

**Animal Diversity- I
(Non-Chordates)**

Minor Phylum: Ctenophora

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I. Phylum: Ctenophora

Introduction: The name ctenophore comes from the Greek word which means “comb bearer”. Its name is better described by H. Foundalis and T. Christopoulos where the word “ctena” means comb and “phora” means to bear. The members of the phylum Ctenophora are known by many other names including comb jellies, sea walnuts and sea gooseberries. This phylum is small and contains about 50 species, the majority of which are planktonic and are found in throughout the water body. All ctenophores are pelagic and marine water living but some live in brackish water particularly in surface waters near shores. They are frequently swept into vast swarms on the sea shores and are found in maximum number in the summer months. Their numbers can vary from year to year. Most species are weak swimmers, carried about by ocean currents, except few which creeps along the bottom of the seas

Most ctenophores are transparent, bioluminescent, fragile and gelatinous. *Pleurobrachia pileus*, *Bolinopsis infundibulum* and *Beroe cucumis* can be found in the coastal waters of the Irish Sea. *Pleurobrachia* and *Beroe* are cosmopolitan in their habitat, while majority have a more restricted distribution pattern. There is an endoparasitic species (*Gastrodes parasiticum*) known which is only 3 mm in diameter. Comb jellies are generally of small size except *Cestus* (Girdle of Venus) which may attain a length of more than 1 meter. Most are oval several are leaf or ribbon shaped e.g. *Cestus*. Body radially or biradially symmetrical, sometimes markedly flattened. They always remain singly and never found forming colonies.

Ctenophore cells are always multiciliated, each bearing two or more cilia. In some other species, the body surface is increased by lateral compression, and major areas of the body are coated with sticky mucus and with colloblast cells.

II. Classification

Phylum Ctenophora is classified into two classes depending upon the presence or absence of tentacles. A brief classification is discussed below.

1. Class: Tentaculata: Ctenophores always bearing two long tentacles.

A. Order: Cydippida

- i. Body rounded or oval.
- ii. Tentacles branched and retractile into pouches.

Examples; *Pleurobrachia* and *Mertensia*

B. Order: Lobata

- i. Body moderately compressed with two large oral lobes to either side of tentacular plane.
- ii. Small tentacles not in pouches.

Examples: *Mnemiopsis*, *Bolinopsis*

C. Order: Cestida

- i. Body ribbon shaped and greatly compressed along tentacular plane.
- ii. The two principal tentacles and two of the four comb rows reduced.

Examples: *Cestum*, *Velamen*

D. Order Platyctenida

- i. Body greatly flattened as a result of a reduction in the oral-aboral axis.
- ii. Adapted for creeping
- iii. Comb rows absent or reduced in adult.

Examples: *Ctenoplana*, *Coeloplana*

2. Class: Nuda: Ctenophores without tentacles.

A. Order: Beroida

- i. Body conical or cylindrical, somewhat flattened along the Tentacular plane.
- ii. Mouth muscular.

Example: *Beroe*

III. Pleurobrachia (Sea gooseberry)

- 1. Habit and Habitat:** *Pleurobrachia* is free swimming, transparent and a marine pelagic animal, commonly found in coastal waters. Its size varies from 17-20mm in length. It is biradially symmetrical instead of radially symmetrical.
- 2. Body Structure:** It has a pear shaped body about 5 to 20mm. in diameter, broader at the aboral end and narrower at the oral end (Fig. 1a). A narrow, slit like mouth is present at the oral end, while a balancing organ called statocyst and two anal pores are present at the aboral end. The external surface of the body bears eight rows of transverse plates called meridional bands (costae or comb rows) placed at regular intervals. Each meridional band is present just above the meridional canals originating from the stomach inside the body. Each meridional band bears a series of small horizontally placed plates called comb plates. Each comb plate is made of large cilia fused together at their attached ends on the surface of the body and resembles the teeth of the comb (Fig. 1b, 1c). The cilia present on the comb plates help the animal in swimming. Towards the aboral end there are two tentacular pouches, one on each side of the animal. The two tentacular pouches are deep ectodermal invaginations opening on the surface of the aboral end. They extend into the interior to terminate on opposite sides of the pharyngeal region of the digestive system. Each tentacular pouch has a tentacle attached to it by muscular base. So, there are two tentacles coming out of the body towards the aboral end. Both the tentacles are highly branched and muscular in nature. There is a row of similar lateral filaments along one side of the tentacles. These tentacles can be easily extended and withdrawn in their respective pouches. When extended fully, they are even longer than the animal. The epidermis of each tentacle is equipped with special adhesive cells called colloblasts or lasso cells and not by cnidoblast as in cnidarians.
- 3. Body wall:** The body wall consists of an outer epidermis, an inner gastrodermis, and a thick gelatinous mesoglea. Epidermis bear characteristic cells called colloblast (Fig. 2a). Each colloblast cell consists of a hemispherical, bulbous, sticky head connected to a long, straight filament and a spiral contractile filament. Spirally coiled filament is wound around the axial filament (Fig. 2c). Axial filaments are fixed into the muscular axis of the tentacle and acts like a spring thus protecting the head from being torn away. Bulbous end is produced in to numerous minute papillae. These papillae secrete an adhesive substance so that prey organisms get stuck to the tentacles, which are then retracted and prey is taken inside the mouth. The epithelial walls of the meridional canals include cells specialized for light production (bioluminescent photocytes), osmoregulation (rosettes),

endocytosis and intracellular digestion, gametogenesis (gonads), and fluid transport (monociliated cells).

The muscles of ctenophores develop from amoeboid cells found within the mesogloea. Therefore, the resulting muscle fibers actually are located in the mesogloea layers suggesting that ctenophores may be triploblastic. They have smooth muscle cells which have originated from mesenchymal cells, but lack the epitheliomuscular cells which are present in cnidarians. Stomach and all the gastrovascular canals are lined with ciliated, secretory and phagocytic cells.

4. **Food and feeding:** They are voracious predators like other ctenophores. They capture their food by extending two long, tentacular arms. Prey is caught by becoming stuck on the adhesive colloblasts that line the tentacular branches. Once the prey is caught, the comb jelly retracts its arms and gets the food into its mouth. The food of this predator consists of fish eggs and larvae, molluscan larvae and adults, zooplanktons and even other ctenophores. Therefore, they also have a substantial role in controlling the population of other zooplankton. They also have a commercial importance to fisheries as they feed on larvae and eggs of economically important fish species.
5. **Gastrovascular system:** It starts with the mouth present at the oral end of the animal. Mouth leads into a flattened, highly folded pharynx lined by epidermis. The pharynx runs about two-third of the distance and narrows down to the stomach near the center of the animal. From the stomach arises an extensive system of canals (Fig. 3). It includes 8 meridional canals inside the body, bearing 8 comb plates on the external surface, 2 tentacular canals around the tentacles, 2 pharyngeal canals running parallel to pharynx, a pair of transverse canals joining comb plates, and an aboral canal which opens out via two anal pores at the aboral end of the body. Stomach and all the gastrovascular canals are lined with ciliated, secretory and phagocytic cells. All these canals are meant for the intracellular digestion, and also act as the distributing system for the food, water and oxygen.

Extracellular digestion starts in the pharynx with the secretion of hydrolytic enzymes. Partially digested food moves into the stomach. From the stomach, food is circulated into the canal system with the help of ciliary current. Partially digested food is phagocytosed or pinocytosed and digestion is completed intracellularly (within the cells lining the gastrodermal canals). Undigested food passes through the aboral canal and is thrown out through one of the two anal pores present at the aboral end of the body.
6. **Bioluminescence:** They exhibit luminescence. Light is produced in the walls of the meridional canals which appear to be emitted from the comb plates present on the meridional canals.
7. **Locomotion:** Locomotion is performed by the activity of comb rows having partially fused long cilia. The power stroke of the cilia of each comb plate beat towards the aboral surface of the animal, and the ctenophore swims with the mouth forward. Ctenophore locomotion depends largely upon the coordinated activities of the comb rows. Some ctenophores use these comb rows for feeding and to run away from the predators. Statocyst also plays an important role in coordinating activities of the comb plates and comb rows respectively.
8. **Nervous system:** Nervous system is in the form of net work of nerve fibers similar to those of the hydrozoan polyps. There is an epidermal net work of nerves and nerve cells underneath the epidermis. This nerve net is specifically better developed beneath the comb rows. Sub-epidermal nerve net plays an important role in coordinating the

activities of the comb plates and comb rows. For example, mechanical stimulation of the oral end of the animal results in a sudden reversal of the ciliary beat in all comb rows. This response is visible even if the statocyst is removed

- 9. Sense organ:** An organ of equilibrium called statocyst is present at the aboral end and thus also called as an aboral organ. It contains a calcareous statolith. The statolith is situated on four tufts of balancers (Fig. 4a, b). Each balancer may consist of several hundred cilia. From each balancer arise two ciliary grooves. Each ciliary groove is attached to the posterior ends of the comb rows. Therefore, there are eight ciliary grooves attached to the eight meridional canals respectively. When the body of the animal is displaced from its vertical orientation, pressure of otolith on one or two of the balancers are increased. With the result, beating rate of its cilia gets changed. This change in rate of beating of cilia of otolith is transmitted to the cilia of the ciliary groove and then to the cilia of the comb plates. The cilia of the comb plates beat faster and return the animal to its vertical position. This change in orientation is transmitted mechanically to the animal and not by the neurons.

Mechanism to maintain equilibrium: Animal is displaced by water currents → pressure of statolith on any one or two balancer is increased → beating rate of cilia of balancer is changed → cilia of ciliary groove beats → cilia of comb plates beats faster → animal moves and restore its vertical position.

- 10.Respiration:** There is no special organ meant for respiration. Exchange of gases takes place through general surface of the animal by a simple process of diffusion. As food enters within the body through mouth, a ciliary current is maintained within the body which helps in oxygenation of the body too. In addition carbon dioxide is diffused of the body in the outgoing water through mouth.
- 11.Reproduction:** It is hermaphrodite i.e. it bears both male and female sex organs. Gonads of both sexes are located in the lining of the meridional canals (gastrovascular canals). Each of which has an ovary extending along the whole length of one side and a testis along the whole length of the opposite side. The sex organs are so arranged that in adjacent canals those of the same sex face one another. Gametes are first released through numerous small gonopores in the meridional canal, then into the digestive tract, and finally released in the sea water through mouth.
- 12.Fertilization and Development:** The mature eggs and sperms are released out in the water through mouth. The mature egg consists of a central mass of vacuolated yolk and a peripheral layer of protoplasm containing the nucleus. The fertilization is external and cleavage starts soon after fertilization. Cleavage is highly determinate i.e. cell fates are fixed at the first cell division. Gastrulation is achieved by epiboly (a process in which dividing micromeres spreads over the macromeres) or invagination (a process in which macromeres start moving inside the blastocoel and forms the inner layer). Mesogloea is secreted later on in between the two layers. The gastrula develops into a characteristic cydippid larva which resembles the adult. The body of cydippid larva is spherical and it has 8 comb rows, a mouth, a statocyst, two tentacles and it resembles the adult. Initially, eight parallel comb rows are clustered interradially. During development, the comb rows lengthen and separate. The tentacles base invaginates to form a tentacular sheath and tentacular canal. The lateral filaments also develop on the tentacles. That is how cydippid larva grows into adult. Cydippid larva is considered as a true larval stage besides the fact that it undergoes a gradual change to metamorphose into an adult.

13.Affinities: The Ctenophores are of considerable zoological interest. It has many characters in common with cnidarians but still differ from them and other group of animals in many respects, which are being discussed below (also see Table 1).

A. Features of ctenophores which they share with cnidarians:

- i. The radial and tetramerous symmetry of the body like the medusa of the hydrozoans.
- ii. Presence of gelatinous mesogloea within ectoderm and gastroderm.
- iii. Arrangement of parts along oral-aboral axis.
- iv. Presence of branching gastrovascular canals and absence of coelom.
- v. Presence of tentacles and statocyst.
- vi. Endodermal nature of gonads.
- vii. Presence of nematocysts in the ctenophore *Euchlora rubra*, which possess them but it is reported that they are derived from the cnidarians it has used as a prey.

B. Ctenophores differ from the cnidarians in the following respects:

- i. Presence of 8 meridional rows of comb plates arranged in oral –aboral axis.
- ii. Origin of muscle cells from the mesoderm or mesenchyma.
- iii. Special adhesive cells called colloblasts instead of nematocysts of cnidarians.
- iv. Only two tentacles coming out from the tentacular sheaths instead of many tentacles present on the periphery of the medusa.
- v. Position of tentacles towards the aboral surface shows biradial symmetry.
- vi. Only one statocyst is present at the aboral end in contrast to medusa in which there are 8 statocysts present at the base of the tentacle.
- vii. Digestive system is better organized, with mouth on oral end, and two anal openings at the aboral end, while cnidarians have only mouth but no anal opening.
- viii. Determinate type of cleavage, which shows that the organ forming areas are determined at a very early stage (See table 1).
- ix. Presence of distinct larval stage, the cydippid larva, and absence of planula larva of cnidarians.
- x. Absence of polymorphism which is exhibited by cnidarians.
- xi. Always found singly in contrast to hard, colonial structures like corals present in cnidarians.

As we have seen above, on one hand comb jellies are related to hydrozoans, scyphozoans and anthozoans, on the other hand, they may be related to turbellarians because of few characters common to them. The phylogenetic position of ctenophores has been and still is in dispute. They have a pair of anal pores which have sometimes been considered as homologous with the anus of bilateral animals like worms, snails etc.

C. Affinities with Platyhelminthes:

- i. Presence of dorso-ventrally and uniformly ciliated body as in *Coeloplana* and *Taenoplana*.
- ii. Presence of creeping forms like *Coeloplana* and *Taenoplana*.
- iii. Presence of branched gastrovascular canals and thus are considered related to Polycladida, which are supposed to be ancestral to the remaining flat worms.
- iv. Early cleavage, like segmentation and gastrulation are similar.

Advancement of ctenophores over cnidarians: Among the Cnidarians, the Ctenophora seems to be more closely related to *Hydroctena*, a trachyline from which it arose along with the Scyphozoa and Actinozoa. Since among the turbellarians, acoela and not polycladida are regarded more primitive, the theory of the affinity with the Turbellarians does not seem to be well founded. Possibly they are not directly in the line of evolution of the higher animals at all, but indicate to us how morphological differentiation has taken place by the development of the mesenchyma, bilateral symmetry and the determinate type of development.

There is no doubt that the ctenophores are much more advanced than the cnidarians. This is reflected by the nature of the development, the existence of separate muscle cells and their mode of origin and the presence of a permanent aboral nervous region. These features have led some scientists to regard the ctenophores as the ancestors of the turbellarians. They found support for their hypothesis in the aberrant

Forms of the Ctenoplanida which are also dorso-ventrally flattened and sometimes uniformly ciliated, creeping forms like *Coeloplana*, *Taenoplana* etc. On account of their branched gastrovascular canals, they were considered related to the polycladida, which were thus regarded to be primitive to the remaining flat worms. An evolutionary chain was thus contemplated consisting of the cnidaria, ctenophora, polycladida and finally other flat worms.

Table 1: Features highlighting similarities and differences between Cnidarians and Ctenophores.

S.NO.	FEATURES	CNIDARIA	CTENOPHORES
1.	Habitat	Fresh water and marine water	Exclusively marine
2.	Colonial, solitary	Both solitary and colonial	Always solitary
3.	Polymorphism	exhibited by class hydrozoa	Completely absent
4.	Resemblance	Polyp/Medusa	Like Medusa
5.	Tentacles	Hollow, many, surrounding mouth, cannot be retracted within.	Solid, two, present away from mouth, can be retracted within the tentacular sheath.
6.	Body wall	Diploblastic i.e. ectoderm and gastroderm with gelatinous mesogloea in between	Diploblastic, with gelatinous mesogloea having amoebocyte cells.
7.	Statocyst	Many(8) present at the margins of medusa	Only one is present at the aboral end. Also called apical organ.
8.	Nematocyst (Stinging cell)	Present in ectoderm and on tentacles. Paralyze the prey	Absent , if present, borrowed from other cnidarians
9.	Colloblasts (Adhesive prey capturing cells)	Absent	Colloblasts are present in the ectoderm and on tentacles. Release mucous and sticks the prey.
10.	Muscles	Present in mesogloea	Present in gastrodermis
11.	Ciliary cells	Monociliated	Multiciliated
12.	Digestive System	Gastrovascular canals, opens only by mouth, no anus.	Gastrovascular canals open by mouth and anus.
13.	Comb plates	Completely absent	8 comb rows of partially fused ciliary comb plates present.
14.	Swimming	By jet propulsion	By coordinated activities of partially fused cilia in various comb rows.
15.	Sex organs	Hermaphrodite	Dioecious/Gonochoristic(having separate sexes)
16.	Egg yolk	Alecithal(no yolk), microlecithal(little yolk)	Lecithal(yolk present) or centrolecithal(yolk in centre)
17.	Cleavage	Inderminate(cell fates are not decided)	Determinate (cell fates are fixed at the 1 st cell division.
18.	Gastrulation	Delamination, epiboly or invagination	Epiboly or invagination
19.	Common larval stage	Planula larva (a free swimming, double layered, ciliated larva)	Cydippid larva (8 comb rows, a statocyst, and 2 tentacles) resembles adult.

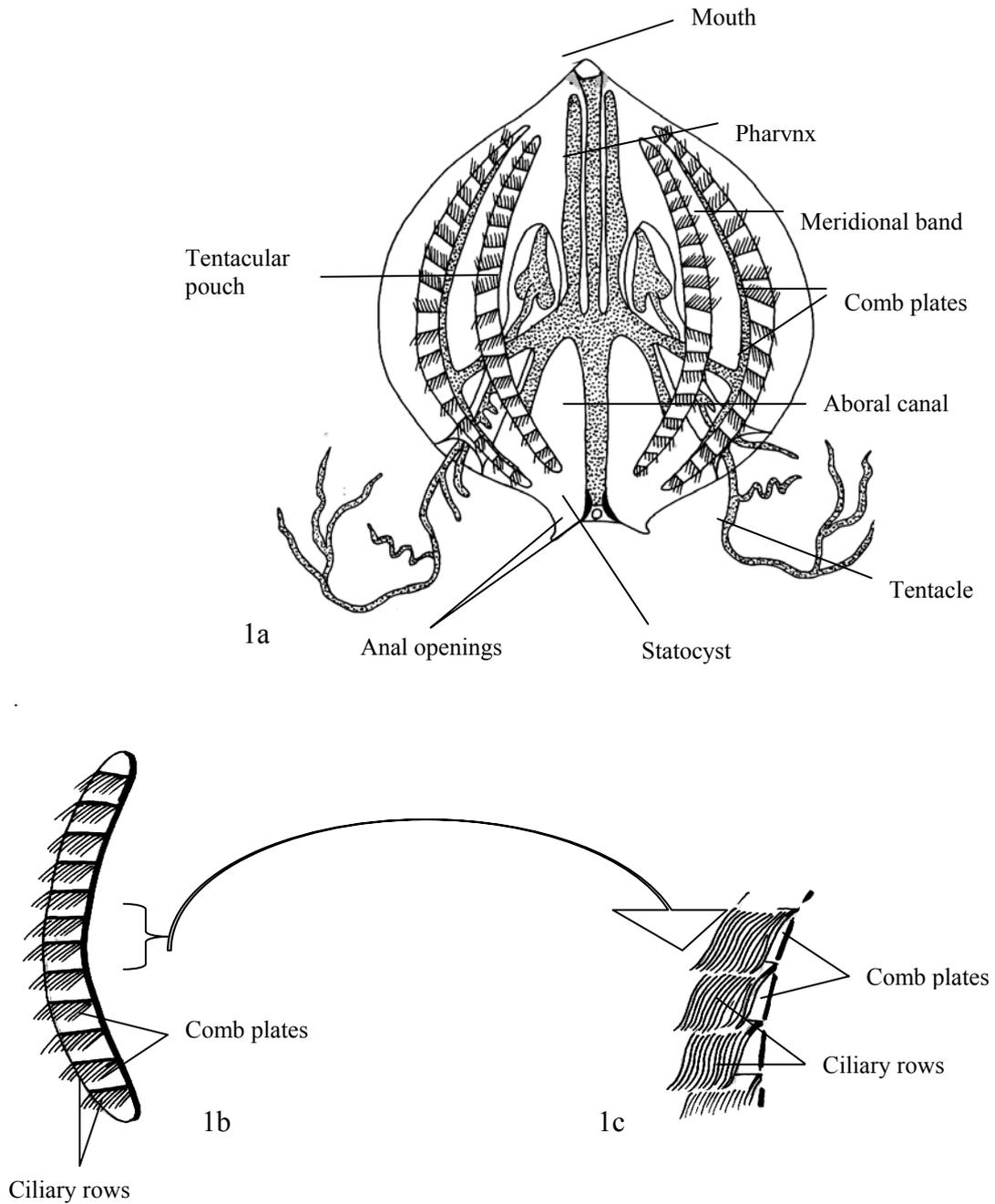


Fig.1a Side view of *Pleurobrachia*. Fig. 1b. A single meridional band. Fig. 1c. Comb plates enlarged

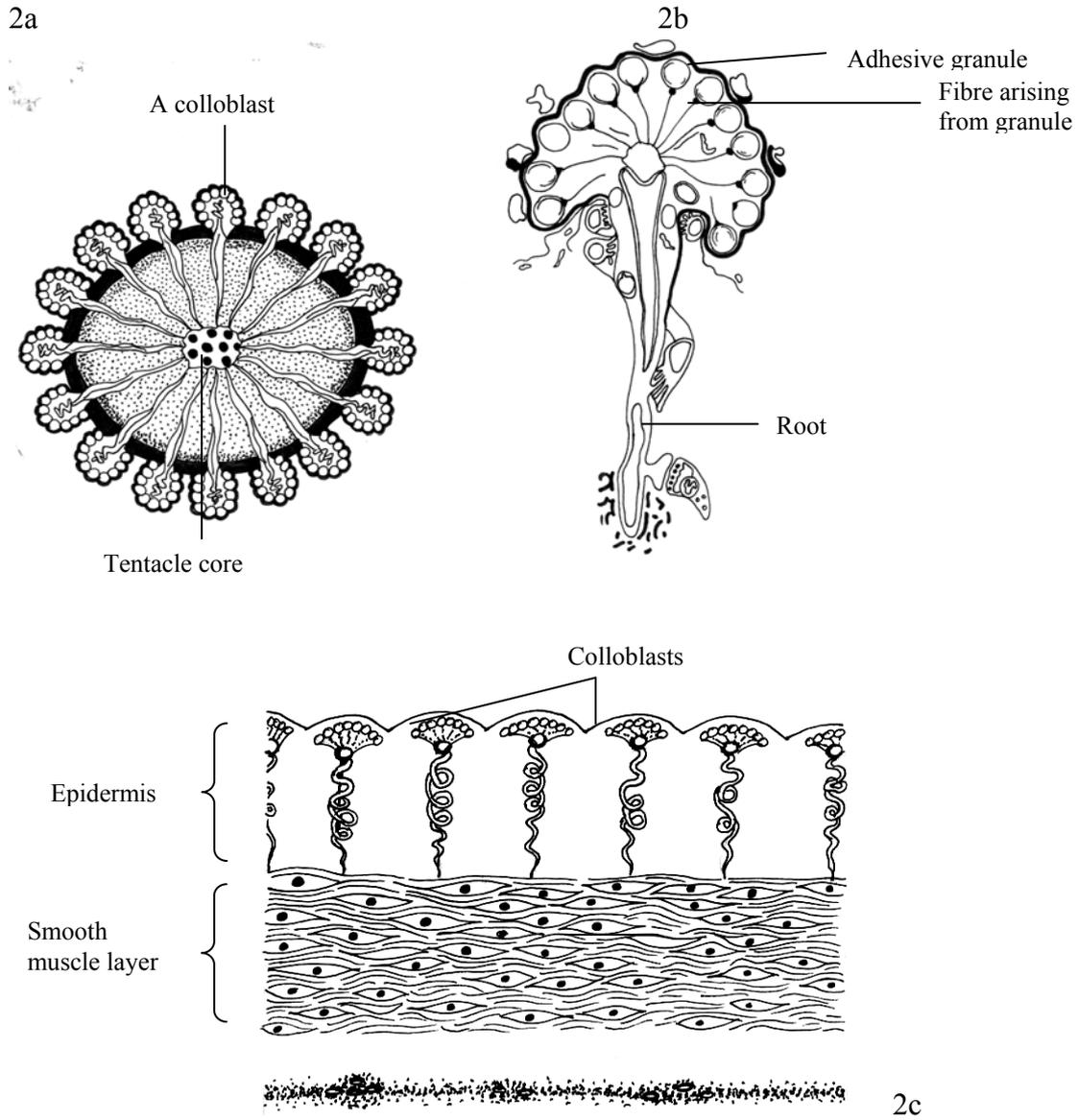


Fig. 2a. Transverse section through a tentacle
 2b. A single colloblast
 2c. A section of the epidermis showing arrangement of Colloblasts

3

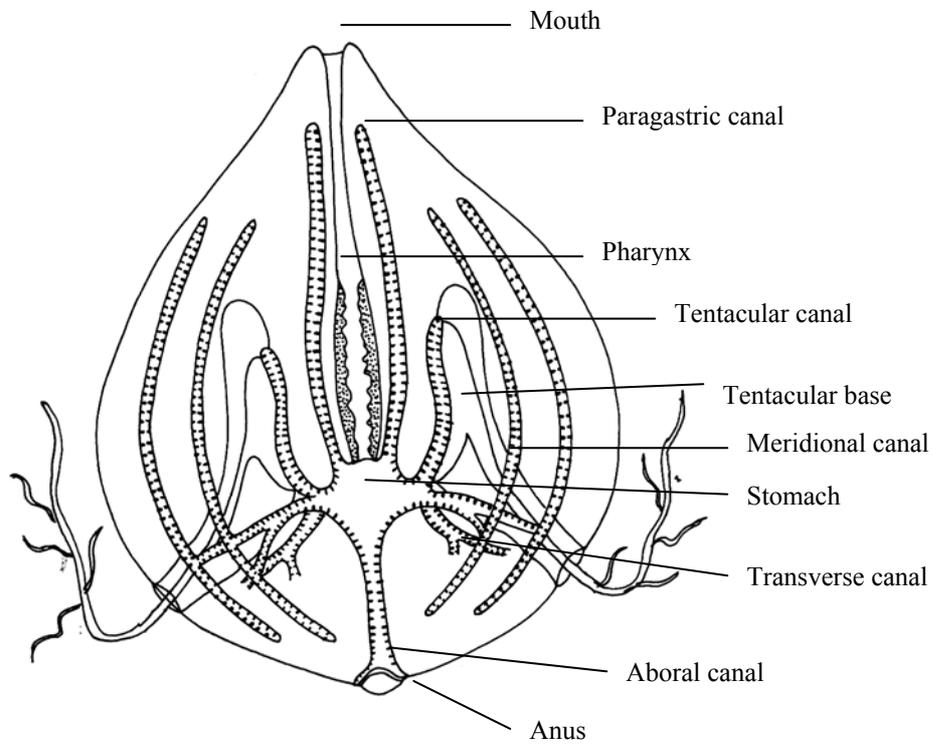
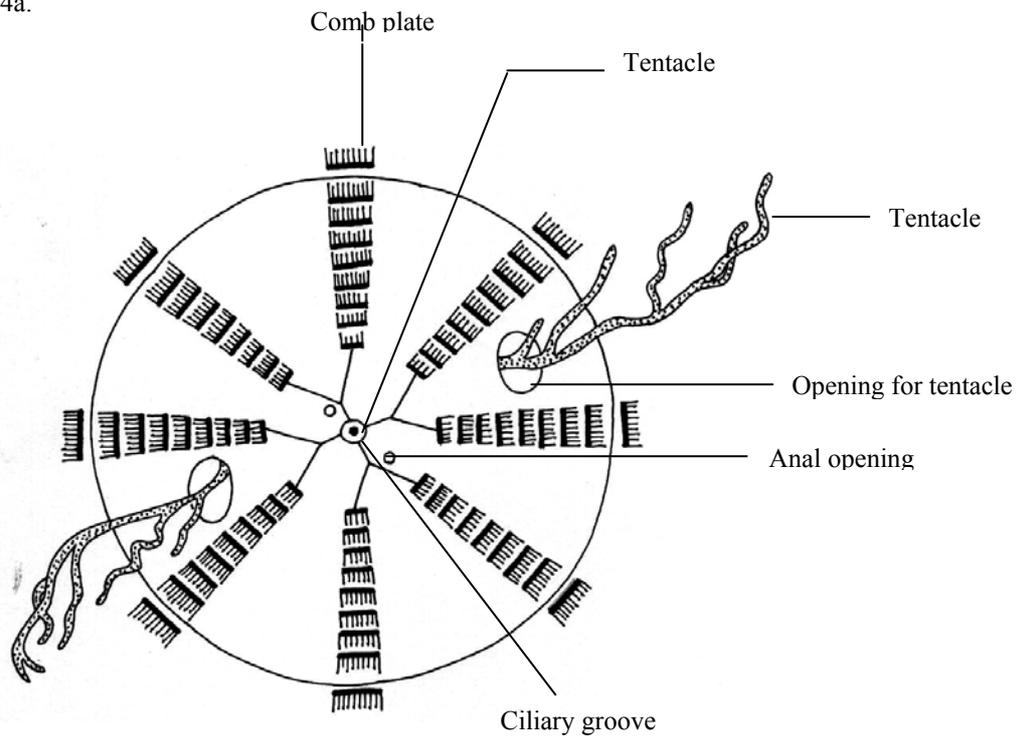


Fig. 3. Digestive system of *Pleurobrachia* shown with mouth upside.

4a.



4b.

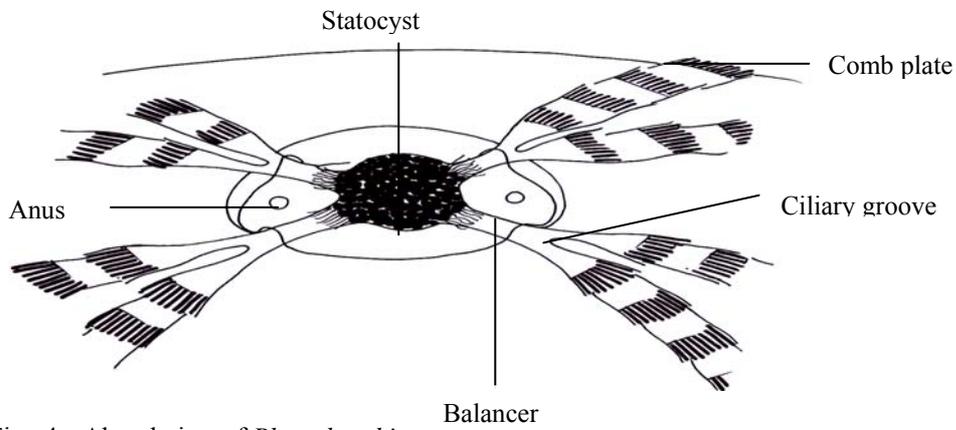
Fig. 4a. Aboral view of *Pleurobrachia*

Fig. 4b. Enlarged aboral view of the ctenophore to show statocyst.

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