# ON A NEW SPECIES OF *PRAEGERIA* OCCURRING IN THE SANDY BEACH, MADRAS*

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CONTENTS



## *Historical, Material and Methods*

The genus *Praegeria* belonging to the family Pisionidæ was first constituted by Southern in 1914 for the reception of a small polychæte obtained from Clew Bay during Clare Island Survey and the genotype *P. remota* has been briefly described by him. Later in 1932 Smith has recorded the abundant occurrence of this species in the infauna of the shell-gravel deposits of the Eddystone Grounds near Plymouth. The present form is the next addition to be made to the genus and is the first record of *Praegeria* from India. A single mature male specimen of the species under consideration was also

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obtained from the sandy beach at Pathinettarayālom on the West Coast (Malabar) of India.

The worms live in large numbers in coarse sand from half to low water level of the intertidal region of the Madras Beach. Like most of the intertidal animals the range of distribution of these worms in the tidal zone is limited and examination of samples of sand from low to high water level reveals a steady decrease in their number until they are completely absent from about 2/3 tide level upwards. With regard to the habitat of *P. remota* Southern says, 'It is a small species living on a bottom of sand and shells or gravel and would escape capture by the dredge unless special precautions are taken'. As has been already mentioned the Madras form also prefers a coarse substratum for habitat.

The time of low tide is the most favourable for collecting these minute worms. When a quantity of sand from the particular zone in which the worms are found is taken in a glass trough and vigorously shaken with sea water they come up and swim in the supernatant water. This water is then quickly decanted into a glass dish from which the worms could be easily pipetted out. Collections at the spot are made by directly pipetting the worms from the disturbed sand (and water) even though this method is more tiresome. When disturbed the worms roll themselves into minute balls which are practically indistinguishable amongst the sand grains, and then firmly attach themselves to the bottom by the posterior end. It may be mentioned that the worms can be obtained practically throughout the year. However, during November and December when the salinity of the shore water is considerably lowered and undergoes sudden variation due to the N. E. Monsoon and the influx of fresh water from the Cooum and the Adyar, most of the worms perish and only few of them manage to survive.

The following account is based upon observations on living worms, whole mounts and serial sections. Fixation in Bouin's fluid gave good results. Double embedding in cedukol was also found to be very useful, especially for longitudinal sections. Iron hæmatoxylin and Delafield's hæmatoxylin were used for staining.

In the course of the present investigation two more species of *Praegeria* —*P. remota* and a second new species, *P. complexa*,—have been discovered and have been the subject of detailed study, the results of which will form the subject-matter for separate papers. Knowing, therefore, the anatomical features of three species of the genus of this little known family (Pisionidæ) a comparison of the forms has been made possible.

*External Characters*

The worms are very small and slender and measure about 3 to 10 mm. in length. Segmentation is distinct and the number of segments varies from 20 to 50 in the mature individuals. The male is invariably smaller than the female. The fully ripe males possess a small white area in one of the middle segments of the body, representing the position of the sperm-sacs, while in the ripe female the second half of the body is greenish in colour due to the accumulation of ova. By these characters alone the sexes can be distinguished with the unaided eye.

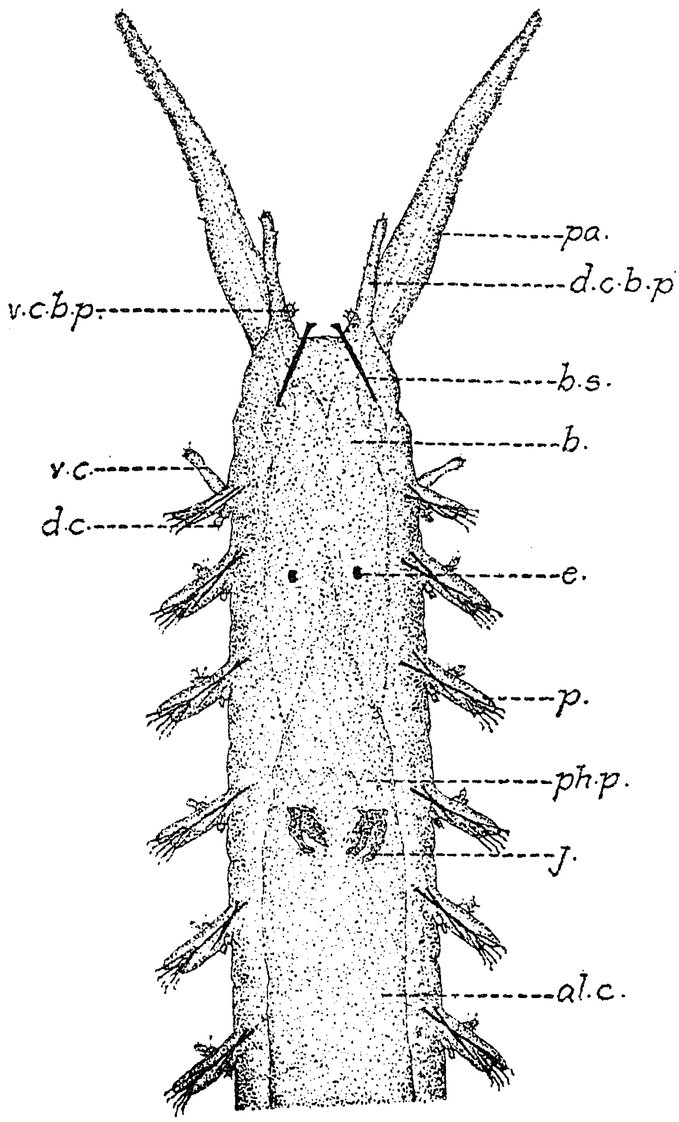



FIG. 1

In the general structure and build of the body the present form (Fig. 1 and Photomicrograph 1) resembles *P. remota*. The body which gradually tapers to the tail, is often flesh coloured and as mentioned above, this colouration makes it difficult to distinguish them when amongst the sand grains. The segments are broader than long but at the posterior extremity a few of the segments are longer. The parapodia are all well developed and conspicuous. The head is highly reduced and fused with the anterior segments such that there is no marked differentiation of the former from the trunk. The brain is anteriorly situated and is in the form of two elongated lobes fused in front and stretching behind into the posterior half of the third setigerous segment. At the level of the second setigerous segment and placed on the lobes of the brain in direct communication with them is a pair of dark eyes.

The bases of the buccal parapodia are highly swollen and are fused in front of the head, the fusion being marked by well defined deep grooves. The groove on the ventral side is deeper and extends upto very near the mouth. The parapodial base is supported by a small spine, usually about 66 microns long. It is slightly swollen in the middle and is expanded at the tip which is smooth and devoid of any teeth or serrations. Each of these spines is placed in a slanting position, pointing forwards and towards the median line, so that the tips of the two often touch each other. In contrast to *P. remota* these spines are small and more anteriorly situated, there being a considerable space between their inner ends and the base of the first setigerous foot. The swollen base of the buccal parapodium is prolonged dorsally into a slender tapering cirrus, usually measuring about 115 microns in length. Beneath the base of this is a minute globular cirrus with a few palpocils at the tip. These two probably represent the dorsal and ventral cirri of the buccal parapodium. To the ventral surface of the buccal parapodia are attached the bases of a pair of large tapering cirri measuring about 350 microns in length. These are the palps. Towards the base of each palp is a conspicuous collar-like tissue or sheath from which it appears to pass to the ventral surface of the head above the mouth. The palps and cirri have a ringed or jointed appearance and are provided with palpocils at every constriction.

*Parapodium.*—The parapodia are all uniramous. The first setigerous foot is slightly smaller than the succeeding ones and has the ventral cirrus slightly elongated, measuring about 30 to 40 microns in length. In *P. remota* the ventral cirri of the first pair of parapodia are considerably elongated so that when directed forwards they reach beyond the base of the palps; but in the present form these cirri when directed forwards reach only half way to the base of the palps.

All the parapodia are almost similar in structure. The tenth foot may be described here (Fig. 2). The main setigerous lobe is elongated and deeply t the tip, having two blunt processes or papillæ. The ventral one of papillæ is more pointed and projects beyond the dorsal one. The and ventral cirri are globular structures attached by narrow bases with minute terminal papillæ carrying long palpocils. The setigerous

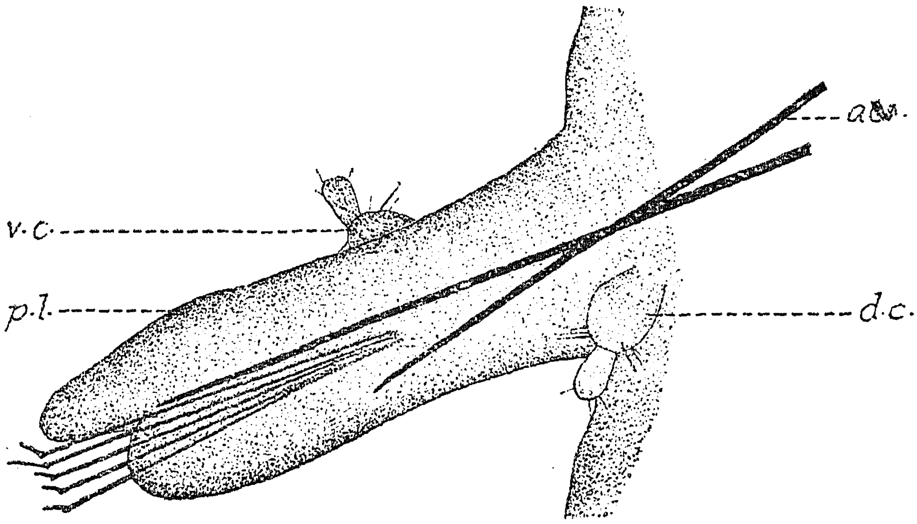



FIG. 2

t of the parapodium consists of two acicula and five setæ. Of the two which are simple spines, one is smaller than the other and is situated dorsal part of the parapodial lobe. Among the five setæ one is simple he rest are compound. This simple seta, which is present in all the thicker than the compound ones and has an expanded and bevelled ovided with a row of minute teeth (Fig. 3 *a*). Of the compound setæ e situated nearest to the simple seta differs from the rest in having

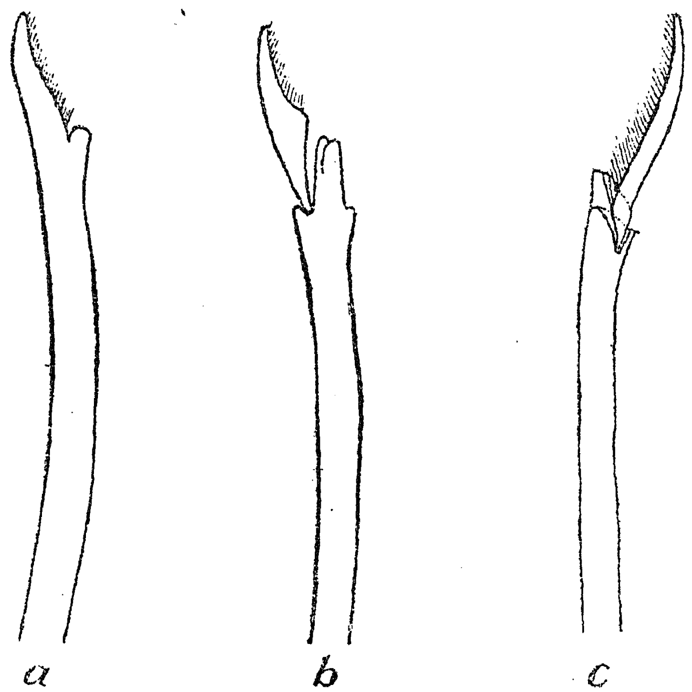



FIG. 3

bifid at the tip, having two blunt processes or papillæ. The ventral one of these papillæ is more pointed and projects beyond the dorsal one. The dorsal and ventral cirri are globular structures attached by narrow bases and with minute terminal papillæ carrying long palpocils. The setigerous

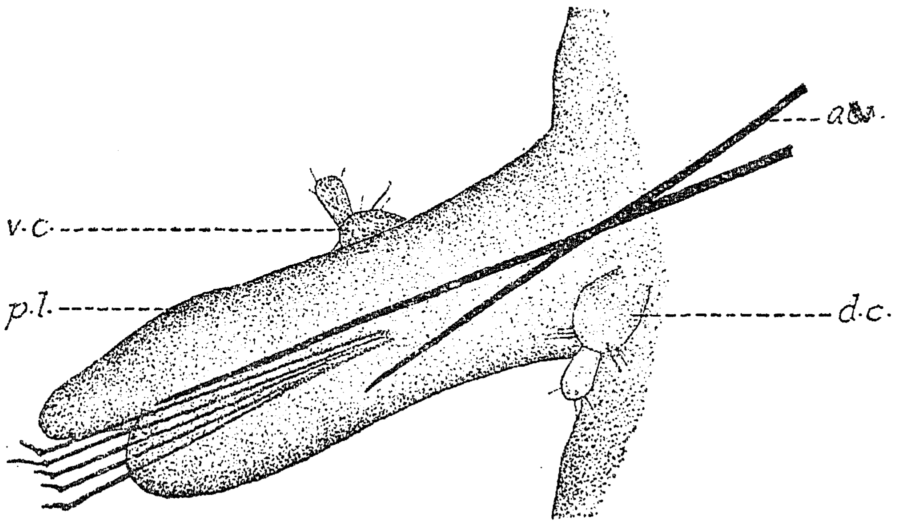



FIG. 2

support of the parapodium consists of two acicula and five setæ. Of the two acicula which are simple spines, one is smaller than the other and is situated in the dorsal part of the parapodial lobe. Among the five setæ one is simple while the rest are compound. This simple seta, which is present in all the feet, is thicker than the compound ones and has an expanded and bevelled tip provided with a row of minute teeth (Fig. 3 *a*). Of the compound setæ the one situated nearest to the simple seta differs from the rest in having

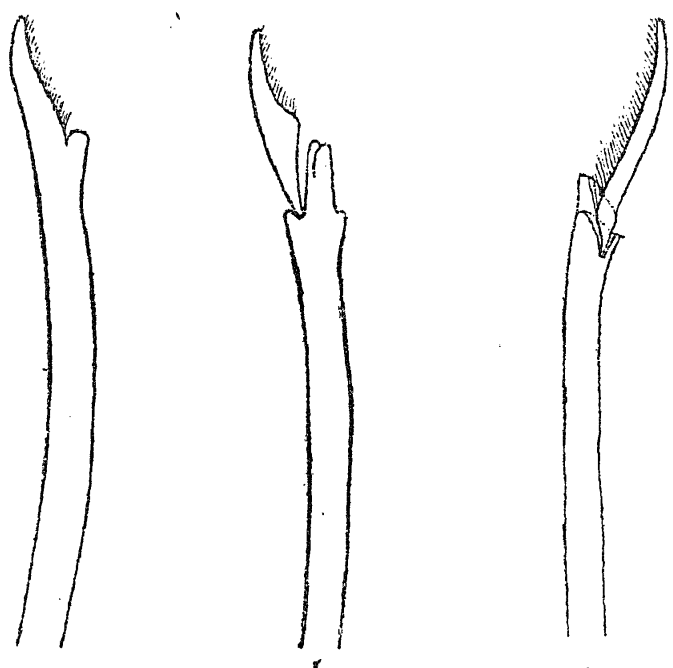
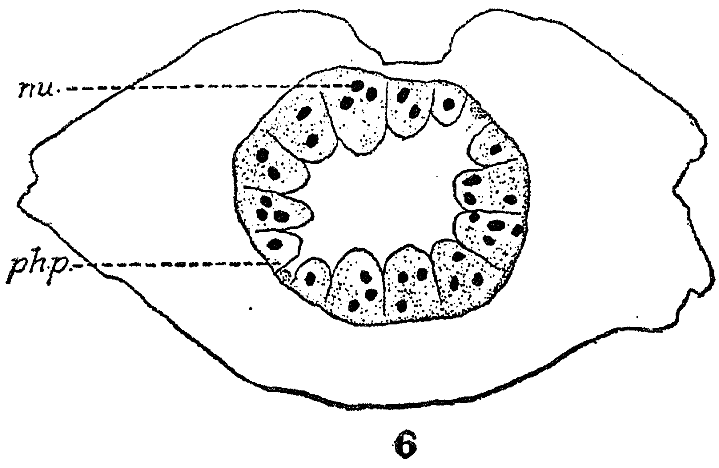


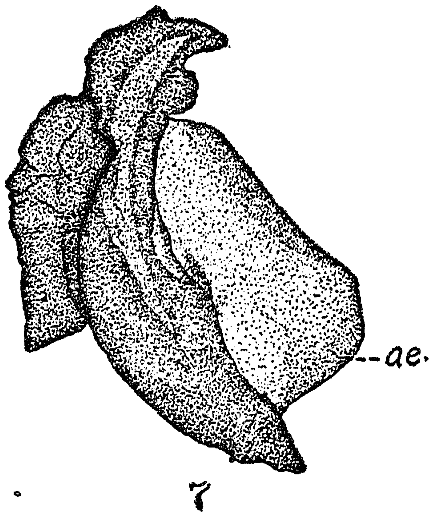

FIG. 3

often they touch each other. The ventro-lateral muscle bands are thicker and larger than the other two and near the ventral nerve cord they show a tendency to turn inwards. In the other two species of *Praegeria* the corresponding muscle bands are better developed and the tendency to turn inwards at the border is more pronounced. A further advance in the development of these muscles has been observed in the case of *Pisionella indica* (Aiyar and Alikunhi, 1940)—an allied genus—wherein this turning inwards is complete, the inwardly turned edge coming in contact with the opposite end of the muscle band, thereby enclosing a space. Towards the anterior edge of the body, in the region of the pharynx, the longitudinal muscles are poorly developed and inconspicuous. An epithelial lining, the coelomic membrane, forms the innermost layer of the body wall.

*Alimentary Canal*

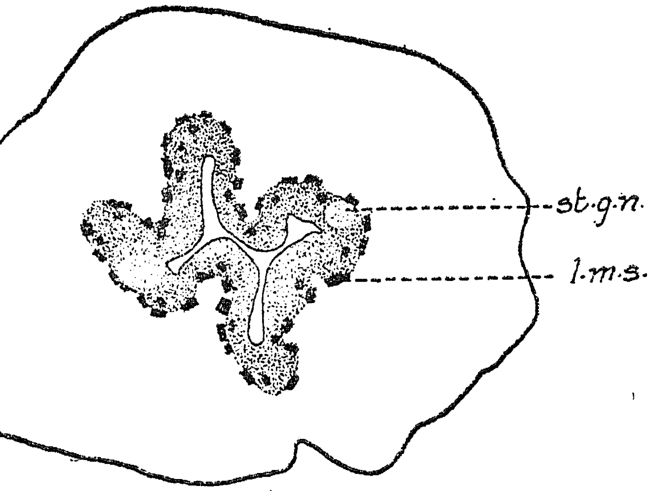
The mouth is median and ventral and is supported by a muscular lower lip. It leads into an œsophagus which extends into the third setigerous segment (Fig. 1). This is followed by a highly muscular protrusible pharynx which normally extends to the sixth segment. The pharynx is provided with a crown of 14 conical, pointed papillæ of almost equal size (Fig. 6). The pharyngeal armature consists of two pairs of chitinised jaws which are supported by broad foliaceous aeilerons (Fig. 7). Of these jaws

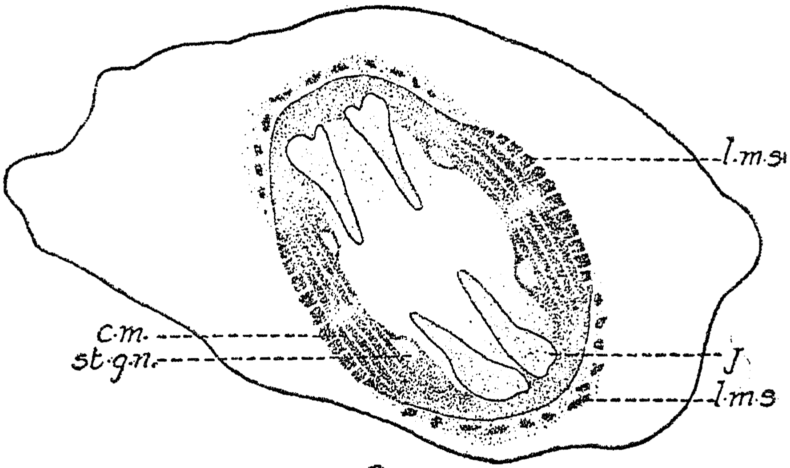



FIGS. 6—7

the outer one of each pair is provided with two or three blunt projections at the anterior pointed end (Fig. 7) while the inner one is devoid of such projections. The œsophageal wall is thin and around it are several bundles of longitudinal muscle fibres (Fig. 8), forming an almost complete layer. The inner epithelium in this region is constituted by fairly large protoplasmic cells. At the level of the jaws a strong development of circular

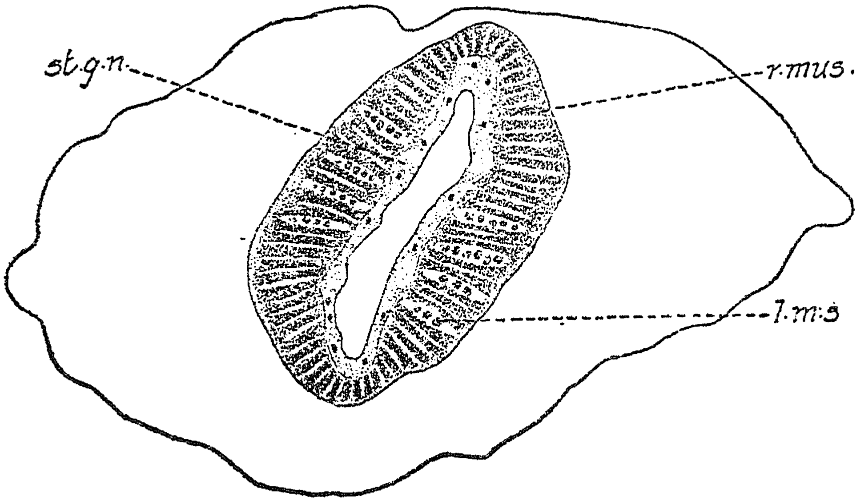



FIGS. 8—9

muscles is found besides a discontinuous layer of longitudinal muscle bundles on the exterior (Fig. 9). The pharynx, extending from the level of the jaws to the 6th segment, is highly muscular. Internally there is a strong epithelial layer in which only a few nuclei can be made out. On the outside there is a fibrous membrane in which nuclei are not seen. Between these two layers run powerfully developed bundles of radially disposed muscles (Fig. 10). Attached to the hinder extremities of the jaws and running down slightly to the sides are a few longitudinal muscle strands which keep the jaws in position and probably regulate their movements. In transverse sections (Fig. 10) these muscles are seen to pass through the spaces in between the radial muscle bundle of the pharyngeal wall. From a little behind this region a layer of longitudinal muscle strands appears surrounding the pharyngeal wall. The inner epithelium here is more protoplasmic and the nuclei of the cells stain more deeply (Photomicrograph 3). The pharynx is followed by the stomach which extends to the 9th or the 10th segment.

It is thin walled and devoid of any constrictions and is surrounded by a layer of longitudinal muscles, arranged in bundles (Fig. 11). The digestive epithelium here consists of protoplasmic cells the nuclei of which take a comparatively deep stain. From the 10th segment onwards the intestinal portion gets intersegmentally constricted at the level of the septa. The inner epithelial wall of the intestine is formed of a single layer of large cells with deeply staining round basal nuclei. Externally there are a number of scattered, extremely minute longitudinal muscle strands. Circular muscles in the wall of the alimentary canal have not been detected even under high magnification. The anus is posterior and ventral and is situated just in front of the caudal glands. The posterior portion of the alimentary canal and the anus are richly ciliated.

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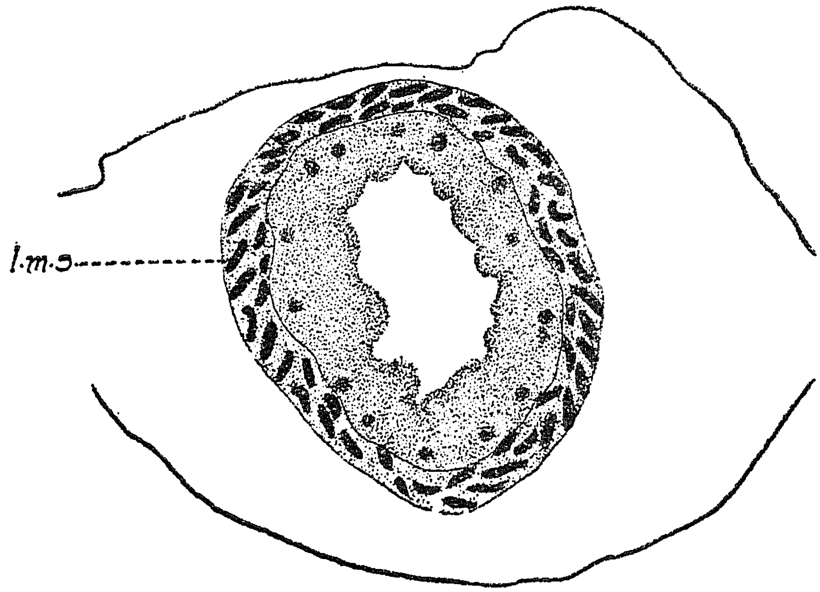


Figs. 10—11

*Nervous System and Sense Organs*

*Brain.*—As has been mentioned, the brain is very anteriorly situated and is in the form of a pair of elongated tapering lobes, fused together in front and extending behind into the third setigerous segment. Anteriorly, the lobes fuse together after which they project as blunt processes and there is a groove in between (Figs. 12 *a* and 13). Posteriorly the lobes are far more separate and stand apart. The outer part of the brain is formed by a rind or sheath of ganglion cells while the inner region is made of the punctated substance which is best developed before the bifurcation into the posterior lobes. Transverse sections of this substance give the appearance of fine granules, interspaced with minute fibrils, while in longitudinal sections it has the appearance of extremely thin, wavy fibrils. Nuclei have not been observed in this substance, and it does not stain with iron hæmatoxylin.

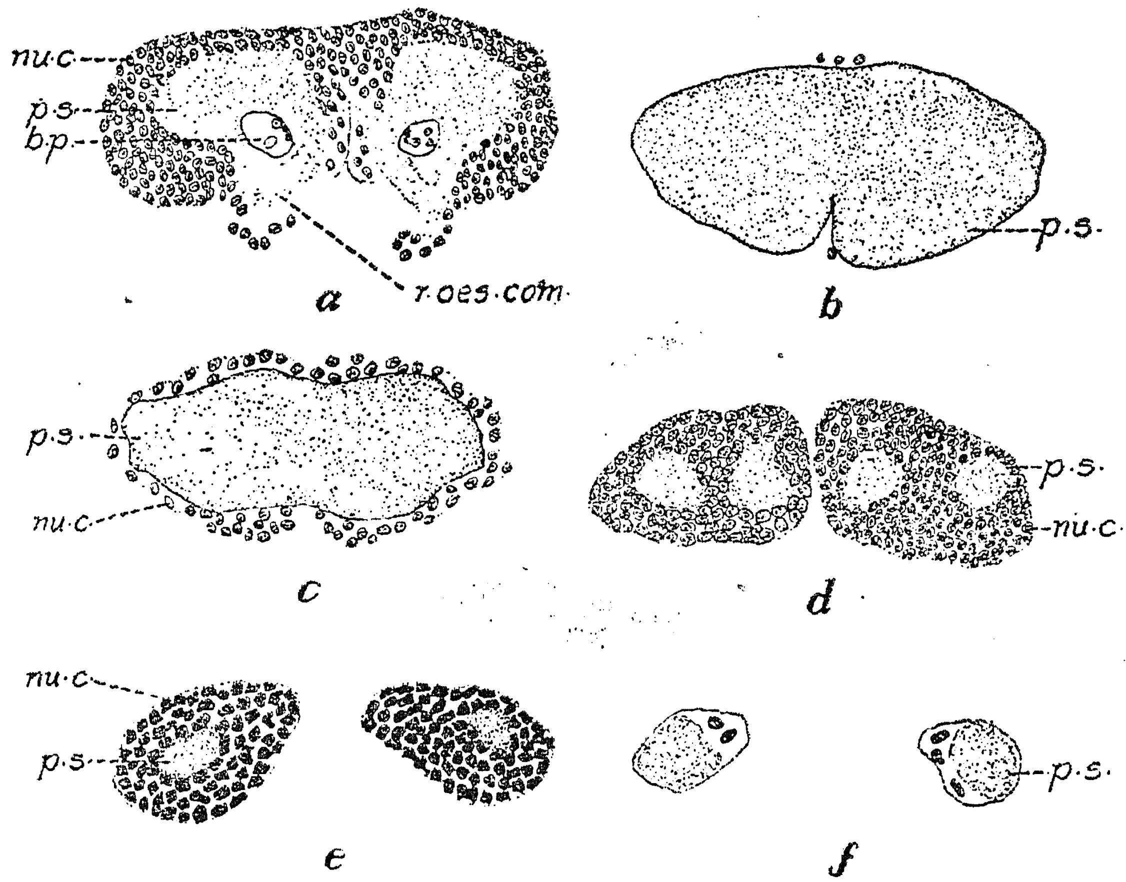


FIG. 12

The nuclei of the ganglion cells are very large and rounded and each
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ections stained in iron hæmatoxylin the nuclei stain moderately and are
to be very closely aggregated. Towards the anterior end of the brain
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ventral side and are grouped together dorsally near the median line,
in the anterior fissure between the two horns of the brain. At
point of union of the two anterior lobes the ganglion cells are
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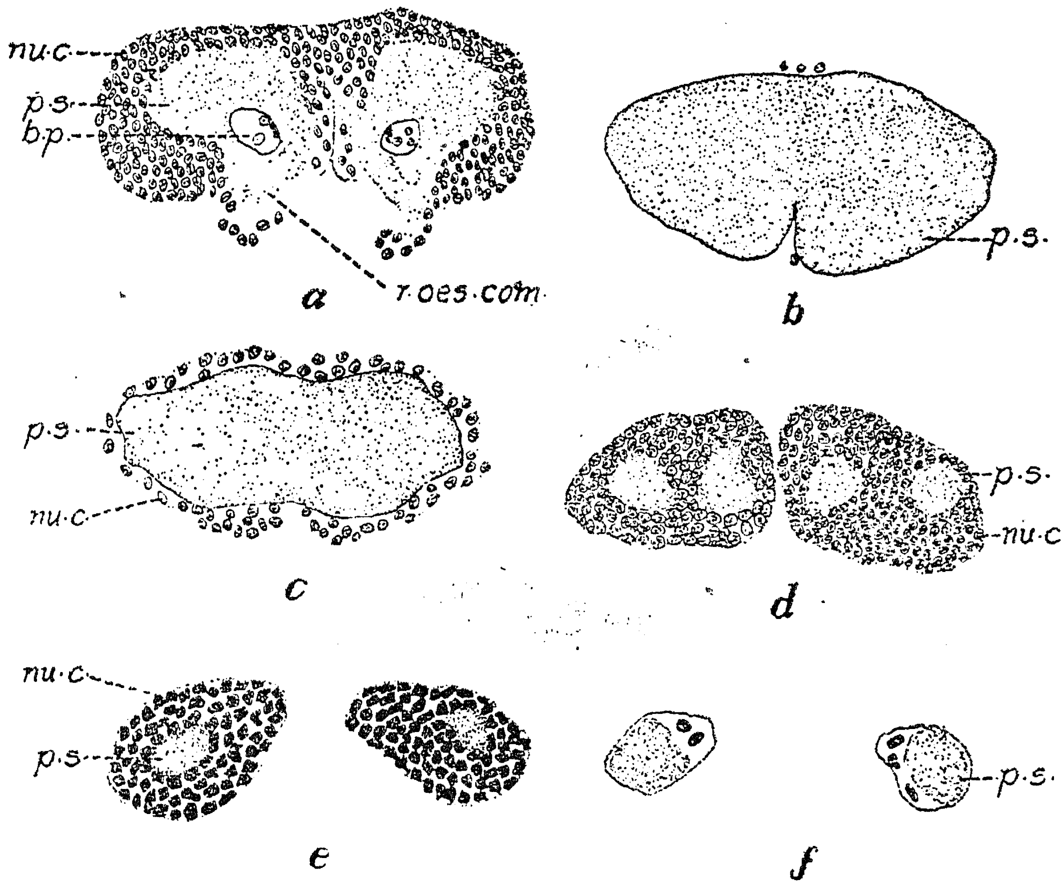



FIG. 12

The nuclei of the ganglion cells are very large and rounded and each occupies the major portion of the cell, the cytoplasm being much reduced. In sections stained in iron hæmatoxylin the nuclei stain moderately and are seen to be very closely aggregated. Towards the anterior end of the brain where the two lobes stand apart, these cells are few dorsally but are aggregated ventro-laterally. Proceeding backwards they are reduced on the ventral side and are grouped together dorsally near the median line, *i.e.*, in the anterior fissure between the two horns of the brain. At the point of union of the two anterior lobes the ganglion cells are present on the dorsal and lateral sides but are absent from the ventral side. Immediately behind the fusion of the anterior lobes the ganglion cells are completely absent from the outer aspect of the brain and dorsally the brain is in intimate contact with the hypoderm. In the middle portion of the brain only very few ganglion cells are present (Fig. 12 *b*). But further behind they again make their appearance (Fig. 12 *c*) and soon a thick covering of them is formed all round the brain. Here, in longitudinal as well as transverse sections, the central core, formed of the punctated substance, is seen to be divided into two parts due to the nucleated cells having encroached in the form of a bed in between (Fig. 12 *d*). The eyes are lodged in amongst the ganglion cells and just touch ventrally the upper surface of egion of the brain (Fig. 13). In forms like *Eunice torquata* and *Marphysa ravelyi* also the œsophageal commissures have been described as arising y means of two roots. In transverse sections it is seen that the inner core f the palps pass between the roots of the œsophageal commissures Fig. 12 *a*). A few ganglion cells form a covering to the bases of the com- iissures but as they pass to the ventral side very few such cells are noticed. Iowever, they are present on the posterior part of the commissures com- iencing from a little in front of the region where they fuse together to form he ventral nerve cord.

*Ventral Nerve Cord.*—The first pair of ganglia of the ventral chain is ormed at the level of the eyes, *i.e.*, in the second setigerous segment where he two commissures fuse together. The posterior lobes of the brain pro- ect backwards well beyond the level of these ganglia. The ventral nerve ords fuse together at the ganglionic swellings but in the intervals they stand eparate (Fig. 13). Well developed ganglionic swellings are present and vhole mounts stained in Delafield's hæmatoxylin give a good picture of them. The ganglionic enlargement in each segment commences immediately behind he anterior septum and it is interesting to note that each pair of ganglia uses together in two places, one immediately behind the septum and the ther at the level of the parapodium. In front of the anterior septum the ierve cords are thin and devoid of ganglion cells (Fig. 14 *c*). A thick sheath

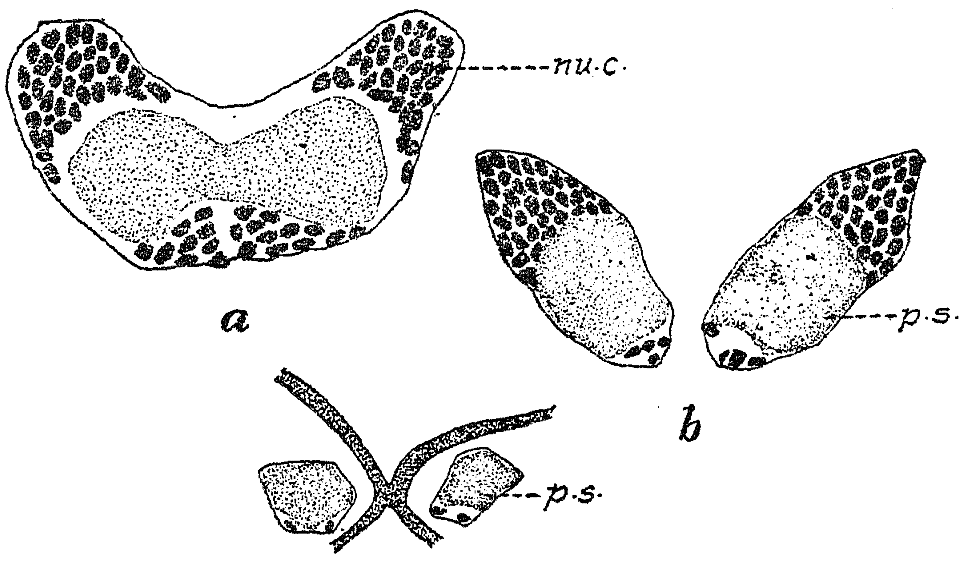



FIG. 14

of ganglion cells, usually arranged in three groups—two dorso-lateral and one ventro-median—is, however, present surrounding the punctated substance (Fig. 14 *a*). Where the two ganglia are separate, as well as immediately behind the ganglia, the ventro-median group of ganglion cells is absent, and the dorso-lateral groups are in the form, of two conical lids (Fig. 14 *b*).

The fusion of the ganglia at two places reminds one of the condition of the ventral nerve cord in the Sabellaridæ, Serpulidæ, and Amphictenidæ, in which each segment is provided with two pairs of ventral ganglia, one in the anterior and the other in the posterior part of the segment (Hempelmann, in Kukenthal). It may also be mentioned that in *Pectinaria* Lamarck and *Petta* Malmgren even three pairs of ganglionic swellings are present in each segment.

Giant nerve fibres have not been noticed in the course of the nerve cord. A neural canal is absent. On the dorsal aspect of the nerve cords are inserted the bases of powerful oblique muscles, which in the hinder region of the segment pass between the nerve cords (Fig. 14 *c*). The ganglion cells are practically absent in this region.

*Parapodial Ganglia and Nerves.*—Well defined nerves are present supplying the parapodia and the palps (Fig. 13), the latter of which will be described in a subsequent section. The nerves to the first pair of parapodia arise from the œsophageal commissures while those to the second pair take their origin from the first pair of ventral ganglia. No other nerves could be made out in these two segments. In the succeeding segments, however, two pairs of nerves are seen to arise from the ganglia. The first pair takes its origin from the anterior part of the ganglia, immediately behind the septum, and are extremely slender nerves. In sections they can be traced only for a short distance between the muscles. The second pair arising from the posterior portion of the ganglia from the ventral aspect constitutes the parapodial nerves. They are much thicker than the anterior pair and, as usual, run between the longitudinal and circular muscle layers to the sides. At the outer border of the ventro-lateral longitudinal muscle band each of them enlarges into a ganglion—the parapodial ganglion. They are fairly conspicuous and in sections the ganglion cells are present in the form of a compact group towards the inner aspect, while the inner core or the punctated substance is situated close to the body wall. From each of these ganglia a slender nerve is given off to the parapodial lobe.

These ganglia correspond to the 'Ganglion de renforcement' of the French authors and from which nerves are supposed to be given off to the parapodia. The presence of these parapodial ganglia, though common in many families of Polychætes (Nereidæ, Amphinomidæ, etc.) is not universal.

*Nerves to the sperm-sacs.*—The ganglia of the segment bearing the sperm-sacs in the mature male worm are slightly larger than the others and as in the other segments two nerves are given off from the posterior ventral aspect of them. These nerves are distinctly thicker than the rest and the two lateral ganglia in which they enlarge are about the same size as the ventral ganglia (Photomicrograph 8). Unlike the condition in the non-genital segments, these nerves after the outer border of the ventro-lateral longitudinal muscle bands turn inwards to the body cavity with the result that the ganglia come to lie in a dorso-lateral position to the ventral nerve cord, attached to the ventral wall of the sperm-sacs. As in the parapodial ganglia the ganglion cells are grouped into a compact mass which, though much larger than in the former, forms a dorso-median cap to the punctated substance. From each of these ganglia a stout nerve is given off along the dorsal aspect of the sperm-sac, to the tip of the copulatory organ, but unlike the parapodial nerves ganglion cells are present along the course of these nerves. In transverse sections passing through the region of the sperm-sacs the origin of these nerves from the ventral ganglia, their course through the muscle layers and the ganglia at their tips can all be made out easily. A more or less similar condition of the nerve cord has been observed in the male genital segments of the other species of *Praegeria* also.

*Stomatogastric Nervous System.*—As in several polychætes a stomatogastric nervous system is present in this form also. A pair of slender nerves—the stomatogastric nerves—arises from the inner core of the ventral surface of the fused portion of the brain, almost at the same level as the roots of the œsophageal commissures (Fig. 13). These nerves proceeding ventrally become attached to the walls of the œsophagus on either side (Fig. 8). At the level of the jaws they are pushed more to the interior where each of them splits into two. The four slender nerves thus formed innervate the wall of the pharynx and come to lie external to the inner epithelium—two on either side of the lumen and each situated at some distance from the other (Figs. 9 and 10). In certain regions along the course of these nerves a few nucleated cells, similar to those on the outer surface of the brain, are present. Unlike the condition in *Marphysa gravelyi* (Aiyar, 1933) distinct ganglionic swellings are not visible but it seems that the presence of the nucleated cells along the course of these nerves probably indicates the position of ganglia, however inconspicuous they might be. Towards the posterior portion of the pharynx the two nerve strands on either side are seen to get united together by means of an elongated connective and beyond which they do not proceed.

*Sense Organs.*—The entire surface of the body is sensory in nature while the eyes, the palps, the elongated dorsal cirri of the buccal parapodia, the ventral cirri of the first pair of parapodia and the anal cirri also serve as sensory structures. As has been mentioned, the eyes are mere pigment spots in direct communication with the central core of the brain. In living specimens the palps are often moved about, probably feeling the surroundings and each of these is innervated by a stout nerve arising from the anterior

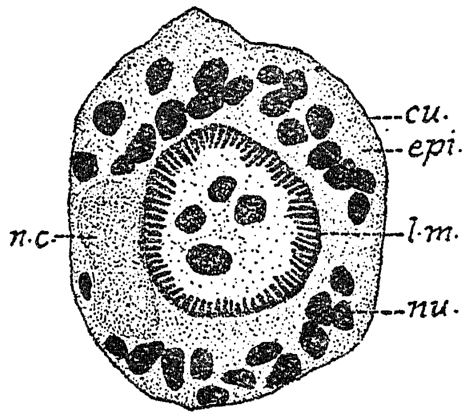



FIG. 15

horn of the brain (Fig. 13). Transverse sections of the palps show that there is an outermost layer of cuticle and below which is situated the hypoderm (Fig. 15) formed of cells with prominent nuclei and with very little cytoplasm around. Embedded in the hypodermal layer and in contact with the cuticle on one side is the nerve supplying the palp. Occupying the centre is a tubular sheath of longitudinal muscles the inside of which is filled up by a system of reticulated fibrils and a few deeply staining dark nuclei. This region has the appearance of a cavity just like the prolongation of the head cavity in the cephalic tentacles of *Saccocirrus* and *Protodrilus*; and this appearance is found even at the basal core of the palp. The nuclei present seem to indicate that the space is filled up by cells very probably loosely arranged. Osbervations on living specimens seem to show that there is a distinct lumen for the palp (Fig. 1) which extends to its very tip. From the base of the palp this lumen enters the head, enlarges slightly and then tapers to the posterior extremity which is situated between the base of the buccal spine and the first parapodium. This lumen is thickly packed by minute refractile corpuscles which are moved to and fro and which give the reticulate appearance in sections. The existence of such a closed cavity, though not so much specialised as in *Saccocirrus*, is highly interesting.

*Nephridia and Genital Funnels*

*Nephridium.*—The nephridia are very small and are present from the 6th setigerous segment onwards. As in *Pisionella indica* the nephridium is a closed structure and the nephridial swelling projects conspicuously into the body cavity from the corner between the body wall and the septum

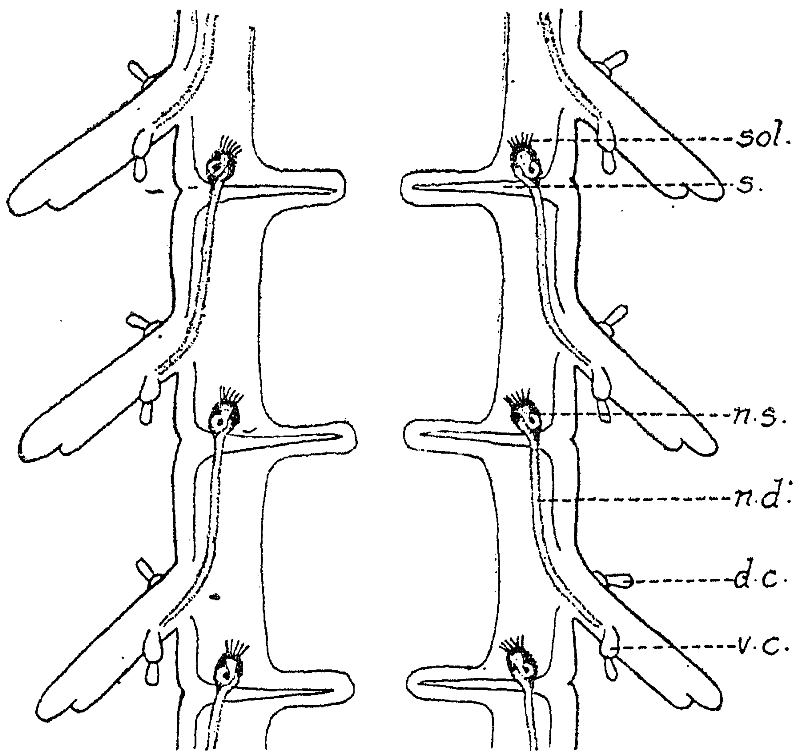



FIG. 16

(Fig. 16). The first two or three pairs of nephridia are distinctly larger and more prominent than the succeeding ones, and are provided with a larger number of solenocytes (about a dozen) which are arranged more or less fanwise, starting from the anterior part of the nephridial swelling. The nephridia are developed upto the last segment but in the posterior region they are much smaller and the number of solenocytes is much reduced. The nephridial swelling consists of a compact glandular cluster of cells which in the living specimens has a slightly yellowish tinge. A number of minute globules, probably of an excretory nature, are present in the wall of the nephridial swelling (Fig. 17). From the anterior portion of this swelling arise a few minute tubular structures representing the solenocytes. Each solenocyte has a slightly swollen base. The cell body is not conspicuous and there is no marked swelling at the tip. In sections the nephridial swelling is lightly stained while the solenocytes take deep stain. As in *Pisionella indica* the long flagella of the solenocytes converge and enter the central ciliated lumen of the nephridial swelling. The nephridial duct which immediately follows the lumen takes one or rarely two spiral loops (Fig. 17), pierces the septum and thereafter runs backwards straight and close to the body wall until it reaches the level of the parapodium when it bends outwards and finally opens to the exterior at the base of the ventral cirrus (Fig. 16).

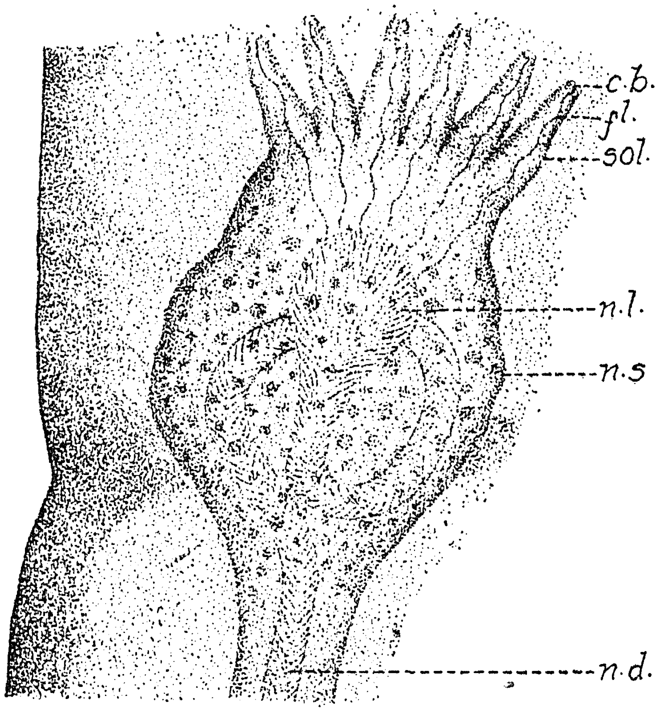



FIG. 17

*Intra vitam* staining with a weak solution of neutral red in sea-water was found to be very useful in following the course of the nephridium. In specimens stained for about half an hour the major portion of the nephridial swelling takes a deep red stain which marks out the cells clearly. The anterior extremity of the nephridial swelling as well as the solenocytes are poorly stained while the tip of the solenocyte takes deep stain and can be clearly made out as minute circular red spots. The wall of the nephridial duct being easily stained red, the central canal can be easily followed to its external aperture, situated at the base of the ventral cirrus. A comparison with the nephridial structure of *Pisionella indica* makes it evident that the nephridia of the present form differ from those of the former, in size, in the shape of the nephridial swelling and solenocytes, in the number and position of the solenocytes and in the coiled condition of the nephridial duct at its commencement.

*Genital Funnels.*—Ciliated organs or genital funnels begin to develop in the genital segments as the worm becomes mature and in fully ripe specimens they are in association with the nephridia. In a ripe female one or two pairs of genital funnels are developed, depending upon the number of ovarian groups. To take a specific example, in a worm with 34 setigerous segments two pairs of genital funnels were developed one in the 18th and the other in the 27th segment, each following an ovarian group and preceding a pair of receptacula seminis. In the males also the genital funnels are restricted to the reproductive region and usually only a single pair of them is developed in the testis bearing segment.

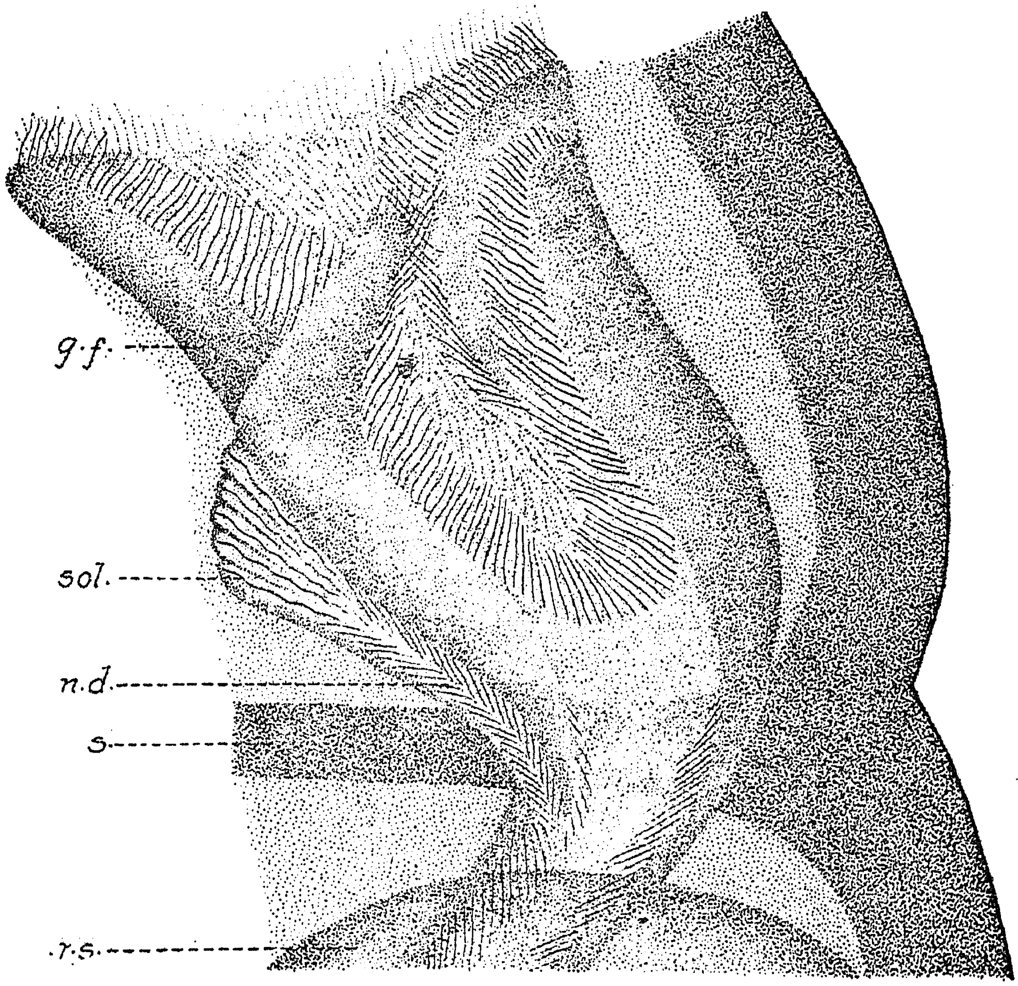



FIG. 18

The genital funnels are formed from the coelomic epithelium between the body wall and the septum of the particular segment in which they are found. When fully formed these funnels are quite distinct and are about 3 to 4 times the size of the nephridial swelling. In the females they are much larger than in the males. This larger size is probably necessitated by the bigger size of the ova that have to pass through them. The nephridial swellings with which these funnels are closely associated are highly reduced and can be made out only under high magnification (Fig. 18). The coiled condition of the lumen, mentioned as occurring in this region in the normal nephridium, has been lost and there is only a straight lumen. However, in transverse sections of 3 microns thickness the nephridial portion can be clearly made out from the genital funnel (Fig. 19). The nuclei in the wall of the nephridial swelling are few. They stain less deeply than the nuclei of the wall of the genital funnel and the nephridial portion as a whole is but lightly stained. The broad mouth of the funnel is dorsally directed, richly ciliated and clearly differentiated (Photomicrograph 4). The inner surface of the funnel is also richly ciliated. Its wall, though considerably thick,

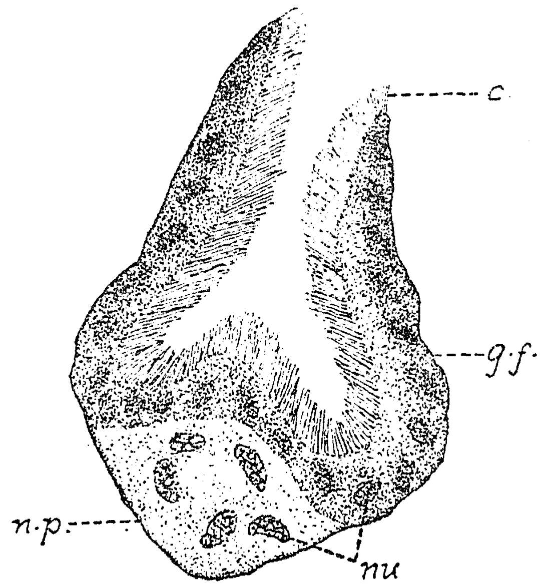



Fig. 19

is formed of a single layer of cells, with the nuclei more closely situated than in the nephridial wall. Transverse sections passing through the anterior one-third part of the ciliated organ is roughly in the form of a U, the dorsal lip projecting freely. The genital funnel is, therefore, in the form of a spatula with raised lateral edges which are fused behind. The funnel opens into the nephridial duct just at the point where the latter pierces the septum.

*Reproductive System*

*Male*: (1) *Testis*.—In the male the testis may usually be developed in any one of the segments between the 14th to 21st. It is in the form of a diffused mass of cells which in certain cases may extend to the next segment also (Photomicrograph 5). In transverse sections the testis is seen to encircle the alimentary canal which is pushed to the dorsal side (Photcmicrograph 6). In the immature condition the testis is in the form of a pair of cell groups, one on either side of the median line, and attached to the anterior septum of the segment. As growth progresses the two groups enlarge and grow over the alimentary canal and encircle it (Photomicrograph 6) giving rise to the impression of a single structure in which distinction between the two contributing halves is lost. The whole mass is enclosed in a very delicate membrane. The testis cells are very large in comparison to the size of the worm and are also larger than those of *P. remota*. Towards the posterior extremity of the testis the cells are smaller with relatively smaller nuclei which do not differentiate so easily as those at the anterior part. The median or unpaired condition of the testis, in the adult, is seen in *P. remota* also, but in this latter case the anterior as well as the posterior extremities of the testis mass remain separate. The mature sperms which are non-motile float freely in the body cavity or coelom of the segment bearing the testis and when the segmental chamber is filled with these liberated sperms they get pushed further into

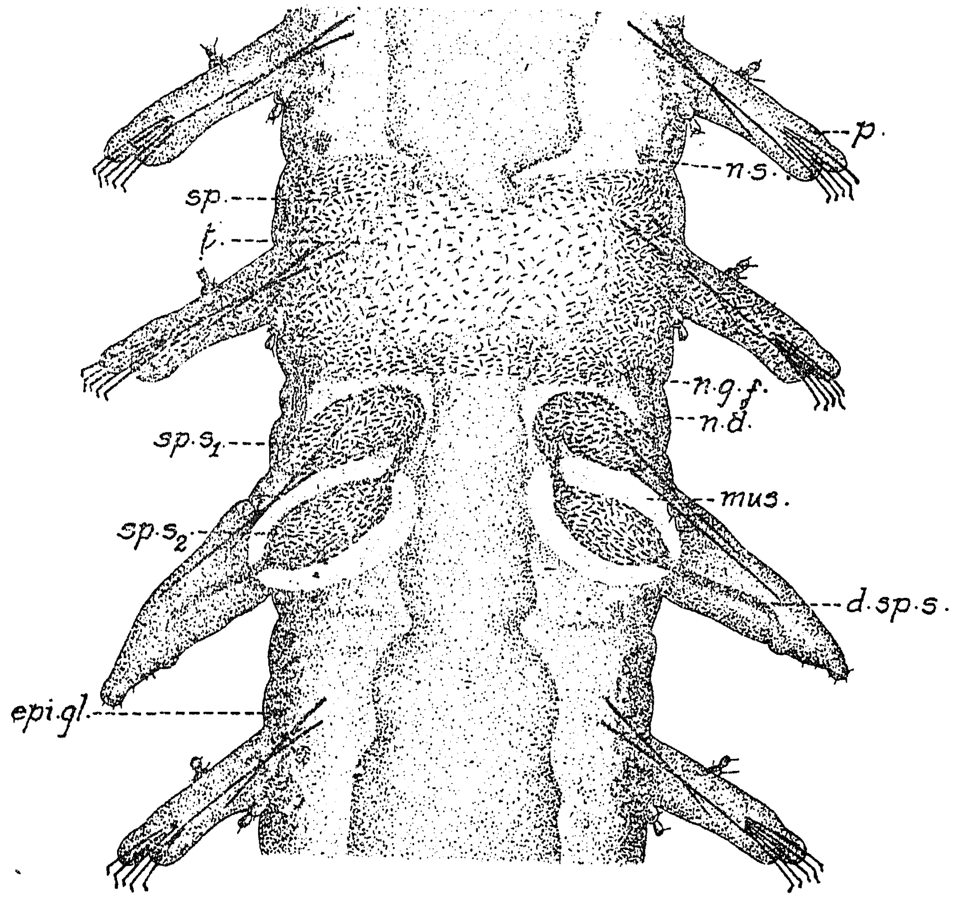



FIG. 20

the lumen of the parapodial lobe (Fig. 20). It is interesting to note that almost invariably the mature sperms are confined to the one segment containing the testis and only rarely are found in the preceding segment. In this feature the present form markedly differs from *Pisionella indica* in which the sperms freely pass into the neighbouring segments. The segment following the testis bearing one invariably carries a pair of sperm-sacs, the conspicuousness of which makes it one of the external distinguishing features of the male sex. The sperm-sacs are usually full of sperms and in the place of the normal parapodia of the segment there is a pair of complicated copulatory organs.

(2) *Sperm-sacs.*—The genital funnels in the testis bearing segment attract the mature sperms towards them by powerful ciliary action. In fact, in mature specimens the liberated sperms are very much crowded at the hinder part of the segment such that it is comparatively easy for them to get drawn into the genital funnels. The nephridial duct after piercing the septum runs down as a narrow tube and then takes a sharp curve upwards and forwards,

at the same time getting enlarged into a thin walled sac (Fig. 21). This sac again narrows into a short duct and bends downwards and backwards

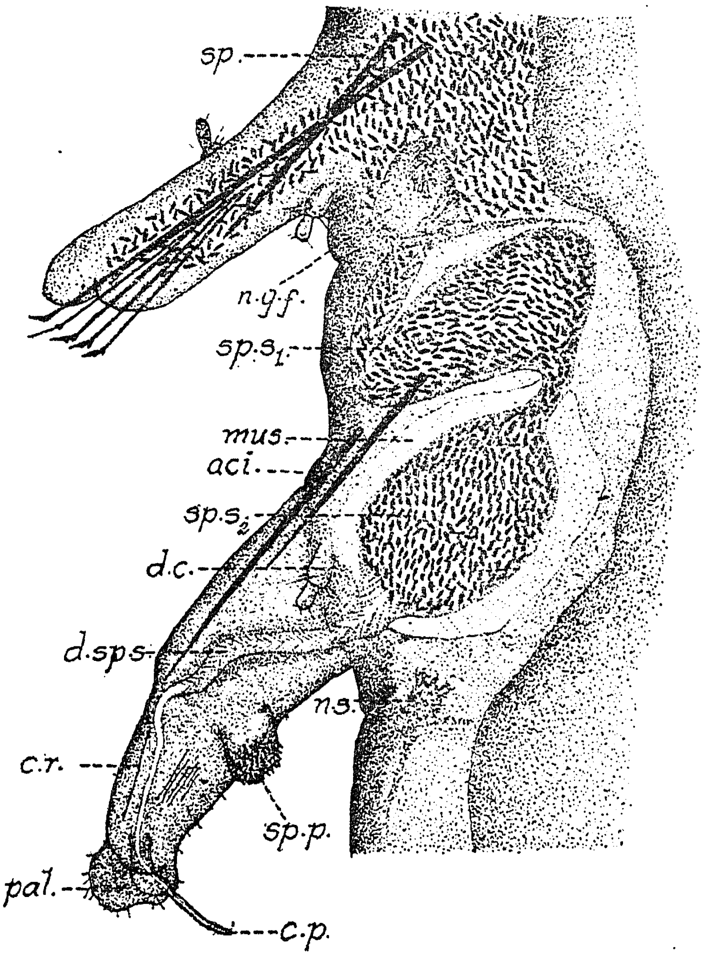
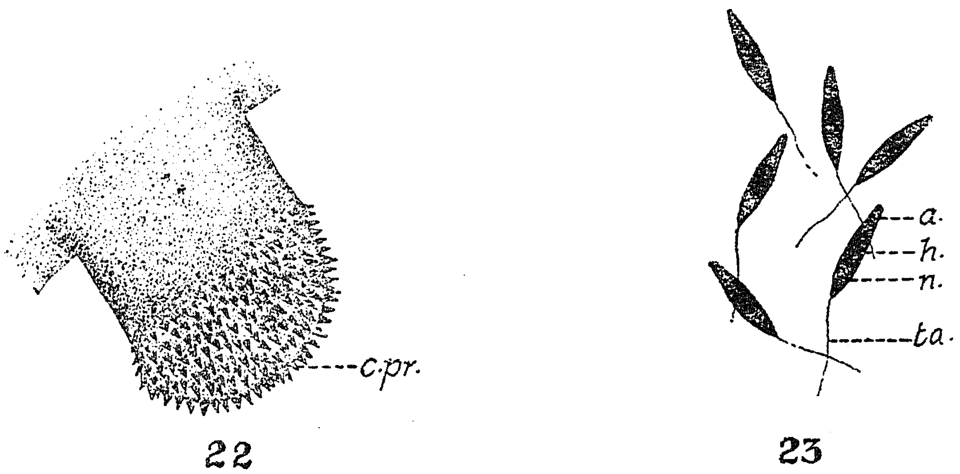



FIG. 21

and soon enlarges to form a second dilatation provided with a thick layer of muscles. The sperm-sac has a spacious lumen which is filled with sperms. The wall of the descending portion of the nephridial duct and that of the first saccular portion are much distended, thin, internally furnished with cilia and formed of a single layer of flattened cells. Transverse sections passing through the second saccular portion show a number of concentric rings of circular muscle fibres around the spacious lumen which is bounded by a single layer of ciliated cells (Photomicrograph 7). In contrast to *Pisionella indica* the structure of the sperm-sac is simple and the cells are devoid of any refringent granules. The sac again narrows into a duct which runs down and enters the copulatory organ (Fig. 21) to open finally to the exterior at the tip of a curved hook like papilla. The wall of this duct is partly cutinised and is ciliated at least in its proximal part. It will thus be seen that the sperm-sac actually consists of two separate dilatations, a feature in which it is widely different from the other two species of *Praegeria*.

(3) *Copulatory Organs.*—The copulatory organs are in close association with the sperm-sacs and it is noteworthy that invariably only a single pair of them is developed in each individual. In this feature the form more or less resembles *P. remota* but markedly differs from the third species, *P. complexa*, to be described elsewhere. In the formation of these structures the two parapodia of the segment in which the sperm-sacs are situated are highly modified and partially suppressed, the two dorsal cirri alone remaining unaltered (Figs. 20, 21). The setæ have disappeared and the two acicula alone persist. Each copulatory organ is broad at the base and gradually tapers to the tip where it is crenulate and covered over by stiff cilia. Behind the tip there is a prominent muscular, retractile papilla with the tip beset with a number of minute stiff cuticular projections (Fig. 22). At the tip of the copulatory organ which is supported by three or four cuticular rods, is a narrow, curved, hook-like, retractile structure, at the extreme end of which the efferent duct of the sperm-sac opens. This process is very small and when protruded stands erect, supported by the cuticular lining of its wall.




FIGS. 22—23

The condition of the copulatory organ in the other species of *Praegeria* is different. The completely retractile nature of the copulatory organ in *Pisionella* has been described and it may be noted that while in *Praegeria* the copulatory organs are always in the protruded condition, in the former they are protruded only at the time of copulation. Again, while in the present form the entire parapodium excepting the dorsal cirrus gets suppressed during the formation of the copulatory organ, in *P. remota* the copulatory organ is developed as a separate structure, the dorsal cirrus and an atrophied parapodial lobe persisting in the adult.

(4) *Sperms.*—In comparison with the size of the worm the sperms are very large and each measures 10 to 12 microns in length in the fresh

condition. Curiously enough, they are non-motile and do not exhibit any of the active movements so characteristic of sperms in general. Each sperm is elongated and slightly compressed from the sides so that when viewed from above it has a pointed spindle like appearance, while when on the side it presents a blunt anterior extremity. The tail or flagellum is extremely slender being visible only under very high magnification, and is usually of the same length as the preceding portions of the sperm or even slightly longer. Each sperm is divided into four parts (Fig. 23), the acrosome, the head, the neck and the tail. The acrosome is of almost the same length as the head, measuring about 2·3 to 2·5 microns and has a broad blunt anterior extremity. In sections and in smear preparations it takes only light stain. The head or nuclear portion in fresh preparations is more refractile than the other regions, is almost oval in outline and takes a deeper stain than the acrosome. It is, however, interesting to note that the neck region which follows the head is highly conspicuous and is as long as, or even slightly larger than the head and this region takes a light stain as the acrosome. In sections of materials fixed in Flemming's fluid without acetic and stained in iron hæmatoxylin the acrosome is in the form of a bluntly conical cap-like lid lodged on the anterior margin of the head and is moderately stained (Photomicrograph 8). The nucleus is in the form of a deeply stained circular area slightly compressed from the sides. Immediately behind the head at the commencement of the neck region is a minute circular spot—the centriole. The axial rod of the flagellum has not been found to extend to the centriole through the neck. On treatment with an aqueous (sea water) solution of eosin the sperms are seen to swell up and attain a rounded shape. The nuclear portion is surrounded by a vesicle like structure and its posterior half is more deeply stained than the anterior. In sections and smears the nucleus takes a uniform stain.

*Early Stages of the Male Reproductive Organs.*—The development of the complicated copulatory organs, sperm-sacs and genital funnels has been traced by examining a number of worms of varying stages of sexual maturity. As a rule in the segment destined to contain the sperm-sacs in the adult, the parapodia are not fully developed even at the beginning. In place of the parapodium a more or less foliaceous structure (Fig. 24) slightly bifid at the tip, is formed. This is supported by two acicula which persist in the adult. The dorsal cirrus of the parapodium is developed as usual but the ventral cirrus is absent. Of the two processes at the tip of the foliaceous structure the upper one is bluntly conical and probably represents the main lobe of the parapodium. The acicula are placed in this structure. The other process is more pointed and ends in a papilla at the tip of which the nephridial duct opens (Fig. 24). A little distance behind the tip there is a conspicuous muscular knob representing the spinous papilla in the adult. At this stage sperms are not seen in the body cavity but still the testis is found to be

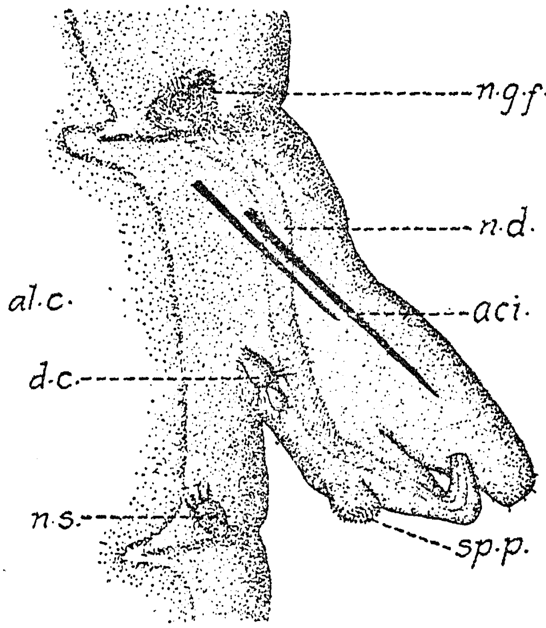



FIG. 24

developed. The genital funnel has not reached the adult condition. It has, however, established communication with the nephridial canal which is considerably wider than in the other segments and has now lost its previous coiled condition. After piercing the septum the nephridial canal runs down straight into the developing copulatory organ without any bend or curve in its course. However, the development of circular muscles half way down the nephridial duct, *i.e.*, at the portion which in the adult will from the second saccular dilatation of the sperm-sac, can be detected on closer observation. At this stage, therefore, the nephridial duct as a whole, has not undergone much change, save a general widening.

In specimens more advanced in development the genital funnels have assumed larger dimensions and have developed longer and larger number of cilia. The middle portion of the nephridial duct, *i.e.*, the second dilatation in the adult, with its surrounding muscles, has become conspicuous. The part of the duct leading to the exterior in the copulatory organ is bent and has assumed the adult characters. The copulatory organ has further elongated and is more pointed. In the posterior part of the testis mass fully formed sperms could now be seen but they are not liberated. In the next stage the nephridial duct just behind the septum enlarges into the first dilated part of the adult sperm-sac. The nephridial duct has thus been modified into the sperm-sac and has now more or less reached the adult condition, but has not been filled with sperms. At a later stage sperms get liberated into the body cavity and are drawn into the sperm-sacs by the ciliary action of the genital funnels.

It may be noted that the copulatory organ, even though in its early stage of development has a bifid appearance, gets itself transformed into a conically pointed, entire process in the adult. From the structure of the adult copulatory organ it is probable that the blunt papilla in the developing copulatory organ gets gradually suppressed as development proceeds and that only the pointed papilla carrying the nephridial duct develops further and gets elaborated into the adult structure. It might, therefore, be that the suppressed papilla represents the parapodial lobe in the early stages and which is, however, not indicated in the adult except by the presence of the two acicula.

*Female.*—In the females also the gonads are developed in the posterior half of the body. Usually the ovaries are developed in definite groups after the 13th or the 14th segment. They are in the form of diffused clusters or groups of cells which are usually paired. In certain worms they may be developed only on one side. When developed on both sides in sections

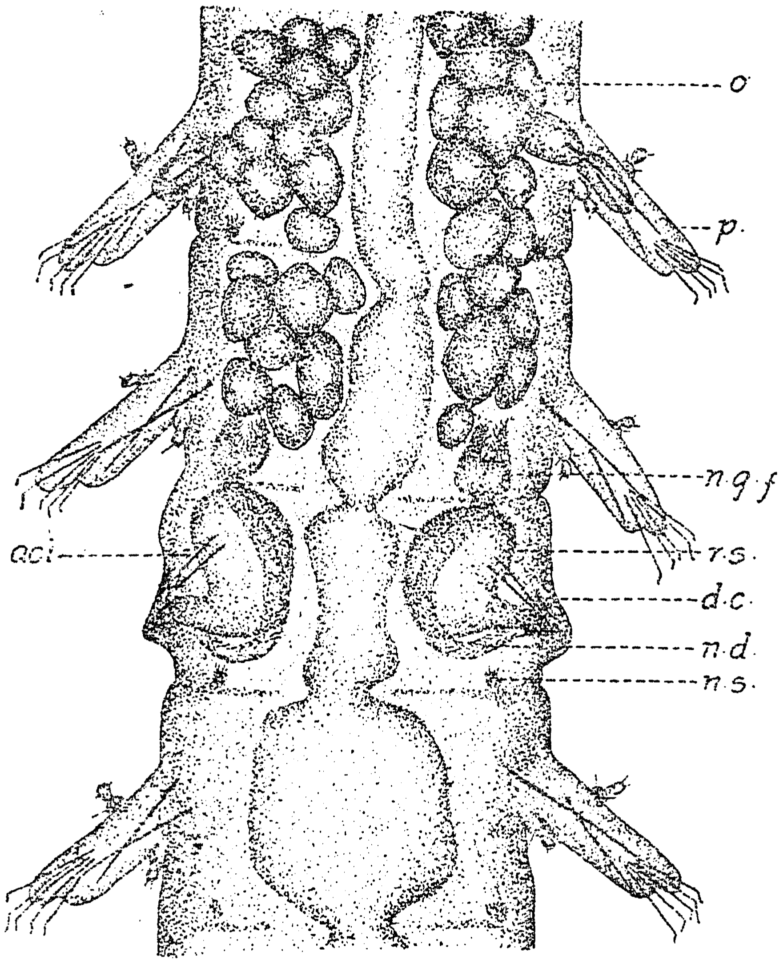



FIG. 25

they are seen to surround the alimentary canal (Photomicrograph 9) and are covered over by a delicate membrane. Each ovarian group extends into three to ten or fifteen consecutive segments and often one or two such groups may be developed. Immediately following each ovarian group there is a pair of receptacula seminis (Photomicrograph 10) which are spacious sacs usually filled with sperms. A pair of genital funnels is developed in the last segment containing ova (Fig. 25). To take a specific example, in a specimen with 34 setigerous segments two groups of ovaries were found developed. The first group occupied the segments 14 to 18 and a pair of receptacula seminis was present in the 19th segment. The second group of ovaries occupying the segments 23 to 27 was also immediately followed by a pair of receptacula seminis in the 28th segment. There were two pairs of genital funnels, the first pair in the 18th and the second, in the 27th segment. In quite a large number of worms only a single ovarian group is developed and as such only a single pair of genital funnels and receptacula seminis.

The receptacula seminis are thin walled sacs there being only a single layer of flattened cells forming their walls (Photomicrograph 11). They are blind internally and each sac is probably developed as described by Goodrich (1930) for *Pionosyllis neapolitana*, as an invagination of the body wall In the earlier stages the cavity of the receptaculum seminis is clear and spacious (Fig. 26). The nephridial duct can be clearly seen to open into the posterior portion of the developing receptaculum seminis, where there is a narrowing in the lumen. Its wall is considerably thick at this stage. The internal cavity is completely devoid of cilia and this fact points to a possible separate mode of origin of this cavity, unlike the sperm-sacs. In the later stages of development the portion of the receptaculum seminis where the nephridial duct opens, gets elongated into a duct with the result the nephridial duct and the receptaculum seminis open to the exterior by means of a common aperture.

When filled with sperms the receptacula seminis occupy the major portion of the segment in which they are placed. They are contractile in nature and their external ducts are provided with muscular walls. The parapodia of the segment carrying the receptacula seminis are completely atrophied and the setæ are absent (Figs. 25 and 26). In the place of the parapodium there is only a blunt stump supported only by a pair of minute acicula. The common external opening of the receptaculum seminis and the nephridial duct is situated at the tip of this stump. In the absence of parapodia in the segment bearing the receptacula seminis the present form markedly differs from the other species of *Praegeria* wherein the parapodia

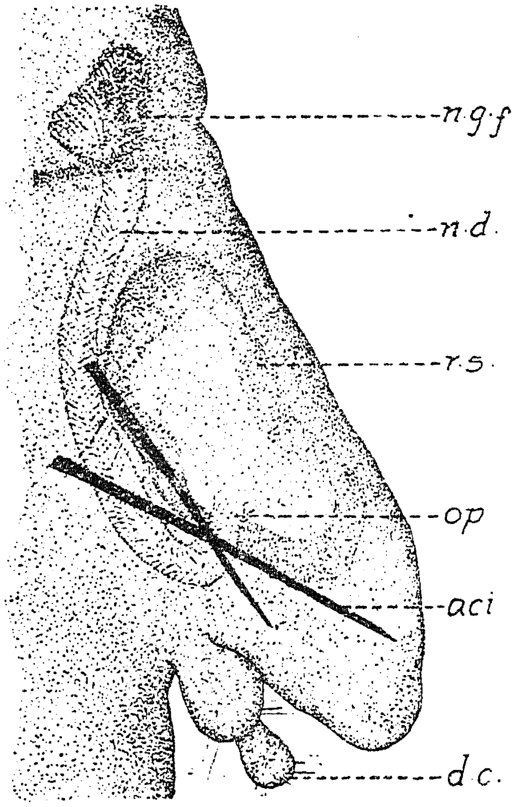



Fig. 26

of the like segments are unmodified. The nephridial duct in the genital segment is much dilated and after piercing the septum runs down close to the receptaculum seminis, bends outwards and joins the distal part of the duct of the receptaculum seminis. Several ova become mature simultaneously and are found to crowd at the posterior end of the ovarian group where the genital funnels are situated.

As has been mentioned in the beginning the ova are greenish in colour, large and with big transparent nuclei. By means of the dilated nephridial duct the mature ova, gathered in by the active vibrations of the cilia of the genital funnel, are taken to the exterior. The actual process of fertilisation has not been observed but from the union between the nephridial duct and the duct of the receptaculum seminis terminally and the presence of a single external aperture it can be inferred that the passage of the ova down the nephridial duct acts as a stimulus for the contraction of the receptaculum seminis and the consequent discharge of the sperms stored in there, with the result the ova get fertilised at the point of extrusion. The fertilised eggs soon commence development in the surrounding medium.

*Sperms from the receptaculum seminis* (*Spermatheca*).—The structure of the sperms found in the receptacula seminis of the female is very peculiar (Fig. 27) and different from that of the sperms present in the spermsacs of the male. It is quite obvious that the sperms are received into the receptacula seminis at the time of copulation and the structure of the sperms at the time of transference should normally be the same as that described in the male. The differences observed should, therefore, have been acquired while inside the receptaculum seminis. The sperms do not form spermatophores. When pressed out they are all perfectly separate and as in the male they are also non-motile. But the head of the

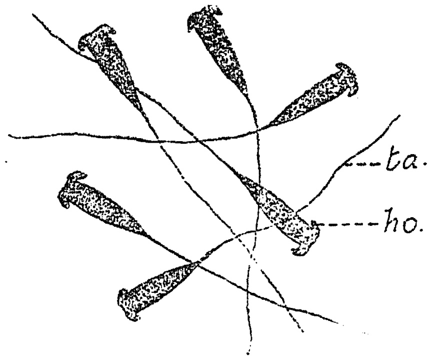



FIG. 27

sperm has undergone important transformations. Each sperm has developed a more or less oval shaped—sometimes circular—hood at the anterior extremity (Photomicrograph 12), thereby acquiring a nail shaped appearance. The hood measures about 3·3 microns along the longest part and is about 0·83 microns in thickness. At the outer margin the hood turns inwards a little. In the middle or the centre of the hood externally, there is a slight depression. When viewed from the sides this terminal hood gives the sperm a more or less anchor-shaped appearance and also the central depression in the hood is seen more clearly (Fig. 27). Immediately below the hood the body of the sperm is slightly narrow in the form of a short neck, but after this the body gets swollen in the form of a thick spindle which tapers suddenly. From the hood to the posterior extremity of the body the sperm measures about 6 microns. The swollen body is followed by an elongated slender tail measuring about 16 to 20 microns, *i.e.*, about three times the length of the body. In sections of Flemming fixed material stained in iron hæmatoxylin the structure of these sperms can be easily made out (Photomicrograph 12). The anterior hood takes only a very light stain, so that it is just indicated while the nuclear portion is darkly stained. From the nature of the staining property of the hood and that of the acrosome of the sperm in the male, it is suggested that the hood is a modified representation of the acrosome.

From the measurements of the sperms from the receptaculum seminis of the female it is seen that the head region is of almost the same length as that of the sperms from the male, while the tail, besides becoming more prominent and thick, is considerably more elongated and is even longer than an entire sperm from the male. The more complicated structure and the increase in size of these sperms are important features which show that the sperms have not been undergoing any deteriorating changes inside the receptaculum seminis, but were undergoing some modifications, which have to be assumed as having some definite purpose in the act of fertilisation that is to ensue.

A large number of female specimens in various stages of sexual maturity were examined in the hope that some explanation to this curious phenomenon might be found. It has thus been observed that copulation takes place between a mature male and a rather immature female, judged by the minute size of the ova and the full development of the receptacula seminis in the copulating female specimens. In some of the specimens that were not fully ripe the receptacula seminis contained sperms identical in structure with those found in the males. In view of the changes, already described, undergone by the sperms inside the receptacula seminis, it might be inferred that in these specimens copulation had taken place only recently and sufficient time had not elapsed for any change to take place in the structure of the sperms. In certain other specimens that were also not fully ripe, the receptacula seminis contained both typical (as described in the male) as well as hooded sperms. It is, therefore, believed that the sperms at the time of copulation (in the male) are not ripe enough to effect fertilisation and have to undergo the above mentioned changes, while inside the female, to reach complete maturity. Though the condition is greatly different, it may be observed in this connection that the sperms in most or perhaps in all the Oligochæta do not mature in the testis or even in the body cavity, but they are received into the sperm-sacs where they ripen, before being used during copulation.

As to when these changes commence after copulation and the time taken to reach the final nail shaped stage, are points I have not been able to settle, since the worms have not been observed to copulate in the Laboratory. However, when mature female specimens are kept in the Laboratory they shed all the ova developed in a few days' time. This is soon followed by the complete disintegration of the genital funnels and the receptacula seminis and the development of fresh parapodia on the segments that contained them. All these organs have been found to be developed afresh when the ova develop again. Since sperms of the kind found in the males have been noticed only in the immature females and such sperms have never been found in the mature females containing ripe eggs, it seems highly probable that sperms are received by the females just prior to maturity and such sperms modify themselves quickly and last only for a single period of ovarian activity, after which when regeneration of the sexual organs takes place, a fresh supply of sperms has to be taken. In this connection the condition in the Insects may be recalled, wherein in many cases copulation takes place only once in the life-time of an individual (Imms, 1934) and the sperms transferred into the spermatheca retain their motility and vitality for a considerable period. In the honey-bee itself the sperms in the spermatheca have been found to be functioning an year after copulation.

The role of the terminal hood remains a matter for conjecture. But I have often observed some of the sperms, when pressed out, attaching themselves to the partially everted wall of the duct of the receptaculum seminis by means of their hooded ends. The depression in the centre of the hood might facilitate this adhesion. As has been mentioned, motility of the sperms is absent unlike other polychætes with receptacula seminis. It might therefore be that the hood is a sort of an adhesive structure which coming in contact with the surface of the ovum readily attaches itself to it and thus ensures fertilisation, this being a possible means by which a strict economy in the use of sperms is maintained in view of their limited number inside the receptacula seminis and the large number of ova to be fertilised by them.

The non-motile condition of the sperms has been found in certain other groups of animals also, like the Decapod Crustacea, certain Myriapods (Chilognatha) and Arachnids (Palpigrada). Amongst the Decapods the spinous projections of the sperm are adhesive in nature and according to Koltzoff (as quoted by Wilson, 1925) fertilisation is affected by the action of an explosive capsule which is carried by the spermatozoon. As regards changes undergone by the sperms, formation of spermatophores is not uncommon in the Molluscs, Insects and Annelids. In many instances receptacula seminis are developed for the storage of spermatozoa which have been converted into spermatophores at or before the time of copulation. In *Pionosyllis neapolitana* Goodrich mentions the presence of spermatophores inside the receptacula seminis, in the female segments. In *Saccocirrus* and *Microphthalmus* paired receptacula seminis containing motile sperms inside are present in all the ova bearing segments, but the sperms have not undergone any change. Receptacula seminis are developed in the Alciopidæ and in certain Spionids (*Pygospio elegans*). In the Insects also sperms have been observed to be actively motile while inside the receptaculum seminis (Patton and Cragg, 1913).

Usually in the formation of spermatophores a number of sperms are enclosed in a common capsule, or attached together by their heads so that individual sperms themselves do not undergo very considerable modifications. In the case of *Praegeria*, on the contrary, spermatophores are not formed but individual sperms undergo modifications while inside the receptaculum seminis, a feature in which it stands unique. Non-motility of sperms is extremely rare amongst polychætes but in *Pisionella* and *Praegeria* the sperms are found to be non-motile. In the light of this fact I am led to think that this will be the case, also in *Pisione*—the internal characters of which, unfortunately, are unknown at present and which is the only other genus of the family Pisionidæ. In this respect, therefore, the Pisionidæ should be considered unique. It is also probable that in the sperms of *Praegeria* when motility has been lost, the power of attachment by means of a hood, thereby ensuring fertilisation, seems to have been developed as in the Crustacea wherein the same result has been achieved in a totally different manner by the formation of adhesive spines and explosive capsules.

Along with the development of the genital elements certain internal changes also take place so as to accommodate the newly formed structures. In the ripe males as well as females in the genital segments the alimentary canal is in the form of a very narrow tube, pushed more to the dorsal side so that more coelomic space is available in the segments. The longitudinal muscle bands are very much reduced and especially in the sperm-sac bearing segment of the male they are extremely thin and inconspicuous. Though breeding takes place continuously, as evidenced by the availability of mature specimens throughout the year, it has been found, as already mentioned, by keeping the worms alive in the Laboratory, that the genital elements developed are all shed within a short period and after which the various organs developed in connection with reproduction are cast off. The details of these changes have been studied carefully in another species, *P. complexa* and an account of the same has already been given before the 28th Session of the Indian Science Congress, held at Benares in January 1941, and will form the subject matter for another paper.

*Sexual Maturity and Position of Gonads.*

The worms become sexually mature very early in their life history. Reproductive organs make their appearance when the worm has developed about 17 or 18 segments. Usually in the case of males, they become mature when there are about 20 setigerous segments. A comparison of several worms of different lengths shows that only a single pair of sperm-sacs is developed and that their position is always constant being situated in any one of the segments between 14 and 21. The worms continue to grow even after sexual maturity and fresh segments are developed at the posterior end. In a specimen with 20 segments the position of the sperm-sacs, situated in the 16th segment, is posterior. But in another specimen with 34 segments the position of the sperm-sacs, situated in the 16th or 18th segment, is in the middle region of the body. In another specimen with 48 segments the sperm-sacs were situated in the 20th segment. In this specimen, therefore, their position is a little in front of the middle region of the body. This can only be so as in polychætes new segments are added only at the posterior end. In the female the ova are developed only when the receptacula seminis are fully formed and the worms become mature when there are about 24 to 26 segments. As has been mentioned, the ovaries commence from segments varying from the 13th to the 18th. Unlike the condition in the males, here, the posterior segments are not sterile and a second group of ovaries may be developed after the first.

*Summary and Conclusions*

From the foregoing pages it is clear that the present form shows a number of interesting features in which it markedly differs from the other species of the genus. These characters seem to me of sufficient value for the creation of a new species for its reception and for which I propose the name *Praegeria gopalai.** The important characters of this species can now be summarised as follows:—

*Praegeria gopalai* n. sp.

Minute slender worm, 4 to 10 mm. long, with 25 to 50 setigerous segments; ventral cirrus of the buccal parapodium globular; ventral cirrus of the first setigerous foot slightly elongated; anal segment with two conspicuous groups of caudal glands; only a single pair of sperm-sacs, genital funnels and copulatory organs in the male; secondarily median testis enclosed in a membrane and often extending into two segments; tapering entire copulatory organ provided with a large spinous papilla sperm-sacs having double saccular expansions; in the female, one or two ovarian groups covered over by a membrane and each group extending into 6 to 15 consecutive segments; receptacula seminis and genital funnels corresponding to the number of ovarian groups; parapodia of the segment carrying the receptacula seminis completely atrophied and carrying only two acicula; sperms from the receptacula seminis nail shaped having developed a conspicuous terminal hood.

*Locality*:—Sandy Beach, Madras.

*Holotype*:—In the Indian Museum, Calcutta.

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* It gives me great pleasure in associating the specific name with Prof. R. Gopala Aiyar, Director, University Zoological Research Laboratory, Madras, at whose suggestion the study of the Fauna of the Sandy Beach, Madras, was undertaken.

## *Acknowledgements*

I take this opportunity to express my deep sense of gratitude to Prof. R. Gopala Aiyar, for his valuable help and suggestive criticisms throughout the course of this study and to the University of Madras for awarding me a Research Studentship.

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## EXPLANATION OF FIGURES AND PHOTOMICROGRAPHS

(All the figures have been reduced to ⅔ the original.)

FIG. 1. Anterior end of *Praegeria gopalai* n. sp. showing cephalic appendages. × 120.

,, 2. Parapodium of the tenth segment. × 600.

,, 3. Setæ from the tenth parapodium. × 1800.

(*a*) Simple seta. (*b*) compound seta with long terminal blade. (*c*) Compound seta with short terminal blade.

,, 4. Posterior end of the worm showing the structure of the anal segment. ×160.

,, 5. Transverse section through the caudal glands. × 900.

,, 6. Transverse section through the region of the pharyngeal papillæ. × 600.

,, 7. Jaw after treatment with caustic potash. × 600.

,, 8. Transverse section through the œsophagus to show the musculature. × 600.

,, 9. Transverse section of the pharynx at the level of the jaws. × 600.

,, 10. Transverse section of the pharynx passing through the region immediately behind the jaws. × 600.

,, 11. Transverse section of the stomach. × 600.

,, 12. Diagrams of sections of the brain showing the relationship between its lobes and the distribution of the ganglion cells. × 600.

(*a*) Section through anterior end of the brain showing the separate nature of the two halves.

FIG. 12. (*b*) Section of the anterior part of the brain showing the completely fused condition of the two halves and the absence of ganglion cells.

(*c*) Section of the hind region of the mid-brain. Note the reduction in the number of ganglion cells.

(*d*) Section through the middle of the posterior lobes of the brain.

(*e*) Section of the lobes of the brain behind the level of the eyes. Note the nature of the ganglion cells.

(*f*) Section of the lobes of the brain at the posterior extremity.

,, 13. Diagrammatic representation of the brain and the ventral nerve cord with their important branches. The podial nerves are shown only in three segments. The eyes have been indicated though on the dorsal side.

,, 14. Diagrams of sections of the ventral nerve cord.

(*a*) Transverse section showing the fused condition of the two halves at the ganglion. × 800.

(*b*) Transverse section after the first fusion of the ganglia. × 800.

(*c*) Transverse section after the ganglionic swelling. × 800.

,, 15. Transverse section of the palp. × 1350.

,, 16. Diagrammatic representation of the position and arrangement of the nephridia.

,, 17. Anterior portion of the nephridium from one of the middle segments. × 1800.

,, 18. Nephridial swelling and associated genital funnel of the female. Drawn from live specimen pressed under coverglass so as to show the reduced nephridial swelling. × 1800.

,, 19. Transverse section of the nephridial swelling and the associated genital funnel showing the intimate relation between the two. × 1350.

,, 20. Genital segments of a mature male showing the nature and distribution of the reproductive organs. Drawn from live specimen pressed under coverglass. × 200.

,, 21. Magnified drawing of the sperm-sac and copulatory organ of one side. × 400.

,, 22. Spinous retractile papilla of the copulatory organ. × 1350.

,, 23. Sperms from the male. × 1350.

,, 24. Developing copulatory organ. Note the bifid nature of the organ and the course of the nephridial duct. × 200.

,, 25. Genital segments of a mature female showing the distribution of the ovary, genital funnels and receptacula seminis. Drawn from live specimen pressed under coverglass. × 200.

,, 26. An early stage in the development of the receptaculum seminis. × 900.

,, 27. Sperms from the receptaculum seminis. × 1350.

PHOTOMICROGRAPH 1. Anterior end of *Praegeria gopalai* n. sp.

,, 2. Hind end of the worm showing the conspicuous caudal glands.

,, 3. Transverse section through the posterior region of the pharynx.

,, 4. Transverse section passing through a pair of genital funnels.

,, 5. Genital segments of a mature male. Note the presence of sperms in two segments immediately preceding the sperm-sacs.

,, 6. Transverse section through the testis.

,, 7. Transverse section through the middle of the sperm-sac bearing segment.

,, 8. Sperms from the male. Smear.

,, 9. Transverse section through the ovary showing the ova fully packed surrounding the alimentary canal.

PHOTOMICROGRAPH 10. Genital segments of a mature female showing the pair of receptacula seminis immediately behind the ovarian group. Note the condition of the parapodia of the segment bearing the receptacula seminis.

„ 11. Transverse section passing through the receptacula seminis.

„ 12. Sperms from the receptacula seminis.

KEY TO LETTERING IN TEXT-FIGURES AND PHOTOMICROGRAPHS

| | |
|---|---|
| *a.* | Acrosome. |
| *a.c.* | Anal cirrus. |
| *aci.* | Aciculum. |
| *ae.* | Aeileron. |
| *al.c.* | Alimentary canal. |
| *b.* | Brain. |
| *b.p.* | Basal core of the Palp. |
| *b.s.* | Buccal spine. |
| *c.* | Cilia. |
| *c.b.* | Cell body? |
| *c.g.* | Caudal glands. |
| *c.m.* | Circular muscles. |
| *cop.or.* | Copulatory organ. |
| *c.p.* | Cuticular papilla. |
| *c.pr.* | Cuticular projection. |
| *c.r.* | Cuticular rod. |
| *cu.* | Cuticle. |
| *d.c.* | Dorsal cirrus. |
| *d.c.b.p.* | Dorsal cirrus of the buccal parapodium. |
| *d.sp.s.* | Efferent duct of the sperm-sac. |
| *e.* | Eye. |
| *epi.* | Epidermis. |
| *epi.gl* | Epidermal glands. |
| *fl.* | Flagellum. |
| *g.f.* | Genital funnel. |
| *g.sp.s.* | Ganglion of the sperm-sac. |
| *h.* | Head. |
| *ho.* | Hood. |
| *j.* | Jaw. |
| *l.b.* | Posterior lobe of the brain. |
| *l.m.* | Longitudinal muscle. |
| *l.m.s.* | Longitudinal muscle strands. |
| *mus.* | Muscular sheath |
| *n.* | Neck. |
| *n.c.* | Nerve cord. |
| *n. d.* | Nephridial duct. |
| *n.g.f.* | Nephridial swelling and associated genital funnel. |
| *n.l.* | Nephridial lumen or cavity. |
| *n.p.* | Nephridial portion. |
| *n.pal.* | Nerve to the Palp. |
| *n.s.* | Nephridial swelling. |
| *nu.* | Nucleus. |
| *nu.c.* | Nucleated or ganglion cells. |
| *o.* | Ovum. |
| *œs.com.* | Oesophageal commissure. |
| *op.* | Opening of the nephridial duct into the receptaculum seminis. |
| *p.* | Parapodium |
| *pa.* | Palp. |
| *pal.* | Palpocils. |
| *p.g.* | Parapodial ganglion. |
| *ph.p.* | Pharyngeal papilla. |
| *p.l.* | Parapodial lobe. |
| *p.s.* | Punctated substance. |
| *r.mus.* | Radially arranged muscles. |
| *r.oes.com.* | Roots of œsophageal commissure. |
| *s.* | Septum. |
| *sol.* | Solenocyte. |
| *sp.* | Sperms. |
| *sp.p.* | Spinous papilla. |
| *sp.s1.* | First saccular portion of the Sperm-sac. |
| *sp.s2* | Second saccular portion of the sperm-sac. |
| *st.g.n.* | Stomatogastric nerve. |
| *t.* | Testis. |
| *ta.* | Tail. |
| *v.c.* | Ventral cirrus. |
| *v.c.b.p.* | Ventral cirrus of the buccal parapodium. |
| *v.g.* | Ventral ganglion. |

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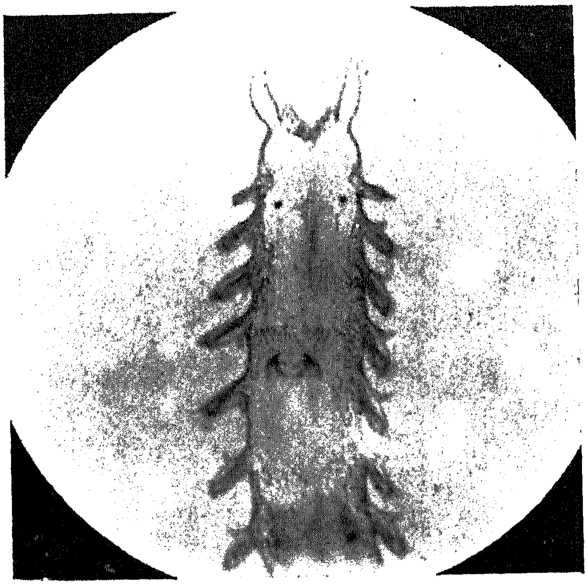

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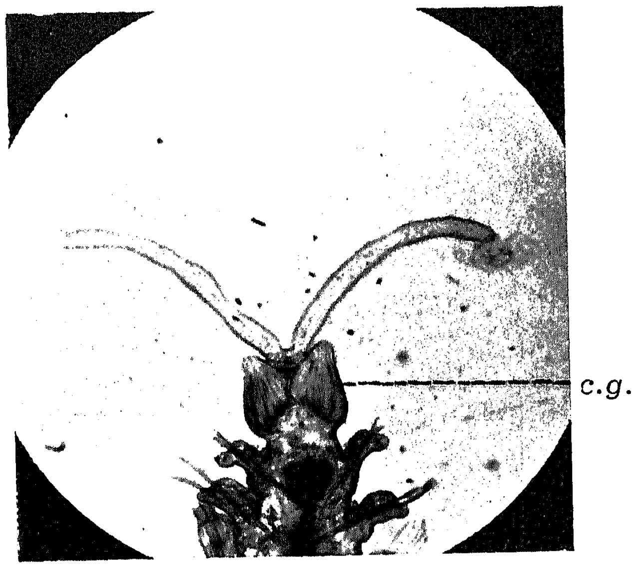


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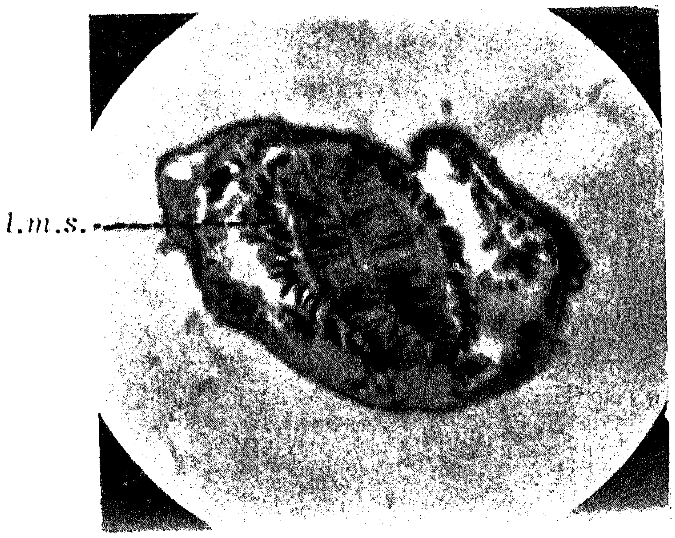


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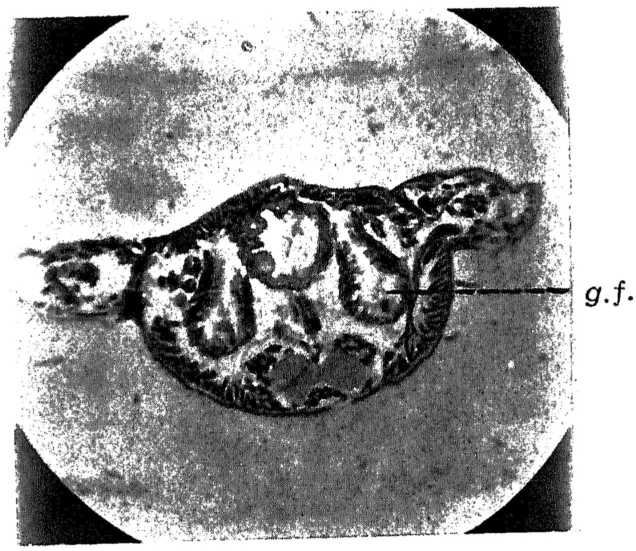


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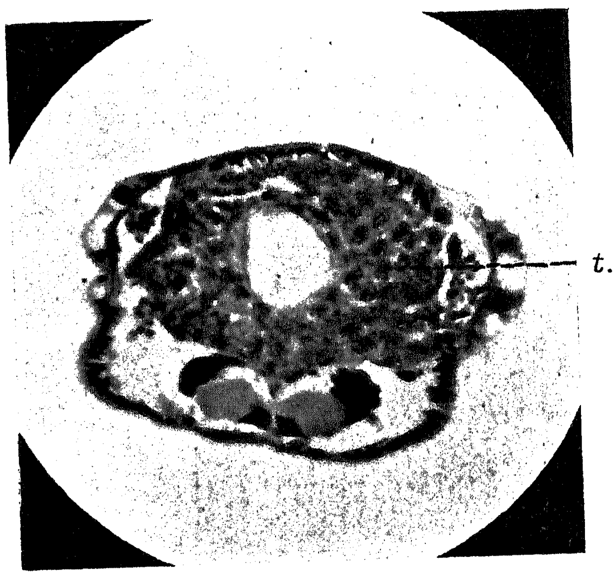


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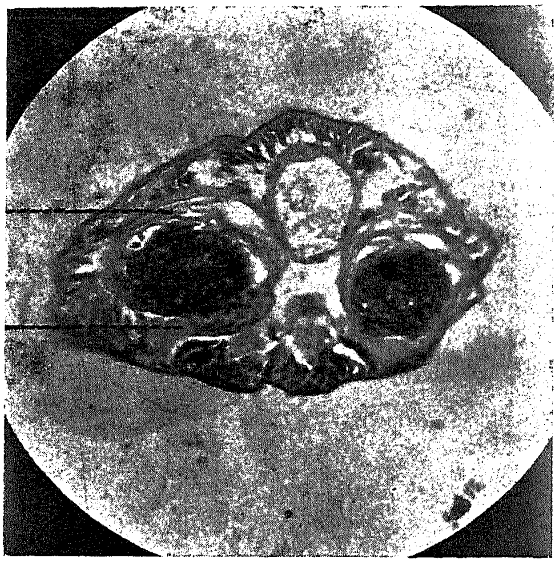


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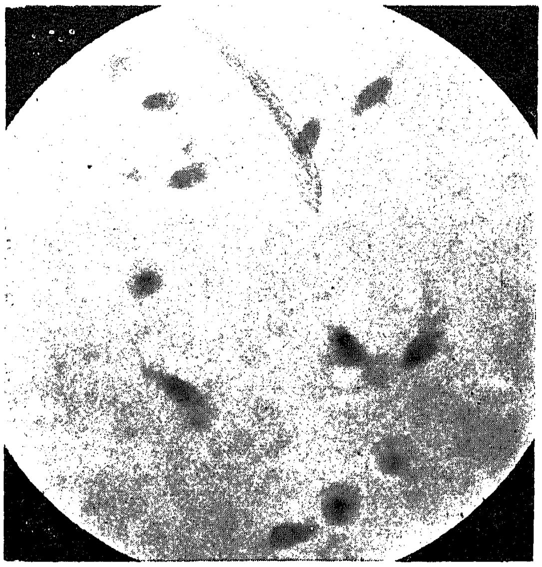

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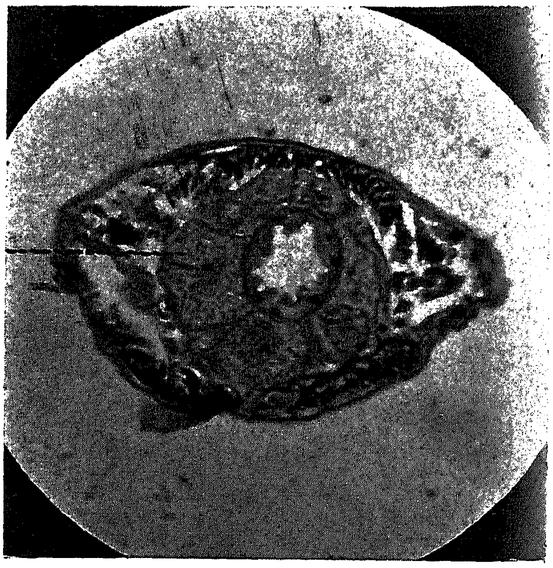


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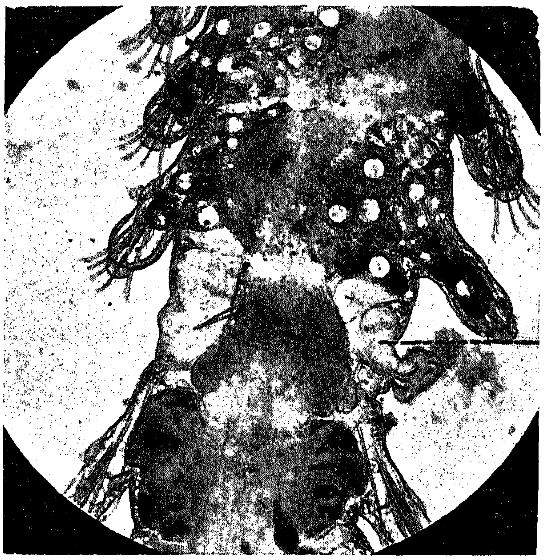


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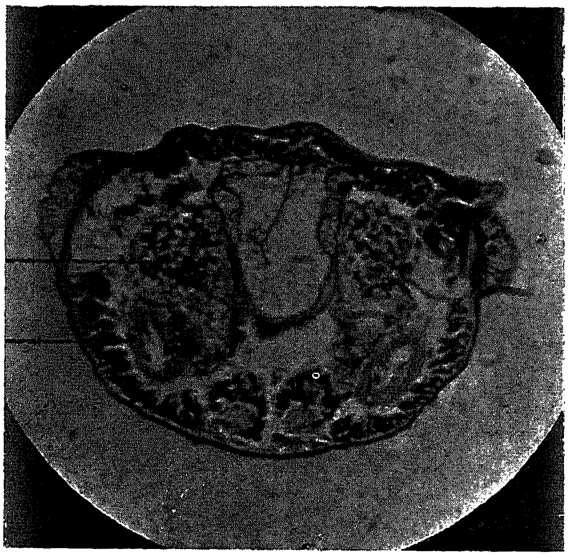


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