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Two New Species of the Phoronidea from Vancouver Island.

By

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With 16 Text-figures.

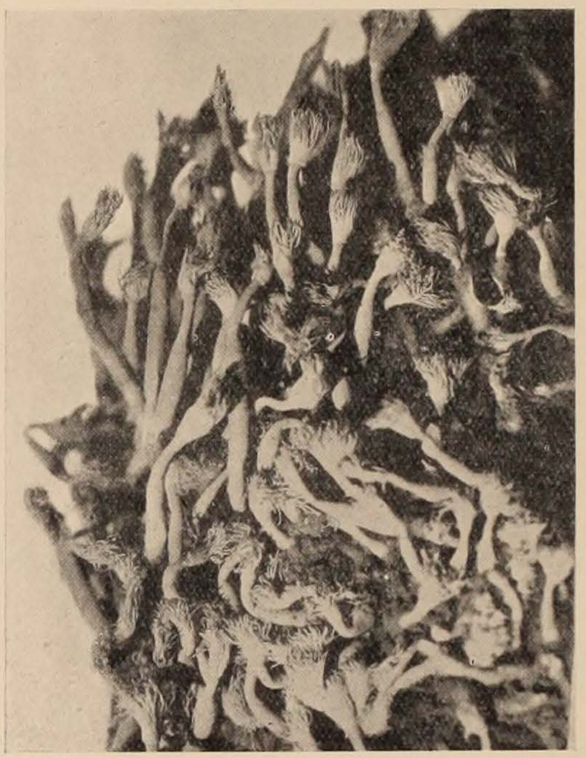
The animals described in this paper were obtained while I was working at the Marine Biological Station, Departure Bay, Vancouver Island, in the summer of 1911 during my tenure of the Reid Fellowship. They include two species—one belonging to the genus Phoronis (Wright, 1856), the other to the genus Phoronopsis (Gilchrist, 1907).

I. Phoronis vancouverensis n. sp.

This is a colonial form occurring in large compact, more or less hemispherical masses attached to the cretaceous sandstone forming the islands situated in Departure Bay. The colonies (Fig. 1) measure 5 cm. or more in diameter, and generally adhere to overhanging rocks near low-water mark. Each colony is composed of numerous individuals with brownish chitinous tubes, so very much intertwined that it is difficult to obtain a complete specimen from the tangled mass. The proximal ends of the tubes are rounded off, and the whole tube seems scarcely as long as the expanded animal. The total length of an average large specimen is 40 mm., the tentacles forming 2 to 3 mm. of this; the width of a large specimen just below the lophophore is rather less than 1 mm., while the ampulla measures 1·2 mm. in diameter.

The animals are colourless and transparent except for a greater or smaller number of irregularly arranged opaque white spots. These spots are quite conspicuous in the living

TEXT-FIG. 1.



Part of a colony of Phoronis vancouverensis from a photograph. (× 2.)

animals, and are caused by masses of minute granules on the surface of the epidermis, occurring chiefly on the tentacles and distal region of the body. They can be scraped off the surface of the animal, and in cutting sections the granules become liberated, and obscure to a considerable extent the cell details in the animals, in which they are numerous. The masses are white and opaque when viewed with reflected light, but the individual granules are more or less transparent and refringent with transmitted light. The nature of this pigment will be considered later in relation to the vaso-peritoneal tissue.

The lophophore is somewhat horseshoe-shaped, and is provided with about ninety tentacles; these varied in specimens counted from about 72 to over 100, but the average for ten fairly typical forms was 90·9.

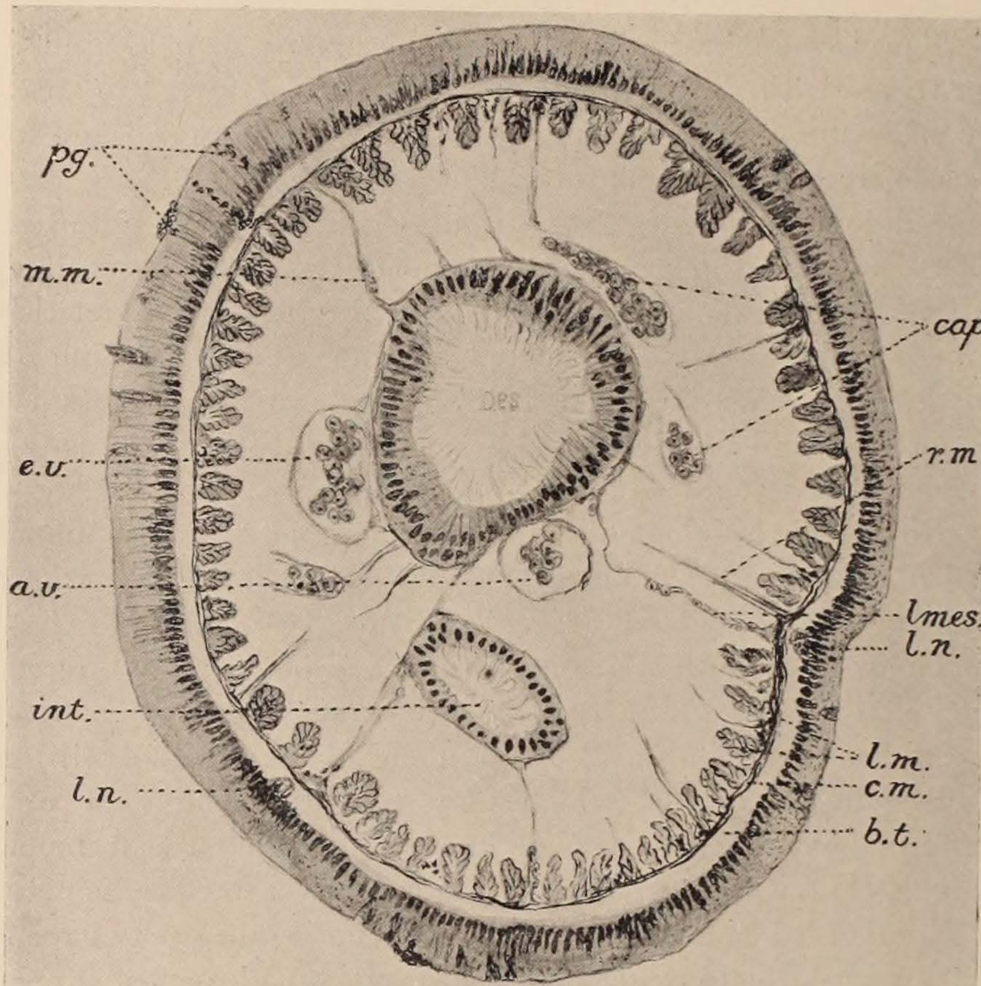
The lophophore organ is absent—at least I have found no trace of it in the series of specimens (twenty-five to thirty) that I have examined; this is probably due to the fact that the specimens were collected during the beginning of September, when practically all the generative products had been shed, and a brood chamber, as Gilchrist (7) supposes this organ to be, would no longer be required.

Body-wall.—The epithelium is composed of tall columnar cells, except over the greater part of the ampulla, where they are almost cubical (Figs. 2, 3, 4).

The glandular cells are numerous, and have three different contents: (i) very fine granules, (ii) much coarser spherical granules or globules, 2 to 3 μ in diameter, and (iii) a homogeneous mucus, which may sometimes be seen protruding on to the surface, leaving the goblet cell below empty (Fig. 12, *m. g.*). All these contents are yellowish and refringent when unstained; they do not stain easily except with iron-hæmatoxylin. They are all found in the upper regions of the body as well as on the ampulla, in this resembling, according to Selys Longchamps ([**14**], p. 38), Ph. psammophila and Ph. sabatieri rather than Ph. hippocrepia.

The proximal region of the ampulla is covered with very long columnar cells, interspersed with numerous glandular ones, whereas Ph. australis has no glandular cells, or very few in this position (Benham [**2**], p. 11). These long epidermal cells extend for a short distance up the sides, and gradually merge into the typical cubical epithelium covering the ampulla. The proximal body-wall is often invaginated to form a pit, but this is by no means always the case, and in one that had a convex, proximal end I found in longitudinal

TEXT-FIG. 2.[1]



Transverse section through the lower œsophageal region to show low irregular fascicles of longitudinal muscles. Formula: $\frac{19}{7}\Big|\frac{22}{13} = 61$. (× 180.) For lettering see footnote.

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[1] [Figs. 1 to 5 are of Ph. vancouverensis, and Figs. 6 to 16 of Phoronopsis harmeri.]

[The abbreviations used are the same throughout the paper.]

LETTERING OF THE FIGURES.

a. c. Anterior cœlom. *a. p.* Anal papilla. *a. v.* Afferent vessel. *b. c.* Red blood-corpuscles. *b. t.* Basement tissue. *c.* Collar. *cap.* Capillary cocca. *c. b.* Ciliated band in pregastric region of digestive tube. *c. m.* Circular muscles. *col. ep.* Columnar epithelium. *cu. ep.* Cubical epithesections that the mesentery which attaches this extremity to the bend in the digestive tube during life was broken; consequently it seems probable that the pit which has been so often described is only caused by tension in this mesentery due to its contraction. A similar slight concavity is frequently seen in the body-wall at the insertion of the lateral mesenteries (Figs. 2 and 4, *l. mes.*).

The basement tissue (Figs. 2 and 5, *b. t.*) consists of a homogeneous membrane without any cells such as have been observed in Phoronopsis harmeri, subsequently to be described.

Muscular Layers.—The circular muscles seem to be as usual in other species of Phoronis, and the distal region of the body is traversed by numerous radial muscles (Figs. 2 and 5, *r. m.*).

The longitudinal muscles are greatly developed, and differ from those of all species so far described in the fascicles having a different character at different levels. In the distal region the fibres are arranged somewhat irregularly to form fascicles as described for Ph. hippocrepia, Ph. buskii (McIntosh [**12**]), Ph. australis (Benham [**2**]) (Fig. 2, *l. m.*), whereas in the region of greatest development, i.e. about

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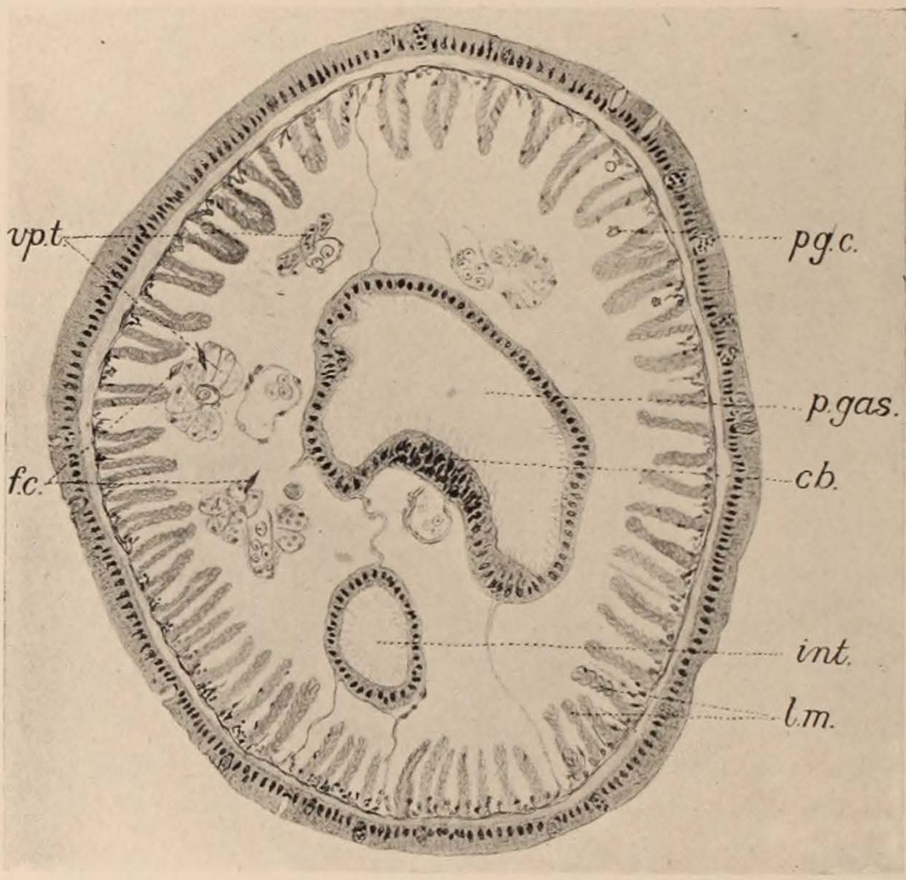
lium. *d.* Diaphragm. *d. a.* Digestive areas of stomach. *d. b. c.* Degenerating blood-corpuscles. *ep.* Epistome. *e. v.* Efferent vessel. *f.* Nerve-fibrils. *f. c.* Fusiform corpuscles. *fol.* Follicle cells of ova. *g.* Ganglionic mass. *g. g.* Epithelial glands with spherical granules. *gr.* Groove in stomach. *gr. p.* Granular peritoneum. *h. p.* Hypertrophied peritoneum round afferent vessel. *int.* Intestine. *i. t.* Tentacle of inner series. *l.* Lumen of afferent vessel. *l. m.* Longitudinal muscle. *l. mes.* Lateral mesentery. *l. n.* Lateral nerve. *l. o.* Lophophoral organ. *m. g.* Mucous glands. *m. mes.* Median mesentery. *n.* Nuclei. *n. d'.* Nephridial duct. *n. d.* Terminal part of nephridial duct. *n. f.* Nephridial funnel. *n. p.* Nephridiopore. *n. r.* Nerve-ring. *n. t.* Nervous tissue. *o.* Ova. *œs.* Œsophagus. *o. g.* Oil-globules. *o. t.* Tentacle of outer series. *p.* Peritoneum. *p. c.* Posterior cœlom. *p. g.* Pigment-granules. *p. gas.* Pregastric region of the digestive tube. *pg. c.* Pigment-bear-bearing corpuscles. *pg. s.* Perigastric sinus. *r.* Rectum. *r. m.* Radial muscles. *st.* Stomach. *vp. t.* Vaso-peritoneal tissue. *y.* Yolk-spherules.

one third from oral end, they have the pinnate arrangement found in Ph. psammophila (Cori [**3**]), architecta (Andrews [**1**]), pacifica (Torrey [**15**]), i. e. the fascicles appear feather-like in transverse section.

TEXT-FIG. 3.



Transverse section through the pregastric region to show the high pinnate character of the fascicles of longitudinal muscles. (× 150.)

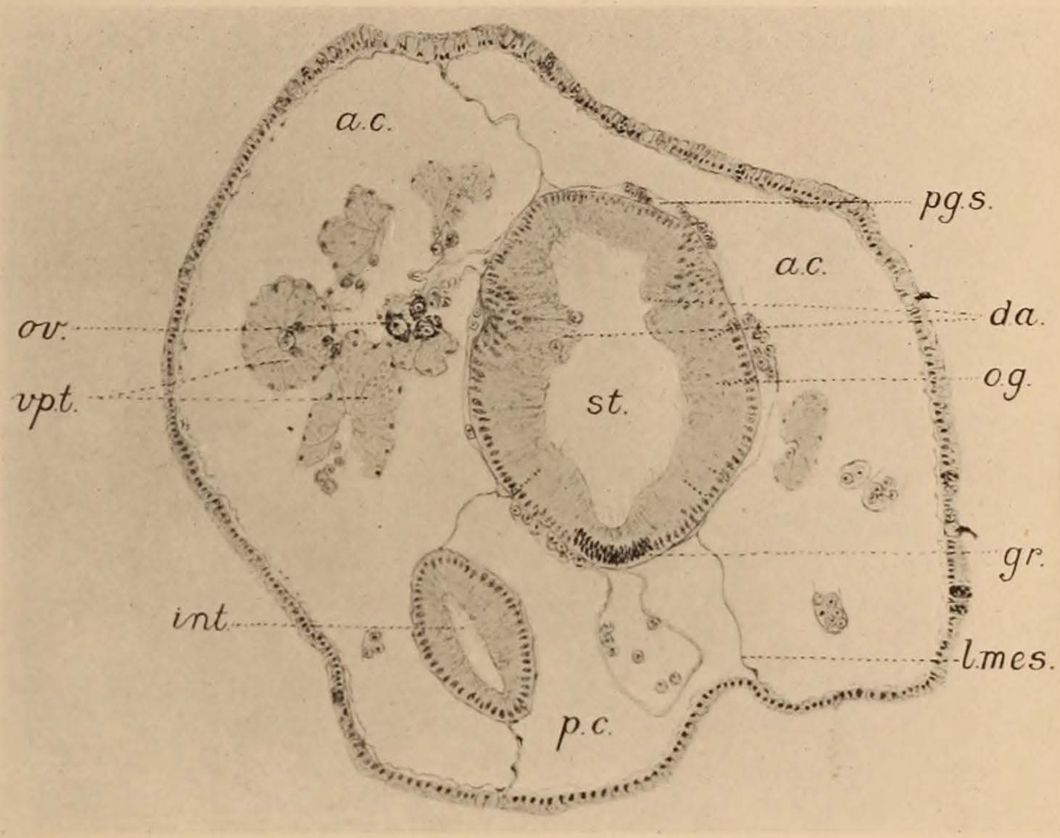
Frequently there are 19 of these in the left anterior cavity, 22 in the right anterior, 13 in the right posterior and 7 in the left posterior, or according to Selys Longchamps' convenient formula—

$$\frac{19 \mid 22}{7 \mid 13} = 61 \text{ as in fig. 2.}$$

Or there may be more in the anterior cavities as in Fig. 3;

$$\frac{24}{4}\Big|\frac{24}{7} = 59.$$

TEXT-FIG. 4.



Transverse section through ampulla showing cœlom divided into two anterior cavities (*a. c.*) and one posterior cavity (*p. c.*). (× 150.)

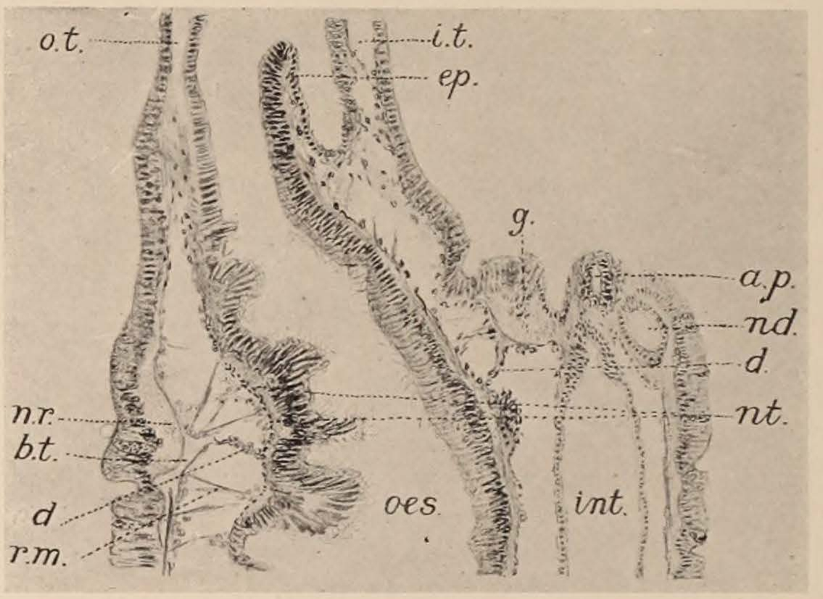
Shortly behind this region the posterior cœlom appears to be undivided, or rather the left post-cœlom merges with the anterior owing to the disappearance (Fig. 4) of the left lateral mesentery.

Ph. hippocrepia, which in many ways closely resembles Ph. vancouverensis, shows in my sections only about twenty-eight fascicles of longitudinal muscles. Selys Longchamps states that in this species they do appear to vary particularly, but gives as the highest recorded by anyone :

$$\frac{12}{6}\Big|\frac{13}{7} = 38.$$

This is a great deal lower than the average number of sixty in Ph. vancouverensis, and such an anatomical characteristic seems to be of far more importance from a systematic

TEXT-FIG. 5.



Longitudinal section through the base of the lophophore approximately in the median dorsal lines. (× 100.)

point of view than such variable details as size and number of tentacles. Both Cori (**3**) and Selys Longchamps (**14**) point out that within limits the number of fascicles of longitudinal muscles is constant.

The diaphragm or transverse septum (Fig. 5, *d*) slopes upwards from the oral to anal side, meeting the dorsal surface just in front of the anal papilla. The two layers of peritoneum covering it are widely separated at the sides by the basement membrane, which is continuous with that of the body-wall near the lower border of the nerve-ring, but towards its centre this median layer of the septum is so thin that it may easily be passed over. I do not think, however, that it is entirely eliminated as in Ph. capensis described by Gilchrist (**7**), who suggests that such a character of the septum would probably be of value in specific determination, stating that Ph. hippocrepia agrees with Ph. australis in having the septum uniformly invaded by a basement tissue. In Ph. vancouverensis there is certainly no uniform median layer, so I have included this characteristic in the table at the end as a minor feature distinguishing this specimen from Ph. hippocrepia.

The mesenteries also contain a very thin layer of basement tissue.

Nervous System.—The ring of nervous tissue at the base of the lophophore is quite apparent (Fig. 5, *n. r.*) and is continued posteriorly, following the course of the tentacles, up each of which passes a fine strand of the same tissue. Across the dorsal surface in front of the anus is a large ganglionic mass (Fig. 5, *g.*) composed of the usual punctated tissue with definite striation and numerous cells with large nuclei. This tissue is everywhere in close relation with the inner ends of the elongated epithelial cells.

In some sections can be seen a small lateral nerve-cord running along each side of the body close to the point of attachment of the lateral mesenteries (Fig. 2, *l. n.*), and projecting into the basement tissue as a small mass of punctated tissue. These appear to be very short, for they have not been seen beyond the œsophageal region.

Traces of nervous tissue have been observed in the centre of the pit at the proximal end of the body and also along the alimentary canal on the outer side of the epithelium. This is especially marked in the upper œsophageal region opposite the nerve-ring. Gilchrist (**7**) mentions this sensory patch and suggests that it may represent an organ of taste.

Alimentary Canal.—The various regions of the alimentary canal are named in the figures in accordance with Cori's views (**3**), these being also adopted by Selys Longchamps (**14**).

The œsophagus (*œs.*), with its thick walls often much folded, only extends for a short distance. Fig. 2 is a transverse section through its posterior part where the two branches of the lateral vessel have just united.

This is followed by the pregastric region (Fig. 3, *p. gas.*) ("préestomac" of Selys Longchamps, Vormagen of Cori) which has a large cavity irregular in shape with thin walls. The epithelium is cubical, ciliated, and has oval nuclei. Along the postero-median region close to the afferent vessel is a longitudinal band of epithelium (Fig. 3, *c. b.*) thicker than the rest and with several layers of elongated nuclei. This has been described in P. pacifica (Torrey [**15**]) and in P. architecta (Andrews [**1**]), but is very little developed in Ph. hippocrepia.

The stomach (Fig. 4, *st.*) is the large terminal region of the descending part of the tract situated in the ampulla. It has a thick epithelium with ovoid nuclei. On the postero-median side there is a longitudinal groove directly continuous with the thickened band in the pregastric region and having similarly several layers of nuclei which stain more deeply than the ordinary ones (Fig. 4, *gr.*). The cells along this groove have very long cilia. The digestive areas which carry on intra-cellular digestion (Fig. 4, *d. a.*) have no cilia, and the free ends of the cells are distinctly amœboid during functional activity. The whole of the ascending limb of the alimentary canal is called the intestine except for the very short part contained in the anal papilla, which Cori considers to be a proctodæum and calls the rectum. The part of the intestine in the ampulla (Fig. 4, *int.*), the only part called "intestine" by Benham, has thick, closely ciliated walls and generally an oval lumen. The epithelium is cylindrical, with oval nuclei. The upper part of the intestine (figs. 2 and 3, *int.*), has cubical epithelium, with long cilia and large nuclei. In transverse sections the intestine appears oval or elongated, only occasionally showing the usual triangular shape due to the pull of the three mesenteries.

The cells in the lower part of the stomach and intestine are frequently seen to contain rows of spherical deeply-staining masses, probably oil-globules (Fig. 4, *o. g.*), such as are often seen in the intestinal cells of mammals. They appear to collect near the outer borders of the cells and to be taken up by the blood-corpuscles in the surrounding sinus. Some blood-corpuscles appear to be crowded with these globules, which appear slightly smaller than the nucleus—possibly after slight chemical changes this product is deposited in the vaso-peritoneal cells as yolk-spherules.

One specimen contained a few nearly spherical coccidia about 50 μ in diameter in some of its intestinal cells; these are the only parasites that I have observed in either of the species.

Vascular System.—The general arrangement of the blood-vessels can be made out without difficulty in the living animals, for owing to the red colour of the blood it can easily be seen through the transparent body-wall. The two longitudinal vessels, the lateral or efferent and the median or afferent, extend the whole length of the alimentary canal, and at intervals only near the proximal end connect with the perigastric sinus by the breaking down of the intervening walls (Fig. 4). I have seen the median vessel very dilated and crowded with corpuscles quite close to the bend in the digestive tube.

The numerous capillary cœca project freely into the cœlom, and do not branch as they do in Ph. australis (Benham [**2**], fig. 18) and in Phoronopsis harmeri, to be described later. The corpuscles are 8–10 μ in diameter, and have a pale yellow colour when seen singly. They take up eosin easily, and the nucleus and granules stain readily with iron-hæmatoxylin, but I have not found them to stain well with either Delafield's hæmatoxylin or carmine.

In some specimens the corpuscles in various stages of development may be seen along the afferent vessels, being developed from the lining epithelium (Fig. 15, *b. c.*) just as shown by Cori (**3**, pl. xxvii, figs. 2 and 3).

A fine granular precipitate is present in some of the vessels, indicating the presence of a serum as well as corpuscles.

Excretory System.—There are as usual a pair of excretory organs at the distal end; they are small tubes bent once only on themselves, and each opens into the cœlom on either side of a lateral mesentery by a small funnel. That into the posterior cœlom has a process extending down the mesentery for a distance of about 160 μ; they are both closely applied to the transverse septum above.

The tube, which is about 250 μ long, runs first outwards close to the mesentery, and then upwards embedded in the basement tissue, forming a slight ridge visible on the outside; it then turns inwards, running along the dorsal surface to open on one side and in front of the anus.

The question as to how far the general peritoneum and the blood-corpuscles derived from it have retained their excretory function is considered later.

The Vasoperitoneal tissue (Gefässperitonealgewebe of Cori [**3**] or nutriment tissue of Ikeda [**9**], and constituting Kowalevsky's corps adipeux) is developed on some of the capillaries on both sides of the digestive tube (Figs. 3, 4, *vp. t.*). It consists of the usual large flat cells with small nuclei at their outer ends. The contained yolk-spherules vary much in size and stain easily with eosin, Licht grun and other stains. Iron-hæmatoxylin can be washed out of them more easily than from the nuclei.

Blood-corpuscles apparently in various stages of degeneration are also to be seen in the cells (Fig. 16, *d. b. c.*), and generally some fusiform corpuscles (*f. c.*). These are often especially numerous in the pre-ampulla where the vasoperitoneal tissue is only present in small amount, and they have also been observed floating freely in the cœlomic fluid, occasionally in the distal end right away from this tissue. Ikeda (**9**, p. 145) states that he has never found these corpuscles anywhere in Ph. ijimai, and thinks they are of no great physiological importance. I have sometimes found them in immense numbers, giving no sign of a nucleus, but generally showing a delicate striation. They do not stain with Delafield's hæmatoxylin, but take up iron-hæmatoxylin and stain homogeneously like the yolk-spherules.

Besides the above substance quantities of refringent non-staining granular substance (Fig. 16, *p. g.*) occur in the vaso-peritoneal tissue, either in separate granules or massed together, and contained in corpuscles similar to the sphæruliferous corpuscles described by Durham (**4**, p. 329) in Asterias rubens.

I have seen corpuscles associated with degenerating blood-corpuscles or with fusiform bodies and others filled to a greater or less extent with these refringent granules, in the vaso-peritoneal tissue (Fig. 16, *pg. c.*), and also free in the body-cavity, sometimes close to the body-wall between the fascicles of longitudinal muscles (Figs. 3 and 14, *pg. c.*).

It is apparently these same bodies which are often to be seen traversing the body-wall (Fig. 12, *pg. c.*), and they seem to be similar to the wandering cells, described by Durham in Echinoderms (**5**, p. 88), which are able to get rid of effete material from the system. The granules are set free on the surface (Figs. 2, 12, *p. g.*), where they form the opaque white pigment masses so conspicuous in some specimens on the outside, especially on the tentacles and distal parts of the body.

Micro-chemical tests showed that these granules are unaffected by weak acids, alkalies or ether, as well as by the ordinary reagents and stains. They also give the murexide reaction, and therefore contain some uric acid compound. It seems probable that this may be guanin, which is such a common excretory substance in many invertebrates.

The deposit of these pigment granules in the distal regions of the body may be accounted for by the action of light, but, if, as I feel confident, they are excretory products, we should expect, as Harmer (**8**, p. 122) has pointed out for the excretory vesicles of Tubulipora, that they would occur chiefly in such regions where waste products would be most easily carried away.

I cannot be sure whence these pigment-bearing corpuscles arise. They may be derived from the peritoneum, which is so greatly hypertrophied in places, e.g. on the afferent vessel (Fig. 15, *h. p.*), where the cells enlarge and then appear to be liberated, also probably some of the cells covering the capillary cœca develop into such corpuscles instead of ordinary vaso-peritoneal tissue. Cells having such an origin would be in close relation with the blood-corpuscles, and hence able to extract excretory substances similarly to the chloragogen cells of Oligochætes.

Eisig states that in the Capitellidæ (**6**, p. 758), whose nephridia are limited to small regions of the body, certain peritoneal cells laden with concretions are liberated into the body cavity (p. 762), and that both blood and peritoneum play an important part as true excretory organs, and not merely as conveyors of excretory products to other organs.

The subject of the excretory pigment in Phoronis seems to require further study. I have never seen any such pigment in Ph. hippocrepia, which is the only other species of Phoronis that I have personally examined, and can find no reference to any. Gilchrist (**7**, p. 154) mentions the presence of white pigment-spots irregularly arranged on the tentacles of Phoronopsis albomaculata, but he states that these consist of finely branching chromatophores.

Generative Tissue.—All the specimens examined for reproductive cells contained ova only, and of these only a few on the left side of the animal arising from the walls of capillaries close to their origin from the efferent vessel (Fig. 4, *ov.*). It seems probable that this species is protandrous, or possibly diœcious.

Affinities.—In size and mode of growth this Phoronis resembles somewhat closely Ph. ijimai, whose external characters were briefly described by Oka (**13**, pp. 147–8), and which was separated from other species owing to difference in the length or number of tentacles. Ikeda, who has studied the structure of Ph. ijimai (**9** and **10**) and has compared specimens of Ph. hippocrepia with it, says that he is unable to discover any points by which they can be differentially diagnosed, pointing out (**9**, p. 582) that the length and number of the tentacles vary tremendously from one season of the year to another.

I therefore assume that both Ph. ijimai and Ph. kowalevski are encrusting varieties of Ph. hippocrepia, and from a comparison of specimens and sections of the latter and from descriptions given by other writers I conclude that there are several important anatomical differences separating it from Ph. vancouverensis. In the absence of any definitely formulated features by which the various forms included in the genus Phoronis may be separated, I think that such anatomical characteristics must be far more important from a systematic point of view than such variable details as size and number of tentacles.

Characteristics of Phoronis vancouverensis, which it is suggested should distinguish it from Ph. hippocrepia and its varieties:

(1) The character and greater development of the fascicles of longitudinal muscles.

(2) The presence of two nerve-cords in the anterior region of the body.

(3) The structure of the diaphragm.

(4) The well-developed band of specialised cells in the pregastric region.

(5) The possible separation of the sexes (diœcious), or, if monœcius, then protandrous.

II. Phoronopsis harmeri n. sp.

This animal is placed in the genus Phoronopsis, established by Gilchrist (**7**) to include the form Phoronopsis albomaculata described by him from South Africa, on account of the following characteristics :

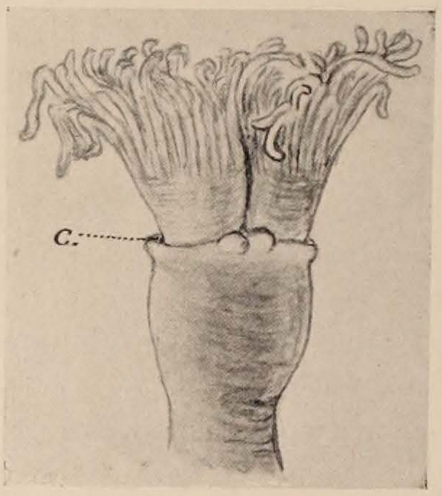
(1) The nerve-ring lies in an involution of the epidermis.

(2) Only the left nerve-cord is developed.

(3) The longitudinal muscles of the body are in numerous well-developed fascicles.

Habitat.—Specimens of the animal are easily obtained from the sandy shores of some of the smaller islands in the neighbourhood of Nanaimo. The tubes, 100 to 150 mm. long with a diameter of 3 to 4 mm., are found embedded in a vertical position with their upper ends slightly below the surface of the sand near extreme low-water mark, their positions being only indicated by minute holes in the sand above. The tubes are cylindrical, composed of a hard resistant membrane coated with fine sand grains; the lower end is rounded

TEXT-FIG. 6.



Posterior view of distal region of Phoronopsis harmeri. (× 10.)

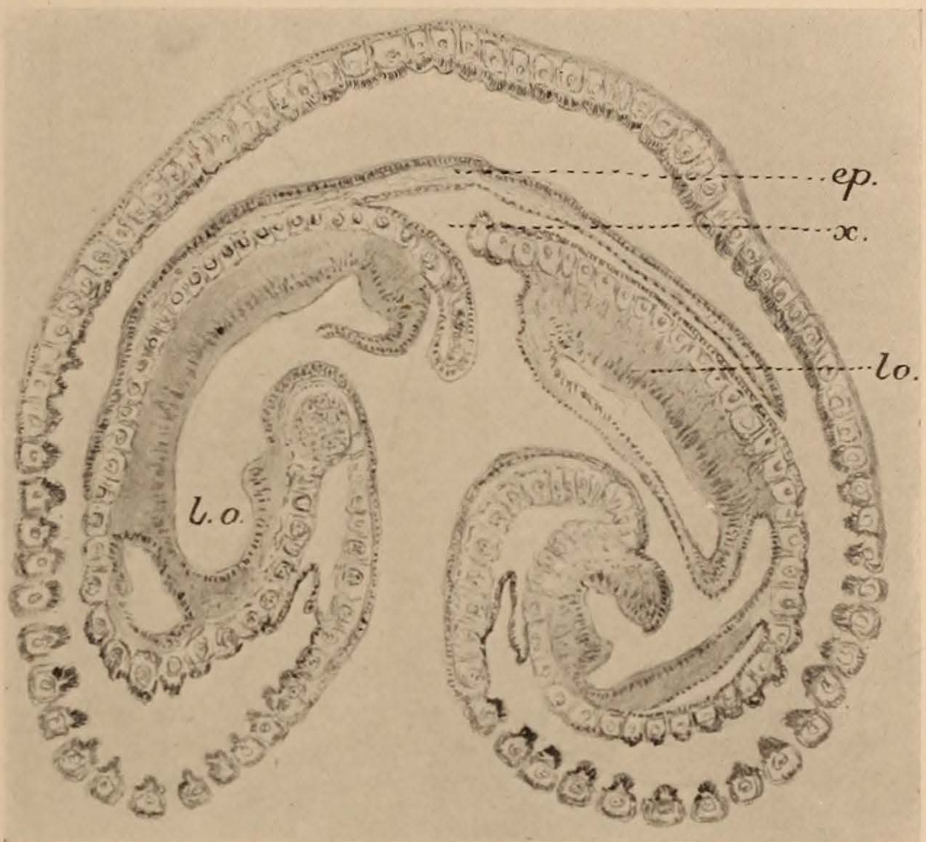
off, forming a blunt point. In some the distal end was limp and had no sand grains attached to it.

The animal so completely fills the circumference of the tube that it is only with difficulty removed.

Colour.—The tentacles and distal part of the body generally appeared during life to be of a pale greenish colour, and to be more or less covered with opaque white spots of exactly the same nature as in the case of Ph. vancouverensis. The ampulla was brownish-red. The last 5 or 6 mm. in some specimens were clearer and separated by an annular constriction. The red blood-vessels were clearly visible through the body-wall, and the rectum could often be recognised owing to its dark contents.

Size.—One of the largest specimens measures 147 mm. in length after preservation, 65 mm. of this being the ampulla, which, as a rule, seems to extend for nearly half the length of the animal. Some specimens are slightly under 100 mm.

TEXT-FIG. 7.

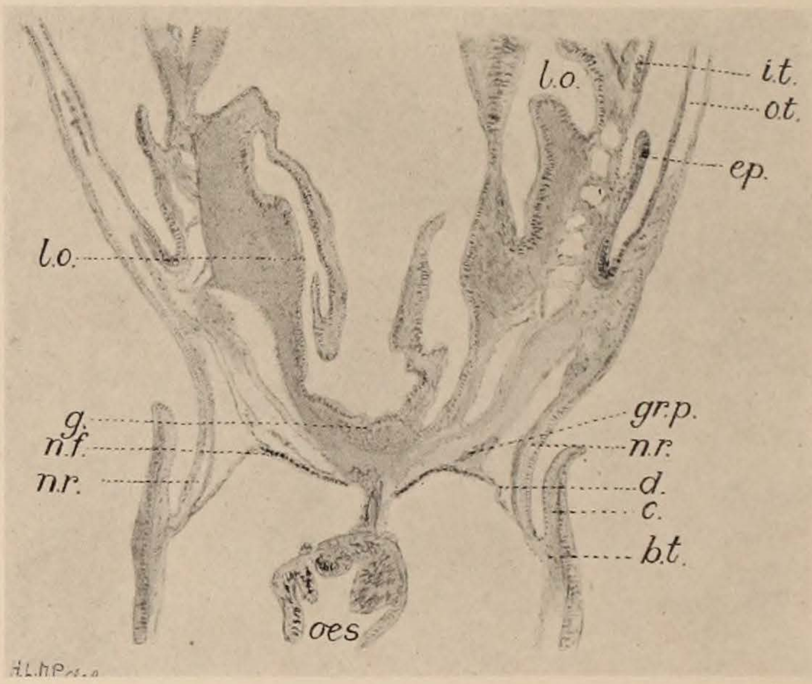


Tranverse section through lophophore showing lophophoral organ (*l. o.*), and gap in inner row of tentacles (*x*). (× 50.)

long. The tentacles, which are frequently found regenerating, are, when fully grown, 3 to 4 mm. long (Fig. 6). The general width of the body is 1 to 2 mm. in the anterior region and 3 mm. across the ampulla.

Lophophore.—The extent to which the lophophore is coiled is shown in Fig. 7, from which it may be seen that there is a more distinct spiral than in the horse-shoe form of Phoronopsis albomaculata. The tentacles are also more numerous than in this species, for which Gilchrist gives 126, being in every case over 200 (215 to 230). At the base of the tentacular membrane is the very distinct collar formed as a fold of the body-wall just behind the nerve-ring (Figs. 6, 8, 9, 10, *c.*). This collar is deeper at the sides than on the oral surface, and on the anal side it is interrupted by a bifid process, the anal papilla, into which the trunk cœlom is continued, and which is divided internally by the rectal mesentery suspending the short terminal rectum (Fig. 11).

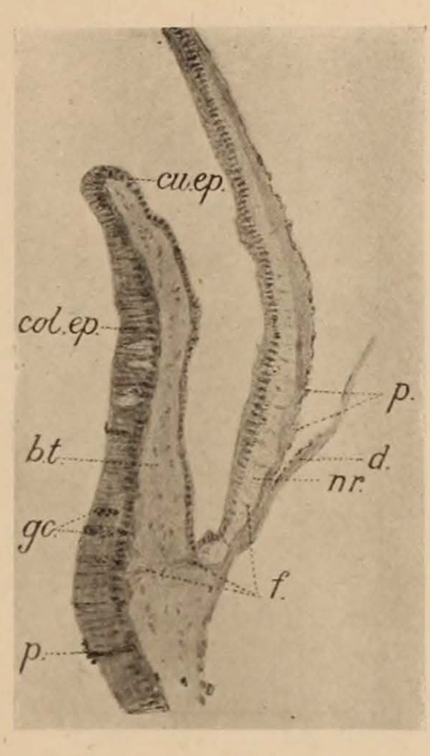
TEXT-FIG. 8.



Longitudinal section through the collar and base of lophophore in front of anal papilla. (× 40.)

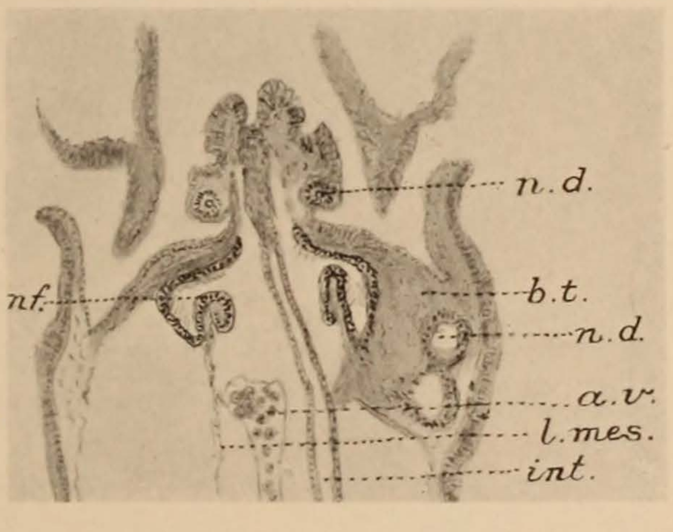
The lophophoral organ (Figs. 7 and 8 *l.o.*) is extremely variable; in some specimens it was large, and apparently similar to that described for Ph. psammophila by Cori (**3**) and for Ph. capensis by Gilchrist ([**7**] p. 158). The inner leaf-like fold forms a covered passage from close to the nephridiopores forwards and outwards into the lateral lophophoral spaces, which are lined by thick glandular epithelium. This epithelium also extends up the inner side of the tentacles, and has been seen by Gilchrist to secrete mucus by which the

TEXT-FIG. 9.



Part of a longitudinal section through collar region on one side. (× 100.)

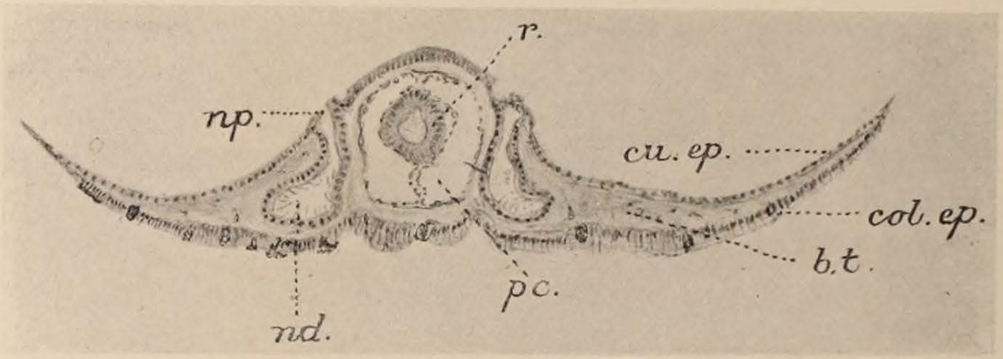
TEXT-FIG. 10.



Longitudinal section through anal papilla. (× 50.)

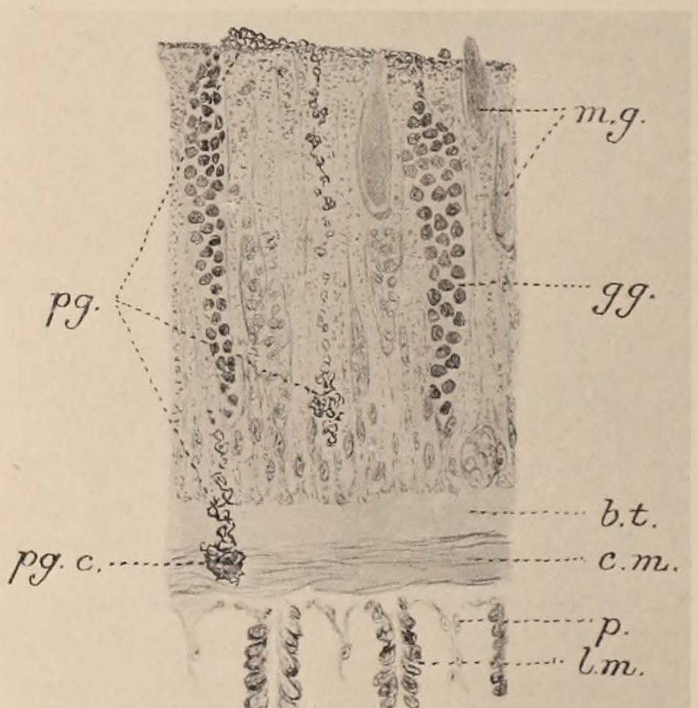
eggs are held together, and this author refers to the organ as a brood-chamber.

TEXT-FIG. 11.



Transverse section through collar and anal papilla at the level of the left nephridiopore. (× 60.)

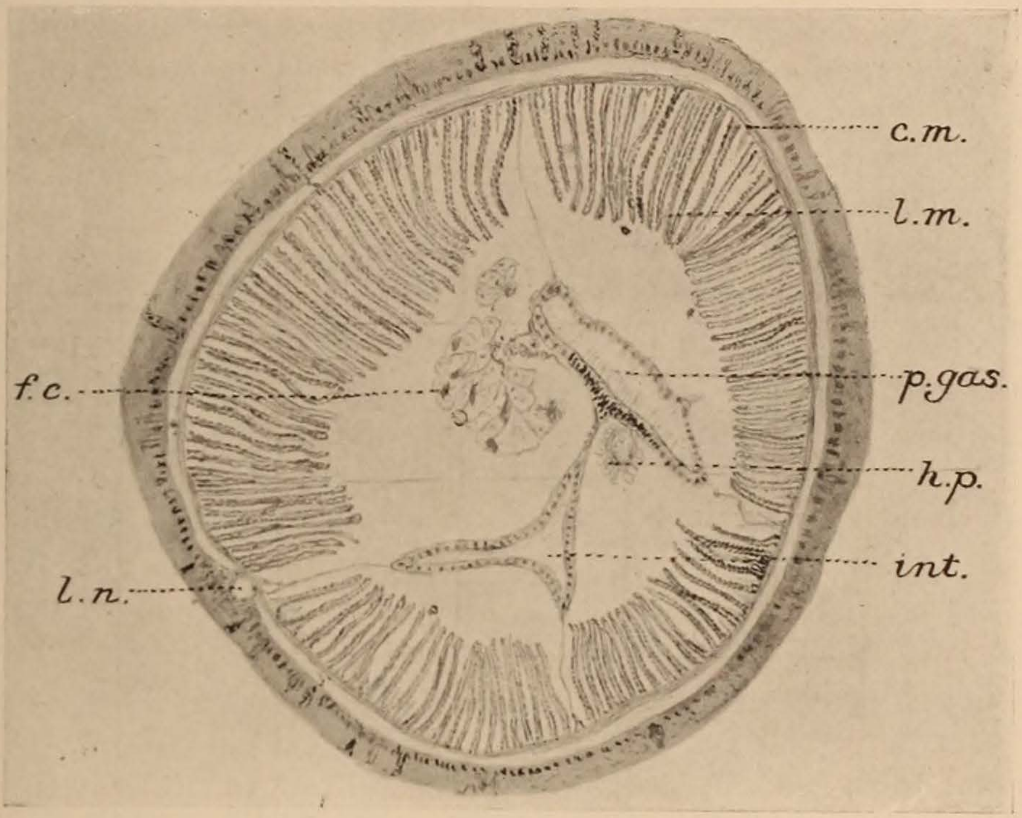
TEXT-FIG. 12.



A portion of a transverse section of the body-wall towards the distal end; only the outer ends of the longitudinal muscles (*l. m.*) are shown. (× 660.)

In the majority of specimens the organ is absent, which is probably to be accounted for as in Ph. vancouverensis by the lateness of the season. The ovaries are in Phoronopsis more full of ova, though both were collected in September. Specimens with a lophophoral organ can easily be distinguished by the greater width of the tentacular crown.

Text-fig. 13.



Transverse section through the œsophageal region showing the high pinnate fascicles of longitudinal muscles. (× 60.)

Body-wall.—The epidermis (Fig. 12) agrees with that described for Ph. vancouverensis, and the excretory pigment is here again very noticeable. The same remarks apply to it as given for the former species.

The basement tissue (Figs. 9, 10, 11,. *b t.*) has here numerous small cells embedded in the clear matrix similar to that described by Benham (**2**) for Ph. australis.

Muscular Layers.—The circular muscles are as usual (Fig. 13, *c.m.*), and a few radial muscles traverse the cœlom, especially in the distal part of the body.

The longitudinal muscles (Fig. 13, *l. m.*) are very greatly developed. The fascicles are more numerous than in any other described species of the Phoronidea. The usual number in the region of greatest development, i. e. about 50 mm. from the distal end, is about 126. These longitudinal muscles are distributed as follows: 41 in the left oral chamber, 42 in the right, 23 in the left anal chamber, and 20 in the right, or according to Longchamps' formula—

$$\frac{41 \mid 42}{23 \mid 20} = 126.$$

The fascicles are pinnate in transverse sections, and may extend inwards to a distance of 160 μ.

The nuclei of the peritoneum covering them are very prominent (Fig. 12, *p.*). Between the muscles a fold of the peritoneum extends inwards for a short distance; four of these folds are much longer, and reach the alimentary canal forming the mesenteries which divide the body cavity into the two anterior or oral and two posterior or anal compartments.

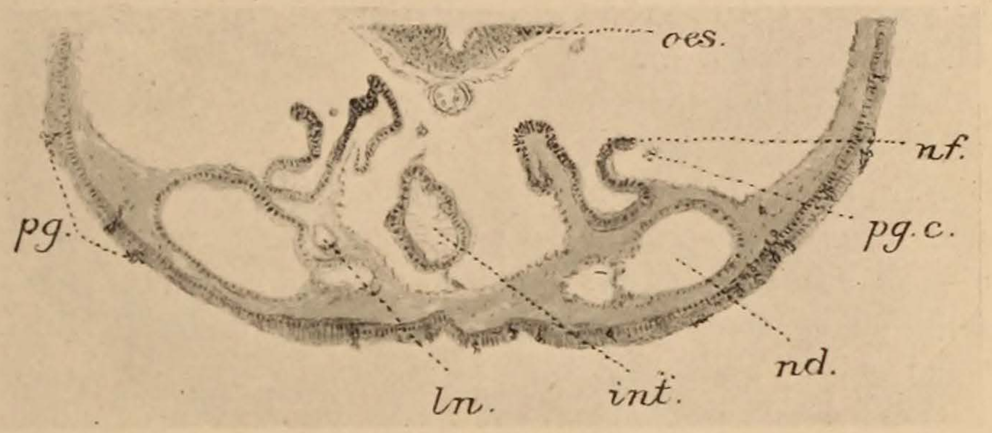
The collar (Figs. 5, 7, 8, 9, 10, *c.*) contains no cœlom, but consists of basement tissue with numerous small cells. The epithelium covering its outer side is columnar and similar to that over the general body surface (*col. ep.*), but at the tip and down the inner side it is replaced by small cubical cells (*cu. ep.*). There are no muscles developed in connection with the collar, so that though it suggests the introvert of the Sipunculoidea and Polyzoa it is apparently quite functionless in that respect. Gilchrist (7) suggests that "it is the remnant of an ancestral introvert which has been retained with the new function of protection of the nerve-ring."

The diaphragm (Figs. 8, 9, *d.*) is thin, but apparently consists of the usual three layers. I have seen it appear to branch owing to the emergence of a blood-vessel, which has evidently been running for some distance obliquely across the region where the glandular layer of the nephridial funnel is closely opposed to the septum. I do not know whether this would account for the septum appearing to give off an off-shoot towards the epistome, which Gilchrist (7, p. 156) stated required further examination.

Some of the peritoneal cells covering the part of this blood-vessel in the lophophoral cœlom near to the septum appear to hypertrophy, and become granular and possibly assume an excretory function.

Nervous System.—The nerve-ring has its usual position

TEXT-FIG. 14.



The posterior part of a transverse section through the region of the anterior nephridial funnels. (× 60.)

about the level of the diaphragm, but is protected on its outer surface by the very distinct collar.

The punctated substance forming the ring (Fig. 9, *n. r.*) contains a few cells and is traversed by delicate fibrils. These, I think, must be nerve-fibres going to the epidermal cells, and not merely inner boundaries of these cells as has also been suggested, for similar small bundles of fibres pass out at intervals and cross the base of the collar and enter the epidermal cells, forming its outer layer (Fig. 9, *f.*).

The whole layer of nervous tissue forming the ring is narrower and more elongated than in most species of Phoronis, and there is no indication of its becoming separated from the epidermis, as Gilchrist (7, p. 156) suggested might possibly occur in a completely developed specimen. On the anal side it turns inwards, following the curve of the lophophore, and is connected from side to side just in front of the anal papilla by a large ganglionic mass (Fig. 8, *g.*). From this passes downwards on the left side the conspicuous nerve-cord. In the nephridial region it is separated from the epithelium, and is embedded in the basement tissue (Fig. 14, *l. n.*). After passing internally to the nephridial duct (*n. d.*) it turns outwards and rejoins the epithelium a little to the oral side of the left lateral mesentery. From here it extends nearly to the ampulla as a very conspicuous cord in contact with the epithelium, but protruding slightly into the basement membrane (Fig. 13 *l. n.*). The centre is occupied by a clear substance which stains only slightly and around this are the nerve-cells.

Alimentary Canal.—In the stomach the ciliated groove with deeply chromatic nuclei is much smaller and less noticeable than in Ph. vancouverensis. The distal part of the intestine is markedly triangular in section and lined with small cubical cells (Fig. 13, *int.*), the short terminal rectum having columnar cells (Fig. 11, *r.*); the cœlom is divided into its usual four compartments even in the ampulla as far as the bend in the digestive tube.

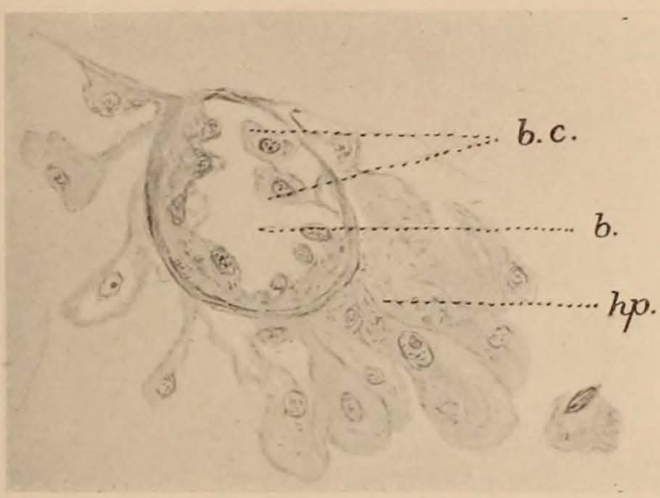
Vascular System.—The corpuscles are but very slightly larger than in Ph. vancouverensis, being on an average 10–12 μ in diameter, and the same remarks as to staining, etc., apply to them.

The cœca frequently branch, which they have never been seen to do in Ph. vancouverensis.

Excretory System.—The excretory tubes have the usual position, but differ slightly from those hitherto described. Each has a large funnel opening into the anterior cœlom and a smaller one higher up opening into the posterior cœlom; neither of these has its wall prolonged downwards for any distance as is usually the case. In addition to these funnels there is a wide orifice for communication between the anterior and posterior cœlomic spaces owing to the lateral mesenteries not meeting the œsophagus for some distance below the transverse septum.

The lower lip of the large anterior funnel wraps over the top of the lateral mesentery as shown in Fig. 10, *n.f.* It also extends round the sides and inner ends of this mesentery where it is free from the œsophagus (Fig. 14, *n.f.*). The top of the funnel is closely applied to the septum (Fig. 8, *n.f.*). Below the funnels the duct runs downwards for a short distance close to the mesentery in the anterior cœlom, then

TEXT-FIG. 15.



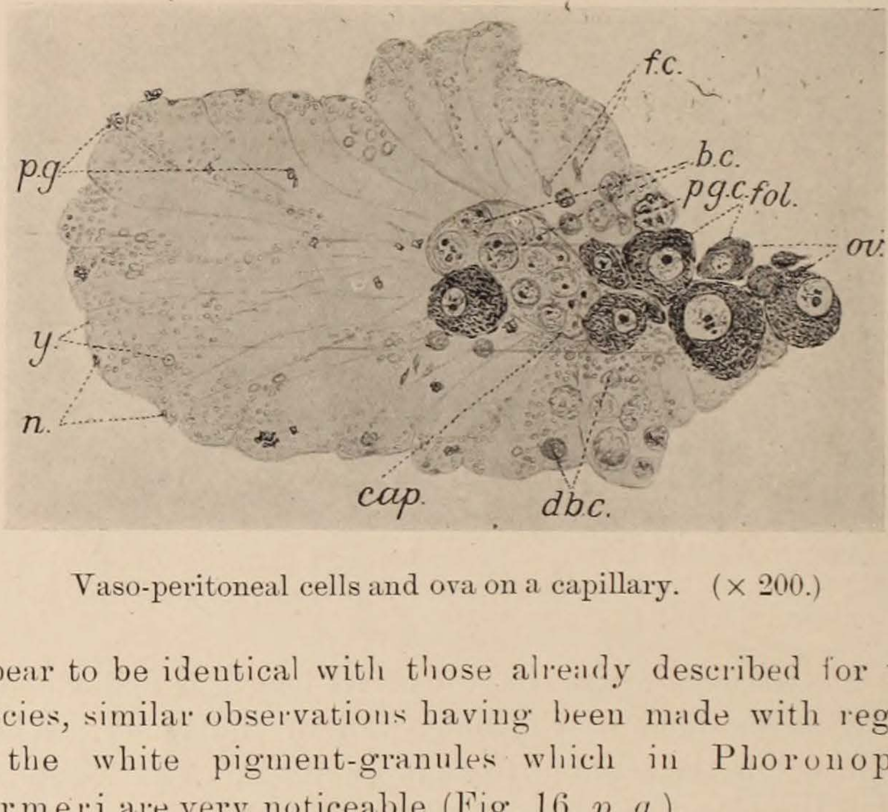
Transverse section through afferent vessel showing developing blood-corpuscles and hypertrophied peritoneum (*h.p.*) on the outside. (× 660.)

turns outwards, and for the rest of its length is embedded in the basement tissue of the body-wall of the trunk. About ·5 mm. below the septum it bends on itself. The ascending part of the tube is often much distended; it passes obliquely upwards externally to the nerve-cord on the left side (Fig. 14, *n. d.*), and on reaching the collar region narrows considerably and runs forwards embedded in the walls of the anal papilla to open a little in front of and below the anus (Fig. 11, *n. p.*).

The funnel consists of deeply staining ciliated epithelium and the duct is lined with ciliated cubical cells as usual.

The vaso-peritoneal tissue is developed on the walls of the capillaries on both sides of the body in the anterior cœlomic spaces, and the peritoneum covering the afferent vessel in the posterior cœlom is frequently greatly hypertrophied. These latter cells, however, appear to become detached, so that there is generally only one layer of them (Figs. 13 and 15, *h. p.*). They may possibly give rise to pigment-bearing corpuscles as suggested in the case of Ph. vancouverensis. The contents of the vaso-peritoneal cells

TEXT-FIG. 16.



Vaso-peritoneal cells and ova on a capillary. (× 200.)

appear to be identical with those already described for this species, similar observations having been made with regard to the white pigment-granules which in Phoronopsis harmeri are very noticeable (Fig. 16, *p. g*).

There are numerous ova in various stages of development to be found in the vaso-peritoneal tissue on both sides of and below the alimentary canal in all the specimens of which the proximal ends have been cut, and they are surrounded by distinct follicle cells (Fig. 16, *ov.*, *fol.*). No spermatozoa have been seen, nor have any ova been observed either free in the body cavity or in the excretory ducts.

Affinities.—There can be no doubt that this animal is a species distinct from Phoronopsis albomaculata, the other member of the genus. The latter, from South Africa, described by Gilchrist (7), was 18 mm. long, and the tube was attached by one side to its substratum with the two ends near together. The lophophore was horseshoe-shaped and carried 126 tentacles. There were 94 fascicles of longitudinal muscles.

The comparatively enormous size, greater number of tentacles and different habit of life of Phoronopsis harmeri are, I venture to suggest, minor points of difference, and the shape of the lophophore and the possession of a far larger number of muscle fascicles are the more important systematic characteristics.

In conclusion I should like to thank the Rev. G. W. Taylor, F.R.S.C., Curator of the Marine Laboratory, Departure Bay, for his courtesy and help during my visit. I also wish to express my thanks to Dr. Harmer, F.R.S., for kindly giving me assistance, especially with regard to literature, and to Dr. Marett Tims for his help and interest throughout.

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University of London;
March 5th, 1912.

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