GENERAL TOPICS
2.1 PROTOZOA

LOCOMOTION IN PROTOZOA

- Locomotion is the movement of progression through the medium in which the animals change their place and position so as to get food materials, partners, protection and suitable environment.
- The protozoa exhibit three different types of locomotion.

1. Amoeboid or Creeping
2. Swimming
3. Metaboly or Gliding

1. Amoeboid or Creeping:

- It is performed by changing frowning and cytoplasmic processes, the pseudopodia.
- It is characteristic of class rhizopoda and many sporozoa

2. Swimming:

- It may be performed either with the help of flexible protoplasmic thread, the flagella or with the help of shorter vibratile threads the cilia.
- It is characteristic of class mastigophora and ciliate respectively.

3. Metaboly or Gliding:

- In class sporozoa, external locomotory organelles are absent but gliding and change in form takes place in some of them due to the contraction of the myonemes found in the body.
- The locomotory organelles are closely associated with the body surface and may also help in food capture besides locomotion.
- They may be combining with internal contractile organelles.

Pseudopodia: Pseudopodia are generally temporary outgrowths of protoplasm from any part of body. They are found in those protozoa which do not possess a definite pellicle. They may be of ectoplasm. They can be retracted when not needed and formed a new. They are of various shape, size, structure and activity found in different protozoa.

Lobopodia: These are thick, finger like, outgrowths with rounded or blunt tips. They are usually composed of both ectoplasms. They are quickly formed and quickly withdrawn.

Example *Amoeba, Pelamyxa, Arcella*

Filopodia: These are slender, thread like or filamentous with pointed tips and radiating from the body in all directions. They are made up of only hyaline ectoplasm. Example *Euglypha*

Reticulopodia: These are thin, long and branching. The branches anastomose to form a large, complex network which also serve as a trap for capturing. Example *Elphidium*

Axopodia: These are stiff spine like and semi-transparent pseudopodia and mainly serving for food capture rather than locomotion. They are made up of ectoplasm with a hard central axial filament of endoplasm. Example *Actinophyrs*

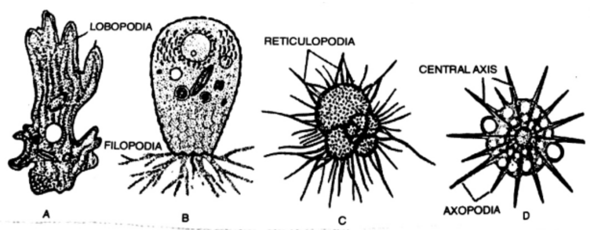


Fig. 1. Types of pseudopodia. **A.** Lobopodia of *Amoeba*. **B.** Filopodia of *Euglypha*. **C.** Reticulopodia of *Globigerina*. **D.** Axopodia of *Actinophrys*.

1. Amoeboid Movement

This type of locomotion is also called as pseudopodial locomotion. Here locomotion is brought about by the pseudopodia. It is the characteristic of rhizopod protozoans like *Amoeba proteus* and *Entamoeba histolytica.* Also, such movement is exhibited by amoeboid cells, macrophages and phagocytic leucocytes like monocytes and neutrophils of metazoans. Various theories have been proposed to explain the amoeboid locomotion.

Sol Gel theory:

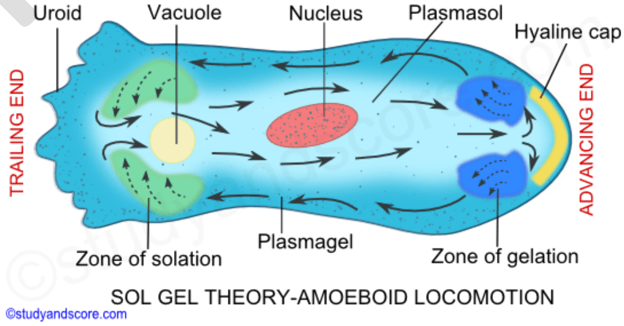
Sol Gel theory convincingly explains the mechanism involved in the formation of pseudopodia. This theory, also known as Change in viscosity theory was advocated by Hyman. Later Pantin and Mast explained this theory. According to this theory, the cytoplasm of amoeba can be distinguished into outer ectoplasm/Plasmagel and the inner endoplasm/Plasmosol.

The plasmagel which forms the outer layer of the cytoplasm is thick, less in quantity, non-granular, transparent and contractile. The plasmosol which forms the inner layer of the cytoplasm is more in quantity, less viscous, fluid like, more granular and opaquer. Due to change in the viscosity, the plasmagel and plasmosol inter-convert and consequently the pseudopodia form and disappear causing the movement of Amoeba.

Amoeboid locomotion can be explained in the following steps:

Step 1: Initially Amoeba attaches itself to the solid substratum by the plasma lemma at the temporary anterior end.

Step 2: Then the hyaline layer of the ectoplasm at the anterior end forms a thickened hyaline cap. It is the first stage in the formation of the pseudopodium.



SOL GEL THEORY-AMOEBOID LOCOMOTION

Step 3: Behind the hyaline cap, a point of weakness in the elasticity of plasmagel is formed. Hence the inner plasmosol flows forward, forming a pseudopodium.

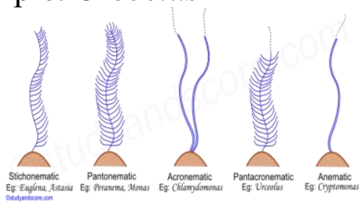
Step 4: The plasmosol that flows outward behind the hyaline cap changes its colloidal state from sol to gel and joins the ectoplasm.

Step 5: The outer region of the plasmosol, which is flowing forward undergoes gelation and produces a rigid plasmagel tube. The gelation of plasmosol extends the plasmagel tube forward.
Step 6: Two ends appear in Amoeba at this stage. The anterior end is smooth with the rounded surface which the retractile end also called as Uroid has a wrinkled surface.
Step 7: Around the region of the hyaline cap, an annular region of sol to gel transformation is formed. It is called the zone of gelation. At the uroid end a region where gel transforms into sol is called as zone of solution.
Step 8: Plasmagel at the uroid end changes into sol and flows forward continuously through the gelatinized tube. As the plasmosol flows forward, the pseudopodium elongates further and the body of amoeba moves in that direction. The ectoplasm does not move but grows at the leading tip and is broken down at the uroid end.
Step 9: The gelation at the advancing end and the solation at the trailing end occur simultaneously and at the same rate thus making the forward movement of amoeba continuous.
Step 10: The contraction of the plasmagel at the trailing end causes hydraulic pressure on the sol and makes the plasmosol flow forward continuously in the plasmagel tube.
Step 11: As the pseudopodium advances continuously in the direction of the movement the body of amoeba also moves.
Flagella:

- Flagella are thin, delicate and highly vibratile, thread like extensions of the protoplasm.
- They are used for swimming, for creating food currents for anchorage and as sensory organelles for exploring the media.
- A flagellum is a cylindrical or band like, filament, the axonema, enclosed by a protective contractile protoplasmic sheath. The axonema may be straight or spirally twisted.
- In some flagella sheath may bear a row of minute lateral processes, the mastigonemes along one or both the borders.

On the basis of the arrangement of mastigonemes the flagella are of the following types

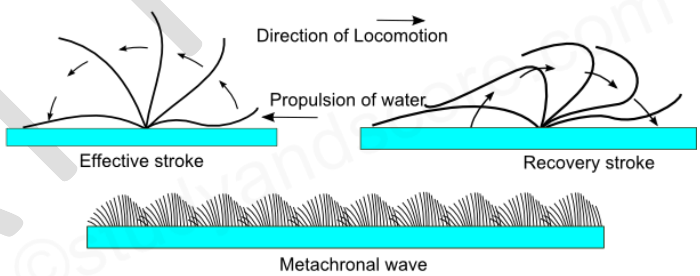
1. Stichonematic: It bears a single row of mastigonemes along on side of the sheath. Example: *Euglena*
2. Pantonematic: It bears two or more rows of mastigonemes.
   Example: *Paranema, Monas socialis*
3. Acronematic: It is also known as lash or whip flagellum. It bears terminal filament, which is the free distal part of axoneme projecting beyond the sheath. Example: *Chalamydomonas*
4. Pentachronematic: It bears terminal filament as well as two rows of mastigonemes, Example: *Urcoelus*



Flagellar movement:
Flagellar movement, or locomotion, occurs as either planar waves, oarlike beating, or three-dimensional waves. All three of these forms of **flagellar** locomotion consist of contraction waves that pass either from the base to the tip of the **flagellum** or in the reverse direction to produce forward or backward **movement**.

Ciliary Movement:
Ciliary movement is exhibited by the beating of the **cilia**. It is the most advanced, complicated and co-ordinated mode of **locomotion**. Definition: • "**Cilia** are fine, short, hair-like, centriole-based protoplasmic processes, characteristic of many **protozoan** and metazoan cells"

- Ciliary locomotion mainly occurs by movement of cilia.
- It can move forward and backward.
- While moving forward, cilia strongly move from anterior to posterior. Similarly, for backward movement cilia strongly move from posterior to anterior.
- All the cilia do not move at a time. Cilia of transverse row move at the same time.
- It is called synchronous rhythm, whereas cilia of longitudinal row move one after another.
- It is called Metachronous rhythm.
- The back-and-forth movements of the cilia are also called as effective and recovery strokes respectively.
- Cilium moves just like a pendulum or a paddle.
- The cilium moves the water parallel to the surface of its attachment like that of paddle stroke movement.
- The movement of water is perpendicular to the longitudinal axis of cilium.



CILIARY MOVEMENT-TYPES OF STROKES

NUTRITION IN PROTOZOA:
Nutrition is the process by which the organisms derive their nourishment and digest and assimilate it.

1. **Holozoic Nutrition:**
    - Holozoic nutrition is found in the majority of the free-living protozoans.
    - They depend upon ready made solid food particles comprising various microorganisms such as diatoms, rotifers, crustacean larvae etc.
    - They are unable to utilize simple substances for making their own food such protozoans are called holozoic or zootrophic, Example Amoeba.

- Some holozoic forms take large food particles and are called microphagous or raptorial.
- Other feeds on minute particles and are termed microphagous or ciliary feeder, Example Paramoecium
- This type of feeding involves three definite steps are as ------------

Ingestion of food,
Digestion and Assimilation and
Egestion of indigestible residue.

Ingestion of Food:

- The mode of food ingestion in Protozoa is characteristically referred to as phagocytosis or phagotrophic.
- In fact, in flagellates which are colourless or who have lost their chromatophores capture food with the help of their flagella.
- The captured food is ingested either at definite sites on their naked bodies through characteristic oral apparatus like Euglena where cytostome and cytopharynx help in ingestion.
- In Sarcodina, pseudopodia help in food capturing by forming food cups.
- Rhumbler (1930) has reported that the ingestion of food in Amoeba occurs by circumvallation, circumfluence, import and invagination.
- The feeding apparatus is provided with some specialised cilia.
- The beating of the cilia of cytopharynx creates a whirl pool of water current.
- The food particles in the water current are directed into the cytopharynx through cytostome.

Circumvallation: In this process **Amoeba** takes mobile and solid food substances. With the help of pseudopodia, it surrounds the food material. Without touching the food material, the edges of the pseudopodia come close together and with the ectoplasmic membrane form the food vacuole along with water.

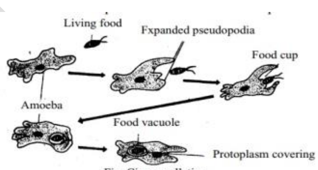


Fig. Circumvallation
Fig : 8.3

Circumfluence: In this process Amoeba takes immobile food materials. Immediately after coming in contact with the food material, amoeba forms a "food cup" and by stretching the pseudopodia it brings the enclosed food in direct contact with the body. In this way, Amoeba takes the food material inside the body.

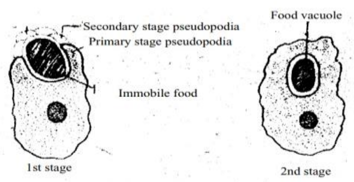


Fig : Circumfluenee
2nd stage
Fig : 8.4

Import: If any food material comes on its body, by being motionless and without stretching any pseudopodia, Amoeba makes the food inactive. Then the inactive food material is taken inside the body. This is called import process.

Invagination: When the body of amoeba comes in contact with any food particle it secretes sticky substance and fixes it with the body surface. Besides Amoeba secretes a kind of toxic juice from the body which kills the living food material. The ectoplasm along with the food enters the endoplasm in the form of a tube. Then the plasma membrane disappears and forms a food vacuole. In this process no pseudopodium is required to receive the food material.

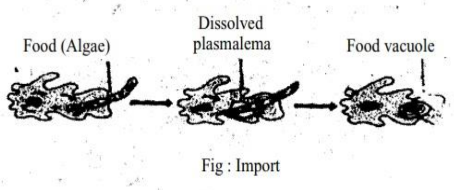


Fig : 8.5

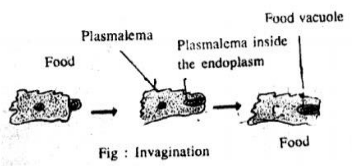


Fig: 8.6

Digestion and Assimilation:

- Digestion occurs intracellularly within food vacuoles.
- In most protozoans the food vacuoles undergo definite change in hydrogen ion concentration and in size during the process of digestion.
- Acid, Alkalies and digestive enzymes are poured in the food vacuoles from the surrounding endoplasm.
- The vacuole receives alkaline juice from surrounding endoplasm so that its content becomes alkaline.
- Digestion occur during the alkaline phase which last for several hours.
- The digestive enzymes are provided by the lysosomes which fuses with the food vacuoles.
- Digestion is brought about by enzymes protease, amylase, lipase and cellulase.
- The products of digestion are absorbed in to the endoplasm and supplied to every part of the cell body by diffusion.

Egestion:

Digestion in **protozoan** organisms such as amoebas and paramecia take place when a food particle is encased in a food vacuole. The vacuole and a lysosome unite, forming a digestive vacuole, and the products of digestion are absorbed across the vacuolar membrane. Indigestible wastes are ultimately expelled.

2. Autotrophic or Holophytic Nutrition:

- Protozoa with chlorophyll or some allied pigment can manufacture complex organic food, like those of green plants, from simple inorganic substances. Example, *Euglena, Noctiluca*.
- Often there may be protein bodies called pyrenoids which are the centres of photosynthesis.

- Some Protozoa have no chromatophores but they have chlorophyll-bearing algae Zooxantliellae or Zoochldrellae which manufacture organic food for the host by photosynthesis, e.g., *Stentor, Thalassicola, Paramecium bursaria.*

3. Saprozoic Nutrition:

- Some Protozoa absorb complex organic substances in solution through the body surface by the process of osmosis called osmotrophy.
- These Protozoa are called saprozoic.
- Saprozoic forms need ammonium salts, amino acids, or peptones for their nutritional requirements.
- Decaying of animals and plants in water forms proteins and carbohydrates.
- The saprozoic Protozoa are usually parasites like Monocystis.
- But some parasites, like *Entamoeba histolytica* and *Balantidium coli* feeding holozoically also absorb dissolved organic substances through their general body surface.
- However, some colourless flagellates like Chilomonas, Polytoma and species of *Euglena* absorb nutrients from their surrounding environment through their general body surface.

4. Parasitic Nutrition:

The parasitic forms feed either holozoically or saprozoically.

(i) Food-robbers:

- The parasites feeding upon the undigested or digested foodstuffs of their hosts are known as food-robbers, such as some ciliate parasites like Nyctotherus, Balantidium.
- These parasites feed holozoically on solid food particles, while few others like Opalina feed upon the liquid food by the process of osmosis through their general body surfaces.
- The food-robbers are generally non-pathogenic to their hosts.

(ii) Pathogenic:

- The protozoan parasites causing harm to their hosts, usually feed upon the living tissues of the host.
- They absorb liquid food through their general body surface, e.g., *Trypanosoma, Plasmodium*, etc.

5. Mixotrophic Nutrition:

- Some Protozoa nourish themselves by more than one method at the same time or at different times due to change in environment.
- This is called mixotrophic nutrition, e.g., *Euglena gracilis* and *Peranema* are both saprozoic and autotrophic in their nutrition, and some flagellates are both autorophic and zootrophic.

2.2 PORIFERA

Spicules:

- The spicules or sclerites are definite bodies, having a crystalline appearance and consisting in general of simple spines or of spines radiating from a point.
- They have an axis of organic material around which is deposited the inorganic substance, either calcium carbonate or hydrated silica.
- They present a great variety of shape and as reference to the shape is essential in the description of sponges, a large terminology exists.

Spicules are of two general types—

1. Megascleres and
2. Microscleres.

- The spicules are further classified according to the number of their axes and rays.
- Words designating the number of axes end in axons, those referring to the number of ray's end in actine or actinal.

1. Megascleres:

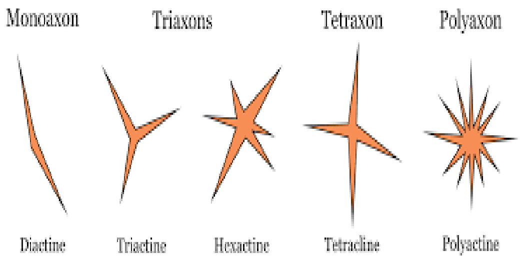
- The megascleres are the larger skeletal spicules that constitute the chief supporting framework of the sponge.
- There are five general types of megasclere spicules, viz., monaxons, tetraxons, triaxons, polyaxons and spheres.

(i) Monaxons:

- These are formed by growth in one or both directions along a single axis, which may be straight or curved.
- When growth has occurred in one direction only, the spicule is called monactinal monaxon or style.
- Styles are typically rounded (strongylote) at one end and pointed (oxeote) at the other.
- Styles in which the broad end is knobbed are called tylostyles; those curved with thorny processes are acanthostyles.
- Usually, the pointed end of styles projects to the exterior.
- Monaxons that develop by growth in both directions from a central point are named diactinal monaxons, diactines or briefly rhabds.

(ii) Tetraxons:

- Tetraxon spicules are also called tetractines and quadriradiates.
- They consist typically of four rays, not in the same plane, radiating from a common point.
- The four rays of the tetraxon spicule may be more or less equal, in which case the spicule is called a calthrops.
- Generally, one ray, rhabdome, is elongated bearing a crown of three smaller rays; such spicules are termed triaenes.
- By loss of one smaller ray results into a diaene.
- If the elongated ray bears a disc at both ends, it is called amphidisc.
- Loss of elongated ray results into a triradiate or triactinal spicule, called a triode characteristic of calcareous sponges.



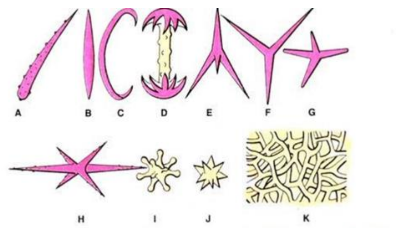


Fig. 28.9. Spicules and spongin. A—Monactinal monaxon; B—Diactinal monaxon; C—Curved monaxon; D—Monaxon with hooked ends; E—Tetraxon; F—Triradiate; G—Calthrops; H—Hexactinal triaxon; I and J—Polyaxon; K—Spongin fibres.

(iii) Triaxons:

- The triaxon or hexactinal spicule consists fundamentally of three axes crossing at right angles, producing six rays extending at right angles from a central point.
- From this basic type all possible modifications arise by reduction or loss of rays, branching and curving of the rays, and the development of spines, knobs, etc., upon them.
- The triaxon spicules are characteristic of class Hexactinellida.

(iv) Polyaxons:

These spicules in which several equal rays radiate from a central point.

(v) Spheres:

These are rounded bodies in which growth is concentric around a centre.

(vi) Desma:

- A special type of megasclere known as desma occur in a number of sponges.
- A desma consists of an ordinary minute monaxon, triadiate, or tetraxon spicule, termed the crepis, on which layers of silica have been deposited irregularly.
- Desmas are named from the shape of the crepis, as monocrepid, tricrepid and tetracrepid.
- They are usually united into a network and such a reticulated skeleton is called lithistid.

2. Microscleres:

- The microscleres are the smaller flesh spicules that occur strewn throughout the mesenchyme.
- However, they do not form the supporting framework.
- The microspheres are of two types, viz., spires and asters.

(i) Spires:

- Spires are curved in one plane or spirally twisted and exhibits many shapes.
- The most common types are the C-shaped forms, called sigmas; the bow-shaped ones, or toxas and the chelas with recurved hooks, plates or flukes at each end.
- When two ends are alike, chelas are called isochelas, when unlike, anisochelas. Spirally twisted sigmas are termed sigmaspires.

(ii) Asters:

- Asters include types with small centres and long rays and large centres and small rays. Among the small centred forms are oxyasters with pointed rays, strongylaster with rounded ends and tylasters with knobbed rays.
- Large-centred forms include spherasters with definite rays and sterrasters with rays reduced to small projections from the spherical surface.

- Short spiny microscleric monaxons are known as streptasters, of which the principal sorts are the spirally twisted spirasters, rod shapes or sanaidasters, plesioasters with a few spines from a very short axis, and amphiasters with spines at each end.
- Microscleric forms of diactines are microrhabds, microxeas, and microstrongyles.

Development of Spicules:

- Spicules are secreted by mesenchyme cells, called scleroblasts.
- Very little is known about the formation of various kinds of spicules.
- The process is best known for calcareous spicules.
- On the basis of development, the spicules may be primary which owe their first origin from a single mother cell or scleroblast, or secondary which arise from more than one scleroblast.

(i) Development of monaxon spicules:

- In calcareous sponges, a monaxon spicule is secreted within a binucleate sclerobast, probably arising by the incomplete division of an ordinary scleroblast.
- The calcium carbonate is deposited around an organic axial thread in the cytoplasm between the two nuclei.
- As the spicule lengthens, the two nuclei draw apart until the scleroblast divides into two.
- One cell, the founder is situated at the inner end, the other the thickner at the outer end of the spicule, since monaxon spicules usually project from the body wall.
- The spicule is laid down chiefly by the founder which moves slowly inward, establishing the shape and length.
- The thickner deposits additional layers of calcium carbonate, also moving inward during this process.
- When the spicule is completed, both cells wander from its inner end into mesogloea, the founder first and the thickner later.
- The development of siliceous spicules is poorly known and requires further exploration.
- It appears that in most cases they are formed completely with one scleroblast called silicoblast.

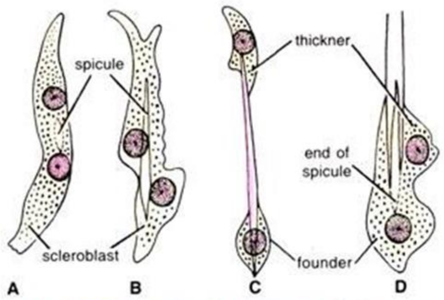


Fig. 28.10. Secretion of a monaxon spicule.

(ii) Development of triaxon spicules:

- Triaxon or triradiate calcareous spicules are secreted by three scleroblasts which come together in triangle and divide in two, each into an inner founder and an outer thickner.
- Each pair secretes a minute spicule and these three rays are early united into a small triradiate spicule.
- Each ray is then completed in the same manner as a monaxon spicule.
- Later on, three rays or spicules unite together forming a triaxon or triradiate spicule.

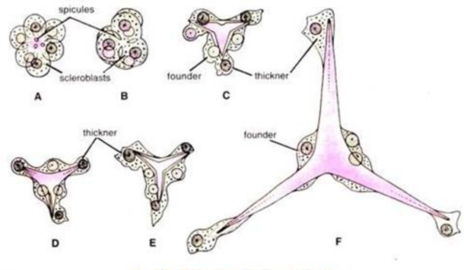


Fig. 28.11. Secretion of a triaxon spicule.

(iii) Development of other spicules:

- In the formation of quadriradiate or tetraxon spicules, the fourth ray is added to forming triradiate spicule by an additional scleroblast.
- The hexactinal spicules of Hexactinellida arise in the centre of a multinucleate syncytial mass which is probably formed by repeated nuclear division of an original silicoblast.

SPONGIN

Spongin is an organic, horney, elastic, substance allied to silk in chemical composition. It is a scleroprotein containing sulphur and is chemically related to collagen, a horney protein. It is insoluble, chemically inert and resistant to protein digesting enzymes.

It may occur as a cement connecting together the siliceous spicules in order monoaxonida.

Development of Spongin:

Spongin fibres are secreted by mesenchyme cells called spongioblasts. The spongioblasts arrange themselves in a row and a spongin rod is secreted by each fuse with those of adjacent spongioblasts to form a long fibre. The spongioblasts becomes vacuolated and degenerate after having secreted a certain amount of spongin.

Uses of Skeleton:

1. It forms the chief skeletal framework and support the soft cellular tissues. It keeps the canals and meshes open and gives stability to the body.
2. It enables the sponge to grow to considerable size.
3. As there are various types of spicules in different classes of porifera, these spicules serve as an important criteria for identification of sponges. For example, calcareous sponges are placed under the class Calcarea because they all have spicules of calcium carbonate. The sponges of class Hexactinellida possess siliceous spicule. Thus, classification is based mainly on kinds and arrangement and nature of skeletal material, the spicules.

CANAL SYSTEM IN SPONGES

A distinguishing feature of all the sponges is the perforation of the body surface by numerous apertures for the inhaling and exhaling of the water current. The most vital role in the physiology of sponges is played by the feeding water current on which their life depends. All the exchanges between the sponge body and external medium are maintained by means of this current. This current is caused by the beating of the flagella of the collar cells. Inside the body the water current flows through a certain system of spaces called as canal system. There are three type of canal system are as below.

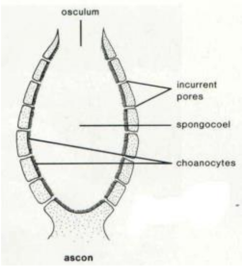
1. Asconoid / Ascon Type
2. Syconoid Type
3. Leuconoid / Leucon Type

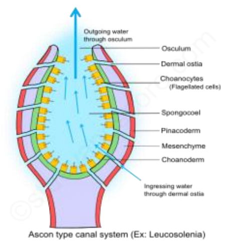
i. Euryphylous Type
ii. Aphodal Type
iii. Diplodal Type
iv. Rhagon Type

1. **Asconoid / Ascon Type:**

- This canal system is the simples of all the three. It is found in asconoid type of sponges like Leucosolenia and also in some of the developmental stages of all the syconoid sponges.
- The body surface of the asconoid type of sponges is pierced by a large number of minute openings called as incurrent pores or ostia.
- These pores are intracellular spaces within the tube-like cells called porocytes.
- These pores extend radially into mesenchyme and open directly into the spongocoel.
- The spongocoel is the single largest spacious cavity in the body of the sponge.
- The spongocoel is lined by the flattened collar cells or choanocytes.
- Spongocoel opens outside through a narrow circular opening called as osculum located at the distal end and it is fringed with large monaxon spicules.
- The surrounding sea water enters the canal system through the ostia.
- The flow of the water is maintained by the beating of the flagella of the collar cells.
- The rate of water flow is slow as the large spongocoel contains much water which cannot be pumped out through a single osculum.

Ingressing water → Ostia → Spongocoel → Osculum → outside



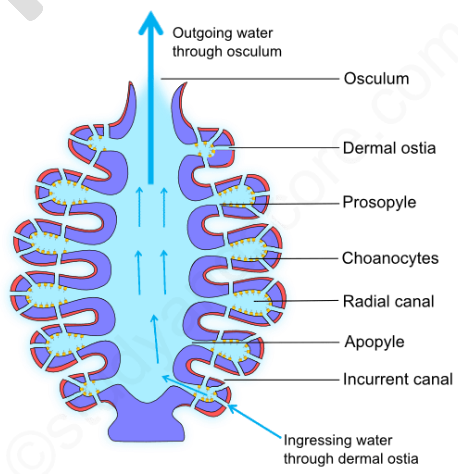


Ascon type canal system (Ex: Leucosolenia)

2. Syconoid Type:

- Sycon type of canal system is more complex compared to the ascon type.
- This type of canal system is the characteristic of syconoid sponges like Scypha.
- Theoretically this canal system can be derived from asconoid type by horizontal folding of its walls.
- Also, embryonic development of *Scypha* clearly shows the asconoid pattern being converted into syconoid pattern.
- Body walls of syconoid sponges include two types of canals, the radial canals and the incurrent canals paralleling and alternating with each other.
- Both these canals blindly end into the body wall but are interconnected by minute pores.
- Incurrent pores also known as dermal ostia are found on the outer surface of the body.
- These incurrent pores open into incurrent canals.
- The incurrent canals are non-flagellated as they are lined by pinacocytes and not choanocytes.
- The incurrent canals leas into adjacent radial canals through the minute openings called prosopyles.
- On the other hand, radial canals are flagellated as they are lined by choanocytes.
- These canals open into the central spongocoel by internal ostia or apopyles.
- In sycon type of canal system, spongocoel is a narrow, non-flagellated cavity lined by pinacocytes.
- It opens to the exterior though an excurrent opening called osculum which is similar to that of the ascon type of canal system.

Ingressing water → dermal ostia → incurrent canal → Prosopyles → Radial canals → Apopyles → Spongocoel → Osculum → Outside

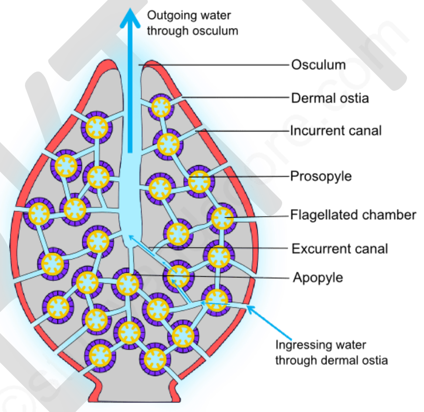


Sycon type canal system (Ex: Scypha)

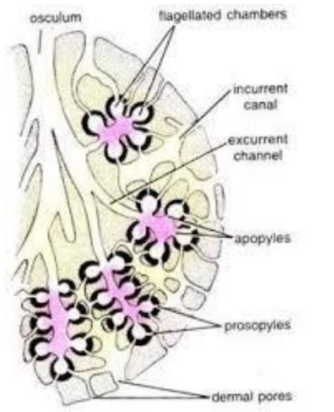
3. Leuconoid / Leucon Type:

- This type of canal system results due to further folding of body wall of the sycon type of canal system.
- This canal system is the characteristic of the leuconoid type of sponges like Spongilla.
- In this type the radial symmetry is lost due to the complexity of the canal system and this result in an irregular symmetry.
- The flagellated chambers are small compared to that of the asconoid and syconoid type.
- These chambers are lined by choanocytes and are spherical in shape.
- All other spaces are lined by pinacocytes.
- The incurrent canals open into flagellated chambers through prosopyles.
- These flagellated chambers in turn communicate with the excurrent canals through apopyles.
- The excurrent canals develop as a result of shrinkage and division of spongocoel.
- The large and spacious spongocoel which is present in the asconoid and syconoid type of canal systems is absent here.
- Here the spongocoel is much reduced.
- This excurrent canal finally communicates with the outside through the osculum.

Ingressing water → dermal ostia → incurrent canal → Prosopyles → Flagellated chambers → Apopyles → excurrent canals → Osculum → Outside

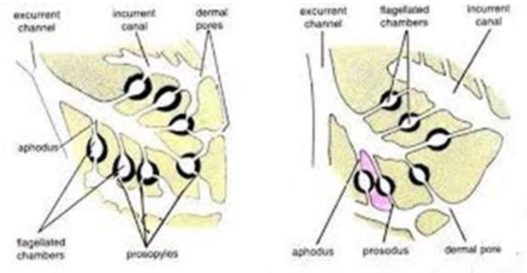


Leucon type canal system (Ex: Spongilla)



Eurypylous type: This is the simplest and the most primitive type of leuconoid canal system. In this type the flagellated chambers directly communicate with the excurrent canal through broad apertures called the apopyles.
Ex: *Plakina*
Aphodal type: In this type of canal system the apopyles are drawn out as a narrow canal called aphodas. This connects the flagellated chambers with the excurrent canals.
Ex: *Geodia*

Diplodal type: in some of the sponges, along with aphodas another narrow tube called prosodus is present between incurrent canal and flagellated chamber. This arrangement gives rise to diplodal type of canal system Ex: *Spongilla*



Functions of Canal System:

1. The canal system helps the sponges in nutrition, respiration, excretion and reproduction.
2. The current of water which flows through the canal system brings the food and oxygen and takes away the CO2 and nitrogenous wastes and faeces.
3. It carries the sperms from one sponge to another for fertilization of the ova.
4. It also increases the surface area of the sponges in contact with the water and thus enables the sponges to increase their volume as surface volume ratio must remain fixed.

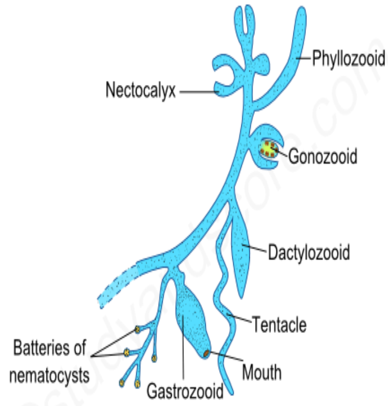
2.3 COELENTERATA

Polymorphism: (GR: POLYS = MANY, MORPHE = FORM)
Occurrence in the same species of more than one type of individual, which differ in form and function is known 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.

Definition of Polymorphism:
Polymorphism may be defined as the "phenomenon of existence of different physiological and morphological forms represented by an extensive range of variation within a single species".

- 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 so that there is a division of 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.



SIPHONOPHORA SHOWING POLYMORPHIC FORMS
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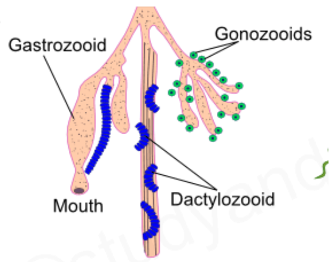
All the zooids of a polymorphic colony fall into two groups, namely polyps and medusa

1. Modification of Polypoid Zooids in Polymorphic Colony:

The polypoid zooids are modified into three kinds of individuals.

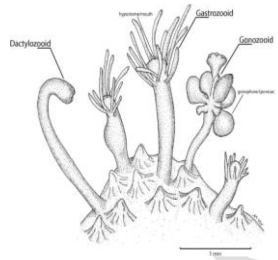
a) Gastrozooids:

➢ It is also called siphon.
➢ They have the usual polyp form which may be tubular or saccular.
➢ A large or dilated mouth is placed at the extremity of hypostome.
➢ Large gastrocoel is present.
➢ At the base of Gastrozooids there may be long, single contractile, hollow tentacle.
➢ The tentacle bears batteries of nematocysts or numerous fine lateral contractile branches called tentilla, each end in a coil of nematocysts.
➢ Gastrozooids are feeding zooids. They inject and digest the food.



b) Dactylozooids: Dactylozooids are for defence (protection) of the colony, also termed as palpons, feelers or tasters. They are tubular without mouth and their basal tentacle is not branched. In *Valella* and *Porpita* the margin of the colony bears long, hollow and tentacle like fringing Dactylozooids called tentaculozooids. In *Physallia* they are very long filaments extending for great distances into the sea.

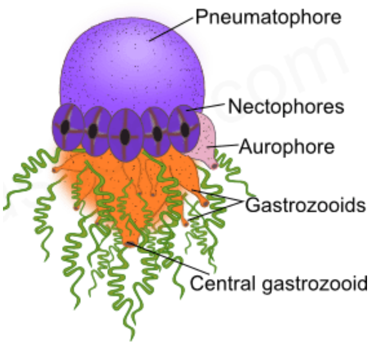
c) Gonozooids: Gonozooids are reproductive in function and also called a blastostyles. Mouth and tentacle are absent. They produce sexual medusoids by asexual budding. In *Valella* and *Porpita*, they possess mouth so resemble the Gastrozooids. Mostly the Gonozooids takes the form of a branched stalk called gonodendron having grape like clusters of gonophores and provided with a gonopalpon, Example, *Physallia*.



2. Polymorphic Modifications of the Medusoid: The medusoid zooids are of four kinds.

a) Pneumatophores:

- Most of the siphonophores possess at one end of the colony a bladder or vesicle filled with gas. It functions as a float and helps in swimming.
- It is situated at the apex of the colony.
- It represents an inverted medusan bell, devoid of mesoglea.
- The exumbrellar surface is known as pneumatocodon and the umbrellar wall forms the air sac or pneumatosaccus.
- In different siphonophores, pneumatophore shows great variation in size and shape. *Agalma* shows a simple type of float.
- The ectoderm of the air sac secretes a chitinous layer.
- At the bottom of air sac there is an enlarged chamber, called funnel which lining of epithelium is glandular forming the gas gland.
- In *Halistemma* the pneumatophore is small, while in *Physallia* very large and inflated.
- In *Porpita* it is disc shaped formed by varying number of concentric chitinoid chambers arranged in plane.
- The pneumatophore is a secretion of oil droplet which is hydrostatic in function.



b) Hydrophyllia:

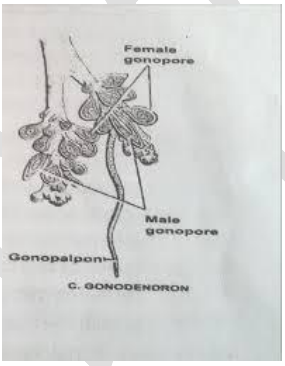
- It is a medusoid form also called as bracts.
- They are leaf like thick, gelatinous, curved plates of mesoglea composed of solid endodermal core covered externally by ectoderm and traversed by a simple or branched gastrovascular canal.
- They are varying in shape shield like prism like, leaf like or helmet shaped. It serves to cover and protect the other zooids of the colony. Example, *Halistemma*

c) Nectocalyces:

- They are bell shaped medusoids with a velum, radial canals and circular canal.
- They have no mouth, manubrium, tentacles or sense organs.
- A nedocalyx is muscular and brings about locomotion of the colony.
- Hence, they are also called swimming bells. Example, *Halistemma.*

d) Gonophores:

- They occur singly or in clusters on blastostyles.
- They degenerate medusae without mouth, tentacles or sense organs.
- They possess velum, canals and manubrium which bears gonads.
- There are two gonophore namely male gonophore and female gonophores contain testes and ovaries. On reaching sexual maturity they replace sperms and ova.



Types of Colonies in Siphonophora:

- The arrangement of various individuals in a colony differs into different groups of Siphonophora.
- In suborder Calycophora, a pneumatophore is absent, so that the summit of the colony consists of one, two or several swimming bells, which may or may not be replaceable by reserve bells.
- The two bells may equal or unequal in size and shape.
- Each cormidium includes typically a bract, a Gastrozooids with a tentacle and one or more gonophores of one sex, which are never free.
- Dactylozooids are lacking in some a bract is also lacking. In some forms more than one Gastrozooids is present in cluster.
- In the suborder Physophorida, the upper end of the colony bears an apical float.
- In Agalma and Halistemma, the float is small and without pore.
- The stem is long with proximal region bearing the Nectocalyces, and a distal region bearing the cormidia.
- In *Physalia* the large oval contractile crested float carries ventrally a much shortened and wide coenosarc bearing larger Dactylozooids with fishing

tentacles, smaller Dactylozooids with tentacles, Gastrozooids without tentacles and gonodendra containing gonophores and gonopalpons.

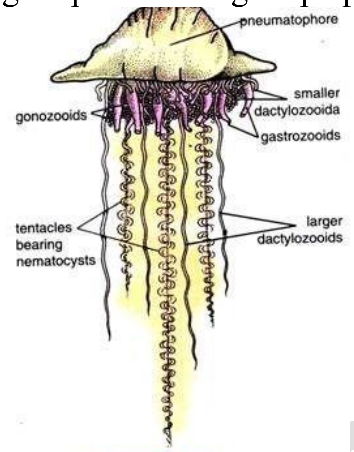
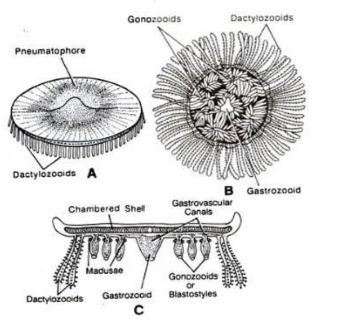


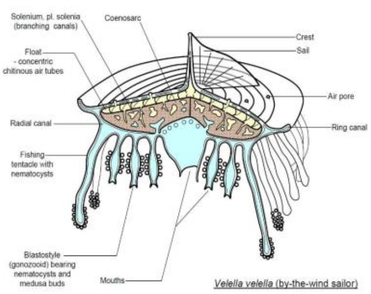
Fig. 35.2. *Physalia.*

Origin of Polymorphism:

There are two theories which explain the origin of polymorphism.

1. **Polyogran Theory:** This theory was proposed by Huxley, Eschscholtz and Metshnikoff. It explains that the different zooids of a colony are really, the organs of single medusoid individual. They opened, that polymorphic siphonophores are the most primitive existing coelenterates.
2. **Polyperson Theory:** This theory put forth by Leuckert, Vogt and Gegenbaur. It states that the various zooids of a colony are only the modified polyps which have the power to produce the medusae. This theory maintains that the parts of a siphonophore are either polyps or medusae but the primitive zooid of the colony is of the polyp type.





Polymorphism and Alternation of Generations:

- It is intimately associated with life history.
- In monomorphic forms like *Hydra* and the class Actinozoa the polyp reproduces both asexually and sexually, so that life cycle remains simple and may represented by the formula polyp – egg – polyp.
- With advance polymorphism, reproductive powers are divided.
- The polyp reproduces asexually to form the medusoid or gonophores which reproduce sexually to form the polyp.
- Thus, life cycle can be represented by polyp – medusa – egg – planula – polyp.

- That is now alternation of generations or metagenesis comes into existence and in the complete life cycle the asexual polypoid generations alternates with a sexual medusoid generations.

Significance of Polymorphism:

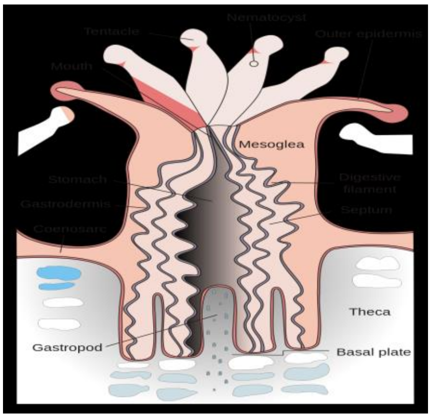
1. Polymorphism helps to perform division of labour.
2. This improves the chances of survival.

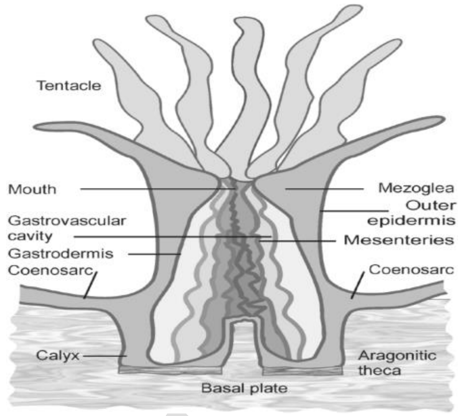
2.3.2 CORALS

Corals are calcareous exoskeleton of certain coelenterates. They are secreted by polyps. The corals secreted by the polyps are something like external shells. The polyps are live inside the corals. The coral of each polyp is called corallite. Thousands of such corallite fuse together to form a large coral stone called corallum.

Structure of a Coral Polyp:

- Coral polyp is very similar in structure to sea anemone.
- A pedal disc is absent as the basal region occupies the skeletal cup.
- Above this the smooth or warty column lacks cinelides or special adhesive or nematocyst bearing structure.
- There are typical oral discs with tentacles in cycles of six, one tentacle over each interseptal space.
- There may be a single marginal circle of 6 or 12 tentacles with numbers on the typical hexamerous plan as 6, 12,24 etc.
- Usually the outer cycles are incomplete, as the tentacles increase coincidentally with the septa and these do not arise simultaneously around the circumference.
- All cyclical arrangement of the tentacles is lost after certain forms of asexual reproduction.
- In *Siderastraea*, tentacles are endocoelic and bifurcated also commonly end in a terminal knob of nematocysts.
- In some cases they may be slender and tapering.
- The mouth is circular or oval and is surrounded by flat, depressed or conical peristome.
- The pharynx is short, circular or oval in section, ridged in some forms and always devoid of siphonoglyphs.
- The septa follow the hexamerous plan.
- There are usually in corals alternating cycles of incomplete septa that arise in pairs in the exocoels to give the usual hexamerous arrangements as 6, 12, 24 etc pairs.
- Due to small size of the coral polyp there are seldom more than three cycles of septa present and the last cycle is usually incomplete.
- In some forms septal pairs of the second cycle may reach the pharynx, increasing the number of complete pairs beyond six.
- In *Acropora,* the incomplete septa are endocoelic and in other genera they are strictly exocoelic.





Loculli:

- ➢ Epidermis and gastrodermis are similar to these of anemones but are syncytial.
- ➢ The ectodermis is ciliated on the free surface and contains number of mucous gland cells.
- ➢ The ectodermis at the base is modified to form the Calicoblastic layer which secrete the skeleton.
- ➢ The pharyngeal epidermis is also ciliated and provided with mucous and granular gland cells.
- ➢ The skeleton is composed of calcium carbonate crystals, secreted by epidermis of the base and column of the polyp. The single cup like exoskeleton formed by an individual coral polyp is known as a **Corallite** which follows more or less closely the shape of the polyp.
- ➢ The skeleton of an entire colony is termed as **Corallum**. In a living colony, the small delicate polyps, can retract completely into their protective corallites emerging at night for feeding.
- ➢ The corallite consists of a cup containing vertical ridges radiating from the centre to the periphery.
- ➢ The bottom of the cup beneath the polyps is called the basal plate. The wall of the cup that encloses the aboral portion of the polyp is termed the theca and the ridges are known as **Sclerosepta**.
- ➢ The theca can be an independent formation or can arise corals feed at night and are contracted during day time. Digestion is very rapid so that by morning all traces of ingested food have usually disappeared. Excess food is stored in the gastrodermis mainly as fat however in Fungia glycogen was also present.
- ➢ Many corals contain symbiotic zooxanthellae within the gastrodermal cells. The algae may reach such concentration as to account for 50% of the protein nitrogen of the coral.
- ➢ **Synapticula** are skeletal bars connecting adjacent Sclerosepta. Horizontal plates between Sclerosepta are called dissepiments when not extended completely across the corallite. If extends completely then called tabulae. The Sclerosepta usually bears spines and their upper edges are jagged or toothed. The whole system of dissepiments in a corallite is called **Endotheca**.

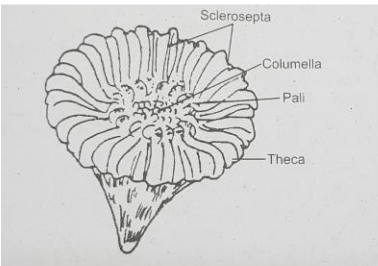


Fig. 2.53: Theca of the solitary coral *Caryophyllia*

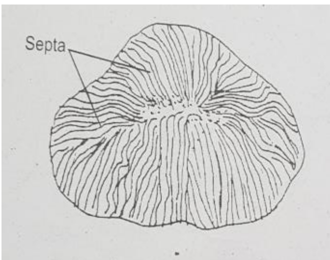
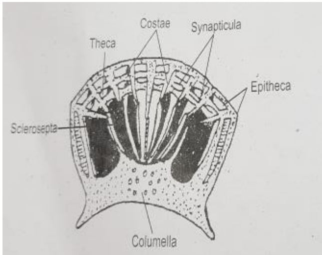


Fig. 2.54: *Fungia*

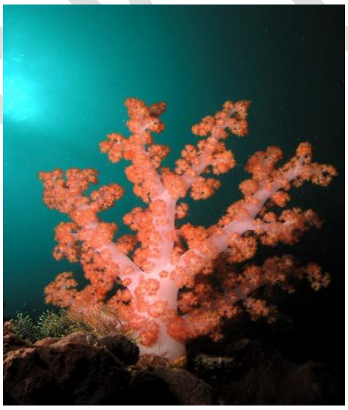


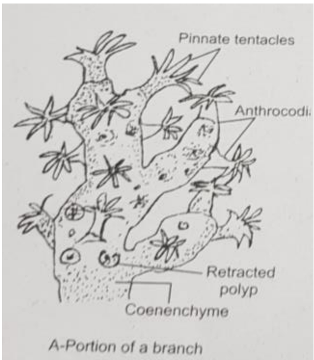
55: Diagram of half a coral skeleton showing different parts

Types of Corals:
Hydrozoa and Anthozoa are the two classes of coelenterates which produced corals. The hydrozoan corals are hydrocorallum. Among hydrozoan corals are produced by only a few animals like *Millepora*, *Stylasterina* etc.
There are two types of corals

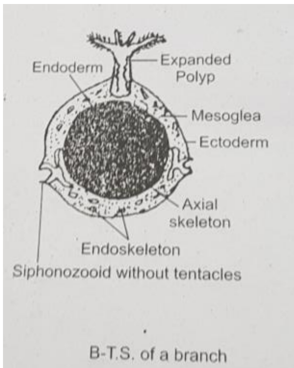
1. **Octocorallian Corals:**

- Polyps of the Octocorallian always have eight tentacles and these are pinnate, that is they possess side branches as does a feather.
- There are eight complete mesenteries on either side of a tentacle base. The coral contains spicules of CaCO3.
- The octocorallians are colonial cnidarians and the polyps are usually rather small, similar to those of stony corals.
- The polyps of an Octocorallian colony are connected by a mass of tissue called coenenchyma.
- This consist of thick mass of mesoglea continuous with the gastrovascular cavities of the polyps. Only the upper portion of the polyp projects above the coenechyme.
- Example *Alcyonium, Tubipora, Helipora, Gorgonia* etc.





(a) Portion of a branch

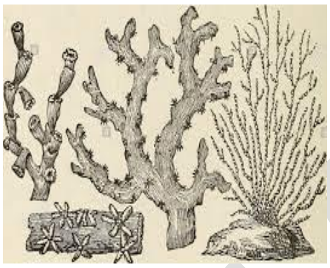


(b) T. S. of a branch

a) **Alcyonium:** It is a soft or leather coral. It is commonly called as dead mans fingers. The colonies are irregular in shape and may reach a large size. Conspicious on Indo-Pacific reefs.

b) **Tubipora:** Commonly called as organ pipe coral. The coral is made of vertical tubes connected by lateral platforms. The vertical tubes contains polyps.

c) **Heliopora:** It is commonly called as blue coral. The coral is massive broad lobed calcareous skeleton called corallum. The skeleton is perforated by closely set cavities which are of two types, larger and smaller. The larger cavities are occupied by erect splenial tubes.



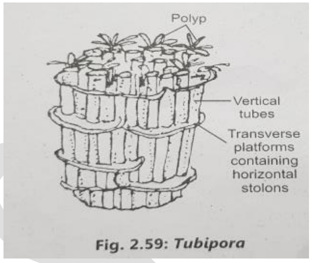
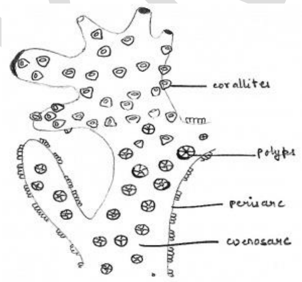


Fig. 2.59: *Tubipora*

d) Gorgonia: It is commonly called as sea-fan. The body consist of central rod or axis is attached to rocks by a basal disc. The skeleton is not calcareous but is made up of a horny material called gorgonin (Protein plus mucopolysaccharides). It is a common and conspicuous member of reef fauna.

2. Hexacorallian Corals:

- The Hexacorallian polyps are colonial polyps.
- The tentacles are unbranched and their number is from six to several hundreds, but never eight.
- The mesenteries are six or the multiples of six.
- There are complete as well as incomplete mesenteries.
- Spicules are absent from the corals.
- Tentacles are simple, rarely branched.
- They produce true or stony corals.
- Example *Fungia, Favea, Astrea, Madrepora, Meandrina*



a) **Fungia:** The coral is convex on the upper side and concave on the lower side. The coral is formed of many septa connected together by calcareous rods called Synapticula. It is produced by a solitary polyp. The disks live as solitary corals lying loose upon bottom. Fungia continues to give off ordinary buds through out their life. It is commonly called mushroom coral.

b) **Favea:** It is an Anthozoan stony coral. It is formed of closely placed polygonal cups. The polyps are placed inside the cups.
c) **Astraea:** It is imperforate star coral. It is a reef builder coral and typically of rounded massive form with contiguous or confluent thecae.
d) **Madrepora:** It is commonly called staghorn coral. It is very porous, branched coral with small polyps and cylindrical cups separated by perforated coenosteum. This coral plays an important role in coral reef formation.
e) **Mendrina:** It is commonly called as brain coral. It is a massive coral. The thecae are confluent into winding valleys occupied by compound many mouthed polyps bordered by a fringe of tentacles that is, each coral is formed of several wavy septa and grooves. These curved grooves resemble the convolutions of human brain.

2.3.3 Coral Reefs:

Coral reefs are tropical, shallow-water, calcareous structures supporting a diverse association of marine plants and animals. A coral reef is a ridge or mound of lime-stone, the upper surface of which lies near the surface of the sea and which is formed of calcium carbonate by the action of organisms, chiefly corals.

Composition of Coral Reef: The coral reef formed by the deposition of calcareous secretions of the coral polyps. Chemically it is formed of $CaCO_3$. Other important contributors are the coralline algae or branching algae impregnated with lime, foraminiferan (Protozoa) shells, molluscan shells, branchiopod shells etc.

Coral Reef as a Habitat: The coral clumps attract a most of other animals. Coral reef is a suitable habitat for marine animals. The cracks, crevices and big gaps between masses of coral furnish shelter to innumerable brightly coloured fish and representative of almost every phylum in the animal kingdom such as shrimps, crabs, barnacles, worms, star-fishes, brittle-stars, sea-cucumbers, snails and coral polyps. They have various size, shape and colour. So, it is described as the beautiful gardens of the sea.

Reef Structure (Kinds of Coral Reefs):

On the basis of structure and the underlying substratum three general types of reefs can be recognized.

a) **Fringing Reefs:**

- The **reef** flat is found in fairly shallow water, and can be uncovered during low tide.

- This area of the **reef** is only slightly sloped towards the open ocean. Since the **reef** flat is adjacent or nearly adjacent to land, it sustains the most damage from runoff and sediments. Typically, few of the flat's corals are alive. Fringing reefs are reefs that **grow directly from a shore**. They are located very **close** to land, and often form a **shallow lagoon** between the beach and the main body of the reef. A fringing reef runs as a narrow belt 1-2 km wide. This type of reef grows from the deep-sea bottom with the seaward side sloping steeply into the deep sea. Coral polyps do not extend outwards because of **sudden and large increase in depth.**

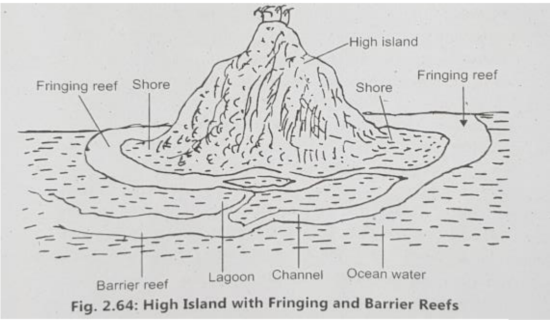
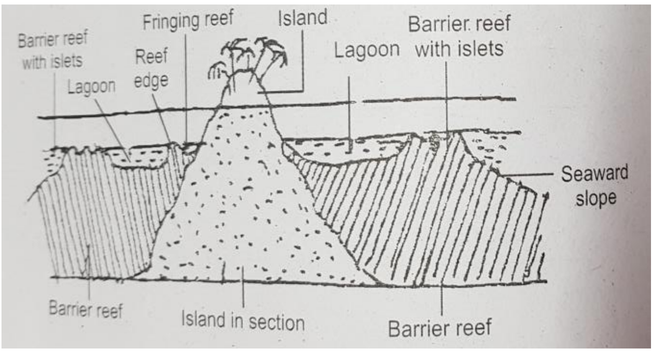


Fig. 2.64: High Island with Fringing and Barrier Reefs

Barrier Reef:

- Barrier reefs are similar to fringing reefs in that they also border a shoreline; however, instead of growing directly out from the shore, they are separated from land by an expanse of water.
- This creates a lagoon of open, often deep water between the reef and the shore.
- Barrier reefs are extensive linear reef complexes that parallel a shore, and are separated from it by lagoon.
- This is the largest (in size, not distribution) of the three reefs, runs for hundreds of kilometres and is several kilometres wide.
- It extends as a broken, irregular ring around the coast or an island, running almost parallel to it.
- Barrier reefs are far less common than fringing reefs or atolls, although examples can be found in the tropical Atlantic as well as the Pacific.
- The 1200-mile long Great Barrier Reef off the NE coast of Australia is the world's largest example of this reef type.



c) Atolls:

- When a fringing **reef** continues to grow upward from a volcanic island that has sunk entirely below sea level, an **atoll** is formed. **Atolls** are usually circular or oval in shape, with an open lagoon in the center.
- An atoll is a roughly circular (annular) oceanic reef system surrounding a large (and **often deep) central lagoon**.
- The lagoon has a depth 80-150 metres and may be joined with sea water through a number of channels cutting across the reef.
- Atolls are located at **great distances** from deep see platforms, where the submarine features may help in formation of atolls, such as a **submerged island or a volcanic cone** which may reach a level suitable for coral growth.
- Atolls are **far more common in the Pacific** than any other ocean. The **Fiji atoll** and the Funafuti atoll in the Ellice/Island are well known examples of atolls. A large ‘number of atolls also occur in the **Lakshadweep Islands.**

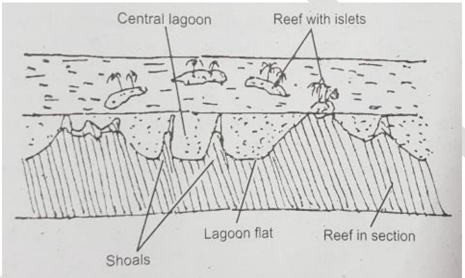


Fig. 2.68: Cross-section of an Atoll Reef

Reef Formation:

The building of the reef platform is not simply a matter of secretion of new calcium carbonate on top of old. The building involved constructive and destructive phases.
Coral reefs begin to form when free-swimming coral larvae attach to submerged rocks or other hard surfaces along the edges of **islands** or continents. As the corals grow and expand, reefs take on one of three major characteristic structures — fringing, barrier or **atoll**. Some theories are regarding to formation of reef are as ----

a) Darwin – Dana Subsidence Theory:

- This theory was proposed in 1931. According to him coral reefs starts growing on the sides of the islands as fringing reef.
- Slowly that coral reef grows upwards at the same rate so as to keep its surface level with the ocean.
- The coral of seaward edge grew more rapidly. So, the original fringing reef became converted into barrier reef, separated from the island by a wide, deep water channel, the barrier lagoon.
- The island then sank down, became smaller and smaller and finally converting the barrier reef into atoll.

b) Volcanic Crater Theory:

- This theory was proposed by Stutchbury in 1832.
- According to him the atolls of Pacific were built upon the summits of extinct volcanoes.

- The crater of volcano became the lagoon while on its elevated rim the coral reefs grew.
- Because of various shapes of atolls, limited depths of lagoons, more or less the same elevation and the great number of craters in a single archipelago made the hypothesis incredible.

c) Semper Murray Solution Theory:

- Sir John Murray in 1874 to 1876 proposed this theory.
- He proposed that corals grow on high summits of the ocean bottom when these have been built up to the right level by elements and that barrier reefs and atolls result from better growth of corals at the edge and through solution of the inner coral rock.

d) Submerged Bank Theory: According to this theory, supported by many recent students of the problem, coral formations how on flat pre-existing surface, during or after submergence of such surfaces.

e) Glacial – Control Theory:

- According to this theory the depth of all the lagoons of atolls and barrier reefs should be uniform but actual observations do not validate this concept. According to W.M. Davis the depth of different lagoons varies considerably. Not only this, even the depth at different parts of the same lagoons ranges between 120 to 300 feet. In some lagoons the depth varies between 20 feet to 600 feet.
- The coasts might have been cliffed due to wave erosion during the phase of the lowering of the sea-level during Pleistocene Ice Age. Thus, the cliffs formed during glacial period should also be present now but they are seldom found. In fact, the corals might have protected the coasts from being cliffed.
- If all the marine islands were eroded up to 33 to 38 fathoms then there should not be islands between the coasts and coral reefs but numerous such islands are found.

Significance of the Coral Reefs:

1. Coral reefs protect the sea-shore from erosion.
2. Corals are used for decorating houses, aquarium, and rock gardens.
3. Brilliantly coloured corals are used to make ornaments.
4. Corals produce islands. The coral islands form habitats for human being and land animals.
5. Stones carved out from the coral reefs are used for constructing buildings and roads.
6. Coral reefs provide an ideal habitat for various marine and thus they form a paradise for animal collections.

2.4 HEMICHORDATA

- This classification was based on the presence of foregut diverticulum in hemichordate which was considered homologus to the notochord of the chordates.
- Recently however the hemichordates have been found to possess greater resemblances with the echinoderms than with the chordates.

Affinities with Echinoderms:

Following are the main resemblances with echinoderms

1. The ciliated bands are identical and follow the same course in both tornaria and the bipinnaria or Auricularia larva except the telotroch and eye spots are not found in the larvae of echinoderms.
2. The alimentary canal has the same shape and same sub division in both the larvae.
3. In both blastopore forms the larval anus.
4. In both the groups the method of formation of the coelom and the arrangement of the coelomic cavities is similar. The coelom is enterocoelic in origin and divide itself.
5. The protocoel of *Balanoglossus* also open outside by a proboscis pore like echinoderms.
6. Both have a poorly developed nervous system consisting of an epidermal nerve plexus.
7. In both the groups a portion of coelom opens out and is filled with sea water to serve as a hydraulic mechanism. This device is not found in any other group of animals.
8. The hemichordates and echinoderms also have common habits and ecological niches and possess a remarkable power of regeneration.

Affinities with Annelida:

1. Both annelids and hemichordates are usually worm like in appearance.
2. The mode of feeding and casting is also similar.
3. The tornaria larva of *Balanoglossus* also resembles in some manner with the trochophore larva of polychaetes although the former is more modified.
4. The vascular system is also shows striking resemblances because heart is placed to the gut in both the groups while it is always ventral in chordates.
5. The presence of ventral nerve cord in the *Balanoglossus* also points out towards the non-chordate affinities.

Affinities with Chordates:

The relationship of hemichordates and chordates are based mainly on the presence of three basic chordate characters are as the notochord, dorsal nervous system and gill slits.

a) **Notochord:** The buccal diverticulum differs from the notochord

1. In general notochord has a supporting function but in *Balanoglossus* it has no supporting function.
2. Buccal diverticulum is not covered by any sheath or covering like that of notochord.
3. The notochord always lies dorsal to the dorsal blood vessel but buccal diverticulum is ventral to it.

b) Nervous System:

1. The nervous system of hemichordates and chordates resembles with each other in many points, such as in its dorsal position, mode of formation of the dorsal nerve cord from the dorsal epidermis and the presence of collar cord which is comparable with neural cord of chordates.
2. But in many respects, it differs from the chordate plan, such as in its intra epidermal position, in the presence of circum enteric nerve ring and in the possession of a ventral nerve cord. Thus, the nervous system in hemichordates is distinctly non-chordate plan.

c) Gill slits:

The gill slits remains as the only chief link between hemichordate and chordate. The branchial apparatus of *Balanoglossus* has the same structure *Amphioxus* although in *Balanoglossus* the gill slits are situated dorsally whereas in *Amphioxus* these are lateral in position.

1. Chordate do not possess the coelomic and body regionation corresponding to that of hemichordates.
2. The nervous and circulatory system are like those of non-chordates.
3. The post-anal tail is also absent in the hemichordates.
4. In chordates the segmentation is clearly express in the plan of muscular nervous, circulatory and excretory systems, whereas the segmentation is absent in hemichordates.