DEPARTMENT OF ZOOLOGY

Allied Zoology – I (Biology of Invertebrates and Chordates)

(Code: 16SACZO1)

PHYLUM: PORIFERA

General Characteristics of Porifera

- Poriferans are commonly called **sponges**.
- These are **multicellular organisms** which are sessile/sedentary in nature.
- Most of them are **marine** while a few are fresh water forms.
- Body is cylindrical, asymmetrical or has radial symmetry.
- Body wall is **diploblastic** which consists of an outer layer called **pinacoderm** and an inner layer called **choanoderm**.
- The middle layer is called **mesenchyme** which has various kinds of wandering amoebocytes.
- Body wall contains numerous pores called **ostia** through which water enters in the body through a canal system into the central body cavity, called **spongocoel**.
- The canal system mainly comprise of **incurrent** and **excurrent canals** which are lined with pinacocytes; and **radial canals** which are lined with **choanocytes** (flagellated cells).
- Body also contains one or more openings called **oscula** (-um/singular) through which water passes out from the body.
- Sponges feed on minute organisms and small organic particles which enter the body through water current and are ingested by the choanocytes.
- Respiration takes place by diffusion of oxygen from water the flowing into the body.
- Sponges have an exoskeleton which is made up of either **spongin fibers** or **calcareous/siliceous spicules** or a combination of both.
- Excretory product, mainly ammonia, is released from the body through outgoing water current.
- Reproduction may be asexual or sexual.
• Asexual reproduction takes place by external or internal budding (formation of gemmules) or by disintegration of body into reduction bodies.
• Sexual reproduction involves internal fertilization. Male gametes enter the sponge body through water current and fertilize with ovum with the help of choanocytes.
• The larval stage of calcareous sponges is amphibalstula while that of demospongiae is rhagon larva.

Classification of Porifera
Porifera is divided into three classes based on the skeleton they possess.
1. Calcarea
   • Skeleton consists mainly of calcareous spicules
   Examples: Sycon, Leucosolenia

2. Hexactinellida (Hyalospongiae)
   • Skeleton consists mainly of siliceous spicules
   Examples: Euplectella, Hyalonema

3. Demospongiae
   • Skeleton consists mainly of spongin fibres which may be in combination with spicules
   Example: Spongilla
Class 1. Calcarea (Calcaneous Sponges):
[Calcarea, L. Calcarious = limy, Calcispongiae, L. Calcis = genitive of calx = lime or chalk]

Features:

(i) Exclusively marine, shallow coastal water species, restricted to depth less than 100 metres and require hard substratum for attachment.

(ii) Small-sized sponges, about 10 cm in height.

(iii) Cylindrical or vase-like in shape.

(iv) Osculum narrow and placed terminally.

(v) Osculum provided with oscular fringe.

(vi) Comparatively large collared cells.

(vii) Skeleton represented by free calcaneous spicules.
(viii) Spicules contain more CaCO$_3$ (87%) than MgCO$_3$ (7%) reported in Leucandra sp. and often differentiated into megascleres and microscleres. Organic matters in traces.
(ix) Megascleres are monaxon, triaxon or tetraxon.

(x) Canal system is asconoid, syconoid and leuconoid type. Asconoid type of canal system is found only in the class Calcarea.

**Class 2. Hexactinellida (Glass sponge):**

[Hexactinellida, Gk. Hex = six, Gk. aktis = ray,

**Features:**

(i) Large sized sponge and on average 10 to 30 cm in height, live mainly in the deep waters of sea and can grow in firm and soft sediments. The deep sea forms live at the depths between 200 m and 1000 m.

(ii) Usually cup, vase or urn (vase with foot)-like shape.

(iii) Skeleton of six-rayed (triaxon) siliceous spicules (SiO$_2$) or their modifications present either as separate entity or as networks.

(iv) Chemical analysis in Monoraphis reveals that the spicule contains SiO$_2$ 86%, water 9%, inorganic elements 3% and spiculin (a protein) 2%.

(v) Megascleres (skeletal spicules) and microscleres (flesh spicules) always distinguished.

(vi) Choanocytes restricted to finger-like simple or folded chambers.

(vii) Wall encloses a spongocoel (- atrium) which opens by a wide osculum.

(viii) Canal system may be either syconoid or leuconoid type.

(ix) There is no cellular dermal epithelium.

(x) Commonly called “glass sponge”.

**Phylum Porifera: Class 3. Demospongiae:**

[Gk. demos = people + spongos = sponge]
Features:

(i) Mostly marine but a few are freshwater or brackish water forms. In sea they live from shallow water to great depths. 90% existing species fall under this class.

(ii) Brilliant colouration in most species, for the presence of pigment granules within amoebocytes.

(iii) Skeleton either absent or silicious (silicious spicules), fibrous (spicules replaced by organic collagenous fibres—spongin fibres, or both spongin fibres and siliceous spicules).

(iv) Silicious megasclere spicules never triaxon (6-rayed); microscleres are of different types

(v) Canal system of leuconoid type only. The leuconoid type canal system is derived from a larval stage, called the rhagon type which does not occur in any adult animals of calcareus sponges.

(vi) Flagellated chambers small and rounded.

(vii) Freshwater species of this class possess contractile vacuoles used for elimination of water from the cells.

(viii) Parenchymula larva in the life cycle of most demosponges.
Structure of Leucosolenia:

The colony of Leucosolenia is whitish yellow in colour. In the simplest species of Leucosolenia, the colony consists of few simple vase-like, cylindrical individuals each terminating in an osculum and united at their bases by irregular horizontal tubes. Most species are more complicated, consisting of a confused network of branching tubes from which stand out a few larger erect cylinders bearing an osculum at their summit.

Finally, in the most complicated species, the outermost tubes fuse together forming a false surface or pseudoderm leaving a few large openings or pseudo pores so that the sponge appears solid and simulates a higher type of sponge; but sections show the network of ascon tubes in the interior.

Each tube of the colony may reach up to 25 mm in height and also produces a number of buds. Each main tube opens to the exterior by an aperture called osculum at the summit. The cavity of the tube is known as spongocoel or paragastric cavity.
Body Wall:
The body wall is thin and consists of an outer epidermis, the pinacoderm and an inner endodermis, the choanoderm separated by a jelly-like non-cellular layer of mesenchyme or mesogloea, enclosing a central cavity, the spongocoel. The wall of each tube is perforated by numerous pores through which water enters the spongocoel and passes out by osculum.

(i) Pinacoderm:
The outer epidermis consists of thin, scale-like, flattened cells, called pinacocytes (Gr., pinako = plank; kytos = cell) which lie with the edges touching and forming a single layer of cells, the pinacoderm. This layer forms the outer protective covering of the tube. A pinacocyte has thin highly contractile margins and contains a central bulging having nucleus.

(ii) Choanoderm:
The inner epithelium consists of a single layer of choanocyte (Gr., choane = funnel; kytos = cell) cells and forms the lining of the spongocoel and also referred to as gastrodermis. A choanocyte is an oval cell having a flagellum which arises from basal granule and is surrounded at its base by a contractile transparent protoplasmic collar.

The nuclei of choanocytes lie at the bases of cells. The beating of the flagella of choanocyte cells maintains a water current in the body of sponge.

(iii) Mesenchyme or Mesogloea:
Mesenchyme is the intermediate layer between the pinacoderm and choanoderm. Mesenchyme is a thin layer and is in the form of gel. It is secreted by the choanocytes and it holds the skeletal elements of CaCO₃ called spicules or sclerites in place. In the mesenchyme are some amoebocytes which are amoeboid cells, they wander about freely. These cells contain RNA and self-replicating in nature. These cells can give rise to different types of cells, hence, totipotent in action; they may give rise to pinacocytes, choanocytes, collencytes, sclerocytes or scleroblasts and reproductive cells. The spicules are crystalline, needle-like which are monaxons, tetraxons (having four rays) or triaxons.
The spicules are secreted by scleroblast cells and remain embedded in the mesenchyme and some monaxon spicules project out of the pinacoderm. A few monaxon spicules form a scanty fringe around the osculum.

**Ostia:**
The wall of each tube is pierced or perforated by numerous pores called ostia or incurrent pores which pass through a space or lumen of cells called porocytes. The porocytes are supposed to be modified pinacocytes. Each ostium or incurrent pore is intracellular, i.e., it is a canal through a single, large, tubular and highly contractile porocyte cell communicating outside with the spongocoel.

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![Fig. 25.1: Types of Leucosolenia. A—Simple; B—Branching; C—Reticulate.](image)

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Spicules of Sponges
- Spicules are formed by scleroblast cells present in the mesenchyme.
- They consist of an axis of organic material around which calcium carbonate or silica is deposited. Thus they are calcareous or siliceous in nature.
- They are of various shapes. Based on their main axis and number of rays, they can be classified into following types-
  1. **Monaxons** - single axis growing in one or more directions.
  2. **Triaxons** - three axes crossing each other and have six rays.
  3. **Tetraxons** - four rays.
  4. **Polyaxons** - many axes and several rays radiating from a single point.
5. **Spheres** - spherical in shape with concentric growth.
6. **Desmas** - formed by deposition of successive layers of silica on an ordinary spicule.

- Spicules form the skeleton of body. They thus support and protect the body.
- Smaller flesh spicules found throughout the mesenchyme are called **Microscleres**. They are of two types - spires (spiral in shape) and asters (star-shaped).
- Large-sized spicules are called **Macroscleres**.

## Gemmules of Sponges

- Gemmules are asexual reproductive bodies of most of the freshwater and a few marine sponges.
- These are internal buds and are response to the hostile environment.
- These are small, hard, ball-like structure consisting of an outer capsule and an inner mass of archaeocytes.
- Capsule is made of two chitinous layers. Outer chitinous layer contains amphidisc spicules to strengthen the capsule.
- Archaeocytes are totipotent cells and are filled with reserve food material formed by trophocyte cells.
- At one end of the gemmules an opening called micropyle is present.
- These are resistant to desiccation (drying out), freezing, and anoxia (lack of oxygen) and can lie around for long periods of time.
- Under favourable conditions, the mass of archaeocytes come out in water through micropyle and develops into a young sponge.

## CANAL SYSTEM IN SPONGES
Body of all sponges is the perforated by large number of apertures through which water enters inside body and flows through a system of criss-crossing canals collectively forming the canal system which is a characteristic feature of poriferans.

Following types of canal systems are found in sponges:

- Ascon type, with flagellated spongocoel
- Sycon type, with flagellated radial canals
- Leucon type, with flagellated chambers
- Rhagon type, with conical shape and broad base

**ASCON TYPE**
- This is the simplest type of canal system and is found in *Leucosolenia* and other homocoela.
- Ostia are present on the surface of body and lead directly into the spongocoel, which is lined by flagellated choanocyte cells.
- Spongocoel opens to the outside through a narrow circular opening, the osculum located at the distal free end of the sponge body.
- Water enters through ostia into spongocoel and goes out of body through the osculum.

**SYCON TYPE**
- This type of canal system is a characteristic of syconoid sponges, e.g. *Scypha* and *Grantia*.
- Body wall is secondarily folded to form incurrent and radial canals, which open into the spongocoel by an opening called apopyle.
- Both types of canals are interconnected by minute pores called prosopyles.
- Incurrent pores or ostia are found on the outer surface of body and open into the incurrent canals, which lead into adjacent radial canals through minute openings called prosopyles.
- Radial canals are the flagellated chambers that open into central spongocoel by internal openings called apopyles.
- Spongocoel is a narrow, without flagellated cells but is lined by pinacocytes and opens to exterior through the osculum.

**LEUCON TYPE**
- In this case, the radial canals get divided into small rounded or oval flagellated chambers by further folding of the body wall.
- This is a characteristic feature of the leuconoid sponges such as *Spongilla*. Incurrent canals open into flagellated chambers through prosopyles.
- Flagellated chambers, in their turn, communicate with excurrent canals through apopyles.
- Excurrent canals are formed as a result of division of spongocoel which has almost disappeared in these sponges.
- Thus excurrent canals communicate with the outside through a small spongocoel and an osculum.
This type of canal system has varying degree of complexity of canals and based on that it can be classified into the following three types:

- **Eurypyloustype**: In this type, the flagellated chambers communicate directly by broad apertures called the *apopyle*, with the excurrent canals. Incurrent canal brings water into the flagellate chamber through *prosopyle*. E.g. *Plakina*

- **Aphodaltype**: In this type, the *apopyle* is drawn out as a narrow canal, called *aphodus*, which connects the flagellated chamber with excurrent canal. Here also incurrent canal brings water into the flagellate chamber. E.g. *Geodia*.

- **DiplodalType**: In some sponges, besides aphodus, another narrow tube, called prosodus, is present between incurrent canal and flagellated chamber. E.g., *Spongilla* and *Oscarella*.

**RHAGON TYPE**

- In Demospongeiae, leuconoid condition is derived from the larval stage, called *rhagon* as found in *Spongilla*.
- The body is conical and tent like in shape, tapering towards the *osculum*.
- The spongocoel is bordered by oval flagellated chambers opening into it by *apopyles*.
- Mesenchyme is considerably thick and is traversed by incurrent canals and subdermal cavity.
- Water enters into the subdermal cavity through ostium and then enters the incurrent canal or it can be called *prosodus*.
- Flagellate chambers are connected to the spongocoel through the excurrent canal or it can be called *aphodus*.
- This canal system is primitive as compared to *diplodal* type and when the larva grows transformed to *diplodal* type.

**Significance of Canal System**

- The flagella of choanocytes beat to produce a water current, which enters the spongocoel through ostia.
- It carries food particles and oxygen and sweeps away the metabolic wastes through *osculum*.
- Therefore, the canal system serves the function of food collection, respiration and excretion.
- In simple type of canal system, there is lesser number of cells and thin body wall but as the canal system becomes more complex, the number of flagellated cells increases and the force to draw water current is increased.
- The *syconoid* canal system is therefore more efficient than the *asconoid* type and the *leuconoid* type is the most efficient.
UNIT – III Phylum Cnidaria/Coelenterata

General characteristics of Phylum Coelenterata

1. Kingdom: Animalia
2. Habitat: aquatic, mostly marine.
3. Habit: solitary or colonial. Each individual is known as zooid.
4. Symmetry: radially symmetrical
5. Grade of organization: tissue grade of organization.
6. Germ layer: diploblastic, outer ectoderm and inner endoderm. Mesogloea separates these two layer
7. The body has a single opening called hypostome surrounded by sensor y tentacles.
8. Coelom: gastrovascular cavity or coelenteron.
9. Nematocyst: organ for capturing and paralyzing pray, present in tentacles
10. Nutrition: holozoic
11. Digestion is both intracellular and extracellular.
12. Respiration and excretion are accomplished by simple diffusion.
13. Circulatory system: absent
14. Nervous system: poorly develop
15. Many forms exhibit polymorphism ie. Polyp and medusa
16. Polyps are sessile, asexual stage
17. Medusa are free swimming, sexual stage
18. Metagenesis: asexual polypoid generation alternate with sexual medusoid generation
19. Reproduction:
   - Asexual: by budding
   - Sexual: by gamatic fusion
20. Fertilization: internal or external
21. Development: indirect with larval stage

Classification of Phylum Cnidaria/Coelenterata
The phylum coelenterate is divided into three classes on the basis of development of zooids:

- **Class 1: Hydrozoa**
- **Class 2: Scyphozoan or Scyphomedusae**
- **Class 3: Anthozoa or Actinozoa**

**Class 1: Hydrozoa**
*(Hydra; water; zoon: animal)*

1) **Hydrozoa** animals are multicellular, diploblastic animals.

2) They show mouth opening, and anus is absent.

3) They show both polyp and medusa forms. Medusa is a reproductive zooid. Polyp is a fixed stage.

4) In medusa the gastro-vascular-system is transversed by canals. In medusa definite sense organs like statocyst, nervous system, and muscular system are well developed.

5) Polymorphic tendency is well developed.

6) Gonads are seen.

7) Alternation of generations is seen in the life history of these animals.

8) Velum is present on the medusa (Craspedote)

**Order 1: Hydroidea** : Solitary or colonial forms. Polyp well developed. Sense organs or medusa are statocysts.

**Sub-Order 1: Anthomedusae.** Ex : Hydra, Bougainvillea.

**Sub-Order 2. Leptomedusae.** Ex : Obelia.

**Order 2: Trachylina**

Fixed stage is absent. They are all mobile medusae. Marginal sense organs are modified tentacles.

**Sub-Order I : Trachymedusae** Ex : Petasus.

**Sub-Order II : Narcomedusae.** Ex : Polycarpa.
**Order 3: Hydrocorallina**: It includes coral like hydrozoans. CaC03 skeleton is secreted by coenosarc. Polyps are dimorphic.

1) Millipora (Hydrozoans coral)
2) Stylaster (Hydrozoan corals)

**Order 4: Chondrophora**: It includes organisms with big floats. Ex: 1) Velella 2) Porpita.


**Order 6: Siphonophora**: They show highest polymorphic tendency. Ex: 1) Physalia (Portugese-man-of-war) 2) Halistemma.

**Class 2: Scyphozoa or Scyphomedusae**

1) Represented by medusoid forms.
2) Sense organs are tentaculocysts.
3) Gastrovascular system shows stomach and 4 gastric pouches. In the gastric pouches gastric filaments are present.
4) Velarium is present with endodermal canal (Acraspedote).
5) Gonads are endodermal in origin
6) Medusa arises by strobilisation.

**Order 1: Stauromedusae**: (Lucernarida) Sense organs absent. Medusa is pyramidal shaped. Sedentary.

Ex: 1) Lucernaria 2) Haliclystus.

**Order 2: Coronatae**: The umbrella shows coronary grooves. 4 to 16 tentaclocysts are present. Ex: 1) Periphylla. 2) Nausithoe (It lives inside Porifera animals (sponges).

**Order 3: Cubotnedusae**: Medusa is cubical 4 perradial tentacalocysts are present. Free swimming.

Ex: 1) Choropsaimum (free medusa) 2) Chatybdaea.
Order 4: Semeastomeae (or) Discomedusae: Most common medusae. Medusa is disc shaped, 4 perradial and 4 interradial tentaculocysts are present.

Ex: 1) *Aurelia* - Jelly fish 2) *Rhopilema* 3) *Pelagia* (Luminescent Jelly fish)

Order 5: Rhyzostomeae: Free swimming medusa. The oral arms are branched. Tentacles absent. 8 or more tentaculocysts are present.

Ex: 1) *Pilema*, 2) *Rhizostoma*.

Class 3: Anthozoa or Actinozoa

(Anthos: flower; zoios: animal “flower like animals”)

1) They exhibit only polyp forms.
2) Medusa stage is absent.
3) Mesentries are present, they bear nematocyst.
4) Gonads are endodermal.
5) Corals coral reefs are common.

This class is divided into 2 sub classes.

i) Sub class: Hexacorallia (or) Zoantharia.

ii) Sub class: Octocorallia (or) Alcyonaria.

Sub class: Hexacorallia: It contains tentacles and mesentries in multiples of six. It includes seven orders.

Order 1: Actinaria: (Sea anemones) Skeleton is absent.

Ex: 1) *Edwardsia* 2) *Adamsia*

Order 2: Madreporaria: (True corals) Stony corals are present Polyps are small. Siphonoglyphs absent.

Ex: 1) *Meandrina* (brain coral) 2) *Fungia*.

Order 3: Zoanthidea: Solitary or colonial organisms. Polyps are united by basal stolons. Only ventral siphonoglyph is present.

Ex: 1) *Zoanthus*. 
Order 4 : Antipatharia: Includes black corals. Two siphonoglyphs are present.

Ex: Antipathes (Black coral)

Order 5: Ceriantharia: Solitary structure. Tentacles many, arranged into two whorls. Only single siphonoglyph occurs.

Ex: Cerianthus.

Order 6: Corallimorpharia: Solitary or aggregate, anemone like polyps. Ex: Corynactis.

Order 7: Ptychodactaria: Includes animals which are anemone like polyps. Ex: Ptychodactis.

Sub class: Octocoralia (Alcyonaria): In these Anthozoan members the tentacles and mesentries are in multiples of eight. On the stomodium never more than one siphonoglyph will be present. It is ventral in position.

Order 1: Stolonifera: Polyps are connected by creeping stolon.

Ex: Tubipora (orange pipe coral).

Order 2: Telestacea:

The colonies contain simple or branched stem which bears lateral polyps.

Ex: Telesto.

Order 3: Alcyonacea: These are soft corals. Polyps may be dimorphic.

Ex: 1) Alcyonium (dead man's fingers).

Order 4: Coenothecalia: It includes a single genus.

Ex: Heliopora (Blue coral)

Order 5: Gorgonacea: It is a compound tree like coral.

Ex: 1) Gorgonia (seafan) 2) Corallium (red coral)

Order 6: Pennatulacea: These are elongated members. Emended in the mud, and sea bottom. Ex: Pennatula (Sea pen).
Habit and Habitat of Obelia:
Obelia is sedentary, marine colonial form found attached on the surface of sea weeds, molluscan shells, rocks and wooden piles in shallow water up to 80 metres in depth. Obelia is cosmopolitan in distribution, forming a whitish or light-brown plant-like fur in the sea; hence, the common name sea-fur is assigned to it.

The Obelia is a trimorphic colony, that is, having three kinds of zooids which are as follows:
1. Polyps or hydranths (nutritive zoooids);
2. Gonangia or blastostyles (budding zoooids);
In fact, to start with Obelia is a monomorphic form having polyp only but later due to the development of blastostyle it becomes a dimorphic colony and finally medusae bud over the blastostyle in a mature colony, then it becomes a trimorphic colony.

**Polyp or Hydranth:**

The colony of Obelia has many polyps (Gr., polypus – many-footed) or hydranths (Gr., hydra = water serpent; anthos = flower) or gastro zooids. Each polyp is very much like a miniature Hydra. It has a cylindrical body attached to the axis of the hydrocaulus by its proximal end and free at its distal end. It is covered by a cup-shaped hydro theca.

The free distal end is produced into a conical elevation, the hypostome or manubrium which is about one-third of the length of the hydranth. The hypostome is surrounded by a circle of numerous (about 24) tentacles. The tentacles are longer than hypostome, tapering and filiform.

The apex of the hypostome bears a terminal aperture called mouth which is capable of great dilation and contraction.

Below the hypostome is the stomach region of the polyp. The body and manubrium of the polyp enclose a spacious enteric cavity or gastro vascular cavity. The polyp is protected in hydro theca, which is prolongation of the perisarc. At the base of the polyp, it forms ring-like horizontal shelf at which the polyp rests.

![Fig. 32.2. Obelia. V.S. of a polyp or hydranth.](image)

**Gonangium:**
The gonangium (Gr., gonos = seed; angeion = vessel) (Fig. 32.3) is club-shaped, cylindrical form. It is covered by a transparent gonotheca and contains an axis or blastostyle on which lateral buds form that develop into medusae or gonophores. The blastostyle has no mouth and no tentacles, but ends distally into a flattened disc.

The gonotheca opens at its distal end by a gonopore, through which the medusae escape. Gonotheica, blastostyle and the gonophores together form a gonangium.

**Asexual Reproduction:**
When the temperature of the water exceeds 20°C, the buds which would normally form gonangia in the colony break free from the colony and settle down; a stolon arises from the lower end of the bud which produces a new colony of Obelia asexually. This is a special mode of asexual reproduction.

**Medusa:**
The medusa is a modified zooid produced as a hollow bud from the coenosarc of the blastostyle in spring and summer. Medusa swims freely on the surface water.
**Structure of Medusa:**

It is saucer-shaped, it is attached by the middle of the convex surface to the blastostyle, when fully formed it breaks free and emerges from the mouth of the gonotheca.

The medusa is circular and tiny umbrella-like in shape. The convex outer surface is known as the ex-umbrella and the concave inner surface is the sub-umbrella. From the centre of the sub-umbrella arises a short projecting manubrium (L., manus = handle), at its apex is a square mouth surrounded by four oral lobes.

The mouth leads into an enteric cavity or gastric cavity in the manubrium. From the enteric cavity, arise four radial canals which are delicate ciliated tubes, they run to the margin of the bell to join a ciliated circular canal running near the margin.

The enteric cavity and the canals represent the enteron which distributes food. Projecting from the middle of the radial canals are four gonads, since sexes are separate they are either four testes or four ovaries, they are patches of modified sub-umbrellar ectoderm.

The gonads mature after the medusae escape from the gonotheca. The edge of the bell is produced inwards as a thin fold called velum.

Velum is characteristic of hydrozoan medusae but it is insignificant in Obelia. The medusae with a velum are called craspedote, and those with no velum are acraspedote (Scyphozoa). From the edge of the bell numerous small solid tentacles
hang downwards. The tentacles have swollen bases due to the accumulation of interstitial cells which are practically absent from other regions.

**Life History of Obelia**

**Fertilization:**
Fertilisation usually takes place in open sea water where the gametes are set free. Sometimes, the sperms are carried into the female medusae with water currents and there they fertilize the eggs in situ. However, the parent medusae die soon after liberating their respective gametes.

**Development:**
The zygote undergoes complete or holoblastic and equal cleavage to form a single-layered blastula with a blastocoele. Some cells migrate into blastocoele, eventually filling it completely to form a solid gastrula known as stereo gastrula. Its outer cell layer becomes the ectoderm and inner cell mass the endoderm.

The gastrula elongates and its outer layer of ectoderm cells becomes ciliated, and now it is called planula. Soon, a cavity called enteron develops in the solid endodermal cell mass by the process of delamination and the planula becomes a two-layered larva having an outer ciliated ectodermal cells and an inner layer of endodermal cells.

The planula after a short free-swimming existence settles on some solid object by its broader end. The free end forms a manubrium with a mouth and a circlet of tentacles. Thus, a simple polyp or hydrula is formed which grows a hydorhiza from its base, from which an Obelia colony is formed by budding.
The free swimming planula stage in the life history of Obelia, helps in the dispersal of the species. The life history may be represented as male and female gametes → zygote → planula larva → hydrula → colony → sexual medusae → gametes → zygote and so on.

**Alternation of Generations and Metagenesis of Obelia:**
It is clearly evident from the life history of Obelia that there is an alternation of polypoid and medusoid generations.
The polypoid generation is asexual and produces polyps and blastostyles by asexual budding. The blastostyle also produces medusae by asexual budding. The medusae do not produce medusae but they give rise to gametes, which after fertilisation develop into a polypoid colony from which medusae are produced again by budding.

Thus, an asexual polypoid generation alternates with a sexual medusoid generation. This phenomenon is known as alternation of generations, till recently. The term alternation of generations means that the individual exists in two distinct forms, which alternate each other regularly in the life history.

One individual possesses the power to reproduce the other by asexual reproduction, which again by sexual reproduction gives rise to the next generation. Therefore, a true alternation of generations is always between a diploid asexual and haploid sexual generations, as is exhibited by fern plant.

But, in Obelia the condition is somewhat different and, therefore, objections were raised to use the term alternation of generations for it. Because, in Obelia, there are no true two generations to alternate each other. The medusae are modified zooids capable of free swimming existence and moreover they are not produced directly from a zygote but are budded off from the blastostyle.

The gonads found in medusa are not formed in it but actually they are formed in the ectoderm of blastostyle which later on migrate into the medusa and become situated on its radial canals. Thus, it is rather difficult to distinguish between sexual and asexual generations. Hence the term metagenesis is used to replace the term alternation of generations in Obelia.

Thus, in the life history of Obelia, there is a regular alternation between fixed polypoid and free-swimming medusoid phases, both of them being diploid.

Such an alternation of generations between two diploid phases is known as metagenesis. Although, the phenomenon of metagenesis is also reported in other groups of animals but it is well represented by polymorphic hydrozoan like Obelia. Obelia shows polymorphism in which the polyps are for feeding the colony, blastostyles for budding and medusae for disseminating gametes.
Types of Coral Reefs
Scientists generally divide coral reefs into four classes: fringing reefs, barrier reefs, atolls, and patch reefs.

- **Fringing reefs** grow near the coastline around islands and continents.
  - They are separated from the shore by narrow, shallow lagoons.
  - Fringing reefs are the most common type of reef that we see.

- **Barrier reefs** also parallel the coastline but are separated by deeper, wider lagoons.
  - At their shallowest point, they can reach the water's surface forming a “barrier” to navigation.
  - The Great Barrier Reef in Australia is the largest and most famous barrier reef in the world.

- **Atolls** are rings of coral that create protected lagoons and are usually located in the middle of the sea.
  - Atolls usually form when islands surrounded by fringing reefs sink into the sea or the sea level rises around them (these islands are often the tops of underwater volcanoes).
  - The fringing reefs continue to grow and eventually form circles with lagoons inside.
FORMATION OF CORAL REEFS


- All coral reefs develop due to growth of polyps at shallow depth, because at greater depth they can't survive.
- Fringes, Barrier, Atoll are successive stages of development of coral reefs. First, Polyps grow at suitable stage below sea level initially and develop. And form fringe reef.
- After, land is subject to subsidence due to tectonic forces, thus coral reef reach greater depth, and there they may not survive.
- The growth of polyp is retarded near the coastal land but vigorous at outer edge of the land.
- Consequently lagoon is formed between coastal land and reef hence Barrier Reef.
- Further subsidence of land and island is completely submerged under water and a ring of coral reef in the form of atoll is formed.
- Depth of lagoon does not increase because of sedimentation.

2. Stand still Theory of Murray
• Corals grow upon suitable stable submarine platforms with unchanging sea level.
• Coral Polyps can live up to depth of 30 fathoms (180 feet).
• Sea level and submarine platforms are stable.
• Several submarine platforms, volcanic peaks, islands are present.
• If submarine platforms above the sea level, they are subjected to wave erosion.
• If submarine platforms are below seal level, they are subjected to deposition of marine sediments.
• After getting suitable depth of 180 feet, coral polyps start growing to form “fringing reefs”.
• Continuous outward growing of polyps form “barrier reefs”.
• Atolls are formed due to outward growth of corals in all directions at the top of submarine platform.
• Lagoon side of atoll is by dead corals while seaward side has living corals which continuously grow outward.

Evaluations:
• 1) Submarine platforms not possible to find everywhere.
• 2) Marine erosion and deposition at depth of 30 fathoms are contradictory.
• 3) Lagoons might be filled with depositions if land is stable. 4) Reefs are found from below 30 fathoms also.

3. **Glacial Control theory of Daly.**
• Daly propounded this theory in 1915.
• He said Corals formed after Pleistocene Ice age.
• The corals in sea died due to the fall in sea level, and lowering temperature because of glaciation on continents during Pleistocene age.
• ‘Wave cut platforms’ were formed due to sea waves.
• At the end of ice age the ice melted, resulting into rise of sea level above the ‘Wave cut platforms’ at coasts.
• The corals, which were able to survive in ice age grown above the ‘Wave cut platforms’
• The Fringing reefs formed on narrow wave cut platforms. - The Barrier reefs formed on broad eroded platforms.
• Atolls were formed around isolated wave eroded island peaks.

Evaluations:
• 1) According to theory the lagoons should have uniform depth, which is not.
• 2) Cliffs formed in Pleistocene should be present till today which is seldom found.
4. Concept of W.M. Davis

- W.M. Davis supported 'Subsidence theory' with proofs. According to him corals grow along subsiding lands.
- The shallowness of lagoons is due to deposition of debris.
- If submarine platforms are stable, the lagoons would have been filled with debris, and over spilling of water could kill the seaward corals.