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# Article XII.—ON THE ANATOMY OF *OZOBRANCHUS BRANCHIATUS* (MENZIES)

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Plates XXXIII to XXXVIII

Early in 1915, Mr. Mowbray of the New York Aquarium, while collecting fishes at Key West, Fla., found a lot of leeches on the skin of a large green turtle (*Chelonia mydas*). Most of these were attached under the flippers, where there were also eggs laid in batches upon the skin and covered with a chitinous material which hardens after the deposit of the eggs and holds them in place until they are hatched. A few young worms were found attached to the ventral surface of the adults.

The most striking character of these leeches consists in their having a thick fringe of gill filaments along each side of the anterior part of the body, but it is also to be noted that the anterior sucker is very inconspicuous and that there is no such sharply demarcated neck as is seen in some closely allied forms.

At first it was thought that these must be representatives of the genus *Branchellion*, on account of the presence of definite gills, but a review of the literature of that genus, after a study of the anatomy of this worm, showed that there are very great differences both in external form and in the structure and arrangement of the internal organs. No further consideration of that genus need be given here except in the form of references to the papers of de Quatrefages[1] and Sukatschoff,[2] where detailed descriptions are given with beautiful plates. De Quatrefages mentioned the fact that Archibald Menzies had found another form of leech provided with gills and parasitic on a turtle in the Pacific Ocean, and, since the name *Hirudo branchiata* given by Menzies did not seem correct, he suggested the generic name *Ozobranchus* (ὀξος, branch). The genus is, therefore, referred to de Quatrefages, although he never saw the worm, and Menzies' description[3] is quite good. It is so short that it may be quoted in full.

H. depressa attenuata albida, setis lateralibus ramosis utrinque 7, interaneis fuscis bifidis perlucentibus.

*Habitat* in *Oceano Pacifico, testudini adhaerens.*

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[1] de Quatrefages, 1852, Ann. Sci. Nat. (Zool.), (3), XVIII, p. 283.

[2] Sukatschoff, 1912, Mitth. Zool. Stat. Neapel, XX, p. 395.

[3] A. Menzies, 1791, Trans. Linn. Soc. London, I, p. 188, Pl. XVII.

The body, when moving, is about an inch long, of a whitish pellucid colour, soft, depressed, annulated with fine rugæ, and towards the head attenuated, having a row of soft pellucid branchy bristles on each side, opposite to one another, making in all seven pair. The head is small and truncated; but the other extremity is larger, round, and dilated. The entrails appear through the body, bifid, and of a dark brown colour.

This species was found in great abundance adhering to a turtle, in the Pacific Ocean between the tropics.

I have been able to find no further reference to this genus prior to Oka.[1] He grouped it with the Ichthyobdellidæ making two subgroups, of which one includes *Pontobdella, Ichthyobdella, Trachelobdella, Callobdella* and *Ozobranchus;* the other, *Carcinobdella* and *Piscicola.* He defined the genus *Ozobranchus* as follows, referring it to de Quatrefages, 1852.

Body small, distinct neck and trunk with 5–7 pairs of tufted gills. Skin smooth: anterior sucker small and not distinguished from the neck, segmented on its dorsal aspect. Posterior sucker large hemispherical and distinct. Somites of the neck formed of two equal segments, those of the trunk of two unequal rings. Parasitic on marine turtles.

He described a new species, *O. jantseanus,* found upon a turtle in Wu-Chang, China; it is a form like *O. branchiatus,* which he seems to have studied and described in a previous paper (1895, Zool. Magazine) which is not accessible to us. But, in Vol. V of the Annotationes Zoologicæ, he discusses the circulation and the body cavity of *O. branchiatus* and decides that the blood vessels form a closed circulation with dorsal and ventral muscular trunks lying above and below the intestine. These blood vessels have no connection with the body cavity; the latter branches throughout the body in capillary form and supplies the branches which carry fluid through the gills. Thus it is the fluid of the body cavity which circulates in the gills and not the blood. A similar idea was expressed by de Quatrefages for *Branchellion* but seems to us open to grave doubt. Oka's description of the genital organs of *O. jantseanus* agrees in general with what we have found in the form we have studied, except that he describes a vagina opening into the posterior surface of the cirrus sac and connected with the ovaries by way of narrow tubes which run through saccular seminal reservoirs. This would be a most anomalous arrangement and it seems from a study of *O. branchiatus* that the supposed vagina is really a sort of seminal vesicle, because it connects not with the ovaries but with the complex enlargements of the vasa deferentia and opens directly into the bulbus ejaculatorius.

[1] Oka, 1902, Annot. Zool., Japan, IV, p. 49; 1904, idem, V, p. 133; 1910, idem, VII, p. 165; 1912, idem, VIII, pp. 1–4. 1895, Zool. Magazine, Tokyo, VII, No. 75.

This will be described in detail later. Oka mentions three species as forming the genus *Ozobranchus: O. margoi* Apathy, with 5 gills; *O. branchiatus* (Menzies), with 7 gills; *O. jantseanus* Oka, with 11 gills. In addition to these, Harding[1] has described a small form parasitic on a terrapin (*Nicoria trijuga*) in Ceylon, which measures 5 mm. in length and has 11 pairs of digitate branchiæ. This he names *Ozobranchus shipleyi.*

The specimens, from which the following study was made, had lain in alcohol a long time, so that the bodies were much contracted and shrunken and no accurate measurements could be made. Furthermore, it was impossible to determine the original color, or to count the segments carefully, or even to make very good sections. It is hoped that at some future time live specimens may be obtained and properly fixed for study, because there are many points in the structure which are extremely interesting but which have been slurred over here or very imperfectly studied because the material was not good enough.

## External Characters

The mature leech (Pl. XXXIII, fig. 1) attains a length of 6 mm., when contracted, with a maximum width of 3 mm., and is of a dirty white color with the contents of the rectum showing through. In the fixed specimens the body arches dorsally and is concave ventrally. There is a short, protrusible neck, which seems capable of being retracted slightly within a ring formed by the first segments of the body. This can be made out very easily in longitudinal sections and is distinguished by the corrugations of its surface which differ somewhat from those of the rest of the body. The mouth is terminal but directed ventrally. It is unarmed. The large posterior sucker is about 2 mm. in diameter. In the mid-ventral line, at about the junction of the two anterior thirds of the body, there are two genital openings, the orifice of male apparatus lying directly in front of that of the uterus. The eyes are no longer visible.

The gills form a compact fringe on each side of the body, arising along the margin throughout the anterior half behind the neck. There are seven trunks on each side, which divide into several filiform prolongations so that there appear to be about thirty-five to forty of the fine threads on each side. They measure 1.5 to 2 mm. in length from their origin at the margin of the body.

It is extremely difficult to count the segmental rings upon the surface

[1] Harding, 1909, Proc. Cambridge Phil. Soc., XV, p. 233.

in the way suggested by C. O. Whitman. There seem to be about forty-five of such rings, counting from the first ring behind the neck to the posterior extremity, but it appears from longitudinal sections that the finer lines correspond with slighter depressions of the surface upon each of the projecting rings. Indeed, these are so irregular that it is frequently impossible to decide what constitutes a whole ring, since the secondary rings are sometimes quite deep. The real difficulty lies, however, in the fact that it is impossible to make out that these superficial rugæ correspond with any segmental divisions of the interior of the body. In sections taken longitudinally in either plane, there are seen to be some transverse septa in the middle of the body which separate such organs as the paired testes, nephridia, etc., so that they evidently lie segmentally arranged, but in the anterior and posterior parts of the body this segmental arrangement is much obscured and not at all easily recognized. At any rate, the true segments must be fewer than the indentations on the surface of the body. The failure to count the segments precisely and to correlate the position of the organs with the numbered segments must constitute a serious weakness in the description of this leech in the eyes of such as Whitman who have made this segmental arrangement such an essential diagnostic factor in the study of leeches.

## Internal Structure

The *digestive tract* (Pl. XXXIII, fig. 2; Pl. XXXIV, figs. 1 and 2, Pl. XXXV) is extremely complicated and well adapted to the accommodation and gradual digestion of a large quantity of blood. The mouth is rounded in outline and furnished with smooth, slightly incurved, thick lips. It is not surrounded by an especially powerful muscle which could act as a sucker nor does it open directly backward into any large tube communicating with the pharynx. Instead, there is a minute orifice on the upper edge of the anterior incurved margin in the middle line from which a very narrow canal curves upward and forward through the substance of the extreme anterior extremity of the head to pass backward over the cavity of the mouth and join the pharynx behind it. The pharynx is a somewhat contorted tube, wider in calibre than this very narrow canal and provided with a very thick muscular wall. Possibly it may act by peristaltic movements as a sucker to draw blood into the digestive tract, and no doubt this is its function. It is partly surrounded by the great nervous ganglion (Pl. XXXVII, fig. 1), partly by a group of enormous cells whose nature we could not determine. They are far larger than any other cells in the body and contain many granules, of which those collected on one side of the cell stain blue in sharp

contrast with the shining eosin-stained granules on the other side. No definite connection by means of duct or protoplasm prolongation between these and the pharynx could be traced. Yet it seemed from their structure that they must have some secretory function and might possibly act as salivary glands.

A narrow thin-walled tube which may be called the œsophagus passes backward from the pharynx. The wall is much plicated (Pl. XXXV) and lined with indefinite, low, deeply staining cells, which seem to present a hyaline margin to the lumen. Almost immediately it receives the ducts of two laterally placed branching glands which are lined with flattened cells which stain very deeply and are provided with rather large nuclei and a ragged cell protoplasm. Again the function of these glands can only be surmised.

The œsophagus broadens laterally and becomes a flattened, arched channel of considerable width which extends back to a point posterior to the middle of the body. It can hardly be called an œsophagus throughout all this extent but, at any rate, names for the various parts of this digestive tract must soon give out if they are only based on analogies with the digestive tracts of vertebrates. At about its middle point it receives the short ducts from two lateral glands. Except in their greater size these glands appear almost exactly like those which join it more anteriorly. Posteriorly, the flattened channel narrows and dips ventrally to a kind of transverse canal, which is very much complicated by the numerous foldings of its walls but which is readily seen to form wide connections to the right and left with enormous lateral sacs or cœca which extend forward only a little way but reach backward to the end of the body. The great cœca are evidently reservoirs for the storing of blood for leisurely digestion. From the central part of the transverse canal there drops ventrally a tortuous channel which soon assumes a more nearly cylindrical form and passes backward in the midline. It, in its turn, receives on its dorsal aspect in rapid succession four pairs of convoluted cœca, which run dorsally forward and back. These are lined with large, prominent, deeply staining cells (Pl. XXXIV, fig. 2) and are not found to contain any of the yellow material which fills the rest of the digestive tract. In all probability they act as digestive glands. Continuing backward in the median line and passing somewhat dorsalward, the intestinal tract dilates into a fusiform widening, which, after narrowing, extends into a cœcum. Just in front of this cœcum a channel passes ventrally to join the rectum, which, while it projects forward into another cœcum, runs backward and upward to open on the dorsal surface just above the large terminal sucker. Thus the digestive tract falls into a number of parts, which, for the sake of clarity, may be designated prepharynx, pharynx,

œsophagus, œsophageal glands, lateral reservoirs, intestine, intestinal cœca, and rectum.

The *circulatory system* (Pl. XXXIV, fig. 1; Plate XXXV) is composed chiefly of great sinuses, which have a rough segmental arrangement and are lined by an endothelium which is peculiar in that the cells appear to be rather loosely arranged and loosely attached. They are quite voluminous and are often seen to project into the cavity of the sinus or to hang partly free in its lumen, being attached to the wall for part only of their length. The sinuses are separated in the middle of the body, at least, by septa made up of various tissues. The organs hang suspended in them in many places so as to come into very intimate contact with the blood.

It is obvious that there must be a propulsive power to keep the blood in motion but, while some evidences of this were found, all our efforts have failed to reconstruct the arterial system clearly and this is one of several features which we must leave incompletely described.

In one series of sections there is visible among the lobules of the female generative organs a muscular tissue which on each side of the median line becomes concentrated at different anteroposterior levels into sac-like structures, the cavity of which is in each case full of blood and in open communication with the cavity of the large central venous sinuses. These are not to be found in other series and we are in doubt as to their interpretation. At first it seemed possible that they might represent a sort of heart but this is hardly probable since the musculature, if such it be, extends quite round the lobules of the yolk gland in such a way as to be useless, in that situation at least, in the propulsion of blood.

Above the œsophagus an arterial tube can be traced in the middle line for some distance forward and backward, but there is no apparent connection with the heart-like mass or with other canals. Laterally there are two wide, thin-walled tubes conveying blood; these are cylindrical in form and continue through most of the length of the worm. They are probably arteries and, although their walls are thin, they may be contractile. They give off branches to the gills, from which the blood is returned by two venous channels which empty into the large, lateral, venous sinuses.

It is quite clear that the statement made by de Quatrefages about the non-existence of blood in the channels of the gills is an error, because blood is plainly seen there. He claimed to have injected the blood vessels with a colored mass which did not enter the gills, for which reason he thought that the vessels of the gills contained only lymph.

The blood is a rather refractive fluid which stains pink with eosin and is moderately rich in nucleated cells which do not stain especially deeply. The fixation is such that little can be made out of the blood cells but they

seem to be of one type, elongated or elliptical, not noticeably granular, and provided with a single rounded or irregular nucleus. They are much smaller than the endothelial cells and measure about 5 $\mu$ in diameter.

### *The Male Genital Apparatus*

The worm is, of course, hermaphroditic and the male genital apparatus is so complicated that it is drawn separately in plate XXXVI, figure 1. There are four pairs of testes, from which narrow ducts lead to two convoluted masses of thick walled tubes which, in turn, send twisted canals to the median ejaculatory bulb. But the latter also send from each side a narrow tube which, uniting with its fellow in the midline, empties into a reservoir which is connected by a wide muscular channel with the cavity of the bulbus ejaculatorius.

The testes are elliptical in form and lie in successive segments a little in front of the middle of the body and far toward the lateral margin. Their long axes run dorsoventrally. From the posterior surface of each testis there springs a thin-walled narrow vas efferens which curves round the ventral end and runs upon the anterior wall. Thence it passes forward to the posterior aspect of the next anterior segmental septum, pierces it, and curves outward to return and join a similar vas efferens from the next testis. At first it seemed that all the vasa efferentia pursued their whole course to the seminal vesicles independently but more careful study showed that they really unite, above the sinuses in which the testes hang, into a long vas deferens on each side which then runs forward piercing successive septa to a point three segments in front of the anterior testis, where it turns inward and downward toward the middle line and passes somewhat backward once more to lose itself in the seminal vesicle. The vas deferens can be traced into this convoluted mass, where the character of its wall changes. The tubules of the seminal vesicles (Pl. XXXV) are thick-walled, muscular, and filled with spermatozoa. They are surrounded by a layer of blue-staining cells. The seminal vesicle on each side presents two diverticula of different types and gives off two canals. Of the diverticula, one is a round sac connected by a short narrow neck with the convoluted canal. It is covered, like the rest, with blue-staining cells, has a rather thick pink-staining wall, and is full of spermatozoa. The other is smaller and elongated and also connected with the muscular common canal. It is not covered with a mantle of cells, is thin-walled, without evident structure, and is quite empty or else contains perfectly clear fluid.

Of the two canals given off from the seminal vesicles, one passes forward

with many convolutions to enter the ejaculatory bulb at its base and to open into one of the branches of its cavity. The other passes toward the midline ventrally and meets its fellow of the opposite side to form a channel which runs ventrally still to enter a large rounded sac with epithelial lining and bluish granular contents. This sac sends a wide thick-walled channel forward to empty directly into the cavity of the ejaculatory bulb. It is like a diverticulum of the bulb with folded walls of the same appearance as those which line the bulb itself. It is quite clear that this is what Oka describes as a vagina with delicate canals connecting it with a transverse bridge of ovarian tissue which joins the two ovaries. He thinks that the uterus does not serve as a channel for fertilization but that this canal, opening, as he describes it, into the cirrus sac into which the penis projects, receives the penis in copulation and thus acts as a vagina. The following out of the connections in serial sections is pretty clear with regard to this particular structure however and there is no doubt that the connections are actually with the seminal vesicles. It must, therefore, constitute a sort of seminal reservoir, emptying the spermatozoa which overflow from the tubular seminal vesicles into the ejaculatory bulb at the time of ejaculation. The ejaculatory bulb itself projects a short way into the wider canal, which opens externally. It is quite muscular and evidently protrusible.

### *The Female Genitalia*

The female genitalia (Pl. XXXVI, fig. 2; cf. also Pl. XXXIV, fig. 1) consist essentially of paired ovaries with associated yolk glands, which open through two wide ducts into the straight tubular uterus whose external orifice lies in the median line just behind the bulbus ejaculatorius. The ovaries with their yolk glands lie at about the middle of the body or a little anterior to this and are found on each side of the midline. The lobulated yolk gland extends laterally and backward, the ovary proper riding on its dorsal, anterior, and mesial surfaces. This description is vague because it is really difficult to determine the relation of the ovary to the yolk gland more precisely, inasmuch as they are so intimately united and lobules of the ovary are found interlaced with convolutions of the yolk gland. The more distal parts of the yolk gland have a somewhat saccular character, while the proximal parts are composed of anastomosing thin-walled sacs of large size filled with hyaline globules. The distal parts are different in that their walls are made up of large, indistinctly outlined cells, which have a bluish-staining protoplasm in which there are many pink-staining droplets of all sizes. These evidently exude into the sac and coalesce to form the highly refractive

pink-staining globules which fill the larger sacs. They look much like red blood corpuscles but are less uniform in size and shape. Apparently, they must be regarded as the yolk which goes to the formation of the eggs, although the direct application of this to the ova is not to be seen in these specimens. The thin-walled sacs are in such wide communication that they form practically one, broad, coiled or folded tube.

The ovary is even more indistinct in the outline of its convolutions, although it is, as a whole, sharply outlined by the surrounding capsule which covers it and extends to the yolk gland. It is composed of numerous folds or layers of cells, which appear to begin as small ova with relatively large nucleus and to grow, as one proceeds to follow along the convolutions of the layer of cells, until they become very large, finely granular cells with relatively abundant protoplasm. In places, and especially as the column of cells approaches the oviduct, there appear what must be ripe ova — huge masses of densely blue-staining protoplasm, each with a pale vesicular nucleus and distinct nucleolus. The protoplasm is finely granular but the granules are so fine as to give a ground-glass appearance.

It is difficult to determine the course of the products of the genital glands toward the uterus since there are only two channels which, running each from one side, join to form the uterine tube. The sacculated tube of the yolk gland is, in most of the sections, completely bounded by its own walls but in places the separation between the cells of the ovary and the refractive yolk globules becomes almost indistinguishable. Nevertheless, there are no yolk globules found among the loosely arranged ova. In cross-sections, it is plainly seen that the oviducts open from the anterior end of the ovarian portion of the mass and proceed directly to join to form the uterus. In that case, the riper ova are nearest the oviduct, although some other large ova are scattered elsewhere, and it is necessary to suppose that the yolk must filter through among the folds of the ovary to surround the ripe ova and enter the oviduct. In a longitudinal series, this is the case on one side but on the other it is a portion of the sac which has the character of a yolk organ which opens directly into the oviduct so that, in that case, the ovum must pass through a mass of yolk to reach the oviduct. The impression remains that there is but one sacculated organ on each side, part of which is modified to the production of ova, while another part produces yolk, and that the escape of both is by way of the broad canal which opens anteriorly but that usually the ovarian portion is in most immediate connection with this canal.

There is no obvious shell gland or anything corresponding to a receptaculum seminis. The uterine tube contains no eggs, in any of the specimens examined, and has collapsed into a straight tube with plicated walls, surrounded by relatively thick musculature. The orifice is unarmed.

### *The Excretory System*

Throughout the mid-portion of the body and extending back into the posterior segments, there are paired nephridia, about twelve in number. These are situated in the segmental septa laterally, but ramify dorsally and toward the median line and even over the blood sinuses dorsally to meet those of the adjacent segments. They run ventrally and turn outward through the ventral muscles to open by minute orifices on the ventral surface of the body along a line about one-fifth of the distance from the margin of the body toward the midline. The tubules which make up these organs are about alike in appearance throughout their course and are lined by pink-staining cells in which the protoplasm has something of a palisade arrangement. The lumen is very narrow and is bent at very sharp angles. The cells have very large nuclei with nucleoli, which are, however, not seen in all the cells but seem to be far apart. The coil of tubules is crushed and flattened together in the septum so that it becomes very inconspicuous. The terminations of the tubule could not be found with certainty and no flame cells or funnels were made out with any clearness. Neither could it be determined whether the extremity of the tubule had any closer relation to the blood channel than the remainder nor whether this extremity was in any way connected with the large gland-like parenchyma cells. Probably it merely ends free in a crevice of the body.

### *The Nervous System*

There is a median, ventral, gangliated chain which runs from the region of the posterior sucker forward to a point just behind the genital pore, where it ascends, curving over the bulbus ejaculatorius to reach and encircle the muscular pharynx, spreading out there to form a large ganglionic mass (Pl. XXXVII, fig. 1), which is rather more bulky below than above the pharynx. At the base of the large posterior sucker there is a wide and thick ganglionic plate, from which nerves pass to the musculature of the sucker. The nerve cells with large pale vesicular nuclei closely grouped together assume a marginal position. They are gathered into fairly definite concentrations to form the ganglia of the cord but these concentrations are not very sharply outlined and it becomes difficult, on account of the scattered ganglion cells in the intervals, to count the ganglia. There is one for each segment, however, and about ten are to be found in the abdominal portion of the worm. There are a few thick branches from the cord passing up into

the region of the rectum and maintaining their ganglionic character there, but in front of that the ganglia assume a more segmental character and send off nerves to the musculature (Pl. XXXVII, fig. 2). Within the ganglion the fibres which form these nerves may be seen to decussate, the ganglion cells being arranged at the extreme lateral poles of the ganglion, so that the fibres for those on the right cross those from the left in the midline in passing to the muscles of the opposite side.

After the chain rises to reach the œsophagus it is difficult to distinguish the nerves that pass out to the muscles and other organs.

The eyes, which are perfectly visible in the young and undeveloped leech, are still to be found in the adult but only in sections, since they have sunken into the interior of the anterior part of the body and lie embedded in the parenchyma at some distance below the skin. Only two are to be found and they are spherical, composed of few, peculiar, large, clear cells (Pl. XXXVIII, fig. 1), and partly surrounded by a deeply pigmented layer within which a few nuclei can be discerned. Most careful search failed to reveal any optic nerve passing to these organs and it may be surmised that this has atrophied through disuse.

The fate of these eyes seems very extraordinary and we were tempted at first to think that it was an error to suppose that they were really withdrawn from the surface but, as sections in all directions show the same result, there is no doubt as to their position.

## *Musculature*

The body of the worm is provided with strong muscular layers, and special arrangements are found about the mouth and the posterior sucker. There is an outer layer of circular muscle fibres throughout the trunk and, inside these, longitudinal layers which are somewhat oblique. Some of these fibres spread out in a fan shape into the body of the sucker, which is also provided with vertical fibres running from convex to concave surface and circular fibres which are placed in the margin.

About the mouth there is a much feebler arrangement of small muscle fibres, which run in several directions.

## *Parenchyma*

The general parenchyma of the body is made up of several types of cells, among which two sorts are especially conspicuous. The first of these types consists of enormous cells of all shapes, with rather large vesicular nuclei

and with a very great amount of protoplasm, the granules of which stain deep blue. In addition to these blue granules, which hang together in a coarse network and remind one of the tigroid bodies of nerve cells, the whole central part of the cell about the nucleus and stretching out to one margin is filled with highly refractive pink-staining granules. The nucleus commonly contains several nucleoli which are oval or elliptical. The cells look like the active cells of some gland, but it has not been possible to ascribe any special secretory function to them. They are especially striking through their very great size and the contrast in their staining properties. The second type is found scattered everywhere, but especially among the fibres of the body musculature. These cells are smaller and have small indistinct nuclei. Their protoplasm is filled with fine, bright yellow granules which give the impression of having a lipoid character, although they are not dissolved by alcohol and ether.

In the head region and in the large sucker, there are great numbers of cells which resemble the large type excepting in their smaller size and in the absence of the red granules.

At one point on the back of the neck, just in front of the collar-like ring, there is a peculiar condition. A fold of skin projects and is quite devoid of the usual deeply staining cells which underly the skin. Instead, there is a sweeping bundle of fine channels filled with the red-staining granules, such as are seen in the larger parenchymal cells. No cells are concerned but they seem to be granules set free somewhere deeper in the tissue and stretching along in strands toward this place on the back of the head. The strands pass quite to the skin and appear to penetrate it and to open on the surface as though for the purpose of discharging the granules by many fine outlets. The reason for this and the nature of the whole thing is quite obscure.

### *The Skin*

The skin is very thin over the whole body and quite unarmed. It consists of a thin homogeneous epidermis, under which there is a layer of small cells discontinuously arranged, giving it the appearance of having a fine papillary arrangement. These cells are closely applied to the epidermis. Just beneath the skin, there are many of the larger parenchymal cells but none seem to have the relation of gland cells attached to the skin.

There are, undoubtedly, many tactile sense organs distributed over the skin, but those about the anterior extremity of the head become quite conspicuous and are rather numerous (Pl. XXXVII, figs. 3 and 4). They appear as bud-like projections, bulging through the ordinary skin and termi-

nating externally just in the level of the protruded skin in a bunch of hair-like processes. Below, these fade into a concentrically arranged group of elongated, fusiform cells. Below these, there are two or three very large, pale cells with large central vacuoles which seem to be lined with cilia, although that may be merely the irregularity of the protoplasm. These are quite like the large pale cells of the eye. Although the fine nerve connections which must reach them can not be made out, this seems to be only the effect of the poor fixation of the tissue.

On the inner side of the anterior lip, there are masses of fusiform cells, similarly arranged, so as to converge upon one or two points of the surface, where they apparently act as sensory organs.

The young worms (Pl. XXXVIII, fig. 3) when hatched are only about 1.20 mm. long by .40 wide at the base, where they are widest. The head is narrow; the mouth is well developed but with no sign of a proboscis. They have, on the dorsal lip, two eyes, well shown even at this period. The worm has seven short branchiæ on each side, nearer the back than the abdomen. They are mere stubs but, as they grow, divide and subdivide. The alimentary canal at this stage is only a crooked tube, double at its posterior half and well filled, but no open anus can be seen, although the situation of the prospective opening is apparent at the end of the body dorsal to the sucker. The sucker is large and well developed, and it is probably used at once.

The eggs, found in clusters, measure .8 mm. in diameter and have a double contoured shell (Pl. XXXVIII, fig. 2).

## Explanation of Plates

### Plate XXXIII

Figure 1. *Ozobranchus branchiatus.* Ventral surface.

Figure 2. *O. branchiatus.* Digestive tract. *Pph.*, prepharynx; *Ph.*, pharynx; *Oes.*, œsophagus; *Oes. g.*, œsophagæ glands; *Int.*, intestine; *Int. c.*, intestinal cœca; *Lat. res.*, lateral reservoirs; *Rect.*, rectum.

### Plate XXXIV

Figure 1. *O. branchiatus.* Horizontal section. *C.*, sinus filled with blood-like fluid; *Gg.*, seven groups of gill filaments; *T.*, testes; *Y. gl.*, yolk gland; *S. v.*, seminal vesicles; other letters as above.

Figure 2. *O. branchiatus.* Cross-section of one of the intestinal cœca. Cf. Pl. XXXIII, fig. 2.

## Plate XXXV

*O. branchiatus.* Transverse section at level of the ovaries. Letters as before; *Ov.*, ovaries; *C. ns.*, ventral gangliated nerve cord; *S. r.*, seminal reservoir.

## Plate XXXVI

Figure 1. *O. branchiatus.* Male genital apparatus. *T.*, testes; *V.e.*, vasa efferentia; *V.d.*, vas deferens; *S.v.*, seminal vesicles; *D.D.*, diverticula; *S.r.*, seminal reservoir receiving canals from seminal vesicles; *E.b.*, ejaculatory bulb.

Figure 2. *O. branchiatus.* Female genital apparatus. *Ov.*, ovary; *Y.gl.*, yolk gland; *Ut.*, uterus.

## Plate XXXVII

Figure 1. *O. branchiatus.* Muscular pharynx (*Ph.*) surrounded by large ganglionic masses (*C.ns.*) and also by very large gland-like cells (*Gl.*). Numerous parenchyma cells with muscle fibres interspersed surround this area and show the relative sizes of the cells.

Figure 2. *O. branchiatus.* Ganglion of ventral gangliated cord with nerve running to muscle. There is a decussation of the fibres.

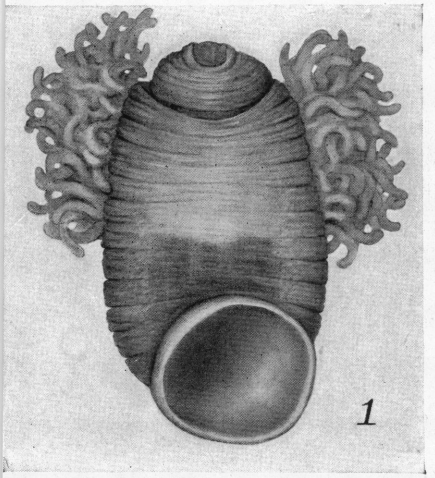
Figures 3 and 4. Tactile sense organs on skin of head.

## Plate XXXVIII

Figure 1. *O. branchiatus.* Submerged eye lying deep in the parenchyma and muscle.

Figure 2. *O. branchiatus.* Eggs from skin of the host.

Figure 3. *O. branchiatus.* Young worm showing eyes, rudimentary gills, and undeveloped intestinal tract.



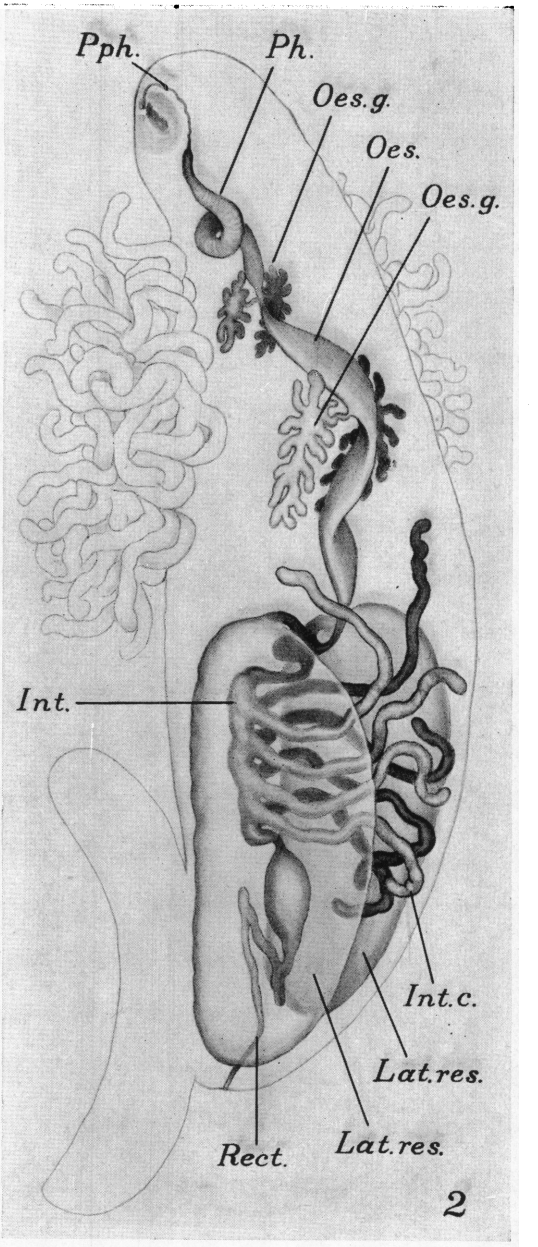
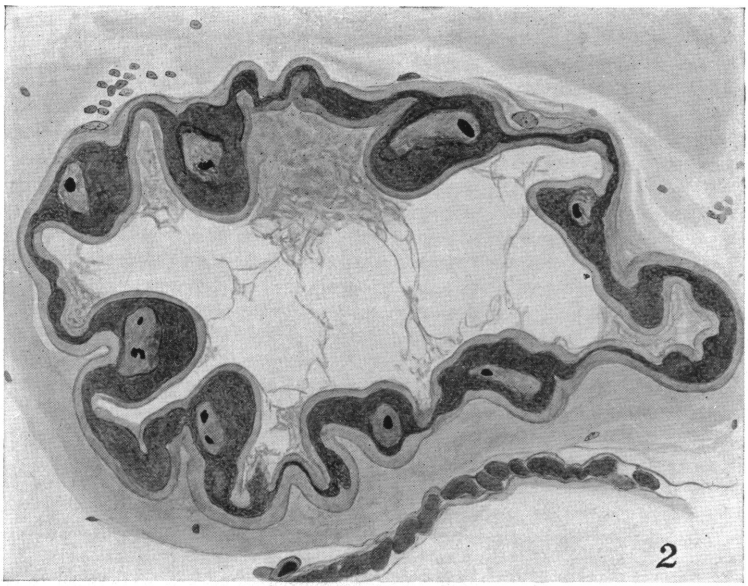




Fig. 1. *Ozobranchus branchiatus.* Ventral surface.

Fig. 2. *O. branchiatus.* Digestive tract. *Pph., prepharynx*; *Ph.*, pharynx; *Oes.*, œsophagus; *Oes. g.*, œsophagæ glands; *Int.*, intestine; *Int. c.*, intestinal cœca; *Lat. res.*, lateral reservoirs; *Rect.*, rectum.



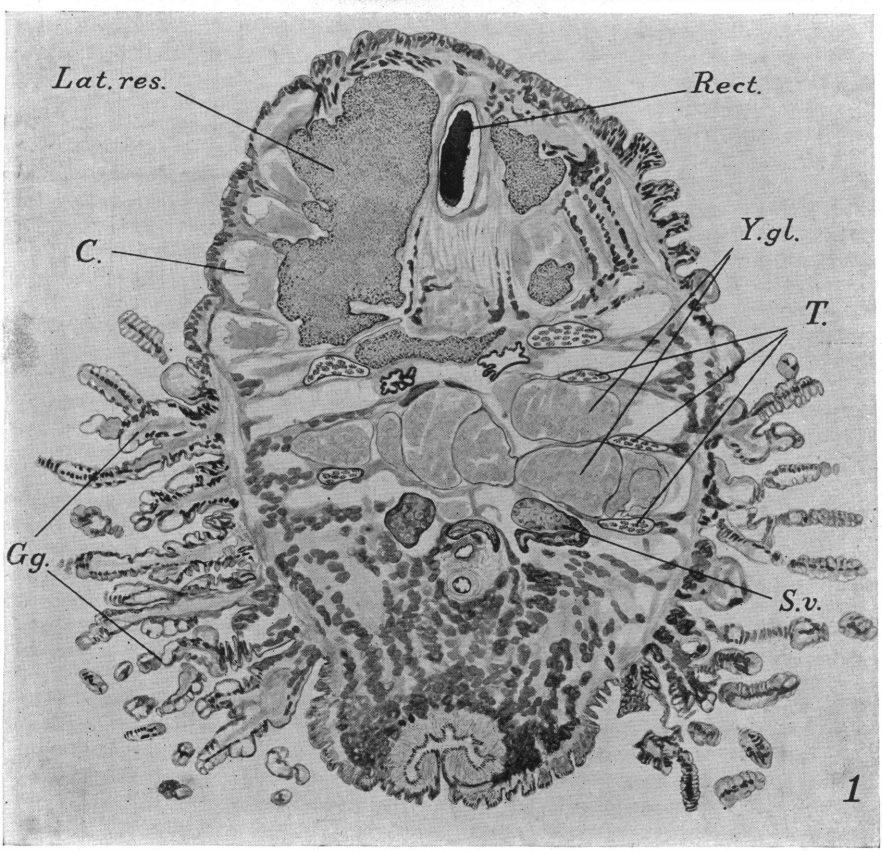
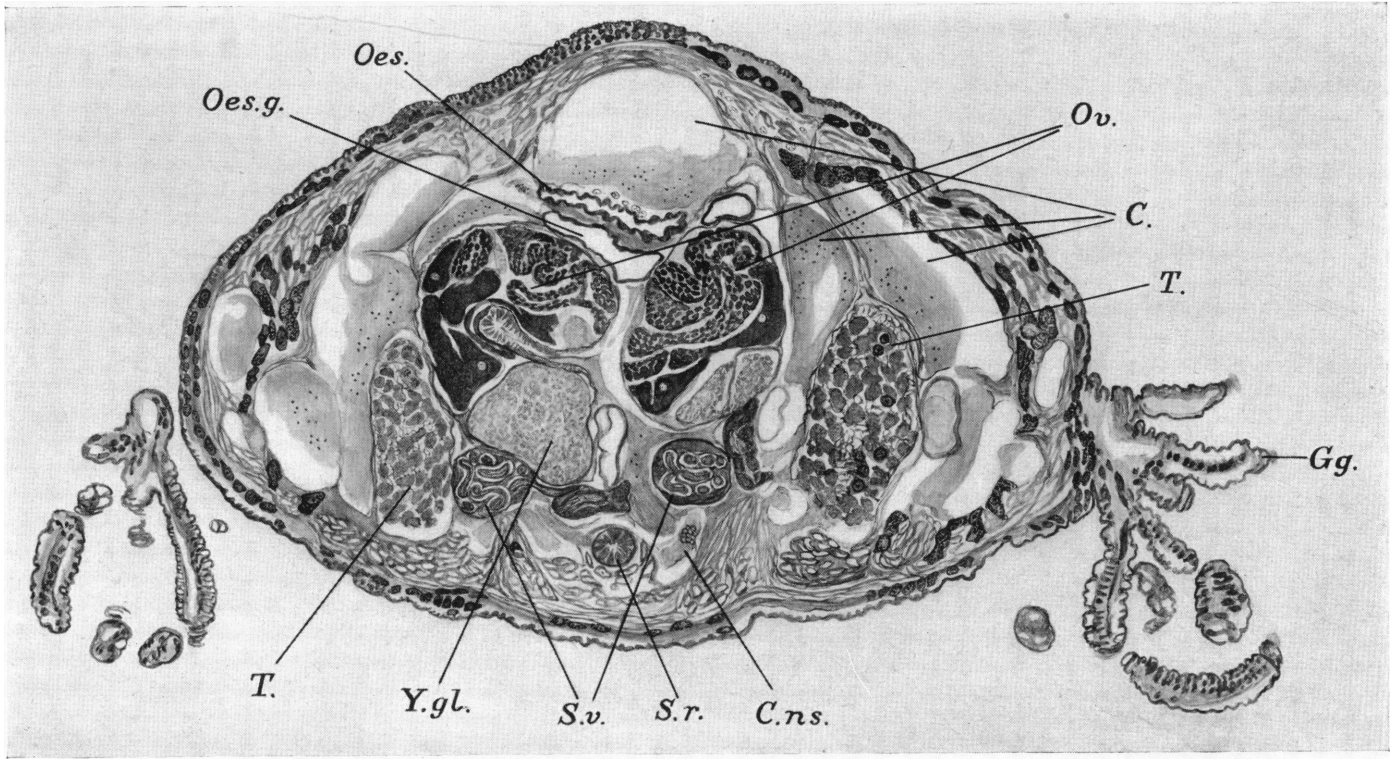
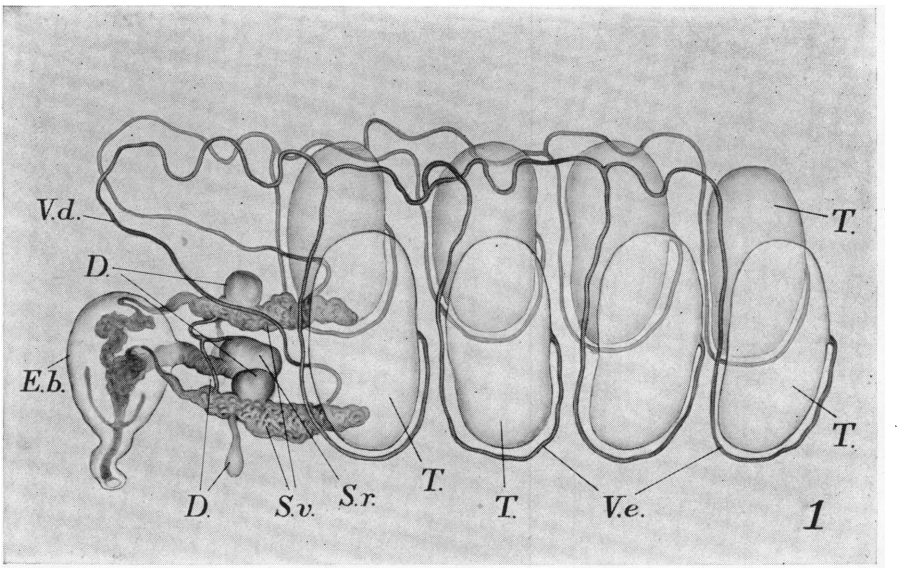




Fig. 1. *O. branchiatus.* Horizontal section. *C.*, sinus filled with blood-like fluid; *Gg.*, seven groups of gill filaments; *T.*, testes; *Y. gl.*, yolk gland; *S. v.*, seminal vesicles; other letters as above.

Fig. 2. *O. branchiatus.* Cross-section of one of the intestinal cœca. Cf. Pl. XXXIII, fig. 2.




*O. branchiatus.* Transverse section at level of the ovaries. Letters as before; *Ov.*, ovaries; *C. ns.*, ventral gangliated nerve cord; *S. r.*, seminal reservoir.



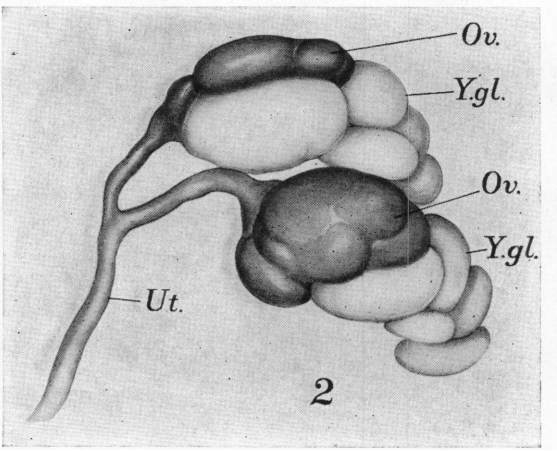
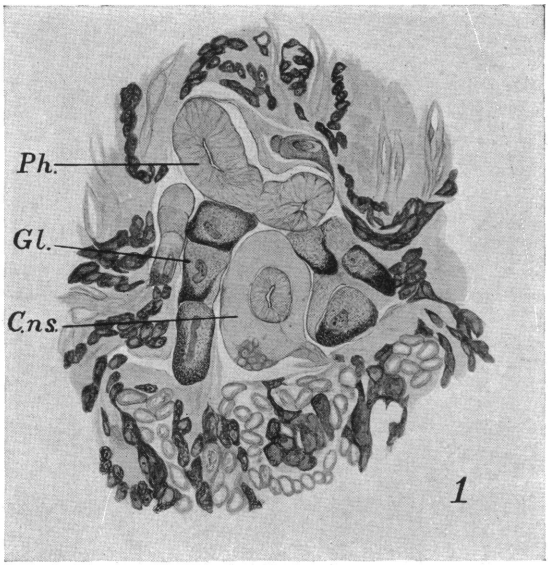
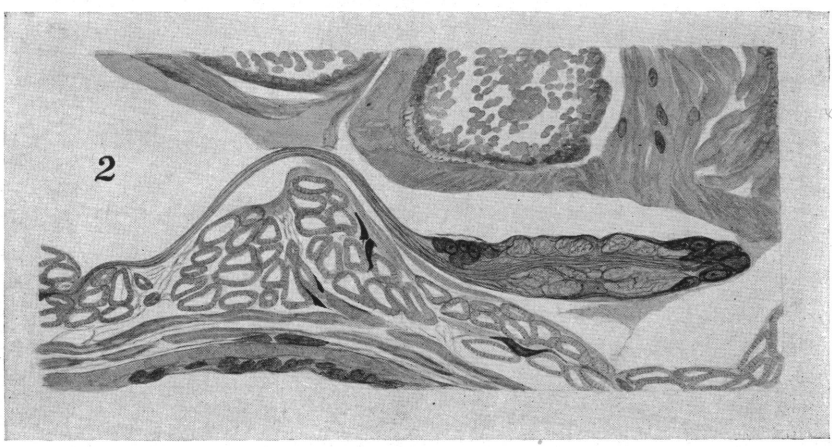
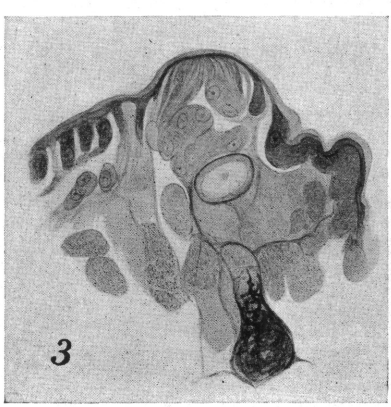




Fig. 1. *O. branchiatus.* Male genital apparatus. *T.*, testes; *V. e.*, vasa efferentia; *V. d.*, vas deferens; *S.v.*, seminal vesicles; *D.D.*, diverticula; *S.r.*, seminal reservoir receiving canals from seminal vesicles; *E.b.*, ejaculatory bulb.

Fig. 2. *O. branchiatus.* Female genital apparatus. *Ov.*, ovary; *Y.gl.*, yolk gland; *Ut.*, uterus.



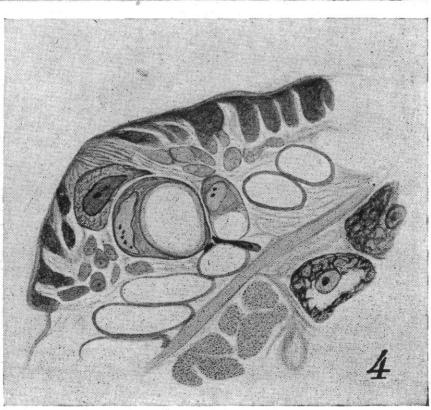
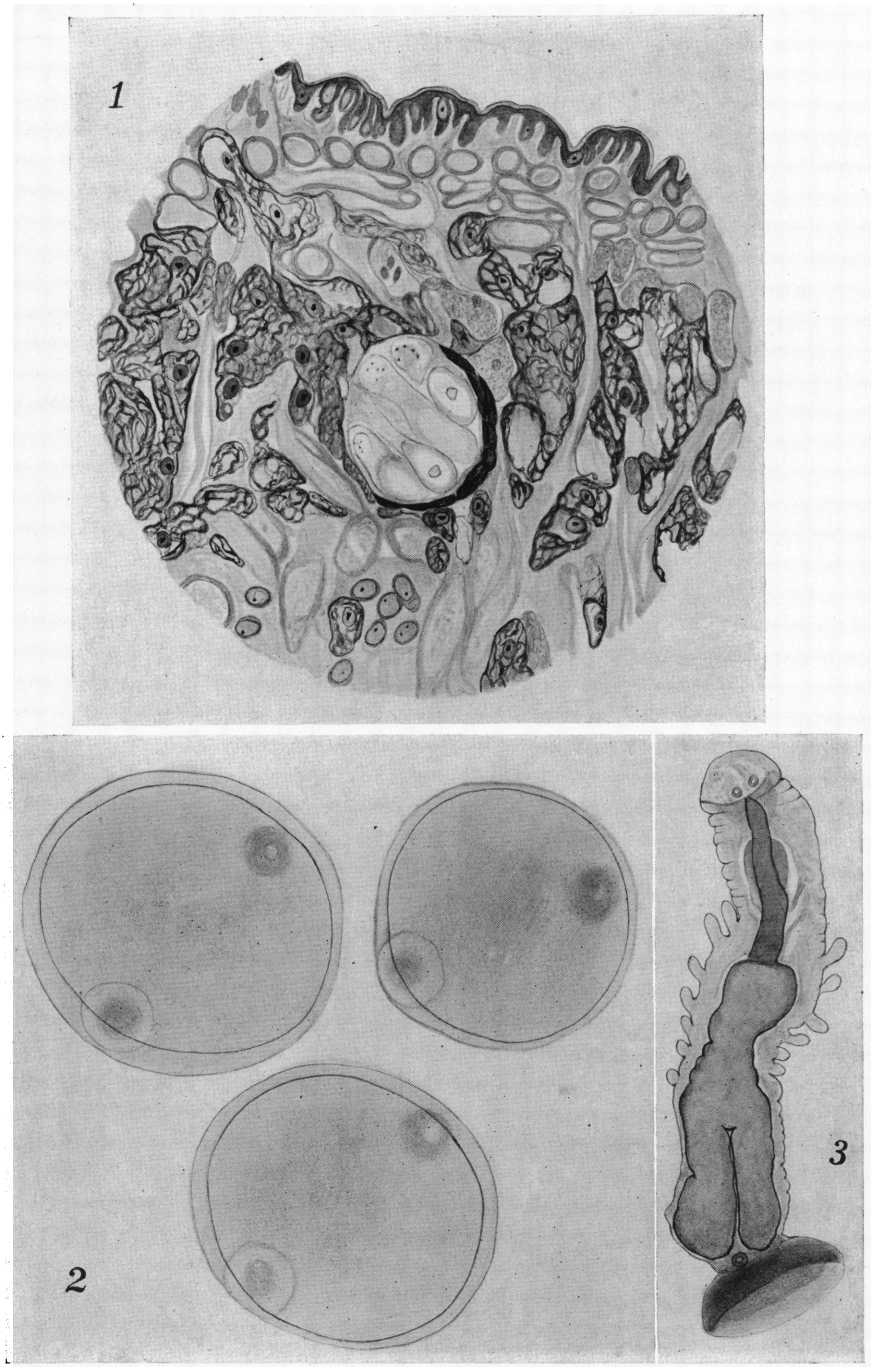




Fig. 1. *O. branchiatus.* Muscular pharynx (*Ph.*) surrounded by large ganglionic masses (*C.ns.*) and also by very large gland-like cells (*Gl.*). Numerous parenchyma cells with muscle fibres interspersed surround this area and show the relative sizes of the cells.

Fig. 2. *O. branchiatus.* Ganglion of ventral gangliated cord with nerve running to muscle. There is a decussation of the fibres.

Figs. 3 and 4. Tactile sense organs on skin of head.

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