PHORONIS OVALIS FROM BRAZIL

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(With 3 plates)

In the bay of Santos *Phoronis ovalis* Wright 1856 was found in july 1948 and march 1949 in the shelly sand that accumulates on the lee-side of the Ilha Porchat in the tidal zone. I first noted the burrows in the fragments of Gastropod-shells and then observed that many of them were inhabited by numerous individuals of a small boring species of *Phoronis*. The size, shape of the lophophore, number of tentacles, length of non--muscular (proximal) region of the body as well as the fission suit to the descriptions of the above-mentioned species. *Phoronopsis albomaculata* Gilchr. is an other Phoronid in which spontaneous division was observed (Gilchrist 1919); the tubes of this species do not penetrate the substratum.

Harmer (1917, p. 115-117) and Brattström (1943, p. 3-4) gave the history of *Ph. ovalis*, the validity of which species had been questioned by Cori (1890, p. 496) and Selys-Longchamps (1907, p. 188). The species was discovered in a decayed oyster-shell (*Ostrea edulis* L.) dredged in the Firth of Forth, Scotland. Harmer found it in an empty shell of the Buccinid *Neptunea antiqua* (L.) obtained to the south-east of St. Mary's Island, off the Northumberland coast, north-eastern England, at a depth of 30 m. (16 fms.). The third finding of *Ph. ovalis* was made by Brattström in The Sound, between the Danish island Sjaelland and the Swedish province Malmöhus. The two localities of the Öresund show the following conditions: depths 28-30 and 18-20 m., yearly averages of salinity 33 and 30 per thousand, temperature of the water 4-5° C. in spring and 11° C. or a little more in autumn. Brattström's specimens were found in shells of the Mytilid *Modiola modiolus* (L.).

The specimens that Meek (1917) called *Ph. ovalis* were newly metamorphosized. They had 22-26 tentacles, a number that he says increases in the adult animal. In his figure III, 6 the horseshoe-shaped lophophore is drawn with a dorso-median interruption and two distinct horns separated by a profound indentation. Therefore I am certain that Meek's classification is not correct. After Cori (1932, p. 127) Meek's species is *Ph. mülleri* Sel.-Longch.

As little as Selys-Longchamps (1907, p. 22) I could find the basis for Kowalewsky's statement that Fritz Müller had in 1863 discovered a *Phoronis* on the Brazilian coast. After the literature it is certain that Hensen's Plankton-Expedition collected the first Actinotrocha in Brazilian waters,

viz. on September 23, 1889, off the coast of Pará (see O. Krümmel 1892, Reisebeschreibung der Plankton-Expedition, p. 210, and Selys-Long-champs 1907, p. 22, 196). As far as I can see, no adult Phoronid was until now recorded from Brazil.

Of course I feel somewhat embarassed in identifying animals that live in the uppermost littoral of the bay of Santos, and were exposed to more than 30° C. in my aquarium, with a species hitherto only known from north european seas. As the morphological description shows, my material differs in several points from the larger and better known species of the genus. For the most part these details have not been considered in the previous descriptions of the small *Ph. ovalis*. I even can emphasize two characters, a morphological and a physiological one, that are different in the Brazilian and European *ovalis*, viz. the cuticular processes (Fig. 10, t) and the budding (Figs. 11-16). The taxonomic value of these particularities can not be judged.

If however the nervous plexus (Figs. 7, 8, u), the valve between the oesophagus and the proventriculus (Fig. 8), or the number of vessels as developed in my specimens (Fig. 4), should prove to be others in the European animals, the present material must receive a new name. The state of our knowledge does not justify a specific separation by geographic reasons. Very little is known about the geographic range of the various species of *Phoronis*. I agree with Brattström (1943, p. 4) who supposes that *Ph. ovalis* may often have been overlooked due to its hidden life and small size. "If one does not consciously search for it and does not know its biotope, it is only found by chance. Therefore it is not surprising that more than 60 years passed between the two first publications, and that since Harmer's report, 25 years ago,   no new occurrence of *Ph. ovalis* was mentioned in the literature."

One fragment of shell (Fig. 1) in my material had more than 150 burrows per square cm., that is a twenty times denser population than that observed by Brattström (p. 6) with 7 animals per square cm.. The expanded tenta-cular crowns swaying slowly from side to side look like a field of daisies. The size of the crowns is much bigger than that of average Bryozoa, and an evaginated Ctenostome, *Terebripora ramosa* d'Orb. (Fig. 2, tr) is dwarfed beside the *Phoronis*. The fragment housing one of the biggest colonies belonged to *Thais floridana* Con., a common Muricid on the rocks of the tidal zone. The shell was quite solid and only broken off, not decayed as Wright's *Ostrea* or corroded ("angefressen") as Brattström's *Modiola*. Other colonies of my material occurred in solid and decayed mussel-shells (*Mytilus*-spec.), fragments of plates of Balanids, and other shells.

I found a well preserved fragment of a *Mytilus*-shell, part of which was still covered by the periostracum that was worn out in the other half. Only here a great number of *Phoronis* came out with their tentacular crowns. In the region covered with the periostracum the offspring of the animals that inhabited the naked lime had perfurated the prismatic layer of the shell (Fig. 17). Their holes were seen immediately below the periostracum. Only where the latter was a little torn, the *Phoronis* had been able to reach the water. But the periostracum, that was about 0,3 mm. thick in the described region, showed concavities of 0,1-0,15 mm. depth on its inner

surface. Also the thin lamellae of conchiolin between the prisms and the layers of nacre of the shell are removed by the boring *Phoronis*. Even their own cuticular tube that is chitinous (Schulze 1924, p. 653) can be destroyed by the animals. This is f. ex. proved by the development of lateral buds (Fig. 11) that diverge from the original tube (Fig. 13). I only can presume that the epidermal cells that are always very high on the growing points (Figs. 12, 13, e) produce this effect by phagocytosis.

In the biggest colony most of the holes open on the outer side of the shell of *Thais*, and the burrows generally lie parallel to the surface. In this fragment there were no other boring organisms except the tiny *Tere-bripora*, so that the canals are certainly caused by the *Phoronis*, as was stated by Harmer (1917, p. 126), Cori (1932, p. 105) and Brattström (1943, p. 7). Some of the other colonies were accompanied by a boring sponge (Fig. 10, cv, ns, sa) that I tentatively classified as *Cliona vastifica* Hancock 1849 (Arndt 1935, p. 45, 126 f. 76), but the tubes of *Phoronis* crossed the burrows of the sponge without taking advantage of them.

The l e n g t h of the extended living animals is up to 8 mm., but they are rarely more than 6 mm.. St. Wright indicated half an inch, Harmer at least 6 mm., and Brattström rarely more than 6 mm.. The longest specimen in balsam-mount measures 4,3 mm.. The slender tentacles (diameter : 0,035 mm.) attain 1,2 mm. in life. In the preserved animals they contract to 0,4 mm. and are a little stouter. As the number of tentacles is small, the lophophore is short. The correlation between the little developed respiratory surface and the small size of the body is obvious. The propor-tions of the muscular and non-muscular part of the body vary greatly according to the stage of fission and regeneration. In full-grown animals (total length : 2,8-4,3 mm.) the muscular part of the body occupies 20-33%, in regenerating fragments (total length : 0,63-1,875 mm.) 28-72% of the body-length.

The t u b e s as well as their openings are 0,2-0,3 mm. in diameter. The cuticular tube (Figs. 10, 15, k) that lines the gallery in the shell does not stand out of the burrow. When freed by descalcification the tube is seen to consist of one or more layers of hyaline secretion. In the Brazilian specimens the tube is not always smooth as in european *Ph. ovalis*, but sometimes beset with a varying number of thin, hollow processes (Fig. 10, t). These are 0,01-0,015 mm. wide and up to 0,13 mm. long. As the processes occur in sections that pass through masses of *Cliona*, they perhaps fit into cavities of the sponge. This opinion is also favoured by the obser-vation that processes were wanting on free tubes. Some such free tubes appeared when the aboral extremities had pierced the inner surface of the shell and the proximal ends of the animals were hanging free. On the other hand cuticular processes were also formed by *Phoronis* boring in a solid shell of *Thais* without any traces of *Cliona*.

In wholly expanded individuals about one millimeter of the body is protruded from the tube, and this salient part affords the tentacular crown free movements. The full number of t e n t a c l e s is 22-24. Frag-ments that form a new anterior part after fission begin with 9 tentacles. Immediately a tenth grows out on the concave side of the lophophore above the anal opening (Fig. 3), and so on successively one after the other, till

the definitive number of about 24 is reached. At the same time the length
of the tentacles is re-established. The expanded tentacular crown has
the shape of a bell with a longer transverse and a shorter median axis, the
anal side is a little indented.

The e p i d e r m i s of the anterior, strongly muscular part of the
body (Fig. 7, e) is high and contains a great number of gland-cells filled
with coarse granules. There are two types of gland-cells, such with acido-
philous (y) and others with basophilous (c) secretion. The chitinous cuticle
is produced by these cells, principally by the acidophilous (erythrophilous)
ones, while the basophilous cells perhaps furnish the substance that dis-
solves the calcareous shell. Erythrophilous gland-cells protrude into each
of the developing cuticular processes that are evidently secerned by these
cells (Fig. 10, y). In the older individuals the cells are withdrawn from
the processes that are empty then. Also the aboral end of the animal is
often covered with a cap of thick, secretory epithelium. In other cases
the epidermis on the proximal end of the body is as flat as that on the distal
part of the non-muscular region (Fig. 9). Where lateral buds are formed
by the body-wall the epidermis becomes high. It is evident that the ramifi-
cation of *Ph. ovalis* (Fig. 11) is correlated with the capacity of the surface
of the whole metasoma to produce a tube and to burrow.

As the central n e r v o u s s y s t e m of *Ph. ovalis* has not yet been
drawn satisfactorily, I give an illustration here (Fig. 6) that shows the
topography of the nerve-ring (rn) and the ganglion (gn) better than a des-
cription. The ganglion lies between the epistome (x) and the anal papil'a
(r) at the right and left side of the epistome. On both sides the ring
is thickened and in the middle of the anal region attenuated. A ganglion
composed of a right and a left intumescence united by an anal median
commissure (cn) has, as far as I can see (Cori 1890, p. 549 ; 1932, p. 106-
-107 ; Selys-Longchamps 1907, p. 49), not yet been described in *Phoronis*,
not even in *Ph. architecta* that has two lateral nerves (Brooks & Cowles
1905, p. 106). These lateral nerves are known to be developed differently
in the various species (Selys-Longchamps 1907, p. 52 and following ; Pixell
1912, p. 265, 280), but the condition that I find in *Ph. ovalis* has not yet
been mentioned. In the muscular part of the body a diffuse nerve-plexus
lies at the bases of the epithelial cells outside the supporting membrane
(Figs. 7, 8, u). In no place this plexus is concentrated to a compact nerve.
In Selys-Longchamps' opinion (p. 53) the paired lateral nerves represent
the primitive condition in comparison with the unilateral nerve. According
to this supposition a diffuse nerve-plexus appears as the most primitive
form.

The general aspect of the a l i m e n t a r y t r a c t (Fig. 5) resembles
that of *Thalamoporella evelinæ*, a cheilostomatous Bryozoon, in a surprising
manner (see Marcus 1941, t. 2 f. 4). The epistome is less developed than
in Harmer's and Brattström's specimens (1917, t. 8 f. 14, t. 9 f. 40 ; 1943,
f. 7 A). It is a slight fold formed at the base of the anal tentacles that projects
towards the mouth without covering it (Fig. 5, x). The oesophagus (h)
is separated from the proventriculus (q) by an infundibuliform valve (Fig.
8), while the proventriculus widens gradually and without distinct limit
to form the stomach (s). The latter shows the dorso-median ciliated gutter
(Selys-Longchamps 1907, p. 86) or ciliated groove (Brooks & Cowles 1905,

p. 113 f. 81), on both sides of which the epithelium is very high (Fig. 9). Its cells contain skeletons of diatoms (j). These digesting elements of the intestine are of equal height along the whole stomach. There are no irregular epithelial processes (Cori 1890, p. 525 t. 28 f. 3), epithelial papillae or "bour-relets" (Selys-Longchamps 1907, p. 86 t. 7 f. 6). In some cases the mass of diatoms is much bigger than the mass of surrounding cytoplasm. In old animals the empty skeletons are no longer eliminated but heaped up in the wall of the intestine (Fig. 9) till the individual dies. Many dead tubes containing a compact mass of empty diatoms still shaped like the stomach are seen in a descalcified colony.

The proximal end of the stomach has narrow, cylindrical, strongly ciliated cells with long nuclei and scarce cytoplasm (p). The following short portion of the gut is verry narrow and forms the connecting tube between the descending and ascending limb (g). It is histologically sharply distinguished by small cells from the following section, the true intestine (i), in which the epithelium contains various granules. This ascending limb of the gut is a thin tube of nearly equal diameter through its whole length that rarely contains residues of food, empty diatoms and other. The most distal part of the gut, the rectum (r), has again small cells without granules, it is not sharply limited against the preceding section.

The v a s c u l a r s y s t e m (Fig. 4) corresponds to the diagram given by Cori (1932, p. 109 f. 10) with some modifications. The ring-vessel (v) (Brooks & Cowles 1905, p. 105) is divided into a distributing and a recipient vessel, (Benham 1890, p. 138), as in the other species of *Phoronis*. But different from these the recipient ring-vessel gives the blood to three, not to two, vessels. The third, accessory, vessel (di) that evidently is a particularity of *Ph. ovalis*, lies in the median line on the abanal (oral) side, like the only branch of the descending vessel in the recently metamor-phosized Actinotrocha described by Ikeda (1901, p. 577 t. 30 f. 64). The two other vessels (d) run on the right and left side, as in the earlier described species. The three vessels unite at the level of the oesophageal valve in the same manner as do the two vessels of the other species. The one lateral left-side descending vessel originates by the union of the three vessels.

In correlation with the small size of the species the descending vessel has no coeca, except some small branches in the vaso-peritoneal or adipose tissue. Around the proximal end of the gut the vessel widens to an intes-tinal sinus (Fig. 5, z), from which the ascending vessel (Fig. 4, 9, a) arises.

The m e s e n t e r i e s (Figs. 7, 9, m) in the present material agree with those figured for *Ph. ovalis* by Harmer (1917, p. 130 f. 22-25, mes.) and Brattström (1943, p. 12 f. 7 F, I, J, mes.). Contrary to what is known from the bigger species (Selys-Longchamps 1907, p. 68) where a median, two lateral, and sometimes even accessory mesenteries occur, the small *Ph. ovalis* possesses only the median mesentery that suspends both limbs of the gut. Each half of the body has about 16 longitudinal m u s c l e-bundles (Fig. 7, l) ; Harmer (p. 124) indicated about 14, Brattström (p. 12) 17-19.

The n e p h r i d i a (n) have very short and straight tubes that pierce the body-wall, and very long, narrow, ciliated funnels that extend inwards

a little beyond the oesophageal valve (Fig. 8, n), similar to those in *Ph. australis* (Benham 1890, p. 140 t. 12 f. 23, 27).

Of the r e p r o-d u c t i v e   o r g a n s the present material contained testes in march and growing ovocytes of different sizes in july. Both kinds of germ-cells lie between the vaso-peritoneal tissue (Fig. 9, b). It is not known whether *Ph. ovalis* is hermaphrodite as the other species of the genus usually are.

As little as Harmer and Brattström I have seen l o p h o p h o r a l o r g a n s.   As also males or male stages occur in the present colonies, the absence of lophophoral organs can be considered as a specific character of *Ph. ovalis*. Among the manifold interpretations of the function of these organs that of Brooks & Cowles (1905, p. 103-105) is well founded. These authors hold at least the distal part of the lophophoral organs for seminal receptacles ; in the material they examined, the organs developed only during the male phase. On the other hand Gilchrist (1919, p. 494) observed in *Phoronopsis albomaculata* that the eggs deposited on the rock were covered over and securely fastened to the substratum by a mucous secretion from a large lophophoral organ.

One colony was kept a l i v e for 6 months in a dish of 20 cm. with *Ulva* and not running sea-water, without airing, and exposed to the afternoon-sun. The temperature often attained 30°C. At the end of this time the *Phoronis* dissapeared suddenly. Perhaps they were eaten by two specimens of the Polyclad *Latocestus ocellatus* Marc., that were turned loose in the same dish. It is very probable that the shell and rock-boring Phoronids are frequently eaten by Polyclads, the sucking pharynx of which is better fit for seizing them than the mouth of fishes (Schultz 1903, p. 392).

Several times most individuals cast off their tentacles and r e g e-n e r a t e d them in a few days. The new crown of tentacles had a reduced number of tentacles, 13-16, but this was completed gradually by one new tentacle at a time growing out on the anal side of the lophophore.

Schultz (1903, p. 392) said that the crown of tentacles is thrown off when conditions become unfavourable, and is replaced as soon as these grow better. Cori first combined (1890) the autotomy under bad conditions (p. 502) with the mutilation of the tentacle crown by fishes (p. 503), and Selys-Longchamps (1907, p. 162) even understood the faculty of regeneration as an "adaptation" acquired in consequence of accidental injuries. This is purely speculative. Later on Cori (1932, p. 121) agrees with Schultz and considers the autotomy correctly as a reduction of the most irritable, nourishing, and respiratory organs, the loss of which brings the animal to rest, thus enabling it to survive periods of bad conditions. Besides Cori is right in combining the casting off of the tentacles with the asexual reproduction of *Ph. ovalis*, the fission discovered by Harmer (1917). The rapid regeneration had misled Selys-Longchamps (1907, p. 162) : "regeneration happens immediately after the tentacles have been shed, under the continuing same external conditions, if not under worse : the stagnant water, f. ex., in which the animals were kept, was not renewed" The observation of such a rapid regeneration agrees with the behaviour of my *Phoronis ovalis*.

However examination of the tentacular crowns that were shed, or that were short before being autotomized, proves that internal conditions are as important as external ones. The tissue of these tentacles is overladen with yellowish granules similar to those that appear in the intestine of the degenerating polypide of Bryozoa. Although provided with a blind--ending vessel in each tentacle, the completely closed mesosoma of *Phoronis* is evidently not sufficiently able to remove waste excretory substances, so that at least under the described conditions it becomes periodically unable for normal function.

During the time that the colony was observed, many new, small individuals appeared beside the old ones. They began with 9 tentacles of 0,2 mm. length and a tenth shorter one (Fig. 3). During the following growth the number and size of the tentacles increased, till after several weeks there were 22-24 full grown ones of 1,2 mm. length. The descalcified material showed many phases of f i s s i o n , as such were first described by Harmer (1917, p. 131-139). The epidermis and the cuticular tubes form septa at any level of the dividing animal and separate it in two, each of which regenerates its missing parts.

Some of the present specimens divided in a different way, not yet described for *Phoronis*, that begins with b u d d i n g . The buds arise on the oral or ventral side, rarely in the distal muscular part (Figs. 11, 12), oftener in the proximal, non-muscular region (Figs. 11-16). The epidermis becomes high and grows out from the original wall at various angles. Immediately afterwards the descending limb of the intestine gives off a side-shoot (si), and the cuticular tube appears on the surface of the bud except the growing point. The latter is covered by a thick pad of epidermic glands (Fig. 13, e ; 14, y), and represents the boring extremity of the bud.

In Fig. 13 and 14 a *Ph. ovalis* of 2,5 mm. length is drawn, the bud of which is 2,8 mm. long. It is surrounded by its own tube that has already developed the characteristic processes (t). A tubular outgrowth of the gut (si) still united with the descending limb of the mother-individual (s) reaches the growing end of the bud. This end is characterized by the already mentioned high epidermis (e) and by a blood-sinus (z) connected by two vessels with the lateral and median vessel of the parent. These vessels are fastened to the descending limb of the intestine by the mesentery (m), and they accompany the simple intestinal tube that grows into the bud. In the proximal region of this some vaso-peritoneal tissue is already present, and a few big ovocytes enter from the mother-animal into the bud. The fold (cs) in the tube of the bud is the preliminary step of a future transverse fission, similar to that of Harmer's figure 31 (1917, t. 9), that represents the commencement of this process.

The physiologically active pole of the bud, that bores and is supplied with blood flowing to and off through the lateral and median vessel respectively, becomes the active fore-end of the individuated animal with mouth, tentacles and anus.

Of these organs the mouth develops first. To judge from a not very rich material it is produced by a depression of the epidermis that joins the terminal dilatation of the bud's gut. The next following organs of the bud are the tentacles that grow out from the epidermis around the mouth with their supporting membrane. Blood-vessels spring from the

blood-sinus at the growing end of the bud and enter the still very short tentacular primordials. While the mouth develops even before the bud has reached the water (Fig. 17), the tentacles grow out only when they can unfold. In the animals that had not yet succeeded to pierce the periostracum, as described above (p. 158), the epidermic cushion was still very high and not divided into tentacles.

The intestinal ascending limb of the bud is the last of the principal organs that develops. It arises from the descending limb generally before individuation (Fig. 16), occasionally even later (Fig. 17). In the first case a simple connecting tube (Figs. 12, 16, si) between the descending limbs of mother and daughter-individual persists in the zone where the dividing septum develops. The other case is only once represented in my material (Fig. 17), and refers to an individuated bud that had hit the periostracum and evidently for a long time tried to break through this obstacle. The growing process may have been disturbed, and it was only drawn because it illustrates an intermediate stage of the growth of the ascending intestinal limb well.

Transverse fission and lateral budding followed by division are comparable to architomy and paratomy respectively. In the Hydridae (Heider 1909, p. 495 f. 335) the two processes occur simultaneously in the same animal like in the Phoronidae. The architomy of *Phoronis ovalis* gives origin to small individuals, the paratomy to bigger ones that are nourished by the parent during their differentiation. Evidently good alimentary conditions possibilitate paratomical division, and by this process the number of individuals in the population of a shell increases more rapidly. In a Balanid shell of the porous *Tetraclita*, where boring is easier than in Mollusc shells, up to 5 buds were seen on the same parent individual (Fig. 11).

The bud arises on the embryologically ventral side as in the Actinotrocha does the tube that represents the physiological hind end of the adult animal (metasoma). The everted tube of the Actinotrocha corresponds to the bud in adult *Phoronis ovalis*. The development of the buds on the oral side of the adult corresponds to the topography of Phylactolaemata, whereas the buds of the Gymnolaemata originate on the anal side of the parental zooid. In *Phoronis* buds and embryos the mouth develops before the anus. The same holds true for buds and embryos of the Endoprocta, whereas the formation of the anus precedes that of the mouth in the buds of the Ectoprocta.

The stomodaeal depression of the epidermis and the rest of the intestine constituted by the endoderm are similar in the bud and in the embryo of *Phoronis*, whereas in Bryozoa and Pterobranchia the development of the gut in the bud is very much modified.

The bud of *Phoronis ovalis* is oriented in the same direction as that in Hydrozoa, Anthozoa, Pterobranchia and Bryozoa. The free end of the bud is the future fore end and separation between parent and bud takes place at the pole that becomes the hind end of the individuated animal. In all Vermes that reproduce by dividing or budding, viz. Turbellaria (Catenulida, Microstomidae, *Planaria fissipara* Kenn., *Rhodax evelinæ* Marc.), Polychaeta, and Oligochaeta, orientation is contrary : the free end is the future hind end, and separation succeeds at the bud's fore end, where it coheres with the mother-individual. As I have been educated

by Heider with the idea of natural relations between Phoronidea and Bryozoa, I register the bryozoan, not vermidean, orientation of the buds with satisfaction.

Resumo

Phoronis ovalis conhecida do Mar do Norte e do Öresund, perfuradora de conchas (*Thais, Mytilus*, etc.) e placas de Balanomorpha, ocorre no litoral da baía de Santos. Pode haver 20 vêzes mais indivíduos em um cm.^{2} de concha que no material europeu. A perfuração é ativa, sem aproveitamento das galerias de *Cliona vastifica* Hanc. ou das muito finas de *Terebripora ramosa* d'Orb. Tanto fragmentos recem-quebrados quanto já corroidos são habitados ; nas placas porosas de *Tetraclita* torna-se a colonização especialmente densa. A cutícula quitínica que reveste os tubos pode formar processos, desconhecidos do material europeu. Das glândulas epidérmicas, as eritrófilas produzem a quitina ; a secreção das cianófilas dissolve o carbonato de cálcio. A conchiolina do perióstraco pode ser perfurada e até a quitina do tubo é removida, quando se formam botões laterais. Responsabilizo uma fagocitose das células epidérmicas por êstes processos.

A válvula post-esofágica, o gânglio com 2 intumescências e um plexo difuso, e 3 em vez de 2 vasos que recebem sangue do vaso anelar apresentam-se como particularidades do material brasileiro ainda não examinadas do europeu. Esqueletos de Diatomáceas acumulam-se nas células intestinais de indivíduos velhos.

Autotomia do lofóforo ocorre sob condições desfavoráveis, às quais pertence também excesso de excretos nas células tentaculares. Nos últimos casos, a regeneração da corôa tentacular é imediata.

Além da divisão arquitômica ocorre ainda, como nas Hydridae, a paratômica que começa com gemação. Esta dá-se no lado oral, como a do metasoma na Actinotrocha e a dos Phylactolaemata. A epiderme e o ramo intestinal descendente com os dois vasos constituem o botão ; o ramo ascendente origina-se, mais tarde, do descendente. O material que fornece o intestino do botão corresponde ao que forma o da Actinotrocha. A terminação livre, perfuradora, do botão de *Ph. ovalis* torna-se a extremidade fisiològicamente anterior, com tentáculos, bôca e anus do animal individualizado. Êste separa-se do animal materno no polo posterior. Tal orientação repete-se nos Hydrozoa, Anthozoa, Bryozoa e Pterobranchia. Em todos os Vermes que se dividem (Turbellaria, Polychaeta, Oligochaeta), o polo livre do botão ou zoóide é o futuro posterior ; o da separação, o anterior.

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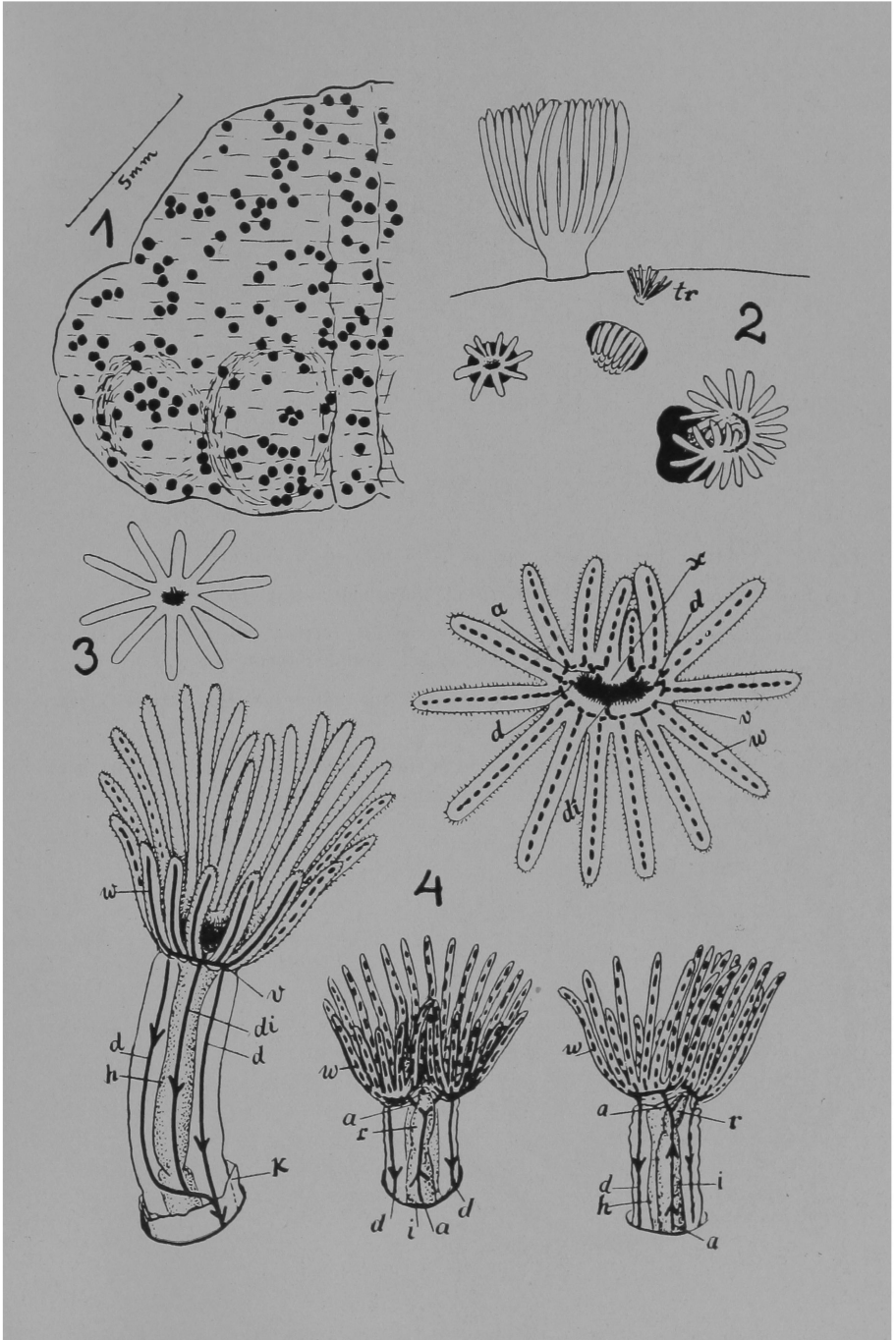
Plates

PLATE I

Fig. 1 — Shell-fragment of *Thais floridana* with burrows of *Phoronis óvalis*.

Fig. 2 — Tentacular crowns emerging from burrows, one of the *Phoronis* newly divided, and one polypide (tr) of *Terebripora ramosa* d'Orb.

Fig. 3 — Tentacular crown of a newly regenerated anterior end.

Fig. 4 — Anterior ends with blood vessels.

a, ascending vessel. am, annular muscles. b, vaso-peritoneal tissue. c, cyanophilous skin-glands. cn, nerve commissure. cs, septum of cuticular tube. cv, spirasters of *Cliona*. d, descending lateral vessel. di, descending unpaired vessel. e, epidermis. f, ciliated gutter. g, connecting gut. gn, ganglion. h, oesophagus. i, intestine. io, outgrowth of intestine. j, diatoms. k, cuticular tube. l, longitudinal muscles. m, mesenteries. n, nephridial funnel. no, nephridiopore. ns, tylostyle of *Cliona*. o, ovocyte. p, pylorus. q, proventriculus. r, rectum. rn, nerve-ring. s, stomach. sa, acanthoxeas of *Cliona*. si, simple tube of intestine in the bud. sm, supporting membrane. t, processes of cuticular tube. tb, budding tentacles. tr, *Terebripora ramosa*. u, nerve-plexus. v, lophophore vessel. w, tentacular vessel. x, epistome. y, erythrophilous skin-glands. z, blood-sinus. zg, skin-glands secerning septum of cuticular tube.

PLATE II

Fig. 5 — Sagittal diagram with the levels of Figs. 6-10 indicated.

Fig. 6 — Transverse section on the level of the nerve-ring (rn).

Fig. 7 — Combined section with nerve-plexus (u), rectum (r), one ascending (a) and 3 descending (d, d, di) blood-vessels and 2 mesenteries (m).

Fig. 8 — Slightly oblique sagittal section of the valve between the oesophagus (h) and proventriculus (q).

Fig. 9 — Transverse section on the level of the stomach (s) with intestine (i), ascending (a), and descending (d) vessel, 2 mesenteries (m), and vaso-peritoneal tissue (b) with ovocytes.
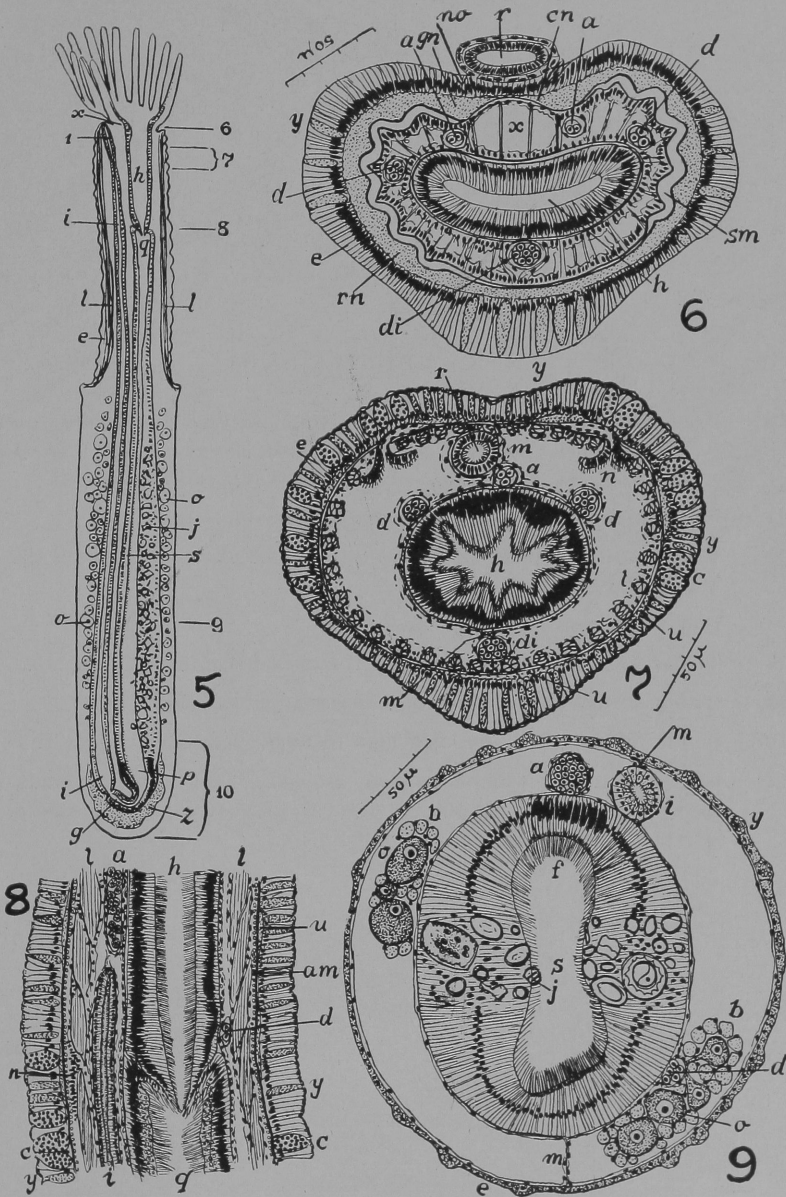
PLATE III

Fig. 10 — Sagital section of proximal end with cuticular tube (k) forming processes (t) in the sponge *Cliona* (cv, ns, sa), and epidermis-glands (c, y), blood-sinus (z), stomach (s), pylorus (p), connecting gut (g), and intestine (i).

Fig. 11 — Specimen from a *Tetraclita*-shell with 5 simultaneous buds.

Fig. 12 — Parent with two buds, an old one in the muscular, a younger in the non-muscular region.

Fig. 13 — Bud with single intestinal tube (si).

Fig. 14 — Transverse sections of the parent (A) and bud (B) drawn in Fig. 13.

Fig. 15 — Bud with differentiation of the tentacular crown (tb).

Fig. 16 — Bud with completed ascending limb (i) of the intestine.

Fig. 17 — Individuated bud with outgrowing ascending limb of the intestine (io) the animal that had not yet succeeded to pierce the periostracum (p. 158) is still without tentacles.

PLATE III