate conditions of the chætæ.

This may be tabulated thus:

Abnormal Specimen.

Segment.	Right Dorsal Bundle.	Left Dorsal Bundle.
II.	3 furcates	. 3 furcates.
III.	1 furcate (most dorsal of bundle) 2 intermediates	3 furcates.
IV.	1 furcate (dorsal) 3 intermediates . . .	. 2 furcates. 1 large palmate. 2 small palmates.
V.	5 (+ 1) palmates . . .	. 5 (+ 1) palmates.

VI to XIII (inclusive) were normal.

Dorsal Chætæ.

Segment.	Right.
XIV.	3 palmates.
XV.	1 furcate and 1 intermediate.
XVI.	1 palmate and 1 furcate.
XVII, &c.	2 furcates.

The palmate chætæ are usually considered as special modi-

fications of the furcate or crotchet-shaped chætæ, with the multidentate forms as an intermediate condition.

I am inclined to regard them in a different light, for—

(*a*) If a palmate bristle be viewed from its edge, I have shown that the tips of the teeth are all curved, and this curve resembles the curve of a furcate chæta if the lower tooth were removed.

(*b*) The divergence of the two outer teeth or ridges of the comb is different from that of the prongs of the fork, in which both prongs are directed towards the same side of the stalk, and the tip of each is frequently curved downwards in the same direction. In the palmate bristles it will be seen that neither of these things occurs (see also Pl. VII, figs. 33, *a*, *b*, 36, *c*, *d*).

(*c*) The plane of the head, i. e. the two prongs of the furcate chæta, is in a state of rest parallel with the long axis of the body, whereas that of the palmate bristle is at right angles to the axis of the body.

(*d*) The so-called "intermediate" forms, or "multidentate" forks, do not represent a stage in the formation of the ctenate bristles. The two prongs are similar to those of the simple furcate forms in relative size, curvature, divergence, &c.

(*e*) I would rather regard the ctenate chæta as having been derived from a simple "sigmoid" chæta (such as is common amongst earthworms, some Lumbriculidæ, some Enchytræidæ, and in Phreoryctes) by a flattening and expansion of the dorsal extremity, so as to form the "membrane," which then becomes thickened or ribbed to give rise to the palm-leaf-shaped arrangement; whilst the furcate chætæ, which are so common amongst the Oligochæta generally, may have been derived similarly from the "sigmoid" form by the appearance of a notch at the extremity, which became deepened to form the angle between the two prongs, these in their turn becoming more and more developed, the plane of two prongs being at right angles—with respect to the axis of the original chæta—to the plane of the "membrane" of the palmate forms.

The "multidentate" chætæ will then be a further develop-

ment of the fork, but not in the direction of the palmate type.

The sigmoid form itself is not necessarily the primitive form of chæta; it is possible that a straight spine, such as we find in the Enchytræids, is an earlier form, which may have given rise to the capilliform shape by elongation, and to the sigmoid form by curvature, and hence to these other forms.

Amongst other external features which are of interest may be mentioned the distinct annulation of the anterior segments of the body (fig. 3). This is distinctly visible during life, and can be detected in longitudinal sections. Each segment is marked out by three grooves into four rings, of which the third is the largest, and on this the chætæ are embedded. The most anterior segments show only two of these grooves, and on the clitellum they are present only ventrally. This feature is mentioned by Claparède, and is of more frequent occurence in aquatic Oligochæta, as in earthworms, than is usually supposed.[1] It is indistinctly marked in some Naids. Claparède mentions the fact in Tubifex and Limnodrilus. It is present, in fact, in the majority of this family, and is carried to an extreme in Branchiobdella. It is present in Hemitubifex, though rendered less noticeable and even almost obscured by the dark cuticular papillæ. In Heterochæta, however, it is so distinct that it is almost the readiest means of distinguishing, under a low power, this worm from other forms with which it occurs, for the characteristic chætæ are not visible if the animal presents its ventral surface upwards.

I am unable to say what may be the "Langsfürchen" in the skin, mentioned by Claparède. I see no such grooves. His figure may represent the bundles of longitudinal muscles which can be seen during movement of the worm, and will at times be thrown into wavy lines such as his drawing represents.

The shape of the prostomium is exhibited in my figs. 3

[1] For example, Mr. W. Hatchett Jackson, in the 2nd edition of 'Forms of Animal Life,' states on p. 593 that "annulation of the somites is very rare."

and 16. It is conical in its general outline, with a circular groove near the tip, giving it a pointed appearance.

The male pores (spermiducal pores) are, as is always the case in the Tubificidæ, in Somite XI slightly dorsal of the ventral chætæ.

The spermathecal pores are in a similar position in Somite X. In both cases the cuticle dips inwards at the pore, and is folded around its lip.

The vascular system is of the usual Tubificid[1] type. There is a pair of lateral dilated hearts in Somite VIII. These contract not together, but alternately. In the genital segments these vessels are contractile, and lie on the sperm- and ovi-sacs; in other segments a pair of narrow convoluted vessels lie immediately below the body-wall.

The most important system of organs after the chætæ are, of course, the genitals. These are shown in situ in fig. 17, which is taken from a careful sketch made from the living worm, sufficiently compressed to prevent movement, and to allow the organs to be seen without undue distortion or displacement. The clitellum covers the dorsal surface of XI, XII, and part of X as far as the chætæ, sometimes even part of XIII.

The Male Organs.—A pair of testes in the 10th segment are attached to the anterior septum of this segment.

The funnels of the sperm-ducts lie against the posterior septum of the 10th segment; from the funnel on each side the narrow ciliated duct passes, with only slight undulations, back through the Segment XI and into Segment XII. Here it enters the glandular "atrium;" this narrows, loses its glandular coat, passes forwards into Segment XI, and here opens to the exterior.

The "cement gland," or prostate, lies in Somite XII, and here opens into the atrium.

[1] In a recent paper ("Monog. českých Tubificidů") Stolc gives some excellent figures of the arrangement of vessels in several genera, and represents several new points; e. g. the lateral hearts in his two new genera Lophochæta and Bothrioneuron arise, not from the dorsal, but from a supra-intestinal trunk.

The male apparatus is represented in greater detail in fig. 18, as seen when "squeezed" out of the body, with exception of the funnel, which remained inside.

The funnel, as in all the aquatic Oligochætes, is simple, and not folded as in earthworms. In the Tubificidæ it is a very large, flattened, and shallow structure, as is also the case in the Lumbriculidæ and Phreoryctidæ. In the Enchytræidæ it has a characteristic form, being long, narrow, thick-walled, and projecting far into the cavity of its segment.

In Heterochæta the funnel, though usually lying flat against the face of the septum, undergoes, with the contraction and extension of the worm, a corresponding movement, in that the lips move to and from the septum, so that its other extreme position is represented in fig. 19.

The duct does not leave the funnel in the centre of the latter, but slightly to its outer side. This asymmetrical condition is shown by Beddard in Clitellio arenarius; but in all other figures by Claparède, Vejdovsky, &c., the duct is represented as leaving the funnel in its centre. Whether there is any differential character in this feature I do not know. I rather think that this is not the case, but that the drawings are to some extent diagrammatic, and make no pretence to represent the thing accurately.

The sperm-duct is thin-walled and ciliated internally, as is always the case.

The "atrium" (fig. 18) is divisible into two regions here, as in Psammoryctes—a region coated with granular cells, which give to it a dark appearance (*gl. atr.*); and a thin-walled, narrower region (*n. gl. atr.*), which passes to the penis.[1]

There are no cilia in the "atrium," using the word to include all that part of the apparatus after the entrance of the solid "prostate." The terminal part of the atrium passes into

[1] To this dark granular region Vejdovsky, in his description of Psammoryctes, gives the name "seminal vesicle," whilst the long narrower region between it and the penis is termed by him the "cement duct."

the protrusible penis, which is surrounded by a specially thickened chitinous coat. The figures 18, 21, 22, representing the arrangement of this region of the duct, aid the description. It will be seen that the male pore leads into a chamber (penial chamber, *a*, *b*) lined by cuticle invaginated at the male pore. Projecting from the bottom of this penial chamber (or "cloaca" of Claparède, or "ductus ejaculatorius" of Vejdovsky) is the "penis." This consists of a soft central part, the "glans," and a thick, refracting, chitinous coat (Vejdovsky's "penis tube"), which has a characteristic form. It is nearly cylindrical, the edge of the outer end of the cylinder being bent outwards so as to form a rim, and is much more noticeable than that of Psammoryctes, Spirosperma, &c. (cf. this with the penis of other members of the family).

The internal soft part is perforated nearly axially by the narrowed continuation of the atrium, the external aperture of this duct being excentrically placed on a protuberant "glans penis" (of Vejdovsky). I have not seen this penial apparatus in a protruded condition, but no doubt a similar process occurs here as in Tubifex.

When I first examined the genital duct, separated from the animal, I found that the "cement duct" (of Vejdovsky) and the "seminal vesicle" exhibited irregular dilatations, as seen in fig. 20, *a* and *b*. I therefore isolated some eight or nine ducts, in order to ascertain whether these dilatations were constant, and I soon found that such was not the case—that these swellings are only artificially produced. This was confirmed by the fact that in situ there are not such definite swellings.

In the fully mature worm Segments IX to XIV, or even XV, are occupied by developing ova and spermatozoa. In some cases, such as the one figured, we find both genital cells fairly equally developed; whereas in other specimens the spermatozoa are predominant, and no large ova are present, and vice versâ.

The developing spermatozoa are included in definite sacs, the sperm-sacs, which are provided with thin membranous

walls, upon which are greatly convoluted and contractile commissural blood-vessels.

These sperm-sacs are asymmetrically arranged. There is usually one in Segment IX, and another starting in Segment XI, and extending back as far as Segment XIV or XV, pushing the intervening septa in front of it. Very usually, though I believe not invariably, this sac crosses from one side of the body to the other dorsally of the gut.

Besides these two sacs (Claparède's "testicles") masses of developing spermatozoa more or less fill Segment X. The minute structure of various parts of the male apparatus deserves a brief description, not from any peculiarity special to the genus, but because we have but few details of the histology of these aquatic Oligochætes. The figures of Claparède, Vejdosky, Eisen, &c., are, in the main, somewhat diagrammatic, even where these authors intend to show detailed structure. Beddard has recently contributed some facts as to the minute structure of Hemitubifex and Phreoryctes, and Michaelsen has recorded something of the histology of Enchytræids.

The sperm-duct, when its surface is viewed, is seen to be striated transversely, as is the case in Tubifex, &c. The minute structure, as seen in sections, is exhibited in my fig. 23, which includes a transverse and a longitudinal section of the sperm-duct.

In transverse section there is a remarkable "striation" of the wall, which is apparently due to radial arrangement of the granules in the cells; this is seen even better in a series stained in hæmatoxylin than in the borax-carmine sections drawn. I can see no boundaries to the cells; and the nuclei are not elongated radially, but tangentially: they are, in fact, ovoid in shape, the long axis being at right angles to the axis of duct, so that in longitudinal section the nuclei have circular outlines. I have seen a similar arrangement in Tubifex, both as regards striation and nuclei.

In earthworms, e.g. Lumbricus, Perichæta, the striation is present, but the nuclei appear to be spherical, giving a

circular section in all directions. Beddard,[1] in his figure of the sperm-duct of Hemitubifex, shows a different arrangement.

The two parts of the atrium, already distinguished externally, are equally distinct in histological structure: the non-glandular part (fig. 23, *ngl. atr.*) is lined by flat cells, with horizontally elongated nuclei and granular protoplasm; whilst the glandular region (*gl. atr.*) is lined by cells of a totally different shape. The epithelium here is more or less cubical; the cells are glandular—at any rate vacuolated, as if a secretion had been discharged; the protoplasm, with darkly staining granules of comparatively large size, is chiefly found in the outer part of the cell, where, too, is the round nucleus (fig. 25); the spaces, or vacuoles, appear sometimes to be occupied by an extremely fine substance—so fine that it is impossible to detect whether it is homogeneous or finely granulated, and requires an apochromatic to be seen at all.

The prostate is a solid structure, built up of a mass of cells having essentially the same structure as the preceding, though differing in shape (fig. 24). These cells are pyriform; the granules are larger and distinctly spherical; probably the neck of each cell serves as a duct, and pours the secretion into the atrium independently of its neighbours.

Mr. Beddard's[2] drawing differs slightly from mine, chiefly as to details, which is perhaps due to the method of preservation. If the cells in Heterochæta were a little emptier, we should have an appearance something similar to that shown by him for Hemitubifex.

I may say that the isolated cells here figured are drawn from sections, and not from teased preparations.

The prostate, like the sperm-duct and atrium, is surrounded by a delicate membrane (*c. ep.*), with a few scattered nuclei; this membrane is continuous, and is the cœlomic epithelium. The atrium has in addition a muscular coat, as shown in the figure (*mus.*).

[1] "On Certain Points in the Structure of Clitellio," 'Proc. Zool. Soc.,' 1889, p. 485, pl. xxiii, fig. 5.

[2] Loc. cit., fig. 7.

In fig. 22 I have drawn a section along the penis, in order to show the character of the cells which give rise to the chitinous penial sheath, and their continuity with neighbouring epithelia. The figure is sufficiently explained, and confirms the drawing (fig. 21) which is made from a living specimen, but where of course only the cuticular structures (except the penis itself) are shown.

The Female Organs.—There is a pair of ovaries in Segment XI, usually concealed in a fully developed individual by other structures.

As is the case in other Oligochæta, eggs leave the ovary and undergo further development in an "ovisac;" this in Heterochæta occupies Segments XIII, XIV, and sometimes XV. Usually this sac contains two or three very large ova, one in each segment; there is a contractile vessel in the wall of the ovisac, as in the case of sperm-sacs.

The oviduct is a small funnel opening externally between XI/XII.

As in other members of the family, there is a pair of spermathecæ in Segment X. Each spermatheca consists of a short, narrow duct, and an elongated, wide, tubular sac. The duct is shorter and the sac longer than in most other genera, the duct being about the same size as in Limnodrilus Udekemianus, Claparède. The pore lies in a line with the spermiducal pore, and, like it, has the cuticle invaginated around it.

The sac of the spermatheca may be entirely confined to Somite X, or may extend into the neighbouring segment. In the specimen from which the figure is taken the spermatheca of the right side is wholly in Segment X; that of the left side had pushed its way into the succeeding somite. In other specimens I have seen the sac of one side extending into Somite IX, that of the other into Somite XI.

The spermatheca, though not externally divisible into very marked regions beyond duct and sac, shows internally certain peculiar cells near the pore (cf. Vejdovsky's picture of Tubifex, Pl. IX, fig. 17). The greater part of the sper-

matheca is lined by columnar cells (fig. 26), the nuclei of which are usually situated near the outer margin. These cells are very granular, and their internal margin sometimes indistinct. But near the neck the cells are pyriform (fig. 27), as in Vejdovsky's figures; and these cells are extremely finely granulated, the nucleus being in the dilated part of the cell, which projects into the cavity of the spermatheca, so that in this region the inner limit of the epithelium is quite irregular.

The spermathecæ are filled with the characteristic Tubificid sperm-ropes (I prefer this term to spermatophores), of which I counted in one specimen as many as thirty-five; some of which were completely formed, others incompletely. A completely formed "rope" is shown in fig. 28, its structure in figs. 29—31.

It is spindle-shaped; one end being drawn out into a point, the opposite end being truncated, slightly knobbed, and apparently perforated. The wall is highly refracting and forms a fairly thick coat, in which the heads of the spermatozoa are embedded (*a*); immediately below this is, in optical section, a layer of granules (*b*) (? sections of spermatozoa), and the interior is filled with loose spermatozoa in addition to those embedded in the wall, whose freely projecting tails give rise to the movement of the whole apparatus. When partially crushed, bundles of spermatozoa protrude from the interior through any breaks in the wall (fig. 30).

Though spindle-shaped like the sperm-rope of Psammoryctes or Limnodrilus, it lacks the peculiar "spines" on the neck which occur in the former, and is relatively much longer, narrower, and more pointed than in the latter.

The structure of spermatophore is further illustrated by fig. 31, which is drawn from a section through a spermatheca. The homogeneous layer (*a*) is in these preserved specimens very highly refractive and scarcely stained. By the use of an apochromatic, and regulation of the light, the heads of the spermatozoa could just be detected; the lines representing them in the figure are much too coarse.

I have added a figure of a specimen of the worm after sexual

maturity is over (Pl. VI, fig. 32), as it shows very distinctly the shrunken sperm-sacs, the ovaries and testes. The spermathecæ are apparently undergoing degeneration; they are filled with highly refracting globules. No trace of the sperm-duct or atrium, nor even penis was present; but in other specimens traces of the male apparatus could be detected. This disappearance of the penis appears to me particularly remarkable, though I am unable to say whether it is due to its solution or absorption by the cells, or whether the hard coat is thrown off.

Comparison of Heterochæta with other Tubificidæ.

The nearest genus to Heterochæta is undoubtedly Psammoryctes (Pl. VII, fig. 33), on which alone are found palmate chætæ closely resembling those of the former genus. In its generative apparatus, too, there is a pretty close agreement,[1] in the division of the atrium into two regions, and in the general form of the chitinous penial coat; but this is quite characteristic in Heterochæta. The chief differences between the two genera are (*a*) the restriction, in the latter genus, of the palmate chætæ to Segments v to xiii, which in Psammoryctes commence in Segment ii and extend to x; and (*b*) the absence of capilliform chætæ in Heterochæta. As the various genera of aquatic Oligochæta occur pretty abundantly in England, and as we have no brief summary of generic characters, I have brought together the chief characteristics in the form of a series of figures, and will point out here the leading features of these genera.[2]

Commencing with the chætæ of the dorsal bundles—for those of the ventral are essentially similar in all the family except Telmatodrilus, we have a fairly ready means of distinguishing groups of genera.

[1] I have not been able to see the dilatations in the atrial duct described by Vejdovsky.

[2] Stolc, in a recent paper in the Czech language, adds considerably to our knowledge, so far as I can judge from the plates.

Telmatodrilus, Eisen, possesses only one kind of chæta, simple, unforked, sigmoid forms, resembling those of Enchytræus.

Limnodrilus and Clitellio likewise possess only one kind of chætæ (Pl. VII, fig. 35), namely, the furcate or "crotchet," which may vary in detail in different regions of the body.[1] In Hemitubifex, too, there is only one kind generally, though Eisen and Beddard mention capilliform chætæ as "sometimes" occurring. I have not seen them in H. ater. Tubifex (fig. 34) and Ilyodrilus (fig. 33) present us with capilliform chætæ, either only anteriorly in Segments III to X (or thereabouts) in the former, or throughout the body in the latter genus; these chætæ are confined to the dorsal bundles, and with them occur furcate chætæ, which possess very usually two or more accessory prongs between the two main prongs in Tubifex,[2] or a membrane, without ridges or teeth, in Ilyodrilus. In both genera these modified furcate chætæ occur in anterior segments only.

Further, in Spirosperma (fig. 36) capilliform chætæ occur all along the body, and are accompanied throughout by a peculiar variety of palmate chætæ (see further on in this paper), which are small and inconspicuous.[3] They differ in shape and size from those of Heterochæta and Psammoryctes.

Another set of characteristic modifications affects the male apparatus.

The shape of the atrium, presence or absence of prostate, and penial coat are among these. The prostate is absent in Clitellio and Ilyodrilus. In the remainder it is a somewhat kidney-shaped, solid mass of cells communicating with the atrium at the point of entrance of sperm-duct.

[1] Bothrioneuron, Stole, so far as chætæ are concerned, agrees with Limnodrilus.

[2] I have not seen the membrane between the forks, as figured by Professor Lankester.

[3] In Stole's genus Lophochæta somewhat similar chætæ occur in the dorsal bundles, together with peculiar feathered capilliform chætæ; but the exact distribution of these I am unable to give, as I have not yet had Stole's paper translated.

In Telmatodrilus there are eight or more small isolated prostates.

The atrium is relatively short in Tubifex and Ilyodrilus,[1] where it is glandular throughout, and there is no distinction of a non-glandular portion or atrial duct.

In Limnodrilus there is a short non-glandular region, which is larger in Spirosperma.

In Psammoryctes (see below) and Heterochæta[2] the glandular region is relatively small, and the non-glandular portions greatly extended.

I append figures of the chitinous coat or tube of the penis (Pl. VII, fig. 37), by which I understand a thick, refracting modification of the cuticle, such that it can be readily recognised.

Such a penial tube is absent in Tubifex and Ilyodrilus.[3] It is short and nearly cylindrical in Spirosperma (37, *c*), Psammoryctes (37, *c*), and Heterochæta (Pl. VI, fig. 21). The last, however, has the outer edge turned out so as to form a rim.

In Telmatodrilus (37, *b*) and Hemitubifex[4] (fig. 37, *a*) it is a short truncated cone (I cannot find a description or figure of this part in Clitellio).

In Limnodrilus (including therein Camptodrilus, Eisen) the tube is usually very long and relatively narrow, cylindrical, or constricted near the middle, or trumpet-shaped (figs. *d*, *e*, *f*). In L. Hoffmeisteri it has a peculiar free end (37, *g*), and in L. silvani it is flask-shaped (fig. 37, *h*).

[1] Stole figures the male apparatus of Ilyodrilus: the atrium appears spherical, and is surrounded by a layer of large cells, which Beddard would call the "prostate," resembling that of Stylaria, &c.

[2] Lophochæta resembles these two genera. Bothrioneuron presents several peculiarities in the male apparatus.

[3] As also in Bothrioneuron.

[4] In Lophochæta also.

Spirosperma ferox, Eisen.[1]

This worm has hitherto been found only in Sweden, and has been observed by Eisen alone.[2]

I have found specimens in the Thames and in the Cherwell.

It is readily recognised by the naked eye, owing to its grey colour, with a bright white clitellum occupying Segment XI, and extending into X and XII. The grey is sometimes less marked, apparently in immature specimens, which are greyish red. The grey colour is due to numerous closely set papillæ, of rather irregular form, usually irregularly rectangular, with long axis, as Eisen states, at right angles to the worm's length; but they are not "dark," as he says. They look dark by transmitted light, but if the surface is viewed by direct reflected light they are white, the dark colour being due to the feebly yellow globules in the papillæ.

The worm is six eighths of an inch long, and relatively thick anteriorly. The chief anatomical point is that the chætæ of the dorsal bundles throughout the body are capilliform, accompanied by, in most cases, extremely delicate webbed chætæ. These are rather stouter in the first half-dozen segments than posteriorly, but throughout they are less than half the thickness of the capilliforms (fig. 36, *c*, *d*).

The shape of these "webbed" chætæ is quite distinct from the multidentate, or even the webbed chætæ of Tubifex, or the palmate chætæ of Psammoryctes and Heterochæta, though they approach the latter.

The ventral chætæ are not all alike (fig. 36, *e*, *f*); they are all crotchets, but in the first six bundles the proximal prong is shorter than the distal prong (*f*). Behind the reverse is the case, and the proximal prong is extremely stout and strongly recurved (*e*), somewhat as in Psammoryctes, but more so.

The capilliform chætæ are usually four per bundle up to

[1] "Oligochætological Researches," 'Annual Report of the Commissioner of Fish and Fisheries for 1883,' Washington, 1885.

[2] Stolc has found it in Bohemia.

Segment x, behind which there are three per bundle. In Segments v and vi I noticed six per bundle.

The webbed chætæ are usually two, rarely three per bundle. The length of the latter is $\frac{8}{1000}$ mm., and of the capilliform chætæ $\frac{32}{1000}$ mm., though those of the Segments vi, vii, viii are $\frac{40}{1000}$ mm.

I have little to add to Eisen's description and figures. The body-wall is so opaque that it is difficult to see accurately the contained organs. By compressing the worm I released the genitals, which agreed almost exactly with Eisen's figures, except that the sperm-rope, of which I found only one in each spermatheca, is much less, and less regularly, coiled than he represents.

Note on Psammoryctes.

It is worth recording that a species which I, for the time, regard as Ps. barbatus, Vejd. (Tubifex umbellifer, Lankester), occurs in the Cherwell, in the mud amongst the roots of reeds. As far as I am aware it has not been recorded from a British locality since Professor Lankester[1] found it at Barking in brackish water.

The palmate chætæ (fig. 33, *a*), are rather different from those of Heterochæta, in that the "head" makes a slight angle with the "stalk," a fact which is not represented in Vejdovsky's nor in Lankester's drawings. It may, perhaps, be characteristic of a new species.

The ridges on the membrane are usually twelve or thirteen in number, and the head has the same curvature (fig. 33, *b*) as in Heterochæta. In existing drawings of these chætæ the outermost prongs are represented as stronger than the rest. This is not the case in my specimens. It is a matter of focussing, as in Heterochæta.

I figure also the ventral chætæ from different regions of the body. Those of the posterior segments (fig. 33, *e*) have a slightly different curve from that represented in existing figures. These, too, may turn out to be specific differences. But I will wait

[1] 'Annals and Mag. Nat. Hist.,' 4th ser., vol. vii, 1871.

till I obtain other specimens from Barking before giving a new name on these grounds.

I find no chætæ, either dorsally or ventrally, in Segment XI in mature worms.

In Segment X the ordinary ventral chætæ are replaced in mature forms by a single long rod-shaped chæta on each side, immediately in front of the pore of the spermatheca.[1]

I do not find the "dilatations" which Vejdovsky figures on the sperm-duct between atrium and penis so long as the duct is uninjured; when, however, it is separated from the body of the worm by pressure there is a variable number of dilatations, as in Heterochæta.

Note on Chætæ of Tubifex rivulorum.

Professor Lankester[2] was the first to record the existence of secondary prongs or teeth in the fork of the dorsal chætæ of this worm, and mentions a web passing between the two main prongs. I have not been able to detect this web, but have not had a very large series of specimens under observation for this purpose. I treated the chætæ in the usual way, i. e. I dissolved the worm, on a slide, in KHO, mounted the chætæ in glycerine, and examined them with a Zeiss's homogeneous immersion lens, but I was quite unsuccessful. It is not impossible that the specimens which Lankester examined belonged to Eisen's genus Ilyodrilus, in which such a membrane exists. But I have noted some peculiar modifications of these dorsal chætæ, which I figure in Pl. VII, fig. 34, *a*, *b*, *c*, *d*; one of the most curious of which is the occurrence in more than one case of a tooth outside the chief prong.

Stylodrilus Vejdovskyi, n. sp.

In a gathering made on July 17, just below Goring-on-Thames, I found a few small red worms about one third the

[1] Since writing this paper I have seen Dr. Antonin Stolc's memoir on Bohemian Tubificidæ, in which he figures this chæta, which is grooved distally, and is inserted in a sac into which a pair of glands open, close to the pore of the spermatheca.

[2] Loc. cit.

size of an ordinary Tubifex—namely, about an inch in length. I found these worms amongst the roots of the bur-reed, which I was examining for Criodrilus, and with them I found a specimen of Spirosperma. Hitherto only two species of Stylodrilus have been described: the first by Claparède,[1] St. heringianus; and the more recent species by Vejdovsky,[2] St. gabretæ. The differences—and these appear to me slight—between the two are such that had not Vejdovsky examined both species, one would be inclined to regard these differences as merely ones of observation. The specific characters of St. Vejdovskyi are as follows:

Prostomium conical, two and a half times as long as the buccal segment, and differing in shape from both that of the previous species (Pl. VII, fig. 42).

The segments, after the first three, are biannulated, the smaller annulus being anterior, as in St. heringianus. This annulus is very small in anterior segments, but behind the clitellum it is a third as large as the posterior annulus (Pl. VII, fig. 43).

The chætæ are essentially all alike; in the other two species some of the ventral ones are simple sigmoid, unnotched chætæ. In St. heringianus these are irregularly arranged, whilst in St. gabretæ they occur only in the pre-genital bundles. But in the present species, though with a low power some chætæ appear sigmoid, a high power reveals an indication of the notch; and the young, non-protruded chætæ are notched as markedly as in the dorsal and posterior ventral chætæ (fig. 44). In fact, these anterior ventral chætæ appear to have had the small upper tooth worn away.

In St. Vejdovskyi, then, all the chætæ are notched; and, like those of Lumbriculus, have the distal or upper tooth much smaller than the lower.

The dorsal vessel is not dilated in any segment; while in St. gabretæ there are dilatations in Segments VI and VII.

[1] Claparède, "Recherches sur les Oligochétes," 'Mém. Soc. Phys. et Hist. Nat. Genève,' xvi.

[2] 'System und Morph. d. Oligochaeten.'

The sperm-sacs are paired, and have the normal arrangement extending as far back as Segment XVI; there are three large eggs in XV, XVI, and XVII respectively (in one specimen one egg occupied the 16th and 17th segments).

The spermatheca lies in Segment IX entirely; in St. gabretæ it extends also into the next segment. I found no crystals, such as Claparède found, in the spermatheca of St. heringianus.

The characteristic penis differs from that of both the previous species in shape and size. In St. Vejdovskyi it has a length just a little greater than half the width of the body (fig. 43). It is not so narrow relatively as that of St. gabretæ; it is not so pointed as in St. heringianus. In normal position its free end is on a level with the chætæ of Segment XI.

The nephridia have a very peculiar arrangement. The first nephridial funnel lies in Segment VI, just in front of the posterior septum; the tube passes backwards with only slight undulations and coils as far as the middle of Segment X, and then returns alongside itself into Segment VII, where it opens externally in front of the ventral chætæ.

The second nephridial funnel lies in normal position in Segment XII; its external pore is in XIII, and the looped tube passes backwards as far as the hinder part of Segment XV.

The third funnel is in Segment XV, the nephridiopore in XVI, and the loop lies wholly in this segment. This is the normal condition for the following nephridia; but I observed one case in which the tube passed through two segments.

This condition of the nephridium is very similar to that described by Vejdovsky for Phreatothrix, and is unknown elsewhere amongst the Oligochæta. The structure of the nephridium agrees with Claparède's figures and description, although in that species he states (p. 265) that the first nephridium lies in Segment VII; that there are none in VIII, IX, X, XI, or XII, and that they reappear in XIII.

The length of St. Vejdovskyi is about an inch; none of my specimens exceeded this length. In colour they are bright red, with a tendency to orange; but the colour is much less

marked anteriorly and posteriorly, where it is dull pale yellow. They are very active little worms. I have found them not only in the Thames, but in the Cherwell, just above Oxford.

Nais elinguis, O. F. Müller.

In a gathering from a ditch in the immediate neighbourhood of Oxford I found, together with a number of specimens of Chætogaster diastrophus, Gruithuisen, some Naids showing zones of budding. A glance at the dorsal chætæ of these latter determined the species as N. elinguis.

It may be useful to recall the characteristic chætæ of this species. In addition to the long capilliform chætæ of the dorsal bundles (fig. 38, *a*), which commence on the 6th segment, there are short needle-like forms, and a third kind, a straight spear-like chæta notched at the free end, with a swelling or node on the stalk at about one third or one fourth from the free end. There are usually two capilliform, two or three short needles, and two notched spears. The ventral chætæ present no important characters (fig. 38, *b*). The blood is red, as in Paranais littoralis and other species.

These specimens were gathered on May 10th of this year (1891), and were then actively reproducing asexually. They were, after examination, placed in a greenhouse; and on the 26th of May, when I examined them again, most of them were sexually mature, whilst some were still showing zones of budding.

In these asexual forms I find generally that $n = 13$, according to Professor Bourne's use of the letter;[1] but one case I noted in which $n = 15$.

The sexual worms agree, in respect of the position of the organs, with Stylaria: that is to say, there is a pair of testes in Somite v, in which also are situated the spermathecæ; a pair of ovaries in Somite vi, in which are also placed the atria and their apertures.

The sperm-sacs have the arrangement shown in fig. 39;

[1] "Notes on Naidiform Oligochæta," this Journal, vol. xxxii, p. 335.

namely, a pair in Somite VI, and a long unpaired, asymmetrically placed sac extending through Segments VII, VIII, IX, and into X.

Masses of developing ova were observed in Somites VII, IX, XI, and a large ovum in Segment X.

I have thought it worth while to figure the arrangement, as Dr. Bourne gives a different position for the "testes" and "ovaries" for Paranais littoralis, which I was unfortunately unable to find in a mature condition. He figures a large, asymmetrically placed mass occupying Segments VIII and IX, which he speaks of as "testes," and he indicates as "ovary" a single mass of developing ova in Segment X. Now, this would be a very exceptional position for the gonads in the family Naididæ; and the "testis" of Oligochæta is not a large structure, but a small organ, occupying only a part of one segment. I cannot help thinking that Bourne has made a slip in writing of these structures as the gonads; he meant probably to speak of them as the sperm-sacs and ovisacs respectively.

It is a well-known fact that in the sexually mature Naid genital chætæ replace the ventral bundles in Segment VI, and that the dorsal chætæ, like the ventral ones, drop out, but are not replaced (fig. 40).

I figure a portion of a nearly mature worm, i. e. with sexual organs, in which the dorsal chætæ are still in situ. The ventral chætæ of one side are also present, but on the other side have been replaced by the genital chætæ (fig. 41). These are stouter and longer than the ordinary ventral chætæ, and are not forked (fig. 38, *c*).

The Supposed Constancy of *n* in a given Species of Naid.

In a recent contribution ('Quart. Journ. Micr. Sci.,' xxxii, Part 2, June) on the Naididæ, Professor A. G. Bourne adds many facts to our knowledge of the family, and gives the position of the zone of budding for many of the species, but says nothing about it for N. elinguis. He regards the position of the zone of budding as a constant character for

the various species, and designates this position by n, which signifies the number of segments in front of the zone.

Now, from my recent observations on this phenomenon, some of which were made before the publication of Professor Bourne's paper,[1] I believe that he is rather too dogmatic on this point; for he only mentions one exception, and that for Pristina breviseta, A. G. B., whereas I have found considerable divergences in the value of n from the value given by him. For example, a number of Stylaria lacustris, collected in different places and at different times, were examined from this point of view.

Dr. Bourne gives for this species "$n = 27$." I find, however, as will be seen from the following table, a good deal of variation in the position of the zone. The list refers to two sets of specimens, each individual being indicated by a letter.

A . . .	$n = 20$	F . . .	$n = 30$
B . . .	$n = 27$	G . . .	$n = 24$
C . . .	$n = 24$	H . . .	$n = 24$
D . . .	$n = 30$	J . . .	$n = 25$
E . . .	$n = 24$		

Six specimens were without zones.

In another lot—

K . . .	$n = 27$	N . . .	$n = 25$
L . . .	$n = 27$	O . . .	$n = 34$
M . . .	$n = 30$		

Three specimens showed no zone.

In all these cases I am counting as Professor Bourne counts; namely, the 1st setigerous segment is Segment II, so that the first dorsal bundle occurs in Segment VI.

Again, in Nais barbata he states, on p. 344, "$n = 17$." I examined a limited number of these, and found the number by no means restricted to 17. I have unfortunately mislaid my notes on the point, but four specimens, taken at random before I had seen his paper, were stained and mounted. Of these two have $n = 14$, and in the two others $n = 15$.

[1] Professor Lankester kindly allowed me to see a proof of the paper, and my attention was thereby drawn more particularly to some of these points.

EXPLANATION OF PLATES V, VI, and VII,

Illustrating Dr. W. Blaxland Benham's "Notes on some Aquatic Oligochæta."

Heterochæta costata.

Fig. 1.—The worm of the natural size.

Fig. 2.—A specimen coiled, about twice natural size.

Fig. 3.—Side view of worm, enlarged, showing the characteristic arrangement of chætæ. The segments are numbered and the annulations shown. *Pr.* Prostomium. *Dors.* Dorsal bundles. *Vent.* Ventral bundles. *Cten.* Palmate chætæ.

Fig. 4.—One of the characteristic palmate chætæ from in front.

Fig. 5.—The "head" of a palmate chæta, more enlarged and in a different focus, showing now the apparently stronger outer prongs.

Fig. 6.—A palmate chæta from the side, to show curvature of head.

Fig. 7.—View of the free edge of a palmate chæta, showing curve, membrane, and ridges.

Fig. 8.—A palmate chæta seen obliquely from above, to suggest Claparède's possible mistake in describing these chætæ as "cup-shaped."

Fig. 9.—An abnormal palmate chæta, with ridges feebly marked.

Fig. 10.—A furcate chæta from the dorsal bundle of Segment III.

Fig. 11.—A chæta from a dorsal bundle behind Segment XV.

Fig. 12.—The free end of a furcate chæta from ventral bundle of Segment IV.

Fig. 13.—The free end of a chæta from a ventral bundle of a more posterior segment to show the recurved proximal prong.

Fig. 14.—The "head" of a furcate chæta from in front, the transverse ridge being the lower or proximal prong.

Fig. 15.—An abnormal chæta, with two teeth between the chief prongs, from dorsal bundle of Segment XIV of a certain specimen.

Fig. 15*a*.—The dorsal bundle of Segment XIV, showing the abnormal multidentate chæta (which is drawn too large, relative to the normal ones).

Fig. 16.—Dorsal view of anterior end of a worm, showing abnormal arrangement of chætæ (see p. 194).

Fig. 17.—A few segments of the worm viewed ventrally by transparency,

showing arrangement of organs. Drawn from a sketch of a living specimen slightly compressed. Portions of body-wall are represented showing the pores of sperm-ducts and spermathecæ.

Fig. 18.—The male duct isolated by compression. *Sp. f.* Spermiducal funnel. *Sept.* Septum between Segments x and xi. *Sp. d.* Sperm-duct. *gl. atr.* Glandular region of atrium. *n. gl. atr.* Non-glandular region of atrium. The extent of cilia is shown. The chitinous coat of the penis is represented in black outline.

Fig. 19.—A spermiducal funnel, with lips partly closed during movement of worm.

Fig. 20.—Two atria, isolated by compression, in order to show the artificial character of the dilatations of atrium. *sp. d.* Sperm-duct. *prost.* Prostate. *gl. at.* Glandular region of atrium. *n. gl. at.* Non-glandular region of atrium.

Fig. 21.—Enlarged view of penis from living worm, slightly compressed. The drawing is sufficiently explained. *a*, *b*, point to the circumpenial and pre-penial regions of penial chamber lined by invaginated cuticle. *v. ch.* Ventral chætæ.

Fig. 22.—Longitudinal section through penis, to show character of the cells of this region. *a.* Circumpenial; and *b*, pre-penial portions of penial chamber. *ch. pe.* Chitinous coat of penis, which is continuous with cuticle lining penial chamber. *ep. b.* Epidermis. *atr.* Portions of atrium.

Fig. 23.—Longitudinal section through portions of atrium and prostate. *c. ep.* Cœlomic epithelium covering prostate, sperm-duct, &c. *ep.* Epithelium lining the non-glandular part of atrium (*n. gl. atr.*). *ep'.* Epithelium lining the glandular part of atrium (*gl. atr.*). *mus.* Muscular coat of atrium. *pro.* Prostate. *sept.* Septum between Segments xi and xii. *sp. d.*, *sp. d'.* Transverse and longitudinal sections of sperm-duct.

Fig. 24.—A cell from prostate enlarged. *vac.* Vacuole.

Fig. 25.—A cell from epithelium of glandular part of atrium.

Fig. 26.—Section through spermathecal pore and neighbouring part of the the organ. *ep.* Epithelium of spermatheca (the internal boundaries of the cells have been made too definite). *ep'.* Epithelium of neck. *ep. b.* Epidermis. *c. ep.* Cœlomic epithelium. *mus.* Muscular coat. *p.* Spermathecal pore.

Fig. 27.—A cell from epithelium of neck of spermatheca.

Fig. 28.—A sperm-rope.

Fig. 29.—A portion of sperm-rope, more highly magnified. *a.* Very highly refracting wall, with heads of spermatozoa. *b.* Layer of granules within. *c.* Mass of spermatozoa in cavity. *d.* Tails of those spermatozoa whose heads are embedded in *a*.

Fig. 30.—Portions of crushed sperm-rope, the wall of which has burst, and spermatozoa from within are escaping. *a*, *b*, *c*, as in Fig. 29.

FIG. 31.—A transverse section of a sperm-rope, from a series of longitudinal sections of the worm. *a*, *b*, *c*, *d*, as in Fig. 29.

FIG. 32.—View of genital segments of a spent worm, seen by transparency. Drawn from living specimen. *D. v.* Dorsal vessel (the dilatation is not a permanent feature, it merely represents a diastole of the vessel). *G.* Intestine. *ov.* Ovary. *sp. s.* Shrunken sperm-sac, with convoluted blood-vessel on its wall. *spth.* Degenerating spermatheca. *t.* Testis. *v. v.* Ventral blood-vessel.

FIG. 33.—Diagrammatic side view of Psammoryctes, to show arrangement of chætæ.

FIG. 33*a*.—A palmate chæta from dorsal bundle of anterior segments, seen from in front.

FIG. 33*b*.—Same in optical longitudinal section to show curvature of free edge.

FIG. 33*c*.—A multidentate chæta from dorsal bundle.

FIG. 33*d*.—A forked chæta from ventral bundle, anteriorly.

FIG. 33*e*.—A forked chæta from ventral bundle, posteriorly.

FIG. 34.—Diagrammatic side view of Tubifex.

FIG. 34 *a*, *b*, *c*, *d*.—Multidentate chætæ from anterior segments, dorsal bundle, after treatment of the worm with KHO and mounting in glycerine. *b* is a young chæta; the others were in use.

FIG. 35.—A diagrammatic side view of Limnodrilus, Clitellio, and Hemitubifex.

FIG. 35*a*.—A dorsal chæta.

FIG. 36.—A diagrammatic side view of Spirosperma and Ilyodrilus Perrieri.

FIG. 36*a*.—Chæta from dorsal bundle of Ilyodrilus Perrieri.

FIG. 36*b*.—Ditto from other species.

FIG. 36*c*.—Palmate chæta from dorsal bundle of 3rd segment of Spirosperma.

FIG. 36*d*.—Palmate chæta from hinder segments. Same magnification (the lines are too coarse).

FIG. 36*e*.—A ventral chæta.

FIG. 36*f*.—A ventral chæta from one of the anterior six segments.

FIG. 37.—Outlines of chitinous coat of penis of various genera, after Claparède, Eisen, and Vejdovsky. *a*. Hemitubifex. *b*. Telmatodrilus. *c*. Psammoryctes and Spirosperma. *d*. Limnodrilus corallinus. *e*. L. igneus. *f*. L. alpestris. *g*. L. Hoffmeisteri. *h*. L. silvani.

Nais elinguis.

FIG. 38.—The chætæ. *a*. Of dorsal bundle. *b*. A ventral chæta. *c*. A genital chæta.

FIG. 39.—View of genital region from above by transparency (from a living worm compressed). *o*, *o*, *o*. Masses of ova at different stages of development which have dropped away from the ovary. *sp. sac*. Sperm-sac. *spth*. Spermatheca. *ne*. Nephridium.

FIG. 40.—Ventral view of anterior region of sexually mature worm, showing position of clitellum and the genital chætæ (*gen. ch.*). *d*. Dorsal chætæ. *v*. Ordinary ventral chætæ.

FIG. 41.—View of a nearly mature specimen, rather from the side, showing presence of genital chætæ (*gen. ch.*) on one side only. *d*. The still persistent dorsal chætæ of Segment VI. *v*. The still persistent ventral chætæ of the same segment on one side.

Stylodrilus Vejdovskyi.

FIG. 42.—Ventral view of head. *Pr*. Prostomium.

FIG. 43.—Ventral view of Segments X and XI, to show penis and annulation (*a*, *b*) of the segment. *v*. Ventral chætæ.

FIG. 44.—Chætæ. *a*. From post-genital region, ventral or dorsal. *b*. Pregenital ventral bundles.

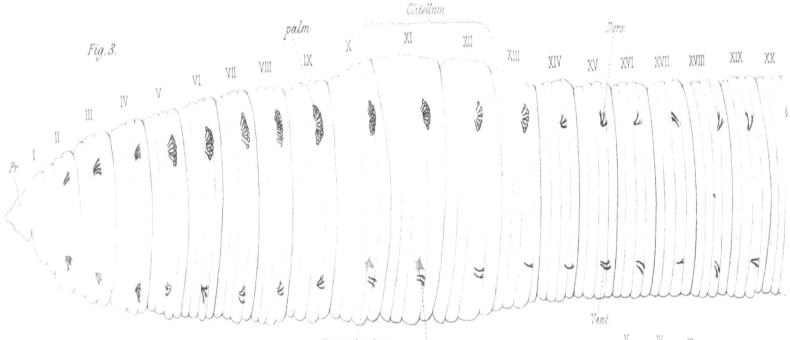


Fig. 3.
Clitellum
palm.
Dors.
Pr.
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
Vent.
Spermatheca pore.
Spermatical pore.


Fig. 16.
V
IV
III
II
I
Pro.

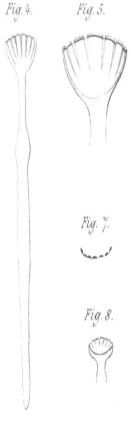


Fig. 4.
Fig. 5.


Fig. 10.
Dorsal III.


Fig. 11.
Dorsal posterior.


Fig. 1.
nat. size.

Fig. 7.

Fig. 8.


Fig. 2.


Fig. 6.


Fig. 9.


Fig. 12.
Ventral IV.


Fig. 13.
Ventral posterior.


Fig. 14.


Fig. 15.


Fig. 15a.

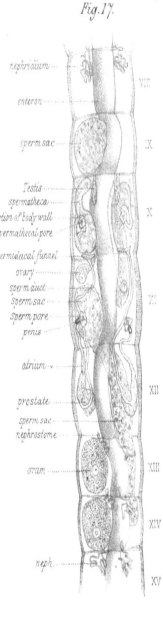


Fig. 17.
nephridium
ovisac
sperm.sac
Testis
spermatheca
portion of body-wall
spermatheca pore
spermatical funnel
ovary
sperm.duct
Sperm.sac
Sperm.pore
penis
atrium
prostate
sperm.sac
raphidistome
gram
neph.
VIII
IX
X
XI
XII
XIII
XIV
XV

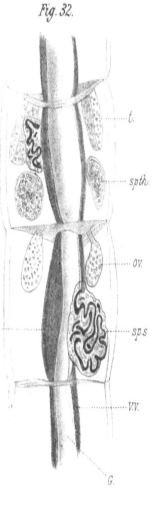
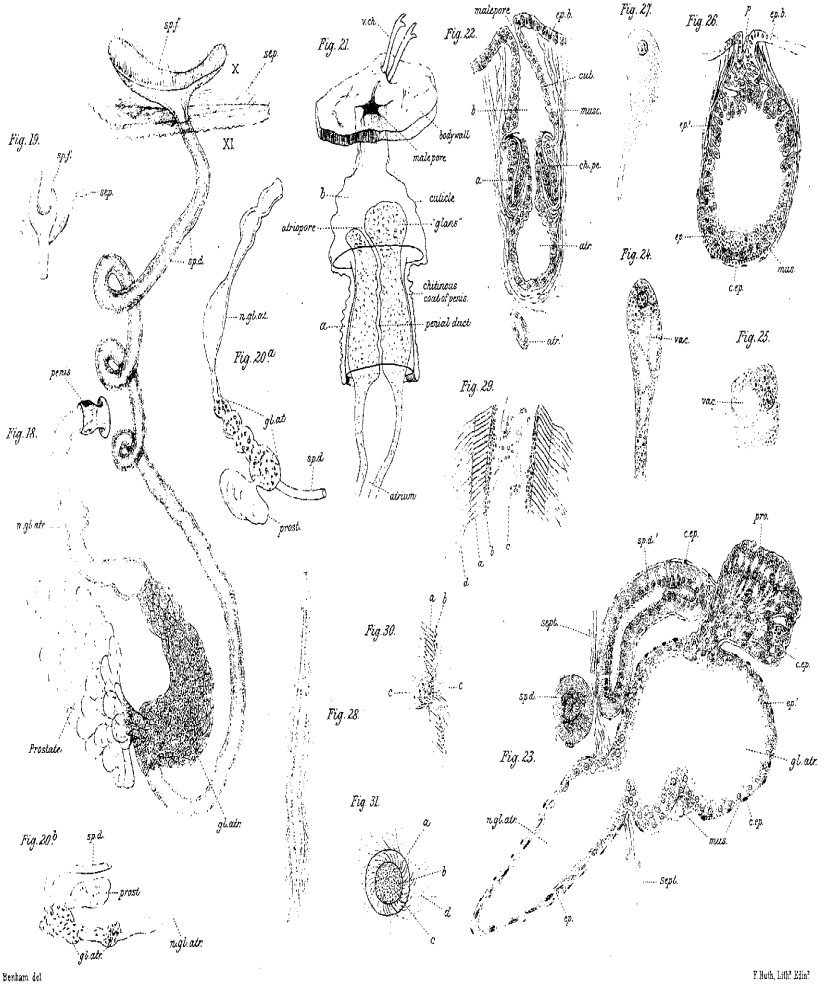


Fig. 32.
X
XI
Dv.
t.
spth.
ov.
sp.s
VV.
G.



Benham del.

P. Huth, Lith.r Edin.r


Fig. 36.
I II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII XVIII XIX
Ilyodrilus perrieri & Spirosperma.

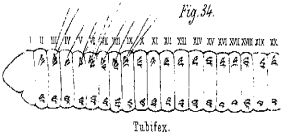


Fig. 34.
Tubifex.

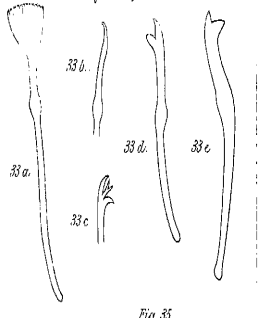

33 a.
33 b.
33 c
33 d.
33 e
34 a
34 b.
34 c
34 d.


Fig. 35.
I II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII XVIII XIX XX
Limnodrilus, Clitellio, Hemitubifex.

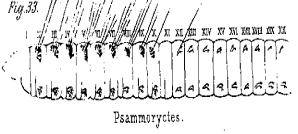
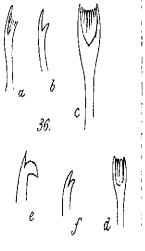
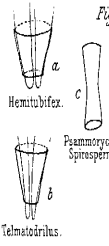


Fig. 33.
Psammoryctes.


a
b
c
36.
e
f
d


a
Hemitubifex.
b
Telmatodrilus.

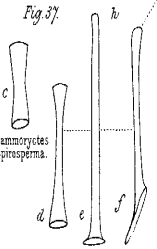
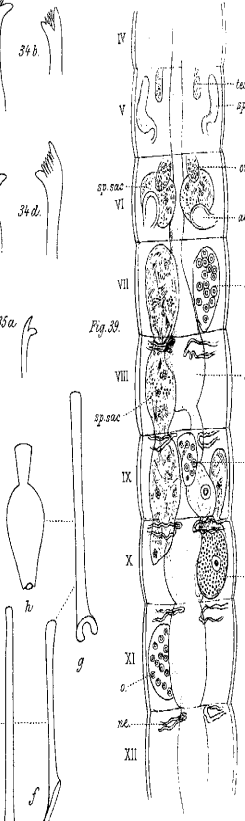


Fig. 37.
c
Psammoryctes Spirosperma.
d
e
f


IV
V
testis
sp.th.
sp.sac
VI
ovary
atrium
VII
o.
Fig. 39.
VIII
stomach
sp.sac
IX
o.
X
o
XI
o.
ne.
XII

35a.
h
g

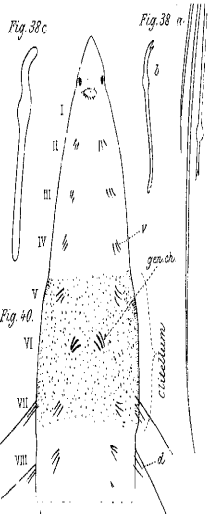


Fig. 38 c
Fig. 38 a
b
I
II
III
IV
V
gen.ch.
Fig. 40.
VI
VII
VIII
a
caudum

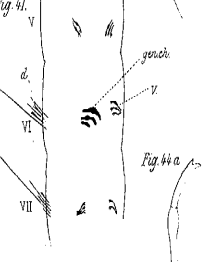


Fig. 41.
V
gen.ch.
d.
V
VI
VII

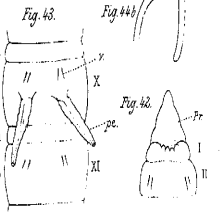


Fig. 44 a
Fig. 43.
Fig. 44 b
a.
b
a
b
X
XI
pe.
Fig. 42.
Pr.
I
II