www.aisectuniversityjharkhand.ac.in | Follow us on:

AISECT UNIVERSITY™

JHARKHAND, HAZARIBAG AN AISECT GROUP UNIVERSITY

Recognized by : UGC

Invertebrate & Cell Biology

(B.Sc.- Zoology Sem. - I)

Contact us:

8252299990

8404884433

AISECT University, Hazaribag

Matwari Chowk, in front of Gandhi Maidan, Hazaribag (JHARKHAND)-825301

www.aisectuniversityjharkhand.ac.in info@aisectuniversityjharkhand.ac.in

Unit I

Definition

Invertebrates are animals that don't have a backbone. The vertebral column is another name for the backbone. Over 90% of all species on Earth are invertebrates, and invertebrate species have been found in the fossil record as far back as 600 million years ago. Molecular biology studies suggest that all invertebrates evolved from a single invertebrate group.

Characteristics of Invertebrates

In addition to not having a backbone, invertebrates have soft bodies because they don't have an internal skeleton (endoskeleton) for support. Instead, many have structures on the outside (exoskeleton) that provide support and protection. In addition, invertebrates are cold-blooded, meaning they can't regulate their body temperature, so it changes depending on the environment.

Invertebrates are incredibly diverse. They live in fresh water, salt water, on land and as parasites in other animals. There are invertebrates that are carnivorous (meat eaters), herbivores (plant eaters) and omnivores (meat and plant eaters). There are even some invertebrate species that grow bacteria and cells inside their bodies that make their food. Some invertebrates stay in one spot, while others fly, swim, float, crawl and burrow.

Types of Invertebrates

Eighty-five percent of invertebrates are arthropods. Molluscs have approximately 100,000 distinct species. Some of the most common types of invertebrates are:

- protozoans – single-celled organisms such as amoebas and paramecia
- annelids – earthworms, leeches
- echinoderms – starfish, sea urchins, sea cucumbers
- molluscs – snails, octopi, squid, snails, clams
- arthropods – insects, spiders, crustaceans such as shrimp, crabs, lobsters

Life cycle of Plasmodium vivax

Life cycle of *Plasmodium vivax* is digenetic i.e. they complete their life cycle in two hosts:

1. Primary host or definitive host: Female Anopheles mosquito is the primary host. The organism which contains sexual phase of the parasite and is regarded as definitive host.

2. Secondary host or intermediate host: human is the secondary host. Human contains asexual phase of the parasite and develops symptoms of disease due to the presence of parasite and is termed as secondary host.

Life cycle of *Plasmodium vivax* is divided into:

1. Asexual life cycle or schizogony in man
2. Sexual life cycle or sporogony in female Anopheles mosquito

Asexual cycle or Schizogony in man

Schizogony is the process of asexual reproduction by which *Plasmodium* undergoes asexual multiplication in liver cell and RBCs of man.

It occurs in human liver cell (liver schizogony) and in RBC (erythrocytic schizogony).

When an infected female *Anopheles* mosquito bites a healthy person, it injects thousands of sporozoites along with saliva into the bloodstream. Inside liver and RBC different form of sporozoite cause infection.

Asexual cycle or schizogony in human is completed in following phases:

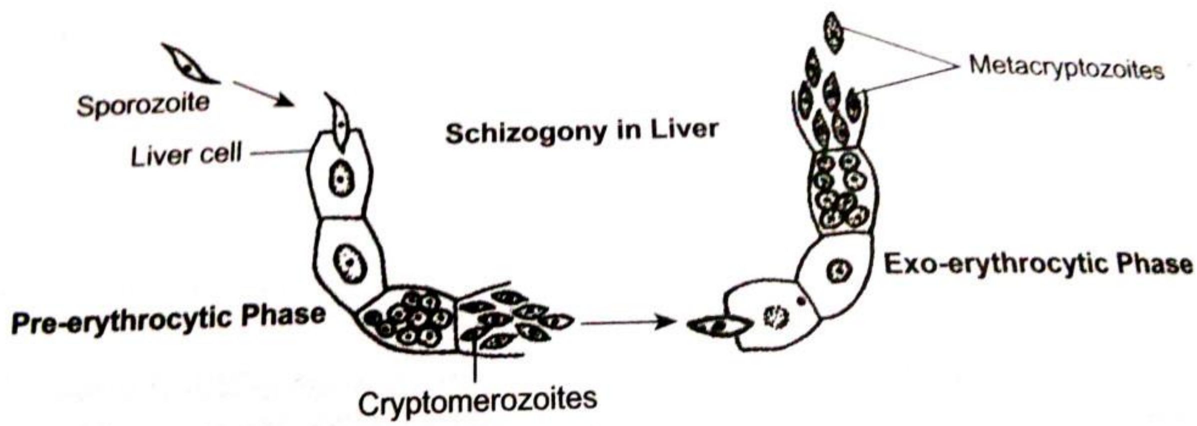
1. Pre-erythrocytic schizogony
2. Exo-erythrocytic cycle
3. Erythrocytic cycle
4. Post-erythrocytic cycle
5. Formation of gametocytes

1. Pre-erythrocytic cycle

When the sporozoites enters the blood, it remains active for about half an hour and disappears from the blood circulation.

Then it enters into parenchymatous cell of liver (to escape the phagocytic action of leucocytes) through blood circulation by secreting lytic enzymes from the apical cap. Sporozoites in liver cell grow in size and become spherical in shape called schizonts. The nucleus of schizont multiply asexually (multiple fission) and forms thousands of merozoites. These gives pressure to the wall of liver cell and liberated out in the form of cryptozoites or cryptomerozoites through ruptured liver cell.
It is completed in 8-10 days.

The process of formation of many cryptozoites from single sporozoites in liver cell is called pre-erythrocytic schizogony.



2. Exo-erythrocytic schizogony

The cryptozoites are ready to infect the fresh liver cell where they grow and become schizont. The same process is repeated several times. The liberated merozoites in this phase is called metacryptozoites.

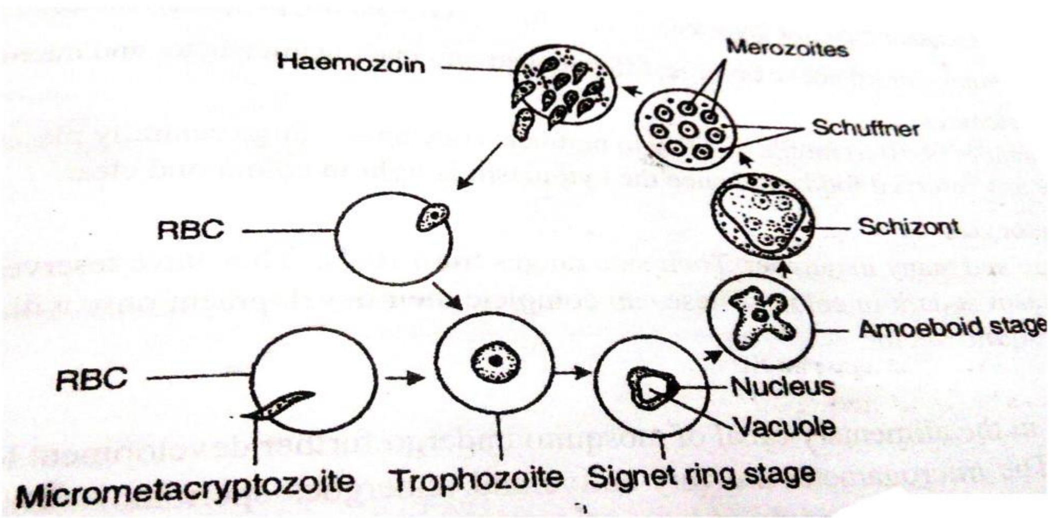
The process of formation of many metacryptozoites from the cryptozoites in liver cell is called exo-erythrocytic schizogony.

Some metacryptozoites are smaller in size called micro metacryptozoites and some are larger in size called macro metacryptozoites.

The micro metacryptozoites enter the red blood cells to start the erythrocytic phase while the macro metacryptozoites infects the fresh liver cells to continue exo-erythrocytic phase.

NOTE: Exo-erythrocytic cycle is absent in Plasmodium falciparum.

3. Erythrocytic cycle



This cycle starts when the micro metacryptozoites enter into erythrocytes. Single metacryptozoite enters into single RBC and passes through trophozoite stage, signet ring stage, amoeboid stage and schizont stage.

When metacryptozoites invade the RBC it becomes rounded with large nucleus *and grows in size by ingesting hemoglobin of corpusles.*

This stage of parasite is called trophozoite stage.

Inside the trophozoite, a large non-contractile vacuole appears which pushes the nucleus towards periphery and forms a ring like structure known as signet ring stage.

Trophozoites enlarges and vacuole starts disappearing and develops pseudopodial processes in the cytoplasm and changed into amoeboid stage. This stage is called amoeboid stage.

The amoeboid feeds completely the component of corpuscles in the form of haemoglobin. During feeding the haemoglobin breakdown into hematin and globin. The globin is absorbed by the cell and hematin is deposited in the form of hemozoin (toxic malarial pigment).

The amoeboid trophozoites after feeding, becomes rounded, grows in size and becomes erythrocytic schizont. Asexual multiplication takes place in schizont and forms merozoites which give pressure to the wall of weak RBC and liberated out in the form of erythrocytic merozoites.

The merozoites are arranged towards the periphery due to the presence of hemozoin at the centre. The arrangement is just like the arrangement of petals in rose flowers. So, this stage is called rosette stage.

Numerous yellowish eosinophilic granules appear in the cytoplasm of the host corpuscles which are called schuffner's granules. These dost are believed to be the antigen excreted by the parasites.

The process of formation of merozoites in the RBCs from the metacryptozoites is called erythrocytic schizogony.

It completes about 48 hours.

Many merozoites enter the fresh RBC and repeat the erythrocytic cycle.

4. Post-erythrocytic cycle

Sometimes, some merozoites produced after erythrocytic cycle invade the liver cell and undergo another schizogonic development in the liver cell. This is called post-erythrocytic cycle.

5. Formation of gametocytes

After some generation of erythrocytic cycle, some of the merozoites invade the new RBC. They grow in size but do not develop into schizonts instead they develop into gametocytes.

The gametocytes are of two types:

i. Macrogametocytes or female gametocytes: These are large (10-12µ) and numerous in number. They have small compact peripheral nucleus. They have reserved food materials and the cytoplasm is dark in colour.

ii. Microgametocytes or male gametocytes: These are smaller (9-10 µ) motile and few in number. They have large centrally placed nuclei. They lack reserved food and stains faintly hence the cytoplasm is light in colour and clear.

Further development of gametocyte stops in man and only possible in mosquito due to its low temperature.

Inoculation

When an infected female Anopheles mosquito bites a healthy person it sucks his/her blood for meal, she injects saliva containing sporozoites into the wound through its needle like mouth parts. This is called inoculation.

Pre patent period

The interval between inoculation and initiation of erythrocytic cyce is called pre-patent period.

Incubation period

The period between the entry of parasite and appearance of first symptoms is called incubation period. It is about 14 days in *P. vivax* and *P. ovale*, 12 days in *P. falciparum* and 28 days in *P. malariae*.

Life-cycle of *Sycon*

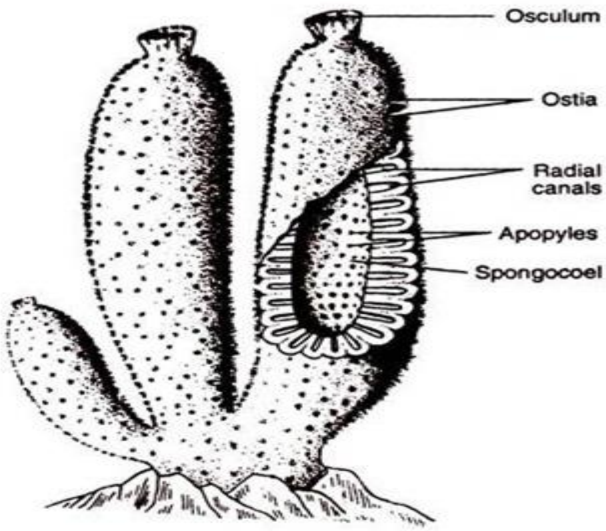
Habit and Habitat of Sycon:

Sycon is a marine sponge and remains attached to solid substrata like rocks, shells of molluscs and corals. The name of genus, Sycon, is replaced by Scypha by de Laubenfels (1936). But in our present discussion the name Sycon is retained. The different species of sponges under the genus do not tend to live at greater depths in the ocean.

2. Structure of Sycon:

The sponges exhibit a great diversity in form. They range from a very simple to more complicated forms. Sycon occupies an intermediate status from the point of structural diversities. It has the form of branched cylinders of about 2.5 to 7.6 cm. in length. All the branches are connected together at the base which remains attached to the sub-stratum.

Though the body has a firm consistency, it is slightly flexible. Close examination of the surface reveals the presence of innumerable minute inhalent pores or ostia. The free end of each cylindrical branch possesses an opening at the summit. This opening is known as osculum.

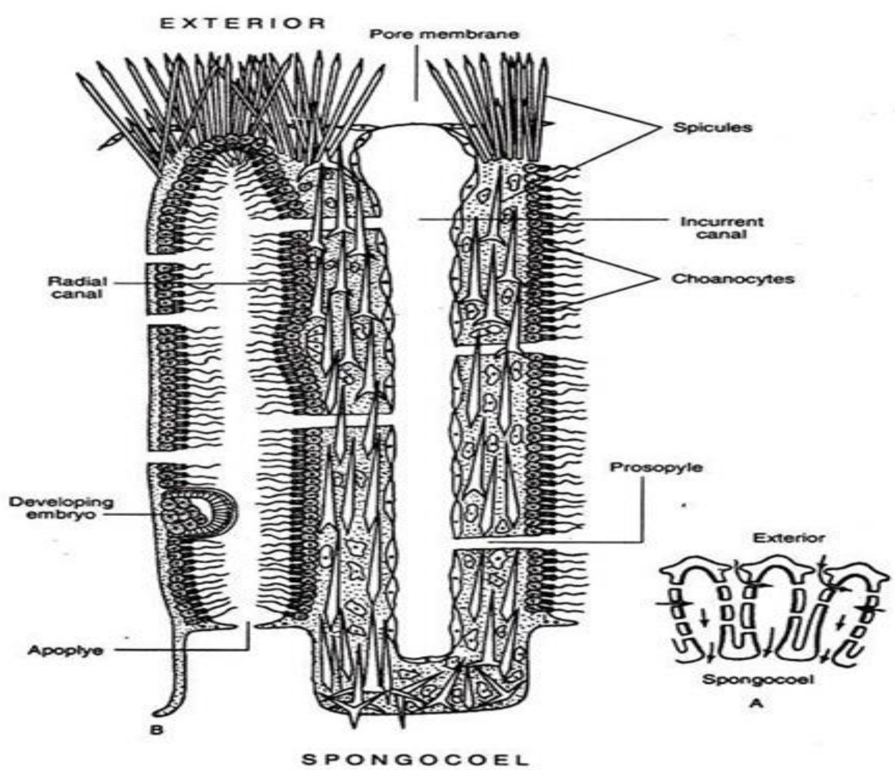


Structure of *Sycon*

3. Canal System of Sycon:

Sycon, like all other sponges, possesses the characteristic anatomical peculiarity—the canal system. It permeates the body with water channels. It plays a very important role in the life of Sycon. Brusca and Brusca (2003) have used the term aquiferous system instead of canal system.

The particular type of canal system encountered in Sycon is known as the syncoid (Stage I) type which is practically more advanced than the asconoid canal system.



The canal system consists of the following parts:

(i) Paragastric cavity or gastral cavity or spongocoel:

If the cylindrical body of Sycon is bisected longitudinally, it is observed that the outer large opening, called osculum, leads into a large central canal. This canal is called paragastric cavity or gastral cavity or spongocoel.

Although this cavity is variously named, the name of spongocoel seems to be more appropriate. The wall of the Sycon is lined by ectodermal flattened cells, called pinacocytes. The osculum is surrounded by a layer of cells, called myocytes which are contractile in nature and act as sphincter. The spongocoel opens to the exterior through the osculum.

(ii) Radial canals:

The body wall lining of the spongocoel is out-pushed at regular intervals as finger-like projections. These projections are called radial canals. The wall of the radial canal is lined with flagellated collar cells or choanocytes. The outer end of the radial canal is blind but the inner end is open which communicates with the spongocoel through the excurrent canal.

(iii) Incurrent canal:

In between two successive radial canals, a tubular space, called incurrent canal or inhalent canal, is present, thus radial canals and incurrent canals are arranged alternately and the latter opens to the exterior through ostia. The inner end of the incurrent canal is blind. The wall of the incurrent canal is lined by ectodermal, flat pinacocytes.

Between the incurrent canal and radial canal there is a thickened mesogloea, called gastral cortex. The ostia are situated on the pore membrane which are intercellular openings and are surrounded by contractile myocytes. These myocytes act as sphincters, by which they regulate the diameter of the openings.

(iv) Prosopyles:

The wall between the incurrent and radial canals is pierced by numerous minute pores called prosopyles. In Sycon, each prosopyle is an intercellular space or channel while in Leucosolenia these pores are intracellular. Through these pores, the incurrent canals open into the radial canals.

The prosopyles are the openings of the porocytes, generally believed to be modified pinacocytes. The porocytes are thick-walled cylinder-like structure with a nucleus in the cytoplasm at one side. It is highly contractile and controls the inflow of water.

(v) Ex-current canals:

The radial canals communicate into the spongocoel through short, wide canals, called excurrent canals. The wall of the excurrent canal is lined by flat, pinacocytes.

(vi) Apopyles:

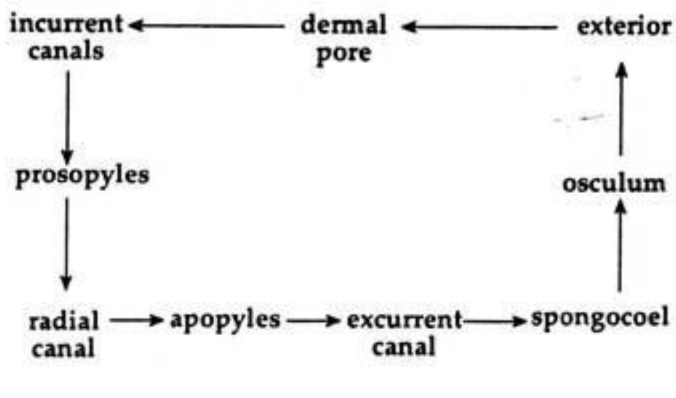
The excurrent canals open into spongocoel by internal ostia or apopyles. The apopyles are surrounded by contractile myocytes.

4. Physiology of Water Current Production in Sycon:

The circulation of water in Sycon takes place in the following way (Fig. 11.4). The course of water current has been studied by the application of fine carmine particles to the surface of the body. The water rushes inside the body through numerous ostia along the external surface.

Each ostium or dermal pore leads into an incurrent canal. From the incurrent canal, the water flows inside the radial canal through prosopyle. From radial canal water passes out through apopyles into the spongocoel. The spongocoel is thus a common chamber within which all the radial canals of the body open.

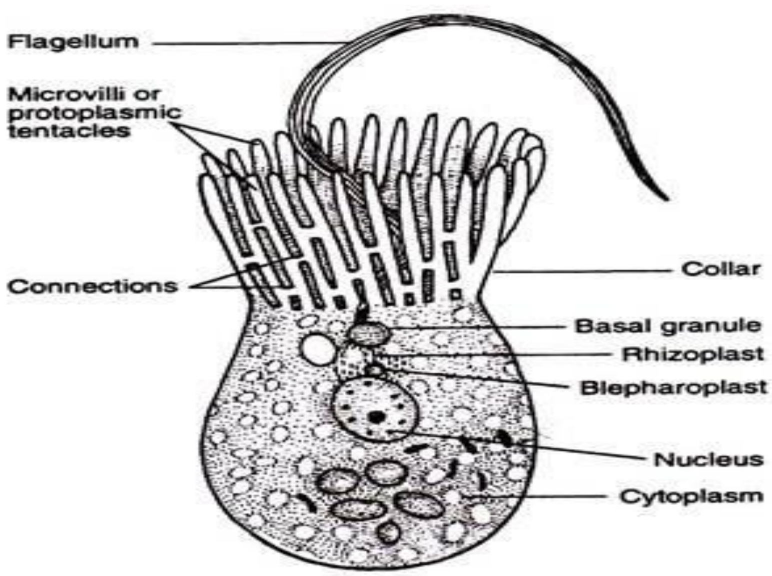
The spongocoel ultimately opens to the exterior through an aperture, the osculum. Water enters inside the body through numerous doors (ostia) but passes out through a single opening (osculum). The planar beating of the flagella of choanocytes in the radial canals produces a current which in one hand draws the water inside and on the other hand forces it to go out.



__5. Microscopic Organization of Sycon:__

The microscopic organisation shows the presence of a single layer of cells covering the outer surface of the body. This outer layer is designated as the dermal layer. Needle-like spicules are seen to project from this layer. This layer is composed of large cells called the pinacocytes.

The spongocoel is lined by a layer of flattened endodermal cells, Radial canals are lined by peculiar collar cells, each having a long whip-like flagellum. These cells are called the choanocytes or collar cells or gastral cells.



Structure of choanocyte

Each choanocyte has a round or oval body. It possesses a nucleus and one or many vacuoles in its cytoplasm. The free end of the cell body has a comparatively longer flagellum and the base of the flagellum is surrounded by a contractile transparent collar-like outgrowth of the cytoplasm.

The flagellum arises from the basal granule which is connected with the blepharoplast by a root called rhizoplast. Electron microscopic studies have revealed that the collar-like outgrowth is composed of cytoplasmic tentacles. The number of such tentacles varies from 20 to 30. The sectional view of flagellum under E. M. reveals the pattern of 9 + 2 arrangement of microtubules, like the flagella of flagellates.

The spicules, which constitute the skeleton of Sycon, develop from the scleroblasts. These structures are regularly arranged and protect the softer parts. Triradiate as well as tetraradiate spicules are common. Besides these, simple club-like oxeote spicules are also present.

The intermediate layer, called mesohyl or mesenchyme, which consists of a gelatinous proteinaceous matrix, contains spicules and numerous amoeboid cells.

The amoeboids are of many types and are as follows:

1. Archaeocytes:

They are undifferentiated embryonic amoebocytes which are large in size and their nuclei show distinct nucleoli. They are totipotent in nature and can transform into different kinds of cells, needed by the animal. They play a role of digestion, eliminating waste material and can give rise to both sperms and ova.

2. Collenocytes:

Most of the other cells are smaller and stellate-shaped and possess radiating processes. These cells are usually called collenocytes or connective tissue cells. They remain fixed by cytoplasmic processes.

3. Chromocytes:

These are pigmented amoebocytes with lobose pseudopodia.

4. Thesocytes:

These amoebocytes are storage cells with lobose pseudopodia.

5. Myocytes:

These are fusiform and highly contractile cells, found around the osculum, apopyles and other pores. These cells are arranged in circular fashion and act as a sphincter and regulate the diameter of the openings. So water flow through osculum is regulated.

6. Gland cells:

These cells are found attached to the body surface by long strands and -secret lime (Fig. 11.6C).

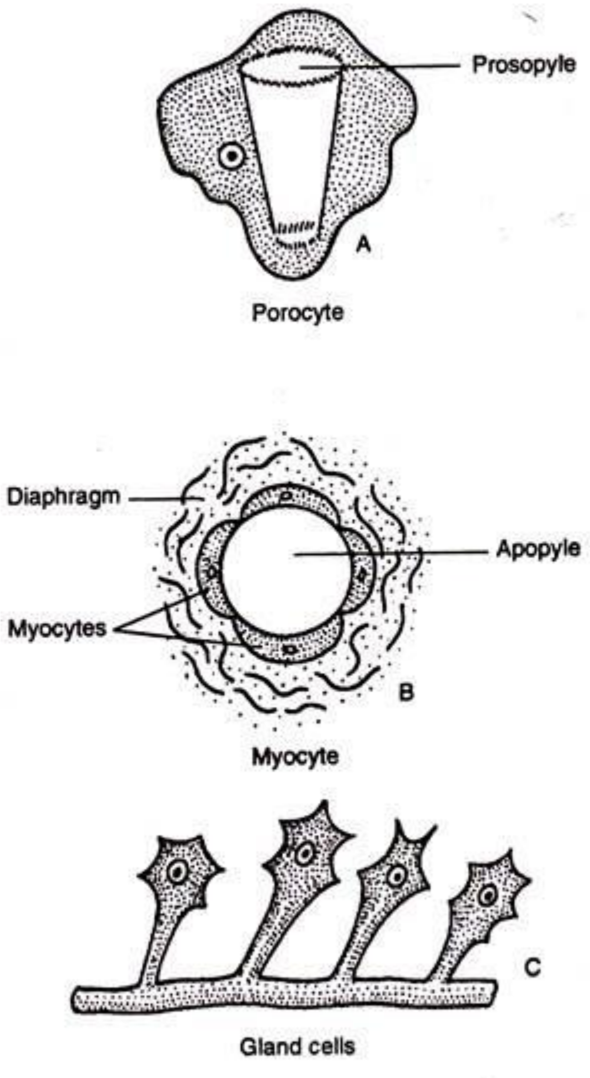


Illustration of A. Porocyte, B. Myocyte and C. Gland cells

The osculum, prosopyles and apopyles have elongated narrow cells which prolong into narrow fibres around the aforesaid apertures and help them to close, when necessary.

6. Nutrition, Respiration and Excretion in Sycon:

The sponges feed on micro-organisms which enter into the body along with the water current. The choanocytes engulf them and pass them to the amoeboid cells situated below the choanocytes. The digestion takes place inside the amoeboid cells and assimilated products are conveyed to the various parts of the body.

Thus, nutrition is holozoic and digestion is intracellular, a process comparable to that of protozoans. Some amoeboid cells often contain chlorophyll or green pigments and carry out autotrophic nutrition like green plants.

The presence of algae within the sponge body also helps in nutrition. Respiration and excretion take place by diffusion. The contractile vacuoles are recorded in the amoeboid cells of freshwater sponges which probably play important role in osmo-regulation and excretion.

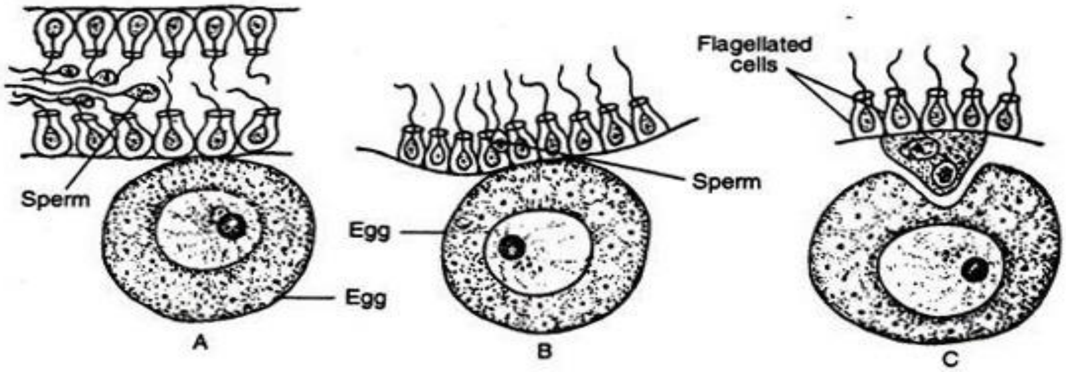
7. Reproduction in Sycon:

Sycon reproduces both asexually and sexually. During asexual reproduction it produces bud and sometimes produces special bodies resembling the gemmules of freshwater sponges.

During sexual reproduction, both sperms and ova are produced from the archaeocytes which are present in the mesoglea. It is claimed that the sex cells are also produced from adult choanocytes. The sperm cells have long tails and swim freely in water current. The ova are amoeboid and wander through the mesoglea.

The ova may grow up in size by ingesting other cells. The sperm cell does not enter the ovum directly. The union is assisted by a choanocyte. When sperm cells enter the radial canal, the choanocyte which is nearer to the egg captures it. The choanocyte which absorbs the sperm discards its flagellum and collar and comes very near the egg.

This choanocyte is named as the carrier cell. The sperm subsequently loses its tail and enters the egg. The carrier cell is ultimately absorbed. The early development takes place within the body of the mother sponge. When the development is complete, the larva forces its way into the radial canal and finally to the exterior.



8. Development of Sycon:

The fertilized egg or zygote divides repeatedly to form a round mass of cells (Fig. 11.8). It is mostly covered with homogeneous cells but at one end a few thickly granulated cells appear.

The homogeneous cells grow flagella and completely enclose the granulated cells. Soon the cells at one half lose their flagella and become large and granular. The hollow and swimming larva at this stage is called amphiblastula stage and the larva in this stage leaves the parent body.

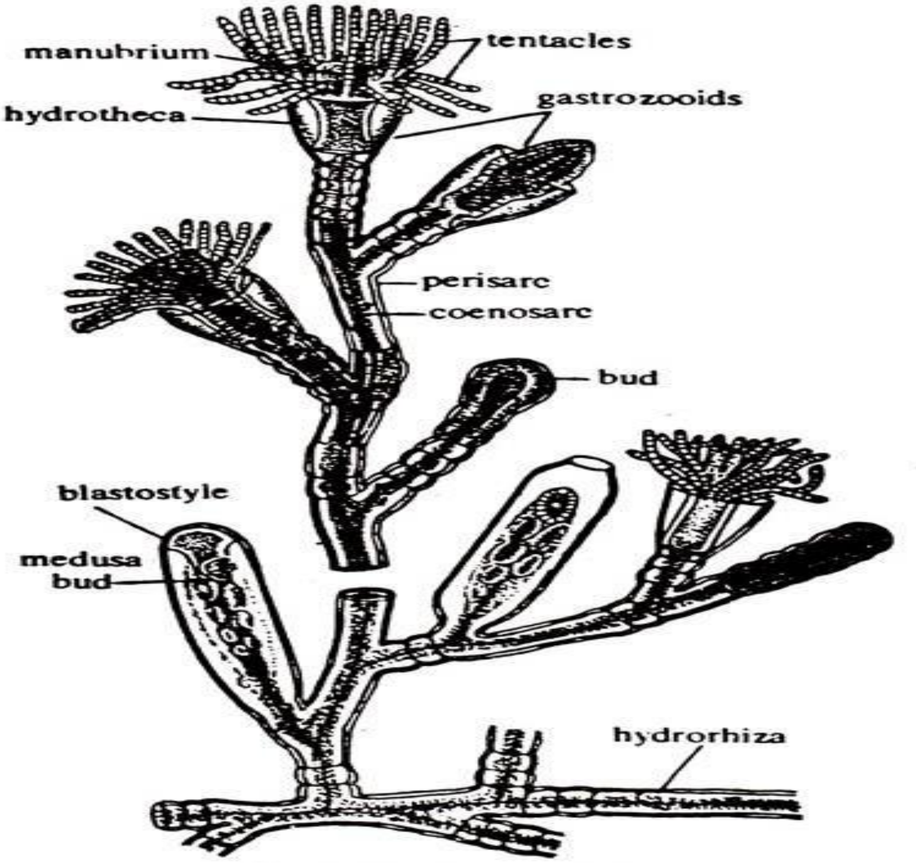
Gradually, the flagellated cells invaginate and finally the granular cells completely enclose the flagellated cells. The flagellated cells form the choanocyte lining while the granular cells give rise to the dermal epithelium. The larva fixes itself to a substratum and an aperture, called osculum, appears at the free end.

Further growth results into the thickening of the wall within which flagellate cells traverse and thus leads to the formation of radial canals. Numerous pores appear on the sides to form inhalent apertures.

Unit II

Life-cycle of *Obelia*:

1. It is a branched, fixed colony (Fig 20.12). Some of the horizontal branches anchoring the colony on some support are called Hydrorhiza while other branches are vertical and known as Hydrocaulus.



2. Each branch consists of a granular coenosarc made of two cell layers enclosing the coelenteron and surrounded by a thin transparent horny perisarc.

3. The vertical branches towards the base are further branched and all the branches end in zooids.

4. Zooids are of three types:

a. Polyps or gastro zooids (vegetative zooids). Barrel-shaped and responsible for the nutrition of the colony. The perisarc enclosing the polyp is termed hydro theca.

b. Blastostyles. or gonozooids. Club- shaped zooids, bearing the medusae buds.

c. Medusae buds. Umbrella-like reproductive zooids bearing gonads, enclosed in a gonotheca.

5. Medusae buds are unisexual and free- living at maturity. One medusa bears either four testes or four ovaries close to the four radial canals.

6. The tentacles in all cases are solid; the solid core or endoderm surrounded by a layer of ectoderm cells.

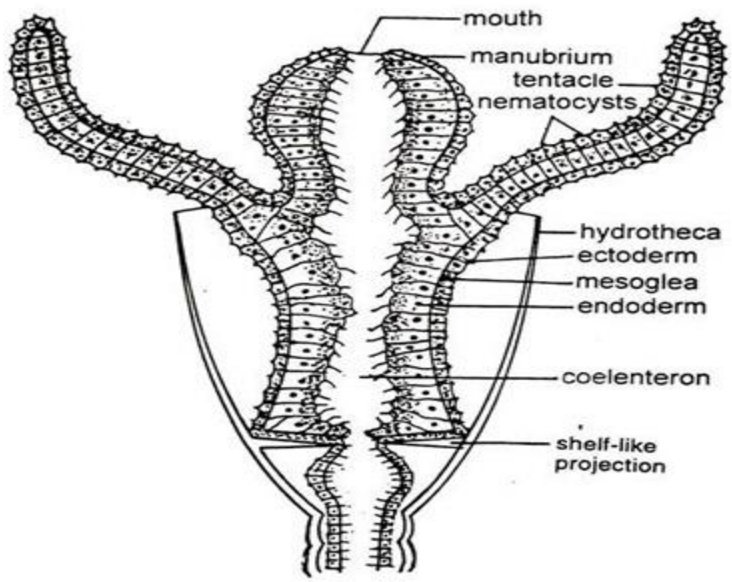
7. The larvae are ciliated and free-swimming.

8. By repeated branching of the simple polyps colony is formed.

Polyps or Gastro zooids or Nutritive Zooids:

1. The zooid is barrel-shaped, partially enclosed by a cup-shaped hydro theca, a continuation of the perisarc.

2. At the distal end a conical projection the hypostome or- manubrium, bearing a mouth is present.



Obelia:- V.S of polyp

3. A circlet of about twenty-four tentacles are present around the hypos tame. The tentacles are solid with a core of endoderm cells surrounded by a layer of ectodermal cells.

4. The tentacles and the hypostome bear cnidocytes.

5. At the proximal end, the zooid is continuous with the coenosare.

Blastostyle or Gonozooid or Reproductive Zooid:

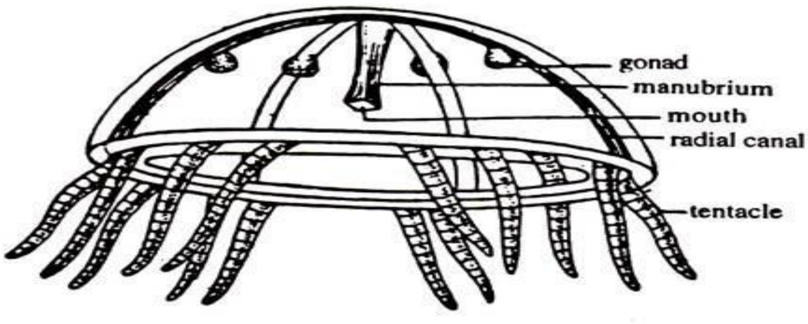
1. These are a few in number and restricted to the basal end of the hydrocaulus.

2. The blastosyle is long, cylindrical and devoid of mouth and tentacles and enclosed in a transparent gonotheca, modified perisarce.

3. A number of small buds—the medusae buds develop on the walls of the blastostyle.

Medusa in Obelia:

1. At maturity, small umbrella-like me dusae buds get detached from the blastostyle and escape to the sea water through an aperture at the free end of the gonotheca. A hydro-medusa (Fig.20.14) is a solitary and free-swimming modified zooid.



Obelia medusa

2. A typical medusa consists of a bowl- shaped gelatinous disc or umbrella, the concave surface of which is described as sub-umbrella and the outer convex surface as ex-umbrella.

3. A cylindrical projection, the manubrium, hangs from the middle of the sub umbrellar surface. A square mouth is present, at the apex of the manubrium.

4. The mouth leads to a small, central, rounded or quadrangular chamber known as gastric cavity or stomach.

5. From gastric cavity four gastro dermal canals radiate to the margins of the bell. These are radial canals, opening into a ring canal or circular canal running in the margin of the bell. The radial canals mark out four principal radii.

6. From the middle of the radial canal four gonads project. Since sexes are separate, these are either testes or ovaries.

7. The gonads mature after the medusae escape from the gonotheca.

8. The edge of the bell is produced inwards as a thin fold called velum. The medusae with a velum are known as craspedote and those without a velum are acraspedote. The hydromedusa is craspedote.

9. From the edge of bell numerous small solid tentacles hang downwards.

10. The tentacles have swollen bases of accumulated interstitial cells, called vesicles or bulbs. Cnidocytes are formed continuously in the bulb and migrate to the tentacles. They are confined to manubrium and tentacles and a few on the bell margin.

11. Near the bulbs the ectoderm has pigment granules and nerve cells called ocelli. The pigments are accumulated excretory products.

12. Marginal sense organs, statocysts or lithocysts are eight in number and attached at regular intervals on the subumbrellar side to the bulbs of the tentacles.

13. A statocyst is a tiny, circular, closed vesicle lined with ectoderm and filled with a fluid containing calcareous granules called otoliths.

14. Otolith produces a stimulus on thin sensory processes of the sensory tells of ectodermal lining which are transmitted to the muscles. The muscles coordinate the snake-like swimming movements of the medusa.

Histology of Hydromedusa (Fig. 20.15):

1. Both exumbrellar and subumbrellar surfaces of medusa are covered by ectoderm cells.

2. The whole canal system is lined by endoderm cells, continued, at the lip of the mouth, into the surface ectoderm.

3. A thin sheet of endodermal lamella, presumably formed by the fusion of an upper and a lower layer of endoderm, lie between the radial canals and between the ex- and subumbrellar layers of ectoderm.

4. The velum is composed of a double layer of ectoderm enclosing a ring canal and a strip of narrow mesoglea in between the canal and ectoderm.

5. The tentacles are solid, each containing a core of vacuolated endodermal cells covered by ectoderm.

6. The gelatinous mesoglea form the main bulk of the body and contains certain non-cellular fibres.

7. Well-developed musculature with regularly arranged circular, longitudinal and radial tracts is present.

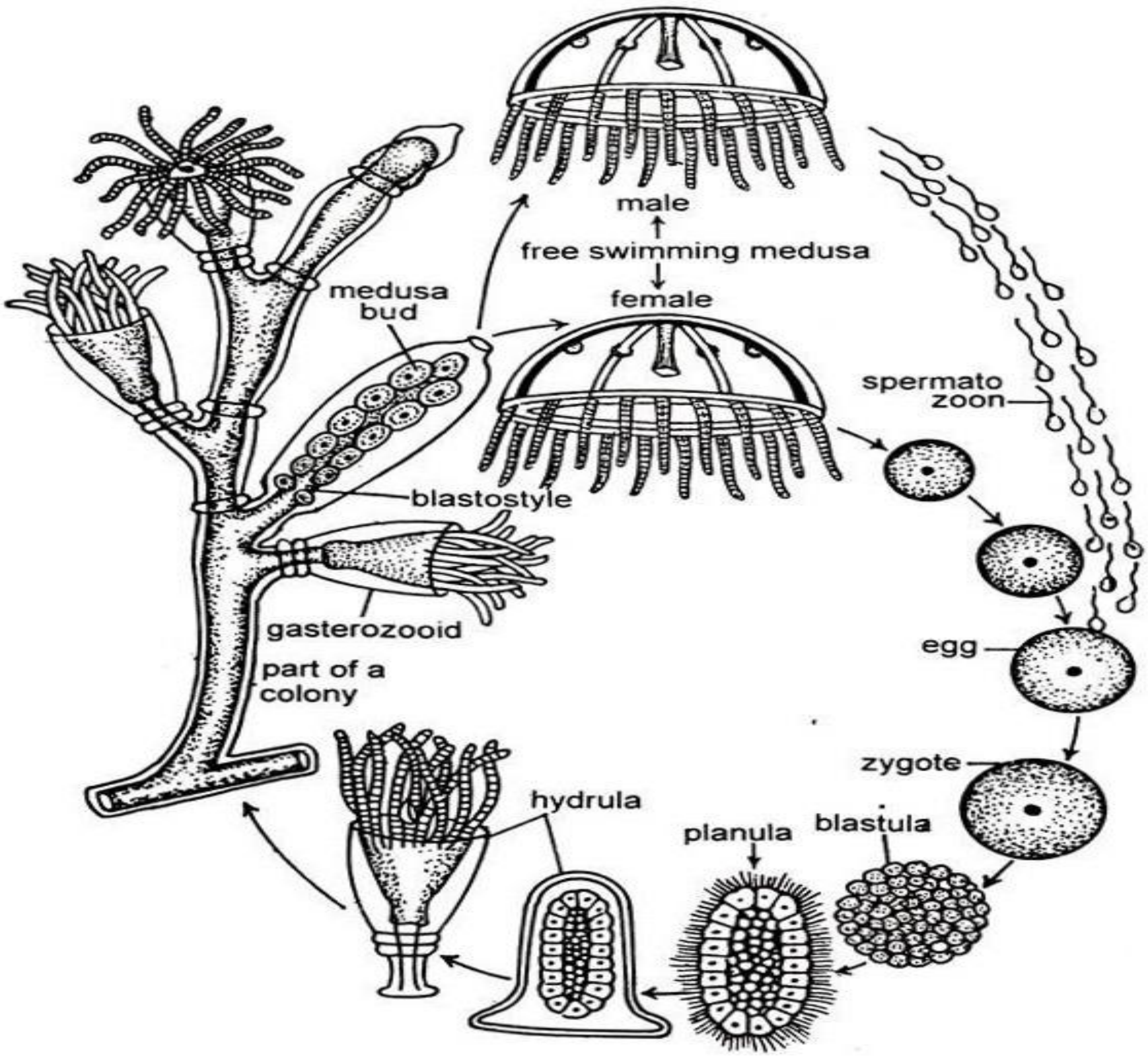
8. The interstitial cells are mainly accumulated at the bulbs or vesicles of tentacles and give rise to cnidocytes of only one type.

Gonads:

1. The medusae are sexual reproductive zooids or gonozooids possessing gonads.
2. They are dioecious—testes and ovaries are borne by separate individuals.
3. Each medusa bears only four gonads situated on the subumbrellar surface, one on the middle of the course of each radial canal.
4. The gonads mature after the medusae escape from the gonotheca.
5. Each gonad (testis or ovary) is an ovoid, knob-like body; it has an outer covering of ectoderm, continuous with that of the sub-umbrella, and an inner lining of endoderm continuous with that of the radial canal (Figs. 20. 14, 20.15)
6. The space between the two layers is filled with a mass of interstitial cells which become differentiated into ova or sperms, as the case may be.
7. The germ cells originate in the ectoderm of the manubrium quite early when the medusa itself remains attached to the blastostyle.
8. Subsequently, they migrate to the gonads to lie between the mesoglea and the subumbrellar ectoderm and undergo maturation.
9. When the gonads are ripe, ectodermal covering ruptures and the germ cells are shed in water.
10. The ova are large rounded cells.
11. The sperms are minute, actively swimming flagellated cells.
12. The medusae die soon after liberating the gametes.

Fertilization and Development in Obelia:

1. Fertilization occurs either in the sea water where the germ cells are set free, or the spermatozoa may be carried by water currents to the female medusae and fertilize the ova in situ. Zygote formed after fertilization, immediately undergoes cleavage.
2. The cleavage is holoblastic and a blastula is formed.



3. By invagination the blastula is converted into an oval, ciliated planula larva.

4. The planula consists of an outer layer of ciliated ectoderm and an inner mass of endoderm cells enclosing a space, the rudiment of coelenteron.

5. The planula swims freely for a brief period and settles down on some submerged substratum by one end.

6. The proximal end gradually narrows down and a disc appears for attachment. The distal end expands and by developing a manubrium and a circlet of tentacles, it turns to a hydrula or simple polyp.

7. The hydrula sends out lateral buds and, by a repetition of this process, it is converted into a complex obelia colony.

Alternation of Generations of Obelia:

A distinct alternation of generations or metagenesis is present in the life history of Obelia. The Obelia colony is sexless, bears no gonads and develops by asexual process, i.e. by repeated budding of the hydrula.

But the medusae buds, some of the zooids of the colony, develop gonads and, from their fertilized egg, new Obelia colony arises. The asexual generation is dependent on, and is alternated by the sexual generation.

Obelia is a permanently fixed colony but the planula larvae it produces are free swimming. The larva can swim from place to place with the help of cilia and, being aided by water current, it can travel a long distance. Thus, a non-locomotory species becomes locomotory and an overcrowding of individuals within a limited area is avoided and, thereby, the species is successfully continued.

****