<u>**UG CBCS Semester-1**</u>

<u>*Sycon (Scypha)*</u>

Scypha is commonly known as urn sponge, as the individuals are shaped like an urn (a water vessel). It is also called as crown sponge, because the fringe of long and straight spicules at the top looks like a little crown. *Scypha* differs from *Grantia*, a European genus, in not having an outer covering, or the cortex, a characteristic feature of the latter. The best studied spots of *Scypha* are S. *coronata, S. ciliation, S. elegant, S. lingua* and *S. raphanus*.

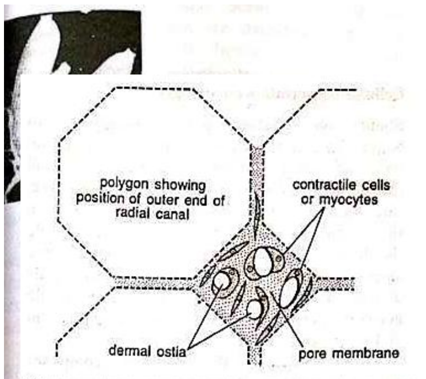


Fig. 6. *Scypha*. A surface view of pore membrane showing ostia.

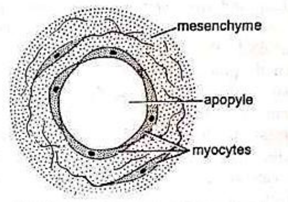


Fig. 7. *Scypha*. Apopyle lined by myocytes.

B—One individual magnified.

Habitat

Scypha (Gr. skyphos, cup) is a marine sponge which is widely distributed, but is best known, from North Atlantic shores. It may be solitary forms a colony by budding. Sessile colonies are cylindrical individuals are found permanently attached to submerged rocks or other solid substrata in shallow sea water along the coasts. They thrive well where wave action is not too strong and at low tide mark.

External Morphology

Scypha or *Sycon* possesses a vase-shaped and radially symmetrical body which measures from 1 to 3 cm in height and 5 to 6 mm in diameter. The colour is not specific but varies from grey to light brown. Near the attached end are found a few small tubular projections, or buds, which are formed not so extensively as in *Leucosolenia* or other asconoid sponges. Free end of the vase shaped individual bears a pore, the osculum (exhalent or excurrent pore), which is fringed with long, straight, needle-like calcareous monaxon spicules. This oscular fringe checks small animals from entering into the body. Just below osculum, the body becomes narrower forming a collar region. The body surface is thrown into regularly arranged polygonal elevations from which project spear-like spicules, called oxeotes (monaxon spicules), that impart a bristly appearance to the body. The polygonal elevations are separated by deep grooves, bearing minute pores, i.e., ostia, which lead into the central body cavity, the spongocoel or paragastric cavity, through a system of canals.

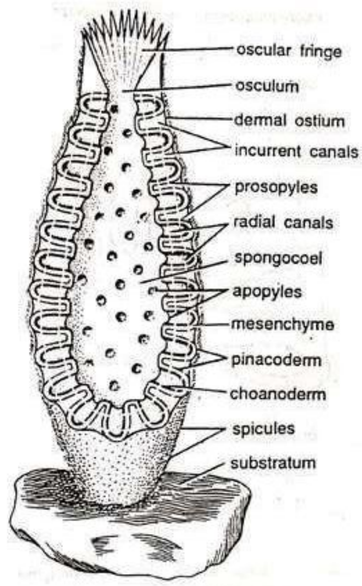
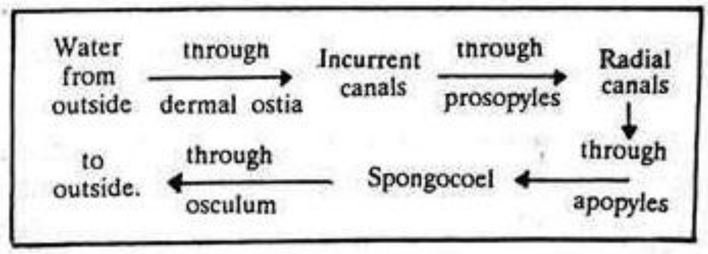


Fig. 2. *Scypha*. A diagrammatic L.S. of a cylinder showing gross internal structure and canal system.

Canal system

Body of *Scypha* is organized in such a manner as to form a complex system of pores and canals. This system is generally referred to as canal system or aquiferous system. Body wall has essentially the same cellular layers, pinacodemi and choanoderm, with a non-cellular gelatinous mesenchyme in between. But the body wall is so folded as to from regularly arranged alternating invaginations and evaginations, establishing the sycon type of canal system. Various components of canal system are as follows:

1. Ostia or dermal pores. The external grooves of body surface arc stretched over by a thin pore membrane. It bears two or more openings for the ingress of outside water into the body of sponge. These pores are known as ostia (L., ostium, door) or dermal pores (Fig. 6). Because of the presence of contractile cells or myocytes around them, the ostia can reduce in diameter and thus regulate the amount of ingressing water.
2. Incurrent canals. These canals are the invaginated folds of body wall and are also called inhalent canals. These communicate with outside through ostia but end blindly at their inner ends. Pinacocytes line these canals throughout.
3. Prosopyles. Incurrent canals communicate with radial canals through intercellular spaces, called prosopyles (Gr., *pros*, near + *pyle*, gate).
4. Radial canals. Evaginations of body wall form thimble-shaped chambers lined by flagellated choanocytes. These chambers are called flagellated or radial canals. Incurrent and radial canals are parallel and alternate with each other, both vertically and radially. The arrangement is such that, in a vertical or tangential section through the wall of a cylinder, each radial canal is surrounded on four sides by incurrent canals, and each incurrent canal is surrounded likewise by four radial canals. Radial canals end blindly at their outer ends but lead at their inner ends into spongocoel.
5. Apopyles. Openings of radial canals into spongocoel are called apopyles (Gr., apo, away from + pyle, gate) or internal Ostia. These are surrounded by contractile myocytes serving as a sphincter.
6. Spongocoel. It is the large central cavity of body forming the vertical axis of the cylinder (Gr., spongos, sponge + koilos, hollow). In *Leucosolenia*, spongocoel is lined by flagellated collar cells or choanocytes. In *Scypha*, the choanocytes line the radial canals, whereas the spongocoel is lined with the epidermal Pinacocytes
7. Osculum. Spongocoel leads to outside quo through a terminal opening, the osculum. The oscula are provided with sphincters to regulate the rate of water flow in the body. Sphincters are lined by special contractile piAacocytes, called myocytes. (Gr., myos, muscle +kytos, cell).
8. Current of water. Flow of water inside canal system is maintained by continuous beating of flagella of collar cells lining the radial canals. Every beat of a flagellum consists of a normal active stroke and a recovery stroke. Electron microscopy has revealed that there is no coordination between the beating of flagella of adjacent cells. The course taken by water current into the canal system is as under:
The rate of flow of water in sponges body is about 0.01 mm/sec.



Cellular organization (Histology)
Studies on structure and morphogenesis of *Scypha* have clearly revealed the presence of two types of cellular layers, the pinacodenn and choanodemt, with an intermediate mesettchyme. The former controls the interrelations between the mesenchyme and the external medium, while the latter controls mainly the nutrition of the animal. Asconoid sponges are not truly

diploblastic because the two cellular layers do not correspond with the ectoderm and endoderm of Eumetazoa.

1. Pinacoderm. Pinacoderm comprises (i) eropinacodenn (dermal epithelium) covering the entire body surface except dermal ostia and osculum, and (ii) endopinacodenn which includes the epithelial lining of incurrent canals and spongococl. Pinacoderm is composed of large, flattened, polygonal cells, the pinacocytes (Gr., pinako, plank +kytos, cell). In profile, each cell presents a central bulging containing the nucleus. Margins of adjacent cells are closely cemented together. Pinacocytes are highly contractile and they can greatly increase or reduce the surface area of sponge body.

In the lining of incurrent canals, some pinacocytes are modified to form tubular cells, the porocytes. These connect the incurrent canals with radial canals through their intracellular channels, the prosopyles. Porocytes are thin-walled cells, open at both ends and with the nucleus present in the peripheral cytoplasm. According to some workers, porocytes are present only in young sponges. In the adult sponges, porocytes degenerate leaving empty spaces or intercellular prosopyles surrounded by contractile myocytes. Pinacocytes surrounding the osculum, outer (dermal) ostia and inner ostia (apopyles) are elongated and contractile and act as muscle cells, called tnyocytes. These cells form sphincters around them to regulate there openings.

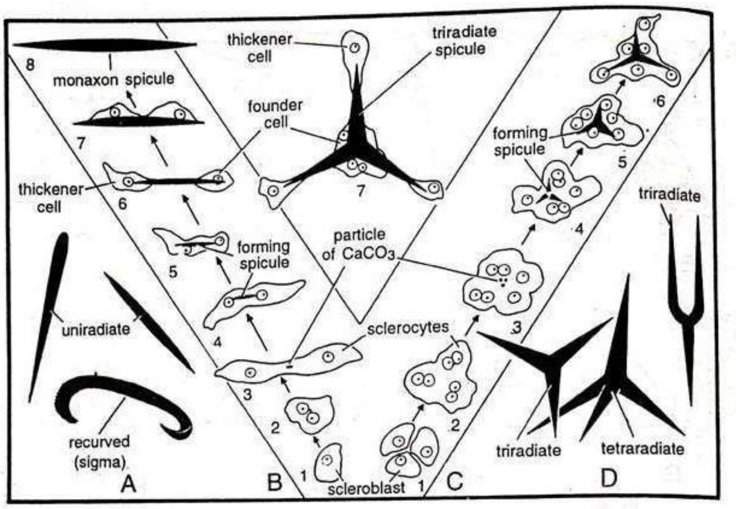


Fig. 10. Scypha. Structure and development of spicules. A – Kinds of monaxon spicules. B – Development of a monaxon spicule. C – Kinds of triradiate spicules. D – Development of a triradiate spicule.

2. Choanoderm. Choanoderm, constituting the gastral epithelium, is formed of flagellated collar cells or choanocytes (Gr., *choane*, funnel + *kytos*, cell). The cells are oval or rounded and arranged in a loose layer upon the mesenchyme. Each cell contains a single nucleus, one or two contractile vacuoles, food vacuoles, reserve food, blepharoplast, rhizoplast and a single basal granule or kinetosome from which originates a long, whip-like flagellum. The flagellum is somewhat stiff towards the base and soft towards the tip. It is surrounded at its base by a cytoplasmic collar.

Electron microscopy has revealed the presence of all the intracellular organelles, such as mitochondria, Golgi bodies, endoplasmic reticulum, ribosomes, etc., in a choanocytes. The collar is shown to be formed by 20 to 30 cytoplasmic processes, the microvilli or tentacles, which are capable of contraction and often jointed together by side connections. The flagellum consists of contractile fibres arranged in the usual 9+2 pattcrn.

3. Mesenchyme. Between pinacoderm and choanoderm lies the interconnecting gelatinous matrix, the mesenchyme (Gr., *mesos*, middle + *enchyme*, iufusion) or mesohyl. It is supposed to be secreted by pinacoderm. It contains a variety of amoeba-like cells, the amoebocytes. These are modified archaeocytes that migrate from one cellular layer and carry on a variety of functions essential to the life of sponge. A few types of amoebocytes found in sponges are as follows:

(a) Archaeocytes. These are undifferentiated embryonic amoebocytes, having blunt pseudopodia and large nucleus with conspicuous nucleolus. They can produce all other types

of cells, needed by the sponge. Such cells are termed totipotent as they give rise to any other kinds of cells within an animal. They also give rise to sex cells, i.e., ova and sperms, and play an important role in regeneration.
(b) Collencytes. Most of the amoebocytes have branching pseudopodia often united into a syncytial network. These cells are collencytes.
(c) Chromocytes. These are pigmented amoebocytes with lobose pseudopodia.
(d) Thesocytes. These have lobose pseudopodia and are filled with food reserves thus acting as storage cells.
(e) Myocytes. These arc fusiform contractile muscle cells present around ostia, oscula and other openings. These form a sphincter which regulates the size of these openings.
(f) Scleroblasts. These manufacture the spicules and according to the nature product are known as calcoblasts, silicoblasts and spongioblasts.
(g) Gland cells. These are attached to the body surface by long strands and secrete slime.
(h) Germ cells. Ova and sperms of sponges differentiate from amoebocytes (archaeocytes), though in some cases they have been stated to be modified choanocytes.

Skeleton

Embedded in mesenchyme are found a large number of minute, crystalline, calcareous bodies called spicules (L., *silica*, point). These constitute the endoskeleton that protects and supports the softer parts of the body. Calcareous spicules arc all megascleres (large spicules).
1. Types and structure of spicules. Spicules in *Scypha* are of two types, monaxon and tetraxon.
(a) Monaxon spicules. These may be uniradiate (monactinal) or biradiate (diactinal) depending on whether they grow in one or both directions along a single axis. They arc slender and straight like, needles, or curved.
(b) Tetraxon spicules. These are also known as tetractines and tetraradiates. Each consists of four rays not the same plane. By loss of one ray, they become triradiate, which are very common.
Three rays and angles may be equal (regular) unequal (sagittal Y-shaped, or T-shaped). Spicules consist very largely of crystal calcium carbonate, but Sollas (1885) showed they were a form of calcite. Qualitative analysis of spicules has shown the presence of magnesium, sulphates, sodium and water addition to calcium carbonate.
2. Development of spicules. Spiculcs are secreted by specialized amoebocycytes known as scleroblasts. According to Minchin (1896, 1898) the scleroblasts are derived from exopinacoderm. A monaxon spicule is formed by two sclerocytes produced by the division of one scleroblast. Outer sclerocyte is referred to as thickener cell and the inner one as founder cell. Thickener cell is responsible for the lengthening of the spicule ray. A triradiate spicule is formed by a group of three scleroblasts, each of which gets divided into two sclerocytes forming a sextet (six cells). A tetraradiate spicule develops like the triradiate spicule and the fourth ray is developed from the junction of the three.

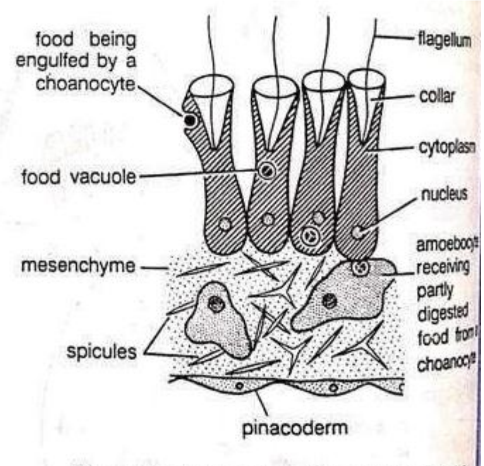


Fig. 11. Scypha. Ingestion of food by choanocytes and its digestion.

3. Arrangement of spicules. In the body of *Scypha*, spicules are oriented in a characteristic way. Long monaxons surround the osculum forming the oscular fringe, while T-shaped sagittals form the oscular rim. Short monaxons lie parallel to radial canals and may project from body surface as bristles. Triradiate spicules mostly lie along the radial canals with one ray facing to outside. Tetra-radiate spicules occur along with the triradiates.

Physiology

1. Movement. *Scypha*, like other sponges, possesses no locomotor organs for moving from one place to another. It is sessile being attached to the substratum. The whole body may show slow contractile movements as its outermost layer of cells, the pinacoderm, is highly contractile. Movements of cells are amoeboid in character rather than muscular.

2. Water circulation. Water is drawn into the canal system through small ostia, present in the pore membranes. Passing through incurrent canals, the water current enters the flagellated radial canals through prosopyles, and the central spongocoel through apopyles, and then !eaves the body through a large opening, the osculum.

Force for water circulation is provided by the beating of flagella of choanocytes which beat in an uncoordinated manner. Beating action of flagellum starts at its base and gradually travels to its tip. Moreover, the beating action is stronger and swifter in one direction (towards the outer side) than in the other.

The rate of flow of water within the body of sponge may be increased or decreased by the enlargement or constriction of ostia and osculum. It has also been reported that water flows at different rates at different points of canal system. The rate of flow is the slowest into radial canals. Water circulation in sponge helps in nutrition, respiration, excretion and reproduction.

3. Nutrition. *Scypha* is a filter feeder, subsisting on minute organisms (plankton) and organic particles. These enter the body with water through ostia which allow the entry of only small particles. Inside flagellated chambers, the beating of flagella of collar cells causes water to circulate through their collars, allowing the food particles to adhere to them. Microvilli of collars act as a filter for trapping food particles which move towards their bases. Consequently, the food particles are engulfed by pseudopodial action of choanocytes at the bases of their collars, and then taken up into food vacuoles.

The phase in food vacuoles is first acidic and then alkaline. Here, the food undergoes partial digestion and partly digested food is passed on to wandering amoebocytes in mesenchyme.

Within amoebocytes, digestion of food is completed and indigestible residue is eliminated with the outgoing current of water. Amoebocytes also distribute the digested food to all other cells of body, while some of them (thesocytes) store some food for future use. A number of enzymes have been isolated from sponges. They include protein, starch and fat-digesting enzymes. Reisning (1971) studied that of the total particles consumed, about 80% consisted of organic matter and 20% consists of bacteria, dinoflagellatcs and other plankton. According to Weissenfel (1976), food particles of 5-50 μ size are phagocyotized by cells lining the inhalant pathways and particles below the size of 5μ arc engulfed by the choanocytes. Amoebocytes `and choanocytes have ability to transfer food particles to other cells and instead of choanocytes, amoebocytes are the main site of digestion.

4. Respiration. Gaseous exchange occurs by simple diffusion between the flowing water and cells of sponge. Oxygen dissolved in water diffuses into cells and brings about oxidation of protoplasmic molecules with the liberation of energy which is entrapped in ATP. The ATP supplies energy to the metabolizing cells.

5. Excretion. Nitrogenous metabolic waste produced in sponges is largely ammonia. No special excretory tissue is present for excreting this to the outer medium. It leaves the body in the outgoing water current by diffusion. Some investigators claim that metabolic wastes are taken up by amoebocytes which discharge them into spongocoel.

6. Nervous system and behaviour. Sponges are devoid of nerve or sensory cells, so that the animal is unable to react to a stimulus as a unified whole. Instead, each cell is sensitive and reacts individually. In the absence of a nervous system, there are no coordinated actions of the whole body. However, they respond directly to certain stimuli. For example, the body may contract when taken out of water and the feeding current may be stopped. The pores and oscula are surrounded by contractile cells, called myocytes, which arc able to close these openings. Power of conductivity is very slight so that reactions to light, touch and chemical, etc, are very slow. Conductivity is best developed at the osculum.

However, O. Tuzet (1953) and M. Pavans de Ceccatty (1955) have attributed a nervous function to collencytes. Some of them, acting as neurons, form a diffuse network connecting the choanocytes with pinacocytes and myocytes. The neurons are supposed to receive and conduct stimuli (Fig.12).

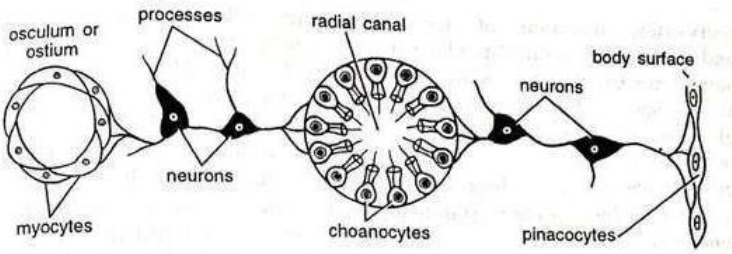


Fig. 12. Probable mechanism of reception and conduction of nerve impulses in a sponge.

Reproduction

Scypha reproduces by asexual as well as sexual methods.

1. Asexual reproduction. Asexual reproduction is accomplished by budding. A outgrowth from the cylinder of sponge aries near its base or attached end to form a bud. As osculum is broken off at its free end. Fully grown bud may remain attached with the parent individual or is detatched to become free and forms a new sponge by fixing itself to the substratum.

2. Sexual reproduction. *Scypha* is a monoecious sponge but due to protogny, only cross-fertilization occurs. Special sex organs are lacking. Male sex cells, or sperms, and female sex cells or ova, are found in mesenchyme. They develop from undifferentiated amoebocytes, called archaeocytes, or from choanocytes.

(a) Spermatogenesis. Sperm mother cell or spermatogonium is said to be an enlarged archaeocyte. However, it is supposed to be a modified choanocyte by Gatenby, who described the transformation of an entire flagellated chamber into spermatozoa. Soon the spermatogonium is surrounded by one or more flattened cover cells to form the spermatocyst. Cover cells are derived either by division of mother cell or from other amoebocytes. Spermatogonium undergoes two or three divisions to form spermatocytes which give rise to spermatozoa. A mature sperm or spermatozoon consists of a rounded nucleated head and a vibratile tail, by the lashing movement of which it moves in water to reach other sponges.

(b) Oogenesis. Egg mother cell or oocyte is derived from a large archaeocyte with a distinct nucleus. This may sometimes arise by transformation of a choanocyte which stores some food, loses its flagellum and sinks into mesenchyme. Oocyte moves like an amoebocyte and grows by engulfing other cells which may amoebocytes or special nurse cells (trophocytes). When full grown, the oocyte undergoes usual two maturation divisions to form the ovum which lies in the wall of a radial canal, ready to be fertilized by a sperm from another sponge.

(c) Fertilization. Fertilization is internal and cross. Sperms from one individual enter other sponges with water current, and the ova are fertilized in situ. Process of fertilization is very remarkable and probably occurs in all the sponges. The spermatozoon enters first a choanocyte or collar cell which lies adjacent to a ripe ovum. It loses its tail and its swollen head becomes surrounded by a capsule. The choanocyte also loses its collar and flagellum and becomes amoeboid. It is now known as the carrier cell or nurse cell. Outer surface of ovum at the point of contact, invaginates so that the carrier cell is received in a conical depression. The capsule containing sperm head now penetrates into the ovum. According to Gatenby and other, carriers cell fuses with ovum. But, according to Duboscq and Tuzet, it simply departs after the transfer of sperm into ovum. Fusion of sperm's head and ovum results in a zygote or egg.

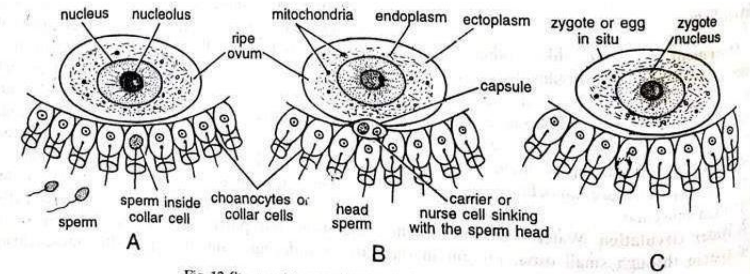


Fig. 13. Stages of fertilization in situ in a calcareous sponge.

Embryogeny or Development

[I] Early embryonic period

1. Cleavage. Fertilized egg begins its development in situ, that is, in the mesenchyme of maternal parent. It undergoes equal and holoblastic cleavage. First truce divisions are vertical, resulting into 8 blastomeres. Fourth division, which is horizontal and unequal, results in the formation of 16 blastomeres in two tiers. 8 cells of lower tier next to parent choanoderm are larger and called macromeres. They are destined to form the pinacoderm. Other 8 cells of upper tier are smaller -and called microrperes. They form the choanoderm. The macromeres remain undivided for the time being but become somewhat rounded. The micromeres undergo rapid mitosis, forming several micromeres that acquire flagella at their inner ends facing the blastocoel. The embryo is now called Nashua with a blastocoel developed between both the tiers. Duboscq and Tuzet have called this stage as stomoblastula.

2. Stomoblastula. One side of stomoblastula is composed of many small, elongated and flagellated micromeres, and the other side is composed of eight rounded and non-flagellated macromeres. The inner cavity or blastocoel communicates to outside through an opening, the mouth, in the centre of macromeres. This mouth is used for engulfing the surrounding amoebocytes for nutrition.

[II] Larval period

1. Amphiblastula. The stomoblastula undergoes a process called inversion, in which it turns itself out through the mouth, as in *Volvox*; so that the flagella of micromeres become directed towards outside. The embryo is now called the amphiblastula (Gr., *amphi*, both + *blastos*, germ), because its one-half bears flagella and the other half does not. The flagellated cells or micromeres are narrow and occupy the greater anterior part. The non-flagellated cells or macromeres are large, eight in number and occupy the posterior part. Amphiblastula does not stay within the maternal mesenchyme. It breaks out into the spongocoel and passes through osculum with the outgoing water to current. It swims freely in water for some time. While swimming, the flagellated pole is directed anteriorly and the force for swimming is supplied by the beating of flagella.

2. Gastrula. Ultimately the amphiblastula settles down and undergoes gastrulation. Now the macromeres multiply more rapidly than micromeres, so that the flagellated half of larva is invaginated into and overgrown by the granular non-flagellated half. The larva now resembles a typical double-walled gastrula with a blastopore at the invaginated side.

[III] Post larval period or metamorphosis

Soon the larva fixes to some substratum by its blastoporal end and lengthens into a cylinder, the free distal end on which opens the osculum. Several small perforations on the wall of cylinder become ostia. Outer non-flagellated granular cells give rise to dermal epithelium or exopinacoderm and to scleroblasts and porocytes. Inner flagellated cells develop into choanoderm and give rise to functional choanocytes, archaeocytes and other amoebocytes. Mesenchyme cells are thus derived from both the embryonic layers. Young *Scypha* now reaches the olynthus stage, which closely resembles a simple ascon sponge. Adult or syconoid stage is derived by the budding of radial canals first at the middle of young sponge which further grows vertically. Flagellated choanocytcs shift into radial canals and body wall further increases in thickness by the growth of middle layer with spicules and canal system. The colony develops by further branching and differentiation.

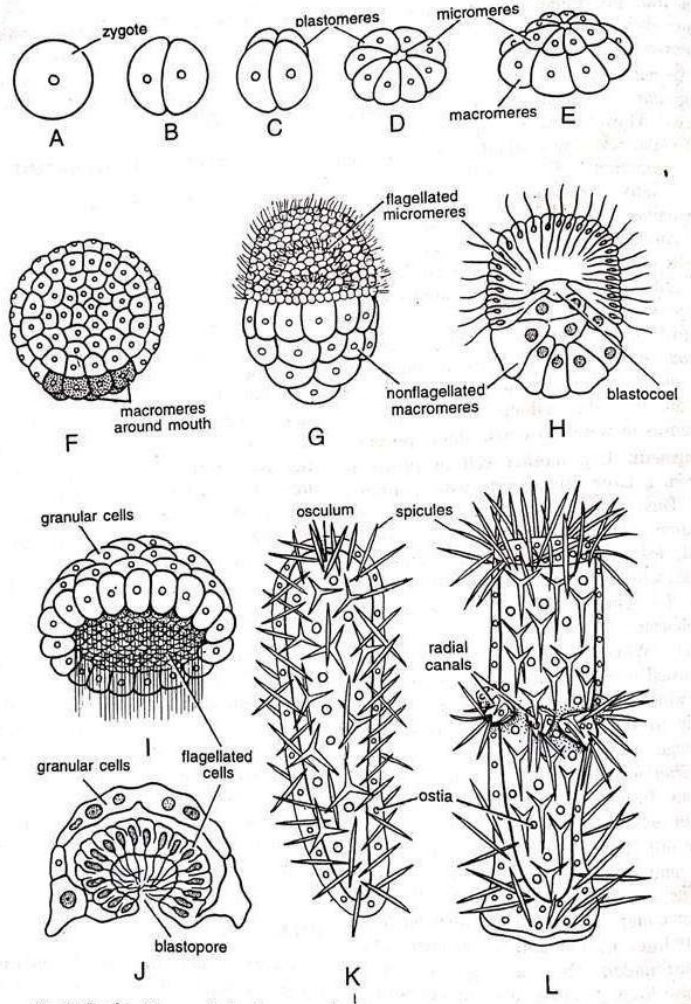


Fig. 14. *Scypha*. Stages of development. A—Zygote. B—2 cell stage. C—4 cell stage. D—8 cell stage. E—16 cell stage. F—Stomoblastula in surface view G—Amphiblastula in surface view. H—Amphiblastula in section. I—Invagination. J—Gastrula in section. K—Olynthus stage. L—Young sponge.

References:

Kotpal RL (2013). Modern Text Book of Zoology: Invertebrates (10th edition). Rastogi Publications, India.