On a New Human Tape-worm (Bothriocephalus sp.).

by

I. Ijima, Ph. D.

Rigakushi; Rigakuhakushi; Prof. of Zoology, Sci. Coll., Imp. Univ., Tōkyō.

and

T. Kurimoto,

Igakushi; Prof. in the Medical Department, 5th Higher Middle School, Nagasaki.

With Plate XVIII.

The human tape-worm to be noticed in this paper is, as will be borne out in the sequel, a very large *Bothriocephalus* species furnished with double genital ducts and openings in each proglottis. So far as we are aware, any similarly characterized species of that genus has not hitherto been included in the human parasitic fauna, though a few such have long been known to occur in seals and certain fishes. We hold it highly probable that this human *Bothriocephalus* is a near relative of those already described from seals,[1] and possibly identical with one of them. The supposition that the patient who discharged it, had acquired his from a source similar to that which furnishes seals with theirs, seems to be not improbable from the fact of his continual residence near the sea-shore.

The specific determination of this tape-worm, whether *species novarum* or not, we have preferred to leave to the discrimination of

1 *Bothr. variabilis* Krabbe, *Bothr. fasciatus* Krabbe and *Bothr. tetrapterus* v. Siebold, from several species of *Phoca*.

those investigators more favourably situated than we are with respect to literature and specimens to compare with.

We owe our material to the courtesy of Mr. Sōichiro Nakamura, who, in 1892, while acting as physician to the hospital attached to the Takashima Coal Mines, near Nagasaki, obtained the worm from one of his patients.

Particulars concerning this patient, partly furnished us by Mr. Nakamura and partly obtained by one of us from the patient's family, run to the following effect:

Tamaji Murazato, male, born 1865, at Taira-mura (a village on the Ariake-Sea, near the town of Shimabara) in the Province Hizen. In boyhood healthy but never muscular. Remained in his native village until 1879, when he went to Nagasaki. Here attacked by cholera but recovered. Up to 1892 resided at several places in the neighbourhood of Nagasaki and other sea-side localities within the Province Hizen, outside of which he seems to have never travelled. Calling: emanuensis, post-office clerk, school-teacher, &c. 1891 settled at the Takashima Coal Mines, where he had been engaged in book-keeping business until his death by accident in November of the following year. Some five years previous to this period, he began to suffer occasional dizziness and colic. Medical help had not much effect, beyond palliating the latter. Gradual anæmia supervened. During October 1892, a piece of tape-worm about one foot long was discharged. About this time violent colic is said to have returned. He was then taken into the hospital before mentioned and submitted to medical treatment by Mr. Nakamura, whose notes taken at the time are as follows:

"Patient aged 28 years. Medium bodily constitution. Badly nourished, weary. Symptoms of cyanosis on face. Liable to fall into insensibility while sitting or otherwise occupied. Pulse weak

and frequent, numbering 120. Palpitation somewhat accelerated. Temperature 36.8° C. Tongue with yellowish covering. Appetite ordinary, sometimes vigorous. Gastric region swollen out and frequently giving spasmodic pain, radiating towards the back and ceasing gradually or suddenly, followed by a feeling of pressure on intestines. This feeling either remains at one place or shifts its position. The attack occurs after taking food but also at other times. Pressing the gastric region from outside has soothing effect on the pain. Sometimes pain also in the pelvic region. Diarrhœa, or costiveness for many days.

"From above symptoms, the presence of *Ancylostomum duodenale* was suspected. Microscopical examination of the fœces however unexpectedly revealed a number of eggs, resembling very much those of *Distomum ringeri* both in size and appearance. Irrespective of what parasite these eggs might belong to, a dose of *extr. filic. mas.* was tried and the result was the discharge of a tape-worm measuring *10 meters* in length and, at the broadest portion, 25 millimeters in breadth. The broad hind end had its extreme tip shrunk, much macerated and easily detachable. Of the other end, a portion as thin as 1.5 millimeter was found but no head could be discovered. From the following day, all the complaints the man had suffered from for so many years entirely disappeared."

But the man did not live long to enjoy this relief, for during the following month a collision with a coal truck broke his back and killed him. Post mortem examination was not allowed to Mr. Nakamura notwithstanding his appeal.

Judging from Mr. Nakamura's statements, the tape-worm, a *Bothriocephalus* as already mentioned, must have been an extraordinarily long and broad one, gradually tapering anteriorly into an almost filamentous collum.

We did not see the entire specimen, but sample pieces from four different regions of the body were kindly placed at our disposal. They were preserved in strong spirit that hardened them into stiffness but kept the tissues in excellent condition.

Sample No. 1 is a piece from near the anterior end of the original specimen. It measures 3 mm. in breadth and 0.5 mm. in thickness at the middle. No trace of reproductive organs is visible in these segments.

Sample No. 2 is a piece somewhere from the anterior quarter of the original specimen. At this region the body already presents considerable dimensions, being 13 mm. broad and about 1.5 mm. thick. The reproductive organs are partly developed ; but of this, later on.

Sample No. 3 is from the middle portion, 14–16 mm. broad and about 1.5 mm. thick. The reproductive organs are fully developed and the uterus is already partially filled with eggs.

Sample No. 4 consists of two pieces from the posterior portion, one of them cut off 40 cm. from the hind end. Breadth varies from 10 mm. to 15 mm ; thickness measures 1.5 mm. or somewhat more. The varying breadth is certainly due to different states of contraction and accordingly, where the breadth is less, the proglottis is comparatively longer. The uteri in this section are much distended and filled up with eggs.

Mr. Nakamura's measurement of maximum breadth, namely 25 mm., was no doubt taken whem the worm was quite fresh. This accounts for the fact that nowhere in the alcoholised and contracted samples before us is that great breadth attained. The foremost portion of the original specimen, stated by Nakamura to have been only 1.5 mm. broad, must have belonged to a section more anteriorly situated than our sample No. 1.

One of the very striking features of our *Bothriocephalus* species

is the extreme shortness and consequent narrowness in antero-posterior direction, of the proglottides. They almost present the appearance of closely set transverse wrinkles to the naked eye (*vide* figs. 1 and 2, Pl. XVIII). In the middle and hind regions, the length of the proglottides averaged only 0.45 mm., and their breadth 14–16 mm. Even where most distended (breadth 10 mm.), their length did not exceed 0.8 mm. The average length given above was calculated by counting *from the outside* the number of proglottides within a measured space *along the median line.* It is important to note here that what appeared externally to be two distinct and consecutive proglottides as indicated by the usual boundaries, very often proved to be one internally, i. e. with respect to certain genital arrangements. For instance, a piece 30 mm. long from sample No. 4, showed but 57 uteri in a series, while the number of proglottides as counted in the way mentioned amounted to about 68. Besides the superficial supernumerary boundaries, both dorsal and ventral, that extend throughout the entire breadth of the body, others which disappear at the middle of it after running for a greater or less distance from the margin, are of quite frequent occurrence; so that, counting the proglottides by the marginal serration would give a still greater number than when counted along the median region. Thus, in the piece above referred to, the number of segments as counted near the margin amounted to 93 or thereabout. The proglottis that has such an incomplete supernumerary boundary on the one side generally shows the same also on the other. Sometimes such a false proglottidal boundary in its course joins a neighbouring true one or loses itself on the general surface to appear again after a short interruption. In rare instances, apparently two incomplete false boundaries in succession were interposed between two true ones in the marginal region. The antero-posterior lengths of consecutive segments, separated by false proglottidal boundaries

and belonging to one internal proglottis, are quite variable but when taken together may be said as approximately equalling or somewhat surpassing the length of those proglottides that show no trace of false demarcations whatever (Figs. 4, 5, and 6). The features of marginal serration as also the manner of indentation of the body-surface essentially agree in all proglottidal boundaries, both true and false, excluding all possibility that the latter might be some mechanical or accidental production. We are inclined to view the phenomenon in the light that the present species of Cestodes has a tendency to produce superficially more proglottides than it does internally, contrary to the well-known case of *Ligulidae* in which the external strobilation remains more or less obsolete. In other words, under the crowded state of proglottides in our *Bothriocephalus* species, one proglottis seems to remain but partially developed, i. e. only superficially marked, in order to give necessary space for the full development of certain genital parts (especially uterus, cirrus, and ovary) in its immediate neighbour. The widely distributed testes and yolk-glands develope themselves as well in the abortive as in the other proglottis and are apparently related to the genital ducts and openings of the latter as if they were its own.

What further seemed to us to be of interest with respect to the strobilation of the present species, is the presence, in our sample No. 1, of indications that certain proglottides are undergoing repeated division. In this anterior region as many as 38 proglottides were counted within a space of 10 mm., giving to each proglottis an average length of 0.26 mm. (by 3 mm. in breadth). The actual lengths were tolerably uniform, except only that the latest formed proglottides were only half or less than half as long as the others. Division of a proglottis into two takes place, not at its middle, but invariably at its anterior portion; consequently, of the two

new proglottides, the anteriorly situated is always the shorter until the normal length is attained by growth. Examining with a hand-lens of low magnifying power, our attention was at once called to the facts that the boundaries of proglottides were not all alike in their sharpness and depths of marginal indentation and that they succeeded one another with a certain degree of regularity. The differences are evidently due to the oldness or lateness of their formation. Usually four or five consecutive proglottides together formed a group or what might conveniently be called a primary segment, terminated anteriorly and posteriorly by much better defined proglottidal boundaries. In other words, every fourth or fifth boundary was generally the most pronounced and presumably the oldest formed. Where four proglottides made up such a primary segment, the boundary between its 2nd and 3rd proglottides was usually the next well-defined, whereas that between the 1st and 2nd and also that between the 3rd and 4th were comparatively somewhat less sharply pronounced. We might interpret this so, that such a primary segment is composed of two secondary segments, each of which again consists of two tertiary segments or proglottides. Often the front proglottis of a primary segment had more or less distinctly divided into two, at apparently a quite late period, in which case that primary segment seemed to consist of five, instead of four proglottides. Sometimes the next tertiary proglottis also showed signs of a similar quaternary division. Thus then, within a given primary segment, the division of proglottides takes place successively backward beginning from the foremost proglottis. This corresponds to the fact already mentioned that in an individual proglottis division occurs at its anterier portion. It is easy to conceive that by a continued process of such division, an individual proglottis would in course of time come to rank as a secondary and this again as a primary

segment. But this process seems not to take place uniformly throughout, as indicated by the fact that primary segments, with and without proglottides undergoing quaternary division, showed no regularity in their order of succession, and also by the fact that sometimes, between two more or less typical primary segments, there were interposed two or more proglottides, which showed no trace of division and were separated from one another by boundaries as marked, and hence presumably as old, as those that bounded any primary segment. At all events, the generally accepted idea that in a tape-worm the more posteriorly situated proglottis is always the older, seems not to hold true in the present species of *Bothriocephalus*. The repeated serial division here described naturally reminds one of a somewhat similar process in *Microstomum* and certain annelids, but we abstain here from entering into comparisons. We regret that Fig. 11, Plate XVIII, which should represent a portion of sample No. 1, has failed to illustrate exactly the ordinal distinctions of proglottidal boundaries plainly visible on the real object.

How far backwards in the entire tape-worm the subdivision of proglottides is repeated, could not be ascertained further than that it probably ceases with the beginning of the development of genital ducts, somewhere between the two portions represented by our samples No. 1 and No. 2. In the latter, in which the formation of genital ducts is almost completed, abortive proglottides before described are plentifully met with. One might regard these as indications of divisions taking place here, though certainly only external, were it not for the fact that similar abortive proglottides are also found in sample No. 3 or No. 4 in about the same proportion. Hence, we rather consider all those present in our samples No. 2–4, as representing the proglottides that were formed about the time when the genital ducts were beginning to develope but too late to develope their own.

Moreover, the body of the present *Bothriocephalus* species is longitudinally traversed by several, more or less deep, furrows on both its ventral and dorsal surfaces. These are few and insignificant on sample No. 1, but numerous on all other samples, in which the most conspicuous are the two on either surface, that run almost uninterruptedly and parallel to each other along the double series of main genital ducts, dividing the tape-worm body into a middle and two lateral longitudinal zones (see figs.). They are slightly nearer to each other than to either body-margin. They may attain the depth of about $^1/_4$ the thickness of the body and must plainly be constantly present in fresh specimens. The same can hardly be asserted of all other longitudinal furrows seen on the middle and lateral zones above mentioned, which are, as seen in alcoholic samples, of quite variable depths and sharpness, often interrupted or losing themselves in their course, and by no means definite in their number. However, some 3–5 in the middle and some 5–7 in the lateral zone are the usual numbers to be met with.

As already indicated, there are, to each (true) proglottis, two sets of genital openings, situated right and left and communicating externally at the bottom of the two most conspicuous longitudinal furrows of the ventral surface (*b*, *b*, figs. 5 and 6). Each set consists, in antero-posterior succession, of a cirrus (*cir. o.*, figs. 10 and 12), a vaginal (*vag. o.*) and an uterine (*ut. o.*) opening, lying close to one another. On account of their secluded position within the longitudinal furrow, they are usually not recognizable from the outside, but a pit-like depression of the latter, associated with a short cross-furrow or two, sufficiently marks their position and at the same time serves as the index to distinguish the ventral from the dorsal surface. In many proglottides of sample No. 4, the cirrus is externally visible as a minute rounded protrusion, evidently the result of its partial evagination (fig. 6).

As might be inferred from the above mention of genital openings, the arrangements of sexual organs in the present species are typically bothriocephaline. To begin with the male organs :

These develope earlier than the female sexual organs, as in other species of Cestodes. The testes, which present the usual features, are present from sample No. 2 downwards. In the sample just mentioned they are not yet fully mature and are separated from one another by somewhat wider spaces than in sample No. 3 or 4, in either of which the production of spermatozoa is actively going on. They may attain a diameter of 0.07 mm. Generally arranged in a single layer, they occupy the usual position in the "*Mittelschicht*" (*h*, fig. 8). The area of their horizontal distribution is divided into three parts by the regions taken up by the double sets of main genital ducts. In cross-sections passing midway between the anterior and posterior limits of proglottides, we have counted 30–40 testicular vesicles in each of the three parts.

The cirrus (*cir.*) is a round or oval-shaped body, essentially agreeing in its fine structure with the same organ of other *Bothriocephalus* species. It lies with the axis of its tortuous lumen slightly inclined from above downwards in an antero-posterior direction (fig. 12). At its superior end, the cirrus is directly continuous with the muscular wall of a spherical *vesicula seminalis*. The latter presents an appearance as though it were a posteriorly bent, knob-like, terminal portion of the cirrus itself. Its cavity, as also the lumen of the cirrus, is narrow and empty in sample No. 2, but filled up with and much distended by spermatozoa in samples No. 3 and No. 4. In these the seminal vesicle measures about 0.12 mm. and the approximately spherical cirrus about 0.25 mm. in diameter. In sample No. 2 both are much smaller, the cirrus being here decidedly oval-shaped as seen in fig. 12. (In this figure, the lettering *cir.* referring to the second

cirrus from left, points to the *vesicula seminalis*, which is better seen on the cirrus next to the right.)

The *vas deferens* (*vd.*, fig. 10) is seen in sample No. 2 as a thin cellular string with no recognizable lumen and in samples No. 3 and No. 4 as a thin-walled, much convoluted tube filled with spermatozoa. After starting from the *vesicula seminalis* it turns towards the median line, i. e., to the right if it belongs to the left set of genital ducts, and *vice versa*. It then pursues its irregular course for a variable distance but always stopping short before the end of the first uterine loop of the corresponding side is reached. How it communicates with the testes could not be observed.—

Of the female sexual organs, the *vitellarium* (*dts.*, fig. 8) is yet very scantily and weakly developed in sample No. 2, but fully developed in samples No. 3 and No. 4. In these it consists of very numerous lobules about 0.025 mm. broad and about 0.045 mm. long, with their long axis directed perpendicularly to the body-surface. Arranged in a single layer, they occupy the usual position outside of the layer of strongly developed longitudinal muscles and are much more numerous on the ventral than on the dorsal side. On the former they are distributed almost uniformly throughout except at regions occupied by the two sets of main genital ducts (fig. 7). At the body-margin they pass in a continuous layer into those of the dorsal side, where, tracing them in the median direction, they become scarcer and irregularly distributed, and finally disappear at a greater or less distance from the position of the uteri. In the middle region of the dorsal side, many proglottides showed none of them, while in others they were developed also in this part but in irregular patches comparatively few in number.

The ovary is present to each set of genital ducts. It is a horizontally and transversely stretched cellular string that divides on

either side into an elongated bundle of anastomosing branches (*ov.*, fig. 10). At its middle, whence the oviduct arises, it measures only 0.01 mm. or less in thickness while the lateral, divided portion may be nearly 0.08 mm. broad. In functional activity, it may measure 1 mm. from the origin of the oviduct to either of its extremities. Its position in the proglottis is on the ventral side of the *Mittelschicht*, along the posterior proglottidal border.

The exact course of the female ducts could only be conveniently studied by combining sections of sample No. 2, where they were yet without contents except some masses of yolk-like granules that occurred here and there in the uterus. The oviduct (*ovd.*, fig. 10), after its origin from the ovary, at first runs backwards, soon to take an irregular ascending course, which is at the same time directed outwards, i. e., away from the median line of the tape-worm. During this course, the oviduct is joined first by the vagina that approaches it from the median side and then, after a short interval, by the yolk-duct that comes up from below. In tracing the lumen of the oviduct from the ovary, it appears to be directly continuous into that of the vagina (as shown by the unshaded passage in fig. 10), rather than into the remaining portion of the oviduct leading towards the junction of the yolk-duct.

The vagina (*vag.*) is a fine duct, that makes a few windings beneath the uterus but crosses the ovary on its dorsal side. Posteriorly and close to the junction with the oviduct, the vaginal tube swells up into an oblong vesicle, which we consider to be the *receptaculum seminis* (*sb.*, fig. 10). Anteriorly it descends almost perpendicularly along the posterior border of the cirrus and opens at the vaginal pore (*vag. o.*, fig. 12) just behind the cirrus opening.

The yolk-duct (*dtg.*, fig. 10) is a very thin tube that after descending a short distance from the oviduct soon becomes untraceable.

Although yolk-granules were often found in its lumen, we could never make out its connection with the vitellarium. Nor could we ever recognize the shell-glands. Nevertheless there can be no doubt that the present species essentially agrees in these as in so many other points with *Bothriocephalus latus*.

The uterus (*ut.*, figs. 10 and 12), as seen in sample No. 2, occupies for the most part the dorsal region of the *Mittelschicht*. Its anterior portion descends ventrally, almost in a straight line to open at the uterine pore situated at about the middle of the length of the proglottis (*ut. o.*, fig. 12). The rest of the uterus, notwithstanding some irregularity in its course, describes in general two loops on each side. The distance between the ends of two opposite loops measures only about half a millimeter. No eggs are yet found and the uterine lumen is for the greater part obsolete.

In sample No. 3, the production of eggs is considerably advanced. They fill the uterus and distend the latter into a wide tube, but not by far to such a great extent as in sample No. 4. The latter, when viewed by holding it against the light, shows the uteri of successive proglottides as blackish spots, about 1 mm. or slightly more in breadth and arranged in two longitudinal series. In each series some may lie somewhat to the right or left of the general line. When compressed and clarified, they are certainly very distinctly visible. In such preparations they present variable forms but the most general and the least disturbed condition is that figured in fig. 7. Each uterus appears as consisting of two pairs of lobes, corresponding to the four loops of the uterine tube in sample No. 2. The anterior pair is the shorter of the two and clasps the posterior side of the cirrus. The numerous eggs contained in the uterus, or more properly their shells, give colour to the uterine lobes which varies from the colourless transparency of the portion nearest the oviduct into the dark brown of

the portion containing older eggs.

An egg, with brown shell and taken from the uterus near its external opening, is represented in fig. 9. In alcohol the shell is collapsed but soon returns to its proper form by leaving it a while in water. It is rather thick. The general form is oval, 0.063 mm. long and 0.048–0.05 mm. broad. The diameter of the operculum measures about 0.02 mm. The contents are oil-globules and a morula-like mass of finely granular spheres, evidently cleavage-spheres.—

With regard to other points in the structure of the present *Bothriocephalus* species, we have made but casual observations. The main longitudinal nerve runs outside the series of uteri, on each side of the body (*ln.*, fig. 8). It lies nearer to the uteri than to the body-margin of the same side. A short distance inside of the longitudinal nerve, the main trunk of the excretory vessels finds its course on both sides. Sections of excretory vessels were sometimes also met with at other places. The muscular system is essentially the same as in *Bothriocephalus latus*. Finally, we ought to mention that nowhere in our samples have we found a single calcareous body in the mesenchyma.

Explanation of Plate XVIII.

a, dorsal groove along the series of main genital ducts.
b, ventral groove along the same.
cir, cirrus.
cir, o., cirrus opening.
dtg., yolk-duct.
dts., yolk-gland or vitellarium.
h., testes.
lm., longitudinal muscular layer.
ln., longitudinal nerve.
m—m., median-line of the specimen.
ov., ovary.
ovd., oviduct.
sb., receptaculum seminis.
tm., transverse muscular layer.
ut., uterus.
ut. o., uterine opening.
vag., vagina.
vag. o., vaginal opening.
vd., vas deferens.

FIG. 1. A piece from sample No. 4, 40 cm. from the hind end of the original specimen. Dorsal view. Nat. size.

FIG. 2. Ventral view of the same. Nat. size.

FIG. 3. Cross-section of the same. Nat. size. The two black spots represent the uteri filled with eggs.

FIG. 4. Dorsal view of a portion of the same. Magnified 10 times.

FIG. 5. Ventral view of a portion of the same. Magnified 10 times.

FIG. 6. Ventral view of another portion of the same, with cirri partially protruded. Magn. 10 times. By an oversight this figure has been placed in a position the reverse of that intended.

FIG. 7. Portion of a preparation from sample No. 4, seen from the ventral side. Magn. 20 times. The piece was somewhat compressed between two glass-plates, coloured and clarified. The numerous dot-like bodies on either side of the uteri represent yolk-gland lobules of the ventral side.

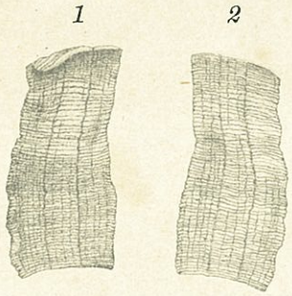
FIG. 8. Portion of a cross-section of sample No. 4. Magn. 20 times.

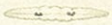
FIG. 9. An egg taken from the uterus. Magn. 440 times.

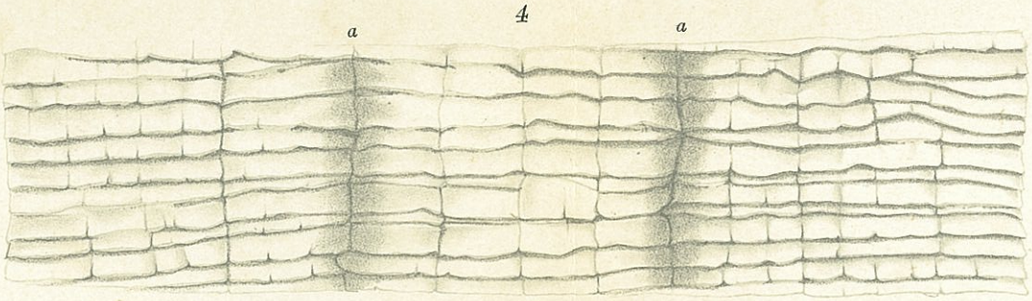
FIG. 10. Half-diagrammatic representation of a left set of main genital ducts, as seen from the ventral side; made out by combining sections of sample No. 2. Magn. 150 times.

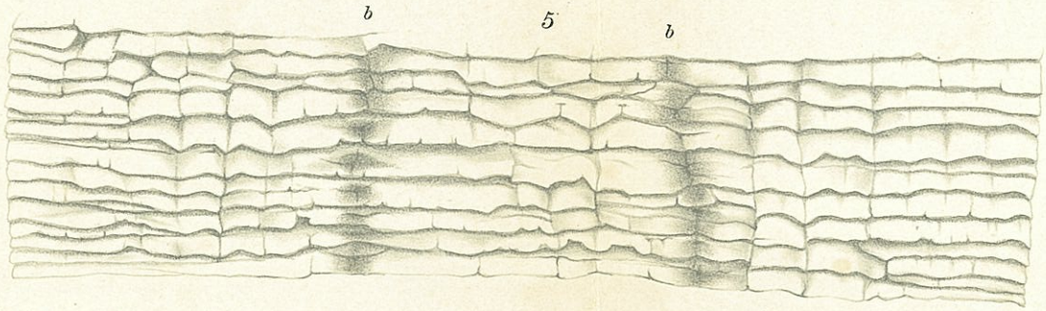
FIG. 11. A portion of sample No. 1. Magn. 10 times. This figure is a failure in so far as it does not properly show the ordinal distinctions of proglottidal boundaries.

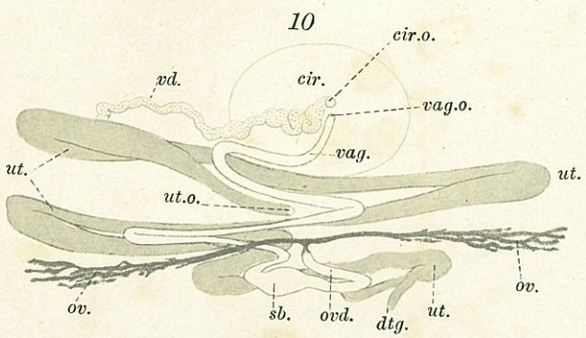
FIG. 12. Portion of longitudinal section passing through the cirri, from sample No. 2.

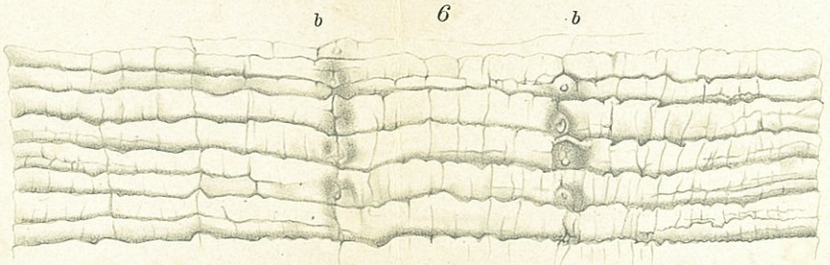


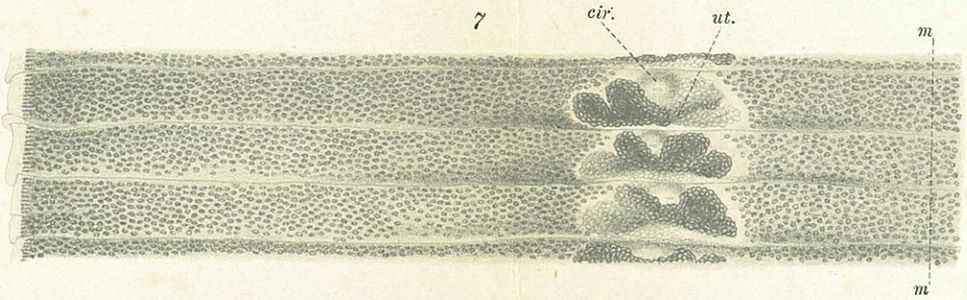


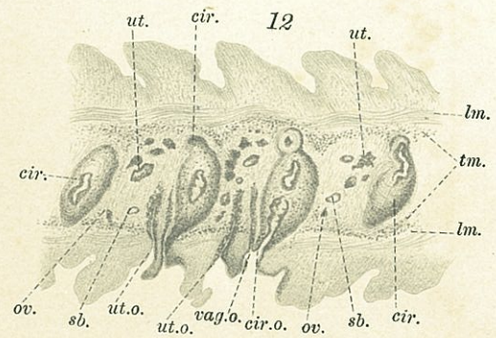


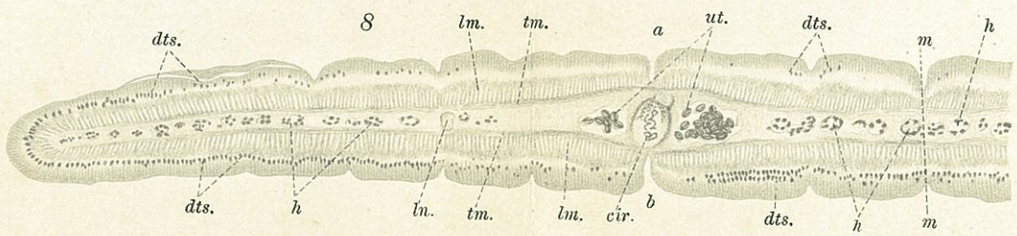












Autor del.

Lith. & Imp. the Tokio-Seishibunsha.