ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN

PALANI

PG DEPARTMENT OF ZOOLOGY

LEARNING RESOURCES

INVERTEBRATA

INVERTEBRATA – I

Basis of Classification

When you look around, you will observe different animals with different structures and forms. As over a million species of animals have been described till now, the need for classification becomes all the more important. The classification also helps in assigning a systematic position to newly described species.

Inspite of differences in structure and form of different animals, there are fundamental features common to various individuals in relation to the arrangement of cells, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems. These features are used as the basis of animal classification and some of them are discussed here.

Levels of Organisation

Though all members of Animalia are multicellular, all of them do not exhibit the same pattern of organisation of cells. For example, in sponges, the cells are arranged as loose cell aggregates, i.e., they exhibit **cellular level of organisation**. Some division of labour (activities) occur among the cells.

In coelenterates, the arrangement of cells is more complex. Here the cells performing the same function are arranged into tissues, hence is called **tissue level of organisation**.

A still higher level of organisation, i.e., **organ level** is exhibited by members of Platyhelminthes and other higher phyla where tissues are grouped together to form organs, each specialised for a particular function.

In animals like Annelids, Arthropods, Molluscs, Echinoderms and Chordates, organs have associated to form functional systems, each system concerned with a specific physiological function. This pattern is called **organ system level** of organisation. Organ systems in different groups of animals exhibit various patterns of complexities. For example, the digestive system in Platyhelminthes has only a single opening to the outside of the body that serves as both mouth and anus, and is hence called incomplete. A complete digestive system has two openings, mouth and anus.

Similarly, the **circulatory system** may be of two types:

(i) **open type** in which the blood is pumped out of the heart and the cells and tissues are directly bathed in it and
(ii) (ii) **closed type** in which the blood is circulated through a series of vessels of varying diameters (arteries, veins and capillaries).

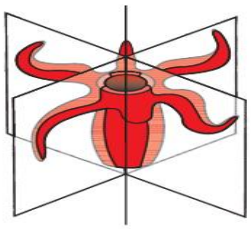
Symmetry

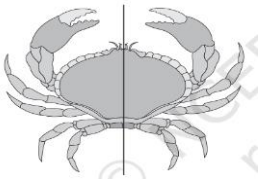
Animals can be categorised on the basis of their symmetry. Sponges are mostly **asymmetrical**, i.e., any plane that passes through the centre does not divide them into equal halves.

When any plane passing through the central axis of the body divides the organism into two identical halves, it is called **radial symmetry**. Coelenterates, ctenophores and echinoderms have this kind of body plan.

Animals like annelids, arthropods, etc., where the body can be divided into identical left and right halves in only one plane, exhibit **bilateral symmetry**

Radial symmetry **Bilateral symmetry**



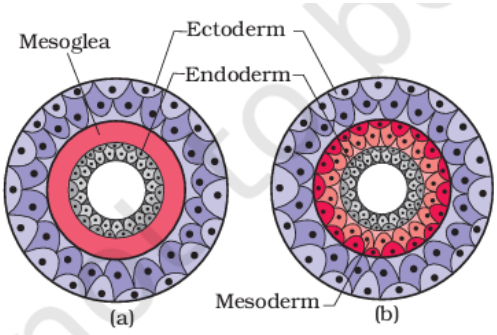


Diploblastic and Triploblastic Organisation

Animals in which the cells are arranged in two embryonic layers, an external ectoderm and an internal endoderm, are called **diploblastic animals**, e.g., coelenterates. An undifferentiated layer, mesoglea, is present in between the ectoderm and the endoderm.

Those animals in which the developing embryo has a third germinal layer, mesoderm, in between the ectoderm and endoderm, are called **triploblastic animals** (platyhelminthes to chordates,

Showing germinal layers : (a) **Diploblastic** (b) **Triploblastic**



Coelom

Presence or absence of a cavity between the body wall and the gut wall is very important in classification. The body cavity, which is lined by mesoderm is called coelom. Animals possessing coelom are called **coelomates**, e.g., annelids, molluscs, arthropods, echinoderms, hemichordates and chordates.

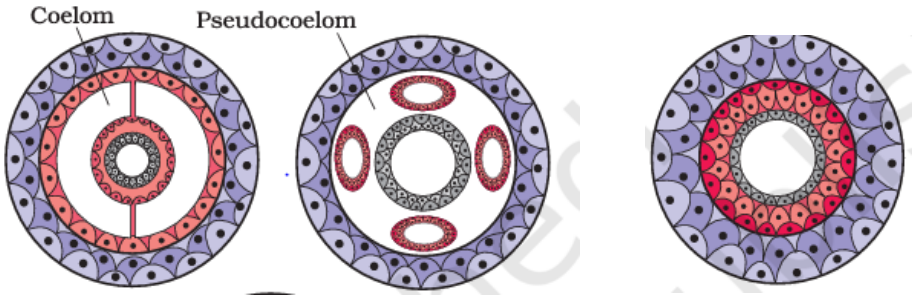
In some animals, the body cavity is not lined by mesoderm, instead, the mesoderm is present as scattered pouches in between the ectoderm and endoderm. Such a body cavity is called

pseudocoelom and the animals possessing them are called **pseudocoelomates**, e.g., aschelminthes.

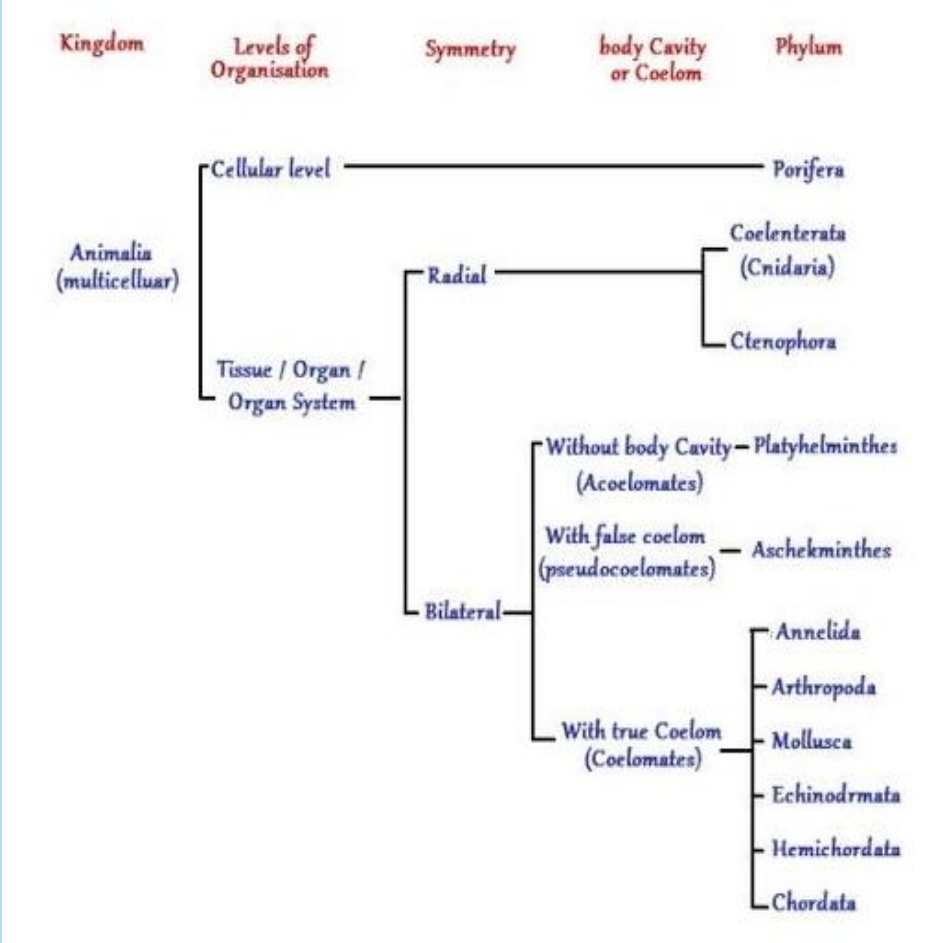
The animals in which the body cavity is absent are called **acoelomates**, e.g., platyhelminthes

Diagrammatic sectional view of : (a) Coelomate (b) Pseudocoelomate (c) Acoelomate

Acoelomate



Animal Kingdom Chart



Earthworm: Morphology And Anatomy

An earthworm is a segmented worm; a terrestrial invertebrate belonging to the phylum Annelida. They are the common inhabitants of moist soil and feed on organic matter.

Earthworms are commonly called as farmer's friend. This is because the worm casting (faecal deposit) increases the fertility and burrowing helps in proper aeration of the soil. The earthworms found in India are *Pheretima* and *Lumbricus.*

Morphology of Earthworm

Earthworms have a tube-like arrangement or cylindrical shaped and reddish-brown segmented body. The body is divided into small segments. The dorsal side is characterized by a dark line of blood vessels and the ventral side is characterized by the genital openings. The mouth and the prostomium (an organ helps in burrowing) distinguish the anterior end.

The segments 14-16 of a matured earthworm consist of a glandular tissue called clitellum which helps us to distinguish the mouth and tail ends. The body is divided into three segments with respect to clitellum- preclitellar, clitellar and postclitellar.

Earthworms are hermaphrodites i.e., they carry both male and female sex organs. Segments 5-9 accommodate four pairs of spermathecal apertures. The female genital pore is situated at the 14^{th} segment and a pair of male genital pores is situated at the 18^{th} segment. The body consists of S-shaped setae, which help in locomotion in the earthworm. Setae are present in each segment except in the first, last and clitellum segments

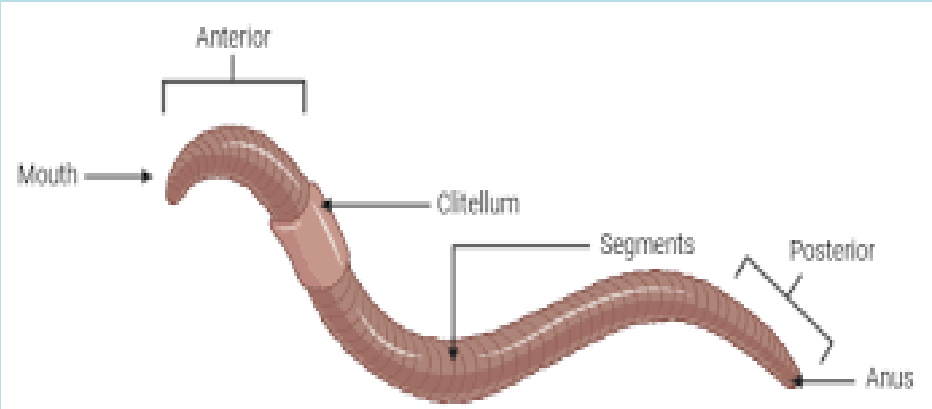


Fig. Structure of an Earthworm

PILA

Pila globosa or apple snail are gastropod molluscs and thus their body shows coiling or torsion. They are freshwater organisms that can be found in ponds, lakes and streams. During the rainy season, they come out of ponds and thrive in the land. Also, it can overcome extreme drought with a period of inactivity by burying itself in the mud. This is called summer sleep or aestivation.

Pila globosa – Classification

Kingdom	Animalia
Phylum	Mollusca
Class	Gastropoda
Order	Architaenioglosaa
Genus	*Pila*
Species	*globosa*

Habitat and Distribution

Pila is abundantly found in tanks, pools, ponds, streams and lakes. It is a freshwater mollusc and can also be found in brackish water environments with low salinity. They are amphibious and thus adapted to live both on land as well as on water. They are mostly confined to the Ethiopian and Oriental regions.

They are herbivores and feed on the plant scrapping and succulent aquatic vegetation.

Description

- Apple snails are found in various colours. They are typically globose in shape and are brown or lemon-yellow in colour.
- They are molluscs and thus have a soft and unsegmented body. Their body can be regionated into the head, visceral mass and foot.
- The head has two pairs of tentacles, one pair of eyes, a ventral slit-like mouth or aperture and nuchal lobes.
- In the shell, the outer margin of the aperture is called an **outer lip,** and the inner margin is called the **columellar** or inner lip.
- The **foot** is a broad, flat, ventral and roughly triangular structure attached to the operculum.

- **Visceral mass** is a hump-like structure containing the main organs. It fills the whorls of the shell and is also spirally coiled.
- The **mantle** covers the visceral mass. It forms a hood over the snail when it is withdrawn. The mantle has a pigmented chemosensory patch called the osphradium that typically tests the quality of water.
- **Radula** is present in the buccal mass.
- The animal is well-protected by a spirally twisted **shell**. Only the foot and head come out of the shell mouth. The visceral mass lies inside the whorls of the shell.
- The shell is coiled spirally to form the apex, body whorl and the penultimate whorl. **Suture** lines are present between the whorls. The shell shows right-hand or dextral coiling.
- The centre of the shell has a vertical axis around which the shell whorls are coiled. This vertical axis opens to the exterior as an **umbilicus**.
- The shell surface shows lines of growth called the **varices**.
- The unique feature of *Pila* is the presence of an **operculum**. Operculum is a calcareous anatomical structure which also has concentric lines of growth. When the snail is inside the shell, it is covered by this structure called an operculum.
- Pila respires with the help of the pulmonary sac and **ctenidium** (gills).
- It has a heart with the pericardium, and renal organs are also present.
- Sexes are separate, and fertilisation is internal.

Nervous System of *Pila*

The nervous system of a gastropod consists of ganglia, connectives, commissures, and the nerves connecting to different organs.

Ganglia

A ganglion is a small compact mass of nerve cells and connective tissue. There are five pairs of ganglia found in *Pila*, namely cerebral ganglia, pleuropedal ganglia, visceral ganglion, buccal ganglia and supraintestinal ganglia.

Commissures

The nerve connections between two ganglia are termed as commissures. The ganglia pairs are placed on the opposite sides of the body such that commissures can connect them. The cerebral ganglia are connected by the cerebral commissure, the buccal ganglia are connected by the buccal commissure, and similarly, the pleuropedal ganglia are connected by the pedal commissure.

Connectives

The nerve connections that join two dissimilar ganglia are called connectives. Cerebrobuccal connective connects cerebral and buccal ganglia. The pleuropedal ganglion is connected to the cerebral ganglia on each side by cerebropleural and cerebropedal connectives.

Nerves

- The cerebral ganglia innervate the eye and tentacles on the sides of the body.
- The pedal ganglion gives out nerves to the foot.
- The pleural ganglion innervates the mantle.
- The supraintestinal ganglion gives out nerves to the pulmonary sac and the ctenidium.
- The buccal ganglion sends out nerves to the buccal mass.
- The visceral ganglia innervate the kidney, intestine, pericardium and genitals.

Digestive System of *Pila*

The digestive system of *Pila* comprises the alimentary canal and digestive glands. Let us look at them briefly.

Alimentary Canal

- The alimentary canal is a coiled structure that starts from the mouth and ends at the anus.
- It is divided into three regions, namely the foregut made up of the buccal cavity and oesophagus, the midgut, which includes the stomach and intestine and the hindgut, which comprises the rectum.
- The buccal cavity is a chamber which is made up of several sets of muscles for the movement of the radula (mouth).
- Oesophagus is a narrow, long tube that extends from the buccal mass and opens into the stomach.
- The stomach is a U-shaped chamber that receives the oesophagus and opens into the intestine via a pyloric chamber.
- The intestine is a long and coiled structure that is present between the gonads and ultimately joins the rectum.
- The rectum is a thick-walled tube that opens into the anus.

Digestive Glands

- There are two salivary glands found on either side of the buccal mass. They secrete carbohydrase enzymes and mucin-like substances.
- The digestive glands are triangular and coiled. The digestive epithelium is lined with alveoli and is made up of three types of cells: secretory cells, resorptive cells and lime cells.
- The oesophageal pouches are rounded structures located below the salivary glands that open narrow ducts at the junction of the oesophagus and buccal cavity. These pouches secrete digestive enzymes.
- The buccal glands are structures present at the roof of the buccal cavity that function as accessory digestive glands.

Respiration in *Pila*

Pila can survive in both water and land. They are amphibians that exhibit double mode of respiration, i.e. they can use oxygen from water during aerobic respiration and inhale atmospheric air while on land. The animal possesses a gill or ctenidium for aquatic respiration and pulmonary sacs or lungs for aerial respiration. Nuchal lobes act as accessory respiratory glands.

CORAL REEF

Coral reefs are the colonies of tiny living creatures that are found in oceans. They are the underwater structures that are formed of coral polyps that are held together by calcium carbonate. Coral reefs are also regarded as the tropical rainforest of the sea and occupy just 0.1% of the ocean's surface but are home to 25% of marine species. They are usually found in shallow areas at a depth less than 150 feet. However, some coral reefs extend even deeper, up to about 450 feet.

Coral polyps are individual corals that are found on the calcium carbonate exoskeletons of their ancestors. Corals can be found in all the oceans but the biggest coral reefs are mostly found in the clear, shallow waters of the tropics and subtropics. The largest of these coral reef systems, The Great Barrier Reef in Australia, the largest coral reef is more than 1,500 miles long.

Factors Affecting Coral Reefs

- **Extreme climate conditions:** High temperature of water leads to the declination of these corals as they cannot survive in high temperature. As estimated by scientists, most of the coral reefs of the world will soon decline with the increasing rates of ocean warming.
- **Overfishing:** It is another major concern as it is leading to an ecological imbalance of the coral reefs.
- **Coastal development:** Development of coastal infrastructure and tourist resorts on or close by these coral reefs causes significant damages.
- **Pollution:** The toxic pollutants which are dumped directly into the ocean can lead to the poisoning of the coral reefs as it increases the nitrogen level of the seawater leading to an overgrowth of algae.
- **Sedimentation:** Construction along the coasts and islands lead to soil erosion increasing the sediments in the river. As a result, it can smother corals by depriving them of the light needed to survive.

Growth Conditions for Coral Reefs

1. The temperature of the water should not be below 20°C. The most favourable temperature for the growth of the coral reefs is between 23°C to 25°C. The temperature should not exceed 35°C.
2. Corals can survive only under saline conditions with an average salinity between 27% to 40%.
3. Coral reefs grow better in shallow water having a depth less than 50 m. The depth of the water should not exceed 200m.

Types of Coral Reefs

Coral Reefs are differentiated into three categories based on their shape, nature and mode of occurrence.

1. **Fringing Reef:** The coral reefs that are found very close to the land and forms a shallow lagoon known as Boat Channel are called Fringing Coral Reefs. The Fringing Reefs develop along the islands and the continental margins. They grow from the deep bottom of the sea and have their seaward side sloping steeply into the deep sea. Fringing Reefs are the most commonly found coral reefs among the three. For example Sakau Island in New Hebrides, South Florida Reef.
2. **Barrier Reef:** Barrier Reefs are considered as the largest, highest and widest reefs among the three coral reefs. They develop off the coast and parallel to the shore as a broken and irregular ring. Being the largest reef among the all, they run for 100kms and is several kilometres wide. One example of Barrier Reef is the Great Barrier Reef of Australia which is 1200 mile long.
3. **Atolls:** An atoll can be defined as a reef that is roughly circular and surrounds a large central lagoon. This lagoon is mostly deep having a depth of 80-150 metres. The atolls are situated away from the deep sea platforms and are found around an island or on a submarine platform in an elliptical form. For example Fiji Atolls, Suvadivo in Maldives and Funafoothis Atoll of Ellice.

Importance of Coral Reefs

Coral Reefs play an important role in the following ways.

- They protect coastlines from the damaging effects of wave action and tropical storms.
- They provide habitats and shelter for many marine organisms.
- They are the source of nitrogen and other essential nutrients for marine food chains.
- They assist in carbon and nitrogen-fixing.
- They help with nutrient recycling.
- The study of coral reefs is essential for scientifically testable records of climatic events over the past million years.
- The fishing industry depends also on coral reefs. Many fish spawn there, and juvenile fish spend time there before making their way to the open sea. The Great Barrier Reef generates more than 1.5 billion dollars annually for the Australian economy from fishing and tourism.
- Coral reefs are also key indicators of global ecosystem health. They serve as an early warning sign of what may happen to other less sensitive systems, such as river deltas if climate change is not urgently addressed.

Coral Reefs in India

India has its coastline extending over 7500 kilometres. It is due to the subtropical climatic conditions, there are a very few coral reefs in India. The major coral reefs in India includes the Palk Bay, the Gulf of Mannar, the Gulf of Kutch, the Andaman and Nicobar Islands and Lakshadweep Islands. Among all these coral reefs, the Lakshadweep reef is an example of atoll while the rest are all fringing reefs.

Palk Bay

Situated in the south-east coast of India, Palk Bay is separated from the Gulf of Mannar by the Mandapam Peninsula and the Rameshwaram Island and is centred on 9 °17’N and 79° 15′. The one fringing reef in the Palk Bay is 25-30km long, and less than 200m wide lies in the east-west direction of the Pamban channel. This reef has a maximum depth of around 3 m.

The Gulf of Mannar

Situated around a chain of 21 islands, the Gulf of Mannar lies between Tuticorin and Rameswaram at a stretch of 140 km. These 21 islands fall between latitude 8°47′ N and 9° 15′ N and longitude 78° 12′ E and 79° 14’E and form a part of the Mannar Barrier Reef which is 140 km long and 25 km wide.

Andaman and Nicobar Islands

The Andaman and Nicobar Islands fall between 6°-14° N lat and 91 °-94° E longitude. They are situated at the south-eastern part of the Bay of Bengal and consist of 350 islands, of which only 38 are inhabited. These islands extend southward from the Irrawaddy Delta of Burma to the Arakan Yoma Range. All the islands of the Andaman and Nicobar groups are almost fringing reefs.

The Gulf of Kutch

The Gulf of Kutch is situated in the northern part of Saurashtra Peninsula and is located between 22°15′-23°40′ N Latitude and 68°20′-70°40′ East Longitude having an area of about 7350 sq km. These reefs are of a fringing type and are about 170 km long and 75 km wide at the mouth which narrows down at a longitude of 72° 20′. Due to the mud deposits on various coral reefs, these coral reefs are in a highly degraded condition.

Lakshadweep Islands

Located between 8°N – 12°3'N latitude and 71 °E- 74°E longitude, the Lakshadweep Islands which lies scattered in the Arabian Sea are situated at about 225 km to 450 km from the Kerala Coast. The islands covering an area of 32 km2 consist of 36 tiny islands, 12 atolls, 3 reefs and 5 submerged banks, with lagoons occupying about 4200 km2.

Due to the warm humid climate of these islands, the temperature of the water varies between 28-31 °C with salinity ranging from 34% – 37%.

Threats to Coral Reefs

Despite their immense ecological, economic and aesthetic values, it is estimated that 20% of the world's coral reefs have been destroyed. Another 24% are at high risk of collapse, and yet another 26% at risk from long term collapse as a result of human activities. If the present rate of destruction continues, 70% of the world's coral reefs will be destroyed by the year 2050.

The list of factors causing threat to coral reefs are as follows:

- Overexploitation (Over-fishing) – for food, aquarium trade, trinket trade, medicinal purposes.
- Often accompanying over-fishing are destructive fishing practices – such as purse seining, fine-mesh fishing, 'moxy' nets, cyanide fishing and blast fishing – that result in unsustainable damage. 'Moxy' nets, fine-mesh nets and bottom trawlers all damage coral reefs.
- Marine pollution in the form of oil (that often leaks into the seas), discharge of ballast water, dumping of solid waste from ships is also causing damage to coral reefs in the region.
- Poorly managed tourism has both direct and indirect negative effects on coral reefs. Snorkelling, diving and boating can cause direct physical damage to reefs, while overexploitation of reef species as food, for aquaria and as curios for tourist markets can threaten the survival of species.
- Global warming and resultant climate change is posing an emerging and severe additional threat to already stressed coral reefs.
- The coral reefs are also threatened by the increase in ocean temperatures, coral bleaching, sea level rise, more dissolved carbon dioxide, Ocean acidification.
- Invasive Alien Species are as much of a threat in marine environments as they are on land. One of the main channels of spreading IAS in marine habitats is through ballast water.


Atoll Reef
Fringing Reef
Barrier Reef

TYPE STUDY - PARAMECIUM

Systematic position

Classification:

Phylum: Protozoa

Sub Phylum: Ciliophora

Class: Ciliatea

Order: Hymenostomatida

Genus: Paramecium

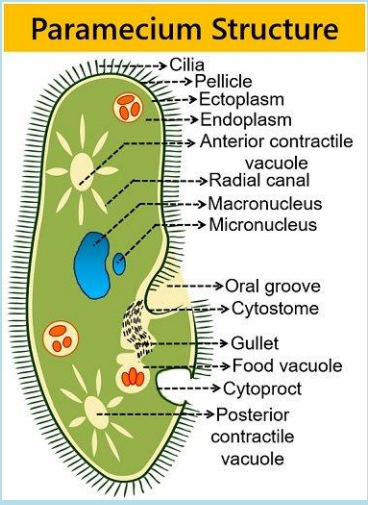
Species: caudatum

Habit and Habitat:

It's a free living organism having cosmopolitan (world-wide) distribution. It lives in stagnant water of freshwater, ponds, pools, ditches, lakes and slow flowing rich in decaying organic matter.

Structure: Shape & Size:

Paramecium cadatum is **a unicellular and microscopic** protozoan. It measures 170 to 290 µm up to 300-350µm. It is visible to the naked eye. Its body has a constant elongated, slipper-like shape, so it's also called **slipper animalcule**. Anterior part of the body is blunt and broad and posterior end is thick, pointed and cone shaped, widest part is just below the middle. Body is asymmetrical showing well defined oral or ventral surface and convex dorsal or aboral surface.



Pellicle:

The whole body is covered by thin, firm, flexible membrane called pellicle. Pellicle is made up of gelatinous substance. It gives shape of the animal but is elastic to permit contraction.

Cilia:

Body is covered by numerous, small hair-like projections called cilia, arranged in longitudinal rows. The length of cilia is uniform throughout the body (a condition called **holotrichous**), but there are a few longer cilia at the posterior end of body. These form caudal tuftof cilia (hence the name caudatum). Cilia have the same structure as flagella, an outer protoplasmic sheath or plasma membrane with nine double longitudinal fibrils, in a peripheral ring. Two central fibrils, which are thinner than the outer fibrils. Each cilium arrives from a basal granule. At the base the cilia has a diameter of 0.2µm (2000 A).

Cytostome:

Oral groove: On the ventro-lateral side is a large oblique, shallow depression called oral groove or peristome which gives the animal **asymmetrical appearance**. The oral groove lends into a short conical funnel shaped depression called **vestibule**. Vestibule leads to an oval shaped opening called **cytostome.** It is followed by a long opening called **cytopharynx;** which leads to the **oesophagous**-that leads to **food vacuole.**

Cytopyge:

The **cytopyge or cytoproctlies** on the ventral surface, almost vertically behind the cytostome. Undigested food particles are eliminated through the **cytopyge.**

Cytoplasm:

The cytoplasm is differentiated into a narrow peripheral layer of clear and dense plasmegel, called **ectoplasm** and an inner large central mass of granular and semifluid plasmasol or **endoplasm.**

Ectoplasm: It forms a firm, clear, thin and dense outer layer. It contains the **trichocysts**, cilia and fibrillary structures and is bound externally by a covering called **pellicle.**

Endoplasm: Endoplasm is the voluminous part of the cytoplasm, contains many granules as well as other structures and inclusions such as mitochondria, vacuoles etc. other students includes nuclei, contractile vacuole, food vacuole etc.

Trichocysts: Small spindle shape bags are embedded in the ectoplasm filled with a refractive, dense fluid having swelling substance. At the outer end there is a conical head on spike.Trichocysts lie perpendicular to ectoplasm.

Nuclei:

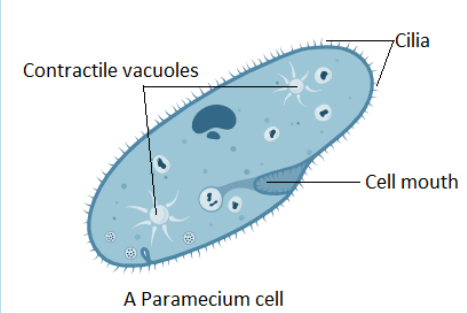
Macro Nucleus: It is a ellipsoidal or kidney like shaped nucleus. Densely packed with chromatin granules (DNA). It is a vegetative nucleus,controls vegetative functions.

Micro Nucleus: Small compact and spherical, found close to macro nucleus. Fine chromatin granules and threads uniformly distributed throughout the structure.It controls reproduction. Number varies with species to species. Nucleolus is absent in caudatum.

Food Vacuole:

Roughly spherical, non contractile lies varying in size and lying in the endoplasm.They contain digested food particle especially bacteria and small amount of fluid. The digestive granules are associated with the food vacuoles helps in digestion.

Contractile Vacuole:



A Paramecium cell

There are two fluid filled contractile vacuoles, one each at the ends of the body close to dorsal surface. Their position is fixed between the ectoplasm and endoplasm. They are temporary organs disappearing periodically.

Five to twelve radical canals are connected to each contractile vacuole. Each radial canal consists of a terminal part, a **long ampula** and a short injector canal which opens into the contractile vacuole. The canal communicate with large part of the body and takes up liquids and pour into the vacuole.

Thus the vacuole increase in size and the liquid discharged outside during systole through the permanent opening (pore) in the pelged. The two vacuoles contract irregulargly, the posterior C.V contract more rapidly because it is close to the cytopharynx and more water comes to it. The main function of contracted vacuole is **osmoregulation** and probably involves respiration and excretion.

NUTRITION IN *PARAMECIUM*

***Paramecium* is a tiny unicellular organism found in water. It follows**

1.Ingestion:

Paramecium engulfs food by the use of cilia. Cilia is a hair like structure present on surface on body of *paramecium*. Food is ingested by cilia through oral groove into gullet. The food is ingested with a little surrounding water to form a food vacuole

2.Digestion:

In *Paramecium*, food is digested in food vacuole by the digestive enzymes released by cytoplasm.Digestion in Paramecium is termed as "**intracellular digestion**".

3.Absorption:

The digested food present in the food vacuole of *Paramecium* is absorbed directly into the cytoplasm by diffusion. After absorption of food, the food vacuoleshrinks.

4.Assimilation:

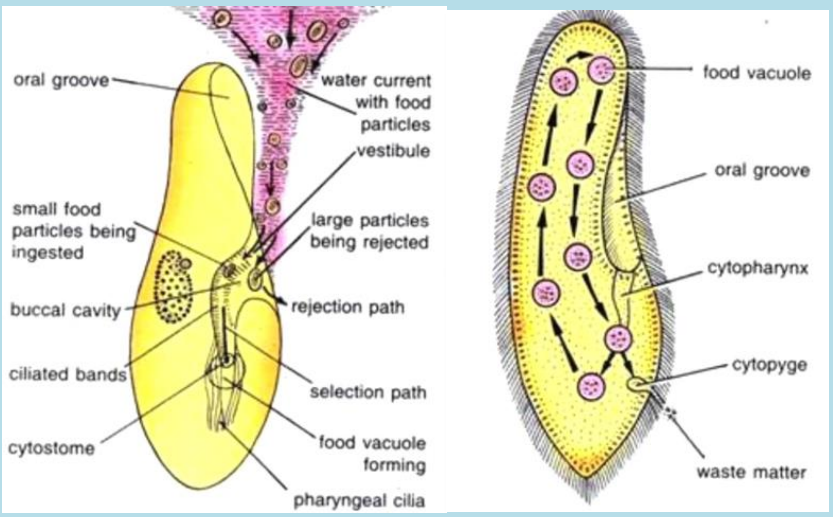
The absorbed food nutrients is stored and utilized later for synthesis of energy.

5.Egestion: The undigested food is expelled out through anal pore.

Feeding Mechanism in Paramecium

Paramecium feeds **holozoically** with the help of **cilium.** Food includes bacteria, unicellular plants (algae, diatoms, yeasts, etc.) and small bits of animal and vegetables. Paramecium swims to place where it can get its food. It does not move while feeding.

Food is ingested by cytosome lying at the bottom of buccal cavity. At first cilia of oral groove move very fast that drives current of water with food particles toward vestibule. Ciliary tracts of vestibule direct the food particles into buccal cavity. Larger food materials are rejected whereas smaller food materials are selected and ingested through cytosome into **cytopharynx**. The food now gradually collects at the bottom of cytopharynx into a membranous vesicle which is later released off as food vacuole.



Digestion:

Each food vacuole consists of food particles and it undergoes circulation in definite path along with **cyclosis.** Digestion takes place with the help of certain enzymes secreted by protoplasm into the vacuoles. The contents of vacuole first become acidic and then become alkaline.

The major digestion of food occurs during the alkaline phase. In digestion proteins are converted into aminoacids, carbohydrates into soluble sugar and glycogen. Products of digestion are diffused into the surrounding cytoplasm and either stored or used for vital activity and growth. Finally the undigested food materials is eliminated from the body through anal spot or **cytoprocton** ventral surface.

Reproduction in *Paramecium caudatam*:

Paramecium caudatum reproduces asexually by transverse binary fission and also undergoes several types of nuclear reorganisation, such as **conjugation, endomixis, autogamy, cytogamy and hemixis, etc.**

(i) Transverse Binary Fission:

Transverse binary fission is the commonest type of asexual reproduction in *Paramecium*. It is a distinctly unique asexual process in which one fully grown specimen divides into **two daughter individuals** without leaving a parental corpse.

The plane of division is through the centre of the cell and in a plane at right angles to the long axis of the body. Division of the cell body as a whole is always preceded by division of the nuclei; indeed it appears that reproduction is initiated by nuclear activity and division.

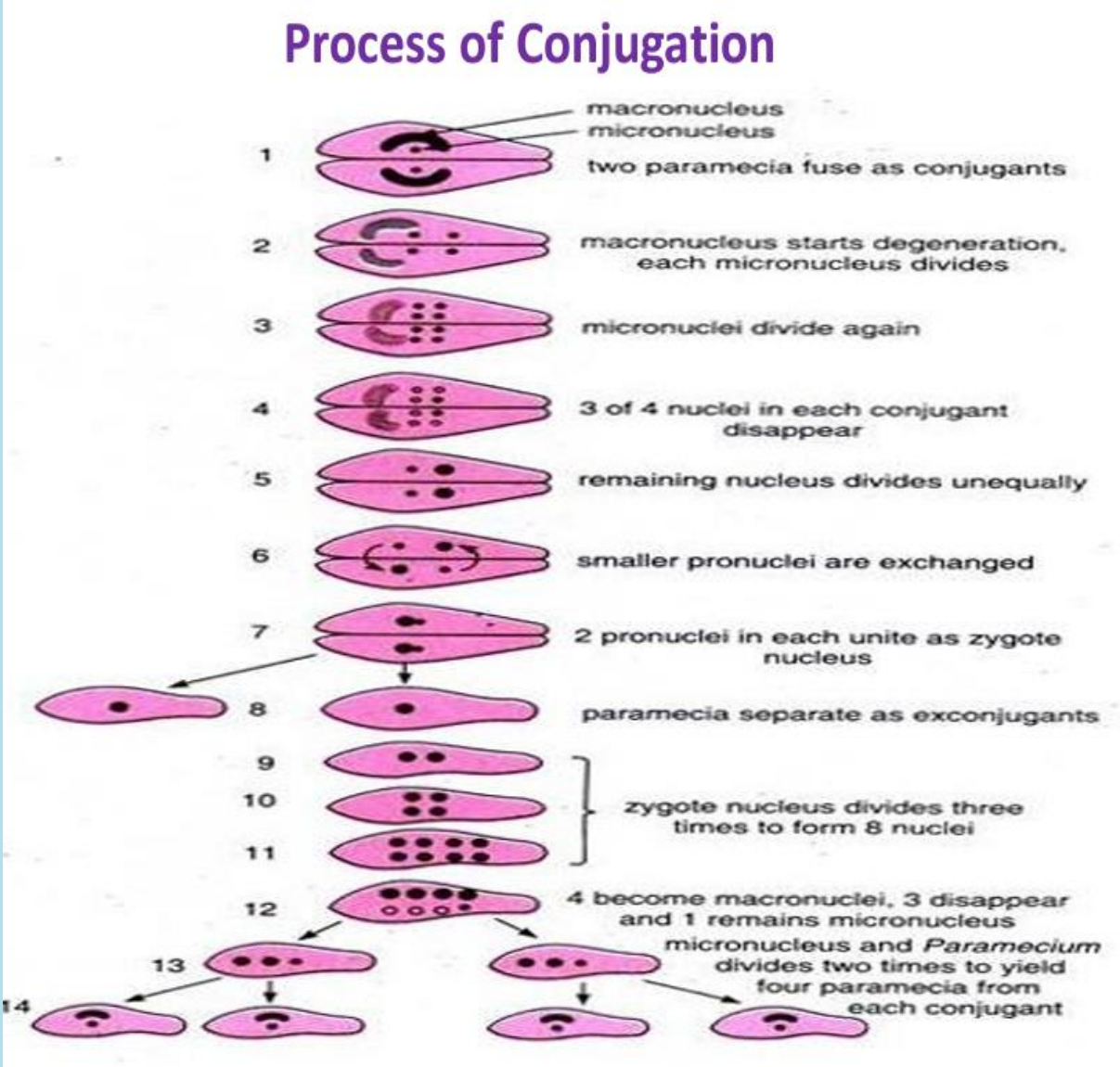
Paramecium caudatum reproduces by transverse binary fission during favourable conditions. In binary fission, the micronucleus divides by mitosis into two daughter micronuclei, which move to opposite ends of the cell. The macronucleus elongates and divides **transversely by amitosis.**

Another cytopharynxis budded off and two new contractile vacuoles appear, one near anterior end and another near posterior end. In the meantime, a constriction furrow appears near the middle of the body and deepens until the cytoplasm is completely divided.

The resulting **two"daughter"paramecia** are of equal size, each containing a set of cell organelles. Of the two daughter paramecia produced, the anterior one is called proter and the posterior one is called opisthe. They grow to full size before another division occurs.

The process of binary fission requires about two hours to complete and may occur one to four times per day, **yielding 2 to 16 individuals**. About 600 generations are produced in a year.

The rate of multiplication depends upon external conditions of food, temperature, age of the culture, and population density; also on the internal factors of heredity and physiology. Naturally, if all the descendants of one individual were to survive and reproduce, the number of *paramecia* produced would soon equal to the volume of the earth.



(ii) Conjugation:

Ordinarily *Paramecium caudatum* multiplies by binary fission for long periods of time, but at intervals this may be interrupted by the joining of two animals along their oral surfaces for the sexual process of conjugation.

Conjugation is defined as **the temporary union of two individuals** which mutually **exchange micro nuclear material**. It is unique type of a **sexual process** in which two organisms separate soon after exchange of nuclear material.

Sonneborn(1947), on the basis of mating behaviour of *Paramecium Caudatum*, has reported that each species of *Paramecium* exists in a number of varieties or syngens

Further, within each syngen there are a number of mating types usually two.

The mating types remain morphologically identical but they exhibit physiological differences. In *P. aurelia*, there are 14 syngensand 28 mating types, while in *P. caudatum*, there are 16 syngens and 32 mating types.

Observations have been made that usually *paramecia* neither conjugate with members of their own mating type nor with the other varieties, but only with the second mating type of their own variety.

POLYMORPHISM IN COELENTERATA

(GR: POLYS = MANY, MORPHE =FORM)

Occurence in the same population of more than one type of as Polymorphism. Polymorphism denotes division of labor among the zooids of the individual.

Polymorphism is one of the characteristics feature of Coelenterate animals.

In coelenterata or in hydrozoa which may be single or colonial, here occur two main types of individuals or zooids-Polyp and medusae.

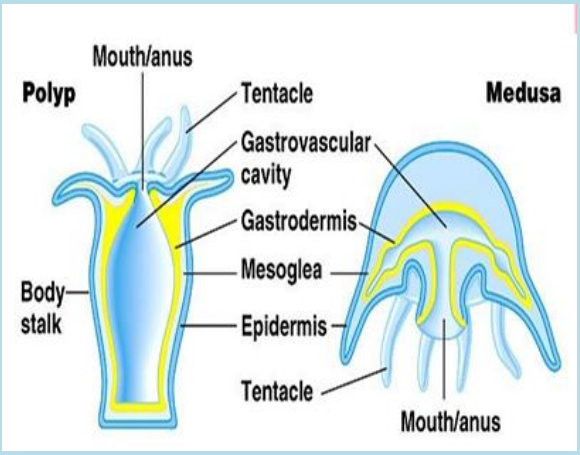
Polymorphism (Gr.,poly=many;morphe=form) is the occurrence of several different types of individuals or zooids in a single species during its life cycle or as members of the colony, the members perform different functions sothat there is a divisionof labour amongst the members.

Coelenterata are noted for their polymorphism,but the various types are reducible to either a polypoid or medusoid type.The polyp and medusa occur

In a number of morphological variations.However, polymorphism may be defined as the representation of a single organism by more than one kind of individuals or zooids which differ in their form and function.

Polyp: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.

Medusa:A medusae has a bowl or umbrella shaped body with marginal tentacles and centrally located mouth or manubrium.



PATTERNS OFPOLYMORPHISM:

Degree of polymorphism varies greatly in different groups of hydrozoa.

1. **Dimorphic**: Simplest and commonest pattern of polymorphsm is exhibited by many hydrozoan colonies like Obelia, Tubulariaetc.,

They have two types of individuals or zooid namely:

Gastrozooids or hydranths are connected for **feeding**

Gonazooids or blastostyles with asexual budding forming **sexual medusae or gonophores.** This phenomenon is termed as dimorphism.

2. Trimorphic:

Besides gastrozooids and gonozooids they also possess a **third type** individuals the **dactylozooids.**

3. **Polymorphic:**

Animals having **more than three types of individuals are called polymorphic.** Some what greater degree of polymorphism is found in the encrusting colony of **Hydractinia with five types of polyps each performing a specialized function.**

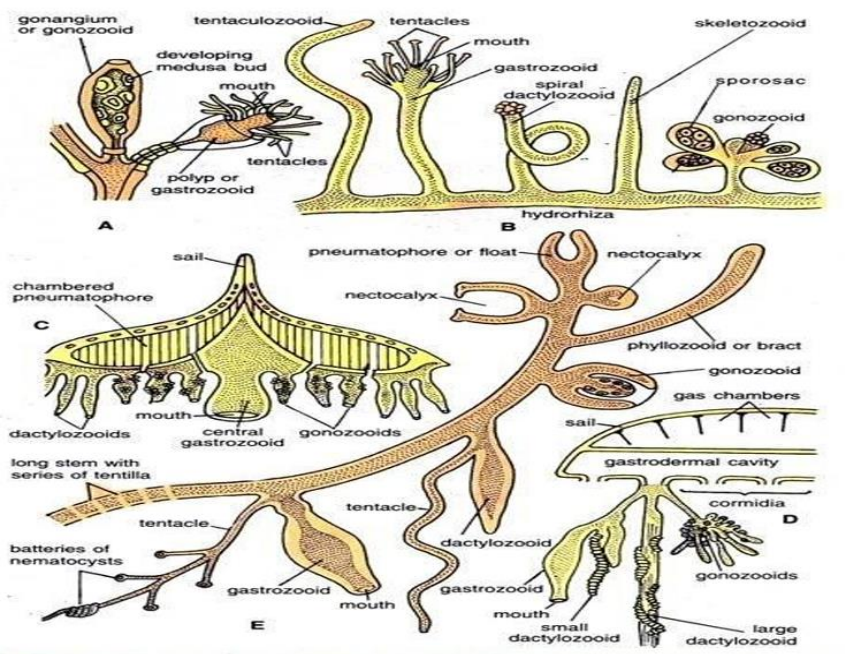
1. Gastrozooids-feeding

2. Dactylozooids-protection.

3. Tentaculozooids-Sensorycells

4. Skeletozooids-Spiny projections of chitin

5. **Gonozooids-Reproductiveindividuals.**



Polymorphic colonies of Hydrozoa. A—*Obelia* ; B—*Hydractinia* ; C—*Velella* ; D—*Physalia showing a single cormidium*; E—Generalised calycophoran Siphonophora showing a single cormidium.

POLYPOID ZOOIDS ARE:

1. Gastrozooids

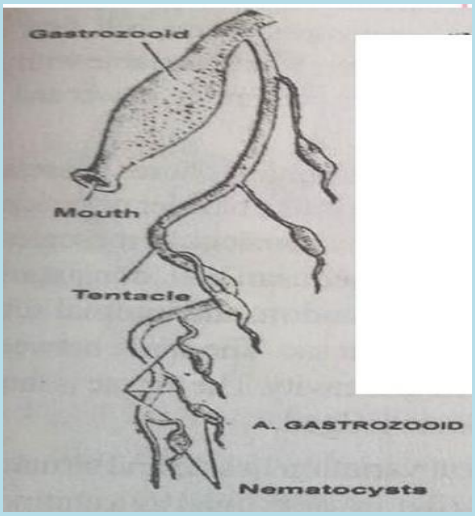
2. Dactylozooids

3. Gonozooids

1. Gastrozooids:

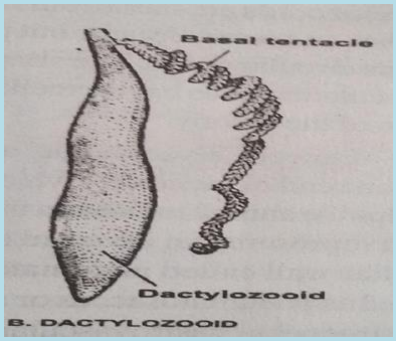
The nutritive polyps are called gastro-zooids. They alone take up nutrition in the colony.

A mouth is present at the tip of the hypostome.Near the base of a gastrozooid usually a single, long and contractile tentacle arises. It shows batteries of nematocysts. Lateral branches are present called **tentilla.** Gastrozooids catch the prey and digest it.The digested food is thrown into the coenosarcal canal.



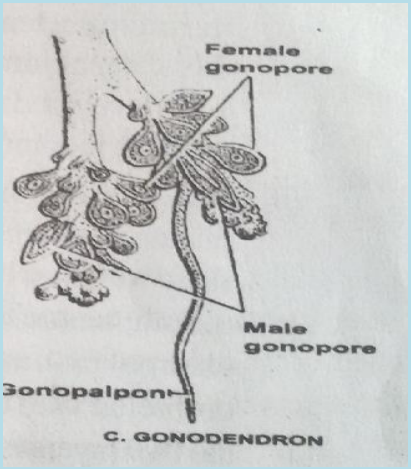
2. **Dactylozooids:**

They are called Palpons,**feelers or tasters.** They resemble the gastrozooids. **They donot show mouth.Their basal tentacle is unbranched**. In **Physalia**, the tentacle is very long. In **velella and Porpita** the margin of the colony bears long and hollow tentacles. These zooids are protective in function. They bear batteries of nematocysts.



3. Gonozooids:

The **reproductive zooids.** They have no mouth. In Physalia branched the gonozooid shows stalk, bearing clusters of gonophores (gonopalpon). Gonozooids produce medusae called **gonophores.** In Porpita and Velella dactylozooids are treated as gonodactylozooids.



Special Zooids

1) **Gonostylesor Secondary Siphono-zooids**: The gonads remain attached with the siphonozooids.

2) **Hydrorhiza:**In **Obelia**, the hydrorhizaacts as the organ of attachment for the whole colony.

3) **Hydrocaulus**: **In Obelia**, the hydro-caulus, arising from the hydrorhiza, bears different zooids and helps to convey the food matters to the different parts of the colony.

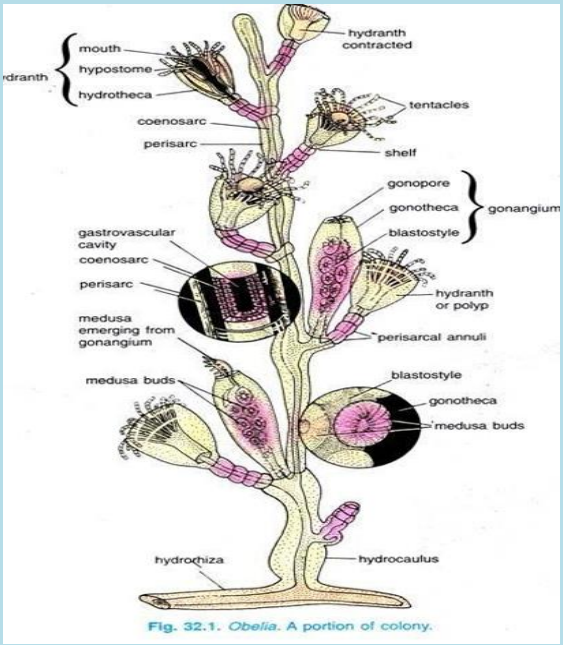


Fig. 32.1. *Obelia*. A portion of colony.

MEDUSOID FORMS:

❖Pneumatophores:

❖Nectopore or Nectocalyx or swimmingzooid:

❖Bracts:

❖Gonophores:

MEDUSOID FORMS:

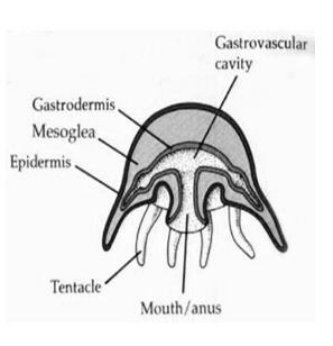
1.Pneumatophores:

It functions as a **float**.It is an inverted medusan bell. The walls are two layered and highly muscular. The epidermal lining becomes glandular to form a gas gland. The gas gland secretes gas into the air-sac.

1) The **pneumatophore** is **small in Halistemma.**

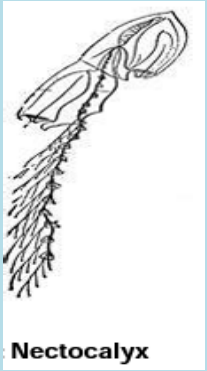
2) The pneumatophore is **very large in Physalia**.

3) It is **disc-shaped in porpita.**



2.Nectopore orNectocalyx or swimming zooid:

Nectocalyces or nectophores are **bell-shaped** medusoids with a velum,radial canals and circular canal, they have no mouth, manubrium, tentacles or sense organs, A nectocalyx is muscular and **brings about locomotion of the colony by swimming**. It is also referred to as **nectophore or nectozooid.**



3.Bracts :

They are also known as **hydrophyllia.** They are leaf like, helmet shaped.

They serve to cover and protect other zooids of the colony.

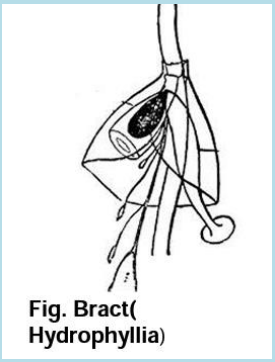


Fig. Bract(Hydrophyllia)

4,**Gonophores:**

Bearing gonads, male gonads **produce sperm and female gonad produce ova.**

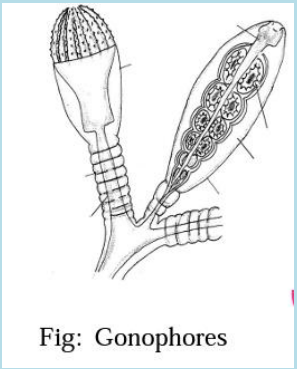
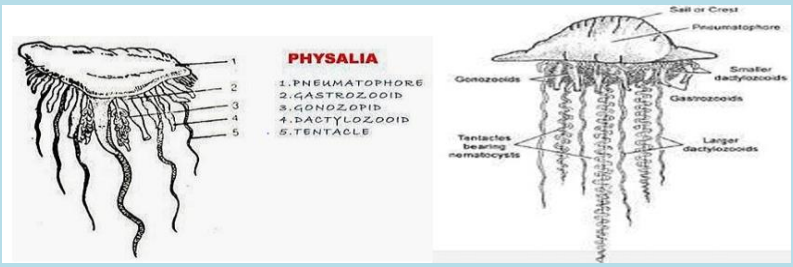


Fig: Gonophores

NOTABLE POLYMORPHIC COLONIES

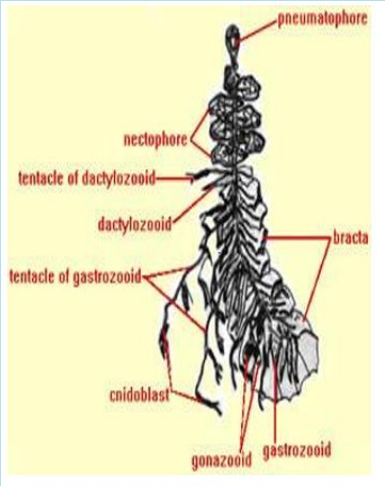
Hydrozoans exhibit remarked development of Polymorphism. Some of them are **Physalia, Halistemma, Porpita**

Physalia: Is commonly called as **floating pelagic colonial form**. **Portuguese man of war.**This is a free The medusa is modified into a big pneumatophore or float which floats above the water. The underside of the float has cormidia. Each cormidium consists of a small dactylzooids with a long slender tentacle,a large dactylozooid with an enormous nematocyst bearing fishing tentacles. A branched gonozooid with male and female gonophores is present.



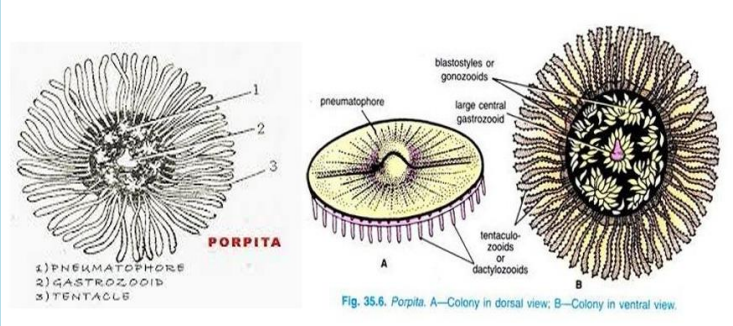
Halistemma:

This is a floating form with long,thin peduncle (with nodes) having different zooid. Pneumatophore is at first anterior end of peduncle and helps the animal float on the surface bottom of the water. The of the float has asymmetric medusa,which are called nectocalyces which help in locomotion. Each nectocalyces is with nodes and bell shaped.Manubrium is absent.



Porpita:

It has medusoid disc like large pnematohore and chitinous shell with many concentric gas chambers. On the ventro-central region is a single large gastrozooid which is surrounded by clusters of small gonozooids which bear sexual medusae. On the edge of it tantacle like dactylozooids armed with nematocysts.



ORIGIN OF POLYMORPHISM

There are many theories to explain the origin of polymorphism in coelenterates.

Poly-organ theory:

This theory was proposed by Huxley(1859), Eschscholtz (1829), E.Metschnik off (1874) and Muller (1871). According to this theory, apolymorphic colony is supposed to be a single medusoid zooid; its various components are regarded to be the modified organs of this medusoid zooid.The various parts of the zooid, i.e., manubrium, tentacles, umbrella, etc.,

multiply independently from one another and they have assumed different forms to perform different functions.

Poly-person theory:

This theory was first proposed by Leuckart (1851), Vogt (1848),Gegenbaur (1854),Kolliker (1853),Claus (1863) and later strongly supported by E. Haeckel (1888),Balfour (1885) and Sedgewick (1888). According to this theory colony is not a single individual but various parts of the colony are modified individuals which have changed their structure due to division of labour.They have all modified from the primitive zooid which was a polyp.

Medusa theory:

This theory was proposed by Haeckel (1888) as a compromise between the above theories.The theory says that the siphonophores formed from gastrula was a medusoid individual, from which zooids or persons appeared by budding from the subumbrella.

SIGNIFICANCE OF POLYMORPHISM

The phenomenon of polymorphism is essentially one of **division of labour** in which specific functions are assigned to different individuals.Thus, polyps are modified for feeding, protection and asexual reproduction, while medusae are concerned with sexual reproduction. This distribution of functions among diversified individuals and their subsequent modifications in coelenterates may have resulted from their initial simple organization and lack of organ specialization. Polymorphism gave the colonies competitive edge in protection and food gathering and eventual survival. polymorphism:colonies of some species have morphologically differing individuals each specialized for certain roles e.g. feeding, reproduction & defense etc.
