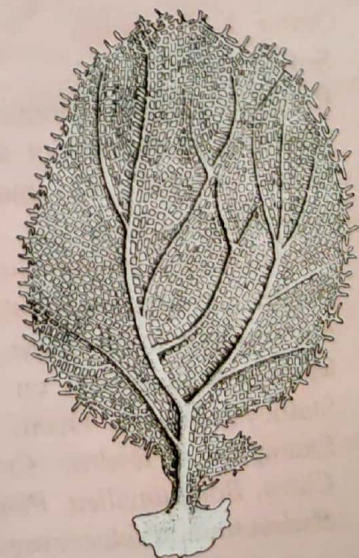
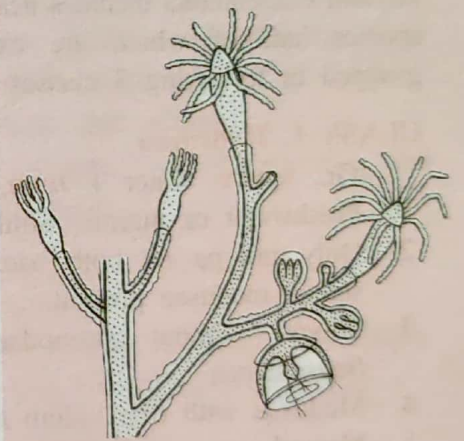


Coelenterata : Characters, Classification and Types

GENERAL CHARACTERS

1. All aquatic, some freshwater, mostly **marine**.
2. Solitary or colonial. Sedentary or free-swimming.
3. Symmetry **radial** or **biradial** about a longitudinal oral-aboral axis.
4. Body organization of **cell-tissue grade**. Cells mostly scattered and specialized for different functions. Some cells form tissues like **nerve net** or **nervous tissue**.
5. Exoskeleton chitinous (perisarc) or calcareous (corals).
6. Body wall **diploblastic** with two cellular layers —outer epidermis and inner gastrodermis — with a gelatinous acellular mesogloea in between. In advanced types mesogloea with cells and connective tissue, hence **triploblastic**.
7. Two types of individuals occur, attached **polyps** and free-swimming **medusae**. Some species are notable for **polymorphism** or variety of forms.
8. Mouth of polyps and bell margin of medusae often encircled by short and slender **tentacles**.
9. Coelom and respiratory, circulatory and excretory systems wanting.
10. Muscular system includes longitudinal and circular fibres formed by epithelio-muscle and endothelio-muscle cells.
11. A single internal cavity, lined with gastrodermis, called **gastrovascular cavity** or **coelenteron**, into which mouth opens. Anus is absent.
12. Digestion intracellular as well as extracellular.
13. One or both body layers with peculiar stinging cell organelles or **nematocysts**, which serve for adhesion, food capture, offence and defense.



21. (Z-1)



14. Nervous system primitive, consisting of a diffuse **nerve net**. Central nervous system absent.
15. Sensory organs form **ocelli** and **statocysts**.
16. **Asexual reproduction** by budding or fission. **Sexual reproduction** by ova and sperms. Sexual forms monoecious or dioecious.
17. Development includes a free-swimming ciliated **planula larva**.
18. Life-history illustrates a regular alternation between the asexual polypoid stage and a sexual medusoid stage. True alternation of generations absent.

CLASSIFICATION

Phylum Coelenterata includes nearly 17,702 known species half of which are extinct. These are grouped in following 3 classes :

CLASS 1. Hydrozoa

(Gr., **hydra**, water + **zoon**, animal)

1. Freshwater or marine. Solitary or colonial.
2. Only polyps or both asexual polyps and sexual medusae present.
3. Polyps without stomodaeum and septa (mesentery).
4. Medusae with true velum (**craspedote**).
5. Mesogloea non-cellular.
6. Gonads epidermal. Sex cells shed directly on outside.

Order 1. Hydroida

1. Solitary or colonial.
2. Polypoid stage predominant.
3. Medusae short-lived or absent.
4. Sense organs of medusae exclusively ectodermal.

Suborder I. Anthomedusae (*Gymnoblastea*)

1. Polyps and blastostyles **athecate**, i.e., perisarc not forming hydrothecae and gonothecae.
2. Medusa with gonads on manubrium.
3. Statocysts absent. Ocelli present in medusa. Examples : *Hydra*, *Ceratella*, *Tubularia*, *Clava*, *Bougainvillea*, *Pennaria*, *Eudendrium*, *Hydractinia*, *Podocoryne*, etc.

21. (Z-1)

Suborder II. Leptomedusae (*Calyptoblastea*)

1. Polyps and blastostyles **thecate**, i.e., with hydrothecae and gonothecae, respectively.
2. Medusa with gonads on radial canals.
3. Both statocysts and ocelli present in medusa. Examples : *Obelia*, *Sertularia*, *Campanularia*, *Plumularia*, *Aglaophenia*.

Order 2. Trachylina

1. Medusoid stage large, dominant, free-swimming and may develop directly from fertilized egg.
2. Polypoid stage reduced or absent.
3. Marginal sense organs or statocysts with endodermal statoliths.

Suborder I. Trachymedusae

1. Tentacles inserted above bell margin.
2. Gonads develop on radial canals. Examples : *Gonionemus*, *Craspedacusta*.

Suborder II. Narcomedusae

1. Tentacles arise between bell margin and vertex of exumbrella.
2. Gonads present on manubrium or on stomach floor. Examples : *Cunina*, *Cunarcha*, *Polycolpa*.

Order 3. Hydrocorallina

1. Fixed, colonial polypoid Hydrozoa in which coenosarc secretes a massive exoskeleton of calcium carbonate.
2. Polyps **dimorphic**, with slender **dactylozooids** and short plump **gastrozooids**.

Suborder I. Milleporina

1. Dactylozooids hollow, with capitate tentacles.
2. Medusae free and devoid of mouth, digestive canals and tentacles. Example : *Millepora*.

Suborder II. Stylasterina

1. Dactylozooids solid, without tentacles.
2. Gonophores reduced to sporosacs. Medusae not free. Example : *Stylaster*.

Order 4. Siphonophora

1. Pelagic colonial Hydrozoa showing extreme polymorphism of zooids.
2. Polyps without oral tentacles.
3. Medusae incomplete and rarely freed.



Suborder I. Calycophora

1. Pneumatophore absent.
 2. Upper end of colony has one or more swimming bells (nectophores).
- Examples : *Diphyes*, *Praya*, *Abyla*.

Suborder II. Physophorida

- Upper end of colony forms a large gas-filled float (pneumatophore).
- Examples : *Physalia*, *Halitemma*, *Stephalia*.

Order 5. Chondrophora

1. Pelagic, polymorphic polypoid colony.
 2. Upper end forms a chitinous, gas-filled, oval float (pneumatophore).
 3. Gonozooids produce free medusae.
- Examples : *Porpita*, *Veella*.

CLASS 2. Scyphozoa

1. Exclusively marine and solitary forms.
2. Medusa stage dominant. Polyp stage reduced or absent.
3. Gastrovascular cavity with gastric pouches and endodermal gastric filaments. No stomodaeum.
4. Medusa **acraspedote**, without distinct velum.
5. Mesogloea extensive, gelatinous, with fibres and cells.
6. Gonads gastrodermal. Sex cells released in digestive cavity.

Order 1. Stauromedusae (Lucernariida)

1. Bell goblet or trumpet-shaped.
 2. Sessile, attached by an aboral stalk.
 3. No marginal sense organs or tentaculocysts.
- Examples : *Lucernaria*, *Halidystus*.

Order 2. Cubomedusae (Carybdeida)

1. Bell cubical, with 4 flattened sides.
 2. Four perradial tentaculocysts present.
- Examples : *Charybdea*, *Chiropsalmus*.

Order 3. Coronatae

1. Bell conical, divided by a deep circular coronary groove.
 2. Tentacles long, borne on pedalia.
 3. Four to sixteen tentaculocysts present.
- Examples : *Periphylla*, *Pericolpa*.

Order 4. Discomedusae (Semaestomae)

1. Flat saucer or disc-like umbrella.
2. Eight tentaculocysts present.

3. Square shaped mouth extending into 4 long oral arms.
- Examples : *Aurelia*, *Pelagia*, *Cyanea*, *Chrysaora*.

Order 5. Rhizostomae

1. Bell usually hemispherical, without marginal tentacles.
 2. Typically 8 or more tentaculocysts.
 3. No central mouth. Oral arms fused with several small mouths.
- Examples : *Rhizostoma*, *Cassiopeia*, *Stomolophus*.

CLASS 3. Anthozoa (Actinozoa)

(Gr., **anthos**, flower + **zoios**, animal)

1. Exclusively marine. Solitary or colonial.
2. All polyps, no medusa.
3. Mouth leads into a tubular stomodaeum.
4. Gastrovascular cavity subdivided by 8 or more septa or mesenteries.
5. Mesogloea stout and cellular.
6. Mesenteries with nematocysts and gastrodermal gonads.

Subclass 1. Octocorallia (Alcyonaria)

1. Exclusively colonial.
2. Polyps with 8 pinnate tentacles and 8 septa.
3. Gullet with one ventral siphonoglyph.

Order 1. Stolonifera

1. Polyps arising independently from a creeping mat or stolon.
 2. Skeleton of calcareous tubes or separate calcareous spicules or absent.
- Examples : *Tubipora* (organ pipe coral), *Clavularia*.

Order 2. Telestacea

1. Lateral polyps on simple or branched stems arising from a creeping base.
 2. Skeleton of calcareous spicules.
- Example : *Telesto*.

Order 3. Alcyonacea

1. Polyps proximally embedded in a fleshy mass or coenenchyme.
 2. Skeleton of separate calcareous spicules.
- Examples : Soft corals. *Alcyonium*.

**Order 4. Coenothecalia**

1. Polyps embedded and connected by solenial tubes.
2. Skeleton massive, calcareous and blue-green from iron salts.

Example : *Heliopora* (blue coral).

Order 5. Gorgonacea

1. Colony usually of plant-like branching form bearing short polyps.
2. Axial skeleton composed of horn-like **gorgonin**, separate or fused calcareous spicules, or both.

Examples : *Gorgonia* and *Corallium*.

Order 6. Pennatulacea

1. Colony elongated, sessile. Lower part embedded in mud. Upper part consists of a very long axial polyp with lateral branches bearing dimorphic polyps.
2. Axial skeleton of separate calcareous spicules or horny substance.

Examples : *Pennatula*, and *Pteroeides*, (Sea pens), *Renilla* (sea pansy).

Subclass II. Hexacorallia (Zoantharia)

1. Solitary or colonial.
2. Tentacles usually unbranched, numerous but never 8.
3. Gullet commonly with 2 siphonoglyphs.

Order 1. Zoanthidea

1. Solitary or colonial. No skeleton. Mostly epizoic.
2. Polyps small and usually united by basal stolons.
3. Only single ventral siphonoglyph present.

Examples : *Zoanthus*, *Epizoanthus*.

Order 2. Actiniaria

1. Simple, often large-sized, solitary anemones.
2. Body muscular, often with an aboral pedal disc.
3. Skeleton absent.
4. Tentacles and mesenteries are numerous.
5. Siphonoglyphs usually one or two.

Examples : Sea-anemones. *Metridium*, *Edwardsia*, *Adamsia*, *Actinia*, *Urticina*.

Order 3. Ceriantharia

1. Long, solitary, anemone-like forms, without pedal discs and skeleton.
2. Tentacles simple, numerous, arranged in two whorls —oral and marginal.
3. Siphonoglyphs single and dorsal.

Example : *Cerianthus*.

Order 4. Antipatharia

1. Colonial and tree-like.
2. Tentacles and mesenteries comparatively few (6-24) in number.
3. Skeleton as branched, chitinous axis.
4. Siphonoglyphs two.

Examples : Black corals. *Antipathes*.

Order 5. Madreporaria

1. Solitary or colonial.
2. Exoskeleton hard, compact, often massive, calcareous.
3. Polyps small, living in cup-like cavities on exoskeleton.
4. Siphonoglyph absent and muscles feeble.

Examples : True or stony corals. *Flabellum*, *Fungia* (mushroom coral), *Astrangia*, *Astraea* (star coral), *Favia*, *Oculina*, *Acropora* or *Madrepora* (stag horn coral), *Meandrina* or *Meandra* (brain coral).

Subclass III. Tabulata

Extinct colonial anthozoans with heavy calcareous skeletal tubules containing horizontal platforms or tubulae.

Examples : *Favosites*, *Halysites*.

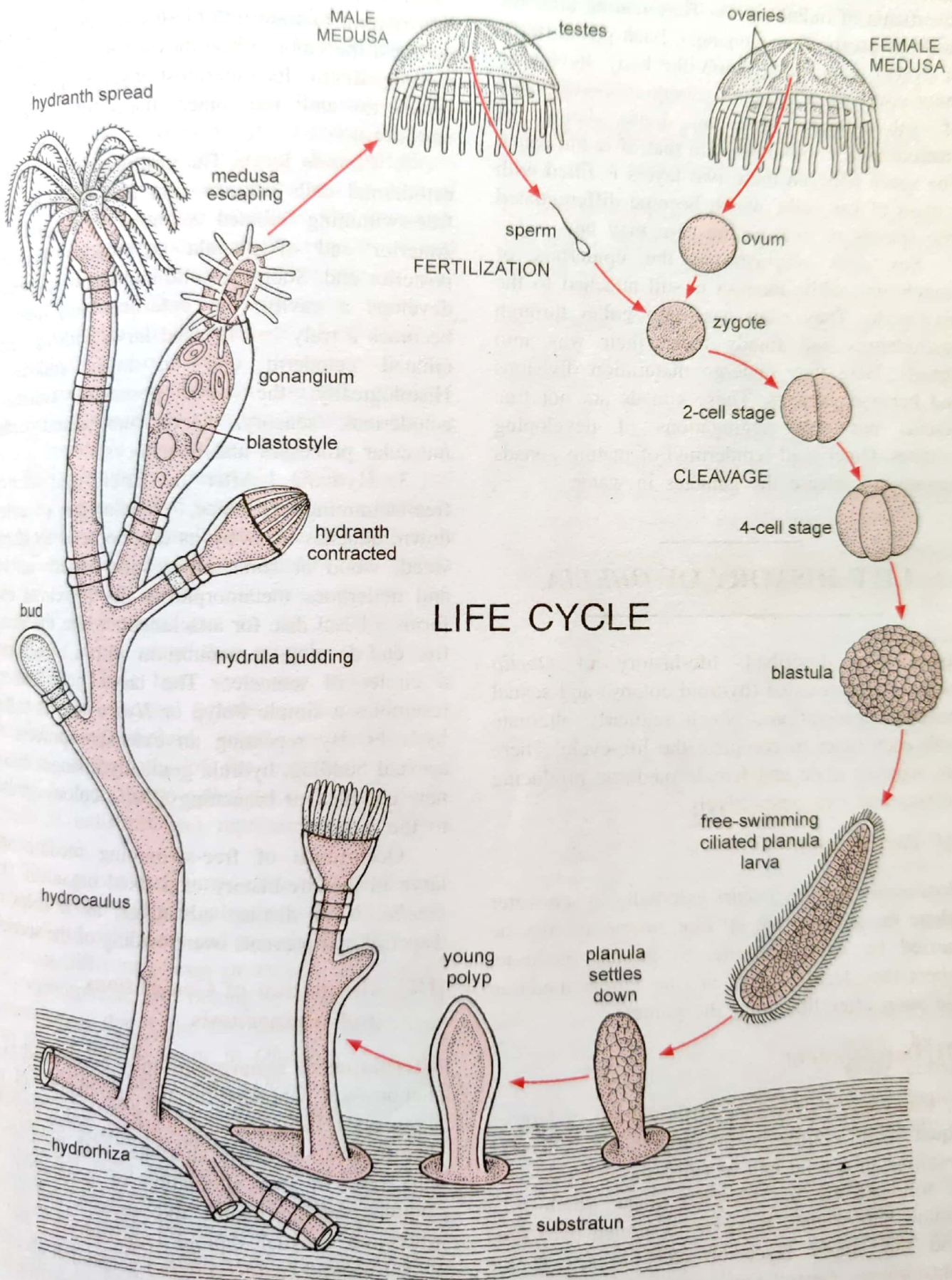
OTHER TYPES OF COELENTERATA

1. **Bougainvillea.** *Bougainvillea* is a colonial hydrozoan which forms a tree-like branching colony. Creeping hydrorhiza gives off vertical stems or hydrocaulii, bearing polyps or hydranths and gonophores or medusae. Hydranth possesses a single whorl of filiform tentacles and is not enclosed within hydrotheca. Blastostyles do not



ASEXUAL STAGE
(SESSILE HYDROID COLONY)

SEXUAL STAGE
(FREE-SWIMMING MEDUSAE)



LIFE CYCLE

Fig. 11. Stages in the life cycle of *Obelia*.

20. (Z-1)



radial canal. Gonads are formed as ventral diverticula of radial canals. They mature after the medusae escape from gonangia. Each gonad (testis or ovary) is an ovoid, knob-like body, having an outer covering of epidermis, continuous with that of sub-umbrella, and an inner lining of gastrodermis, continuous with that of radial canal. The space between these two layers is filled with a mass of **sex cells**, which become differentiated into sperms or ova, as the case may be.

Sex cells originate in the epidermis of manubrium, while medusa is still attached to the blastostyle. They soon pass into gullet through gastrodermis and finally make their way into gonads. Here they undergo maturation divisions and become gametes. These gonads are not true gonads but only aggregations of developing gametes. Outer wall (epidermis) of mature gonads ruptures to release the gametes in water.

LIFE HISTORY OF OBELIA

As already described, life-history of *Obelia* includes both asexual (hydroid colony) and sexual (medusa) generations, which regularly alternate with each other to complete the life-cycle. There are separate male and female medusae producing sperms and ova, respectively.

[I] Fertilization

Fertilization usually occurs externally in sea-water where the gametes are set free, or sperms may be carried by water currents to female medusae, where they fertilize eggs *in situ*. Parent medusae die soon after liberating the gametes.

[II] Development

1. Cleavage. Fertilized egg or **zygote** undergoes equal and complete or holoblastic cleavage resulting in a solid ball of cells, the **morula**. This is followed by the **blastula** stage which is a hollow ball of cells. Its cavity is termed **blastocoel** and the single layer of cells lining it, the **blastomeres**. Gastrulation occurs by two processes. First, the inner surface of blastomeres cut off new

cells into blastocoel. This is called **delamination**. Second, cells detach from one pole (**unipolar ingression**), migrate into blastocoel and finally fill it. Thus, the embryo becomes a **solid gastrula** or **stereogastrula**. Its outermost layer is known as **ectoderm** and the inner mass of cells as **endoderm**.

2. Planula larva. The gastrula elongates, the ectodermal cells acquire cilia and an elongated free-swimming ciliated **planula larva** results. Anterior end of planula is broader than its posterior end. Soon the solid endoderm splits and develops a cavity, the **enteron**. Now planula becomes a truly **two-layered** larva with an outer ciliated ectoderm and an inner endoderm. Histologically, the larva possesses columnar ectodermal, sensory, nerve and gland cells, muscular processes and nematocysts.

3. Hydrula. After a brief and active free-swimming existence, planula larva settles down, attaches itself by its anterior end to stone, weed, wood or some other solid object in sea and undergoes metamorphosis. Its proximal end forms a basal disc for attachment, while the distal free end develops a manubrium with a mouth and a circlet of tentacles. The larva now closely resembles a simple Polyp or *Hydra* and is called **hydrula**. By repeating an extensive process of asexual budding, hydrula gradually changes into a new complex of branching *Obelia* colony similar to the parent.

Occurrence of free-swimming medusa and larva in the life-history of a fixed organism, like *Obelia*, is of distinct advantage, as it helps in dispersal and prevents overcrowding of the species.

[III] Alternation of Generations and Metagenesis

Alternation of generations may be defined as a phenomenon whereby, in the life-history of an organism, a **diploid asexual phase** and a **haploid sexual phase** regularly alternates with each other. This type of true alternation of generations is common among plants, like mosses and ferns, where an asexual diploid (**saprophytic**) and a sexual haploid (**gametophytic**) generation alternate regularly in life-cycle. In fern, the plant (**diploid saprophyte**) produces **haploid spores**, which



develop into flat, green, small heart-shaped **haploid gametophytes**. These produce **haploid ova** and **sperms**. After fertilization, they give rise to a new **diploid sporophyte**. Thus completing one life-cycle.

In *Obelia*, life-cycle includes two clearly defined phases : a fixed polypoid phase (hydroid colony) and a pelagic medusoid phase. Hydroid colony has no gonads and reproduces by asexual budding to give rise to medusae. On the other hand, medusae reproduce exclusively by sexual method (ova and sperms) to give rise to new hydroid colonies. This fact apparently seems to have given rise to the idea of **alternation of generations**, also called **metagenesis**, in coelenterates, in which an asexual polypoid generation appears to alternate regularly with a sexual medusoid generation.

But, in *Obelia*, medusoid phase does not represent a true haploid sexual generation, because: (i) Medusa arises from blastostyle (diploid) by a process of asexual budding. It implies that medusa too is a diploid zooid. (ii) Sex cells do not originate in medusa, but in the epidermis of blastostyle, from where they migrate into gonads of medusa. These facts show that medusa does not represent a sexual generation. It is simply a free-swimming diploid zooid specialized for dispersal of gametes of the sedentary hydroid colony. In fact, the so-called sexual generation in *Obelia* is indistinct and represented by haploid gametes only.

Thus, it is clearly impossible to differentiate between sexual and asexual generations in *Obelia*. Asexual hydroid colony and sexual medusa merely represent different phases or zooids, an example of polymorphism, and belong to a single diploid generation, so that a true alternation of generations can not be said to occur in *Obelia*.

In coelenterates (e.g., *Obelia*), a regular alternation between fixed asexual hydroid and free-swimming medusoid phases, both of which are diploid, has been termed **metagenesis** by some workers. But, according to Hyman, concept of metagenesis should be discarded as there are no haploid and diploid generations in coelenterates. According to this view, medusa is regarded to be

a completely evolved coelenterate while polyp is probably a persistent larval stage.

COMPARISON OF POLYP (HYDRANTH) AND MEDUSA

1. Dissimilarities between polyp and medusa.

The main differences between a polyp and a medusa can be summarised as in *Table 1*.

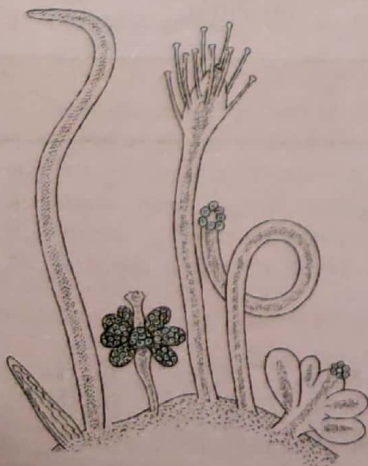
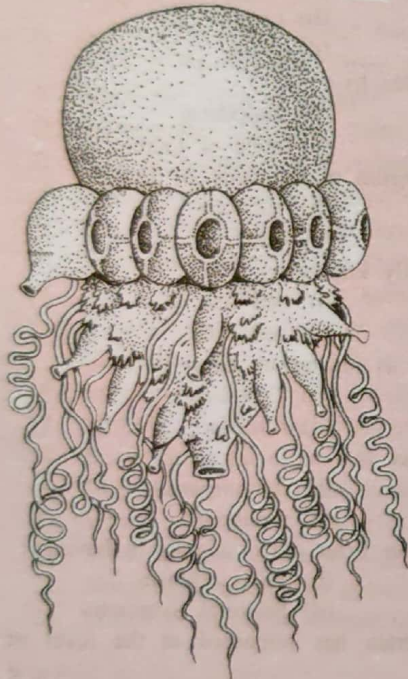
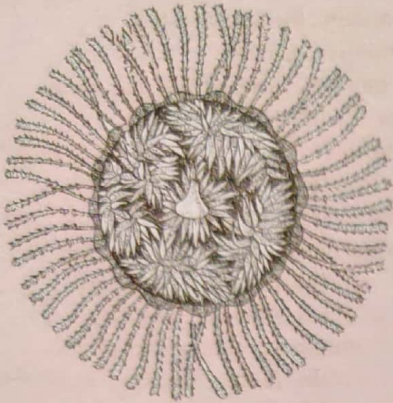
2. Similarities or homology between polyp and medusa. Striking as is the difference between a polyp and a medusa, they are strictly homologous or fundamentally similar structures. The notable features of similarity between polyp and medusa are as given below :

- (1) Body is radially symmetrical.
- (2) Both are diploblastic, derived from two germ layers, ectoderm and endoderm.
- (3) Exumbrellar surface of medusa corresponds with the base of polyp, providing attachment with the parental stem.
- (4) Mouth is homologous in both cases, being situated on a similar process, called manubrium. Anus is absent in both.
- (5) Stomach, radial canals and circular canal of medusa correspond with the gastrovascular cavity of polyp, lined by gastrodermis in both cases and serving for digestion of food.
- (6) Both are carnivorous, capturing and ingesting food with the help of tentacles. Digestion is extracellular as well as intracellular and digested food diffuses throughout body without a circulatory system.

3. Advancement of medusa over polyp.

Free-swimming habit is mainly responsible for the complexity of medusa accompanied by a differentiation of structures lying along certain radii. Thus, medusa shows several morphological advancements over polyp, some of which are as follows :

- (1) Epidermis resembles the epithelium of higher Metazoa, forming a thin, protective and sensitive layer, formed by smaller cells with reduced muscle-tails.



Coelenterata : General Account

POLYMORPHISM

Meaning of Polymorphism

Occurrence in the same species of more than one type of individuals, which differ in form and function, is known as **polymorphism** (Gr., **polys**, many + **morphe**, form). This ensures an efficient division of labour between the several individuals.

Different individuals of a species may remain separate, as represented by various castes in termites, certain ants and cuban snail (*Polymita*). This is also known as genetic **polymorphism**. However, in coelenterates the different individuals or zooids often get united in the form of a colony. Thus, polymorphism is an important feature of hydrozoan colonies which provide some of the best examples.

Two Basic Forms

In Hydrozoa (or coelenterates), which may be single or colonial, there occur two main types of individuals or zooids — **polyps** and **medusae**.

1. Polyps. A polyp has a tubular body with a mouth surrounded by tentacles at one end. Other end is blind and usually attached by a pedal disc to the substratum.

2. Medusa. A medusae has a bowl or umbrella-shaped body with marginal tentacles and mouth centrally located on a projection (manubrium) of the lower concave surface.

Although, polyps are typically sessile, and medusae are generally motile, there exists a homology between the two in their basic features.



Importance of Polymorphism

Polymorphism is essentially a phenomenon of division of labour. Different functions are assigned to different individuals, rather than to parts or organs of one individual. Thus, polyps are concerned with feeding, protection and asexual reproduction, while medusae are concerned with sexual reproduction.

Patterns of Polymorphism

Degree of polymorphism varies greatly in different groups of Hydrozoa.

1. Dimorphic. Simplest and commonest pattern of polymorphism is exhibited by many hydrozoan colonies like *Obelia*, *Tubularia*, *Campanularia*, etc. They have only two types of zooids (individuals). **Gastrozooids** or **hydranths** are concerned with feeding, while **gonozooids** or **blastostyles** with asexual budding forming sexual **medusae** or **gonophores**. Such colonies, bearing only two types of individuals are called **dimorphic**, and the phenomenon is termed **dimorphism**.

2. Trimorphic. Some forms, like *Plumularia*, are **trimorphic**. Besides gastrozooids and gonozooids, they also possess a third type of individuals, the **dactylozooids**. These are functionally non-feeding and defensive polyps bearing batteries of nematocysts.

3. Polymorphic. Coelenterates having more than three types of individuals are called **polymorphic**. A somewhat greater degree of polymorphism is found in the encrusting colony of *Hydractinia* with five types of polyps, each performing a specialized function. These are : (i) **gastrozooids** for feeding, (ii) **spiral dactylozooids** for protection, (iii) long sensory **tentaculozooids** with sensory cells, (iv) **skeletozooids** as spiny projections of chitin, and (v) **gonozooids** or reproductive individuals, bearing male or female gonophores (sporosacs) or medusae for sexual reproduction.

Extreme examples of polymorphism are seen in the pelagic or swimming colonies of the orders Siphonophora (*Diphyes*, *Halistemma*, *Stephalia*, *Physalia*) and chondrophora (*Porpita*, *Velevella*). As

in *Hydractinia*, both polypoid and medusoid individuals, specialized for various vital functions, occur in the same colony. Polymorphism reaches its peak in siphonophora.

(a) Modifications of polyps. **Polypoid** individuals include :

- (1) **Gastrozoid** or feeding polyp with a mouth and a long tentacle.
- (2) **Dactylozoid** or protective polyp without mouth and usually with a long basal tentacle.
- (3) **Gonozoid** or reproductive polyp which produces sexual medusae or gonophores.

(b) Modifications of medusae. The **medusoid** individuals are of the following types :

- (1) **Nectophore** or **nectocalyx** or swimming zooid with a muscular bell without manubrium or tentacles.
- (2) **Pneumatophore** or **float** as a bladder-like medusa filled with secreted gas.
- (3) **Phyllozoid** or **bract**, usually leaf-like and studded with nematocysts, serving for protection of other zooids.
- (4) **Gonophore** bearing gonads, which may be either male, producing sperms, or female producing ova.

Notable Polymorphic Colonies

1. Order Siphonophora. In calycophoran siphonophores, like *Diphyes*, colonies are linear with one or more nectophores located at the apical end. Polypoid and medusoid individuals are grouped as units, called **cormidia**, which are repeated in a linear succession. A typical cormidium consists of a gastrozoid with a tentacle bearing nematocysts, a phyllozoid or bract, and medusoid gonophores of one sex which are never freed. Dactylozooids are lacking.

In physophoran siphonophores, there is a pneumatophore or float at the apex of colony above water level. This is filled with gas, secreted by the gas-secreting tissue, enclosed within an oval disc. In *Physalia*, underneath this disc bears groups of cormidia, each including a gastrozoid, a small and a large dactylozoid, both with long tentacles, and a branched gonozoid with both male and female gonophores. Nectocalyces or swimming bells and bracts are altogether absent.

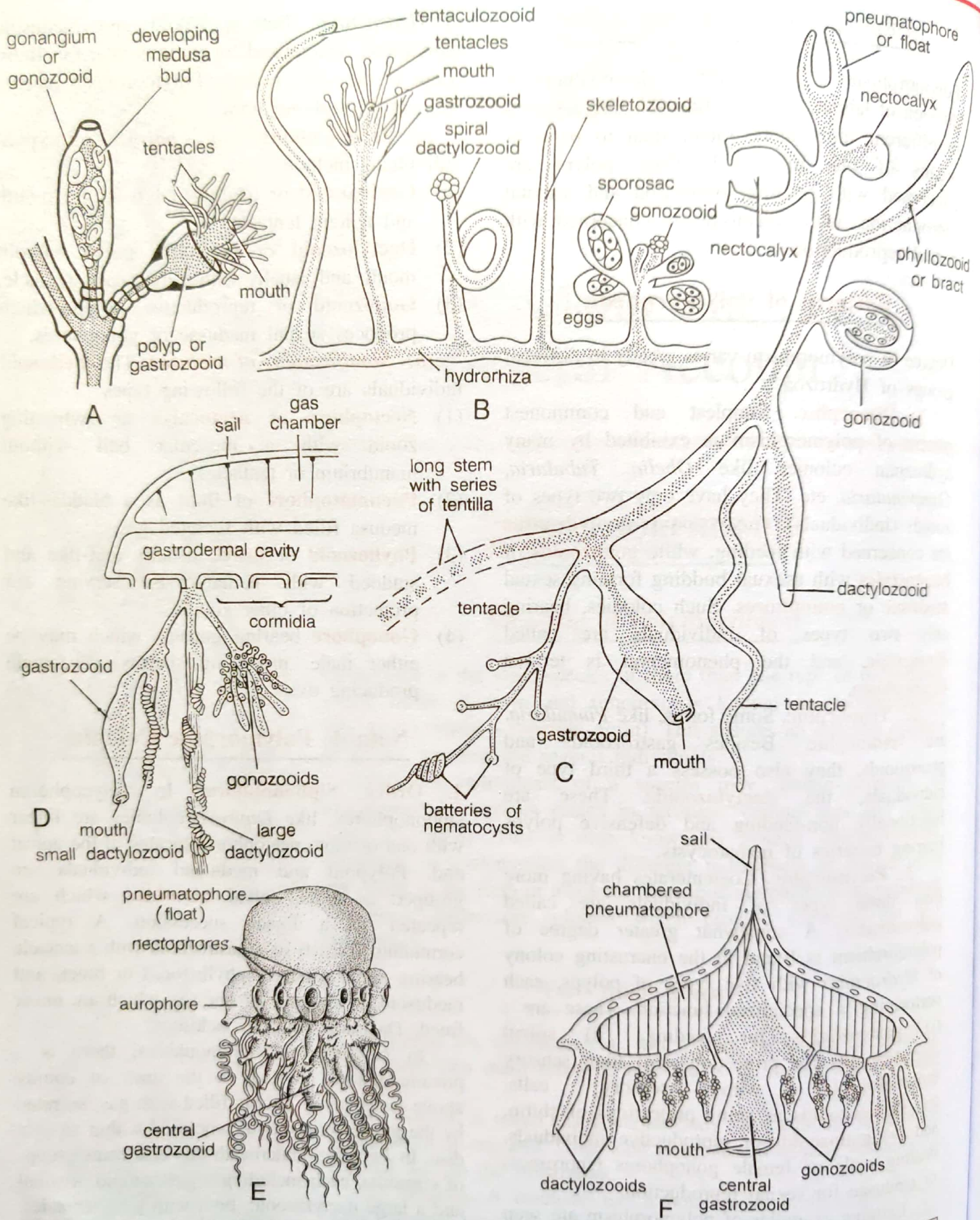


Fig. 1. Polymorphic colonies of Hydrozoa. **A.** *Obelia*. **B.** *Hydractinia*. **C.** Generalized calycophoran Siphonophora showing a single cormidium. **D.** *Physalia* showing a single cormidium. **E.** *Stephanalia* showing swimming bells and aurophore. **F.** *Verella*, in V.S.

22. (Z-1)



In *Nectalia* and *Stephalia*, swimming bells are highly developed. *Stephalia* is peculiar in that a portion of float or pneumatophore is constricted off as a bell-like body, called **aurophore**. Its function and homology remains uncertain.

2. Order Chondrophora. In *Veleva* and *Porpita*, colony seems to be highly organized. There is a single central gastrozoid with a mouth. Around it are concentric rows of gonozooids surrounded by a few rows of dactylozooids. Entire colony looks like a single individual animal.

Origin of Polymorphism

As we have seen, colonies of Siphonophora represent the most specialized of Hydrozoa, attaining the highest degree of polymorphism and presenting the greatest number of medusoid and polypoid types.

There are two views regarding which came first, polyp or medusa, during the evolution of polymorphism in Coelenterata.

According to one view, the ancestral coelenterate was a *Hydra*-like **polyp** (archhydra of Haeckel) which arose from gastraea. It gave rise to hydroid colony by asexual budding. In the sessile colony some polyps became modified into medusae for sexual reproduction and pelagic life. Thus, through division of labour, the hydroid colony became polymorphic.

According to second view (**Brooks**, 1886), which seems to be more acceptable, the ancestral Coelenterata was a primitive **medusa**. It arose from metagastrea by developing tentacles and becoming free-swimming. According to **Huxley**, **Eschscholtz** and **Metschnikoff**, the manubrium, tentacles and umbrella of this primitive medusoid individual were multiplied and shifted from their original positions to become various zooids of the polymorphic colony. According to this view, polypoid stage is considered the persistent larval stage and medusoid the completely evolved coelenterate.

According to **Moser**, various zooids of Siphonophorae are merely organs that have not attained the grade of polymorphic individuals (**poly-organs**). She regards siphonophora to be ancestral to Hydrozoa which has fully differentiated zooids (**poly-persons**). Moser

believes that **poly-organs** of Siphonophora by further differentiation became the **poly-persons** of Hydrozoa. However, Moser's views err too much to deny the full colonial nature to Siphonophora.

CORALS

Meaning of Coral

Coral animals or **corals** are marine, mostly colonial, polypoid coelenterates, looking like miniature sea anemones and living in a secreted skeleton of their own. Their calcareous or horny skeleton is also commonly known as **coral**. Some corals grow into massive, solid structures; others form large, branched colonies. Most of the corals

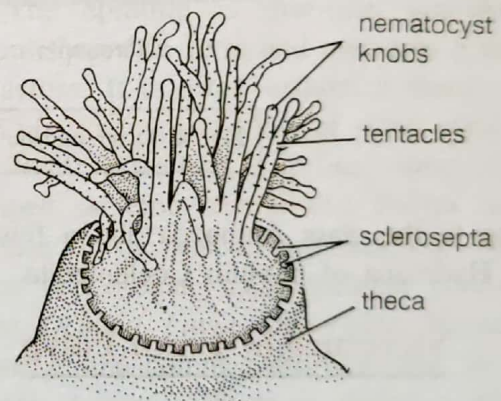


Fig. 2. A coral polyp (*Astrangia*) extended from theca.

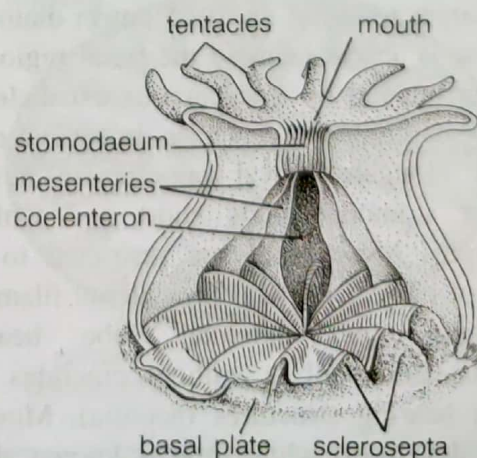


Fig. 3. Internal structure of a coral polyp in semi-diagrammatic V.S.

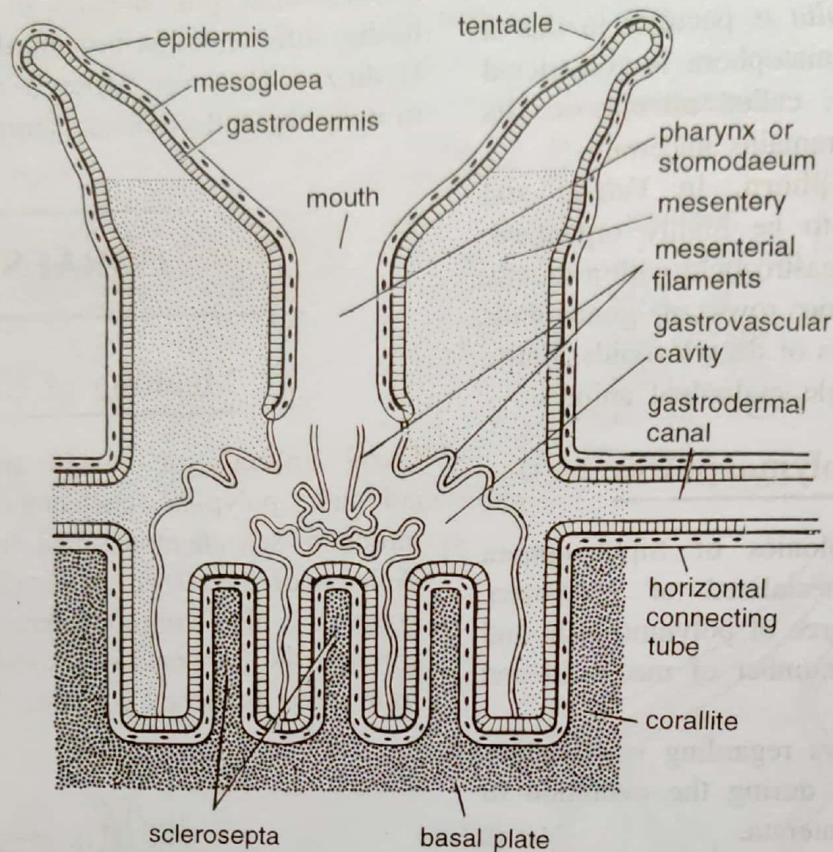


Fig. 4. Diagrammatic V.S. of a coral polyp with its corallite.

belong to the class Anthozoa and a few to the class Hydrozoa of phylum Coelenterata.

Structure of Coral Polyp

Soft structure. A typical coral polyp from a colony is a small organism about 10 mm long and 1 to 3 mm in diameter. Solitary coral polyps are much larger reaching up to 25 cm in diameter. A basal disc is absent because the basal region of polyp is surrounded by a calcareous exoskeleton. Oral disc bears numerous tentacles, in several rows around an elongated, oval or circular mouth. Pharynx or stomodaeum is short and without siphonoglyphs. Mesenteries are restricted to the upper part of coelenteron and mesenterial filaments contain only one glandular lobe bearing nematocysts. Bodywall is without cinclides and nematocyst bearing structures (acontia). Muscles are poorly developed while little is known about nervous system.

Living polyps are found only on surface layers of coral masses. They feed at night both by

raptorial and suspension feeding. When not feeding, they withdraw into cup-like cavities of skeleton.

Coral Skeleton

1. Structure of coral skeleton. Skeleton of a solitary coral is known as **corallite**. It is a calcareous exoskeleton secreted by epidermis. In a colonial coral, corallites of individual polyps fuse together to form a skeletal mass, called **corallum**. Each corallite is like a stony cup with a basal part or **basal plate**, and a cup wall or **theca**, enclosing the aboral portion of polyp. Cavity of cup contains a number of vertical radiating ridges called **sclerosepta**, proceeding from theca towards the centre of cup. Inner ends of sclerosepta are fused to form an irregular central skeletal mass or **columella**.

2. Formation of coral skeleton. In coral polyps, sexual reproduction takes place by fusion of gametes. Zygote develops into a free-swimming ciliated **planula** larva which settles down and



metamorphoses into a young coral **polyp**. There is no medusa stage. By asexual budding, single polyp becomes the parent of all other members of the colony. The coral polyp begins to secrete a skeletal rudiment or **prototheca**. It is secreted by ectoderm, first as a basal plate. Following it, radial folds develop which secrete sclerosepta. At the same time, a rim is built up as a thecal wall around the polyp, lying at the top. Meanwhile further skeletal material is added into the gaps between sclerosepta of skeleton which usually alternates with mesenteries of the polyp.

Coral colony grows in size continuously by budding of new polyps, particularly along the margins and on surface layers of coral masses. Variety in form of compound corals results due to various patterns of budding.

Types of Corals in Different Groups

1. Hydrozoan corals. Order Hydrocorallina includes few genera, like *Millepora*, *Stylaster* and *Distichopora*, which are colonial and secrete massive branched calcareous exoskeletons. These are found in coral reefs with other corals. Skeleton is secreted by a modified epidermis, called **calicoblastic layer**. Living within the skeleton occur two types of polyps, large feeding gastrozooids and defensive dactylozooids.

2. Octocorallian corals. Order Alcyonacea includes marine, colonial and soft corals. A well-known genus is *Alcyonium*, popular as 'dead man's fingers' because of its resemblance to a human hand. It has an endoskeleton of separate calcareous spicules embedded in a massive mesogloea or **coenenchyme**.

Order Stolonifera includes the organ pipe coral, *Tubipora musica*, widely distributed on coral reefs in warm waters. Skeleton is made of mesogloal calcareous spicules forming parallel and vertical tubes, each occupied by one polyp, and connected together by lateral platforms. Skeleton is dull red in colour due to presence of iron salts.

Order Coenothecalia includes a single genus *Heliopora*, commonly known as blue coral. Its massive calcareous, skeleton or **corallium** is

secreted by polyps living in large erect, cylindrical solenial tubes on the surface of skeleton.

Order Gorgonacea includes plant-like colonies of sea fans or horny corals. In *Gorgonia*, colony branches in one plane only. Its axial skeleton is made by horny proteinaceous material intermixed with calcareous spicules arranged around the polyps. In precious red coral, *Corallium nobile*, the branching colony has canaliferous coenenchyme of coenosarc containing dimorphic polyps. Axial skeleton consists of spicules embedded in CaCO_3 forming precious hard red coral which is used in jewellery.

3. Hexacorallian corals. Order Madrepora includes stony corals or true corals, which are the principal builders of coral reefs. While some of them are solitary, most are colonial, assuming a great variety of forms.

(a) **Solitary corals.** *Fungia*, *Flabellum*, *Caryophylla*, etc., are the solitary corals or cup corals. The corallite is disc-like, cup-like or mushroom-shaped in form and measures 5 mm to 25 cm across. It is often without a theca.

(b) **Colonial corals.** Most of stony corals are colonial with plate-like, cup-like, spherical, or vase-shaped skeleton (**corallium**). Polyps live at the surface of the calcareous skeleton. Typical examples of colonial madreporarian corals are *Acropora*, *Oculina*, *Favia*, *Madrepora*, *Meandrina*, etc. Some of the colonies are branched. In stag-horn coral, *Acropora*, there is always a primary

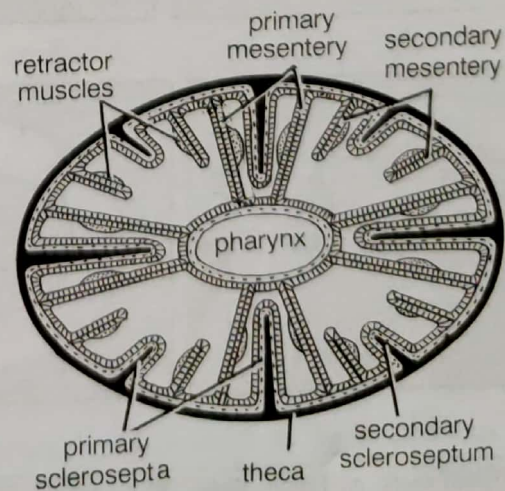
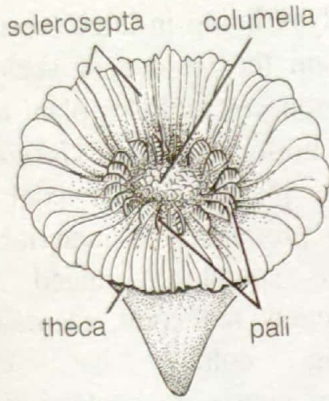


Fig. 5. T.S. of a simple coral polyp with corallite.



CORAL REEFS

Meaning of Coral Reef

Coral colonies grow continuously in size by budding of polyps and often form extensive masses, known as **coral reefs**. According to **T. Wayland Vaughan** (1917), a coral reef is a ridge or mound of limestone, the upper surface of which is near the surface of sea and which is formed chiefly of $CaCO_3$ secreted by coral polyps. Principal builders of coral reefs are stony corals (Madreporaria), but other important contributors are the hydrocorallines and alcyonarians. Coralline algae and Foraminiferan Protozoa also take part in the formation of coral reefs.

Reef building corals require warm shallow waters (normally above $20^\circ C$). They are therefore limited to the Indo-Pacific, the Central-Western Pacific, and the Caribbean regions north of

Fig. 6. Corallite of a solitary coral (*Flabellum*, *Caryophyllia*).

polyp at the top of colony with lateral branches on either side. In some corals, like *Oculina*, polyps remain widely separated, each occupying a separate theca. In others, like *Favia* and *Astraea*, thecae are so close together as to have common walls. In the brain-coral, *Meandrina*, polyps as well as thecae become confluent, occupying valleys separated by ridges, on the surface of corallium.

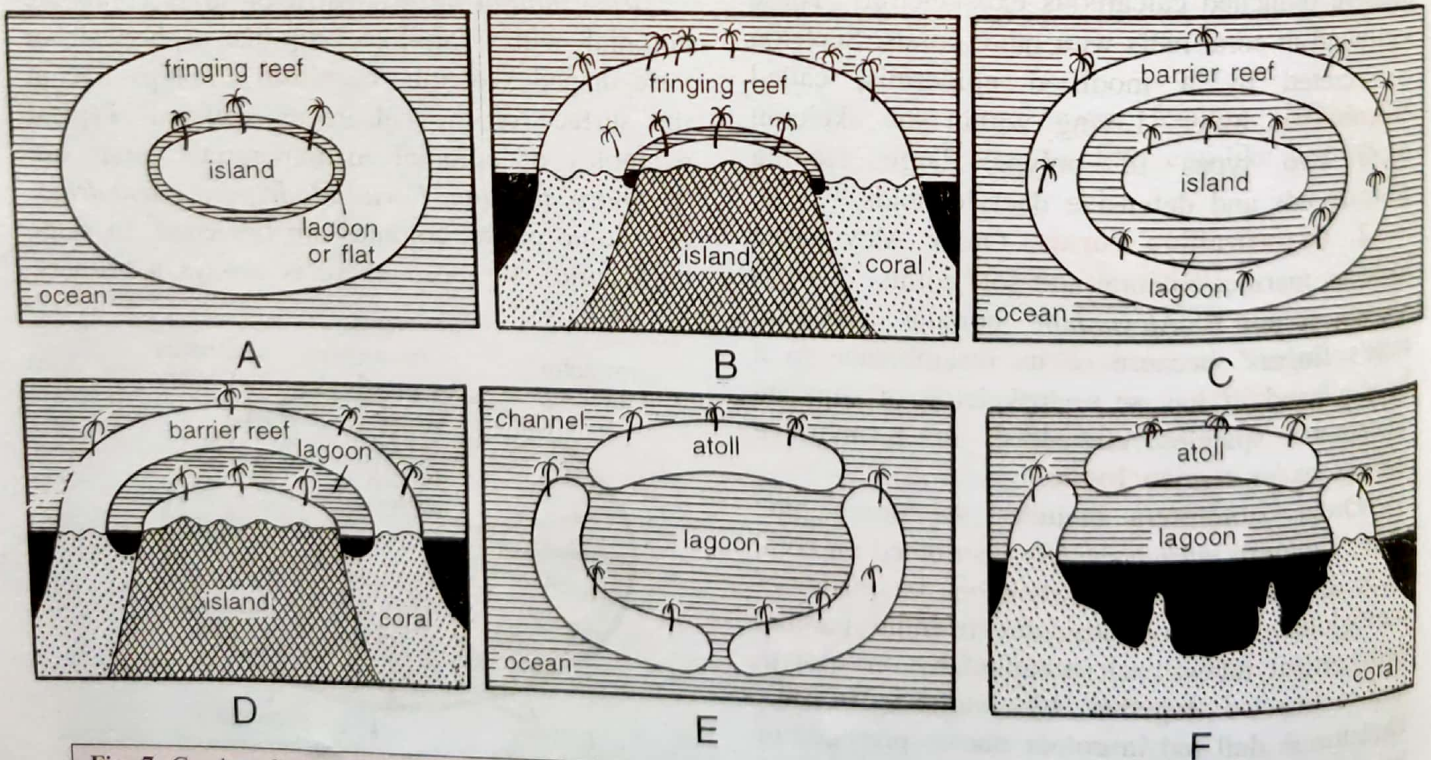


Fig. 7. Coral reefs. A. Fringing reef. B. Fringing reef in section. C. Barrier reef. D. Barrier reef in section. E. Atoll. F. Atoll in section.



Bermuda. About 50 species of corals contribute in the formation of reefs along the Florida Keys and in the West-Indies.

The Great Barrier Reef of Australia is largest runs in 2,600 km. India has them in Andaman-Nicobar, Gulf of Kutch, Gulf of Mannar and Lakshadweep.

Kinds of Coral Reefs

The coral reefs are of three kinds, depending on how they are formed.

1. Fringing reefs. Coral reefs lying close to the shores of some volcanic island or part of some continent are termed **fringing reefs**. A fringing reef may extend out to a distance of a quarter mile from the shore with the most active zone of the coral growth facing the sea. This seaward zone is commonly called the **edge** or **front**. A shallow water channel, 50 to 100 meters broad, lies between the reef-edge and shore. At low tide, water of channel recedes at quickly exposing a flat bottom surface, called **reef flat**. It is largely composed of coral sand, mud, dead and living coral colonies and other animals.

2. Barrier reef. **Barrier reefs** are like fringing reefs but they are located some distance away from the shore. The stretch of water, separating the barrier reef from land, may be half a 16 km or more in width. It is called a **lagoon**. It is 20 meters to 100 meters deep and suitable for navigation.

Most notable example of barrier reef is the Great Barrier Reef along the North-eastern coast of Australia. It is about 2,000 km long and up to 150 km from shore.

3. Atoll. An **atoll** is also termed a **coral island** or **lagoon island**. It is a ring-like or horse-shoe-shaped reef that encircles a lagoon but not an island. The lagoon varies from a few to about 90 km across. It may be complete or broken by a number of channels, of which only a few are navigable. Outer side of the reef slopes off rather steeply into the depth of ocean.

The atoll of Bikine, famous for atomic and hydrogen bomb tests, lies in the Pacific Ocean.

Formation of Coral Reefs

Many theories have been advanced to explain coral-reef formation, but none are entirely satisfactory. Two theories seem to be of some convincing importance.

1. Subsidence theory by Darwin.

According to this theory, as put forth by **Darwin** (1831), fringing reef was first formed on the sloping shore of an island. Subsidence of sea-floor then commenced in the regions of reef followed by upward and outward growth of coral. Thus, the fringing reef became the barrier reef. By gradual sinking the island ultimately vanished and the barrier reef became a coral atoll with a central lagoon. In time it acquired a growth of vegetation.

2. Glacial-control theory by Daly. Another theory, as propounded by Daly, accounts for the lowering of the ocean level by the withdrawal of water for glacial formation. This resulted in the exposing of several flat platforms cut out by the action of waves. When the glaciers melted and the temperature became favourable, corals began to grow on these platforms, building higher as the ocean level rose.

Most reefs grew at the rate of 10 to 200 mm each year. Most of the existing reefs could have formed with in a period of 15,000 to 30,000 years.

Economic Importance of Coral Reefs

Corals of the remote geological past formed reef structures that were highly favourable sites for the accumulation of petroleum deposits. Thus coral reefs are of much importance to oil industry. Large quantities of corals are shipped every year for the curio trade. The coral reefs serve as habitats for many plants and animals like sponges, molluscs, echinoderms, fishes, etc. Some coral reefs are used as habitations by man as well. Some corals are highly priced for their decorative value. *Corallum rubrum* is considered to be a precious stone in India and China and treated as auspicious. The red coral and organ pipe coral are used in some indigenous system of medicine in S. India. Chunks



of coral skeleton belonging to species *Porites* are used as building material. Coral skeletons serve as raw material for the preparation of lime, mortar and cement because of their calcium carbonate and magnesium carbonate content. Coral skeletons

are also helpful in making ridges that may act as natural barriers against sea erosion and cyclonic storms. Coral reefs serve as good nursery grounds for commercially important fishes. Reef fish varieties are more colourful than others.

Important Questions

►► Long answer type questions

1. Write an essay on Polymorphism in Hydrozoa.
2. Describe a corallite. How are corals formed ? Give an account of the principal corals studied by you.
3. What are coral reefs ? Give an account of the various forms of coral reefs met with all over the world.
4. Write short notes on : (i) Atoll, (ii) Barrier reef, (iii) Fringing reef, (iv) Coral polyp, (v) Coral reefs.

►► Short answer type questions

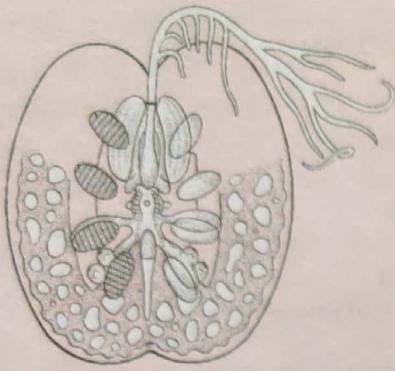
1. How many times can a nematocyst be used ?
2. What is cnidoblast ?
3. Which are the original cells of nematocysts of coelenterates ?
4. Mention an example for a solitary coral.
5. Give an example of commensalism from Anthozoa.
6. Mention the use of coral reefs to other animals.
7. Mention four coral building coelenterates.
8. What are the three types of coral reefs ?
9. Define polymorphism. Illustrate it with a suitable example from phylum Coelenterata.
10. How will you differentiate a hydrozoan polyp from an anthozoan polyp. List at least 5 differences.
11. Describe the sense organs in coelenterates.
12. Explain the concept of polymorphism with reference to Coelenterata.
13. Trace the evolutionary sequence of the gastrovascular system in Coelenterata.
14. One of the important steps in the evolution of metazoans is the differentiation of cells to perform different functions. Justify this statement in relation to the cellular organization of *Hydra*.
15. What are coral reefs ? How does a barrier reef differ from a fringing reef ?
16. Give the structure of a corallite.
17. How are coral reefs formed ?
18. Name the animal living in close association with the stinging Portuguese man of war. What is the type of association exhibited here ? Explain the association.
19. Explain the polyps.
20. Define the medusa.
21. What is polymorphic polymorphism ?
22. Describe polymorphism in order siphonophora.
23. What is corallite ?
24. Describe an atoll.
25. Who proposed glacial control theory to formation of coral reefs ?

►► Fill in the blanks

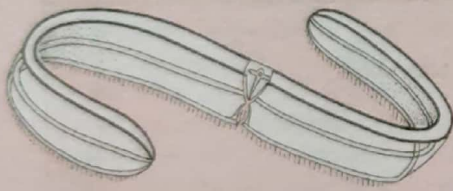
1. Most reefs grew at the rate of.....to.....mm each year.
2.is considered to be a precious stone in India.
3. Coral reefs lying close to the shore of some volcanic island are termed as.....
4. *Alcyonium* popular as.....
5. *Heliopora* commonly known as.....

►► True and false statements

1. Marine coelenterates known as coral.
2. Most of the corals belongs to class scyphozoa.
3. Skeleton of a solitary coral is known as corallite.
4. Principal builders of coral reefs are stony corals.
5. Reef building corals require warm shallow water.



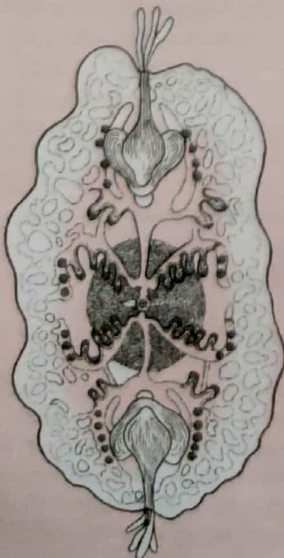
Ctenophora



Ctenophora is a small phylum of marine animals, which are commonly known as **sea walnuts** or **comb jellies**. The phylum takes its name from two Greek words, **ktenos** = comb and **phoros** = bearing, as they possess 8 comb-like plates for locomotion. In previous classifications, ctenophores have been placed in subphylum *Cnidaria* under the phylum Coelenterata. But, the present tendency is to consider them as a separate phylum. Ctenophores were recognized as a distinct group by Eschscholtz and placed under a distinct phylum by Hatschek.

A new species ***Tamoya ohboya***, Bonaire Banded Box Jelly has been described in 2011. It was caught in the sea around Netherlands.

GENERAL CHARACTERS



1. Marine, solitary, free-swimming or pelagic. No polymorphism and no attached stages.
2. Body transparent. Symmetry **biradial** along an oral-aboral axis.
3. External surface with 8 vertical rows of **comb plates** of fused cilia, for locomotion. Hence the name **comb jellies**.
4. A pair of long, solid, retractile **tentacles** present.
5. Cell-tissue grade of body organization.
6. Body **acoelomate** and **triploblastic**, with an outer epidermis, inner gastrodermis, and middle jelly-like mesoglea with scattered cells and muscle fibres.
7. Digestive system with mouth, stomodaeum, complex gastrovascular canals and 2 aboral **anal pores**.
8. **Nematocysts** absent. Instead, special adhesive and sensory cells, called **colloblasts**, present on tentacles, help in food capture.

9. Skeletal, circulatory, respiratory and excretory organs absent.
10. Nervous system **diffuse**. Aboral end bears a sensory organ, the **statocyst**.
11. All **monoecious** (hermaphrodite). Gonads develop side by side on digestive canals and develop from endoderm.
12. Development usually includes a characteristic **cydippid larva**.
13. **Asexual reproduction** and **alternation of generations** absent.
14. **Regeneration** and **paedogenesis** common.

CLASSIFICATION

Phylum Ctenophora contains about 199 known species grouped in 2 classes, as follows :

CLASS 1. Tentaculata

Ctenophores with 2 long aboral tentacles.

Order 1. Cydippida

1. Body rounded or oval.
2. Tentacles branched, retractile into pouches.
Examples : *Pleurobrachia*, *Hormiphora*, *Mertensia*.

Order 2. Lobata

1. Body oval, laterally compressed.
2. Two large oral lobes and 4 slender flap-like auricles around mouth.
3. Pouched tentacles in larva, reduced and without pouch in adult.

Examples : *Mnemiopsis*, *Bolinopsis*.

Order 3. Cestida

1. Body elongated, flat, ribbon-like.
2. Two main tentacles in sheaths but reduced. Many small lateral tentacles along oral edge.
3. Four comb plates prominent, four rudimentary.

Examples : *Velamen*, *Cestum*.

Order 4. Platyctenea

1. Body much flat, oral-aborally compressed.
2. Tentacles well-developed, with sheath.

3. Comb plates reduced or absent in adult.
4. Adapted for creeping.

Examples : *Ctenoplana*, *Coeloplana*.

Order 5. Thalassocalycida

Found from the surface waters down up to 2,765 meters in the Atlantic Ocean and Mediterranean sea.

- (1) The body is shaped like the bell of a medusa and may be up to 15 cm diameter.
- (2) A central cone-shaped peduncle holds the mouth slit.
- (3) A pair of small tentacles hang from the sides of the peduncle. With its transparent, colorless body, this comb jelly is usually very difficult to see.
- (4) *Thalassocalyce* holds the "bell" wide open to capture zooplankton prey.
- (5) Presumably hermaphroditic.
- (6) Compared to other comb jellies, this species has limited swimming ability.

Example : *Thalassocalyce inconstans*.

CLASS 2. Nuda

Ctenophores without tentacles.

Order 5. Beroida

1. No tentacles and oral lobes.
2. Body conical and laterally compressed.
3. Mouth large. Stomach voluminous.

Example : *Beroe*.

AFFINITIES

Different workers have dissimilar views regarding origin and relationships of Ctenophores. No fossil record is available due to their soft bodies. In the absence of fossils, their origin remains obscure.

1. Affinities with coelenterata. In the beginning, **Eschscholtz** (1829-1833) regarded Ctenophora as a class under phylum Coelenterata.

(a) Resemblances with Coelenterata. There are certainly many morphological similarities between Ctenophora and Coelenterata.

- (i) Biradial symmetry.



- (ii) Body parts arranged along an oral-aboral axis.
- (iii) Presence of gelatinous mesogloea.
- (iv) Lack of organ-systems (tissue grade).
- (v) No coelom. Single gastrovascular cavity.
- (vi) Diffuse nerve net or plexus.
- (vii) Presence of statocysts.
- (viii) Endodermal origin of gonads.

(b) Differences from Coelenterata.

- (i) Tentacles oppositely placed. Symmetry bilateral.
- (ii) No polymorphism. No colony formation.
- (iii) Presence of 8 comb plates for locomotion.
- (iv) Mesenchymal muscles present. No epithelio-muscular fibres.
- (v) Nematocysts absent. Instead, special sensory cells or colloblasts present on tentacles.
- (vi) Statocyst present aborally, not marginally.
- (vii) Gastrovascular system with anal pores more organized.
- (viii) Development of determinate type.

2. Affinities with Platyhelminthes.

Platyctenea Ctenophores (*Ctenoplana* and *Coeloplana*) show certain resemblances with polyclad turbellarians (*Cestoplana*).

- (i) Dorsoventrally flattened body.
- (ii) Crawling mode of life.
- (iii) Ectoderm ciliated.
- (iv) Lobed gastrovascular cavity, especially in embryos.
- (v) Gelatinous mesenchyme with muscle fibres and cells.
- (vi) Similar earlier stages of segmentation and gastrulation.

On account of these similarities, *Ctenoplana* and *Coeloplana* have been considered the missing links between Coelenterata and Platyhelminthes. This view is no longer supported because *Ctenoplana* and *Coeloplana* are now considered typical Ctenophores adapted for a creeping mode of life.

3. Position in animal kingdom. Ctenophores have certain characteristics in common with coelenterates. Ctenophora are believed to have diverged very early from the ancestral medusoid coelenterate which was a spherical animal with concentration of cilia along 8 meridional rows which later developed into comb plates. However, they represent a blind offshoot which gave rise to

no higher forms. Ctenophores also present certain advancements over Radiata, such as prominence of apical region, musculature derived from mesoderm, presence of gonoducts and determinate type of cleavage. This implies that Ctenophora are intermediate between Radiata and Bilateria and have undergone considerable specialization with many striking characteristics of their own. Therefore, it seems quite logical to treat Ctenophora as a separate phylum rather than a class or subphylum of phylum Coelenterata.

TYPES OF CTENOPHORA

1. Pleurobrachia and Hormiphora. *Pleurobrachia* (Gr., **pleuron**, side + **brachia**, arms) and the closely allied genus *Hormiphora*, are common marine pelagic forms, found all over the world. Body is glassy transparent and pear-shaped or walnut-shaped, hence commonly known as **sea walnuts**. *Pleurobrachia pileus* is about 20 mm in diameter, while *Hormiphora plumosa* is slightly smaller and 5 to 20 mm in diameter. External surface bears 8 equally spaced **paddle plates** or

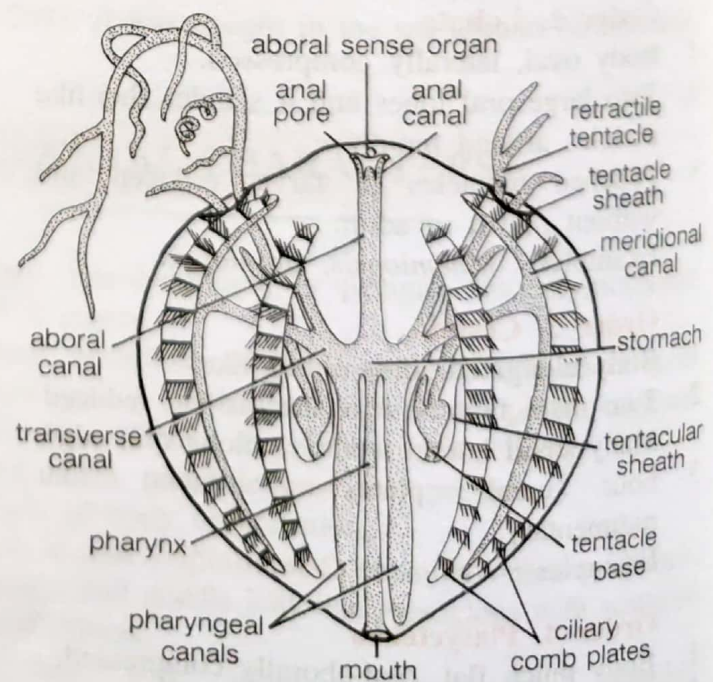


Fig. 1. *Pleurobrachia*.