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On Three New and Remarkable Species of Echiuroids

(*Bonellia miyajimai*, *Thalassema tænioides* and *T. elegans*).

By

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With 4 plates.

While engaged in a study of the Gephyrean worms of Japan, I have devoted special care in examining the organization of three forms which seemed to me to be very remarkable in many respects, *viz.*, of *Bonellia miyajimai*, *Thalassema tænioides* and *T. elegans*. All the three species, considered to be new, have already been described by me in short in a paper entitled "The Gephyrea of Japan."[1] I now propose in the present article to describe them somewhat in detail, for which act I believe no apology is needed in view of the many points of peculiarities presented by them in their organization. Indeed some of their structural points appear to me to be of very great significance both from the systematic and the phylogenetic standpoint. The two species referred to *Thalassema* probably deserve to be made into a new and distinct genus; but for the present they may remain under the same generic designation used by me before.

1) This Journal, Vol. XX., Art. 4, 1904.

In this place I beg again to express my most sincere thanks to Professor MITSUKURI and Professor IJIMA, to whom both I owe much in completing this as well as my former paper on Gephyreans. My thanks are also due to my friend, Mr. MIYAJIMA, to whom I am indebted for the gift of the unique specimen on which I had based *Thalassema miyajimai*. Further I owe a debt of gratitude to Messrs. YATSU and TSUCHIDA for much valuable advice and assistance rendered me at Misaki.

1. *Bonellia miyajimai* I. IKEDA.

Figs. 1, 2, Pl. I. ; figs. 5–17, Pl. II.

1904. *B. miyajimai,* I. IKEDA, Jour. Sci. Coll., Vol. XX., Art. 4, p. 73.

The single (female) specimen as yet known of this species was obtained by Mr. MIYAJIMA in 1900 while on a collecting tour in the island of Okinawa, Loochoo Islands. It was found in a hollow in the coral rock along the shore in Tomari, a village two miles distant from the port of Naha.

On dissecting the female specimen I was fortunate enough to discover in the body-cavity a remarkable worm which I consider to be the parasitic male of the species.

The Female.

A colored drawing, in double natural size, of the female in the living state was made on the spot by the collector. It is now reproduced in fig. 1, Pl. I., of this paper.

External Characters.—The body proper is relatively short and thick ; it is ovoid in shape, being conically rounded posteriorly.

In the preserved state, it measures about 20 mm. in length and 10 mm. in maximum breadth. The proboscis is long and slender, being in the fully extended state nearly six times as long as the body proper. Anteriorly it splits as usual into two long branches; ventrally it is somewhat deeply grooved for the entire length.

The ground-color of the worm is a grayish brown; over it are scattered numberless small specks of a blackish brown color. These pigment specks are especially dense over the basis and the dorsal surface of the proboscis. The skin-papillæ are relatively small and sparse, except in the anterior and posterior parts of the body where they are slightly larger and crowded than in other regions.

One of the most peculiar features of the species is offered by the ventral hooks. Instead of being present in a single pair as in all other known *Bonellia*, they are very numerous, there being no less than twenty-nine in all (fig. 6, Pl. II.). Moreover, they are so small in size that they might easily be overlooked by the naked eye. They are of an elongate conical shape, gently bent like a horn, and measure commonly 0.5–1.5 mm. in length. Their color is a pale yellow. They are found irregularly scattered in a small area directly behind the oral aperture. Examined from the inside of the body-wall, the bases of the hooks are seen to be deeply implanted in two cushion-like muscular pads, symmetrically situated one on each side of, and in direct contact with, the ventral nerve-cord (fig. 5, Pl. II.). In the pads the inflated bulbs of the hooks appear as double-contoured circles (*h.b.*). Several branching muscles (*r.m.*) radiate from the pad periphery, soon to attach themselves to the body-wall.

Internal Characters.—The general internal anatomy of the female seems to agree nearly with that of *Bonellia viridis,* except in a few, not unimportant points.

The alimentary canal, throughout its convoluted course, is kept in position by numerous delicate muscle-threads originating from the body-wall.

The posterior end of the œsophagus is embraced by the heart, a broad vascular sinus of a triangular shape with the apex directed forewards. From the basal angles of the heart, there arise two moderately long vessels (commissures), which eventually join the ventral vessel running over the nerve-cord. That junction takes place somewhat behind the external aperture of the oviduct.

The oviduct (segmental organ) is single and unpaired, that of the right side being absent. The portion of the organ adjoining the external aperture is for a short distance thin and duct-like, the wall of the part being highly muscular ; the rest of the organ is thin-walled, swollen and sac-like, extending behind nearly to the anterior border of the middle third of the body proper. The internal opening into the body-cavity is represented by a small, but very distinct, ciliated funnel, which is borne on the anterior end of the swollen oviduct, closely behind the point of its passage into the duct-like portion. The sac-like oviduct is found to be filled with eggs and presents a pale yellowish color. The ovary is represented by a long cellular band developed along the dorsal median line of the ventral blood-vessel.

The anal glands are relatively short, but bulky on account of the repeated branching of the main canal. The ultimate branchlets are beset with numerous ciliated funnels, each of which appears to be borne on a short thick stalk (fig. 7, Pl. II.). The free end of the main canal is fixed to the body-wall by a fine muscle-thread.

The Male.

As before mentioned, a male worm (fig. 2, Pl. I.) was discovered in the body-cavity of the female. It is to be presumed that the male had wandered into that organ through the genital passage, which in other species of the genus is known to be the seat of the parasitic male. I am strongly inclined to think that in the present species it is normal for the male to get into the body-cavity of the female and there to reach the state of maturity.

The male in question (fig. 2, Pl. I.) may be said, comparatively speaking, to be of very large dimensions. It is probably the largest ever recorded from among the Bonellian species. While in all the cases hitherto described the males rarely exceeded 2 mm. in length, that obtained by me in the present case is 28.5 mm. long and 2 mm. broad in the broadest part. The elongate body is cylindrical but tapers towards both ends. In the preserved state, it is bent into a shape resembling the Greek letter δ (fig. 2).

The unusually large size of the male worm seemed to greatly facilitate the study of its structure, and I have endeavored to take best advantage of that fact, with the hope of being able to contribute towards settling at least some points of dispute concerning the organization of Bonellian males. I think I have succeeded in bringing out several noteworthy points, partly apparently peculiar to the species and partly modifications or emphatically developed phases of corresponding characters in other species.

The skin presents a light yellowish color and a smooth appearance. It was however ascertained by observation under the microscope that the epidermal surface is uniformly covered all over with closely set cilia. No ventral hook is present. The body-cavity, which extends through nearly the entire length of the body, is laterally compressed in relation to the considerable thickening of body-wall on the sides. In the anterior part of the body-cavity there are present four large funnels belonging to the vas deferens. The alimentary canal is not a continuous tube fixed at both ends to the body-wall, but is represented by a number of small isolated vesicles.

With these general remarks I will proceed to put down the results of my microscopic studies on the male.

The Body-wall.—This is of a very considerable thickness and is composed of five distinct layers, *viz.*, the epidermis, the dermal musculature, the trabecular layer, the subperitoneal musculature and the peritoneum.

The *epidermis* (*ep.*, figs. 8, 10, 11, 13) consists of very tall and narrow cells arranged side by side in a layer. The nucleus, rod-like in shape, is situated near the base of the cells. In fig. 8, which shows a part of a paratangential section through the body-wall, there is seen externally to all the structures the epidermis, which, being obliquely cut, presents a crowd of strongly stained nuclei in the basal parts. The cilia on the epidermal surface are developed, as already indicated, uniformly all over the body.

The *dermal musculature*, directly underlying the epidermis, consists of an external system of transverse and an internal system of longitudinal muscle fibers. The two systems are in direct contact with each other. Both are so very thin and the fibers composing them so fine that, in sections passing vertically through them, it is with great difficulty that their presence can be ascertained. Very much easier is it to observe them on sections cutting them in an oblique direction, as, f. i., on a paratangential section such as shown in fig. 8 (*c.m.*, *l.m.*). Seen on such sections the continuity of both systems as layers is interrupted by the presence of a number of variously sized oblong spaces (*l. s.*, fig. 8) that interpose between the fibers. The spaces are elongate in the direction of the course of the fibers constituting the layer. A series of nuclei arranged in a line marks the boundary of the spaces, presenting an appearance as if the latter were provided with an endothelial lining. As a matter of fact, however, I believe the said nuclei belong to the connective-tissue and were apparently brought into the above arrangement by the pressure, as it were, of the spaces in question. These spaces themselves are evidently nothing else than direct continuations of the lacunæ of the trabecular layer.

The *trabecular layer* (*t.l.*, figs. 9–11, 13) forms a voluminous part in the entire thickness of the body-wall. Especially thick is it, on the sides where the body-wall is thickest. It may be said that the layer consists of irregularly branching and anastomosing trabeculæ and of a system of irregular lacunar spaces that surround the trabeculæ. These seem to be essentially composed of fine, reticular and loosely bundled fibers—connective-tissue fibers—amongst which at certain intervals are seen the nuclei of the tissue. The trabeculæ contain, besides, a certain number of other fibers which, from their appearance, may be called muscular (*m.f.*, fig. 9). The lacunar spaces in the layer contain a lymph-like fluid that bathes the trabeculæ on all sides. The fluid can be deeply stained with hæmatoxylin. It is probably of a nutritious nature.

The above trabecular layer corresponds, in position at least, to the parenchymatous tissue of the authors on Bonellian males. That tissue has been generally considered to consist of an aggregation of stellate cells, a view which I am quite at loss to reconcile with what I have seen and described above. Some writers—amongst them VEJDOVSKY ('78) for one—have stated that blood-corpuscles and spermatozoa occur in the tissue-spaces of the parenchyma and that they both are generated from that tissue. Now, in the male of *Bonellia miyajimai* I can say with certainty that free cells never occur in the layer and that the male sexual cells originate, as will be shown further on, from a source apparently quite independent of the tissue in question.

The fourth layer of the body-wall is offered by the *sub-peritoneal musculature*, consisting of fine muscular fibers that run in oblique directions just outside of, and in direct contact with, the peritoneum. The layer is in general exceedingly thin and not always easily distinguishable. Only along the ventral median line of the body-cavity, it presents a not inconsiderable thickness. In this position, it can be plainly made out that there exist in the layer two intersecting systems of obliquely running muscular fibers (*o.m.*, fig. 9, Pl. II.). In each system the fibers are arranged in a single layer, nearly parallel with one another and in short but moderately uniform distances. Their course strikes an angle of approximately 40° in relation to the longitudinal body-axis.

It has been stated by some investigators of *Bonellia* that a peritoneal layer does not exist in the male. Contrary to this statement, I find the inner surface of the body-wall lined with a thin epithelium which might without impropriety be called the peritoneum (*pr.*, figs. 11 and 12). As seen in sections, it consists of very flat cells arranged in a single row. It is uniformly developed throughout, except for a certain extent in the posterior parts of the body-cavity, along the ventral median line just above the nerve-cord, *i.e.*, in the region where the male sexual organ develops from the peritoneal layer.

The Ventral Nerve-cord.—This is an unpaired, medianly situated string of a considerable thickness, running in the ventral body-wall for nearly, but not quite, the entire length of the body (*v.n.*, figs. 9–13 and fig. 16, Pl. II.). In the greater part of its course, the cord heaves up from below the inner surface of the body-wall, thus bringing about a peritoneum-covered, broad, longitudinal ridge projecting into the body-cavity (fig. 16). Only in the anterior fourth of the body-length, this ridge formation does not take place; there the presence of the nerve-cord does not apparently directly affect the thickness of the body-wall (figs. 11–13). Anteriorly the cord terminates with two swellings situated side by side and which are separated from each other by an intervening lamina of the connective-tissue (fig. 10). They lie in about the same level with the anterior end of the body-cavity. Thus the nerve-cord does not reach up to the anterior-most end of the body; nor does it form any sort of a nerve-ring, which in males of other *Bonellia* species is known to exist around the sperm-duct. The bifid anterior termination may possibly be regarded as representing the remnant of a degenerated nerve-ring.

The Alimentary Canal.—Whereas in most Bonellian males hitherto known, the alimentary canal was found to be degenerated to the extent that it lacked both the mouth and the anal opening, the male worm of the present species seems to have fallen into a state in which the degeneration of the same organ has gone a step further. This is manifested in the fact that the digestive tract does not exist as a canal but is evidently represented by a large number of separate vesicular sacs, floating freely in the fluid of the body-cavity. In my opinion, the sacs have arisen in that the alimentary tube has undergone division into pieces, which, by closure of the wall at ends, have each assumed a vesicular form.

My attention was first called to the vesicles as the male specimen was laid into oil preparatory to imbedding. Under the microscope they appeared as smooth-surfaced, regularly spherical bodies, varying in diameter from 0.2 mm. to 0.3 mm. They were found scattered in the whole extent of the body-cavity, apparently without any definiteness as to the manner of their occurrence.

Sections showed that the bodies in question are hollow spheres, closed on all sides and bounded by a thin continuous wall consisting of two epithelial layers (fig. 17, Pl. II.). The outer layer (*pr.*) is made up of excessively flattened cells arranged in a single row and looks quite like the peritoneal epithelium. In fact I believe it is nothing else than the peritoneal covering of the intestinal wall. The inner layer (*ept.*) is much thicker and is composed of approximately cubical or cylindrical cells, arranged likewise in a single row. The inner free ends of the cells are generally seen to be produced into a few pseudopodia-like processes of varying length. Frequently the processes send out branches. They may moreover anastomose with those from an adjacent cell. The body of the cells contain a number of large and small vacuoles, which often press aside the nucleus of the cell. The central cavity of the vesicular bodies in question contains no substance that can be revealed by staining.

It is out of question that the above vesicular bodies are results of mechanical injuries or of some sort of artificial treatment. Their wall never and nowhere shows an interruption or a histological disturbance which might be taken for an indication of recent severance by force. Since, now, there exists in the male specimen no trace of an alimentary canal, one is naturally led to the conclusion that this had broken up into the numerous vesicles above described, presumably by repeated constricting processes at an early period in the male's life.

An identical fate seems to befall upon the alimentary canal of the male of another species called by me *Bonellia misakiensis* (Jour. Sci. Coll., Vol. XX., Art. 4, p. 76). There I have found, instead of a continuous alimentary canal, about ten separate sacs of different lengths and sizes. These were scattered in the body-cavity, apparently standing in no definite relation to one another.

The vas deferens.—This presents some very remarkable peculiarities. In *Bonellia viridis*, *B. minor*, etc., according to SELENKA, GREEFF, RIETSCH, VEJDOVSKY and some other authors, the vas deferens is a long unpaired canal opening near the anterior body-end. It runs free in the body-cavity and should sometimes extend far backwards even into the posterior one-fourth of the body, finally ending with a single, large, ciliated funnel. The above holds good also for the male of *B. misakiensis*, which I studied. In *B. miyajimai*, however, the vas deferens is very short, scarcely longer than one-eighth of the body-length and posteriorly splits up into four branches, which arise in succession one behind another and each of which terminates with a long-stalked, large funnel. Externally the vas deferens opens by a minute aperture situated somewhat ventrally from the anterior body-end. Further, the vas deferens does not run free in the body-cavity as it does in other Bonellian males, but stands throughout its entire length in connection with the ventral body-wall, only the four long funnel-stalks projecting free into the body-cavity. As determined from serial cross-sections, the vas deferens in the anteriormost parts is imbedded quite in the body-wall, running between the nerve-cord and the body-cavity (*v.d.*, fig. 12). The wall is internally lined by an endothelium and externally invested by a dense layer of reticular connective-tissue fibers; the lumen is filled up with spermatozoa, which fact greatly facilitates the tracing of the course of the duct. Posteriorly, the latter gradually recedes from the nerve-cord and comes to pursue its course in a longitudinal ridge that raises itself from the body-wall along the cœlomic floor (*v.d.* in fig. 11). In the ridge just referred to, the vas deferens sends forth dorsally three branch canals in short succession; its posterior elongation after giving off the third branch may be called the fourth; so that it may be said that there exist in all four branch canals into which the vas deferens divides up posteriorly. Of the three canals cut across and indicated by the letters *v.d.* in fig. 12, the two upper ones are sections of the first and the second branch respectively, while the lowest is that of the posterior continuation of the main vas deferens before giving out the third branch. Fig. 13 represents a more posterior cross-section of the worm; in it we see the first and second branches (I. and II.) as free tubes—in the section both cut obliquely crosswise—in the body-cavity; the third and fourth branches (III. and IV.) pursue their course still within the narrow ridge of the body-wall just above the ventral nerve-cord. A short distance still more posteriorly, all the four branches are met with as free tubes as shown in fig. 14. The tubes finally terminate each with a large ciliated funnel and may be called the funnel-stalk of unusual length. Their wall shows the same histological structure as the vas deferens of other Bonellian males, being made up of three layers; *viz.*, 1) the peritoneal epithelium (fig. 14, *pr.*), 2) the thin connective-tissue layer (*c.t.l.*) and 3) the endothelial layer of the lumen (*ent.*). Both the peritoneal and endothelial layers consist of flat cells, except at the outflaring distal end of the funnel where the covering epithelium consists of cylindrical cells thickly ciliated on the exposed surface. The transitions of the flat peritoneum into this ciliated thickened epithelium takes place abruptly. In fig. 15 is shown a cross-section through a funnel right close to the internal opening. In it the non-ciliated thickened epithelium of the lumen is seen at two opposite places to pass directly into the outer ciliated epithelium and at other places to be separated from the latter by the connective-tissue, owing to the uneven configuration of the funnel mouth that had probably been brought about by the action of the fixing reagent.

Male Sexual Cells.—Small masses of spermatozoa are found floating in abundance in the cœlomic fluid. Each mass, spherical or ovoid in shape, consists of a central, comparative large spermatophore bearing numerous spermatozoa in the periphery. The former can scarcely be stained and is commonly vacuolated (fig. 14, *s.m.*).

As to the origin of the sperm-masses, two irreconcilable opinions had been advanced by previous authors. According to one view, they are formed in the parenchyma of the body-wall, *i.e.*, in a tissue which corresponds, as far at least as the position goes, to what I have called the trabecular layer in the male of the present species. The other view maintains their production from the peritoneum at indefinite places. Now, in the male of the present species the question admits of a very clear solution. Here the testis may be said to be definitely developed, apparently from the peritoneum, as a longitudinal series of small cellular masses, projecting into the body-cavity above and along the ventral nerve-cord and borne on a narrow mesentery-like band. The testis in its entire length extends through the posterior three-eighths of the body. Fig. 16 represents, highly magnified, a portion of a transverse section through about the middle of the posterior half of the body. In it is seen the ventral nerve-cord (*v.n.*) in cross-section and surrounded by the reticular connective-tissue, which in its turn is delimited against the body-cavity by the thin peritoneum (*pr.*). In the middle above the nerve-cord is seen the testis in cross-section: supported on the mesentery-like band is one of a series of small spherical or ovoid bodies which I take to be the sperm-cell masses in an early state of development. Each such body consists of a protoplasmic ground-substance, containing in the periphery numerous, small and round nuclei which are probably to be seen in the light of spermatocyte nuclei. The central part of the body usually shows a roundish or oval, very faintly stained space, containing a single, likewise faintly stained nucleus and often one or more vacuoles in addition. I take no heed in identifying the substance of the central space with the spermatophoric mass of the detached and floating sperm-mass. Moreover, it seems to correspond to the central cell of a young egg-follicle in the female. As is the case with the latter, the central nucleated mass appears to undergo degeneration at a later stage; anyway, the single nucleus is no longer visible after detachment of the sperm-masses, the spermatophore then containing several large and small vacuoles only. By a careful observation of serial sections I have come to the conclusion that the several young sperm-masses are attached to the mesentery-like band for the most part in a single row, which, however, is not quite continuous, but is interrupted at intervals by gaps, presumably left behind by the falling off of the riper masses into the body-cavity. I am thus led to endorse SPENGEL's ('79) view, so far as it goes, that the floating sperm-masses originate from the innermost layer of the body-wall, *i.e.*, from the peritoneum. However, in the male studied by me, they certainly do not arise from all over the latter, contrary to the opinion maintained by some investigator. The formative region is strictly confined to a narrow streak in the peritoneum, along the median line of the ventral body-wall. Thus, it is interesting to note, the testis presents a far reaching degree of identity with the ovary of the female, not only in origin and position but also to a certain extent even in structure.

The Cœlomic Corpuscles.—Besides the above described sperm-masses, the cœlomic fluid contains an abundance of free cells or cœlomic corpuscles (figs. 14 and 16, *b.c.*). Spherical or ovoid in general shape, the finely granular cytoplasm shows a nucleus which is full of deeply stained chromatin. They are especially numerously present in the posterior and anterior parts of the body-cavity, being at some places so closely packed together as to present an irregularly polygonal shape.

The principal features of *Bonellia miyajimai* may be summarized as follows:

The female. Body short, cylindrical, narrowed towards both ends. Proboscis six times as long as the body; slender. Color grayish brown with minute blackish brown flecks. Ventral hooks numerous. Anal gland branched, bearing numerous stalked funnels.

The male. Found in body-cavity of female. Unusually large, being nearly 30 mm. long; without ventral hook. The greater part of the thickness of the body-wall presents a trabecular structure. Alimentary canal broken up into numerous vesicles. No nerve-ring is found. Testis in the same position and of essentially similar structure, as the ovary of female. Vas deferens divides posteriorly into four branches, each ending with a ciliated funnel.

2. *Thalassema tænioides* I. IKEDA.

Fig. 3, Pl. I.; figs. 18–22, Pl. II.; figs. 23–36, Pl. III.; figs. 37-47, Pl. IV.

1904. *Th. tænioides,* I. IKEDA, Jour. Sci. Coll., Vol. XX., Art. 4, p. 63.

First an account of the circumstances that led to the discovery of the species may be given.

For a number of past years, the proboscis alone of the worm had been a rather well-known object to Japanese collectors, though its real nature had remained a standing puzzle to them. They had to do with a long, flat, bandlike object that often reached a length of one meter or more and had a breadth of 1–1½ cm. It was somewhat convex on one side and slightly concave on the other, the latter showing further a median longitudinal groove. Both sides presented a bluish-gray ground-color, variegated with markings that consisted of narrow transverse stripes of a deep brown to brownish-black color. The stripes were either continuous from side to side or interrupted more or less in their course. Some of them were much narrower than others. They were very numerous and closely situated on the concave and furrowed side of the body, while on the other side they were present at wider intervals besides being represented always by irregularly broken or discontinuous streaks. The extreme ends of the body were either rounded off or notched in and strongly contracted, in the latter case appearing like the severed end of a preserved tape-worm. Wormlike as the object was, neither the head nor the tail end could be distinguished; nor was ever an opening that might pass for the mouth could be detected on it. In the living state, it exercised a slow wave-like movement that proceeded without a definite rule as to its direction.

The body in question has been taken from time to time in the sea near the Misaki Marine Laboratory. It has also been observed or obtained at several other locatities; f. i., by Mr. NAMIYE in Tsushima (Strait of Corea) and in Tomo (Prov. Bingo, Inland Sea); by Mr. HATTA in Amakusa (Kiushiu); by Mr. YATSU in Haneda (Gulf of Tōkyō); by Professor OKA in Tateyama (entrance to the G. of Tōkyō); etc. It is evident that the creature is distributed over a wide stretch of the coasts of Japan.

At first sight one is irresistably led to assume that the object is a Nemertean. In fact it was surmised to be one—perhaps a highly degenerated form of the group—by several observers and more than one of them had gone into a study of its minute structure. At another time it had engaged the special attention of a student who had suspected in it an aberrant form of Turbellaria. But, after all, none of the observers could come to a definite view as to the systematic position of the object supposed to be an entire animal. Its remarkable size and shape effectually held back idea of its being an Echiuroid proboscis. In 1900, Mr. YATSU took up the problematical object for a renewed study. I was kindly allowed to examine his sections and what at once called my attention was the close structural resemblance of the object with an Echiuroid proboscis. After making comparisons, Mr. YATSU and myself were both convinced of the fact that the object could be nothing else than an enormously long proboscis torn off from an unknown Echiuroid, the body proper of which has apparently never yet been obtained. At this I was given a free hand to track out the species and to continue the investigation. For this liberty and for placing all his material at my disposal, I beg here to express my thanks to Mr. YATSU.

During October and November 1901, I was at work in the Misaki Marine Laboratory, endeavoring to obtain the entire animal of the anticipated Echiuroid. With the kind assistance of Messrs. TSUCHIDA and AOKI of the Laboratory, I have finally had the satisfaction of securing in all six specimens of the animal, all living and with the body and proboscis in natural connection. They were all females.

As then ascertained by myself, the Echiuroid in question, called by me *Thalassema tænioides*, is by no means uncommon in the neighborhood of the Misaki Marine Laboratory. I have met with it most abundantly in the inlet Moroiso, right close to the Laboratory. It inhabits sandy or rather muddy but firm bottom, from between the tide-marks down to a depth of about seven fathoms. There the worm lives concealed in the burrow. Seen under water, the opening of the burrow appears as a small pit of oval or roundish shape, and from it is protruded, in calm warm wealther, the long proboscis of the worm, while the body proper remains entirely hidden. The proboscis may thus be exposed to a length of one meter or more; it is usually extended in a nearly straight line and rests flat on the bottom surface with the grooved (that is, the ventral) side facing upward. It then appears like a band of a dirty grayish color and might easily be mistaken for a dead leaf of *Zostera*. It makes a stretching movement, its free end moving from side to side, as if it were slowly creeping on the bottom. When disturbed by a touch with stick, or even when suddenly covered by shadow as it lies extended on the sun-lit bottom, the proboscis is rapidly and entirely withdrawn into the pit-like burrow.

For obtaining the worms, search was made for the protruded proboscis in such places as will be exposed above water during the low tide. The position was marked by planting bamboo sticks close to the burrow pit. By the time the place was sufficiently out of water, it was revisited and the digging out of the worm was done. In this way I have learned that the burrow sinks perpendicularly to a depth of 70–90 cm. into the moderately firm ground. It is tubular and cylindrical, measuring for the most part about 2 cm. in diameter; near the lower end it is considerably wider, reaching up to 4–5 cm. across. The wall surface of the tube is smooth and bears a rusty reddish color.

External Characters.

Having failed to obtain a male specimen for study, all my observations on the external and internal organization of the species are based on the female.

The species is a remarkably large form. In Pl. I., fig. 3 is shown in natural size the smallest specimen I have obtained. The body proper may measure 40 cm. in length and 2–3 cm. in greatest width. The proboscis in the fully extended state may be 150 cm. long and 1–1½ cm. broad. So that, a large individual when fully extended may reach 190 cm. in total length.

The general appearance of the proboscis has already been described. Here it remains to be mentioned that the basal portion of that organ, for a length of 5–8 cm. in front of the mouth, is quite free of the transverse stripes on both surfaces and presents a grayish to light-brownish yellow color, which deepens in tone towards the position of mouth. At the transition of the proboscis into the body proper, the former forms an incomplete funnel around the mouth. The free distal end of the flat proboscis is simply rounded.

While in life, the worm incessantly changes shape and dimensions by alternately contracting and stretching out, but the shape given in fig. 3 may be considered to represent its normal state of rest. In that condition the body is cylindrical and broadest near the hind end, which is itself conically pointed. Anteriorly it very gradually narrows towards the oral end.

The skin presents a brownish red tint over a pale yellow ground. It is thickly beset with small papillæ of a light ochraceous color and of various shape and size. They are largest and most crowded near both ends of the body, where most of them present a star-like and not a round outline. Except near the body ends, there are seen on the surface narrow longitudinal lines, in all five in number, running equidistant from one another. The lines are of a light yellowish color and are somewhat translucent; they can be best seen when the body is in a contracted state.

On account of their presence the muscular layers of the body-wall appears divided into five broad longitudinal zones.

A short distance (1–1.3 cm.) behind the mouth there exist a pair of moderately long ventral hooks. These are gently curved mediad and are of a bright yellow color.

Some Points of the Internal Structure.

Figs. 18 and 19 in Pl. II. and fig. 23 in Pl. III., all drawn from dissections of the worm, will serve to give a general idea of the arrangement of internal organs. For study of the microscopic structure were employed material which were fixed with either saturated corrosive sublimate solution or FLEMMING's strong solution. HEIDENHAIN's iron-hæmatoxylin or DELAFIELD's hæmatoxylin was used for nuclear stain, and several anilin pigments for plasma stain. In the following description, I will first take up the body proper, leaving the proboscis to be dealt with last.

The Body-wall.—In the living state of the worm, this is relatively thin. It grows somewhat thicker towards both ends of the body, where the surface is beset with largest papillæ. It may be said to be made up of five distinct layers, *viz.*, the cuticle, the epidermis, the cutis, the muscular layer and the peritoneum (fig. 26).

The *cuticle*, which forms the outermost covering, is moderately thick (figs. 27 and 28, *ct.*). As was pointed out by JAMESON ('99) in *Thalassema neptuni*, it is composed of an outer deeply and an inner less deeply staining layer and of the innermost alveolar layer.

The *epidermis* is represented by a single-layered epithelium composed of tall cylindrical cells (figs. 26–28, *ep.*). While it presents a smooth surface against the cuticle, the internal contour is irregular, owing to the fact that the inner ends of the component cells are produced into a few number of finely tapering and branching processes as had been observed by many previous investigators (fig. 27). The processes penetrate for a short distance into the cutis and anastomose with one another as well as with the connective-tissue fibers of the cutis. At places they are further seen to stand in connection with certain processes of subepidermal ganglion cells (*n.c.*), which again are directly traceable to comparatively thick nerves (*n.*) running in the cutis. In rare instances I have observed in the epidermis small compact groups of club-shaped epidermal cells, which were somewhat sunk into the cutis with their swollen inner end (*s.o.*). It looked very much like a sense-organ and I am greatly inclined to consider it to be one, although no hair-like appendage could be made out at the outer end of the cells.

Here and there among the ordinary epidermal cells are found those which look very much like a mucous cell (figs. 27 and 28, *gl.*). They are of a swollen appearance, due to the clear secretory contents which press the cytoplasm and nucleus against the cell base. As JAMESON has said, the glandular cells in question—for they are without doubt unicellular glands—show no external opening. Quite another kind of unicellular glands is numerously met with in the larger dermal papillæ (fig. 28, *g.gl.*). Here we have to do with elongate club-shaped cells of a large size, which lie for the greater part of their length imbedded in the cutis and which with their distal narrowed end pass between epidermal cells and finally open externally each with a pore through the cuticle. I distinguish two varieties of the glandular cells in question. The one is much larger and more elongated than the other and exhibits finely granular contents which stain deeply with hæmatoxylin. The same glandular cells occur also on the dorsal side of the proboscis (fig. 45). They are apparently the same as the similarly situated unicellular glands, known to occur commonly in other Echiuroids. The second variety of the glands is characterized not only by being shorter but also by having an almost homogeneous plasma containing some coarse granules which are intensely stained by eosin or erythrosin. So far as I know, this kind of the glandular cells has never yet been described from other Echiuroids. The cutis (figs. 26–28, *cts.*), the mesenchymatous layer directly underlying the epidermis, is comparatively thick. It attains greatest thickness in dermal papillæ, of which it in fact forms the main internal mass. The tissue consists of a clear ground-substance which is traversed by numerous, irregularly branching fibers, as in a fibrous connective tissue. Most of the fibers take a course vertical to the body surface. Here and there the fibers are seen to emanate from the ends of slender spindle-shaped cells, of which they seem to be direct prolongations. The same connective-tissue cells and fibers occur also in deeper parts of the body-wall among the muscle fibers.

In the cutis and especially numerously in its superficial parts are met with some nerves and ganglion cells, of which mention was already made. Inclosed in the layer are further peculiar pigment bodies (*pg.*). They are of a spherical shape, and contain innumerable minute granules of a brownish color. They occur most abundantly in the deeper part of the cutis and in the non-papillated region. There is another sort of pigment-like bodies (*pg′.*) which are found most abundantly in the peripheral parts of the cutis. They are of various sizes, are quite homogeneous in structure and can be deeply stained with hæmatoxylin. The possibility is not excluded that the bodies here referred to are but coagulated masses produced from the lymph-like fluid that permeates the cutis tissue.

At places in the cutis, especially in close proximity to the epidermis, are found relatively large cells of a roundish shape, with finely granular cytoplasm strongly stainable with eosin (figs. 27 and 28, *w.c.*). They are devoid of plasmic processes and can therefore be easily distinguished from ganglion cells. Possibly they represent a sort of free wandering cells.

The strongly developed *muscular layer* is of the usual composition, consisting, as it does, of the longitudinal (fig. 26, *l.m.*), the circular (*c.m.*) and the oblique systems. The longitudinal system forms a continuous sheet. To special thickenings of that sheet are due the five, equidistant, pale-colored, longitudinal lines visible on the outside of the body-wall.

Here may be mentioned the well developed muscles that are attached to the bulbous bases of the paired hooks. One of them, the interbasal muscle (figs. 18 and 19, *i.m.*), stretches itself transversely between the hook bulbs; the rest are the radial muscles (*r.m.*) that radiate from each of the latter.

With regard to the peritoneal lining of the body-wall, I have found no points of special interest. The internal surface of the body-wall presents a deep brownish red color.

The Alimentary Canal.—This is exceedingly long and takes a convoluted course which is complex but definite (fig. 23). Throughout its length the canal is fixed to the body-wall by means of numerous muscular filaments and by some muscular mesenteries. It may be said to consist of five main parts, *viz.*, the pharynx, the œsophagus, the crop, the midgut and the intestine. The names here employed to designate the different parts are in a measure provisional and may not be exactly identical with the parts called by the same names in other Echiuroids. I have found it not always an easy matter to draw homology between the different regions of the digestive tract in the present species and those in other Echiuroids.

The mouth leads into the *pharynx* which is a sac-like, relatively short, muscular tube (figs. 18, 19 and 23, *ph.*). In preserved specimens it is about 45 mm. long and 7–10 mm. wide. It is the widest and the thickest-walled part of the entire digestive canal. When filled with sand it may be distended into a large thin-walled sac. The outer surface of the wall is smooth; under circumstances the circular folds of the inner surface may be seen on the outside through the semitransparent wall. For its entire length the pharynx is fixed to the body-wall by a pair of tolerably wide and thick suspensory membranes of muscular nature, the wing muscles or lateral mesenteries (fig. 23, *w.m.*). These arise right and left from along the lateral sides of the pharynx and insert themselves on the body-wall along two parallel lines, each running 7–10 mm. apart from, and on either side of, the ventral nerve-cord. The two mesenteries are asymmetrical in that the one on the left side terminates behind with a free edge which slants down ventro-posteriorly from the hind part of the pharynx, while the other on the right side is more prolonged and extends farther backwards in connection with the œsophagus, at the same time the line of its parietal insertion gradually approaching the ventral median line. The right lateral mesentery just referred to terminates posteriorly by becoming confluent with the suspensory membrane (*d.m.*) of the dorsal vessel (*d.v.*), at a point a short distance in front of the junction of the posterior end of the œsophagus with the crop (*cr.*). I shall return to this suspensory membrane in relation with the dorsal vessel.

The *œsophagus* (fig. 23, *œs.*) is a narrow muscular-walled tube 2–4 mm. wide and which, when stretched out, may measure 200–300 mm. in total length. From the hind end of the pharynx it proceeds posteriorly down to about the middle of the body length; then it makes a sharp bend forwards, thus bringing about a narrow U-like loop. The ascending limb of the loop, on reaching a point a short way behind the posterior end of the suspensory membrane (*d.m.*) of the dorsal vessel, makes another sharp bend but this time backwards. Just at this point the œsophagus passes over into the third section of the alimentary canal, the crop (*cr.*). The first part of the œsophagus from the pharynx to the posterior end of the suspensory membrane of the dorsal vessel is, as before indicated, connected with the body-wall by the right lateral mesentery. The same part is further peculiar in that it is internally provided with a typhlosole-like structure projecting into the lumen along the midventral line (fig. 35, *ts.*). In addition to the above mentioned mesentery, the œsophagus is fixed in its entire length by a series of muscular strands which spring from the body-wall close to the ventral nerve-cord on the left side.

The *crop* (fig. 23, *cr.*) is, like the foregoing section, a narrow tube but is characterized by the internal surface being beset with villi-like papillæ. In the empty state it is 70–90 mm. long and 3–4 mm. wide. It takes a linear course and is furnished throughout its length with the ventral mesentery (*v.m.*) which is inserted on the ventral body-wall close to, and on the left of, the nerve-cord. Of this mesentery the parts immediately adjoining the crop wall form a gland-like structure of a reddish brown color (fig. 37, *gl.s.*).

The crop is followed by the *midgut* (fig. 23, *m.g.*). This is about three times as long as the former. The inner surface is put into closely set transverse wrinkles, instead of having papillæ. The tube bends forwards and backwards several times so as to form irregular W-like loops. It is not supplied with a mesenterial membrane but is fixed to the body-wall by a series of numerous muscle-threads, which on the whole are arranged in the manner of a mesentery. In all the specimens examined, the crop was found to be infested by an abundance of a Sporozoan parasite.

The boundary between the crop and the next following section, the intestine, is externally marked by the anterior end of the collateral intestine or the siphon (*c.i.*). The *intestine* proper is a comparatively wide (4–7 mm.), complexly winding tube of a great length. When straightened out, it may measure nearly 1½ meter in length. The inner surface is thrown into small transverse folds, which can be seen from the exterior through the thin wall. Like the preceding part of the digestive tract, the intestine is held in position by a mesentery-like series of very numerous muscle-threads. It may be distinguished into two parts. The first part (*in.*), making up about two-thirds of the length of the entire intestine, is accompanied by the collateral intestine (*c.i.*); it takes an irregularly winding course down to nearly the posterior end of the body-cavity and then turns round forward, to pass over into the second part at a certain distance. The second part (*in'.*) all along exhibits the siphonal groove (*s.g.*), brought into view owing to the absence here of the overlying collateral intestine and which runs down nearly as far backwards as the junction point of the anal glands. The part in question of the intestine lies ventral to the windings of the first part and takes at first an anteriorly directed course up to about the middle of the body; it then makes a sharp bend, thence to run backwards down to the anus at the posterior body-end. The terminal part of the intestine which may be called the rectum, is very short.

The alimentary canal in its entire length, excepting the pharynx and the "typhlosohle" bearing portion of the œsophagus, is always filled with fæces which are in the shape of small rods.

Having given above the gross features of the alimentary canal, I will now pass over to its microscopic structure. In this respect the present species presents not a few points of peculiarity. For the sake of comparison, I have studied histologically the same organ-system of *Echiurus unicinctus*, a species which moreover was thoroughly described by SELENKA ('85) and ALICE EMBLETON ('00); and I have found that, while that species presents an essential agreement with other previously known Echiuroids in the anatomy as well as the histology of the digestive system, the present species shows no small degree of deviation in those respects, especially as regards the microscopic structure of the foregut and of the anterior portion of the intestine.

The wall of the pharynx consists of four layers, *viz.*, the mucous membrane, the muscular layer, the trabecular layer and the peritoneum. See Pl. III., fig. 32, which represents a part of a cross-section through the pharynx and the wing-like lateral mesenteries (*w.m.*).

The mucous membrane (fig. 32, *m.m.* and fig. 33) constitutes a moderately thick, much folded layer, which again is made up of the lining epithelium (*ept.*) and the subjacent connective-tissue layer (fig. 33, *c.t.l.*). The former is composed of tall and narrow cells containing nucleus in about the middle of their length. Their internal or free end is covered with a thick cuticle (*ct.*), while the opposite, much narrowed end seems to be directly continuous with a process of the connective-tissue cell. Hence, there exists no sharp demarkation of the epithelium against the underlying tissue. As was noted by JAMESON ('99) in *Thalassema neptuni*, the pharyngeal epithelium incloses numerous club-shaped, unicellular glands (*gl.*) with colorless homogeneous contents, in which is observable a deeply stainable, more or less reticular structure. The nucleus in these glandular cells lies always near the swollen inner end. The connective-tissue layer (*c.t.l.*) between the epithelium aud the muscular layer, is of a considerable but varying width. It is composed mainly of fusiform or branched cells, which send out slender processes that give a fibrous appearance to the tissue. A quantity of variously sized, deeply stainable spherules are contained in the layer; they are in all appearance the same as those found in the cutis (fig. 26, *pg'.*).

The muscular layer of the pharyngeal wall consists of the inner circular and the outer longitudinal systems (fig. 32, *c.m.* and *l.m.*). The latter, according to both RIETSCH ('86) and JAMESON ('99), should be entirely wanting in *Thalassema neptuni*, while in *Echiurus unicinctus* and *E. pallasi* it is only weakly and inconspicuously developed. In the present species, that system is remarkably well developed, forming a layer nearly equal in thickness as that of the circular muscle system.

Externally to the muscular layers is what I have called the

the trabecular layer (fig. 32, *l.t.*, and fig. 34), which is probably identical in nature with the layer I have described by the same name from the body-wall of the male of *Bonellia miyajimai* (p. 7). The layer in question of the pharyngeal wall consists of an irregular network of strands, inclosing roundish meshes of various sizes. See *fig.* 34, which represents under high magnification a small portion of the layer in section. The said strands are made up of a stainable ground-substance, in which are numerous connective-tissue fibers and a sparse number of cells, besides being traversed by some isolated muscle fibers (*m.f.*). The meshes form in reality a system of irregularly branching and freely anastomosing canals, the lacunar sinus (*l.s.*). The sinus contains numerous amœboid cells (*w.c.*), laden with spherules which are of a yellowish brown color in the fresh state and which stain deeply with hæmatoxylin. The cells are of various sizes, the size apparently depending upon the quantity of the spherules contained in the cell-body.

The peritoneum investing the external surface of the pharyngeal wall requires no special description beyond mentioning the fact that it consists as usual of greatly flattened cells.

Of the several layers composing the pharyngeal wall, the connective-tissue layer of the mucous membrane and the trabecular layer were not known before from any *Thalassema*. In *Th. neptuni*, according to JAMESON ('99), both the inner lining epithelium and the peritoneum should directly overlie the middle layer consisting of circular muscle fibers alone. In *Echiurus unicinctus*, I have found that a connective-tissue layer is present beneath the inner lining epithelium, but no trace of a trabecular layer beneath the peritoneum.

The wall of the œsophagus is structurally nearly similar to the pharyngeal wall, except in the more conspicuous development of the longitudinal muscle system and in the absence of the trabecular layer. The typhlosohle-like ridge (fig. 35, *ts.*) in the anterior part of œsophagus is superficially covered with an epithelium, in which cell outlines are indistinct but which exhibits nuclei arranged in a row (fig. 36, *ept.*). The epithelium contains a large number of small, yellowish brown spherules, either in a scattered manner or in irregular and indefinite groups. The spherules are probably the same as those contained in the wandering cells. The main internal mass of the ridge is a transparent chondroid substance, contained in which are a few cells and some peculiar fibers. The former (*c.t.c.*) are without doubt of mesenchymatous nature; they send forth into the ground-substance a number of long and slender, fiber-like processes. The latter are filaments of a considerable thickness; they are irregularly wavy and run in indefinite directions. Apparently they stand in no direct connection with any of the cells, and their appearance leads one to compare them with elastic fibers in the connective tissue of the higher animals. From its structure the typhlosole-like ridge can scarcely be assumed to be an organ of secretion or of absorption. More probably it is an apparatus which may aid in the mechanical crushing of the food mass taken in.

The villi-like papillæ, the presence of which characterize the inner surface of the crop, are of a very remarkable histological structure. They consist almost wholly of a syntitium, evidently formed by fusion of the epithelial cells (fig. 38, *ept.*). The internal surface shows no ciliation. As seen on cross-sections, there opens a large unicellular gland (*gl.*) nearly regularly in the depression between the bases of every two papillæ. In this section of the alimentary tract as in all following sections, the longitudinal muscle layer (*l.m.*) lies internally to the circular (*c.m.*), the reverse of the order seen in the pharynx and the œsophagus. The former layer is in contact with the basal surface of the internal epithelium and is longitudinally folded. Where the folds recede from the unfolded circular muscle layer there exists a connective-tissue space of a considerable width. The peritoneal covering (*pr.*) of the crop is quite peculiar in that here, as nowhere else on the entire alimentary canal, it is composed of tall cylindrical or even club-shaped cells with coarsely granular contents.

In connection with the crop I may here deal with the structure of the ventral mesentery which joins it to the ventral body-wall. That mesentery (fig. 37, *v.m.*, and fig. 39) is of a considerable thickness; it incloses in the interlamellar connective-tissue layer sinus-like spaces in which are found some wandering cells (fig. 39, *w.c.*). These cells are quite indefinite in shape, being sometimes elongate, sometimes ovoid and at other times amœba-like. Most of them, but not all, contain in the cytoplasm a limited number of yellowish brown spherules, which are in all probability the same as those found in cœlomic corpuscles and in the peritoneal cells to be directly described. As before mentioned, the ventral mesentery presents a glandular appearance in the parts adjoining the crop (fig. 37, *gl.s.*). This is due to the facts that the surfaces of the mesentery are thrown into numerous small folds and that the peritoneal covering is thickened and is converted into a peculiar structure. Fig. 39 shows highly magnified a small portion of a cross-section through the mesenterial part in question, with two folds on its side. It will be seen that the peritoneum of this region is characterized firstly by the fact that it is at most places more than one cell in thickness, and secondly by the relatively bulky component cells containing an abundance of variously sized spherules of a yellowish brown color. Those cells [*a* (*pr.*)], which sit with one end directly on the subjacent connective-tissue, are of an oblong or elongate shape and possess round nucleus with distinct chromatic bodies, while the others [*b* (*pr.*)] more superficially situated are shorter, being roundish or irregular in shape, and show clear looking nucleus with only a few and indistinct chromatic bodies. Some of the latter kind of the cells detach themselves from the peritoneal surface and fall into the cœlomic cavity. Evidences of this fact can be easily obtained by tracing on serial sections. The cells thus liberated can impossibly be distinguished from the corpuscles (*b.c.*) found floating in the cœlomic fluid. In fact I take no heed in regarding the region in question of the ventral mesentery to be the formative source of all the cœlomic corpuscles.

Passing on to the midgut, I find that the small transverse folds on the internal surface are formations of the lining epithelium alone (fig. 40, *ept.*). They are made up of spindle-shaped or pyramidal epithelial cells arranged in several layers with their long axis directed nearly vertical to the epithelial base; whereas at the bottom of the narrow depressions between the folds, the epithelium consists of comparatively short cylindrical cells in a single layer. Near the free internal surface of the folds are some small unicellular glands (*gl.*) of a flask-like shape, opening by narrow duct into the gut lumen. Close to the base of the epithelium is the layer of longitudinal muscle fibers (*l.m.*). That of circular muscle fibers (*c.m.*) lies more externally and close under the peritoneum (*pr.*). This is composed of cells which are not quite flat nor cylindrical but present a somewhat swollen appearance.

To judge from the arrangement of the musculature, the crop and the midgut, taken together, probably correspond to the anterior portion of RIETSCH's "intestine intermediaire" in *Th. neptuni* and to JAMESON's "crop" or the anterior portion of his "intestine" in the same species. However, there exists in this respect a notable discrepancy in the fact that neither the crop nor the midgut in the present species is provided with the siphonal groove, which does not extend, as it does in other *Thalassema* species, farther anteriorly than the anterior end of the collateral intestine.

With regard to the wall of the part called by me the intestine, I have found the finer structure to be essentially the same as is known from the intestine of *Thalassema neptuni*, *Echiurus pallasii*, *E. unicinctus* and several *Bonellia* species. Only the internal epithelium of the collateral intestine presents a condition which seems to deserve a brief description. Fig. 41 represents a portion of a cross-section through that organ, seen under a high power of magnification. The internal epithelium (*ept.*) forms a few number of longitudinal ridges that project into the lumen and greatly narrow it. Each of these ridges may be said to consist entirely of a continuous mass of protoplasm, apparently the result of fusion undergone by the epithelial cells. The nuclei are visible only near the free surface, arranged in a single irregular row. Interspersed among the nuclei are a number of vacuole-like spaces. All the internal parts of the ridges consist of a densely and coarsely granular mass containing numerous pigment spheres of various sizes (*pg.g.*).

The *anal glands* (fig. 23, *a.g.*), present in a pair, open into the very short rectum. They are brown tubes of 6–7 cm. length, fixed at the extreme tip to the body-wall by a long and slender muscular thread. The main canal of the organ is thickly beset all over with tubules, which are either simple or are divided into 2–5 branches (fig. 25). Distally the tubules or their branches pass over each into a relatively large and long funnel-tube of a deep brown color.

The Segmental Organs.—I have devoted special attention to the segmental organs which offer the most striking characteristic of the species. They are present in a very large number (figs. 18 and 23, *seg.*). They were never less than 200 in total number, and in certain individuals I have estimated this to be nearly 400. Moreover, unlike all other known Echiuroids, there is no indication of their segmental arrangement, nor of their strictly paired disposition. On the contrary, they occur densely and irregularly crowded together in two longitudinal zones, one on each side of the ventral nerve-cord, beginning in front just behind the ventral hooks and extending posteriorly to a length of 10–18 cm. In the anterior parts of each zone, some four or five segmental organs stand abreast; in the middle parts, three (see fig. 18, *); more posteriorly, two (fig. 29); and finally in the posteriormost parts, they occur in a single row.

Each single segmental organ is a thin-walled, elongate, bottle-shaped tube, measuring 10–12 mm. in length in the fresh state (see fig. 24). Internally it ends with a relatively large and apically situated ciliated funnel (*fn.*). To my knowledge, such an apical position of the funnel on segmental organs has not been known before from other Echiuroids. All the specimens examined by me being sexually ripe females (obtained in November and December), I have found the swollen part of the segmental organ filled with spherical ova of a light yellow color.

Studies of the segmental organ on sections (figs. 29–31) did not bring to light much structural peculiarities. In fig. 29 is given a sketch of a small portion of the body-wall in cross-section, showing the position of the organs on either side of the ventral nerve-cord (*v.n.*) and the manner of their opening externally on the ventral surface (*ex.o.*). The part of the out-leading duct directly adjoining the external opening is characterized by being lined with a thick epithelium extremely rich in unicellular glands (fig. 30, *gl.*). These are of an elongate oval shape, each opening on the external end with a comparatively large and distinct pore. Their contents show a coarse reticular structure, deeply stainable with hæmatoxylin; the nucleus is found always near the inner cell end. The true epithelial cells lie so narrowly compressed between the glandular cells that their limits can not be made out (*ep.*). However, their nuclei can be easily distinguished by their oblong shape, while those of the underlying mesenchyme cells are round and somewhat larger. The main tubular part of the organ has thin wall, the structure of which is shown in fig. 31 in longitudinal section. The internal epithelium (*ept.*), as also the external peritoneal covering (*pr.*), is composed of very flat cells in a layer. Almost in contact with the internal epithelium is a layer of longitudinal muscle fibers (*l.m.*). Between this and the peritoneum is a connective-tissue layer, in which run a number of muscle fibers in indefinite directions (*o.m.*).

With regard to the form and structure of the ciliated funnels (fig. 24, *fn.*), no point of special interest has come into my notice.

The Circulatory System.—This is essentially of the same arrangement as in other known Echiuroids, except in a few points. One remarkable feature of it consists in the unusual length of the vessel (figs. 18, 19 and 23, *d.v.*), a fact which stands in relation with the posterior situation of the so-called heart. This describes as usual a curve embracing the alimentary canal,—in the present species, at the posterior end of the midgut. As before indicated, a large part of the dorsal vessel in front of the crop is fixed to the body-wall by a mesentery-like suspensory membrane (fig. 23, *d.m.*). Such a membrane is unknown in other Echiuroids, the dorsal vessel running free in the body-cavity throughout its entire course. The parietal insertion of the said suspensory membrane is dorsal in the anteriormost part. Posteriorly its course gradually changes into lateral on the right side of the worm and finally into ventral. Soon after this, the membrane becomes confluent with the right lateral mesentery before described. More posteriorly from this point, the single membrane formed by the confluence connects the dorsal vessel to the dorsal surface of the œsophagus and no longer to the body-wall. This condition obtains for a length of 10–20 mm. in about the region marked with ⁂ in fig. 23. After that, the posterior continuation of the membrane separates from both the dorsal vessel and the œsophagus, and runs for a short distance with free edges until it becomes continuous with the ventral mesentery (*v.m.*), which joins the crop to the ventral body-wall on the left of the nerve-cord. From the point the suspensory membrane leaves off the dorsal vessel, this runs of course free in the body-cavity down to the heart, except at a single point 10–12 cm. from the mouth. The point is marked with + in fig. 23. There arises from the vessel a short and slender muscle thread, which inserts itself on the ventral body-wall on the right of the nerve-cord.

The heart and the ventral vessel are joined by a relatively short (3–4 cm.) commissure or neuro-intestinal vessel (fig. 23, *n.i.*). This arises from the heart with two roots, so that it presents the shape of an inverted Y. The ventral vessel (figs. 18, 20, 23 and 29, *v.v.*) runs throughout its length just above and along the ventral nerve-cord. Like this it bifurcates immediately behind the mouth. The two vessels thus formed proceed into the proboscis and constitute the lateral vessels of that organ (fig. 20, *l.v.*). In three specimens out of the six dissected, I have ascertained the presence, on the ventral vessel, of a peculiar slender branch which probably corresponds to the ring-vessel described by SPENGEL ('80) from *Echiurus pallasii*. The vessel in question (figs. 19 and 20, *r.v.*) branches off from the ventral vessel at a point about 1 cm. behind the ventral hooks and runs forwards over and beyond the interbasal muscle of the hooks. Arrived at a close proximity to the bifurcation point of the ventral vessel (see fig. 20), the vessel under treatment (*r.m.*) splits into three short branches. Of these the two lateral branches soon join the roots of the lateral vessels (*l.v.*) of the same side, while the single median branch communicates with the anterior end of the ventral vessel at the bifurcation point.

As regards the finer structure of the heart and the vessels, I have scarcely anything to add to what is already known from other Echiuroids. Only let it be mentioned that the ventral vessel of the ventral vessel has an internal lining epithelium consisting of tall club-shaped cells with the swollen rounded end projecting more or less free into the lumen. See *ept.* in fig. 42, which shows a longitudinal section of the wall of the vessel in question.

The Ovary.—As already stated, all the six specimens examined by me were females. In all the cases, the ovary was developed as a long narrow band, lying over the posterior parts of the ventral vessel for an extent of about one-sixth of its total length. Structurally the organ offers no new points worth specially mentioning.

On the same ground I may altogether dispense with giving an account of the nervous-system.

Floating Bodies in the Cœlom.—Besides the cœlomic corpuscles already referred to (fig. 39, *b.c.*), the cœlomic fluid further contains two kinds of peculiar floating bodies that require to be described. One of them shall here be called the corpuscular bodies; the other is the so-called "Töpfchen."

The corpuscular bodies are of very various sizes. The larger ones measure 1–2 mm. across and are easily seen with the naked eye. Spherical in shape, they are of a dark reddish or of a dark violet color in the fresh state. Examined under the microscope, they are found to be hollow blastula-like spheres, the wall of which consists of an epithelium-like aggregation of remarkable looking cells disposed in a layer. Seen on the surface, the cells present an irregularly lobed appearance, tightly clasping one another with the lobes (fig. 21 *a*). A distinct boundary membrane exists between them. The finely granular cytoplasm incloses a number of refractive granules or spherules of a deep brownish-violet color. The nucleus is spherical, shows a relatively thick nuclear membrane and is but little affected by ordinary nuclear stains.

The physiology of the above described bodies remains completely in the dark. As to their origin, a clue might be found by a study of the smaller ones which are apparently in the process of development. With the decrease in size of the bodies, I find that the component cells grow continually less in number, the lobe-like processes of these less pronounced and the internal cavity less spacious. So by a gradational series of transitional forms, the blastula-like bodies are led over to a simple group of a few number of cells (fig. 21 *b*) which are simply oblong or subspherical in shape and cohere together like blastomeres in a segmenting ovum. Such a small group may be formed of only four or three or even two cells. Each cell then compares well in appearance with the unicellular blood-corpuscle (fig. 39, *b.c.*) found likewise free in the body-cavity, though generally slightly larger in size. In fact, the identity of the cells referred to seems to scarcely admit of a doubt. It may then be thought of that the polycellular body arises by repeated division of the unicellular corpuscle. And yet, notwithstanding careful researches, I have never been able to detect a sign of cell division in the cells, irrespective of these being isolated or combined. It seems to me not improbable that in view of their extreme poverty in chromatic substance, the nuclei of the cells in question are in an inactive state as regards the dividing power. If now the polycellular bodies are really formed of the unicellular corpuscles, I should think the mode of formation is not by repeated cell-multiplication but by aggregation of the latter in as many number as the body is seen to consist of.

The "Töpfchen," commonly found in the body-cavity of Gephyrean worms, is in the present species a small globular body provided at one part with a relatively large and ciliated funnel-like opening (fig. 22, *fn.*). The funnel wall is covered with a tall ciliated epithelium. For the rest the external surface is covered with a flat non-ciliated epithelium. The interior of the body is filled with a mass of irregularly shaped cells, which mass inclose a number of brownish pigmented spheres. The internal termination of the funnel could not be exactly determined.

The above peculiar body is a thing which is by no means satisfactorily known. Most of the earlier and some recent writers have regarded it to be a parasitic organism, while some others, f. i., METALNIKOFF ('00), have considered it to be a liberated part of the worm-body. Although unable to offer decisive evidence, I am certainly inclined to accept the latter view.

The Proboscis.—The long tape-like proboscis in transverse section presents a crescent-like shape, the concave side of which is the ventral.

The epidermis (*figs.* 43–45, *ep.*) is composed of a layer of cylindrical cells with round nucleus situated nearly in the middle and containing a distinct nucleolus beside numerous chromatic granules. On the external surface the epidermis shows a very thin cuticular layer and bears fine cilia on the ventral side of the proboscis but not on the dorsal. Internally the epidermis sits on a fine but sharp basal membrane (figs. 44, *li.m.*), the cells being quite without the basal processes that we have seen in the case of epidermal cells of the body proper. The epidermis is thickest and the ciliation most conspicuous along the margin of the ventral surface (see fig. 43). Peculiar to the epidermis of the dorsal side is not only the absence of ciliation but also the fact that there open through it numerous unicellular glands (fig. 45. *g.gl.*) similar to those found in certain parts of the body proper. The glands originate without doubt each from an epidermal cell, and assuming a long and club-like shape, have sunk deep into the subepidermal mesenchyme.

Right close to the internal surface of the basal membrane is the dermal musculature, which consists of the two systems of the external longitudinal and the internal circular muscle fibers (figs. 44 and 45, *l.m.* and *c.m.*). Both systems are made up of fine muscle fibers running closely side by side in a single layer.

Almost all the parts internal to the dermal musculature are occupied by the massive mesenchyme or the connective tissue, in which lie imbedded the pigments, the muscles of the deep parts, the nerves and all the rest of internal organs. Structurally, a distinction may be drawn between the mesenchyme of the periphery and that of the inner parts, although the two insensibly merge into each other. The latter forms by far the greater portion of the entire tissue. It is distinctly, though very loosely, fibrous, the fibers running mostly in the dorso-ventral direction. They are seen to be fine long processes, emanating directly from certain isolatedly situated cells—the connective-tissue cells (figs. 44, 46 and 47, *c.t.c.*)—which are either spindle-shaped and bipolar or irregularly shaped and multipolar, so to say. The fibers and cells lie in a space which appear to be occupied by a clear fluid, probably of a lymph-like nature. Occasionally met with in that space are roundish cells without processes and which may be identified as wandering cells (fig. 44, *w.c.*).

The mensenchyme of the periphery (fig. 44, *p.c.*), forming an indefinite, but on the whole thin, layer just beneath the dermal musculature, consists of rather closely disposed, irregularly shaped cells, which at places are apparently in direct fusion and at other places are joined to one another by means of some short processes, leaving mesh-like spaces between them. The cytoplasm of the cells is deeply stained by eosin or erythrosin and shows a finely granular structure. The most deeply situated cells of the layer are not infrequently provided with longer processes than those more superficially situated, and that often in a less number,—thus approaching the form of the ramified mesenchyme cells in the deep parts of the proboscis. On the dorsal side of the proboscis, the continuity of the peripheral mesenchyme layer is much broken as seen on sections, on account of the presence of the club-shaped unicellular glands (figs. 43 and 45).

RIETSCH ('86) has described from *Bonellia minor* and *Thalassema neptuni* a subdermally situated layer of "cellules ganglionaires," which occupy a position outside of the dermal muscle layers and which stand in direct connection with epidermal cells by means of fine processes. Now, the above described peripheral mesenchyme cells are not without resemblance to the "cellules ganglionaires." Nevertheless, it seems not warranted to directly homologize the two, since the former are situated inside, instead of outside, the dermal muscular layers. Moreover, in *Th. tænioides* the epidermis of the proboscis, unlike that of the body proper, is found to be everywhere separated from the underlying tissue by a distinct limiting membrane, and under no circumstance could a direct plasmic connection be demonstrated to exist between the two tissues.

In two ventral regions of the proboscis, the layer of the peripheral mesenchyme is specially thickened internally into a pair of massive, longitudinal bands (marked with + in fig. 43), which on transverse sections present a somewhat triangular outline and are conspicuous on account of an unusually dense appearance of the tissue. The bands run all along the lateral margins of the proboscis, just beneath that ventro-lateral zone of the epidermis where this consists of considerably taller cells than in any other parts of it. The mesenchyme cells in the bands differ in no way from those in more strictly subdermal situations, but what gives to the tissue its distinctive appearance is the fact that the mesh-like intercellular spaces are taken up by the wandering cells present in a large number.

In the mesenchyme space, peripheral as well as deeply situated, are present pigment granules in abundance. To their peculiar distribution is due the brownish markings of the proboscis. Observed under the microscope, the granules are of various sizes and appear greenish yellow in color. They are generally arranged in irregular streaks, mostly around and along those connective-tissue fibers that extend in dorso-ventral direction in the thickness of the proboscis (fig. 44. *pg.g.*).

Of the muscles that traverse the mesenchyme space, there are to be mentioned, in the first place, those muscle fibers that run in the longitudinal direction. These are arranged in numerous, small and separately running bundles (figs. 44 and 47, *m.f.b.*), which show each a delicate sarcolemma-like envelope. Certain other muscle fibers, especially those that take dorso-ventral course, do not form themselves into bundles but run singly. Nevertheless, even these isolated muscle fibers can be readily distinguished from the connective-tissue fibers in that they show a finely fibrillar structure. A special system of fine muscle (fig. 43, *m.f.*) branch off from the circular system of the ventral dermal musculature, on each side of the proboscis at a point about midway between the lateral vessel and the lateral margin. It proceeds obliquely upwards and towards the latter. In the course the single fibers somewhat diverge from one another; and after penetrating through the ventro-lateral mesenchymal band (+) spoken of before, they finally terminate under the thickened epidermis of the region. The system has certainly greatly to do with the incessant movements exhibited by proboscidial margins of the living worm.

With respect to the nerves, I have nothing to add to what has been already known from other Echiuroids. Suffice it to say that there exists a pair of strong longitudinal nerves, the lateral nerves (fig. 43, *l.n.*), which join together near the apex of the proboscis, and that these lateral nerves at intervals of their course give off branches (*n.*) towards the sides. The branches again split into finer branches, which finally become lost from view in the subdermal tissues.

Of the blood-vessels, there are three, exactly as known from other Echiuroids. They are one median and two lateral vessels, all which, running longitudinally, become finally continuous with one another near the apex of the proboscis. As usual, the median vessel lies imbedded in the mesenchyme, while the thin-walled lateral vessel is contained within a continuation of the body-cavity, the so-called perihæmal cavity (fig. 43, *per.c.*).

The perihæmal cavity represents a moderately wide tubular space, running ventral to the lateral nerve. It is internally lined with the peritoneum consisting of somewhat flattened and stellate cells (fig. 46, *pr.*). Basally to the peritoneum is a very thin layer of circularly and longitudinally running muscle fibers. Now, the lateral vessel does not lie quite free in the perihæmal cavity, but is attached all along its dorsal line to the wall of the latter (fig. 46, *x*). Two flat epithelia (*ep.* and *ent.*) of quite similar appearance and an interposed thin layer of muscular fibers (*m.f.*) constitute the wall of the vessel. The inner epithelium may with propriety be called the endothelium, while the outer is the continuation of the peritoneal lining of the perihæmal cavity. This structure of the vessel wall is clear in the present species, though it does not agree quite with our previous knowledge derived from other Echiuroids. Thus, RIETSCH ('86) says that in *Thalassema neptuni* and *Echiurus pallasii* the vessel wall is composed of only the peritoneal layer. SPENGEL ('80) states for the same of *Echiurus pallasii*: "Ich weiss nicht, ob eine innere Zellenauskleidung vorhanden ist. Ich fand nur eine dünne Membran mit eingestreuten Kernen und in oder auf dieser liegend Muskelfasern, vorwiegend longitudinale Bündel bildend, und als äusserste Schicht einen Peritonealzellenbelag............" (*p.* 510). One sees at once that the "dünne Membran mit eingestreuten Kernen" in the above extract corresponds to the endothelial layer.

The median vessel of the proboscis is of essentially the same structure as is known from *Bonellia minor*, *Thalassema neptuni* and *Echiurus pallasii* (RIETSCH, '86), except in some not unimportant points. The reader is referred to fig. 47, which represents a part of a cross-section through the vessel in question. On the external side of the vessel wall and lying against the mesenchyme tissues (*c.t.c.*, *m.f.b.*), is a row of tall club-like cells arranged in an epithelium-like manner (*ept.*). They have the swollen and rounded end directed outwards, and sit with the opposite truncated end on a thin layer of circular muscle fibers. (*c.m.*). Some of the mesenchyme cells in the immediate surrounding are seen to insert their processes between the cells of the row. Inside the circular muscle fibers is a layer, which on cross-sections might at first sight be mistaken for an epithelium consisting of cubical or cylindrical cells arranged in a row. What then appear like cells are in reality cross-sections of sarcolemma-like sheaths that inclose each a bundle of longitudinal muscle fibers (*l.m.*). In most places this layer forms apparently the innermost wall of the median vessel. A continuous endothelium could not be brought into view. However, there exist, here and there on the internal surface of the wall, peculiar isolated cells of irregularly stellate shape (*ent.c.*) They are fixed in position in that a part of their body is inserted in the interstice between the sarcolemma-like sheaths. If the cells can really be considered to constitute a part of the wall, they may possibly represent endothelial cells. In the proboscis of *Bonellia misakiensis*, which I studied fer the sake of comparison, I found the median vessel as well as the lateral vessels provided with distinct endothelium. According to RIETSCH, neither an endothelium nor a layer of longitudinal muscle bundles, such as I have described, should exist in the wall of the median vessel in the proboscis of *Thalassema neptuni*, *Echiurus unicinctus* and *Bonellia minor*.

3. *Thalassema elegans* I. IKEDA.

(Fig. 4, Pl. I.; figs. 48 and 49, Pl. IV.)

1904. *Th. elegans*, I. IKEDA, Jour. Sci. Coll., Vol. XX., Art. 4, p. 65.

During July, 1902, I have obtained in all four specimens of this highly interesting species. At first it was thought they might possibly be the male of *Th. tænioides*, but a closer examination soon revealed the fact that I had before me a new species allied to, but quite distinct from, the one just mentioned. *Th. elegans* inhabits the same shallow and muddy ground as *Th. tœnioides*, in the inlet of Moroiso, close to the Misaki Marine Laboratory. It lives in deep, vertically or somewhat obliquely sunk pits, which may be four feet deep and is scarcely distinguishable from those of *Th. tœnioides*. I must say, however, that I have never had an opportunity of discovering on the sea-bottom the external opening of the pit inhabited by the present species. Nor have I ever been able to see the outstretched proboscis of the worm on the bottom, notwithstanding the special searches I have made. This, coupled with the fact that the species so long escaped the notice of collectors in spite of the peculiar and conspicuous coloring of the proboscis, makes me think that the protrusion of this organ out of the hiding place, takes place under limited physical conditions, probably in the night time only.

As already indicated, the species is much alike *Th. tœnioides* in points of size, shape and color, though there exist remarkable differences in details and especially in the internal structure.

The proboscis, as measured on living specimens held in captivity, is 30–40 cm. long and 1.7–2 cm. broad in the broadest part, which is at the base. It is therefore considerably shorter and somewhat broader than in *Th. tœnioides*. The ground color is a clear yellow, which deepens in tone towards the base and along the free margin. The somewhat concave ventral aspect of the organ is marked in the distal parts with a fine and irregular network of a bright green color. The network is distinct for an extent of 6 cm. or more from the tip; proximally it grows gradually less distinct, at the same time assuming the form of fine transverse stripes. Finally, at about 15 cm. distance from the tip, the marking disappears altogether. The ventral concavity of the proboscis deepens towards the base, so that in this region the organ presents the form of a half-tube semicircular in cross-section.

The cylindrical body proper measures 30–35 cm. in length and transversely 2.5 cm. across. The general color is a brownish red. Of the paler colored, equidistant, longitudinal lines due to special thickenings of the longitudinal muscle layer of the body-wall, there are ten, instead of five in which number they occur in *Th. tænioides*. The dermal papillæ are in all respects similar to those of the species just referred to. They are largest and most closely aggregated in the anterior and the posterior parts of the body. Where the circular muscles of the body-wall has strongly contracted, there appear on the surface small lenticular outbulgings of the skin, regularly and closely arranged in longitudinal rows in the zones between every two of the ten pale-colored longitudinal lines. In the anterior half of the ventral side of the body, there are seen, in the living state, an indefinite number of deep red flecks which incessantly move about, at the same time changing their size (fig. 4). These flecks are brought about by the coming in contact of parts of segmental organs, which are of a milky white color, with the reddish inner surface of the body-wall. The two ventral hooks are situated a short distance —about 1.3 cm.—behind the base of proboscis. They are moderately large and slightly curved needles of a brownish yellow color. No anal hook is present.

Some Points of the Internal Structure.—All the longitudinal lines visible on the outside, excepting the one which runs in the mid-ventral line and is superposed by the nerve-cord, appear on the inner surface of the body-wall as slightly elevated, narrow ridges or thickenings of the longitudinal muscular layer. In the ten zones separated from one another by the above lines, the circular muscle fibers form more or less regularly arranged transverse bundles. The basal parts of the muscular sheath of the ventral hooks are provided with numerous radial muscles, but there exists no interbasal muscle.

The entire *alimentary canal,* when stretched out straight, may be 210 cm. long in a large specimen. It pursues a complex and tortuous, but to a certain extent definite, course (fig. 49). The manner of its winding resembles that of many other Echiuroids, especially of *Echiurus unicinctus* to my knowledge. As in this species, the entire canal is fixed to the body-wall by means of narrow muscular strands only, which are very numerous and of which the points of both origin and insertion are not in a straight continuous row but are distributed in different parts in relation with the convolution of the canal.

Here again, much difficulty is experienced in identifying the parts of the alimentary canal with those that have been distinguished by writers in other species. I can separate the canal into only three parts, *viz.*, the pharynx, the œsophagus and the intestine.

The *pharynx* (fig. 49, *ph.*) is a muscular tube, 4–5 cm. long and in the empty state about 5 mm. wide. Its inner surface is thrown into minute transverse folds. The posterior end of it is marked by the presence of the heart (*ht.*), situated on the dorsal side. No lateral mesenteries are present, but there exist some muscular strands that join the pharynx to the body-wall.

The *œsophagus* (*œs.*)[1] is a somewhat narrower tube, measuring 25–30 cm. in length. Making turns backwards and forwards, it describes narrow S-like curves. The inner surface of the œsophagus is distinguished by the presence of closely set, villi-like protuberances, which look very much like those in the crop of *Th. tœnioides.*

The *intestine* (*in.*) forms by far the largest part of the entire alimentary tract. It may be about 170 cm. long when stretched out straight, and is somewhat wider than the œsophagus, measuring on an average 8 mm. in width in the empty state. The transition of the œsophagus into the intestine is externally marked by the point of origin of the collateral intestine (*c.i.*). At first the intestine, as it starts from the last end of the œsophagus, is directed forwards in the anterior parts of the body on the left side. It then crosses over to the right side, above and across the pharynx. Thenceforth it runs posteriorly, pursuing an irregularly tortuous course, down to a point within a short distance from the posterior body end. Here it makes a sharp bend to continue its irregular winding course this time forwards. Coming up to a position in front of the first beginning of the intestine, it makes a second crossing over from left to right above the œsophagus. After that, it starts on the final, posteriorly directed, irregular course, which brings it to the terminally situated anus.

The *collateral intestine* (*c.i.*) is a moderately wide tube, running along the anterior parts of the intestine for a length of about 80 cm. The posterior parts of same, unaccompanied by the organ just mentioned, exhibit the siphonal groove (*s.g.*), which terminates behind in front of the rectum. This is about 1 cm.

1) In fig. 49, the first part of the œsophagus was inadvertently supplied with the reference *seg.*, which should be *œs.* instead.

long and is slightly dilated, being suspended on the lateral sides by an inconsiderable number of muscular strands.

The *anal glands* (*a.g.*), present in a pair on the sides of the rectum, are long and conspicuous tubular organs, which in large specimens may measure 20 cm. in length. The tube gradually narrows towards the tip. Only in the basal parts the organ is connected to the body-wall and the rectum by a few number of muscular strands; for the rest, it is entirely free. Over its entire surface are distributed numberless small and short-stalked funnels (fig. 48).

As before mentioned, the so-called *heart* (fig. 49, *ht.*) is situated dorsally on the hind end of pharynx. This anterior position of the heart constitutes one of the peculiarities of the species. On that account the dorsal vessel (*d.v.*) is rendered relatively short. The neuro-intestinal vessel (*n.i.*) arises from the ventral median point of the ring-sinus, which surrounds the extreme hind end of pharynx.

The *genital glands*, both male and female, develop, as in many other Echiuroids, from the peritoneum covering the posterior parts of the ventral vessel. In the present species, however, they do not form a specialized band lying on and along the ventral vessel, but cover the surface of the latter all around throughout their length. In all the four males and the single female I have obtained, the segmental organs were filled with fully mature reproductive elements of the respective sex. The spermatozoa are of a relatively large size, with head of an elongate conical shape. The eggs are spherical and relatively small in size.

The *segmental organs* present some very remarkable points, though, taken singly, they are of the ordinary type of structure. Each organ represents a conspicuous sac of an elongate club-like shape, tapering towards the inner end. It may be 3.5 cm. long and about 8 mm. broad at the bulbous base. The internal opening, present at the base, is provided with two, relatively short, spiral lobes.

The organs are present in a rather numerous number, though in a far less number than in *Th. tænioides*. Moreover, the number varies with individuals and presumably also with the sex. In a general way I may say that it ranges from 13 to 27. The organs are by no means indefinite as to the mode of occurrence, but show a decided tendency towards a symmetrical and segmentally paired arrangement. Six or seven pairs of them may be distinguished, opening ventrally on both sides of the nerve-cord. The pairs are well separated and lie equidistant from one another, the first pair occurring only a short distance behind the mouth and the last pair behind the middle of the body. But it must be mentioned at once that the pairs are not always perfect nor strictly symmetrical with respect to the number of segmental organs composing each half-pair on either side of the ventral nerve-cord. Thus, while in some cases a pair consists of two segmental organs—one on each side of the body—and is thus perfect, in other cases a half-pair may consist of a group of 1–3 segmental organs, the number in each group varying in different pairs and very frequently also on the two sides of one and the same pair, which is thus rendered to consist of two symmetrical or assymetrical groups of the organs. It may even happen that a single organ exists on one side, but none on the other to complete a pair. Where more than one segmental organs occur in a group to form a half-pair, they open close together apparently without a definite rule as to the relative position of the pores.

The exact manner of the grouping of segmental organs may be best seen from the following tables, which I have drawn up from four specimens available for the purpose.

Specimen A, ♂. (Dissection figured in fig. 49).

Order of pairs.	I.	II.	III.	IV.	V.	VI.	VII.	Total number of segm. bodies.
Number of segm. bodies on the right side.	1	1	1	2	1	1	1	21
Ditto on the left side.	1	2	2	3	3	2	0	

Specimen B, ♂. (Somewhat smaller than Spec. A).

Order of pairs.	I.	II.	III.	IV.	V.	VI.	VII.	Total number of segm. bodies.
Number of segm. bodies on the right side.	0	2	3	3	2	1	2	27
Ditto on the left side.	1	2	3	2	3	2	1	

Specimen C, ♂. (Somewhat smaller than Spec. A).

Order of pairs.	I.	II.	III.	IV.	V.	VI.	VII.	Total number of segm. bodies.
Number of segm. bodies on the right side.	1	1	2	3	2	1	1	25
Ditto on the left side.	1	3	3	2	1	2	2	

Specimen D, ♀. (The single female at disposal).

Order of pairs.	I.	II.	III.	IV.	V.	VI.	VII.	Total number of segm. bodies.
Number of segm. bodies on the right side.	2	1	1	1	1	1	0	13
Ditto on the left side.	1	1	1	1	1	1	0	

Noteworthy is the fact that in Specimen A, the first pair of segmental organs lies just behind the ventral hooks; whereas in all the other specimens I have found it situated in front of the hooks. It seems then assumable that the pair which presents itself as the first and the anteriormost in some individuals is entirely lost in others. In this respect, Specimen B may be considered to represent in a way a stage in which the pair in front of the ventral hooks is on the way of disappearing, that pair in the said specimen being represented by a single segmental organ on the left but by none on the right side. This way of looking at things leads one further to infer that the posteriormost pair is also disappearing; the process seems to stand on the way of progress in Specimen A, and to be consummated in Specimen D, as will be clear from a comparison of the above tables referring to the specimens in question. Granting that the segmental organs in the present species show signs of having undergone numerical diminution, it may be admissible to assume that the state of their pairwise or pseudo-pairwise arrangement has been derived from the condition obtaining in *Th. tænioides,* in which the organs in question occur crowded together without apparent order. In support of this view may be adduced the fact that whenever more than one segmental organs from a half-pair group in the present species, they are grouped together without a definite rule as to their relative position. Anyway, with respect to the number and the mode of arrangement of segmental organs, the present species may be said to stand in a measure intermediate between *Th. tænioides* and other Echiuroids with only 1–3 pairs of that organ.

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Explanation of Plates.

Explanation of Index Letters.

a.g. ......anal gland.
b.c. ......cœlomic corpuscle.
c. ....body-cavity.
c.i. ......collateral intestine.
c.m. ......circular muscle.
cr..........crop.
ct. ... .cuticle.
c.t.c. ......connective-tissue cell.
c.t.l. ......connective-tissue layer.
cts. ......cutis.
d.m. ......suspensory membrane of the dorsal vessel.
d.v. ......dorsal vessel.
ent. ......endothelium.
ep..........epidermis. In fig. 46, peritoneal layer of the wall of lateral vessel.
ept. ......epithelium.
ex.o. ......external orifice of segmental organs.
fn..........funnels of anal glands and vas deferens.
g.gl. ......large unicellular glands.
gl..........unicellular glands in body-wall and alimentary canal.
gl.s. ......gland-like structure of the ventral mesentery suspending the crop.
h.b. ......bulbular portion of ventral hooks.
ht..........heart.
i.m. ......interbasal muscle of ventral hooks.
in..........intestine.
li.m. ......limiting membrane beneath epidermis.
l.l..........trabecular layer of pharyngeal wall.
l.m. ......longitudinal muscle.
l.n. ......lateral nerves of proboscis.
l.s..........lacunar space.
l.v. ......lateral vessels of proboscis.
m.f. ......muscle-fibre.
m.f.b. ...muscls-fibres in bundles.
m.g. ......midgut.
m.m.......mucous membrane.
m.p. ......muscular pads.
n. ....nerve.
n.c. ......nerve-cell.
n.i. ......neuro-intestinal vessel.
œs. ......œsophagus.
o.m. ......oblique muscle.
p.c. ......peripheral mesenchyme cells.
per.c.......perihæmal cavity of proboscis.

pg..........pigment-bodies.
pg'. ......pigment-like bodies in cutis.
pg.g. ......pigment granules.
ph..........pharynx.
pr..........peritoneum.
r.m. ......radial muscles of ventral hooks.
r.v. ......ring vessel.
seg. ......segmentel organs.
s.g. ......siphonal groove.
s.m. ......sperm-mass.
s.o. ......sensory organ.
sp..........spermatozoa.
t.l..........trabecular layer.
t.s..........typhlosole-like ridge in œsophagus.
v. ....vacuole-like spaces.
v.d. ......vas deferens.
v.m. ......ventral mesentery.
v.n. ......ventral nerve-cord.
v.v. ......ventral vessel.
w.c. ......wandering cells.
w.m. ......wing-muscles of pharynx.

Plate I.

Fig. 1.—*Bonellia miyajimai* (female). 2 ×.
Fig. 2.—Male of *Bonellia miyajimai*. From a photograph. $1\frac{1}{4}$ ×.
Fig. 3.—*Thalassema tænioides*. Drawn from a small specimen in the living state. Nat. size.
Fig. 4.—*Thalassema elegans*. Anterior half of the body proper with the proboscis, in the living state. Nat. size.

Plate II.

(Figs. 5–17, *Bonellia miyajimai.*)

Fig. 5.—Magnified figure showing the two muscular pads (*m.p.*) enclosing the roots (*h.b.*) of ventral hooks, together with the ventral vessel (*v.v.*) and the ventral nerve-cord (*v.n.*) as seen from inside of the body-wall. A number of radial muscles (*r.m.*) radiate from the periphery of the pads.

Fig. 6.—Ventral hooks seen from the external surface of the body. About 65 ×.

Fig. 7.—One of the primary branches of the anal gland, giving off numerous secondary branches, each of which ends in a small funnel (*fn.*). About 40 ×.

Fig. 8.—Part of a paratangential section of the body-wall of the male (near the posterior body end), slicing the epidermis (*ep.*) and the dermal muscular layers. The epidermis is cut obliquely, so that its one-cell layered structure is made obscure. The small roundish or oval spaces (*l.s.*) among the dermal muscular fibres (*c.m.*, *l.m.*) are lacunar spaces which form an anastomosing network continuous with same of the subdermal trabecular layer. About 180 ×.

Fig. 9.—Part of a horizontal section of the body-wall of the male, passing partly through the ventral nerve-cord (*v.n.*) and partly just below it where the oblique muscle-layer (*o.m.*) is much thickened. About 180 ×.

Fig. 10.—Transverse section through the anterior region of the male, passing through the anterior swollen extremity of the ventral nerve-cord (*v.n.*). The section also shows the vas deferens (*v.d.*) and the narrow body-cavity (*c.*), both cut across near their anterior end. About 180 ×.

Fig. 11.—Part of a transverse section through the body of the male in about the middle of the anterior one-eighth of its length, in which region the vas deferens (*v.d.*) is somewhat widened and its position slightly raised so as to project into the body-cavity (*c.*). About 180 ×.

Fig. 12.—Highly magnified figure representing a transverse section through the ventral nerve-cord (*v.n.*) and the vas deferens (*v.d.*). The latter is here divided into three canals, all which are still con-

tained in a common connective-tissue ridge, projecting prominently into the body-cavity (*c.*). Zeiss, oc. 2 and hom. imm. $\frac{1}{12}$.

Fig. 13.—Part of a transverse section of the male, passing through the posterior portion of the anterior one-eighth of the body. Two (I and II) of the four terminal branches of vas deferens are seen free in the body-cavity. About 65 ×.

Fig. 14.—Sections of the tubular terminal branches (four in number) of the vas deferens. All the branches lie free in the body-cavity; they are cut through in various directions. Zeiss, oc. 3 and obj. E.

Fig. 15.—Cross-section through a ciliated funnel of the vas deferens, close to the inner end. As the result of preservation, the funnel has lost its natural shape and the section is seen to have passed at two opposite places through the parts where the inner and outer epithelia are directly continuous. About 410 ×.

Fig. 16.—Highly magnified figure showing a sperm-cell mass (*s.m.*) together with the underlying ventral nerve-cord (*v.n.*), both in cross section. The sperm-cell mass is fixed to the body-wall over the nerve-cord by a short mesentery-like stalk. Zeiss, oc. 2 and hom. imm. $\frac{1}{12}$.

Fig. 17.—Part of the wall of the vesicular body, representing the degenerated alimentary canal of the male. The inner epithelial cells (*ept.*) are vacuolated and are provided at the inner end with pseudopodia-like processes. Zeiss, oc. 2 and hom. imm. $\frac{1}{12}$.

(Figs. 18—22, *Thalassema tænioides.*)

Fig. 18.—Anterior part of a dissected specimen, showing, among other things, segmental organs *in situ*. In the regions marked with ⁂, a number of the organs have been cut off at the roots, in order to show the manner of their arrangement. About 1.5 ×.

Fig. 19.—Same as above, to show the anterior courses of the dorsal (*d.v.*), and the ventral vessel (*v.v.*), and also the ring vessel (*r.v.*). The ring vessel runs over and beyond the interbasal muscle (*i.m.*) of the ventral hooks; at the proboscis basis it divides into three short branches, for which see the following figure. 2 ×.

Fig. 20.—Greatly magnified figure representing the manner of communication between the bases of the two lateral vessels (*l.v.*) of proboscis and the three anterior branches of the ring-vessel (*r.v.*) mentioned above.

Fig. 21.—Corpuscular bodies floating in the cœlomic fluid. *a*, surface

view of irregularly lobed cells composing the wall of a very large corpuscular body. *b*, an entire small corpuscular body consisting of only four cells yet without lobe-like processes. 410 ×.

Fig. 22.—Optical longitudinal section of a "*Töpchen*." Zeiss, oc. 2 and hom. imm. $\frac{1}{12}$.

Plate III.

(All figures in this plate refer to *Thalassema tænioides.*)

Fig. 23.—Internal anatomy of a female specimen. The body-wall was cut open along the mid-dorsal line to expose the viscera into view. Reduced to $\frac{7}{10}$ natural size.

Fig. 24.—Some segmental organs greatly magnified. Each organ consists of a basal tubular portion, a swollen portion containing numerous eggs and of the ciliated funnel.

Fig. 25.—Magnified view of ciliated funnel-tubes on the surface of anal gland. Some tubes stand single, while some others are branched, each branch ending with a funnel.

Fig. 26.—Part of the body-wall from a transverse section, passing through nearly the middle of a small papilla. 180 ×.

Fig. 27.—Part of a section through a small papilla under higher magnification than in fig. 26, to illustrate the finer structure of the peripheral parts. Zeiss, oc. 4 and hom. imm. $\frac{1}{12}$.

Fig. 28—Part of a section through a large papilla. In the cutis-layer are imbedded numerous large unicellular glands (*g. gl.*), distinctly opening each for each through the epidermis on the cuticular surface. Zeiss, oc. 2 and hom. imm. $\frac{1}{12}$.

Fig. 29.—Median part of a transverse section through the ventral body-wall. Some segmental organs are seen in section on both sides of the ventral nerve-cord. Zeiss, oc. 2 and obj. a_2.

Fig. 30.—Part of a longitudinal section of the wall of a segmental organ near its external opening. Owing to abundance of large unicellular glands, the epithelial wall in this region is conspicuously thickened, as shown also in the preceding figure (*ex.o.*). Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 31.—Part of a longitudinal section of the wall of the tubular portion of a segmental organ. Between the two epithelial layers (the

peritioneum *pr.* and the inner epithelium *ept.*), there exists a connective-tissue layer comprising the internal longitudinal (*l.m.*) and the external oblique muscles (*o.m.*). Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 32.—Part of pharyngeal wall and of muscular lateral mesentery (*w.m*). in transverse section. Circular folds of the mucous membrane (*m.m.*) and the muscular arrangement are well seen. About 40 ×.

Fig. 33.—Small part of the pharyngeal mucous membrane greatly magnified. Unicellular glands (*gl.*) are interposed between strongly compressed epithelial cells (*ept.*). Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 34.—Highly magnified figure showing the structure of the trabecular layer in the pharyngeal wall; taken from a cross-section. In the lacunar spaces (*l.s.*) are contained amœboid cells (*w.c.*). Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 35.—Cross-section of the anterior portion of œsophagus with the typhlosole-like ridge (*ts.*). *w.m.* (misprinted *v.m.* in the plate) in this figure indicates the posterior continuation of the right lateral mesentery. 56 ×.

Fig. 36.—Showing the histological structure of the typhlosole-like ridge of œsophagus. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Plate IV.

(Figs. 37–47, *Thalassema tænioides.* Figs. 48 and 49, *Thalassema elegans*).

Fig. 37.—Cross-section of the crop and of the ventral mesentery (*v.m.*), on which a gland-like structure (*gl.s.*) is developed. About 40 ×.

Fig. 38.—Part of the crop-wall in cross-section. The villi-like prominences of the mucous membrane are seen to be composed of a syncytial mass of protoplasm. Peritoneum (*pr.*), peculiarly modified, consisting of tall cells. Longitudinal and circular muscle layers in reversed order against same in pharynx and œsophagus. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 39.—Part of a cross-section through the gland-like structure of the ventral mesentery. Above, two side-folds of the mesentery proper (A,B). *a* (*pr.*) and *b* (*pr.*) indicate two forms of the peritoneal cells. *b.c.*, cœlomic corpuscles, probably derived from the peritoneal cells. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 40.—A small part of the midgut in cross-section. Only one of the epithelial folds is shown. The peritoneal lining (*pr.*) consists of moderately tall cells in a row. Relative position of the two muscular layers (*c.m.* and *l.m.*) as in crop. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 41.—Highly magnified figure of a part of the wall of collateral intestine in cross-section. Only one of the folds is shown. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 42.—Part of a longitudinal section through the wall of ventral vessel. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 43.—Left marginal portion of proboscis in cross-section. 65 ×.

Fig. 44.—Ventral part of a cross-section through proboscis. On this side the epidermis is ciliated. Zeiss. oc. 2 and obj. hom. imm. $\frac{1}{12}$

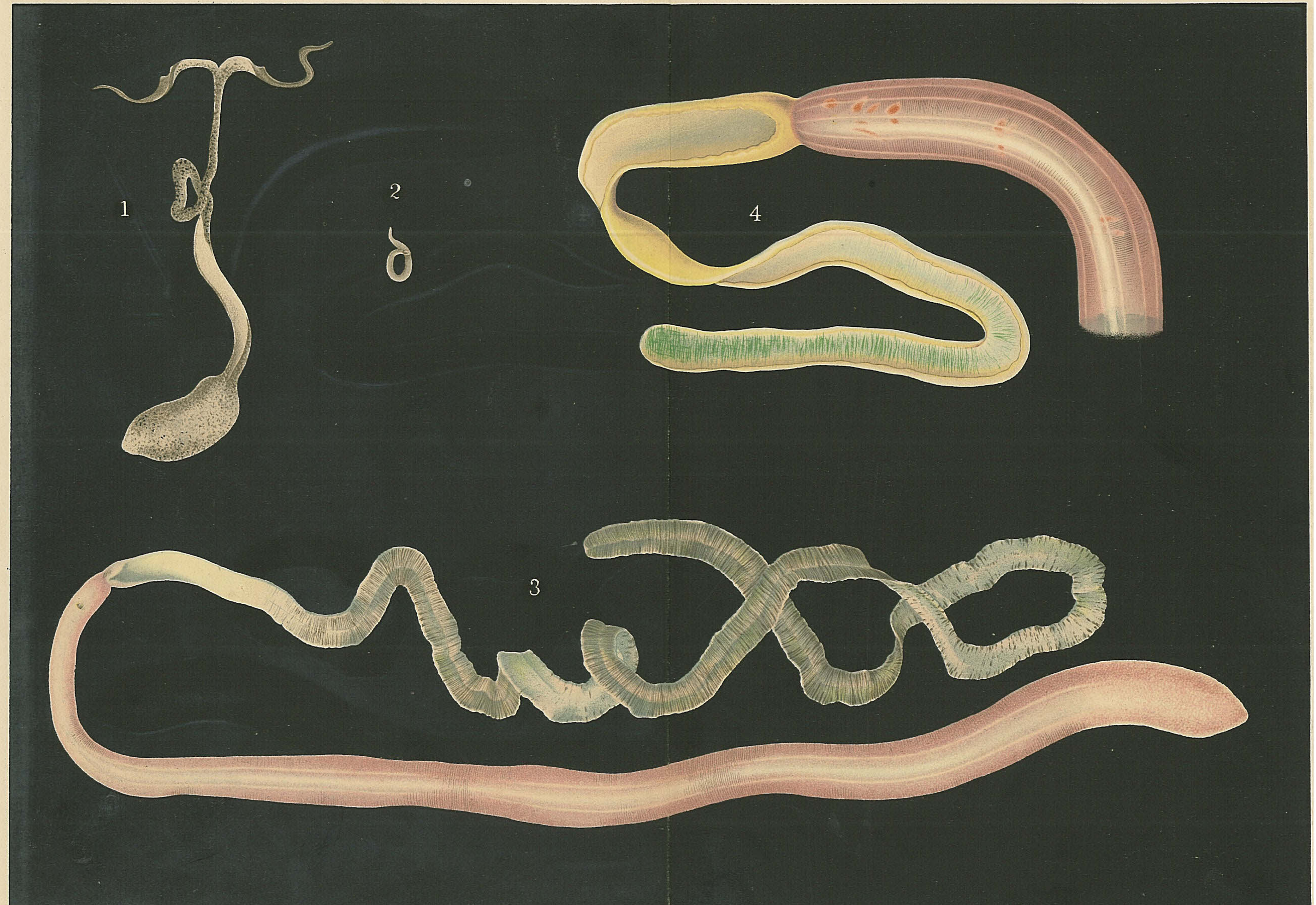
Fig. 45.—Dorsal part of a cross-section through proboscis. On this side the surface is not ciliated; numerous unicellular glands (*g.gl.*) are present seated deeply in subdermal mesenchyme. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 46.—A small part of a cross-section through proboscis, showing the relation of the perihæmal cavity (*per.c.*) to the lateral vessel (*l.v.*) and also the histology of the region. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 47.—Greatly magnified figure of a part of a cross-section of the median vessel of proboscis. Zeiss, oc. 2 and obj. hom. imm. $\frac{1}{12}$.

Fig. 48.—Magnified figure showing a number of ciliated funnels (*fn.*) situated on the surface of anal gland in *Thalassema elegans.*

Fig. 49.—A specimen of *Th. elegans* dissected to show the internal organs *in situ.* The body-wall has been cut open along the dorsal median line. Reduced to $\frac{3}{4}$ natural size.



1, Bonellia miyajimai, ♀. 2, ditto, ♂. 3, Thalassema taenioides. 4, Thalassema elegans.

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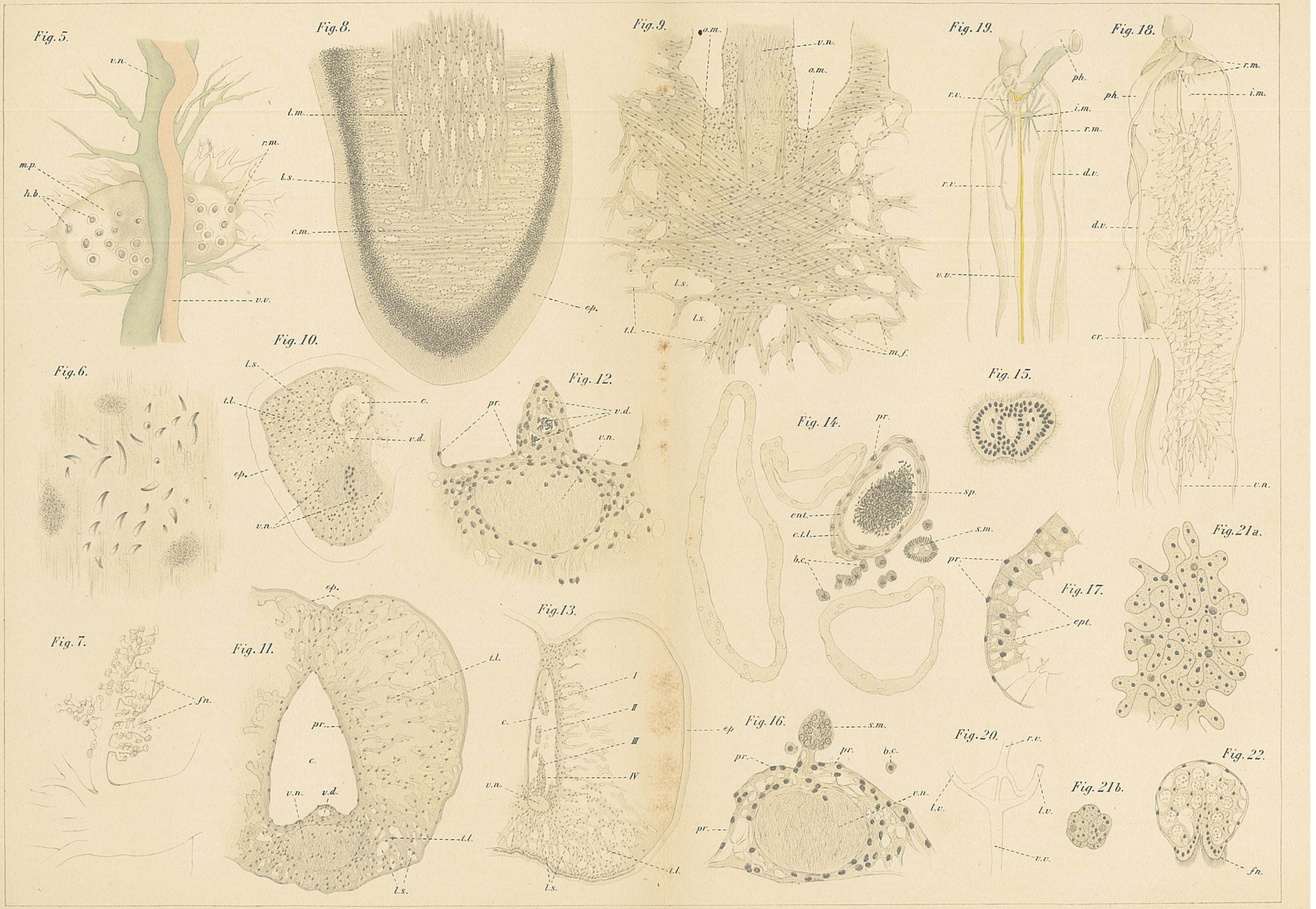
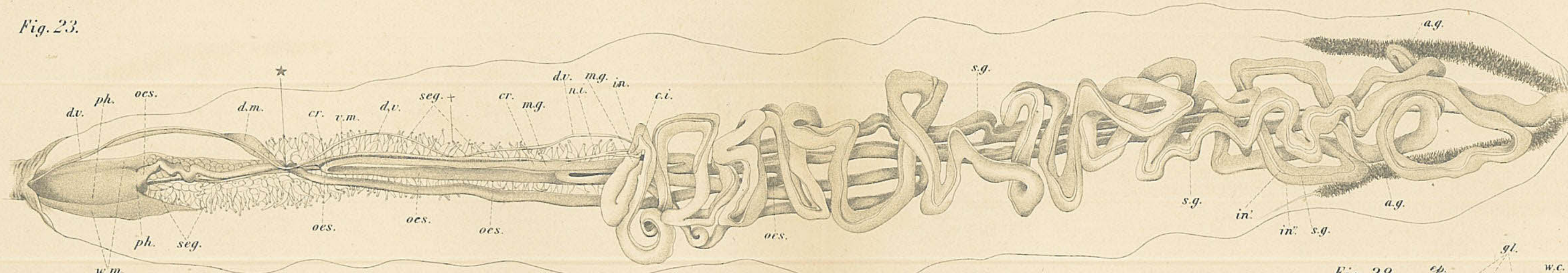


5-17, Bonellia miyajimai. 18-22, Thalassema taenioides.

Fig. 23.



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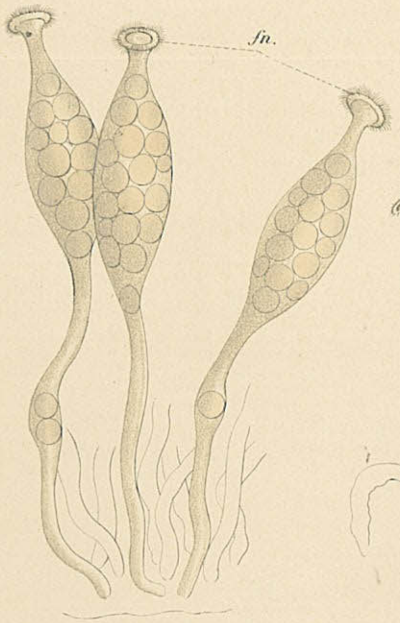
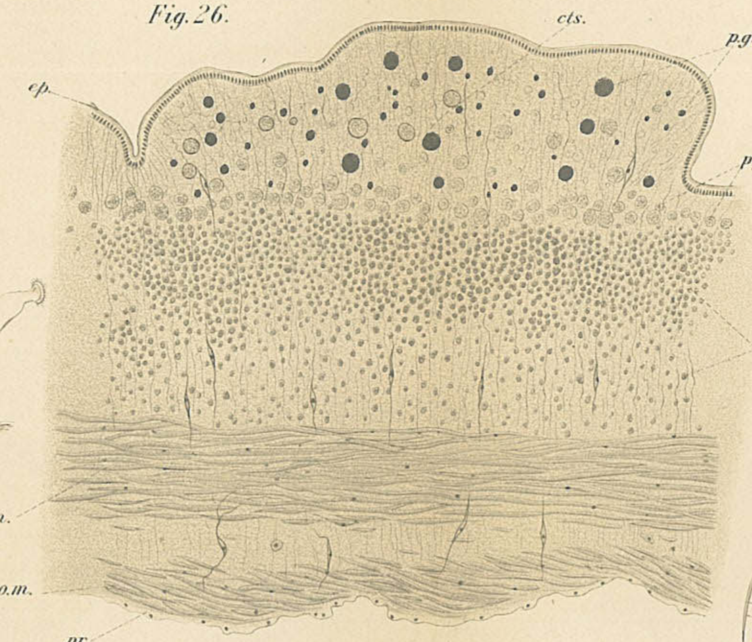


Fig. 25.

Fig. 26.



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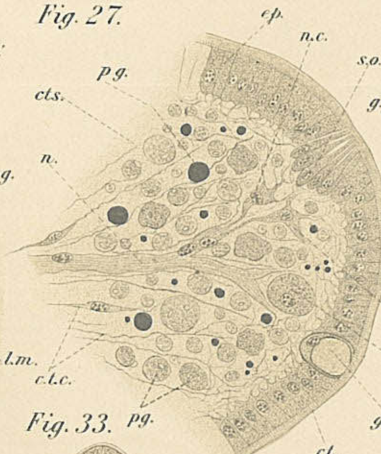

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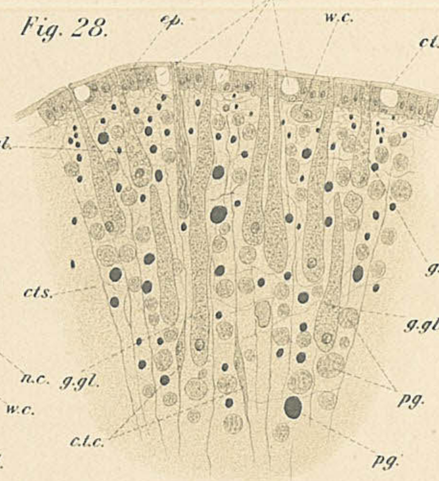

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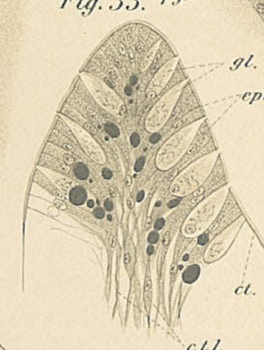

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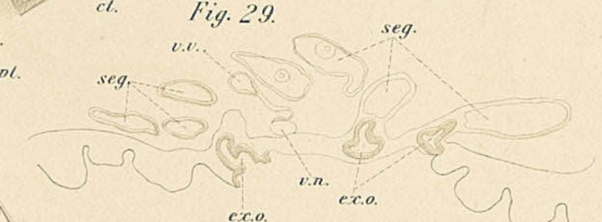

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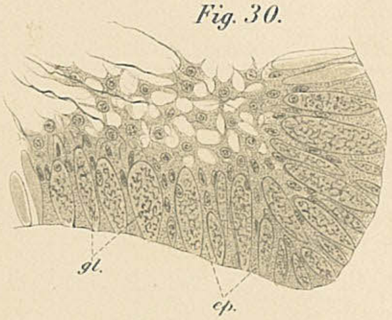

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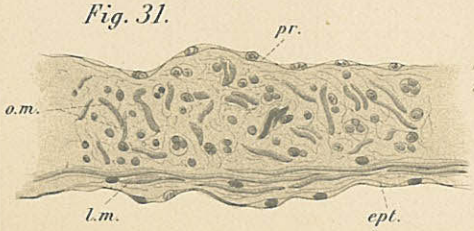

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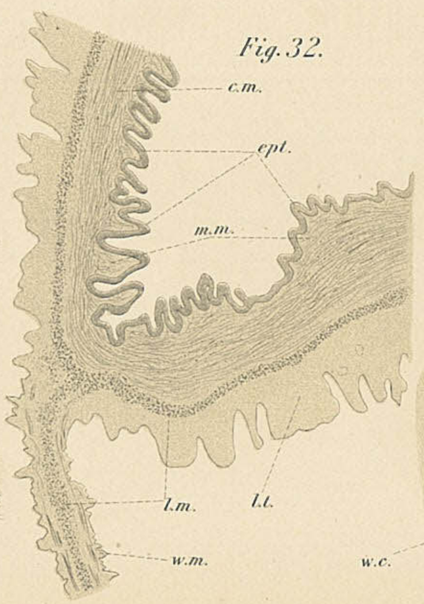

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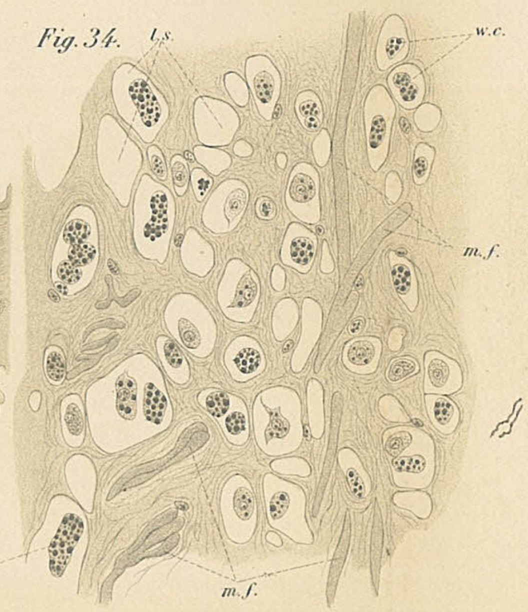

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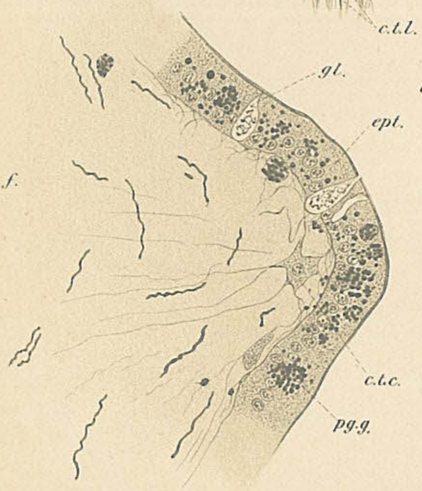

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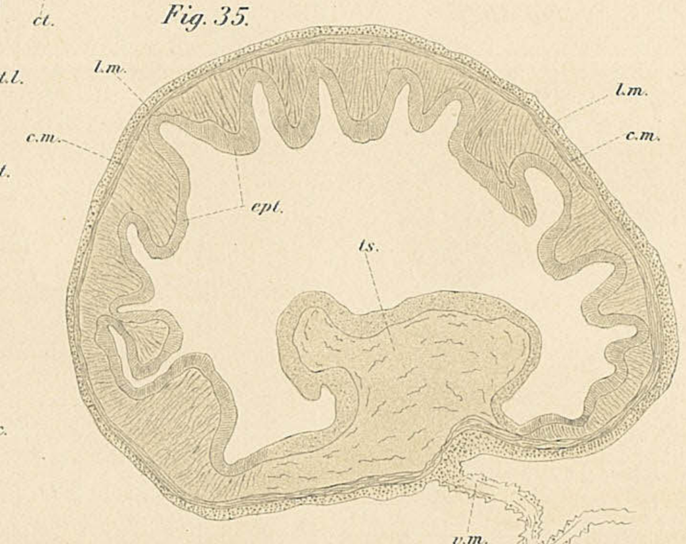
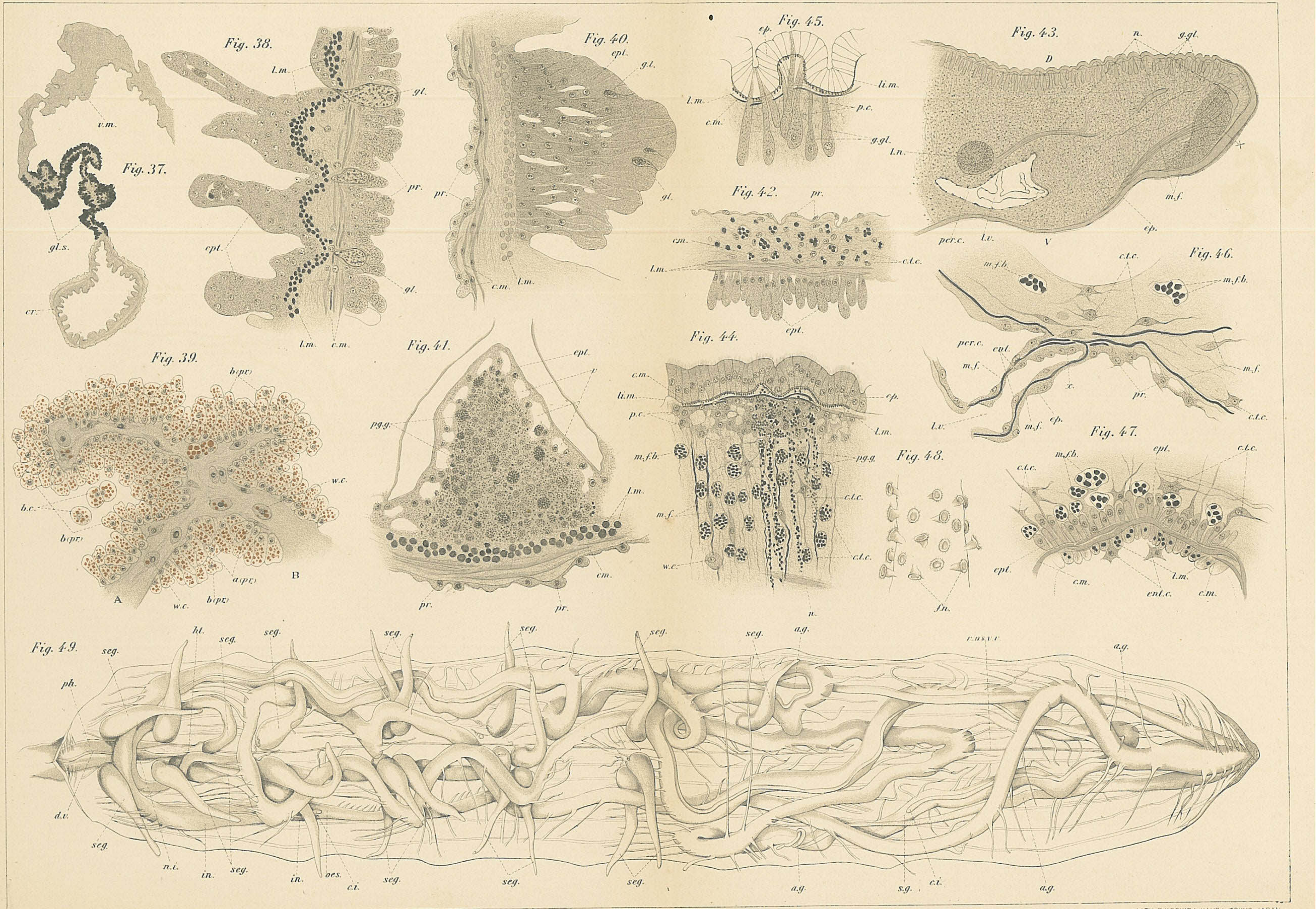


23–36, Thalassema taenioides.



37-47, Thalassema taenioides. 48-49, Thalassema elegans.

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