PART XI.

REPORT

OF

THE COMMISSIONER

FOR

1883.

A.—INQUIRY INTO THE DECREASE OF FOOD-FISHES.
B.—THE PROPAGATION OF FOOD-FISHES IN THE WATERS OF THE UNITED STATES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1885.

XX.—OLIGOCHÆTOLOGICAL RESEARCHES.

By Gustav Eisen.

INTRODUCTION.

In the beginning of the present year (1879) I had the honor to present to the Academy of Sciences of San Francisco, Cal., and also to the Royal Academy of Sciences of Stockholm, Sweden, preliminary reports on the same subject of which I now propose to treat more extensively. Neither of these reports, however, is as yet published, and this will explain why in the following no mention of them has been made, and no citations from them quoted.

The theories advanced in them I have had little opportunity to change. Only in few instances have further investigation and access to a greater number of specimens necessitated any material modification of my former views, and whenever any such change has been made, I have always called special attention to the same.

My investigations have been confined principally to the characterizing of the species and to the anatomical structure of the generative organs. The following treatise, therefore, has no pretension to being exhaustive, even if such a word could properly be applied to any work in natural science; but, on the contrary, I must freely confess that many an important point pertaining to this subject has here been only lightly touched, or even not at all enlarged upon—mostly the result of a limited time and library.

The many new forms here described for the first time may perhaps to some degree compensate for the above defect, and, as I trust, call a more general attention among zoologists to the fresh-water oligochæta —a class which, I am sure, will in the near future be found to contain thousands of forms.

My field of investigation has been limited to Sweden and California, and in both countries to comparatively few localities.

In the following I propose first to give a description of all the species found by me, and afterwards to treat more minutely of some points in their anatomy and physiology.

A.—DESCRIPTION OF THE SPECIES OF TUBIFICIDÆ.

Oligochætous, limicolide worms, with spines in fascicles, of which four in each segment. One ventral and one dorsal longitudinal vessel, the latter of which is pulsating. Both vessels are connected by transversal gastric or perigastric vessels. Receptacles of the spermatozoa, two in the ninth setigerous segment. Efferent ducts, two in the tenth setigerous segment. Each duct furnished with only one efferent funnel. The oviduct is invaginated by the penis. Habitat: Fresh or brackish water. Two subfamilies, viz:

Telmatodrilini: Atrium furnished with several prostata glands; penis and penis sheath united at apex.

Tubificini: Atrium with a single prostata gland; penis and penis sheath not united.

I.—*Sub-fam.* TELMATODRILINI, *nov. fam.*

Atrium is surrounded with several prostata glands, not connected with each other.

The penis is connected with the penis sheath at its exterior apex.

Oviduct is large, muscular, and opaque.

The receptacle is situated in the ninth and the efferent duct in the tenth setigerous segment.

Nervous system.—The two longitudinal parts of the ventral nerve trunk are connected by anastomosing, minute commissures.

The spines resemble those of *Enchytræidæ* in general form, but are more numerous in every fascicle and all of the same length. In young specimens they are indistinctly forked.

Of this family as yet only one species and genus is known, viz:

Gen. TELMATODRILUS *nov. gen.*

No distinctly pulsating or differentiated hearts, but the secondary vessels in the sixth to tenth setigerous segments are indistinctly pulsating, without having the shape of distinct hearts. The ventral vessel is not strictly ventral, but pushed towards the dorsal side of the body, and so near to the dorsal vessel that both seem to run close together; the ventral vessel not pulsating, the dorsal vessel pulsating.

Only one species is as yet known, viz:

TELMATODRILUS VEJDOVSKYI *nov. sp.*

(Pls. I and II; Figs. 1*a* to *k*.)

Vascular system.—The ventral vessel is forked in the fourth setigerous segment. The transversal or secondary vessels are of two kinds in every segment, viz, gastric and perigastric. The perigastric vessel is situated close to the posterior end of the segment; it sends to the integument of the body numerous minor tertiary vessels, forming together

a dense dermal vascular net. The gastric vessel embraces the alimentary canal at the middle of each segment; its many minute, tertiary side branches form a dense gastric vascular net.

The perigastric vessels in the sixth to tenth setigerous segments form a kind of weakly pulsating heart, however without being distinctly differentiated. The largest pair is found in the tenth setigerous segment, the smallest in the sixth segment. The perigastric vessels forming the hearts are extremely long and relatively narrow, being thickest near the dorsal vessel, and from there gradually decreasing in size towards the ventral vessel. The blood is yellowish red.

Nervous system.—The cerebral ganglion is very unlike that of *Tubificini;* nor does it in fact resemble that of any other known *Limicolide.* Its general shape is somewhat triangular, furnished with a large posterior projection. Its sides are concave, with two anterior projections towards the cephalic lobe. The ventral ganglion emits one pair of nerves in each segment; its swelling in each segment is inconsiderable.

Gastric system resembles that of *Tubificini* to a great extent. The œsophagus is long and narrow, extending to the eleventh segment; is from here considerably elongated and forming the commencement of the intestine, which is here hyaline, not furnished with hepatic cells. In the fifteenth segment the canal contracts considerably, and is from here to the end of the body covered with dark brown, glandular, hepatic cells.

Generative system.—Efferent duct, atrium, and penis are well characterized. The efferent duct is unusually narrow; its interior end is gradually increasing in size, forming a pear-shaped funnel. A bundle of spermatozoa is often found in its opening, considerably protruding, as is the case in *Enchytræidæ.* The atrium is crescent-shaped, cylindrical, and furnished with a set of about ten or more globular and well-defined prostate glands, surrounding the atrium on all sides. Both atrium and penis consist of two different layers. The prostate glands and also the efferent duct are apparently developed from the interior one of these layers. This explains why the atrium in *Tubificidæ* is "double," as it has been described by Claparède,* Udekem and others (Pl. I, Fig. 1*e*). This exterior coat of the atrium was originally only a continuation of the oviduct, and is so yet in the younger stages of the worm. (About this see further ahead in this paper.)

The penis is large, its upper part being of somewhat the same shape as the atrium. Its lower end is first somewhat swelled and afterwards immediately tapering, forming a real external penis. This external part of the penis is furnished with a funnel-shaped penis sheath (Fig. 1*c*, p. sh.). But, contrary to what is the case in *Tubificini*, this sheath is connected with the apex of the penis. The same is the case with the penis sheath in undeveloped specimens of *Tubificini*, but as the worm develops is the sheath wholly separated from the apex (Fig. 18 *c*, *d*, *g*, *h*). The penis consists of two layers; the interior one is a continuation of the inner-

* *Recherches Anotomiques*, p. 23, and others.

most layers of the atrium. The exterior one, of the second layer of atrium. The third layer of the atrium is not in continuation with the layers of the penis. The penis sheath is very pellucid, and difficult to discover; especially so is its upper margin. Its lower interior sides are covered with numerous diagonal muscles, one end of which is attached to the body of the penis. In the center of both atrium and penis is found a continuous row of spermatozoa. The penis is only external in fully matured specimens.

The oviduct consists of a heavy muscular coating or sack, one end of which is attached to the body wall, the other free in the neighborhood of the lower end of the atrium. This oviduct is extremely heavy which makes it often impossible to discover the nature of the organ covered by the same.

The testes consist of two oblong amorphous bags, situated in the eighth and ninth setigerous segments, one on each side of the ventral nerve.

The ovaries consist of two rounded, sack-like bodies, situated between the ninth and tenth segments, their anterior ends being attached to the body wall of the ninth segment and part of their body to the dissepiment between the ninth and tenth setigerous segments. The ripe ova are always found in the broadest end of the ovary, the smallest or least developed ones in the narrowest part of the same (Fig. 1*g*).

The receptacle consists of two minute oblong sacks, one on each side of the ventral nerve in the ninth setigerous segment. Their exterior porus is found on the body wall between and somewhat in front of the ventral fascicles, not in front of one of them, as in *Tubeficini*.

No spermatophores are found in this species, the spermatozoa being simply agglomerated together in pear-shaped or globular balls. In the atrium they form a continuous row in the middle of the inmost cavity (Fig. 1*e*, spz).

The segmental organs resemble those of *Tubificini* in their general structure. The whole tube of the organ is surrounded by large pellucid cells, sometimes of a globular, sometimes of a more oblong shape (Fig. 1*h*). In the majority of these a large nucleus is plainly visible. The above cells are found not only surrounding the segmental organs in front of the efferent duct, but also on those behind the same.

The exterior aperture of the organ is the largest one, and from here the tube tapers gradually towards the interior aperture, at the lower end of which is found two sack-like appendices. The aperture is strongly ciliated (Fig. 1*i*).

The integument of the body is very thick, and the body accordingly not very flexible. The worm, when found, therefore, resembles more a small pointed stick or straw, the tail being the most flexible part of the animal. In this respect this worm is unlike most of the other species of *Tubificidæ*, which, with few exceptions, are lively and very movable animals.

Body.—The length of the same in alive specimens is generally from 35^{mm} to 50^{mm}, and the width between 1^{mm} and 2^{mm}. The anterior part

is the thickest, the body gradually tapering towards the posterior end. The color of the body is fleshy, brownish red, rather opaque, with the vascular system plainly visible.

Setæ are found, as usual, in the family, in four fascicles in every segment, every fascicle containing numerous, or from eight to fifteen, spines. These are in adult specimens entire, considerably curved, and, generally speaking, not unlike those found in *Enchytræidæ*. In young specimens the spines are found to be indistinctly forked (Fig. 1*d*).

Habitat.—California, Sierra Nevada, in Fresno and Tulare Counties, at an altitude of from 6,000 to 10,000 feet.

It lives in the marshy meadows, and is sometimes found in decaying wood, sometimes again in the bottom mud, most frequently where the water is very shallow. In small hollows, where manure has been deposited, this worm is most certain to be found; in poor ground it will, with certainty, be looked for in vain.

This worm is decidedly of a nightly habit. In day-time it is never found above the ground, but in night-time its tail is always seen protruding in the water above the same.

Adult specimens found in August and later.

II.—*Sub-fam.* TUBIFICINI.

KEY TO THE GENERA.

I.—More than one kind of spines present, viz, hair spines, comb-like spines, and forked spines, two of which kinds are always present (except Hemitubifex.)

A. The cephalic ganglion anteriorly furnished with a large conical processus. Spermatophores extremely long and spirally coiled. Oviduct single.

SPIROSPERMA.

B. The cephalic ganglion is not furnished with an anterior processus. Spermatophores short and broad, not spiral.

a. The efferent duct is comparatively short and broad, not longer than the atrium and copulative organs together.

ILYODRILUS.

b The efferent duct is comparatively long and narrow, always longer than the atrium and copulative organs together.

1. The base of the receptacle is furnished with glands. Efferent duct or atrium furnished with *a* (*a* and *c*) "vesicula seminalis." Hair spines and forked spines, but the former not always present. No comb-like spines. The middle part of atrium is glandular.

HEMITUBIFEX.

2. The base of the receptacle is not furnished with glands; a "vesicula seminalis" present. The middle part of the atrium not glandular. Three kinds of spines always present.

PSAMMORYCTES.

3. The base of the receptacles not furnished with glands. No "vesicula seminalis." Two kinds of spines always present, viz, hair spines and forked spines.

TUBIFEX.

II.—Only one kind of spines, viz, forked spines.

1. Penis and oviducts not surrounded by spiral muscles.

LIMNODRILUS.

2. Penis and oviduct surrounded by spiral muscles.

CAMPTODRILUS.

Gen. SPIROSPERMA *nov. gen.*

(Pl. II and III; Fig. *a* to *g*.)

The cephalic gangloin is furnished with a large conical frontal processus, which does not branch itself in the cephalic lobe.

The posterior margin is concave.

The spermatophores are long, narrow, and spirally coiled.

The spines are of three kinds, viz, hair spines, forked spines, comb-like spines.

The integument is covered with dark, convex papillæ.

The whole of the atrium is glandular, no vesicula seminalis, and no glands at the base of the receptacle. Of the forked spines we can in reality distinguish four varieties, with from two to four prongs. This genus is one of the best characterized in the family. As yet only one species known, viz:

SPIROSPERMA FEROX, *n. sp.*

Nervous system.—The cephalic ganglion is cordate, conical in front, emarginated behind. The conical part is about as long as the rest of the ganglion. The posterior side-lobes are well rounded. The ganglionic cells are comparatively numerous and closely packed. (*Fig.* 2 *g*.)

Generative system.—The efferent duct is long and narrow, resembling that of other genera except *Ilyodrilus*. The atrium is crescent-shaped, its lower end long and narrow, and in some specimens terminating in a helix-like swelling, situated immediately at the upper end of the penis proper (*Fig.* 2*h*, *h. s.*). Penis proper has the form of a long and broad cylinder, somewhat contracted at the middle, and with the lower end terminating blunt. The upper half of the penis is surrounded by a chitinous penis sheath, the upper and lower openings of which are nearly of the same size. That part of the penis which is covered by the sheath is of different structure than the lower free part. While the former seems to be merely an unmodified part of the atrium proper, and consisting of numerous small, massed cells, the latter, on the contrary, is found to consist of very large, often angular cells, more regularly arranged. The oviduct consists of a large, narrow-walled tube, or rather sack, as it seems more muscular than chitinous, inclosing the penis and its sheath to their whole length. Exteriorly the oviduct is surrounded by longitudinal muscles, connecting the same to the body wall (*Fig.* 2*h*, msc.). The receptacles are of an enormous size, extending through

several segments. Its main vesicle is oblong and sack-like, supported on a stem of its own length. The receptacle contains a few (two to three) spermatophores of unusual form and size. The latter can nearest be compared with the tongue of a moth, when coiled in a spiral. It is nearly cylindrical, slightly thicker at the middle, with both ends considerably tapering and pointed (*Fig.* 2*i*). When more highly magnified it is seen to be divided in large diagonal segments of nearly equal size (*Fig.* 2*k*). The tails of the spermatozoa are seen to be protruding all along the upper third of the whole length of the spermatophore, the other two-thirds being perfectly smooth (*Fig.* 2*i*). The ovaries are large, oblong bodies, with the ripe ova situated at the free extremity. The interior of the ovary contains undeveloped ova of different sizes, mixed. The smallest ones are not always found nearest the point of attachment to the dissipiment (*Fig.* 2*f*).

Segmental organs consist of long and narrow tubes, not covered with any globular cells. At different places we find the tube enlarged, forming large more or less circular chambers, which, however, are not further differentiated (Fig. 2*g**). Such chambers I have also found in the segmental organs of several species of *Limnodrilus*. If they are temporary or constant is difficult to decide upon.

The integument of the body is covered with numerous minute, oblong, and elevated papillæ, which seen by the microscope, present a dark, opaque appearance (Figs. 2*c* and 2*d*). They are absent in the tenth setigerous segment, which contains the efferent duct, &c. The longitudinal axes of the glands are all running in the direction of the width of the body. Somewhat similar papillæ are found in *Enchytræidæ*, but I have observed them nowhere else in this family.

The spines are of six different kinds, viz, hair spines, comb-like spines, and four kinds of forked spines. The hair spines occur in numbers of three to five all along the upper side of the body, and mostly alternating with the comb-like ones, at least in the segments anterior to the cingulum. The prongs of the comb-like or fan-shaped spines are very little separated, and the membrane forming the comb or fan between them very pellucid and often difficult to discern (Figs. 2*l* and 2*m*). The forked spines are of two principal kinds: *a*, spines behind the cingulum, and partly even in front of the same, have the lower prong much broader and longer than the upper one, and the angle between the same nearly a right one (Fig. 2*o*; *b*, the spines in front of the cingulum have the upper prong much longer and even somewhat broader than the lower one. The lower prong is sometimes single, but more often double or even triple (Fig. 2*n**, 2*n*, 2*p*). Similar spines are not found in any other species of the family.

The length of the body, about 15^{mm}, by 1^{mm} wide. The front part of the body is the thickest, and from here it tapers considerably and gradually toward the posterior end. Only the very frontal segments are

Fig. 2*g* at * shows one of those chambers in optical section.

tapering. The tenth segment is thicker than any other two segments, and forms a well defined-cingulum in adult specimens.

Habitat.—Europe, Sweden: Motala River, in shallow water, together with *Hemitubifex* and *Lumbriculus*. Professor W. Lilljeborg has also kindly communicated specimens taken in Ifö Lake, in Scania; here, however, found at a depth of 25 fathoms.

The specimens from both places were pretty much alike, except in regard to the helix-like swelling of the atrium, which was absent in the specimens from Ifo.

It may be possible that a worm described by Kessler,* under the name of *Nais papillosa*, is identical with our present species. The length of the body and the "*papillæ*" are similar in both species. Kessler's description is, however, so insufficient that nothing can be decided with any degree of certainty, except by autopsy. External characteristics are in no way sufficient to distinguish one species from the other, and have only a relative value as a help in classifying and arranging the specimens in a collection, when it oftentimes is of the highest importance that said work can be done quickly and without destruction or mutilation of the specimens.

Gen. ILYODRILUS *nov. gen.*

The *cephalic ganglion* emarginated both in front and behind.

The *efferent duct* is, compared with the same duct in other genera of the family, short and broad. Its length does never exceed the length of the atrium and penis together. The whole of the atrium is glandular and its lower end is comparatively broad and short. No vesicula seminalis. No glands at the base of the receptacle. No spermatophores. The oviduct is funnel-shaped, the upper end being the widest. The *spines* are of three kinds, viz, hair-spines, comb or fan-like spines, and forked spines. The gap between the prongs of the fan-like spines is comparatively narrow, and the striated membrane between the prongs not always present. In other respects this genus resembles *Tubifex* and *Psammoryctes*. The form of the efferent duct is the most prominent characteristic of the genus.

Only three species are as yet found, and which may easily be classified as follows:

1. True comb-like spines present. The receptacle is bent; oviduct is double; cephalic ganglion about as broad as long.

   IL. PERRIERII.

2. Pseudo comb-like spines. The receptacle is bent; oviduct is single; cephalic ganglion is broader than long.

   IL. SODALIS.

3. Pseudo comb-like spines. The receptacle is not bent, but globular and inflated; cephalic ganglion about as broad as long; oviduct is single.

   IL. FRAGILIS.

---

* Beiträge zu der Abhandl. der Petersburger Nat.-forsh. Versaml. 1868, pp. 103 to 108. Leuckarts Bericht, 1871.

The pseudo comb-like spines are similar to the comb or fan-shaped ones, but the membrane, between the prongs, is absent. It is evident that the comb-like and pseudo comb-like spines are only modifications, one of the other. To the simply forked spines they are not closely related.

Ilyodrilus Perrierii *n. sp.*

The cephalic ganglion is about as broad as long, and its anterior end is not broader than the posterior one (Fig. 3*d*).

The efferent duct is shorter than the atrium and penis together, but nearly of the same length as the atrium alone. The penis has no chitinous sheath, is very short and conical, and pointed, gradually tapering towards the apex. The oviduct is double, the interior one being chitinous, extended, funnel-shaped and somewhat bent, gradually tapering towards the exterior porus (Figs. 3*e* and 3*f*). The exterior oviduct is inflated, sack-like, very broad at its base, and from here irregularly tapering towards the exterior apex. It is surrounded by numerous longitudinal muscles, which are connected with the body wall (Fig. 3*e*).

The receptacle is bent, its top being sack-like and not globular (Fig. 3*g*); no spermatophores. The ovaries form two large bodies in the tenth setigerous segment. The testes are comparatively small in the three first segments behind the cingulum, or in the eleventh, twelfth, and thirteenth setigerous segments.

The integument is darker and thicker than in the following species. The membrane between the prongs of the comb-like spines is very pellucid and difficult to perceive. Both prongs are bent in the same direction. The comb-like and hair spines are found all along the upper side of the body (Figs. 3 *h*; 3 *i*; 3 *k*). The integument is flesh-colored.

Length of the body, 10^{mm} to 12^{mm}; width of the same about 1^{mm}. The anterior part is considerably the thickest, and from here the body tapers gradually towards the posterior end (Figs. 3 *a*; 3 *C*; 3 *c*).

Habitat.—Fresno County, California, in irrigation ditches sparingly. In ponds in King's River more frequently met with. I have never found this species much above the level of the prairie, or about 300 feet above the sea.

This species is easily recognized by the thickness of the anterior part of its body.

Ilyodrilus Sodalis *n. sp.*

Nervous system.—The cephalic ganglion is much broader than long, the posterior margin being lined with several (6) ganglionic swellings, of which the two on each side are globular. The two middle ones are oval or conical, constituting the posterior apex of the ganglion (Fig. 5 *C*).

Vascular system.—No differentiated pulsating hearts, only indistinctly or weakly pulsating perigastric vessels, beginning in the ninth setigerous segment and extending towards the cephalic lobe, one pair in every segment; but the nearer the cephalic lobe the smaller are the vessels

and the weaker the pulsations. No dermal vascular system. The gastric secondary vessels are rectilinear. One perigastric and one gastric vessel in every segment. The perigastric vessel is branched, and situated behind the latter near the posterior margin of the segment.

Generative system.—The efferent duct is about one and a half times longer than the atrium and copulative organs together; its width is about the same as in the other species of this genus (Fig. 5 *g*). Atrium is very short and broad, nearly crescent-shaped (Fig. 5 *g*), and the apex of the penis is globular and very much larger than its base. No penis sheath. The oviduct is single, bell or cone like, the lower or exterior end being the widest. The whole organ is full of small spiculæ, somewhat similar to those found in the same organ of *Psammoryctes umbellifer.** The testes are situated in the 10 setigerous segments, beginning in the twelfth and extending to the twenty-second setigerous segment. The ovaries are found in the nineteenth to the twenty-second segment, entirely covered by the testes. The receptacle (Fig. 5 *h*) is somewhat irregular, has two main sack-like lobes, supported on a short narrow stem, at the base of which is found a comparatively large accessory gland (Fig. 5 *h*, gl.).

Numerous perigastric cells of a circular form, and containing numerous globules. The spines are of three kinds, viz, hair spines, forked spines, and pseudo comb like spines, the latter with no membrane between the prongs. The prongs themselves, however, have their inner surface striated (Figs. 5 *e* and 5 *f*).

Similar or nearly similar spines are found in *Ilyodrilus fragilis*. The forked are somewhat similar to the above, but the prongs are not serrated (Fig. 5*c* and 5*d*).

The length of the body is about 25^{mm}; the width of the same about 1^{mm} or more. The integument is reddish-flesh colored.

Habitat.—California, San Francisco, in a spring emptying into the Marine Hospital lake. I have not found the worm in the lake itself.

Ilyodrilus sodalis is a very distinct species, characterized by its cephalic ganglion, receptacle, efferent duct, and pseudo comb-like spines. Its copulative organs are extremely pellucid.

Ilyodrilus Fragilis *n. sp.*

(Pl. V; Figs. 4*a* to *g*.)

Nervous system.—The cephalic ganglion is longer than or as long as broad, cordate, with the posterior end considerably narrower than the anterior part (Fig. 4*c*).

Generative system.—The efferent duct is longer than the atrium, but not longer than the atrium and penis together. The atrium is shorter and thicker than in the preceding species; the penis is longer than in

* Vejdovsky, *Zeitsch. f. w. Zoologie*, Bd. xxvii, page 137.

H. Perrierii, but of about the same length as in *H. Sodalis*. The distance between the ventral ganglion and the external generative porus is comparatively great, or about as long as the length of the penis and oviduct together (Fig. 4*d*). The penis is not furnished with any penis sheath (Fig. 4*e*). The oviduct is single, chitinous and somewhat funnel-shaped. Both penis and oviduct are narrowed a little below the middle, but from here they increase in size, and the apex of both are considerably swelled (Fig. 4*e*). Numerous longitudinal muscles are attached with one end to the interior surface of the upper end of the oviduct and with the other to the body wall (Fig. 4*e*, *ms. cl.*). The receptacle is straight, the top inflated, very large, globular, supported by a small narrow stem of less length than half the diameter of the inflated top. The walls of the receptacle are extremely pellucid, much more so than in the preceding species. No spermatophores found.

The integument is more pellucid than in any other species of the genus. The body is of a fine red flesh color, and in size its anterior part not much thicker than its tail.

The spines are of three kinds, viz: hair spines, pseudo comb-like spines, and forked spines (Fig. 4*c*). The prongs of the pseudo comb-like spines are only very slightly serrated.

The length of the body about 15^{mm} (Fig. 4*a*).

The segmental organs are covered with large oblong inflated cells, especially their inner free end (Fig. 4 *g*).

Habitat.—California, Fresno County, Sierra Nevada; in running water in meadows, at an altitude of from 5,000 to 7,000 feet.

Gen. HEMITUBIFEX, *nov. gen.*

(Pls. VII and VIII; Fig. 6.)

Nervous system.—The cephalic ganglion emarginated both in front and behind.

Generative system.—The efferent duct is very long and narrow, as in *Tubifex*. The upper end of the atrium is enlarged, and forms a globular, so-called "vesicula seminalis," upon which the prostate gland is grafted. The lower end of the atrium is glandular. The penis sheath is chitinous, shorter than the oviduct. The oviduct is double-sheathed, both sheaths being chitinous and funnel-shaped, and the outer one surrounded by longitudinal muscles. The base of the receptacle is furnished with accessory glands. The spermatophores are short, thick, and inclosed in a pellucid bag.

The integument is not covered with opaque papillæ. The spines are of two kinds, viz, forked spines and hair-spines. The latter, however, are not always present, as some individuals are found without them. Whenever found they are only sparingly distributed on the upper side of the body. No comb-like spines.

The shape of the atrium, the double oviduct, and the irregularity of the number of the hair-spines are characteristics distinguishing this genus

from any other in the family. The nearest allied one is evidently *Psammoryctes;* but this genus has large and distinctly fan-shaped spines, which are entirely wanting in *Hemitubifex.* As yet only one species known, viz:

HEMITUBIFEX INSIGNIS *n. sp.*

(Pls. VII and VIII; Fig. 6.)

Nervous system.—The cephalic ganglion is nearly square. Its anterior margin is deeply concave; the lobes of the posterior margin are well rounded, and the sinus between them deep and narrow (Fig. 6*g;* Pl. VIII).

Generative system.—The efferent duct is about one-half longer than the atrium and penis together. The atrium is comparatively narrow, except its upper part, which is globular, forming a "vesicula seminalis," upon which the prostata is grafted. This globular part of the atrium is of exactly the same consistency as the lower part of the atrium itself, and differs in this respect from *Psammoryctes,* which genus is said * to have a non-glandular atrium proper. The globular chamber of the atrium can more properly be called a receptacle for the mucus of the prostata gland, when it is mixed with the spermatozoa, descended from the efferent duct. The penis proper is extraordinarily large, thickest a little below its base, and from here gradually tapering towards the exterior apex, which, however, is somewhat swelled and rounded. The penis sheath is chitinous and covers only a part of the penis, leaving the swelled apex and the larger portion of the upper part uncovered. The oviduct is double, both its sheaths being chitinous, funnel-shaped, and about twice as large as the penis sheath (Fig. 6*c*, ovd). Numerous muscles are attached to the interior upper surface of the oviduct and penis proper, binding them to the interior of the body wall. The receptacle is supported by a long, narrow stem, at the base of which are several wing-like glands. The spermatophores are thick and short, generally bent, each one surrounded by a pellucid membrane (Fig. 6*h*).

The segmental organs are long and narrow. The interior aperture is surrounded by two nearly equal lobes; no inflated cells and no enlarged chambers, as in *Spirosperma.*

The integument is very smooth, and the body of the worm resembles much that of *Limnodrilus* or *Tubifex.* The spines are of two kinds, hair-spines and forked spines. The latter are regularly dispersed two and two in each fascicle, except on the upper or dorsal side of the body, where we occasionally also find a few hair-spines. The distribution of these is very irregular. In one specimen they were found in the third, fourth, seventh, twelfth, and thirteenth segments, but even here not in all the upper fascicles. In another specimen from the same locality I

* Vejdovsky, *Zeitsch. f. w. Zoologie;* Bd. XXVII, page 138.

found no hair-spines at all. Of the forked spines the lower prong is much wider and longer than the upper one, and the angle between the prongs is nearly a right one (Fig. 6 C.).

The length of the worm is about 30mm, and the width less than 1mm. The cingulum is small and hardly perceptible.

Habitat.—Sweden, Europe, Motala River, in shallow water near the shore.

Gen. PSAMMORYCTES *Vejdovsky*, 1877.

Syn. 1868. *Sœnuris*, Kessler, Beitrage znd. Obhandbung. d. Petersburger Nat. Forsch. Versaml., p. 108.

1871. *Tubifex*, E. Ray Lankaster, Annals & Mag. of Nat. Hist., vol. vii, 1871, pp. 90, 101.

1875. *Tubifex*, Ed. Perrier, Syr. l. Tubifex etc. Arch. Zool. exper. et gen. tom. iv, No. 1. Notes et Revue, p. 6, 1875.

1877. *Psammoryctes*, Vejdovsky, Zeitschr. f. wiss. Zoologie; Bd. xxvii p. 137.

From the descriptions of the above authors the following seem to be the main characteristics of the genus: The atrium is furnished with a large globularc hamber called vesicula seminalis, upon which the prostate gland is "grafted." That part of the atrium which is situated between this chamber and the penis proper is *not glandular*, but translucid, narrow, and sometimes furnished with small circular chambers.

The comb-like spines are fan-shaped, the membrane between the prongs being very plainly visible.

For further particulars about this genus I beg to refer to the above cited authors.

Only one species as yet known, viz:

Psammoryctes umbellifer (*Kessler*, 1868).

Syn. 1868. *Sœnuris umbellifera*, Kessler l. c., p. 108.

1877. *Psammoryctes umbellifera* Vejdovsky l. c., p. 137.

Species characteristics the same as for the genus. The spines are of three kinds, viz, hair-spines, comb-like spines, and common forked spines. Of the latter we find two varieties.

Habitat.—Europe, Russia, Bohemia, England, &c., in fresh or brackish water, as it seems very widely distributed.

Further ahead, when speaking of the general organization of the oviducts and penis sheath, I will return to this species and give some reasons why I think that said organs have been in this as well as in some other species erroneously observed or misunderstood.

Gen. TUBIFEX *Lamark*, 1818.

Nervous system.—The cephalic ganglion emarginated both in front and behind.

Generative system.—The lower end of the atrium is comparatively broad; not so broad, however, as in Ilyodrilus. Both oviduct and penis sheaths present. The oviduct is wide and short.

Integument furnished with only two kinds of spines, viz, hair-spines and forked spines. Fan-shaped or pseudo comb-like spines never present.

As can be seen, the above characteristics are neither very pointed nor at all sufficient to fully characterize the genus, but the descriptions of the different species belonging to this genus are mostly so inadequate that no better genus-characteristics could at present be compiled. Of the four species known I have seen only one, viz, *Tub. campanulatus*. *Tub. Bonneti* is sufficiently described by *Claparide*, and seems easily distinguished from any other. Of the remaining two species, I have seen neither specimens nor descriptions, and must, in regard to them, trust to the authority of the respective authors.

TUBIFEX RIVULORUM Udekem, 1853.

SYN.: *Tubifex rivulorum.*

D'Udekem, J. Hist. Nat. d. Tub. riv. Mem. Cour. par. l'Acad. d. Belgigue, Tom. XXVI, 1855.

TUBIFEX COCCINEUS Vejdovsky, 1875.

SYN.: *Tubifex coccineus* Vejdovsky.

Sitzungsb. Mathend, Nat. vissensch. Classe d. Böhm, Gesellsch Wessenschaft, Oct. 29, 1875, p. 3.

This and the following species, *Tub. Bonneti*, are said to have the receptacle in the tenth, and the sexual pore in the eleventh segment.

Tub. rivulorum and *Tub. campanulatus*, on the contrary, have the same organ in the respective segments, 9 and 10, or in one segment nearer to the cephalic lobe. I can hardly account for this seeming difference in any other way than that the respective investigators have counted the segments in different ways. It is natural that when every investigator has not only had his own way of counting the segments, but also changed that way at different times, that much confusion will ensue. For our purpose it is materially indifferent if we count the cephalic lobe as a segment *per se*, or if we, as the first segment of the body, assign the first setigerous one, if we only can agree to one or the other. Myself and d'Udekem count the first setigerous segment as the first segment of the body, and accordingly we find the receptacle to be situated in the ninth and the sexual porus in the tenth segment. Claparède and Vejdovsky, on the contrary, consider the first setigerous segment to be the second segment of the body, which, of course, places the sexual porus in the eleventh segment.

I have, to prevent further complications, and in order to immensely simplify the counting of the segments, here adopted the plan to name the segments surrounding the oral orifice, respectively the *cephalic lobe* and the *buccalic segment;* and, further, to assign the name of the first segment only to the first setigerous one. And, to avoid any possible misunderstanding, it would, when speaking of the segments, be well to add "setigerous."

TUBIFEX BONNETI *Clap.* 1868.

SYN.: *Tubifex Bonneti.* Claparède, Recherches Anatomiques, etc., p. 13.

The most characteristic feature of this species is the vase-like form of the oviduct, which latter is of about the same length as the penis.

Habitat.—Europe; Switzerland.

TUBIFEX CAMPANULATUS *n. sp.*

[Pt. VIII, Fig. 7.]

Nervous system.—The cephalic ganglion is longer than broad, and in front considerably broader than behind, where the emargination is deep and narrow (Fig. 7*a*).

Generative system.—The penis is broadest at the middle, and from there tapering toward both ends. The penis sheath is of the same form as the penis, only broader and longer (Fig. 7*c*). The oviduct is bell-shaped, the widest end being turned towards the exterior penis. The length of the oviduct is only half that of the penis, but its width at its lower end is nearly three times that of the penis (Fig. 7*c*). The exterior oviduct is membrane-like, and surrounded by two large trunks of longitudinal muscles, which connect the oviduct with the body wall. This exterior oviduct is twice as long as the interior one (Fig. 7*c*). The receptacle is bent in the shape of an **S**, with the upper end enlarged and sack-like (Fig. 7*d*).

Spines.—The two prongs of the forked spines are of nearly the same size, and the angle between them is less than a right angle.

Length of the body about 15^{mm}.

Habitat.—Europe, Sweden, Christianstad.

Tubifex profundicola Verrill (American Journal of Science, 3d series, vol. ii, p. 450, 1871) is evidently no *tubifex* at all, if the spines are correctly described. Those of the ventral fascicles are said to be longer than those of the dorsal ones. All the setæ are hooked or forked—characteristics which place the worm in or near the genus *Limnodrilus.*

Gen. LIMNODRILUS *Claparède*, 1862.

SYN.: *Limnodrilus* Claparède l. c., p. 25, 1862.

Nervous system.—The cephalic ganglion emarginated both in front and behind.

Generative system.—The lower end of the atrium is generally long and narrow, and comparatively narrower than the corresponding parts of *Tubifex* and *Ilyodrilus.*

The copulative organs are not surrounded by spiral muscles; generally by longitudinal, seldom by circular ones.

Integument.—Only one kind of spines, viz, forked spines.

The principal characteristic of this genus is evidently the total absence of hair spines and fan-shaped spines. In other respects this genus seems to resemble *Tubifex.* It is, however, likely that when a larger

number of species has been studied new and more distinct characteristics may be discovered. A prominent feature of the genus is also the elongation and narrowness of the copulative organs. In all other genera except *Camptodrilus* said organs are much shorter, especially so the oviduct. In *Tubifex* we find the shortest and widest oviducts; in *Limnodrilus* and *Camptodrilus* the longest and narrowest.

In the following synoptic table the three species, *L. Hoffmeisteri* Clap., *L. Udekemianus* Clap., and *L. Claparèdianus* Ratzel, are not classified. I have not had opportunity to see those species myself, and as some points in the description of their reproductive organs, &c., are wanting, it has as yet been impossible to arrange them systematically among the other species. They seem, however, to be nearest related to *L. monticola* and *alpestris:*

A. The oviduct is single. The upper end of the penis sheath furnished with a crown of star-like concretions.

LIMNODRILUS ORNATUS.

B The oviduct is double. The upper end of the penis sheath not furnished with star-like concretions.

1. The penis proper projecting outside the penis sheath and here forming a globular head. Inner oviduct muscular.

LIMNODRILUS STEIGERWALDII.

2. The penis proper not projecting outside the penis sheath, and its lower end not forming a globular head. The inner oviduct is not muscular, but chitinous.

a. The lower end of the penis proper is truncate and somewhat wider. The lower end of the interior oviduct is wider than its middle.

LIMNODRILUS MONTICOLA.

C. The lower end of the penis sheath is pointed. The lower end of the interior oviduct is wider than its middle.

LIMNODRILUS ALPESTRIS.

c. The lower end of the penis proper is pointed or rounded. The lower end of the oviduct is much narrower than its middle or upper part.

LIMNODRILUS SILVANI.

LIMNODRILUS ORNATUS *n. sp.*

(Pl. IX; Fig. 8.)

Nervous system.—The cephalic ganglion is broadest posteriorly, the two lobes being well rounded and separated, but the sinus between them is rather shallow (Fig. 8*c*).

Generative system.—The penis is long and slender, broadest at its upper end, and from here gradually tapering towards the apex, which, however, is not tapering, but cylindrical. The penis sheath is long, cylindrical, trumpet-shaped at both ends, and slightly narrowest at the middle. Its upper end, at the entrance to the oviduct, is furnished with a crown of star-like concretions, of a brown, chitinous consistence (Fig. 8*d* crn.) The oviduct is single, sack-like, and longer than the penis sheath. In the same no cellnuclei are visible. Surrounded by longitudinal muscles. The receptacle is elongated, and of a flask-like shape,

sometimes constricted at the middle (Figs. 8*e*; 8*f*). No spermatophores are found.

The segmental organs are long and very narrow; not surrounded by bladder-like cells (Fig. 8*h*).

Integument is hard and tough. The spines are short, and their exterior end not much curved. The opening between the prongs is narrow, and the upper prong is longer than the lower one.

Length of the body, about 30^{mm}; width of the same, about 1^{mm} or less.

Habitat.—California, San Joaquin River, in a pond, found attached to decaying wood floating on or immersed in the water.

The principal characteristics of the species are the star-like concretions round the upper end of the penis sheath. The brown color of the concretion fades when the animal has been preserved in glycerine. The generative organs are comparatively minute, or of about half the size of those of *L. alpestris*.

Limnodrilus steigerwaldii *n. sp.*

(Pl. X; Fig. 9.)

Nervous system.—The anterior part of the cephalic ganglion is the widest, and emitting several large ganglionic lobes toward the cephalic lobe of the body. The posterior margin is abruptly emarginated, and the whole posterior part of the ganglion is nearly globular (Fig. 9*c*).

Generative system.—The generative organs are, in proportion to the great length of the body, comparatively short. The lower end of the penis is globular, the globular part being situated outside of the penis sheath, within which it cannot be retracted. The penis sheath is chitinous, about eight times as long as wide. Its form is cylindrical, with trumpet-shaped ends, the lower one being the widest (Fig. 9*c*, ps.). The oviduct is muscular, thickest at the middle, round the globular swelling of the penis, from here gradually tapering toward the exterior orifice. The exterior orifice is sack-like, much wider and with thinner walls than the interior one. In its walls the cell nuclei are all plainly visible. The atrium is unusually small, and the lobes of the prostate gland minute and globular. The ovaries are much bent, tapering toward the extremities. The ripe ova are found on the middle of the ovary (Fig. 9*f*). The receptacle is nearly straight, broadest at its inner apex.

Segmental organs are not furnished with globular cells, except their inner orifice, which is surrounded by globular swellings, increasing in size toward the orifice itself (Fig. 9*e*). The orifice is surrounded by two lips, the upper one of which is furnished with a long vibrating epithelium (Fig. 9*e*).

The length of the body in large specimens 30^{mm}; width of the same from 0.75 to 1^{mm}. The body tapers gradually toward the posterior end.

Habitat.—Sierra Nevada, California, in the bottom of running springs, in meadows, at an altitude of 7,000 feet.

The principal characteristic of the species is the enlargement of the lower end of the penis.

Limnodrilus monticola *n. sp.*

(Pl. XI, Fig. 10.)

Nervous system.—The cephalic ganglion is nearly square, the posterior lobes well rounded but not much projecting (Fig. 10*c*).

Generative system.—The generic organs are comparatively minute. The lobes of the prostata are not globular and not much elevated, the whole gland being larger and more compact than in the preceding species. The penis is nearly cylindrical, and only slightly widening toward the exterior truncate end. The penis sheath is also cylindrical, slightly widening toward both extremities. Its exterior end is not deflected, sometimes rather the contrary. The penis and penis sheath are of the same length. The oviduct is double. The interior one is chitinous and resembles closely the penis sheath, being only wider but not much longer. Its lower extremity is sometimes deflected and plate-like, especially in very matured specimens (Figs. 10*e* and 10*f*).

The exterior oviduct is, as usually, sack-like. Its upper part covers the interior oviduct closely; its lower end is wider, with plainly visible cell nuclei. The receptacle is straight, sometimes constricted at the middle, generally found containing spermatophores of usual shape (Figs. 10*g* and 10*h*).

The spines are very slender, curved, the upper prong of the fork slightly the longest (Fig. 10*c*).

The length of the body 30^{mm}.; width of the same 0.75^{mm} (Fig. 10*a*).

Habitat.—California, Sierra Nevada, at Seven Spring Meadow, on the east side of the North Fork of King's River. Numerous specimens found in or between decaying wood submerged in the water. Altitude about 9,000 feet.

The principal characteristic of the species is the cylindrical form of the penis and its truncate end. The other species of the genus have the extremity of the penis either globular or pointed, or present other forms easily recognizable.

Limnodrilus alpestris *n. sp.*

(Pl. XII, Fig. 11; Pl. XVII, Fig. 11; Pl. XVIII, Fig. 18.)

Nervous system.—The posterior part of the cephalic ganglion is the broadest, sometimes furnished with three well-rounded lobes. The swellings of the ventral ganglion are almost circular. In not fully developed specimens the cephalic ganglion is two-lobed (Fig. 91*a*).

Generic system.—Of the generic organs, the penis and the oviduct are comparatively longer than in any other species of the genus. The lower extremity of the penis is slightly swelled and pointed. The penis sheath is trumpet-shaped at both extremities, the exterior one being the widest.

The interior oviduct is of nearly exactly the same form and size as the penis sheath; if anything a little shorter. The exterior oviduct does also inclose the penis sheath and interior oviduct securely, and is only sack-like at its lower end, which is rather muscular and unusually short (fig. 11C). The atrium is of somewhat variable form, its upper part sometimes being rather unusually swelled (fig. 11, Cx). More generally the atrium tapers toward both extremities. The receptacle is enlarged at both extremities, the upper one being bent and helix-like (Fig. 11*d*). The testes are found in the tenth to fourteenth or fifteenth setigerous segments. The spermatophores are numerous, and of variable form (Fig. 11*efg*).

The segmental organs are comparatively short, surrounded by a heavy mass of granulated matter, but not by any globular cells (Fig. 11*h*).

The length of the body about 25^{mm} by 0.75^{mm} wide. The integument is very tender, causing the worm to easily break.

Habitat.—California, Sierra Nevada, in the mud of running springs, at an altitude of 7,000 feet.

The principal characteristic of the species is the length and form of the penis sheath and oviducts, also the form of the cephalic ganglion.

Limnodrilus Silvani *n. sp.*

(Pl. XIII, Fig. 12; Pl. XIV, Fig. 12.)

Nervous system.—The form of the cephalic ganglion is variable. In large specimens the ganglion is much wider than long, and sometimes furnished with three posterior lobes; in smaller specimens the ganglion is much longer than broad and never three-lobed (Figs. 12*e* and 12*f*). Between these two forms intermediate ones are found but rarely.

Generative system.—The lower end of the penis proper is rounded and somewhat swelled. The penis is only half as long as its chitinous sheath and only slightly thicker than the lower end of the atrium (Figs. 12*p* and 12*q*).

The penis sheath is seen from the side gradually tapering towards the exterior apex, with the exception of an abrupt enlargement at the middle, just at the end of the penis proper. Seen from the front, however, it presents a very different appearance. It then nearest resembles an arrow-head or trowel (Fig. 12*q*, p. s.).

The oviduct is double. The interior one is about three-fourths as long as the penis sheath. Seen from the side, it resembles an arrow quiver. Seen from the front, its lower end is found to closely inclose the lower, or an arrow-head resembling part of the penis sheath, but its upper third is wider than the upper half of the penis sheath. The exterior oviduct is more sack-like, and somewhat loosely incloses the interior generic organs. The efferent duct is extremely long; the prostate is very irregular, but rather compact.

The receptacle consists of three parts, viz: One middle part, which

is narrow, and the two extremities, which are swelled and sack-like, especially the upper one. The latter and the middle part are bent over and cover the lower part sometimes entirely. In the long form of the worm the receptacle was found always more or less straight (Fig. 12*q*).

The spermatophores are numerous and of various forms. The ovaries are long and comparatively very narrow, developing the ripe ova at their middle (Fig. 12*r*).

The segmental organs are long and narrow (Figs. 12*n* and 12*o*); not surrounded by globular cells.

The integument is very tough. The spines are slightly curved; the angle between the two prongs is in the anterior spines nearly a right angle, but in the posterior spines of much smaller aperture. (Fig. 12, *c. d.*)

Of this species exist two different sized forms. One is about 18^{cm} long and 2^{mm} broad. The other is only 5^{cm} long by 1½^{mm} to 1^{mm} broad. Both forms are found fully matured, and both differ somewhat anatomically from each other. Intermediate forms are found, but not very numerous. In one of two neighboring ponds both forms are found, and intermediate ones between them. In the other pond or lake I have as yet found only the smaller form, and no intermediate ones (Fig. 12*a* and *b*).

Habitat.—California, San Francisco. In Laguna del Mercedes only the smaller form. In Mountain Lake or "Marine Hospital Pond" both forms are found. In "Laguna del Tache" only the smaller forms.

The following species are sufficiently well described to be recognized, but not sufficiently enough to enable me to arrange them systematically in the genus. For their characteristics I must refer to their respective describers.

LIMNODRILUS UDEKEMIANUS *Clap.*

SYN.: *L. Udekemianus* Claparède, Recherches anatomiques sur les Oligochætes, prz. 27, Geneva, 1862.

LIMNODRILUS HOFFMEISTERI *Clap.*

SYN.: *L. Hoffmeisteri* Claparède, *l. c.*, prz. 32.

LIMNODRILUS CLAPARÈDIANUS *Ratzel.*

SYN.: *L. Claparèdianus* Ratzel, Z. f. wissenschaftl. Zoologie, Bd. xviii, s. 563 to 591.

All of the above three species are found in Europe.

Gen. CAMPTODRILUS *nov. gen.*

Nervous system.—The *cephalic ganglion* is both anteriorly and posteriorly emarginated, and in this respect resembling all other genera except *Spirosperma.*

Generative system.—The copulative organs are much elongated, and partly surrounded by spiral muscles, one end of which is attached to

the exterior oviduct, the other to the interior surface of the body wall, near to the genital porus. In other respects this genus resembles *Limnodrilus*. Generally it may be said that the copulative organs of this genus are comparatively longer and narrower than those of any other genus of the family.

The spines are only of one kind, viz, forked spines.

Camptodrilus is well distinct from all other genera; from most of them by having only forked spines, and from all of them, especially from its nearest allied *Limnodrilus*, in having spiral muscles wound round the copulative organs.

Only four species as yet known.

A. The oviduct is double; the interior one chitinous; the lower end of the penis sheath suddenly increasing in size, deflected and plate-like.

C. SPIRALIS.

B. The oviduct is single, not chitinous.

a. The anterior margin of the cephalic ganglion is broader than the posterior one. The exterior end of the penis sheath is suddenly expanded and plate-like.

C. IGNEUS.

b. The cephalic ganglion is nearly square, broader behind than in front. The exterior end of the penis sheath is very gradually increasing in width, and not suddenly expanded nor plate-like.

C. CORALLINUS.

c. The posterior margin of the cephalic ganglion is the broadest, and well rounded. The exterior end of the penis sheath is suddenly increased in width, funnel-shaped, but not plate-like.

C. CALIFORNICUS.

CAMPTODRILUS SPIRALIS *n. sp.*

(Pl. XVII, Fig. 15.)

Generative system.—The spiral muscles surrounding the copulative organs are finer than those of any other species known, and may sometimes be easily overlooked. The penis sheath is long and narrow, and nearly perfectly straight. Its exterior end is suddenly increasing in size, deflected, but not plate-like (Fig. 15, *a*). The oviduct is double. The interior one is of the same shape and general size as the penis sheath, only wider in both extremities. The exterior oviduct is sack-like at its lower end, and somewhat resembling the same organ of *Camptodrilus igneus*. The receptacle is long, sack-like, and bent at the middle.

The segmental organs are not furnished with globular cells, and their interior apertures are not surrounded by glandular agglomerations (Fig. 15, *d*).

The spines are slightly curved, and the angle of the prongs is larger in spines from the posterior segments than in those from the anterior ones (Figs. 15 *b* and *c*).

The body is about 25^{mm} long by 1^{mm} wide, and of a steel-blue color. When touched the animal coils itself into a spiral, and accordingly alcoholic specimens are never found extended. The integument is tender.

Habitat.—California, Sierra Nevada, Fresno County, at an altitude of 7,000 feet, in stagnant water in the meadows; never in the very stream.

CAMPTODRILUS IGNEUS *n. sp.*

(Pl. XIV, Fig. 13.)

Nervous system.—The cephalic ganglion is broadest in front; its posterior margin is deeply emarginated, on both sides surrounded by very pointed lobes. The frontal lobes are each covered with several globular swellings (Fig. 13, *b*).

Generative system.—The penis sheath is long and extremely narrow, its lower or exterior end is suddenly expanded, deflected, and rather plate-like. From behind this deflection the penis sheath gradually increases in thickness towards the upper or inner end of the sheath (Fig. 13 *e* and 13 *g*, Pl. XVIII). The oviduct is single sack-like, of a very elongated form. The lower end of the oviduct is very much the widest, and in the same the cell nuclei are plainly visible. The spiral muscles surrounding the copulative organs are very strong and distinct, unlike those of the preceding species, *C. spiralis*. The receptacle is bent and sack-like, not found containing any spermatophores (Fig. 13, *d*).

The segmental organs are in all the segments furnished with a coating of perfectly globular cells, with plain cellnuclei situated close to the tube of the organ (Fig. 13, *e*).

The perigastric cavity contains free and floating perigastric cells of somewhat variable form (Fig. 13, *f*).

The integument of the body is extremely tender. Color fiery red, under the microscope yellowish. Size of the body about 30^{mm} by 0.75^{mm} wide.

Habitat.—California, San Francisco, Oakland, Santa Clara Valley and neighborhood. Adult in March.

This species is especially remarkable for its fiery color, which gives to the borders of the ponds wherever it is found a very vivid appearance. The shape of the cephalic ganglion and the plate-like extremity of the penis sheath are distinct characteristics of the species.

CAMPTODRILUS CORALLINUS, *n. sp.*

(Pl. XVI, Fig. 14; Pl. XVII, Fig. 14; Pl. XVIII, Fig. 14.)

Nervous system.—The cephalic ganglion is nearly square, and its posterior emargination rectangular, or nearly so (Fig. 14 *d*).

Generative system.—The penis sheath is gradually increasing in width towards its exterior extremity, which is considerably bent, not much deflected nor plate-like. Figs. 14 *e* and 14 *l* represent the reproductive organs as generally found. Figs. 14 *i* and 14 *k* represent the lower end of the penis sheath, with a small deflection of its margin, as it sometimes is found. The oviduct incloses the penis sheath tightly, except

at its lower end, which is sack-like and extending beyond the same. The cell nuclei in the same are not plainly visible. The ovaries are short, bent in a right angle, in which latter the ova are developed (Fig. 14 *g*). The receptacle is short, wide, and sack-like, and the stem which supports it is much smaller than in any other species.

The segmental organs in front of the cingulum are all furnished with globular cells, but those in the segments behind the same have no globular cells. No glandular agglomerations round the interior aperture of the organ.

The color of the body is yellowish red, with a light or not colored band between every segment, giving the worm somewhat the appearance of a string of red corals. The last posterior segment is five or six times longer than the segment preceding the same. The length of the body is variable, the general size being from 25^{mm} to 30^{mm}, but sometimes it reaches from 60^{mm} to 70^{mm}, with a width of from 1^{mm} to 1½^{mm}. The integument is tough, giving some tenacity to the body.

Habitat.—California, Fresno County, in ponds, or even in the running waters of King's River, Dry Creek, &c., always near the level of the prairie.

CAMPTODRILUS CALIFORNICUS, *n. sp.*

(Pl. XVIII, Fig. 16.)

Nervous system.—The cephalic ganglion is nearly square, posteriorly well rounded, with a shallow emargination.

Generative system.—The copulative organs are all strongly built, and the spiral muscles heavier than in any other species of the genus. The penis sheath is at its lower end suddenly increased in size, deflected, but not plate-like. The oviduct is single, surrounds the penis sheath tightly; its lower end is, however, more sack-like, resembling in this respect the corresponding part of *C. corallinus*.

The segmental organs are not furnished with globular cells.

The body is of about the size, color, and tenacity as that of *C. igneus*. The tail is distinctly segmented, and the last segment not longer than the preceding one.

Habitat.—California, San Francisco, Oakland, Lagunitas, Russian River, &c., in ponds or stagnant water, only seldom in the streams themselves.

As the species of this genus are somewhat difficult to distinguish the one from the other, the following comparison of their principal characteristics may prove useful.

C. spiralis has a double oviduct. Its penis sheath resembles that of *C. igneus*, but is comparatively shorter. The copulative organs have also some resemblance with those of *L. alpestris*, but this species has no spiral muscles.

C. igneus has a single oviduct, and is further distinguished by the plate-like deflection or enlargement of the lower end of the penis sheath, above which it is suddenly decreased in size.

C. corallinus has also single oviduct, but the penis sheath is gradually increasing in size from the middle toward its lower or exterior end. This species is somewhat larger than any other in the genus, and the integument of its body tougher.

C. californicus has the exterior end of the penis sheath suddenly expanding and deflected, but the deflection is not plate-like, only trumpet-shaped. The whole organ is also comparatively shorter and thicker than in *C. igneus*. The oviduct is single. The copulative organs of this genus are comparatively longer and narrower than those of any other genus, *Limnodrilus* excepted.

B.—GEOGRAPHICAL DISTRIBUTION.

Our present knowledge of the distribution of the genera and species of *Tubificidæ* is so very limited that any general comparison between the countries and the species inhabiting the same can hardly be expected. *Tubificides* are as yet known only from Europe and North America, but there is every reason to believe that we will find them distributed all over the globe wherever ponds, streams, lakes, or wells can be or are found. I have as yet not seen any permanent water, and hardly any larger temporary ones, where *Tubificidæ* could not be collected.

The above list of species must by no means be considered as in any way exhaustive; on the contrary, the few species known can only constitute a small portion of what in reality exists, and I feel fully satisfied that hundreds, if not thousands, of species will be found, when the different waters of the continents and islands are thoroughly searched.

Here, then, will we find a class of animals, as yet hardly investigated and very insufficiently known, which in the near future may furnish a rich supply for the student of natural history.

The study of the geographical distribution of the species of *Oligochætæ* must also be in the highest degree an interesting one, even more so than the geographical distribution of most other classes of animals, such as birds, reptiles, and mammalia. While the latter have numerous ways of transportation on land, through air and water, the slowly moving *Oligochætes* are mostly confined to the very element in which they live, and outside of which they and their eggs would soon perish. The fauna of terrestrial animals, with their various means of locomotion, may have changed many times, while the *Oligochætes* in the earth, relatively secure from enemies and less subject to climatic changes, may have survived for ages. Thus the study of the distribution of the *Oligochæta*, especially the purely terrestrial ones, may not only be of value in considering the former connection of continents and islands, but also in the study of the climatic changes they have undergone. So have I, for instance, been led to believe with a reasonable degree of cer-

tainty that the climate of California, dry as it is, is gradually changing to a damp one, and that for the following reasons:

If Middle and Southern California in former, not to say distant, ages had enjoyed a moist and rainy climate, its soil in favorable places would most likely contain numerous earth-worms. I naturally judge this from analogy, as there is no country which is not absolutely dry for any length of time where earth-worms are wanting. If now, therefore, the climate of California began to get drier, the worms formerly distributed over the whole of the country would naturally recede to the remaining moist land around the water-courses, and, finding here the necessary conditions for existence, remain to the present day.

But in Middle and Southern California I have hunted in vain for native *Lumbricides*, and even so in the always moist earth around King's and San Joaquin Rivers, places at present climatically isolated. From these facts I draw the conclusion that even in former time no climatical connection existed between the said river valleys and other countries inhabited by earth-worms and that the climate, if changing at all, is getting moister, being formerly an arid one.

Around San Francisco and other cultivated places throughout California we find in the gardens several imported European species of earth-worms and only one single species which at present is known only from California.

If similar conclusions can be drawn from the study of *Lumbriculidæ* or terrestrial *Oligochæta*, it may also be reasonable to suppose that even the geographical distribution of the Limicolide worms will enlighten us upon subjects related to a country's former geographical and climatological connections.

It is, of course, as yet too early to speculate further upon these points, or to draw any conclusions from the few with certainty known facts, but I have here only wished to call attention to the importance of the geographical distribution of this class of animals, and, which of course is partly the same, to the study of their different species.

While many classes of animals exhibit both more attractive features, more gorgeous colors, and are more easily studied, they therefore in no way are any more valuable to the science of natural history, and it would even be well if scientific expeditions and private collectors would more generally and with more generosity divide their attention between the popular and not popular classes of the animal kingdom.

But, returning to the geographical distribution of the species, we find that about 22 species of *Tubificidæ* are as yet known, and about equally divided between Europe and North America, provided we only consider species which are sufficiently well described to be recognized and classified.

Among species as yet insufficiently known I consider *Sænuris abyssicola*, *Sænuris limicola*, *Tubifex profundicola*, *Chirodrillus larvæformis*,

and *Chirodrillus abyssorum*, all of which are American species.* It is even very doubtful if *Chirodrillus* can be considered a *Tubificidæ*, it having six fan-shaped fascicles of setæ on each segment.

The species from Russia, described by *Kessler*, *Nais papillosa*, *Nais gigantea*, *Sænuris longicauda*, may all be what we call good species, but as yet we know too little of them to enable us to properly classify them. Of a supposed identity of *Nais papillosa* and *Spirosperma* I have spoken under the heading of the latter species.

Besides the above species, we know from Europe the following 10, viz: *Spirosperma*, 1 species; *Hemitubifex*, 1 species; *Tubifex*, 4 species; *Limnodrilus*, 3 species; and *Psammoryctes*, 1 species.

The rest of the species are all from California. From the eastern part of America I have not seen any species of *Tubificidæ*, but have the authority of several zoologists for their numerous occurrence.

The following table will better show the distribution of the species:

	Sweden.	Russia.	Bohemia.	Switzerland.	Germany.	France.	Belgium.	England.	California.
Telmatodrilus Vejdovskyi									*
Spirosperma feroz	*								
Hemitubifex insignis	*								
Ilyodrilus Perrierii									*
sodalis									*
fragilis									*
Psammoryctes umbellifer		*	*			*		*	
Tubifex rivulorum							*		
coccineus			*						
campanulatus	*								
Bonneti			*	*					
Limnodrilus Hoffmeisteri			*	*					
Udekemianus			*	*					
Claparedianus					*				
ornatus									*
Steigerwaldii									*
monticola									*
Silvani									*
alpestris									*
Camptodrilus spiralis									*
igneus									*
californicus									*
corallinus									*
	3	1	5	3	1	1	1	1	13

C.—SPINES.

The most prominent external characteristics of the species of this family are derived from the spines. We can of them distinguish five different kinds or varieties, viz:

1. Entire spines.
2. Forked spines.
3. Hair spines.
4. Fan-shaped or comb-like spines.
5. Pseudo-comb-like spines.

*Verrill, in extract from report of S. F. Baird, Commissioner of Fisheries, Part II, Rep. for 1872–'73, pp. 697–699.

The entire spines resemble those of *Enchytræidæ*. They are found only in *Telmatodrilus*, and occur here in fascicles, of which four are found in every segment. In each fascicle we find nine or more spines, all of nearly equal length. In very young individuals the exterior end of these spines show a tendency to forking, which, however, entirely vanishes by advanced age.

Nearest related to these spines are the forked spines. They resemble the former, except in regards to their exterior apex, which is forked. Such spines occur in all the species of *Tubificini*. The angle of the fork and the length and form of the prongs are important characteristics of the species. The fork of the spines is oftentimes different in different segments of the same species. Such is the case in *Psammoryctes** and in *Spirosperma* (Fig. 20; 2 *n*.)

Generally the prongs of the spine are only two, but in *Spirosperma* we find three or sometimes even four (Figs. 2 *n*, 2 *o*, and 2 *p*). Such spines, however, are only found in the interior segments of the body.

The forked spines are generally found in fascicles by themselves, but sometimes also, as in *Tubifex* and *Hemitubifex*, alternating with hair spines in the same fascicle on the upper side of the body. Forked spines and fan-shaped spines are never found mixed or alternating in the same fascicle. In *Limnodrilus* and *Camptodrilus* we find only forked spines, but in all the other genera we find at least two kinds of spines, viz, forked and hair spines.

The hair spines are characterized by their length, oftentimes exceeding the width of the body of the worm. They are only found on the upper side of the body, and generally only in the anterior segments. In *Tubifex* and *Hemitubifex* they are found alternating with common forked spines, but in *Ilyodrilus*, *Spirosperma*, and *Psammoryctes* with fan-shaped or pseudo-comb-like spines. The general number of spines in such a fascicle is from five to six of each kind, varying, however, in the different segments.

The fan-shaped or comb-like spines are peculiar to the genera *Psammoryctes*, *Spirosperma*, and *Ilyodrilus*. They are characterized by having a finely striated membrane stretched between the prongs of a forked spine. There is, however, a difference between the prongs of a purely forked spine and a comb-like one. Those of the former are always more curved than the latter, which sometimes even are both bent either inward, as in *Psammoryctus*, or outward, as in *Spirosperma*. The comb-like spines are only found in the upper side of the segments, and always alternating with hair-spines.

As pseudo comb-like spines, I have designated spines the prongs of which resembled those of the former class, but which were not connected by any membrane whatever. The inner side of the prongs presented a strongly striated surface, evidently the first beginning of a distinct striated membrane. Such spines I have found only in the genus *Ilyodrilus* (Figs. 5 *e*, 5 *f*).

* Vejdovsky, Ueber *Psammoryctes*, page 140.

D.—VASCULAR SYSTEM.

The vascular system of *Tubificidæ* takes an intermediate place between those of *Enchytræidæ* and *Lumbriculidæ*. It is more complicated than in the former family, but less so than in the latter.

The main trunes are found to be a ventral vessel and a dorsal one. The former is forked in the fourth setigerous segment, the latter continues entire to the cephalic lobe of the body. Only the dorsal vessel is pulsating. Besides the above primary vessels we find three other kinds, viz, gastric, perigastric, and dermal.

The gastric vessels, again, are of two kinds, viz, secondary and tertiary. The secondary gastric vessels are in every segment two, and situated near the anterior dissipiment of the segment, one on each side of the body. They are found to closely embrace the gastric canal, hence their name, and serve to directly connect the ventral and dorsal vascular trunes.

From these secondary and gastric vessels we find numerous others, very minute ones, spreading and branching on the alimentary canal; they serve eminently to carry the blood to this organ, and are most likely present in all the species of the family.

Of the perigastric vessels we also find one pair in every segment, but situated behind the gastric pair. In the same way as this latter it connects the ventral and dorsal vessels with each other, but is narrower, longer, and its windings are more irregular. As their name implies, their chief function is to supply the perigastric cavity with blood, and partly, also, the sexual organs suspended in the same cavity. Thus we find always the perigastric vessels much larger and longer in those segments which contain receptacles and testes, &c., and their windings are oftentimes inseparably united with the latter organs. Such is especially the case in *Telmatodrilus* and *Ilyodrilus*.

The perigastric vessel in the seventh setigerous segment is generally considerably dilated, shows a strongly pulsating movement, and takes evidently the function of a heart. Of such hearts I have never found more than one pair in each worm.

In *Telmatodrilus* and *Ilyodrilus*, however, the perigastric vessels are not dilated, and no distinct hearts can be said to be existent in those worms. A substitute is, however, found in the great extension of the perigastric vessels in some of the anterior segments. In *Telmatodrilus* it is the perigastric vessels in the tenth to the sixth setigerous segments which are thus unusually long. Those of the tenth setigerous segment are the longest, and that part which is situated nearest to the dorsal vessel the thickest; that part, again, which is nearest the ventral vessel is vanishingly minute, and any pulsation in this part nearly impossible. Each anterior pair of those perigastric vessels is smaller than the posterior pair, and in the fifth setigerous segment the pair has again assumed its normal size.

In *Ilyodrilus* the perigastric vessels in the nine first setigerous segments

are all slightly pulsating, but none dilated nor differentiated enough to be called a heart. The most posterior of them is the longest and the most anterior one the most minute, just as in *Telmatodrilus*.

The dermal vascular system is always composed of tertiary vessels, mostly emitted from the perigastric vessels, and from them branching into and between the dermal and muscular layers of the body. The dermal vessels in *Limnodrilus Hoffmeisteri* are said to originate direct from the ventral vessel, and from here extend between the layers of the integument.* I have observed a dermal vascular system in *Telmatodrilus*, and in *Camptodrilus corallinus*, and *Claparède* in *Limnodrilus Udekemianus* and *Hoffmeisteri*.

The blood is always yellowish red, more or less dark in different species.

E.—NERVOUS SYSTEM.

The nervous system of *Tubificidæ* resembles the same system of *Lumbriculidæ* and *Enchytræidæ*, the former, however, more than the latter. Along the ventral line of the body and closely attached to the same we find the ventral nerve trunk, in the buccal segment branching itself, forming the œsophagial commissures, again to connect on the upper side of the body in the cephalic lobe with the suprapharyngial or cephalic ganglion.

This ventral ganglionic trunk is composed of two longitudinal and parallel fibrous nerve truncs, more or less fused together, and in every segment surrounded by a ganglionic swelling or agglomeration of cellular ganglionic globules. The cellnuclei in this ganglionic substance are mostly round and regularly defined; only in *Telmatodrilus* we find them more irregular, both in regard to their general form and to the smoothness of their inclosing membrane. In every segment we find one pair of lateral secondary nerves projecting from the ventral nerve cord.

In *Tubificini* the fusion of the ventral fibrous nerve cords is nearly perfect, and the longitudinal space between them, when such one exists, is never traversed by transversal commissures, so common in the true *Polychæta*. In *Telmatodrilini*, however, those nerve truncs are everywhere connected by numerous transversal and ramifying commissures. Both truncs, however, are surrounded by the same ganglionic swellings, no division in the same being perceptible (fig. 1 k; Pl. II).

The most important differences presented by the nervous system of *Tubificidæ* result from the varying form of the cerebral ganglion, and especially its anterior and posterior margins. The concavity of the anterior margins seems in this family, as well as in *Lumbriculidæ*, to be the rule, and in the species I have had opportunity to investigate I have met with only one exception. In *Spirosperma* we find thus the anterior margin to be considerably projected, the ganglionic matter here forming a large conical processus, rivaling in size the rest of the cerebral ganglion.

Claparède, Recherches Anatomiques, p. 33.

In *Telmatodrilus* the posterior margin of the cephalic ganglion projects in a very sharp angle, and the processus formed is partially forked, perhaps the result of being attached to two different muscular bands.

In all the other species of this family both margins of the cephalic ganglion are concave in smaller or lesser degree, and the differences in the ganglion of the different species are mostly actuated by their own size and form and by that of their lateral cephalic projections.

In some species, such as *Limnodrilus Silvani* and *Limnodrilus alpestris*, the posterior upper part of the cephalic ganglion is sometimes three-lobed. The third or the middle lobe, however, was not present in all the specimens, and never in immature forms.

The lateral globular swellings of the cephalic ganglion of *Ilyodrilus sodalis* are also worthy of mentioning, but for this as well as other minor variations of the ganglion I must refer to the descriptions given under the headings of the different species.

F.—GENERATIVE SYSTEM.

In no class of animals are the generative, or especially the copulative, organs so complicated and so remarkable for their delicate structure as in the family of *Tubificidæ*. These organs consist here, as in other families of Oligochæta, of two classes, viz, *reproductive* and *conductive*. Each of these classes can further be divided into male and female.

The reproductive organs are—

1. Male: Testes.
2. Female: Ovaries.

The conductive or receptive organs are—

3. Male: Efferent duct and copulative organs.
4. Female: Oviducts and receptacles.

Of these the lower end of the efferent duct, or the copulative organ proper, penis, is invaginated in the oviduct, and both form, so to say, one single but rather complicated organ. Both will therefore be considered together.

TESTES.

These organs consist of one or several large, sack-like, amorphous bodies, situated either in front or behind, or sometimes both in front and behind, the cingulum (segment containing the efferent duct and oviduct). In *Telmatodrilus* we find one pair of testes occupying the eighth and ninth setigerous segments, one testicle on each side of the ventral ganglion. In this genus no testes are found behind the cingulum. In *Tubificini* the testes are generally situated behind the cingulum or copulative organs. They consist either of one single sack-like testis, extending through several segments, or of several small ones more or less connected with each other. In *Ilyodrilus sodalis* the testes occupy ten segments, beginning in the twelfth and extending to the twenty-second setigerous segment. They seem in this species not to be connected with each other. In *Ilyodrilus Perrierii* they occupy four seg-

ments, from the eleventh to the fourteenth, and in *Ilyodrilus fragilis* we find them not only in the three first segments behind the cingulum, but also in front of the same.

In *Spirosperma* a large single testis is found in the ninth setigerous segment, occupying that segment and a part of the next or the tenth segment. But also in the eleventh, twelfth, and thirteenth segments are found testes, but here not a single one, but one pair in each segment, or, all in all, seven testes.

In *Psammoryctes*, according to Vejdovsky*, testes are as well found in the eighth setigerous segment as in the eleventh, extending as far back as to the twentieth segment. The testes in this species seem to be single.

In *Limnodrilus* we find the testes generally behind the cingulum, except in the two species described by *Claparède*, viz, *L. Hoffmeisteri* and *L. Udekemianus*, both of which have testes, one in front of the cingulum, or in the eighth segment, and one or two behind the cingulum, or in the tenth, eleventh, and twelfth setigerous segments.

In *Limnodrilus Silvani* we find one pair of testes in the eighth segment, and one single continuous testis behind the cingulum in the eleventh to the fourteenth setigerous segment. In *Limnodrilus ornatus*, as in most of the species, we find testes only behind the cingulum.

In *Camptodrilus igneus* we find one testis extending through the eleventh to fourteenth setigerous segment, and one through the fifteenth and sixteenth ditto. In *Camptodrilus corallinus* the testes form a continuous body from the seventh to the fifteenth setigerous segment.

In *Hemitubifex* we also find a continuous testis extending from the eleventh to the sixteenth setigerous segment. None in front of the cingulum.

The exact number and position of the testes are oftentimes difficult to ascertain, because the different testes seem, at least apparently, to connect with each other, and every attempt to dissect them will often prove unsuccessful on account of their delicate structure. The exact number and position of the testes is also of less importance as a characteristic of the species. The most important point is to know if a testis is found in front or behind the cingulum, or if the testis is single or occurs in pair.

The single testis is the most common one. In pair the testes are found only in three species, viz:

a. In front of the cingulum in *Telmatodrilus* and *Limnodrilus Silvani.*

b. Behind the cingulum in *Spirosperma ferox.*

The testes in all the above species are not much lobed, but almost entire or amorphous. Testes similar to those of *Enchytræus profugus* and *nervosus* and *Pachydrilus* Claparède are not yet observed in *Tubificini.*

OVARIES.

The ovaries in *Tubificidæ* resemble to a great extent those met with in *Enchytræidæ.* They are mostly found in the tenth setigerous segment,

* Ueber Psammoryctes, p. 143.

close to the efferent duct, generally in front of the same. In *Telmatodrilus* they extend even into the ninth setigerous segment, and take the form of pear-shaped, sack-like bodies, of a rather larger size than those of other species.

In all the genera of *Tubificini*, except in *Ilyodrilus*, we find the ovaries in the segment of the several porus, but in *Ilyodrilus* they are situated behind the cingulum, and in *Ilyodrilus sodalis* in the nineteenth to the twenty-second setigerous segments, nearly entirely covered by the testes in those segments.

The shape of the ovaries, and the place in the same where the ova develop, vary in different species, to some extent at least, but are not of sufficient constancy to be considered as good genus and species characteristics. In *Spirosperma* the ovaries are very long and broad, sometimes triangular, with an ova developing at their anterior and broadest end. In *Ilyodrilus* we find the ovaries to be plate or dish like, concave, covering the testes like a shell, and developing the ova in one of the margins.

In *Limnodrilus ornatus* the ovary is long, narrow, and ribbon-like; in *Limnodrilus Steigerwaldi*, broad, lobed, and tapering at both ends, with the ova developing in the middle of the organ. In *L. Silvani* the ovaries are extremely long and narrow, thicker at one end than at the other, with the ova also developing at the middle of the ovary. In *Camptodrilus* they are short and narrow, bent in a right angle, with the ova developing in the same. The form, but seldom the place, of the ovary is variable, and, however interesting and important from an anatomical point of view, is of little value as characteristics of genus and species.

EFFERENT DUCT AND COPULATIVE ORGANS.

From the many different opinions and theories, supported by as many different authors, on the true nature of the oviduct and the invagination of the penis into the same, it is pretty evident that the subject is a difficult and important one, and the more interesting because being unique in the animal kingdom. Such eminent investigators as von Siebold,* d'Udekem,† Claparède,‡ and Vejdovsky§ have all advanced the opinion that the penis in *Tubifex*, *Limnodrilus*, &c., is invaginated in the oviduct, and that accordingly both the spermatozoa and the ova are ejected through the *same external porus* by means of two different organs, the penis and the oviduct. All the above investigators have seemingly agreed upon the porus through which the ova should have been ejected, but in regard to the interior opening of the oviduct, through which the ova should enter the same, not two of them have been of the same opinion.

---

*Vergleichende anatomie, p. 228.

† Histoire naturelle des Tubifex, p. 25.

‡ Recherches anatomique sur les Oligochætes, p. 23.

§ Ueber Psammoryctes Zeitschr. f. w. Zoologie, Bd. xxvii, p. 147.

Other investigators, on the contrary, such as E. R. Lankaster,* oppose the above advanced theories, and state as their opinions that oviducts independent of the penis will eventually be found, being of such a delicate structure that they have as yet escaped detection. In this case all the organs considered as oviducts should only be parts of the efferent duct and penis.

That the investigation of this subject is a difficult one is recognized by both Claparède and Lankaster, and both believe that we will always remain in doubt as to the nature of the oviduct, because direct observations of the passage of the ova through the oviduct must be and are extremely difficult to make. As yet I have not heard of any such observation.

Before I begin to review the different opinions of Claparède, Vejdovsky, and others upon this subject it will be necessary to first shortly describe the different membranes sheaths, and muscles which I have found to belong to the copulative organs, and some of which I believe must belong to the oviduct.

The male organ consists in well-developed specimens of two different parts, viz:

a. Efferent funnel, efferent duct, atrium with prostata and penis.

b. Penis sheath.

The different parts under *a* are all connected with each other, and constitute what is generally known as the "efferent duct." Not so with the penis sheath, which can be considered, in a fully developed specimen, as an accessory organ; surrounding the penis proper at its lower end, and being open at both extremities, is connected with the penis only, if at all, by minute muscles.

The efferent duct, with its funnel-shaped aperture, is, next to the atrium, the least variable part of the copulative organ, and constitutes always the upper part of the organ, and is in our present family of *Tubificidæ* always single. The middle part, or atrium, of the copulative organ is always thicker and somewhat bent, and furnished with either one single prostata gland, as in *Tubificini*, or with several ones, as in *Telmatodrilini*. The cells of the atrium are generally large and distinct, and quite different from those of the efferent duct proper. The interior of the efferent duct is coated with a ciliated epithelium, but in the atrium, or penis proper, this is absent.

The lower end of the atrium is tapering towards the exterior apex, forming the penis proper. The penis is somewhat differentiated, the cells sometimes having a more regular form and arrangement than those of the atrium. Where, however, the atrium ends and the penis proper begins is impossible to decide upon, as the change from one organ to the other is very gradual, and sometimes even none at all. When the atrium has entered the penis sheath and the oviduct it may, however, be considered as a true penis.

---

* Ann. and Mag. of Nat. Hist., Vol. VII, p. 90–100.

The penis is sometimes, not always, surrounded by a penis sheath, chitinous and generally of a cylindrical form, which, more than any other, seems especially adapted to strengthen the organ and direct its course at copulation. The penis sheath is situated outside the penis, surrounding the same, and if any connection between them exists it is only through minute muscles.

As female organ or oviduct I consider several sheaths surrounding the penis sheath, and generally resembling this latter, both in form and length, the width, of course, being larger. The interior of those sheaths incloses always the penis sheath tightly, and resembles the same both in form and size. It is sometimes chitinous, sometimes muscular, sometimes even entirely wanting. Both its extremities are free, neither connected with the atrium nor with the body wall. Its interior surface is never connected with the penis sheath, but both have evidently free motion, one outside the other. I have called this sheath "the interior sheath of the oviduct," or sometimes shortly "the interior oviduct." When it is absent I have called the oviduct "single;" when present, "double."

The exterior oviduct generally consists of a large, sack-like organ, surrounding the inner sheath entirely. One end of the same is always attached to the body wall all around the genital porus. The interior aperture is free in one respect, viz, that it is not directly connected with any parts of the atrium, penis sheath, or interior oviduct. With the body wall, however, it is nearly always connected by longitudinal, circular, or spiral muscles. This organ I consider as the true oviduct, and its inner aperture, which is always to be found in the neighborhood of the aperture of the inner sheaths, as the true inner aperture of the oviduct, through which the ova enter the same, after having been freely suspended in the perigastric cavity of the cingulum.

After having entered the inner aperture I have reason to believe that they pass between the inner and outer sheaths of the oviduct towards the exterior genital porus. The muscles, nearly always surrounding the exterior oviduct, are often so numerous that they obscure that organ entirely, or at least make it very difficult to discover its inner aperture.

In the different figures appended to this paper the following abbreviations are used: p.=penis; p. s.=penis sheath; ovd.=oviduct; ex. ovd.=exterior oviduct; in. ovd.=interior sheath of the oviduct; atr.=atrium; eff.=efferent funnel; effd.=efferent duct; in. aptr.=interior aperture; ex. aptr.=exterior aperture; pr.=prostate gland, and g. p.=genital porus. As figures for reference I would suggest figures: 1*e*; 2*h*; 3*h*; 5*g*; 6*c*; 9*c*; 10*e*; 10*f*; 12*g*; 15*a*; 16*a*, in which the different parts of the copulative organs as described above are delineated.

After this preliminary review of the copulative organs as I have understood them, we may return to a perusal of the same organs as they have been described by Claparède and Vejdovsky.

Claparède, in his celebrated and excellent work "*Recherches Anatomiques sur les Oligochètes*," describes three species of worms belonging to the family of *Tubificidæ*. Of these, two species are named *Limnodrilus*, a genus here for the first time introduced, and one classified in the old genus *Tubifex*. *Tubifex Bonneti*, as being the best known species in the genus, can evidently serve as type for the same. This species is also the best described and figured of the three, and for this reason I believe that Claparède studied the same last of all.

If we turn to the above-mentioned work (Pl. II, Figs. 1, 3, and 4), we find here not less than three different delineations of the copulative organs proper, and as far as I can judge his drawings of this species correspond more with my general description of the copulative organs than with his own. In the above Fig. 4, *e* is evidently the lumen of the penis; *f* the lower end of the penis sheath, the upper end of which is not seen; *l* is the lower or exterior orifice of the interior oviduct, the upper end or interior orifice of which is plainly drawn, but not marked with any letter of reference. Between *g* and *b* is seen a circular line, which I believe must indicate the exterior orifice of the exterior oviduct. The upper end of this oviduct is not seen in the drawing. In Fig. 1, which represents the same organ, we find the interior orifice of both oviducts, the exterior one being represented as seen in optic section. What I here have designated as the exterior oviduct is by Claparède represented as being a cloaca, and is in all the figures delineated as being continuous with two longitudinal trunks of muscles outside the same. That they, however, are entirely separated from the former is quite certain, and I have also figured them as such whenever they have been present, which, however, has not been the case in every species. According to Fig. 3 the exterior coating of the atrium *e* ends somewhere near b^1, and does not inclose the oviducts. This is also in conformity with my own observations of the development of the oviduct and penis (see Figs. 17 and 18.)

If this is the case, and (in Claparède figures) if *e* does not inclose the oviduct *m*, *b*, and *g*, why could not the true interior aperture be found at b^1, and the ova enter through the same? The aperture at b^1 is evidently there for some purpose, and it is most reasonable to consider it the aperture of the oviduct. But, according to Claparède, the interior aperture should be looked for much higher up, near the upper end of the atrium, just at its junction with the efferent tube proper. A more inconvenient and difficult entrance for the ova could hardly be found, it not only being very small, but, worst of all, is covered by the prostate glands. It is true that the exterior layer of the atrium ends at the base of the efferent duct proper, but I have not been able to see any aperture here, and cannot imagine which power or which muscles should convey the ova towards the genital porus. Further on I will explain why the exterior coating of the atrium ends here and is not continued round the efferent duct.

If we now turn to Pl. I, Figs. 4 and 1, we find here representations of the copulative organs of two different species. It is most reasonable to suppose that the copulative organs of the species in the same family are formed in the same principal way, and that no very large variations will occur in nearly related genera. If, therefore, the exterior coating of the atrium in one species ends above the oviduct, it is also reasonable to suppose that it will do the same in other species of the same family.

According to the drawings of Claparède this is, however, not the case. In the figures last referred to the penis sheath is seen in both, but instead of inclosing the penis, or lower end of atrium, it is represented as inclosed in the same. The oviduct is seen as if connected with the exterior coating of the atrium, and any organ resembling the oviduct as figured for *Tubifex* is not to be found. This, however, is in full accordance with the description.

To me it appears that Claparède, in studying the *Tubifex*, really discovered the nature of the oviduct, but misunderstood it in trying to reconcile its aspect with his old ideas and those of previous investigators. Why the exterior coating of the atrium should be considered as an oviduct I cannot readily see. It would be far more natural to think that both the spermatozoa and the ova were captured by the same funnel-shaped organ and conveyed through the efferent duct to the genital porus. Besides, if the exterior coating of the atrium is considered as the oviduct, what then are all the peculiar funnel-shaped organs surrounding the penis and the penis sheath?

The copulative organs of *Psammoryctes*, as described by Vejdovsky,* exhibit some characteristics similar to those of *Tubifex*, as they are understood by Claparède.

In Fig. 9, Taf. VIII, the ovd. represents evidently the exterior sheath of the oviduct, and the lower bell-shaped organ surrounding the penis and connected with the atrium is perhaps the interior sheath of the oviduct. The interior aperture is, however, not delineated, and must, I think, be sought for in the neighborhood of *g b*. If such an aperture really exists, the whole organ resembles, to a considerable extent, not only the same of *Tubifex Bonneti*, but also that of the most of the new species described in this paper, especially so *Tubifex Campanulatus*. According to the above figure the ova pass between the exterior oviduct and what I have designated as the interior sheath of the same. I have myself had no observation on this point, and must reserve my opinion until some future time.

We will now again return to our new species, and more minutely review their copulative organs and compare them with each other and with those of formerly known species.

In a preliminary report† on this subject I stated as my opinion that

* Zeitschrift f. w. Zoologie, Bd. xlvii. Ueber Psammoryctes.

† Preliminary report on genera and species of Tubificidæ, by Gustaf Eisen. Bihang till k. Svenska Vet. Akad. Handlingar, Band 5. No. 16. 1879.

the most primitive and simplest oviduct was found in *Telmatodrilus*, and that it here consisted merely of a fold of the body wall. Investigation of a larger number of species, however, has led me to considerably change my former views, and the discovery of a minute penis sheath even in this species is evidence that the penis and oviduct here are just as complicated as in the subfamily of *Tubificini*.

The oviduct of *Telmatodrilus* (Fig. 1, *e*, ovd.) consists of a large, heavy, opacous, muscular sack, inclosing the whole of the interior penis. One end of the same is attached to the body wall all round the genital porus. The other end is free, but its aperture is not clearly defined, and so surrounded by muscles that all observation is very difficult. The oviduct in this species is single.

In *Tubificini* the oviduct always consists of a more or less sack-like organ, extending from the genital porus towards the interior of the body. In the species of *Tubifex* this organ is broad and rounded; in *Camptodrilus* elongated and narrow. In *Limnodrilus* and *Camptodrilus* the interior aperture of the oviduct is extremely narrow, inclosing the atrium tightly, at least when the animal is dead, and the most careful observation is needed to detect it at all. In *Hemitubifex*, *Tubifex*, *Spirosperma*, and also in some species of *Ilyodrilus*, this aperture, however, is wide and easily detectable. In many instances the oviduct is funnel-shaped, and sometimes the widest opening turned toward the body wall, as in *Ilyodrilus sodalis*. In other species, such as *Hemitubifex* and *Ilyodrilus fragilis*, the contrary takes place. In *Ilyodrilus sodalis* the membrane of the oviduct is full of very minute spicula irregularly distributed. Such spicula are also found in the oviduct of *Psammoryctes*, but here only at the upper end of the organ where it touches the atrium proper. The exterior oviduct is more or less chitinous, but also muscular, as in *Spirosperma* and *Ilyodrilus Perrierii*.

An interior sheath between the oviduct and the penis sheath, or what I have designated as a double oviduct, is found in many species. We find it thus in all the species of *Limnodrilus* except in *L. ornatus*. In *Camptodrilus* we find it only in *C. spiralis*, but not in any other species of the genus. The oviduct is also double in *Hemitubifex*, *Tubifex*, and *Ilyodrilus Perrierii*. This interior sheath of the oviduct is free at both ends, and not directly connected with the body wall. In *Camptodrilus spiralis*, *Limnodrilus alpestris*, and *L. monticola* this interior sheath is chitinous, and resembles closely the form of the penis sheath, which it incloses. In *Limnodrilus Steigerwaldii* it is decidedly muscular, composed of numerous layers of concentric muscles of apparently great strength. In *Hemitubifex* the exterior and interior sheaths of the oviduct are exactly of the same form as the penis sheath, or funnel-shaped, but of course of different sizes, as the one is inclosing the other.

The exterior oviduct is always more or less surrounded by muscles. Generally these are longitudinal, and attached either to the exterior surface of the oviduct, and in this case of a greater number, or to the

upper and interior surface of the oviduct, but in this case consisting only of two main longitudinal trunks. Such muscles are found in *Tubifex*, *Ilyodrilus fragilis*, and *Hemitubifex*, but not in any species of *Limnodrilus* or *Camptodrilus*.

In *Limnodrilus Silvani* and *Hoffmeisteri* we find the oviduct surrounded by circular or concentric muscles. In the former species, however, they are very few. In the genus *Camptodrilus* we find the most characteristic feature to be the large spiral muscles surrounding the oviduct. They are of an enormous length, many times longer than the oviduct, around which they wind themselves several times. The exterior end of these muscles are attached to the body wall, near to the genital porus, but the interior one to the lower part of the oviduct. We get the best idea of these muscles if we to the blunt end of a lead-pencil attach a number of equal threads and afterwards wind them spirally round the pencil towards the pointed end and from here return towards the blunt end again, always winding the threads in the same direction, or towards us.

In some instances it seems as if the spiral muscles were wound round the oviduct several times; in others again as if only twice.

The work such muscles can perform may be easily understood. The upper end of the plexus is funnel-shaped, and, as it seems, eminently adapted to capture the ova, and when once captured a few successive contractions may suffice to push them towards and through the sexual porus.

In different species said muscles are found to be of very different size. In *C. spiralis* they are so minute and fine that careful searching is necessary to detect them; but in other species, however, their strength and thickness make them easily discernible. The occurrence of such muscles is unique, not only in the class of *Oligochæta*, but also, as far as I know, in the whole animal kingdom.

EFFERENT DUCT.

The efferent duct is less subject to variation than any other part of the copulative organ.

We distinguish of the same, however, two different types, viz:

a A short and broad tube, found in the genus *Ilyodrilus*, and similar to the same organ of *Mesenchytræus* of the family *Enchytræidæ*.

b A longer and more slender tube, found in all the other genera, and corresponding in form to the same organ of *Archienchytræus* and *Neoenchytræus* of the family above referred to.

In *Ilyodrilus sodalis* we find the form intermediate between the two, not quite so broad and short as in the two other species of the genus, but also far from reaching the relative length of the same organs of the other genera of *Tubificidæ*. In *Telmatodrilus* the efferent duct is unusually short, but also correspondingly narrow.

The inner end of the efferent duct is always furnished with a large

funnel-shaped orifice, especially adapted for capturing the spermatozoa. This efferent funnel is mostly covered along its inner surface with vibrating cilia, protruding far outside its exterior margin. In *Limnodrilus alpestris* and *Camptodrilus spiralis*, however, the cilia must either be very minute or entirely absent, as I have repeatedly failed to observe them, at least in the margin of the funnel. The funnel cilia of *Hemitubifex* are longer than the funnel. The exterior of the efferent funnel is in *Ilyodrilus Perrierii* covered with dark oblong glands. In some species, such as *Spirosperma*, etc., the cells composing the funnel are large and plainly visible; in others again, such as *Ilyodrilus fragilis*, only the cell-nuclei can be seen.

The main body of the atrium consists of two separate layers or coatings, one overlaying the other. Only the interior one of those extends clear down to the apex of the penis. The exterior one, on the contrary, does not extend farther than to the upper end of the penis sheath, and ends here somewhat abruptly. Its lower continuation, from which it was easily separated, forms the exterior sheath of the oviduct when such a sheath is present. When not present, it must either have been absorbed or grown together with the interior oviduct, and forming what I have here mentioned under the name of a single oviduct. Further ahead in this paper I will endeavor to show how such separation has taken place and in what way the oviduct has originated.

The form of the oviduct varies some in different genera, but not enough to furnish good genus characteristics. In *Telmatodrilus* the atrium is cylindrical, bent like a crescent, but not tapering towards the ends. The atrium in this family is furnished with several distinct prostate glands, cropping out, as it were, on all sides of the atrium. In *Tubificini* the form of the atrium is less regular, and resembles more an oblong sack, more or less tapering towards both ends, especially towards the penis. In *Tubifex* this lower part of the atrium is shorter than in any other genus. In *Limnodrilus* it is longer—longer even than the upper part, which is swelled. In *Ilyodrilus* the atrium is very irregular and its form inconstant. In the same species it is sometimes considerably extended, sometimes again contracted in length, and constricted in several different places, however without forming anything like a "*vesicula seminalis*."

From this general form of the atrium we meet with two notable exceptions: the one in *Psammoryctes*, the other in *Hemetubifex*. In both these genera the upper end of the atrium, which carries the prostate gland, is enlarged and perfectly globular, and at least in form distinct from the other part of the atrium. In *Psammoryctes* the lower end of the atrium, or that part which is situated between the "globular chamber" and the penis proper, is long, narrow, tube-like, and not glandular.* But, according to E. Ray Lankaster, this peculiar tube should resemble the corresponding part in *Limnodrilus*. If this is the case the tube must

* Vejdovsky, Ueber Psammoryctes, p. 145.

certainly also be glandular and be no exception to the rule, and the difference should then only refer to the form or perhaps pellucidity of the organ. According to Vejdovsky, who calls this organ "kittgange," anything similar should not be found anywhere else, not even in *Limnodrilus*, and would in such a case, together with the globular chamber, form an accessory organ entirely distinct from the atrium. I am satisfied, however, that this is not the case, and think that the two parts just referred to, the circular chamber and the pellucid tube, constitute nothing else than the atrium proper. And that part to which Vejdovsky has given the name of atrium proper is evidently nothing else than the upper part of the penis proper. When we in all the other species of *Tubificidæ* assign the name of atrium to that part of the efferent duct which supports the prostate gland, why should we give it another name in *Psammoryctes* only because it here has a somewhat different form? Is it not easier to imagine that an old organ has been modified than to believe that a new one has been added?

In *Hemitubifex* we meet with an atrium of somewhat similar shape. The upper end of the same, close to the efferent duct proper, is also globular and supports the prostate gland, and is, as far as I can judge from figures and descriptions, entirely homologous to the same organ of *Psammoryctes*. The narrower part of the atrium, however, is not quite so regular and tube-like as in this latter genus, but the homology of the organs seems evident. Also, in *Hemitubifex* this lower part of the atrium is less glandular than the circular chamber, but this is also the case in nearly all the species I have investigated and is not characteristic of the genus. That part of the organ which corresponds with what Vejdovsky calls "*atrium*" is, at least in *Hemitubifex*, nothing else than the upper part of the penis proper.

The figures will in every instance give a better idea of the organs in question, and I must therefore mainly refer to them. (For Hemitubifex see Pl. VII, Fig. 6 *c*.)

In *Tubificini* we find the atrium furnished with only one single-lobed prostate gland, the form of which only varies little in the different species. It always takes the shape of a more or less sponge-like, or even fan-shaped, body, the latter when seen in optical section. The size of the cells composing the prostate varies in different species, but not enough to furnish species characteristics.

If we now turn to the last remaining part of the copulative organ, the penis proper, we will find it of considerably different form in the different species. The most common form of the penis is that of a long, narrow cylinder, tapering towards its exterior apex. The exterior apex of the penis is either rounded, as in *Camptodrilus* and certain species of *Limnodrilus*, or truncate, as in *Limnodrilus monticola*. In *Limnodrilus Steigerwaldii* the apex of the penis is considerably swelled; in *Limnodrilus Silvani* the penis is swelled above the apex. In *Hemitubifex* and *Psammoryctes* the upper end of the penis is considerably enlarged above

the penis sheath, and in the latter species this part has, as I think incorrectly, been considered as the atrium proper. In *Spirosperma* the lower end of the penis is composed of very large octagonal or rounded cells, quite different in form and size from those which constitute the upper part of the penis and lower part of the atrium, but more resembling those of the upper part of this organ.

Penis is surrounded by a sheath of chitinous consistency in all the genera of the family, except in *Ilyodrilus*. In *Ilyodrilus Perrierii*, however, we meet with a chitinous sheath, but it is difficult to decide upon whether this sheath should be referred to the oviduct or to the penis.

The penis sheath is nearly always free at both its ends, and never attached to the body wall. The shape and relative size of the sheath is always of the utmost importance as characterizing the species; but as I have in a former part of this paper more minutely described the same, it will now suffice to point out the few principal forms under which all other may be arranged.

The upper end of the penis sheath is always free; the lower end is free in *Tubificini*, but is in *Telmatodrilini* connected with the apex of the penis proper. That this latter is a more primitive form of the penis is evident, as in undeveloped specimens of *Tubificini* the penis sheath is always connected with the penis itself, and separates from the latter first in a later stage of development. But to this I will return further on. In *Telmatodrilus* the penis sheath is funnel-shaped, the interior end being the widest. In *Tubificini* the form of the sheath is either that of a funnel, as in *Hemitubifex* and *Ilyodrilus Perrierii*, or tube, cylindrical, or trumpet shaped, as in the most of the species of *Limnodrilus* and *Camptodrilus*. In *Limnodrilus Silvani* we meet with an aberrant form, its penis sheath taking the shape of an arrow-head, at least when seen from the front. The upper end of the penis sheath is in *Limnodrilus ornatus* furnished with a ring of star-like glands, the functions of which are not understood. Generally the penis sheath covers the penis clear to apex, but in *Spirosperma* and *Limnodrilus Steigerwaldii* the penis protrudes considerably beyond the sheath.

In adult specimens of *Telmatodrilus* the penis appears to be constantly projecting through the genital porus, but in *Tubificini* this projection takes place only during copulation. This sexual porus is always found in the tenth setigerous segment, and in *Tubificini* just in front of the ventral spines, but in *Telmatodrilini* between the spine fascicle and the ventral ganglion.

DEVELOPMENT OF THE COPULATIVE ORGANS.

Vejdovsky, in his most beautiful work, *Monographie der Enchyœtriden*,* gives evidence of the development of the efferent duct and copulative organ in that family. It is only natural to suppose that the course of development of such an important organ as the *efferent duct* should be

* Plate I, Fig. 12.

about the same in two so nearly related families as *Enchytræidæ* and *Tubificidæ*, the much more so because if we consider the same development of this organ to take place in both families it would at once explain the invagination of the oviduct in a most easy and, as it would seem, most natural way. The oviduct, once formed by an inturning of the body wall, would easily have been invaginated by the efferent duct, originated on and projecting from the septal tissues of a neighboring segment. Its exterior end, instead of connecting with the body wall, would then merely remain suspended in the oviduct, or perhaps even later be connected with this organ through accessory muscles.

However plausible such a theory may seem, and however easily it may explain one of the most complicated anatomical facts, my own observations have necessitated me to reject the same; and I will in the following endeavor to demonstrate the course of development of the copulative organs in *Tubificidæ*. The species I have studied for this purpose were *Limondrilus alpestris*, *L. corallinus*, and *Telmatodrilus*. The first named of this species was especially favorable for observation.

The first sign of the efferent duct I find to be a small glandular, or at least cellular, agglomeration, situated on the body wall of the tenth setigerous segment, one on each side of the ventral nerve, and exactly on the place where in a future stage of development the genital porus will be found. (Figs. 18 *a* and *b*.)

This cellular agglomeration is convex, and in shape somewhat resembling a raspberry. When viewed from above it will be found to consist of two different layers, one exterior or cortical (Fig. 18 *a*: cr. l.), and one interior (in *l*). In the same specimens I looked in vain for any agglomeration of cells on the septal tissues which could be considered as the first beginning of the efferent duct.

In a further advanced stage this primary agglomeration is found to have increased in size towards the perigastric cavity, and assumed the form of an oblong body, tapering slightly towards its free interior end. Both the interior and exterior layers are now more differentiated, the former one being more or less transversely striated and the latter seemingly composed of longitudinal tissues (Fig. 18 *c*). The cortical layer is also seen to be covered by a minute coating of pellucid cells, and the interior cellular mass is pierced by a narrow lumen or canal, the future seminal duct.

When this large glandular body has reached a certain size or a certain stage of development, it opens at the top and the interior matrix grows out and forms a long and narrow tube, the future efferent duct proper.

In more advanced specimens this tube is found to be connected with the septal tissues, and its interior end furnished with a large circular body, considerably flattened, and composed of large round cells. This round body is situated on the other side of the dissepiment, and evidently the first beginning of the efferent funnel (Fig. 18 *f*). The way

this efferent duct is developed from the interior matrix of the sexual gland explains at once why it has one coating less than the atrium, the exterior coating of the latter being the original cortical layer of the primitive gland.

Thus the efferent duct and copulative organs are exteriorly modeled long before their interior parts are in any more advanced state of differentiation. In maturer specimens we find the first signs of such a differentiation to be a bursting of the cortical layer somewhere midway between its base and top (Figs. 18 *d:* x, 18 *g:* c, 18 *h:* ap. ps.), and shortly afterwards a hoof-like line is perceived in the interior of the inner matrix, the convexity of the line being turned towards the sexual porus (Fig. 18 *d:* xx). At the same time another fissure is seen to extend from the opening in the cortical layer towards the interior of the inner layer or matrix, without, however, uniting itself with the hoof-like line (Fig. 18 *d: f*). This first-mentioned hoof-like fissure is only the outline of a cavity, which, developing, shortly fills the larger part of the interoir matrix, and as yet communicates with the exterior only through the lumen leading to the sexual porus.

This cavity I consider as the beginning of the future oviduct. That part of the matrix which surrounds the cavity, and which is directly inclosed by the cortical layer, is destined to become the oviduct proper; that part, on the contrary, which is surrounded by the cavity becomes the penis proper and its sheath (Fig. 18 *g:* ca. = cavity, p. = penis, ps. = penis-sheath, and ovd. = oviduct).

When this cavity has reached a certain development all connection between the oviduct and the penis proper is severed at the top of the former (Fig. 18 *h:* in. ap.), or just inside the first circular fissure in the cortical layer.

Gradually a penis sheath is separated from the main body of the penis by the further extension downwards of the above-mentioned vertical fissure (Fig. 18 *g: f;* Fig. 18 *h: f*). To begin with, this fissure does not reach the cavity of the oviduct, and the primitive penis sheath remains connected with the penis at the exterior apex. Further on, however, this connection is fully severed in species of the subfamily *Tubificini*, but in *Telmatodrilini* this connection remains even in the highest developed specimens, and forms one of the principal characteristics of this family (Fig. 17 *a:* ps.).

The penis sheath, when first separated, is very thick and cellular, but is finally partially absorbed and assumes a chitinous consistency; even the oviduct decreases in thickness, at least in the species of *Tubificini*. In species with a double oviduct, the cortical layer remains separated from the interior oviduct, and forms the exterior sheath of the oviduct, but in species where the oviduct is single I believe the cortical layer and the interior oviduct to have grown together to form the final single oviduct. Even the pellucid epithelium, which once surrounded the cortical layer, is absorbed, leaving the entrance to the oviduct free (Fig. 18 *h:* in. ap.).

The atrium and prostate gland are, to begin with, entirely surrounded by the cortical layer, and the prostata evidently develops only from the interior matrix. While developing they burst through the cortical layer, which remains as the exterior coating of the atrium (Fig. 17 *a*: ps.).

From the above investigations, imperfect as they are, I think the following facts can be considered as established:

1. The oviduct, atrium, and penis proper do not originate on the septal tissues; but
2. Develop from a large gland which originates on the body wall.
3. The oviduct and penis are originally united.

RECEPTACLE.

The receptacles are found in the ninth setigerous segments, and consist of two more or less sack-like bodies, one on each side of the ventral nerve trunk, and are in *Tubificini* attached to the body wall just in front of the ventral spine fascicles, but in *Telmatodrilini* between the ventral and dorsal fascicles. In *Lumbriculidæ* the receptacle opens behind the ventral spines, and in *Enchytræidæ* between certain segments. Of the receptacles we can distinguish three different forms, which, however, are connected by numerous intermediate ones. The most simple form of the receptacle is that of a sack, gradually increasing in size from the external porus to the internal apex. Such is the form in *Telmatodrilus* and in certain species of *Camptodrilus* and a few other genera. The upper end of such a receptacle is sometimes bent.

In other species we find the receptacle to consist of two unequal parts, the lower one of which is tube-like and narrow—a mere duct for the spermatozoa. The upper or inner part, on the contrary, is generally enlarged and bent, and serves mainly as a receptacle proper. Such a form is met with in *Tubifex campanulatus*, *Ilyodrilus Perrierii*, *Ilyodrilus fragilis*, and in *Spirosperma*, in which latter genus it reaches an unusual size, extending as it does through several segments. In its highest developed form the receptacle consists of three different parts, one upper sack-like or receptacle proper, one middle narrow tube, and one lower muscular part situated nearest the external porus. Such receptacle is found in *Hemitubifex insignis*, *Limnodrilus alpestris*, and *L. Silvani*. Intermediate forms are found in *Ilyodrilus sodalis*, *Limnodrilus ornatus*, &c.

The base of the receptacle is furnished with accessory glands only in two species, viz, *Ilyodrilus sodalis* and *Hemitubifex insignis*. In the former species we meet with only one single gland at the base, in the latter with three for each receptacle (Fig. 5 *h* and Fig. 6 *e*).

I have as yet found spermatophores only in few species, but am inclined to believe their occurrence to be the rule rather than the exception. Of the spermatophores we can distinguish three different forms, viz:

a. The spermatophore is shuttle-like, generally tapering toward one

end. The tails of the spermatozoa extend outside of the main body of the spermatophore.

In some spermatophores the tails are more numerous in one end than in the other. (See *Limnodrilus Silvani* and *L. alpestris.*)

In *Tubifex campanulatus* the spermatophore was surrounded by a large pellucid bag, which, perhaps, also may be the case in other species.

b. The spermatophore is more cylindrical and not covered with the tails of the spermatozoa. Such is the spermatophore of *Tubifex coccineus.**

c. The spermatophore extremely long and narrow, coiled into a kind of spiral and surrounded by a large pellucid membrane. The exterior is here seemingly divided in numerous oblique segments. Such a spermatophore is found only in *Spirosperma.*

The form of the spermatophores is more or less variable, and can only exceptionally be of any value as a specific or generic characteristic. Only in *Spirosperma* the spermatophores appear to be of a more constant form, and in fact resemble each other closely.

G.—SEGMENTAL ORGANS.

The segmental organs in *Tubificidæ*, and in fact in all the families of *Oligochæta*, open in front of the ventral spines. They are found in all the setigerous segments, except in 1st to 5th or 1st to 6th, and in 8th to 10th or even 8th to 11th. It is evidently this absence of segmental organs in those segments which are occupied by the sexual conductive organs which first gave impulse to the theory advanced by Claparède and others that the conductive sexual organs were nothing else than modified segmental organs. Vejdovsky† has, however, shown that in *Enchytræidæ* the conductive sexual organs have a quite independent origin, and considers the same to be the case even in *Naididæ.* It seems out of the question to assume that the segmental organs and *receptaculum seminis* are homologous anywhere in this class of Anelida, as there is little doubt as to their different origin, but concerning the efferent duct the question must as yet remain open, no direct observations having been made on the origin and development of the segmental organs of *Tubificidæ.* The efferent duct in this family seems to originate and develop on a quite different way from what it does in *Enchytræidæ*, and when this is the case the relationship between those respective organs and the segmental organs may also be quite different in the different families, and in any case we must regard the question as as yet unsettled and requiring a good deal more direct observation than I have had opportunity to make. I hope at a future time to be able to return to this subject, and will at present restrict myself to a description of the organs in question as they are found in this family.

The segmental organs of *Tubificidæ* resemble those of *Lumbriculidæ*

---

* *Vejdovsky:* Ueber Psammoryctis, Taf. VIII, Fig. 13.

† *Monographie der Enchytræiden*, page 40, &c.

and also those of *Enchytræidæ*, but those latter, however, to a lesser degree. The general form of these organs is in the first two of the above families exactly the same, and with *Enchytræidæ* the only difference is that the tube there is surrounded by one single mass of granulated or glandular matter, giving the whole organ a more compact consistency. In *Tubificidæ*, as well as in *Lumbriculidæ*, the duct is comparatively free, and only in *Limnodrilus alpestris* have I found a tendency to cellular agglomeration, as a few windings of the duct are here surrounded by a common cellular matrix.

The tube of the organ is sometimes surrounded all along by numerous oblong or round cells, more or less inflated, always pellucid, and sometimes furnished with a very conspicuous nucleus. Such globular cells are found in *Telmatodrilus Vejdovskyi*, *Limnodrilus alpestris* and *L. Hoffmeisteri*, *Camptodrilus corallinus*, and *C. igneus*. In *L. Hoffmeisteri* and *Limnodrilus alpestris*, and also in *C. corallinus*, they are found only on those segmental organs which are situated in front of the cingulum, but in the other species also on those situated behind the same.

Such pellucid cells are also found attached to the segmental organs of *Rhynchelmis*,* of the family of *Lumbriculidæ*.

The tube at the base of the interior aperture of the segmental organ is sometimes surrounded by glandular agglomerations of mostly a brownish or yellow color. Such agglomerations, however, are rarely met with, and I have encountered them only in *Camptodrilus igneus*. By Clarapède they are described in *Limnodrilus Hoffmeisteri* and *L. Udekemianus*.

In *Lumbriculidæ* they are found in all the genera except *Ochnerodrilus*, and in *Enchytræidæ* in *Enchytræus puteanus*, *lobifer*, and *Leydigii*.

In *Ilyodrilus fragilis* the wall of the tube below the funnel-shaped aperture was found to be considerably enlarged, or, perhaps, rather covered by several large cells, each with distinct nucleus. But the rest of the tube did in nothing particular differ from the general form.

FRESNO, CAL., *March* 15, 1880.

Vejdovsky: Anat. Studien an Rhynchelmis, page 346.

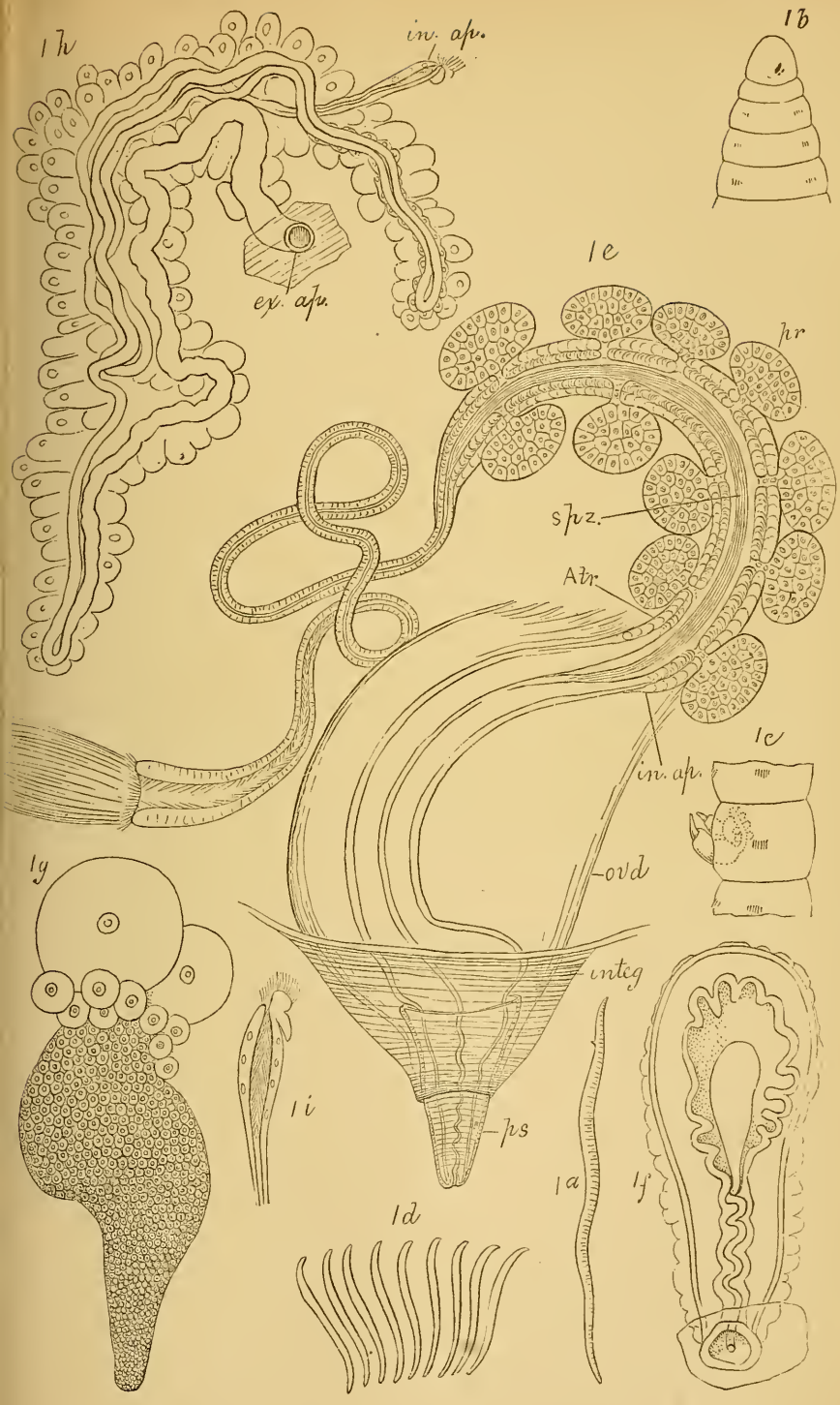
EXPLANATION OF THE REFERENCE LETTERS USED IN THE PLATES.

atr.—Atrium.
eff.—Efferent duct.
eff. f.—Efferent funnel.
p.—Penis.
p. s.—Penis sheath.
ex. ovd.—Exterior oviduct.
in. ovd.—Interior oviduct.
in. apt.—Interior aperture.
ex. apt.—Exterior aperture.
sp. mscl.—Spiral muscles.
pr.—Prostate glands.
sp.—Spines.
v. v.—Ventral vessels.
d. v.—Dorsal vessel.
n. s.—Natural size.
h. mgfd.—Highly magnified.
ovd.—Oviduct.
s. bc.—Buccale segment.
l. cep.—Cephalic lobe.
f.—The first fissure between the penis and the penis sheath.

EXPLANATION OF PLATE I.

FIG. 1.—TELMATODRILUS VEJDOVSKYI.

Fig. 1 *a*.—The worm, natural size.
1 *b*.—The anterior part of the worm.
1 *c*.—The 10th setigerous segment, showing the exterior penis.
1 *d*.—A fascicle of spines, h. mgfd.
1 *e*.—The efferent duct, atrium and penis, and oviduct. The prostate glands are seen surrounding the atrium. The muscles surrounding or constituting the oviduct are not represented.
1 *f*.—One of the receptacles in the ninth setigerous segment.
1 *g*.—One of the ovaries; at its upper end are seen some ripe ova.
1 *h*.—One of the segmental organs.
1 *i*.—The interior aperture of the same, highly magnified.


1h
inv. asp.
ex. asp.
1b
1e
pr
spz.
Abr.
inv. asp.
1c
ovd
1g
1i
ps
integ
1a
1f
1d

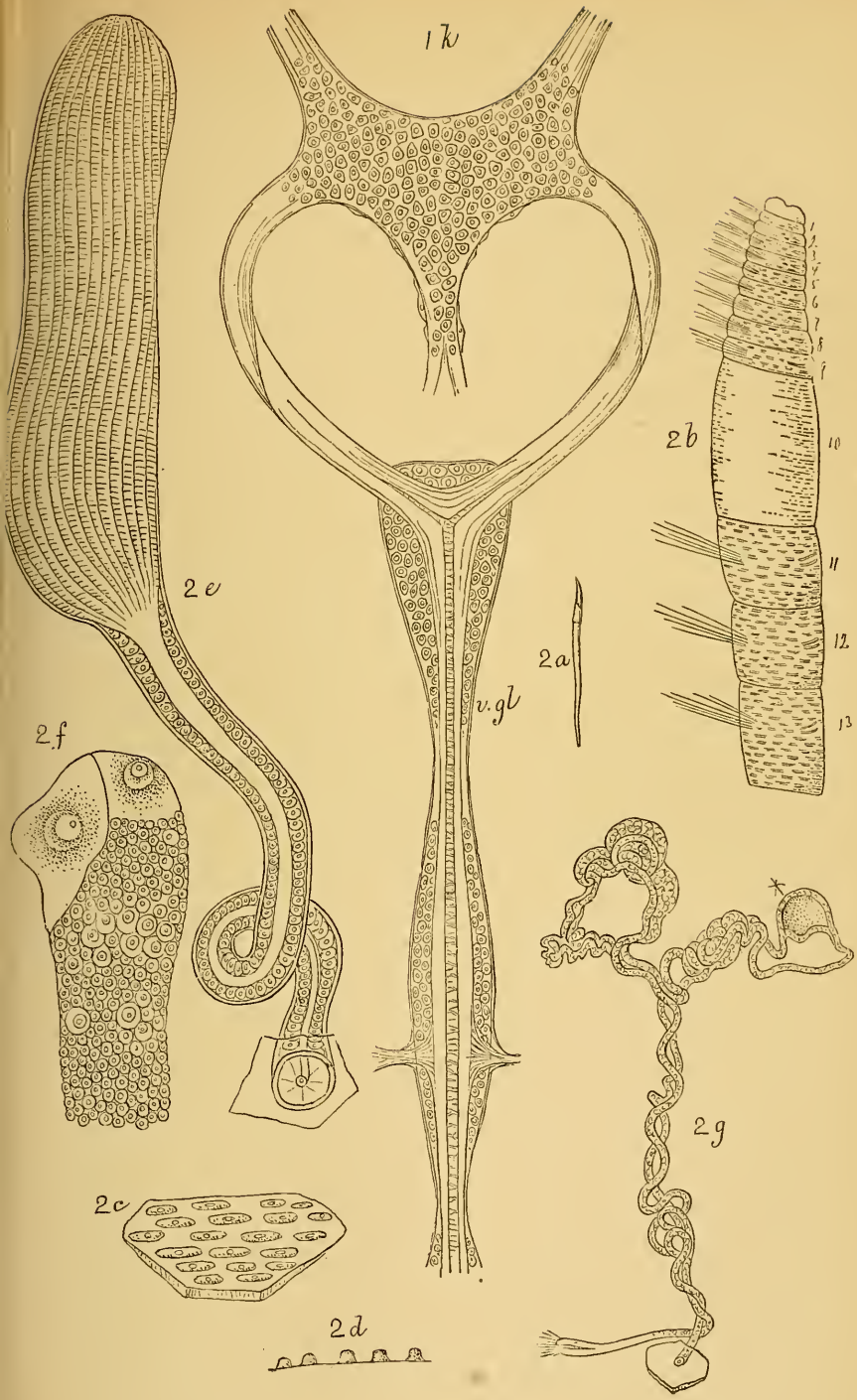
EXPLANATION OF PLATE II.

FIG. 1.—TELMATODRILUS VEJDOVSKYI.

Fig. 1 *k*.—The cephalic ganglion and the ventral nerve cord.

FIG. 2.—SPIROSPERMA FEROX.

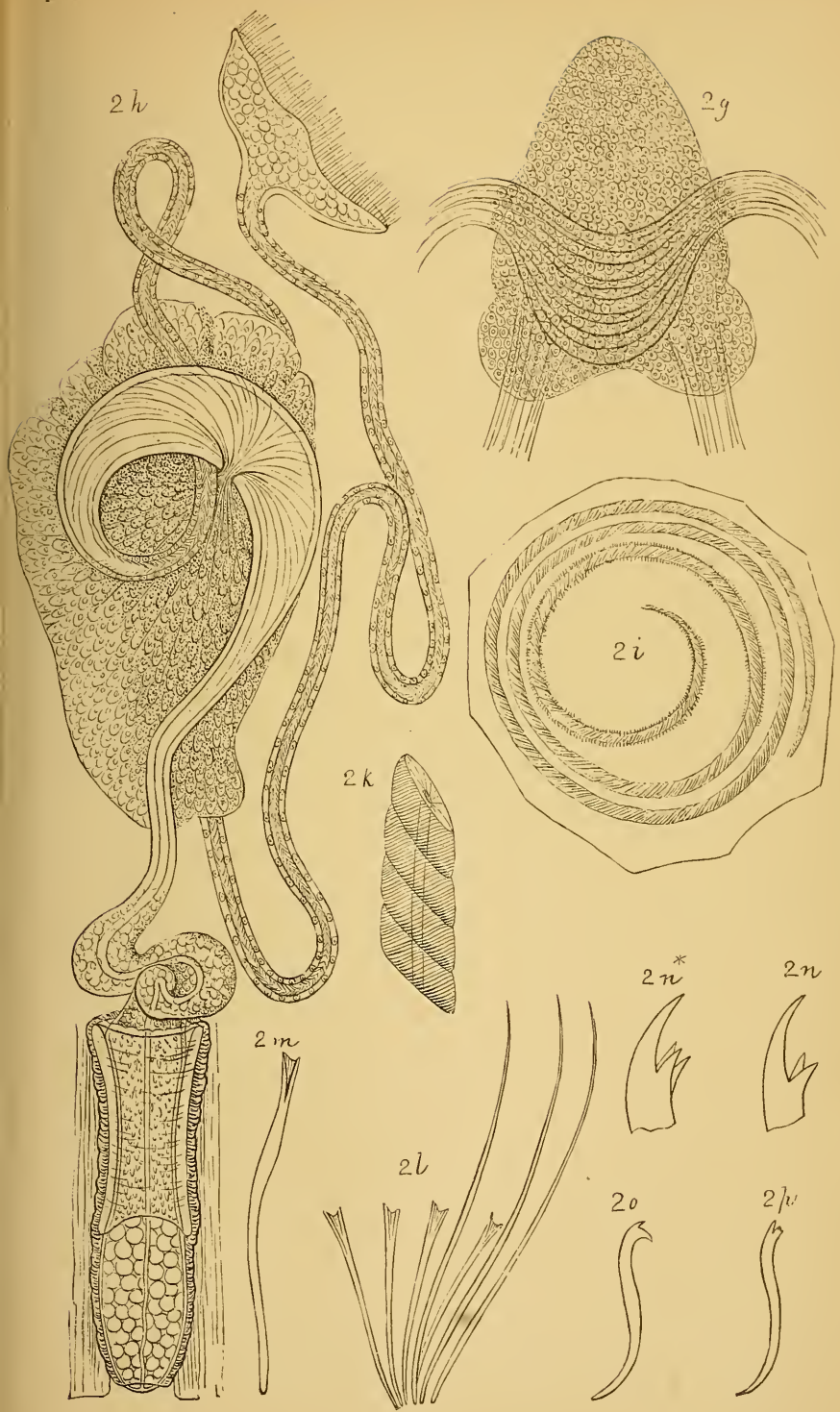
Fig. 2 *a*.—The worm, natural size.
2 *b*.—The front part of the worm, highly magnified.
2 *c*.—A part of the epithelium, showing the elevated cells.
2 *d*.—The same, side view.
2 *e*.—One of the receptacles in the ninth setigerous segment.
2 *f*.—The free end of one of the ovaries.
2 *g*.—One of the segmental organs. At * is seen an enlarged chamber in the main duct.


1k
2e
2f
v.gl
2a
2b
1
2
3
4
5
6
7
8
9
10
11
12
13
2g
2c
2d

EXPLANATION OF PLATE III.

FIG. 2.—SPIROSPERMA FEROX.

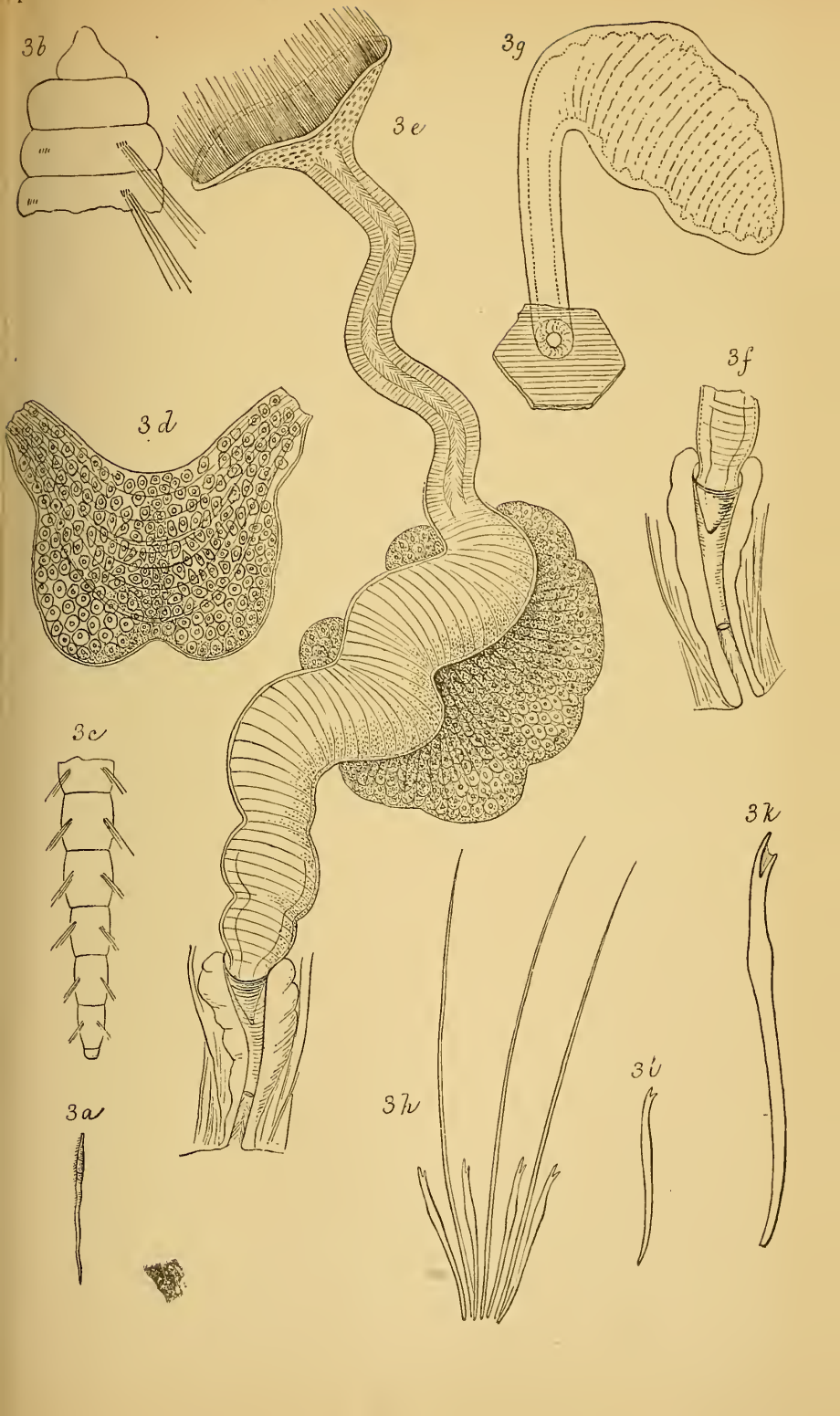
Fig. 2 *h*.—The efferent duct, atrium, prostata, penis, and oviduct.
2 *i*.—One of the spiral spermatophores, surrounded by a pellucid sack.
2 *k*.—A part of the same spermatophore, more highly magnified.
2 *l*.—A fascicle of spines from the upper side of the body.
2 *m*.—One of the fan-like spines from the above fascicle, highly magnified.
2 *n*.—The free end of a 3-forked spine.
2 *n*.*—Free end of another spine with 4 prongs.
2 *o*.—One of the biforked spines, highly magnified.
2 *p*.—Another spine with 4 prongs. The spines with more than 2 prongs are from the cephalic segments.
2 *q*.—The cephalic ganglion, seen from above.


2h
2g
2i
2k
2n*
2n
2m
2l
2o
2p

EXPLANATION OF PLATE IV.

FIG. 3.—ILYODRILUS PERRIERII.

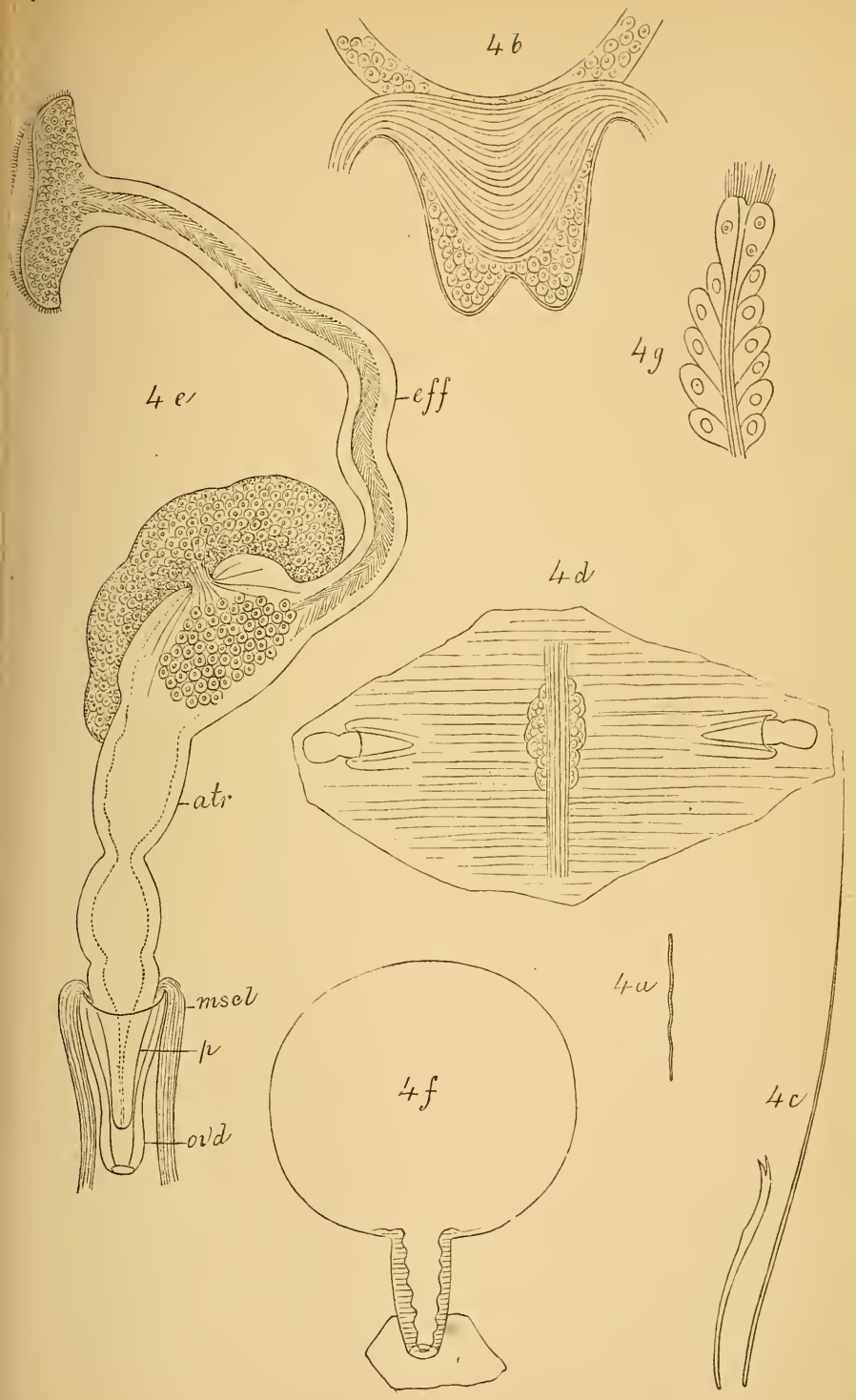
Fig. 3 *a*.—The worm, natural size.
3 *b*.—The front part of the worm, magnified.
3 *c*.—The hind part of the same.
3 *d*.—The cephalic ganglion.
3 *e*.—The efferent duct, atrium, penis, and oviducts.
3 *f*.—The penis and oviducts, more highly magnified.
3 *g*.—One of the receptacles.
3 *h*.—A fascicle of spines from the upper side of the body.
3 *i*.—One of the spines from the lower side of the body.
3 *k*.—One of the fan or comb like spines.


3b
3e
3g
3f
3d
3c
3k
3h
3i
3a

EXPLANATION OF PLATE V.

FIG. 4.—ILYODRILUS FRAGILIS.

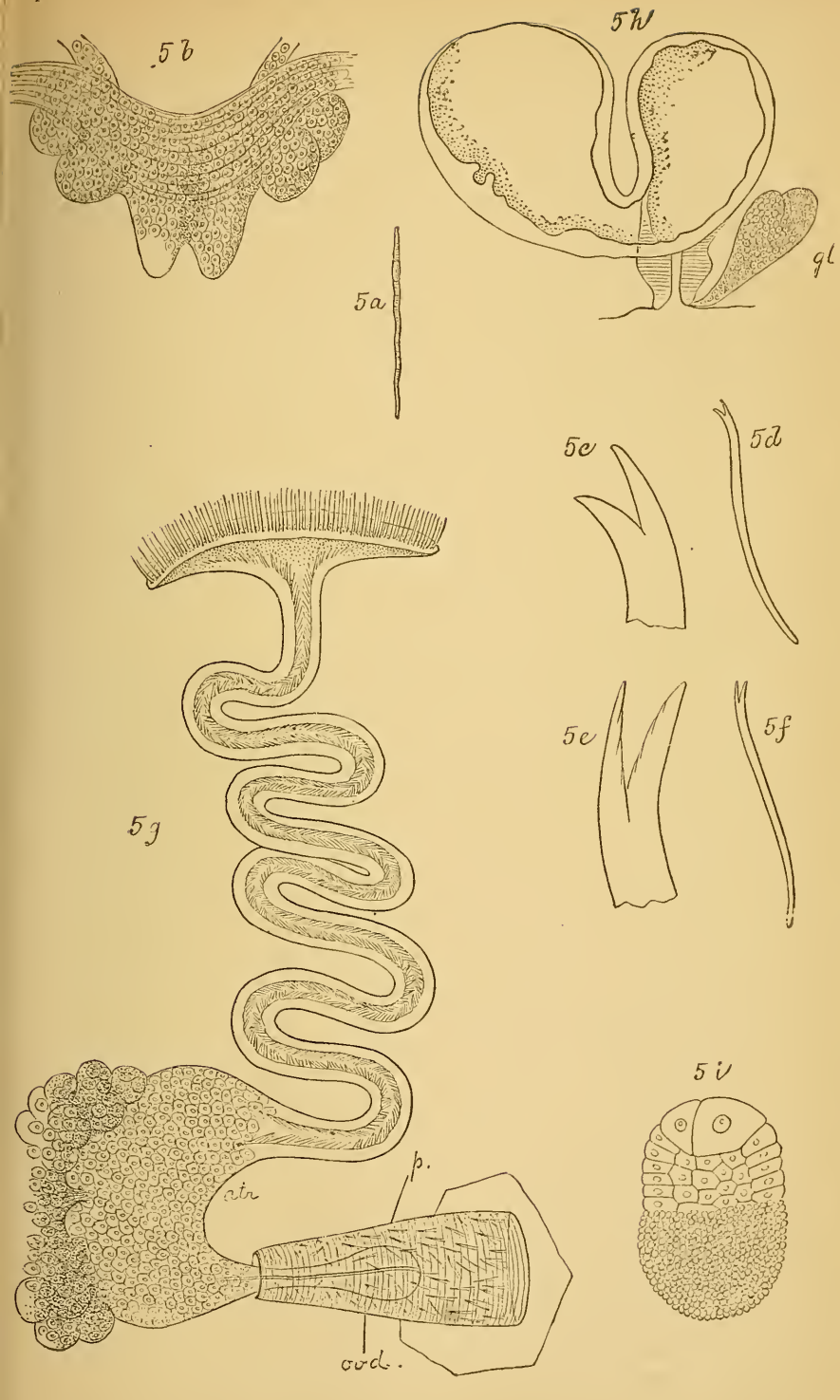
Fig. 4 *a*.—The worm, natural size.
4 *b*.—The cephalic ganglion.
4 *c*.—One of the forked and one of the hair-spines.
4 *d*.—A part of the segment containing the efferent duct, showing the distance between the exterior opening of the penis and the ventral ganglion.
4 *e*.—Efferent duct, atrium, penis, and oviduct.
4 *f*.—One of the receptacles.
4 *g*.—The interior aperture of one of the segmental organs.


4b
4g
4e
eff
4d
atr
msel
p
ovd
4a
4f
4c

EXPLANATION OF PLATE VI.

FIG. 5.—ILYODRILUS SODALIS.

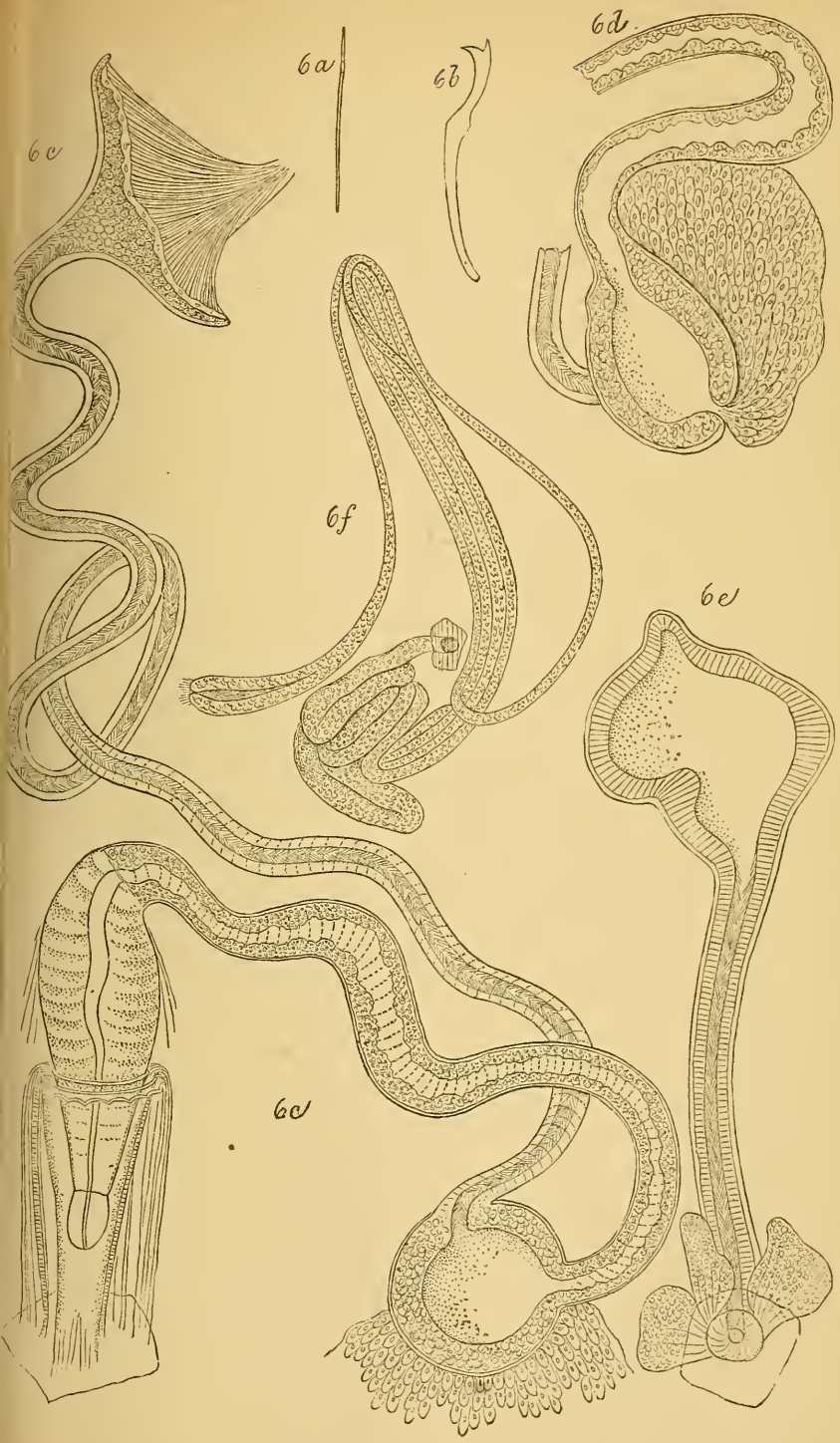
Fig. 5 *a*.—The worm, natural size.
5 *b*.—The cephalic ganglion.
5 *c*.—The front end of one of the forked spines.
5 *d*.—The same spine, whole.
5 *e*.—The front end of one of the spines, which occurs together with the hair-spines. It shows the beginning of a comblike structure.
5 *f*.—The same spine, whole.
5 *g*.—The efferent duct, atrium, prostata, penis, and oviduct. In the latter are seen numerous spicula.
5 *h*.—One of the receptacles. At its base is seen an accessory gland.
5 *i*.—One of the ovaries.


5b
5h
gl
5a
5c
5d
5e
5f
5g
5i
ov
p.
ovd.

EXPLANATION OF PLATE VII.

FIG. 6.—HEMITUBIFEX INSIGNIS.

Fig. 6 *a*.—The worm, natural size.
6 *b*.—One of the spines.
6 *c*.—The efferent duct, atrium, vesicula seminalis, prostata, penis, penis sheath, oviduct (exterior and interior). Numerous muscles are seen attached to the oviducts. *r. s* = vesicula seminalis.
6 *d*.—A part of the atrium, with the vesicula seminalis and the prostata gland.
6 *e*.—One of the receptacles. At its base are seen 3 winglike glands.
6 *f*.—One of the segmental organs.


6a
6b
6c
6d
6e
6f
6g

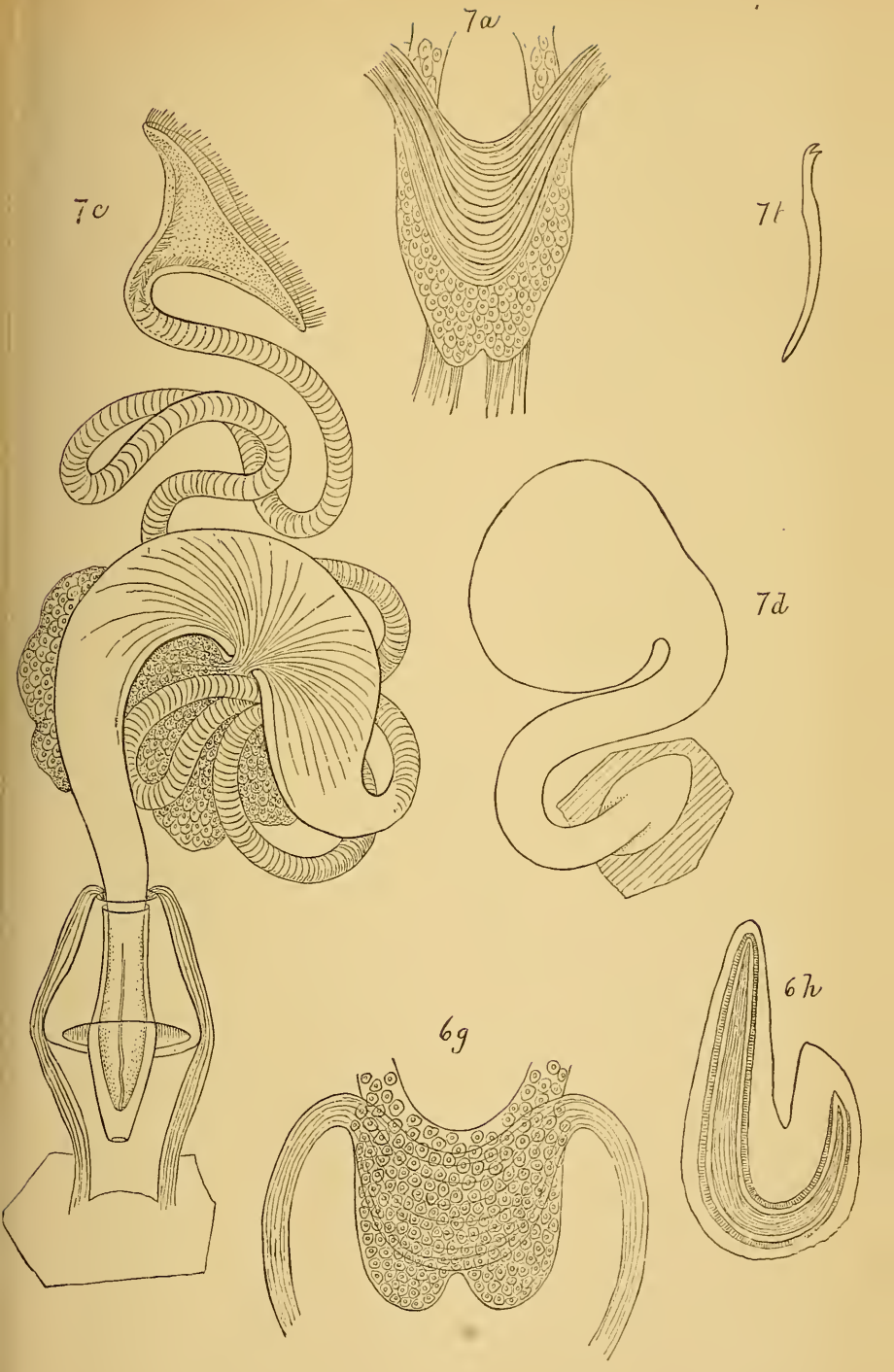
EXPLANATION OF PLATE VIII.

FIG. 6.—HEMITUBIFEX INSIGNIS.

Fig. 6 *g*.—The cephalic ganglion.
6 *h*.—One of the spermatophores.

FIG. 7.—TUBIFEX CAMPANULATUS.

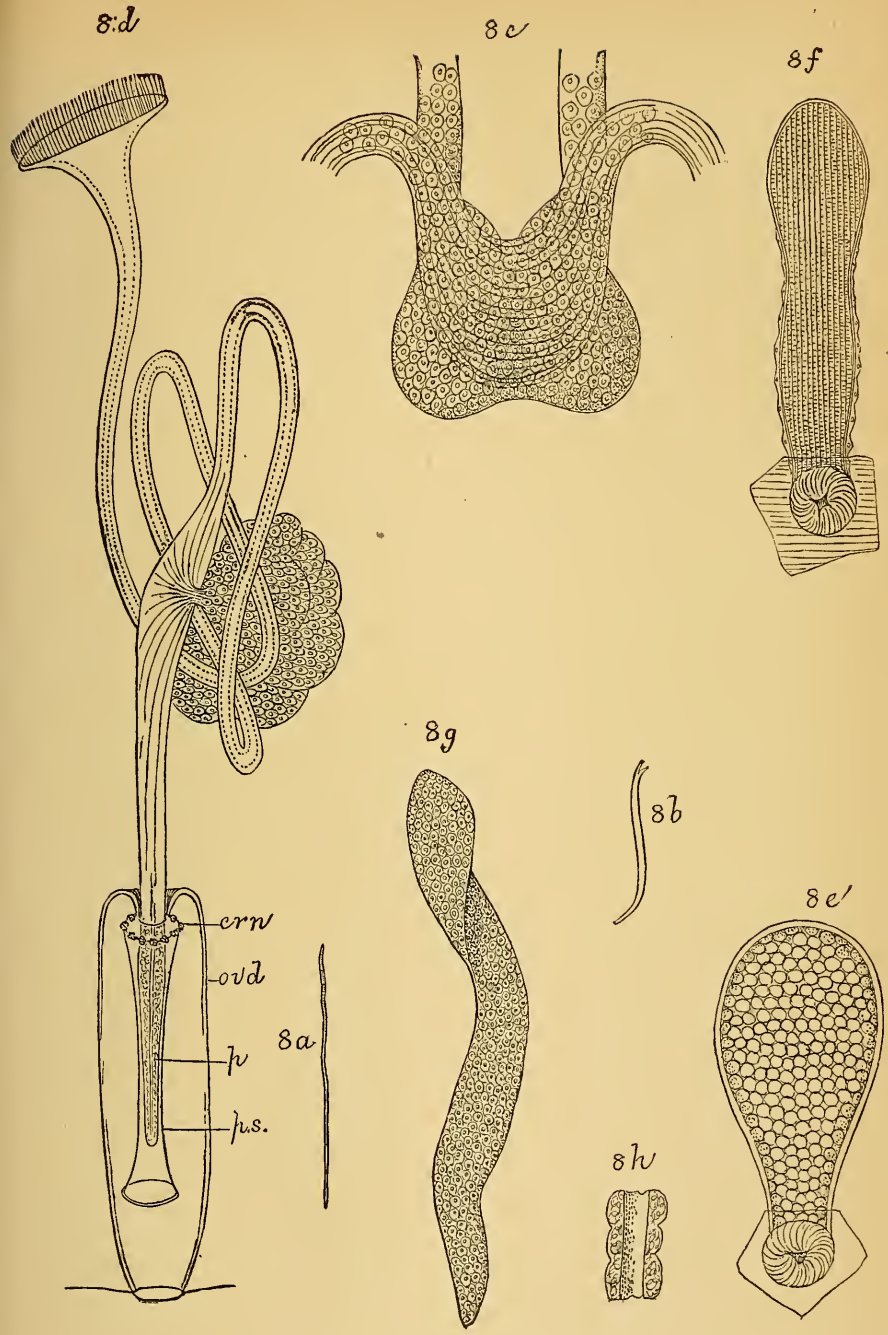
Fig. 7 *a*.—The cephalic ganglion.
7 *b*.—One of the spines.
7 *c*.—Efferent duct, atrium, prostata, penis, penis sheath, and oviducts.
7 *d*.—One of the receptacles.


7a
7c
7b
7d
6h
6g

EXPLANATION OF PLATE IX.

FIG. 8.—LIMNODRILUS ORNATUS.

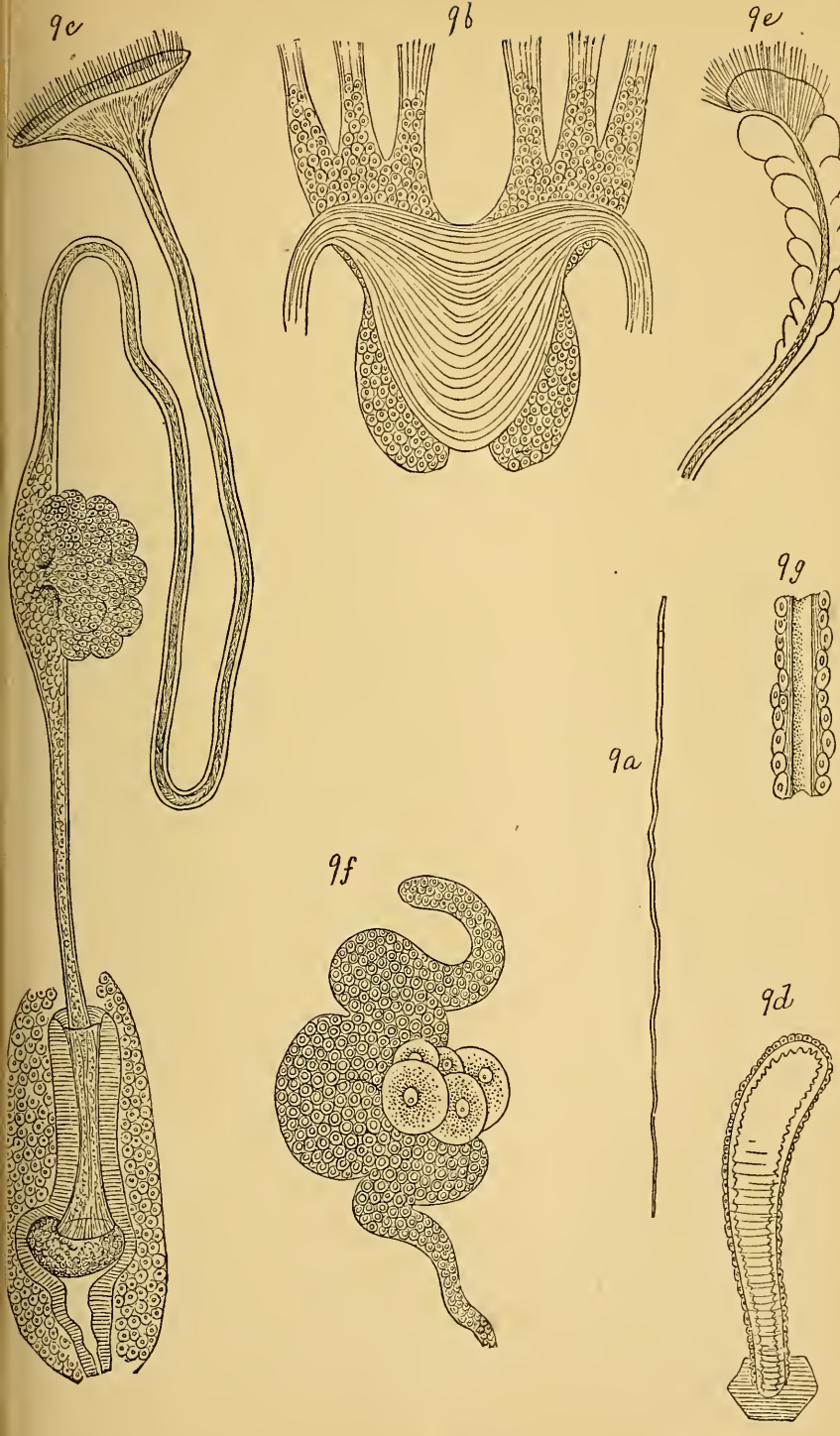
Fig. 8 *a*.—The worm, natural size.
8 *b*.—One of the spines, magnified.
8 *c*.—The cephalic ganglion.
8 *d*.—Efferent duct, atrium, prostata, penis, penis sheath, and oviduct. Round the upper end of the penis sheath is seen a crown of starlike concretions.
8 *e*.—One of the receptacles.
8 *f*.—Another slightly modified receptacle, showing the striated surface.
8 *g*.—One of the ovaries.
8 *h*.—A part of the tube of the segmental organ.


8d
8c
8f
crn
ovd
h
h.s.
8a
8g
8b
8e
8h

EXPLANATION OF PLATE X.

FIG. 9.—LIMNODRILUS STEIGERWALDII.

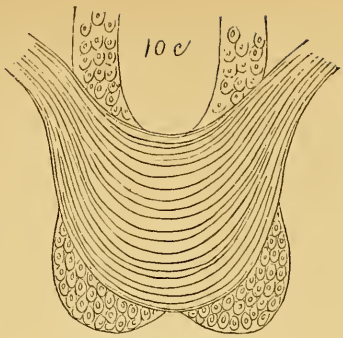
Fig. 9 *a*.—The worm, natural size.
9 *b*.—The cephalic ganglion, seen from below.
9 *c*.—Efferent duct, atrium, prostata, penis, penis sheath, interior and exterior oviduct.
9 *d*.—One of the receptacles.
9 *e*.—The interior aperture of a segmental organ, highly magnified.
9 *f*.—One of the ovaries.
9 *g*.—A part of the tube of a segmental organ.


9c
9b
9e
9g
9a
9f
9d

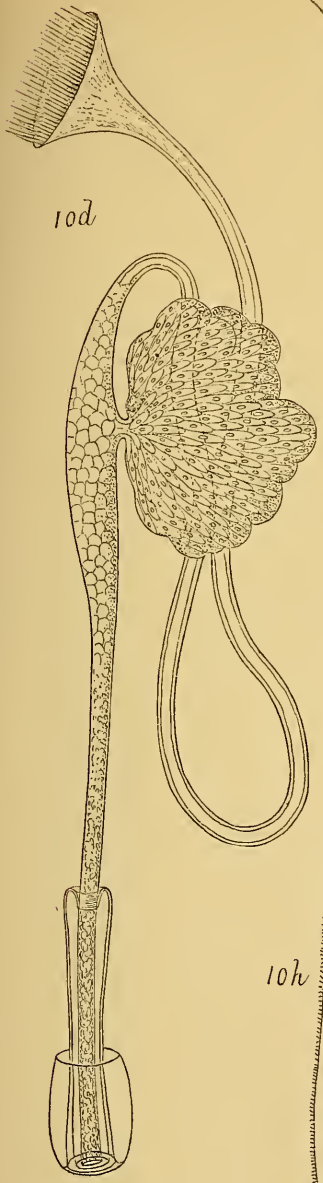
EXPLANATION OF PLATE XI.

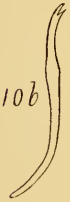
FIG. 10.—LIMNODRILUS MONTICOLA.

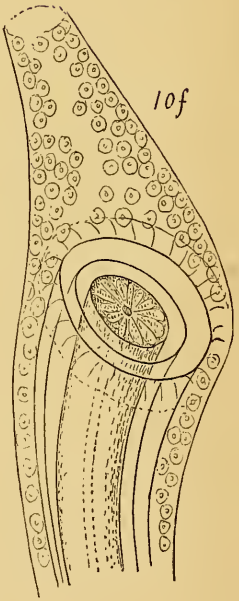
Fig. 10 *a*.—The worm, natural size.
10 *b*.—One of the spines.
10 *c*.—The cephalic ganglion.
10 *d*.—Efferent duct, atrium, penis, penis sheath, oviducts (interior and exterior).
10 *e*.—Penis and oviducts, more highly magnified.
10 *f*.—The exterior end of the penis, penis sheath, and oviducts.
10 *g*.—One of the receptacles, with spermatophores.
10 *h*.—One of the spermatophores, highly magnified.

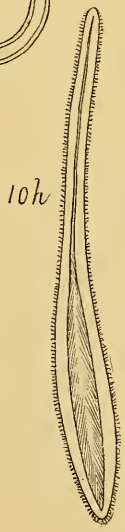

10c


10g


10d


10b


10f


10h

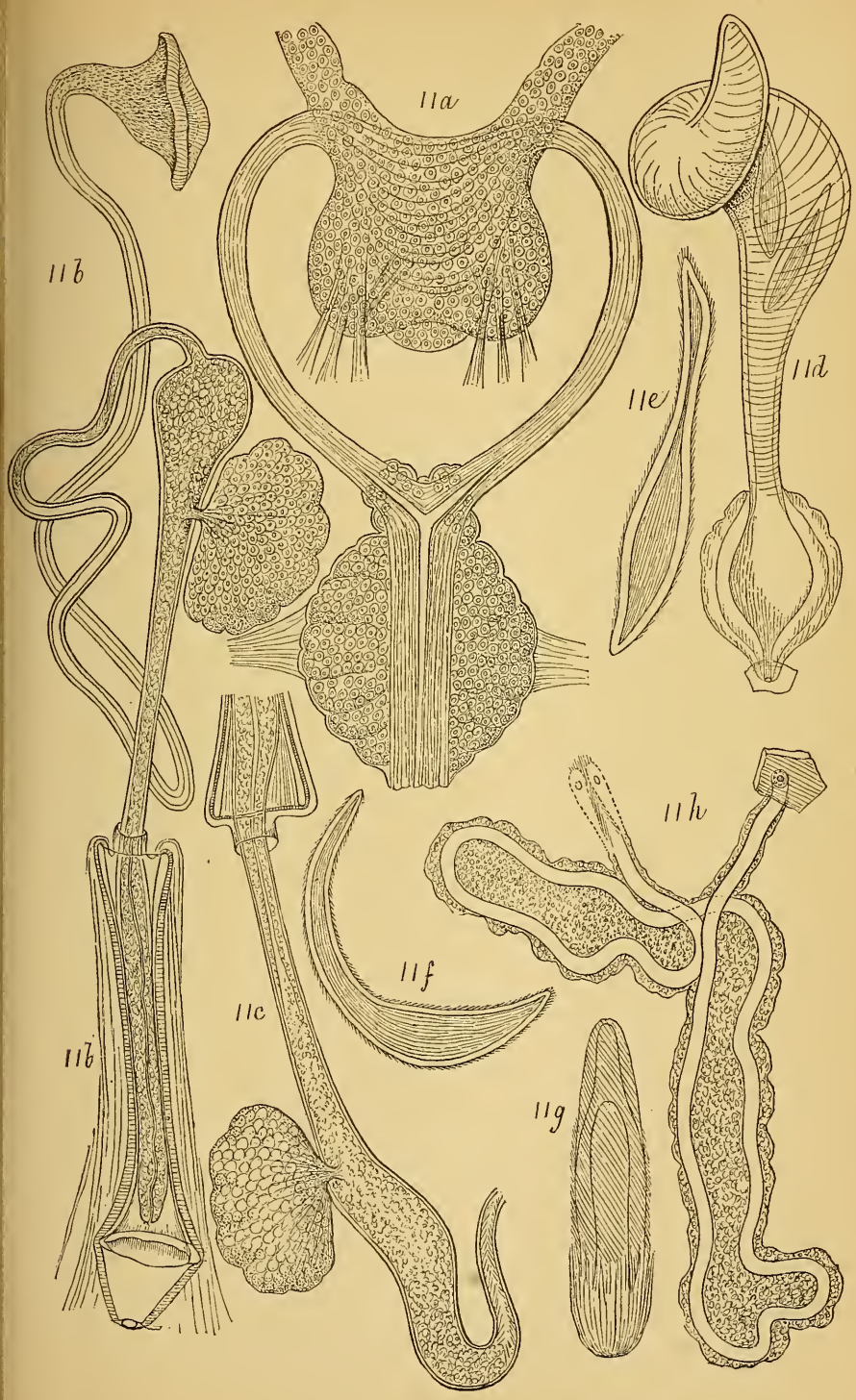

10e


10a

EXPLANATION OF PLATE XII.

FIG. 11.—LIMNODRILUS ALPESTRIS.

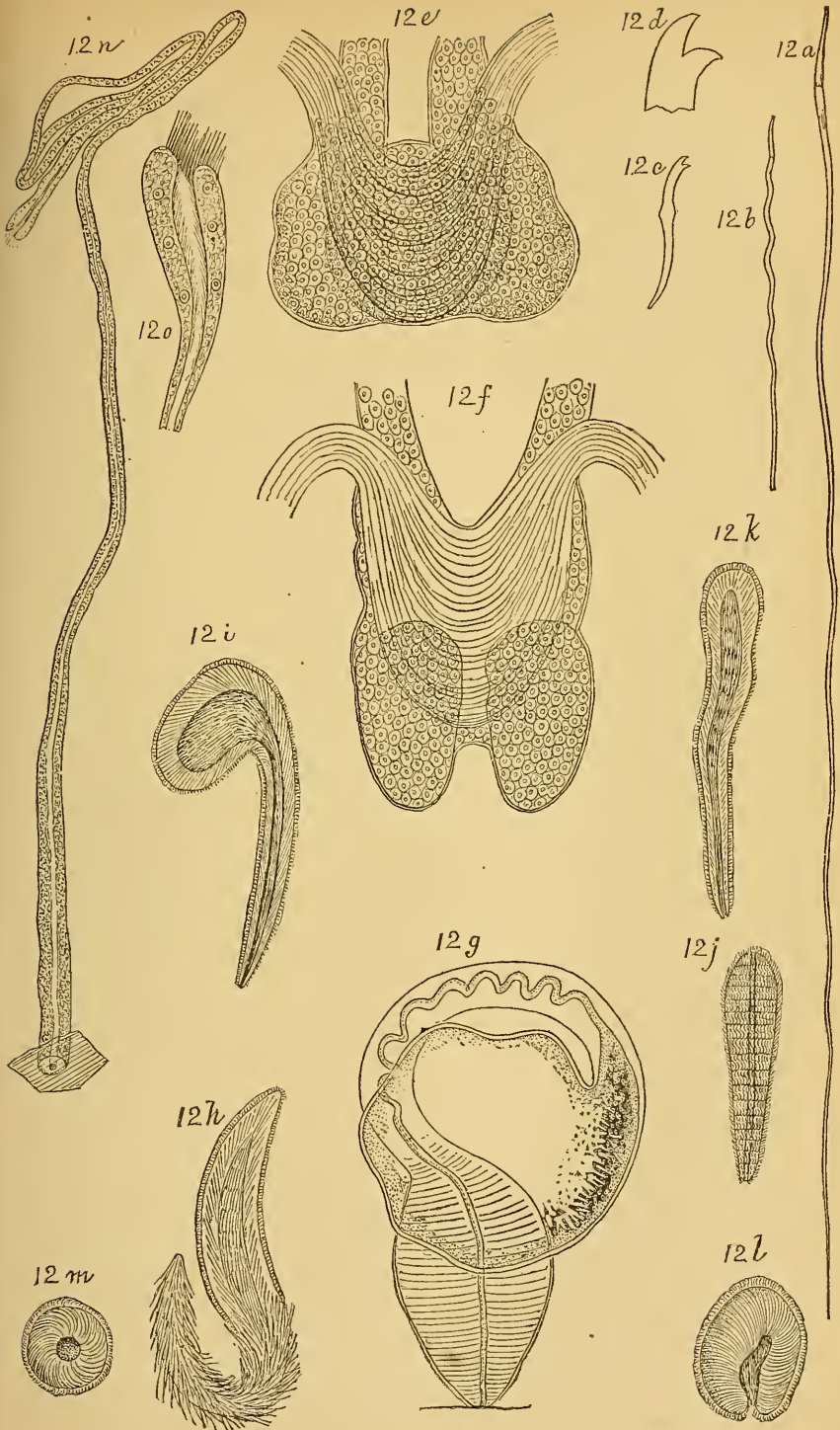
Fig. 11 *a*.—The front part of the nervous system, showing the (sometimes) 3-lobed cephalic ganglion, seen from above.
11 *b*.—Efferent duct, atrium, prostata, penis, penis sheath, and the two oviducts.
11 *c*.—Atrium and upper part of the copulative organs; common form.
11 *d*.—One of the receptacles.
11 *e*.—Spermatophore.
11 *f*.—Spermatophore.
11 *g*.—Spermatophore.
11 *h*.—One of the segmental organs.


11a
11b
11c
11d
11e
11f
11g
11h
11i

EXPLANATION OF PLATE XIII.

FIG. 12.—LIMNODRILUS SILVANI.

Fig. 12 *a*.—The worm, large form, natural size.
12 *b*.—The worm, smaller form, natural size.
12 *c*.—One of the spines.
12 *d*.—The front part of the same spine.
12 *e*.—Cephalic ganglion, broadest form.
12 *f*.—Cephalic ganglion, longest form.
12 *g*.—One of the receptacles.
12 *h*.—Spermatophore.
12 *i*.—Spermatophore.
12 *j*.—Spermatophore.
12 *k*.—Spermatophore.
12 *l*.—Spermatophore.
12 *m*.—Spermatophore.
12 *n*.—One of the segmental organs.
12 *o*.—The interior aperture of the same organ.


12 n
12 e
12 d
12 a
12 o
12 c
12 b
12 f
12 k
12 i
12 g
12 j
12 h
12 m
12 l

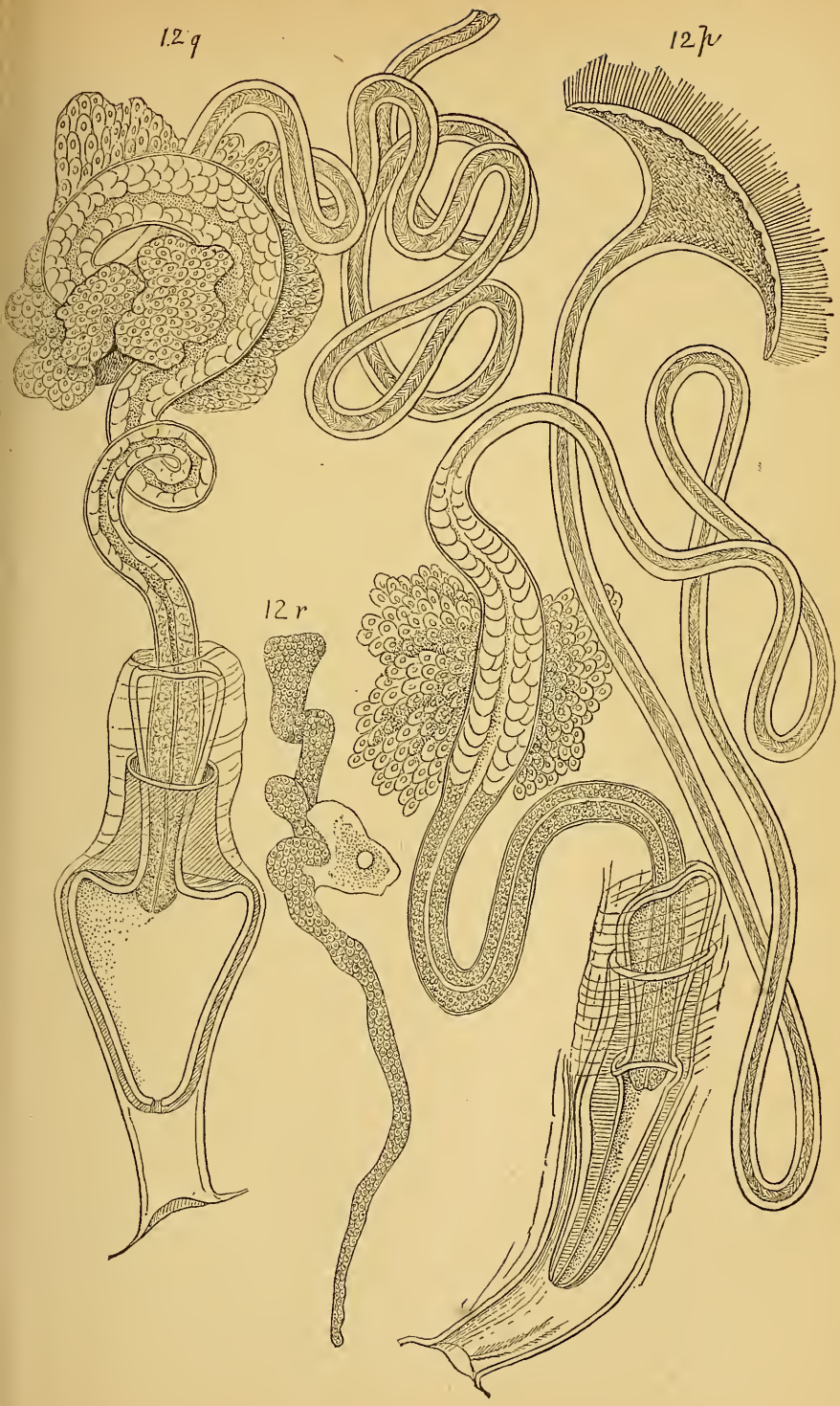
EXPLANATION OF PLATE XIV.

FIG. 12.—LIMNODRILUS SILVANI.

Fig. 12 *p*.—Efferent duct, atrium, penis, penis sheath, interior and exterior oviducts. The organ is seen from the side.

12 *q*.—The same organ, seen from the front.

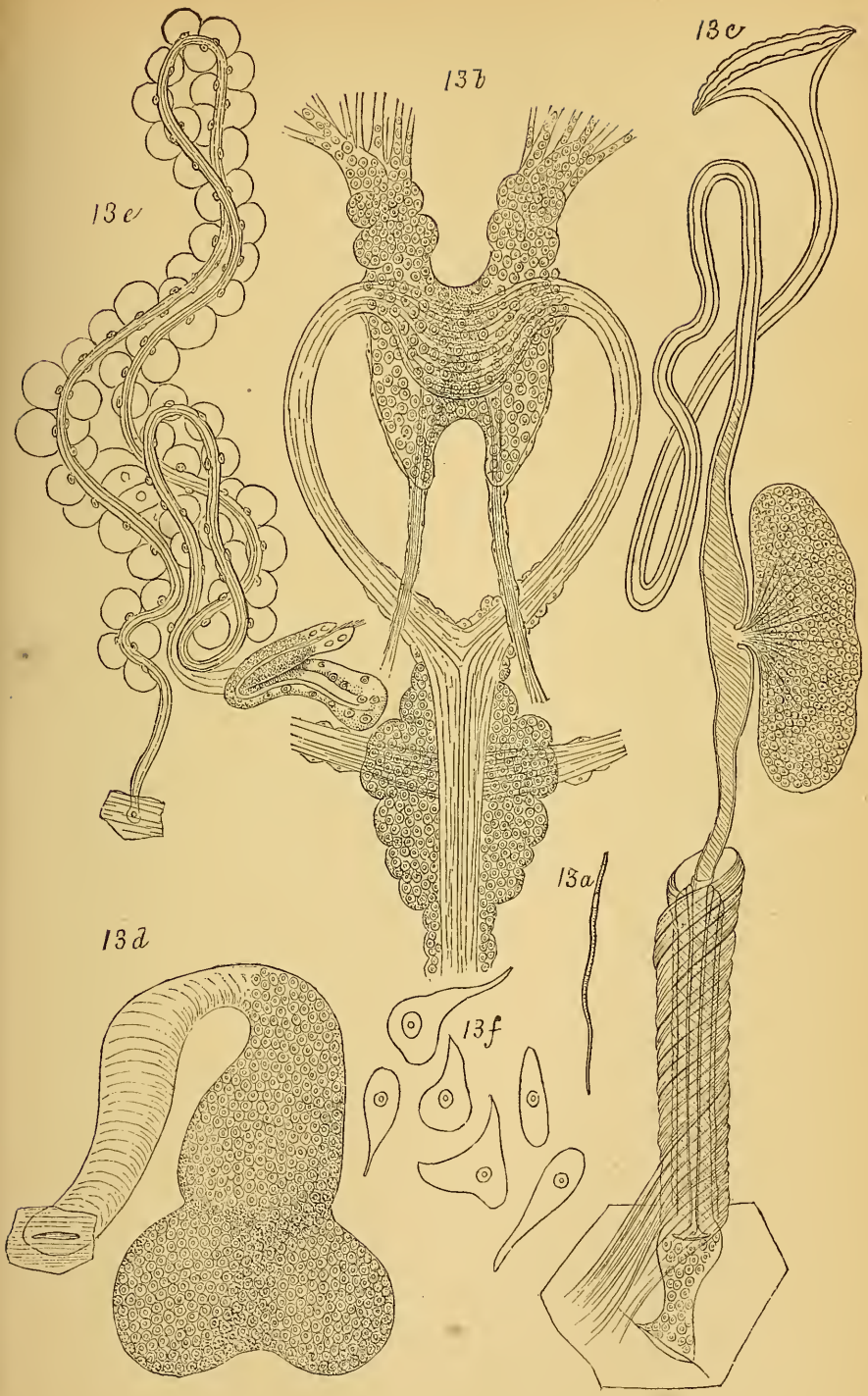
12 *r*.—One of the ovaries.


12 q
12 r
12 s

EXPLANATION OF PLATE XV.

FIG. 13.—CAMPTODRILUS IGNEUS.

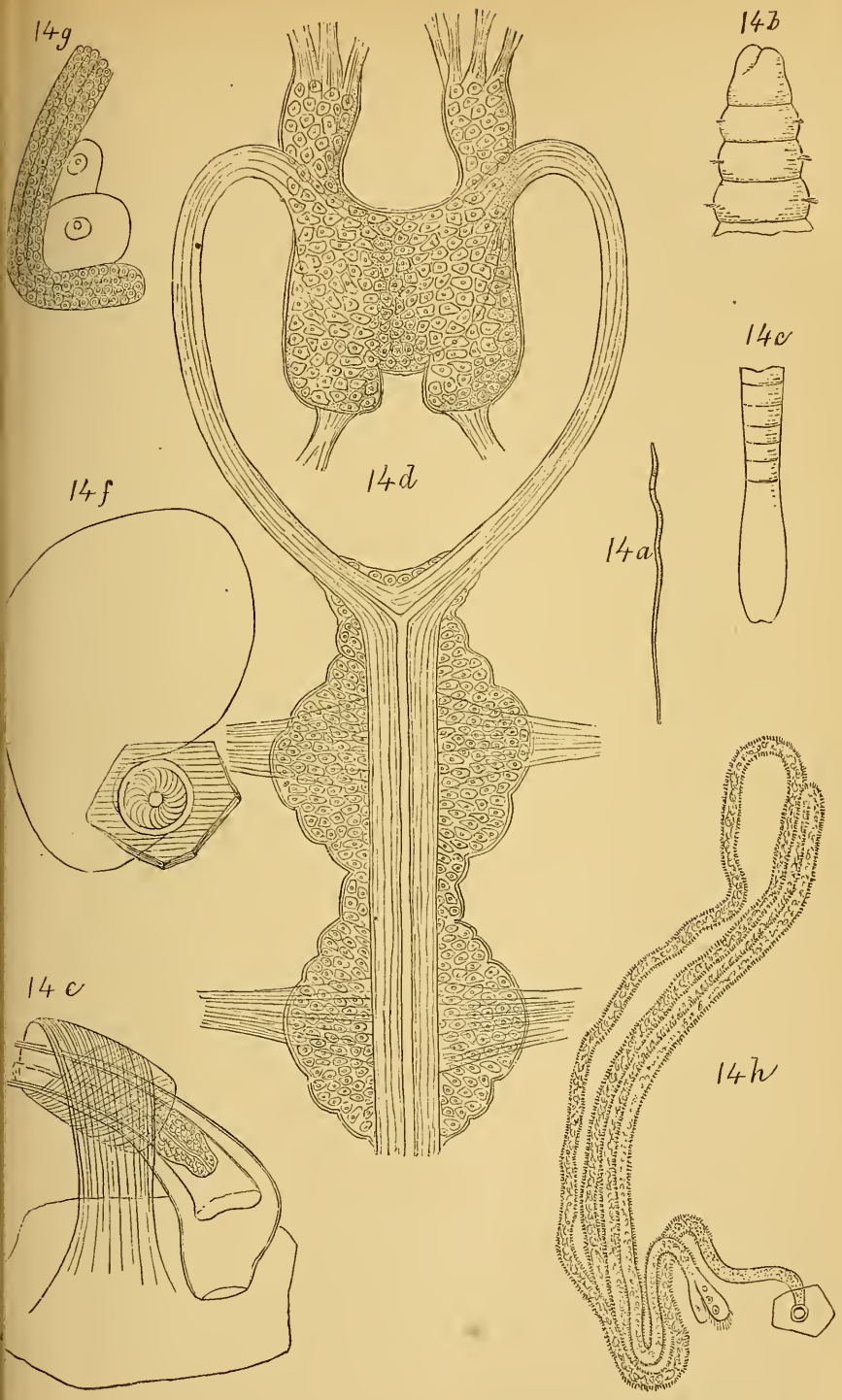
Fig. 13 *a*.—The worm, natural size.
13 *b*.—The front part of the nervous system, seen from above.
13 *c*.—Efferent duct, atrium, prostata, penis, penis sheath, oviduct, and spiral muscles.
13 *d*.—One of the receptacles.
13 *e*.—One of the segmental organs.
13 *f*.—Perigastric cells, of different form.


13c
13b
13e
13a
13d
13f

EXPLANATION OF PLATE XVI.

FIG. 14.—CAMPTODRILUS CORALLINUS.

Fig. 14 *a*.—The worm, natural size.
14 *b*.—Front part of the worm, magnified.
14 *c*.—Posterior part of the worm, magnified.
14 *d*.—Front part of the nervous system, seen from above.
14 *e*.—The lower part of the copulative organs, showing part of penis, penis sheath, oviduct, and spiral muscles.
14 *f*.—One of the receptacles.
14 *g*.—One of the ovaries.
14 *h*.—One of the segmental organs.


14g
14b
14c
14d
14f
14a
14e
14h

EXPLANATION OF PLATE XVII.

FIG. 11.—LIMNODRILUS ALPESTRIS.

Fig. 11 *i*.—The copulative organs in a very young specimen.
11 *k*.—The same organ in a more advanced individual.

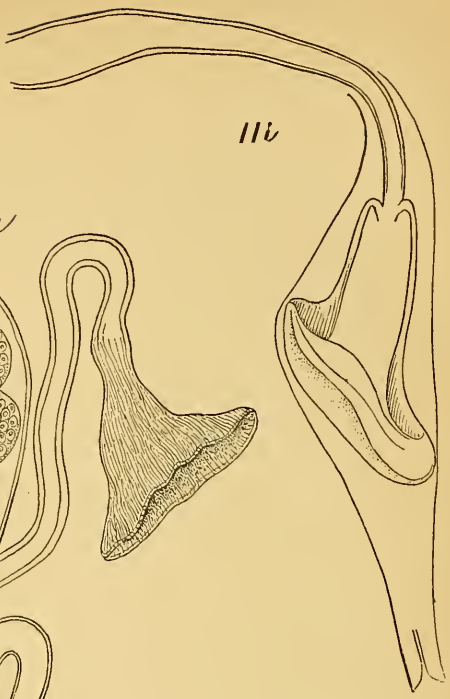
FIG. 14.—CAMPTODRILUS CORALLINUS.

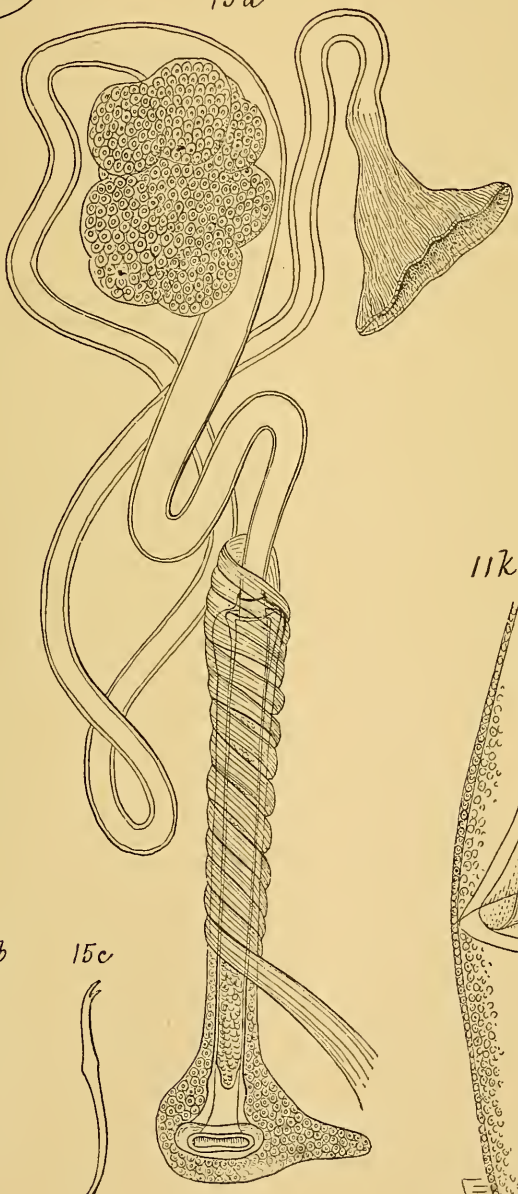
Fig. 14 *i*.—The lower end of the copulative organs, showing the penis, penis sheath, and oviduct.
14 *k*.—The same as above, from another individual.

FIG. 15.—CAMPTODRILUS SPIRALIS.

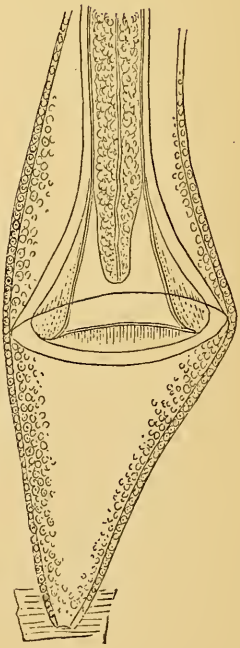
Fig. 15 *a*.—The efferent duct and funnel, atrium, prostata, penis, penis sheath, exterior and interior oviducts, and spiral muscles.
15 *b*.—One of the spines from behind the cingulum.
15 *c*.—One of the spines from one of the anterior segments.
15 *d*.—The front part of the interior aperture of a segmental organ.


14i


11i


15a


14k


11k

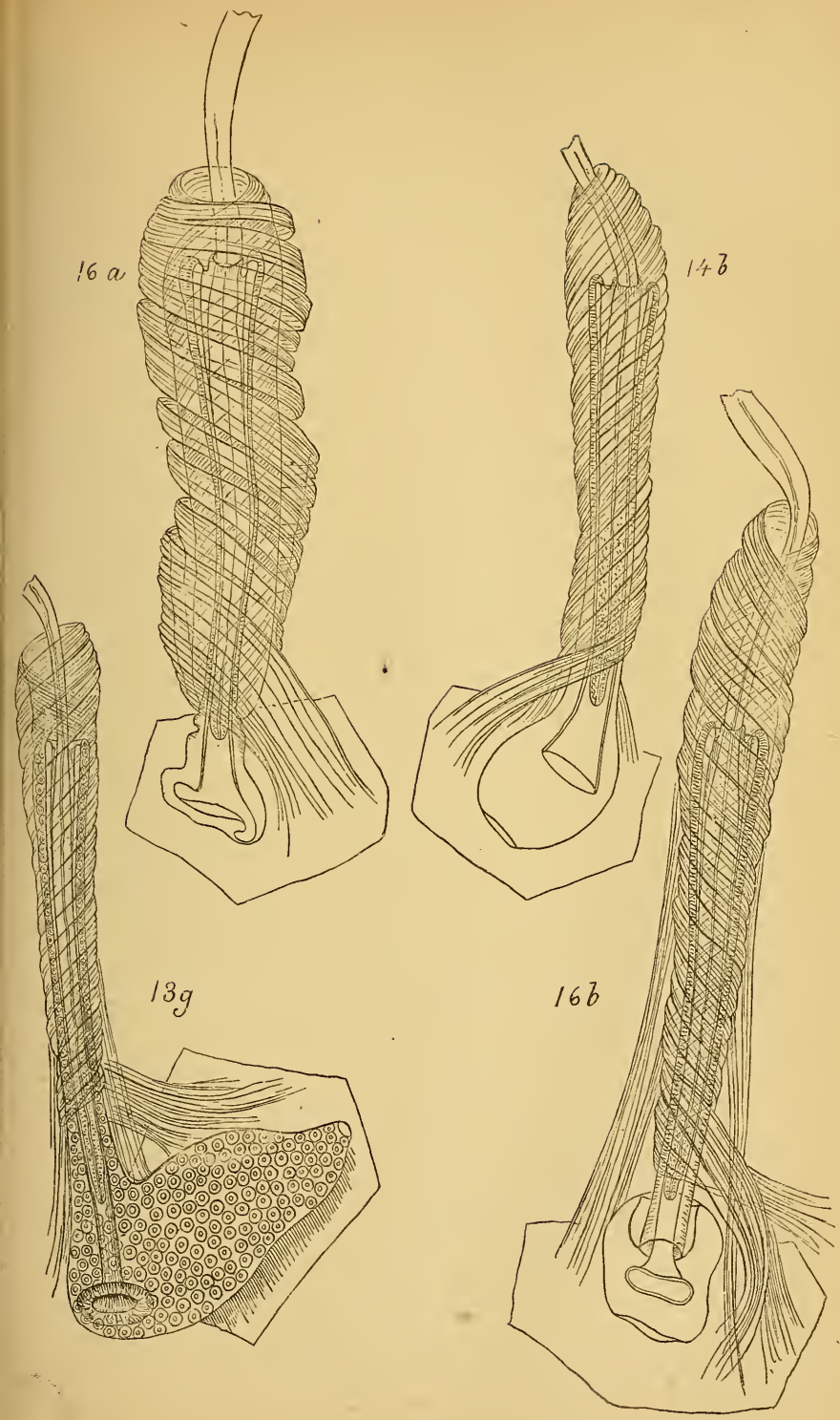

15d


15b

15c

EXPLANATION OF PLATE XVIII.

Fig. 13 *g*.—*Camptodrilus igneus.*
14 *b*.—*Camptodrilus corallinus.*
16 *a*.—*Camptodrilus Californicus.*
16 *b*.—*Camptodrilus Californicus.*
All the figures represent the lower end of the copulative organs.


16 a
14 b
13 g
16 b

EXPLANATION OF PLATE XIX.

FIG. 17.—TELMATODRILUS VEJDOVSKYI.

Fig. 17 *a*.—A part of the copulative organ of a young individual. The oviduct (=ovd.) is not yet fully differentiated, but is seen entirely inclosing penis, atrium, and prostata glands.

17 *b*.—The same as above, in a fully developed individual.

FIG. 18.—LIMNODRILUS ALPESTRIS.

All the figures represent the copulative organs, demonstrating their mode of development from the original generative gland to the fully developed form of the adult individual.

Fig. 18 *a*.—The generative gland as it is first seen on the body wall of the tenth setigerous segment, seen from above.

18 *b*.—The same as above, side view, and somewhat more magnified.

18 *c*.—The same gland, but in a more advanced state of development. The cortical layer is well separated from the interior matrix. In the latter is seen the lumen of the penis. (This figure is from *L. corallinus*.)

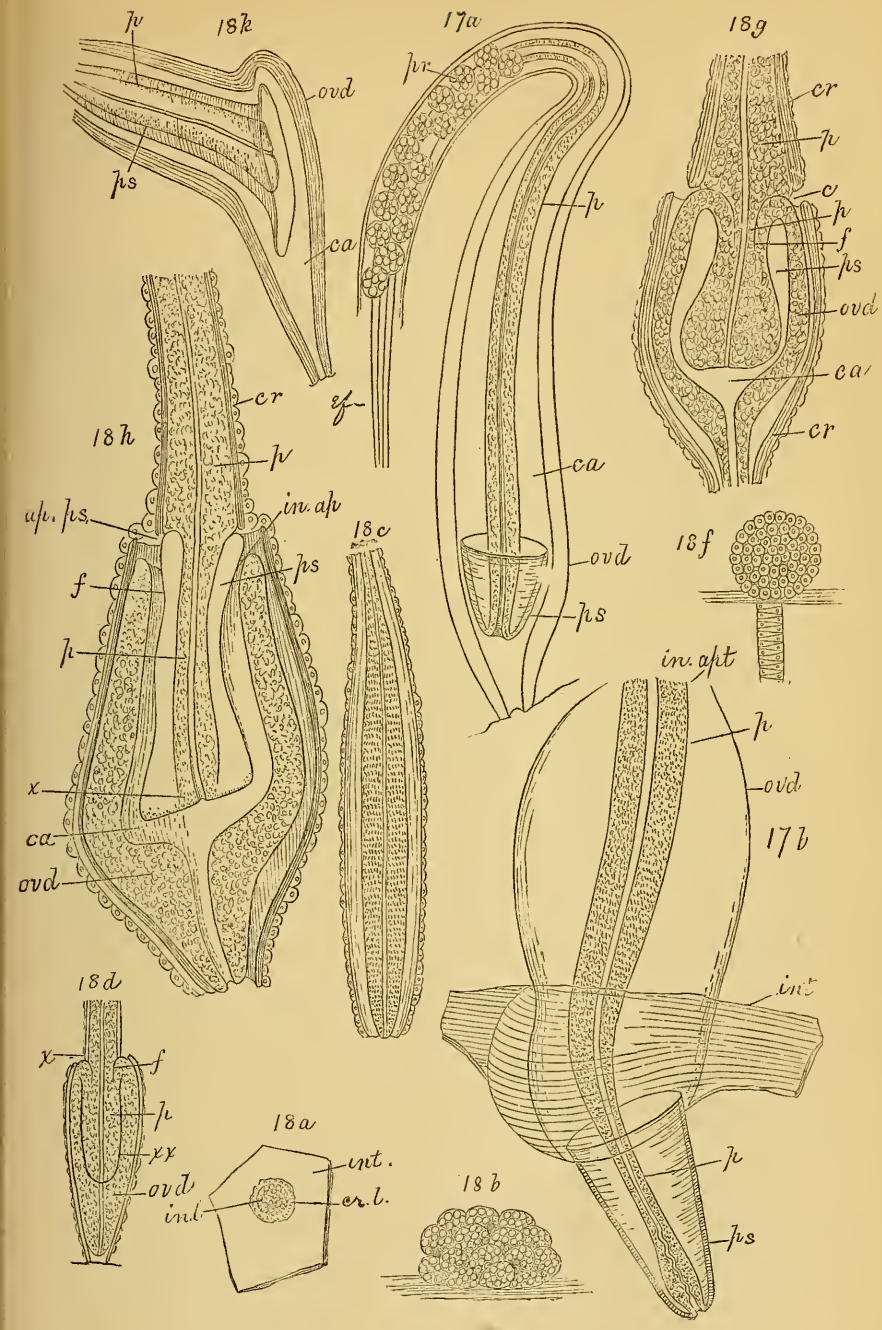
18 *d*.—The same as above, in a yet more advanced state of development. In the interior of the matrix is seen a semi-elliptic line (*x x*) separating the future penis (*p*.) from the oviduct proper (*ovd*.). At *x* is seen the first sign of the aperture of the penis sheath. (This figure is from *L. alpestris*.)

18 *f*.—The first beginning of the efferent funnel. The aperture is not yet differentiated.

18 *g*.—The same as 18 *d*, but in a more advanced stage of development. The cavity (*ca*.) between the oviduct and penis sheath is further developed, but the oviduct (*ovd*.) is not yet fully separated from the penis and penis sheath, the connection being at *c*. The cavity between the penis and the penis sheath is enlarging. The cortical layer (*cr*.) forms an exterior oviduct and is separated by a cavity from the interior sheath of the oviduct (*ovd*.).

18 *h*.—The same as above, in a more advanced stage of development. The interior oviduct is fully separated from the penis sheath (*p. s*.), and the aperture (*in. ap*.) is defined. The penis sheath (*p. s*.) is also nearly fully separated from the penis, but connects as yet at *x*. The oviduct (*ovd*.) and the cortical layer are fully separated, but the former is yet connected with the sexual porus. The aperture of the penis sheath is well defined (*ap. p. s*.).

18 *k*.—The lower end of a perfectly developed copulative organ of a *Limnodrilus*, with a single oviduct. The penis sheath is fully separated from the penis proper.


18k
lv
ovd
hs
ca
17a
hr
lv
ca
ovd
hs
ef
18g
cr
lv
c
h
f
hs
ovd
ca
cr
18h
cr
lv
up. hs
in. ah
hs
f
h
x
ca
ovd
18c
18f
in. aht
h
ovd
17b
int
h
hs
18d
x
f
h
xx
ovd
18a
int.
ind
cr. l.
18b

INDEX.

[NOTE.—The references are to page-figures in brackets.]