the life cycle with diploid individuals. In such a haplodiploid cycle meiosis does not occur in the formation of gametes but in the formation of haploid spores, from which the haploid individuals arise. The diploid individuals arise from the zygote.

Phylum: PROTOZOA

The Protozoa (first animals) are the simplest and most primitive animals; some of them are even considered as plants. They are mostly microscopic but a few attain a considerable size. They live either singly or in colonies, in the sea, fresh water, and damp soil; some are parasitic. They are usually defined as "unicellular" animals, but actually a protozoon is not a loose cell moving about and equivalent to one of the cells of the more complex Metazoa. It is a complex organism whose protoplasm generally displays but little differentiation into organelles, performing all functions of life. Therefore, they are " acellular " rather than unicellular, that is, their body is not partitioned into cells. Also when they produce gametes the whole body divides to form them. The normal method of nutrition is holozoic. Their unique structure necessitates including them in a separate subkingdom, which comprises only one phylum bearing the same name — Protozoa. They are classified into four classes on the basis of the structures they possess for locomotion: Sarcodina' or Rhizopoda', Mastigophora (or Flagellata', Sporozoa , and Ciliophora.

A. Class: SARCODINA

The class Sarcodina includes forms which move by false feet called pseudopodia, although the gametes and young forms may move by flagella.

1- *Amoeba*

Amoeba lives in freshwater ponds and the backwater of rivers among decaying vegetable matter in which bacteria abound, securing its food from these bacteria and other microscopic organisms. Some species are marine and others live in the soil, while still some others are parasitic. *Amoeba* moves by pseudopodia, reproduces asexually by binary fission, and under unfavorable conditions it encysts.

— *Amoeba* is quite irregular in shape; the body changes its shape constantly with the formation and withdrawal of broad irregular processes called **pseudopodia.** The animal usually progresses in the direction of its pseudopodia **(amoeboid movement)** which are also used in searching for and capturing food.

— **The body,** is in the form of a translucent mass of protoplasm distinguishable into an outer thin clear **ectoplasm** (the analogue of the skin), and an inner granuular more fluid mass, the **endoplasm.**

— **In the endoplasm,** distinguish: **food vacuoles** with micro-organisms on which *Amoeba* feeds **(intracellular digestion); nucleus,** plate - like and more refractive than the rest of the endoplasm, with an **endosome** and can better be seen in a stained preparation; **contractile vacuole,** one, sometimes more, as a clear spherical structure filled with a clear fluid which bursts out at regular intervals and reforms, thus ridding off the animal from excess water (**osmoregulator**) and incidentally helps to eliminate carbonaceous and nitrogenous waste products (see figure 7).

2- *Entamoeba*

The species of this genus live mostly as parasites in the alimentary canals of vertebrates. Three of them occur in man : *E. gingivalis* lives in his buccal cavity, *E. coli* in his large intestine, (both of which are harmless, feeding only on bacteria), and *E. hislolytica* (or *E. dysenteriae*) also lives in the large intestine but is a dangerous endoparasite since it feeds on the tissues and blood of its host, causing **amoebic dysentery.** Examine under compound microscope a stained preparation of any of the above mentioned species and note:

Small size of the animal as compared with *Amoeba*, very thin ectoplasm, food particles in the endoplasm, mostly bacteria but blood corpuscles and cell-debris in *E. histolytica*, **no contractile vacuole** (because its protoplasm is isotonic with the medium in which it lives, osmo-regulation being unnecessary), and nucleus with an endosome.

Entamoeba multiplies by binary fission.lt also encysts, the cyst passing with the faeces and transmitted to other individuals. The cyst of *E. coli* contains 8 nuclei, that of *E. histolytica* only 4, but on emergence from the cyst the 4 nuclei divide with the cytoplasm to form 8 little amoebae (see figure 7).

Foraminifera

An order of the Sarcodina is of great importance in building the **oozes** which cover enormous areas of the floor of many seas. This order is the **Foraminifera.** They usually build a calcareous **skeleton** in the form of one-or many-chambered perforated **test** or **shell** through which long thread-like branched pseudopodia protrude. Occasionally the shell is chitinous, siliceous or gelatinous with embedded foreign bodies. The shells of the dead foraminifera are often drifted ashore and constitute a considerable proportion among the sand grains of the sea shore (see figure 7)

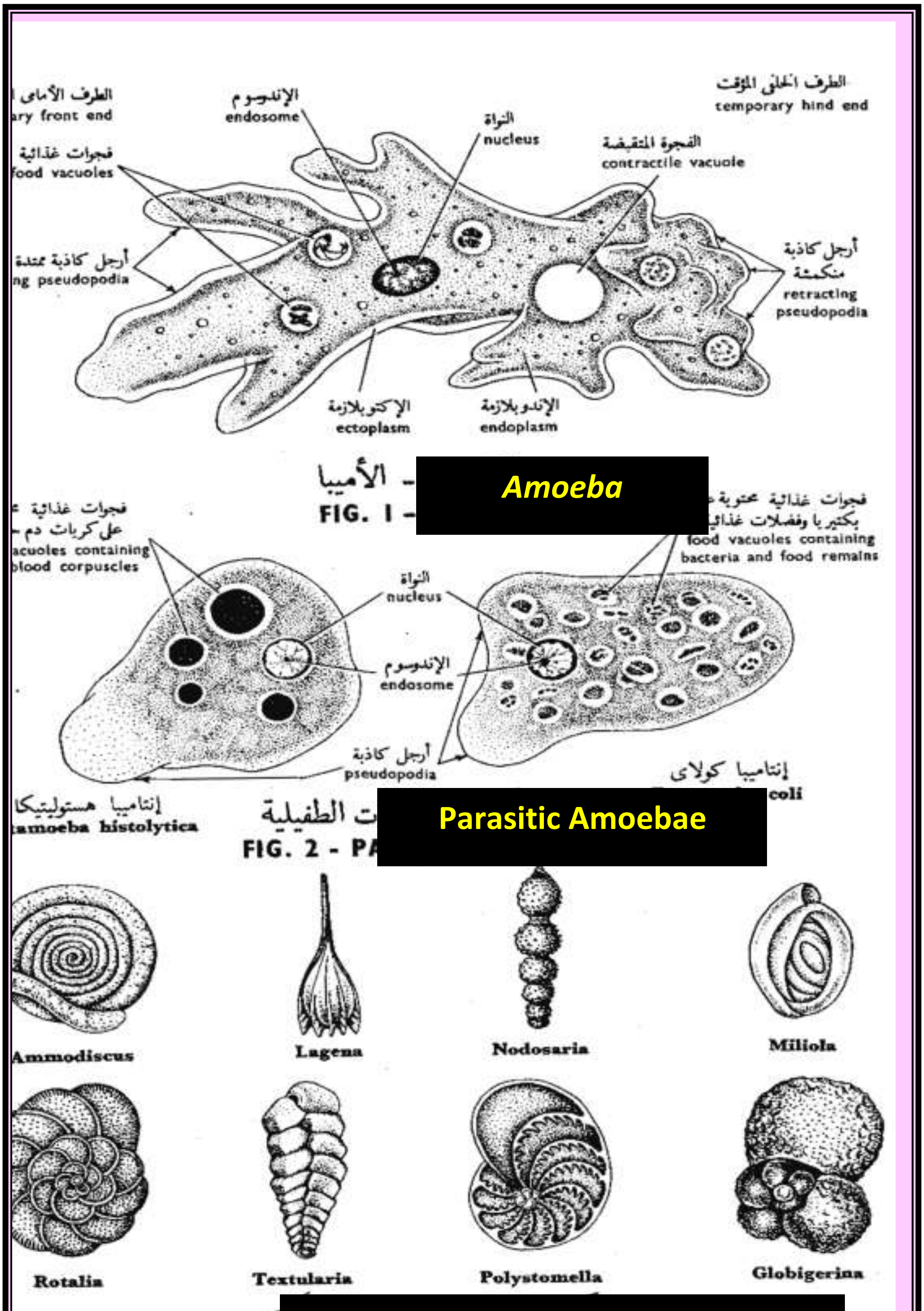


Figure 7: The structure of some species of Sarcodina

B. Class MASTIGOPHORA

This class includes forms which move by **flagella**, either one or more, and have a definite form because of the presence of a firm pellicle (although some may develop pseudopodia). Two subclasses are recognized according to the method of feeding : the **Phytomastigina,** usually feed holophytically, and the **Zoomastigina** are mostly parasitic and holozoic or saprozoic.

1- *E u g l e n a*

Euglena is one of the Phytomastigina which appears in ponds and stagnant water in enormous numbers producing the green coloration of the water. *Euglena* moves by a whip-like process of the ectoplasm called the **flagellum** and by the contraction of its body **(euglenoid movement)** . It is holophytic, although it is able to live as a saprophyte. It reproduces asexually by longitudinal binary fission and is able to form a cyst.

— **General body form,** spindle, pointed posteriorly and with a long flagellum coming out from the blunt anterior end. Movement is by twisting the body spirally, by its contraction and expansion in the direction of movement, and by the flagellum beating right and left.

— **The body** is differentiated into an outer thin **ectoplasm** toughened by an outer firm **pellicle,** and an inner much larger **endoplasm.** This contains numerous **chloroplasts,** or green bodies containing chlorophyll (aids in carbohydrate synthesis), either scattered singly or connected together; **paramylum granules,** which contain a reserve of a starch-like carbohydrate ; **nucleus,** a spherical body with an **endosome; and a stigma or eye-spot** at the anterior end (sensitive to light).

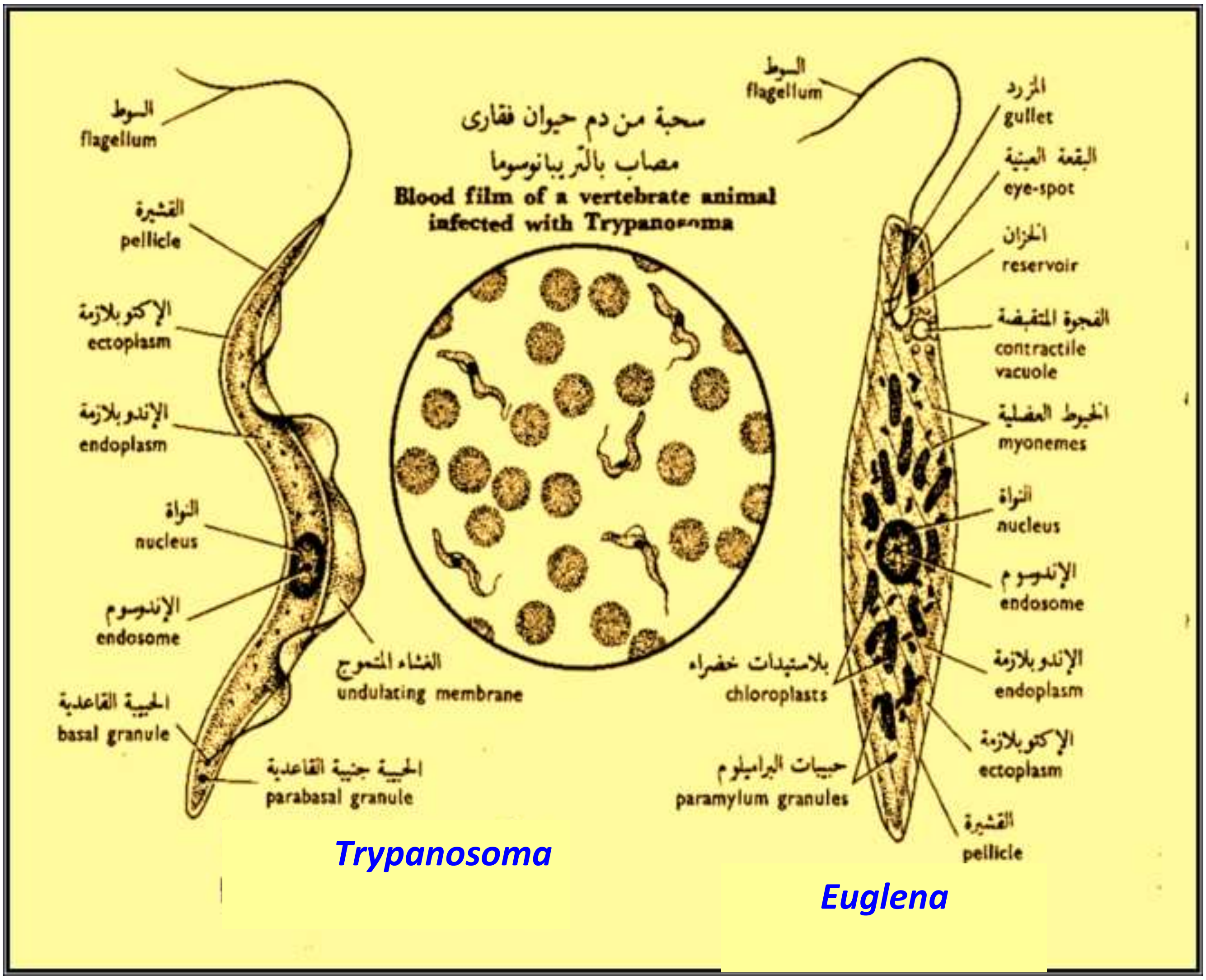
Examine *Euglena*, look for details of structure of the anterior end and note :

— **The gullet or cytopharynx**; the dilated **reservoir** at its base; the long **flagellum** which passes out through the gullet and appears connected at its base to a tiny **basal granule or blepharoplast** embedded in the wall of the reservoir; the second but very short flagellum which arises close to the first and connects with a second basal granule; the complex **contractile vacuole** which comprises a main central vacuole and a circle of small accessory ones (see figure 8).

— Why is *Euglena* included among animals ?

2- *Trypanosoma*

Trypanosomes are flagellates of distinctly animal nature and belong to the subclass Zoomastigina. They usually live in two hosts, an invertebrate, either insect or leech, and a vertebrate host. In the former, they usually infest the alimentary canal while in the latter they live in the blood (see figure 8).



syngamy and have no locomotory structures, but may be amoeboid and their gametes and young forms may develop flagella.

1- *Monocystis*

There are several species of this genus which live as parasites in the seminal vesicles of earthworms. The feeding stage, the **trophozoites,** lie in the centre of the sperm morulae formed of the sperm-mother cells of the worm which are developing into spermatozoa. They absorb the nutrient fluid surrounding them. As they feed, they grow transforming ultimately into **gametocytes** which conjugate in pairs and give rise to **gametes** . Gametes from two associated gametocytes unite in pairs to form **zygotes.** Each zygote secretes a resistant cyst, the **pseudonavicella, within** which it divides to produce 8 **sporozoites.** The pscudonavicellae (infective stage) either escape through the vasa deferentia to the soil, or are eaten with the worm by a bird through the alimentary canal of which they pass out to the soil unaltered. On reaching the soil, they may be eaten by another worm whose digestive enzymes set free the sporozoites which attack sperm morulae to repeat the life cycle.

— **The trophozoites** appears inside a sperm-morula, first as a small nucleated body and later becomes cigar-shaped surrounded by the tails of the developing spermatozoa which shrivel up as tiny filaments. Notice that the body of the full grown trophozoite is differentiated into a thin outer **ectoplasm** containing longitudinally arranged markings called the **myonemes,** and an inner much larger endoplasm containing a **nucleus** with a dark staining **endosome.** It is capable of wriggling movement by its myonemes **(gregarine movement).**

— **The gametocytes** are full grown trophozoites conjugating in pairs; each pair is surrounded by a thin cyst called the **oocyst or gametocyst.** The nucleus of each gametocyte undergoes multiple division **(schizogony)** giving rise to about 64 nuclei, each of which becomes surrounded by a small amount of cytoplasm, thus giving rise to the gametes; a small amount of cytoplasm, the **residual cytoplasm,** remains in the middle, while the gametes are then set free inside the gametocyst and fuse in pairs giving rise to the **zygotes** (**sporoblasts).**

— **The sporozoites.**

Each zygote secretes a cyst called **pseudonavicella** because of its resemblance to the diatom *Navicella,* meaning boat-like case, and *pseudo,* meaning false. The zygote divides within its cyst three successive times **(sporogony)** giving rise to 8 sporozoites which will repeat the life cycle (see figure 9).

— The life-cycle of *Monocystis* manifests the phenomenon known as "alternation of generations".

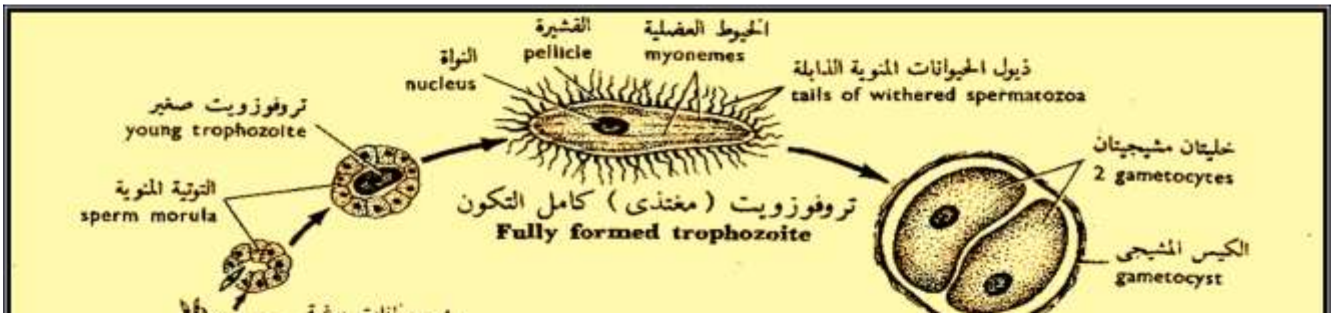


Figure 9: Life cycle of *Monocystis*

2. *Plasmodium*

This is again a sporozoan like *Monocystis.,* but differs from it in the facts that its trophozoites live *intracellularly* in the blood corpuscles of its vertebrate host, that the male and female gametes are different, the zygote is motile and the sporozoites are naked.

Plasmodium causes malaria fever to man, and is transmitted from the patient to an uninfected person through the agency of a mosquito belonging to the genus *Anopheles.* Three species of *Plasmodium* are known to infect man : *P. vivax* which causes benign tertian malaria, *P. falciparum* causes malignant tertian malaria, and *P. malarias* causes quartan malaria.

Three phases or cycles are known in the life-history of *plasmodium* a sexual cycle which begins in man and is continued in the mosquito, an asexual cycle (sporogony) in the mosquito, and another asexual cycle (schizogony) in the hepatic cells and erythrocytes of man (see figure 10):

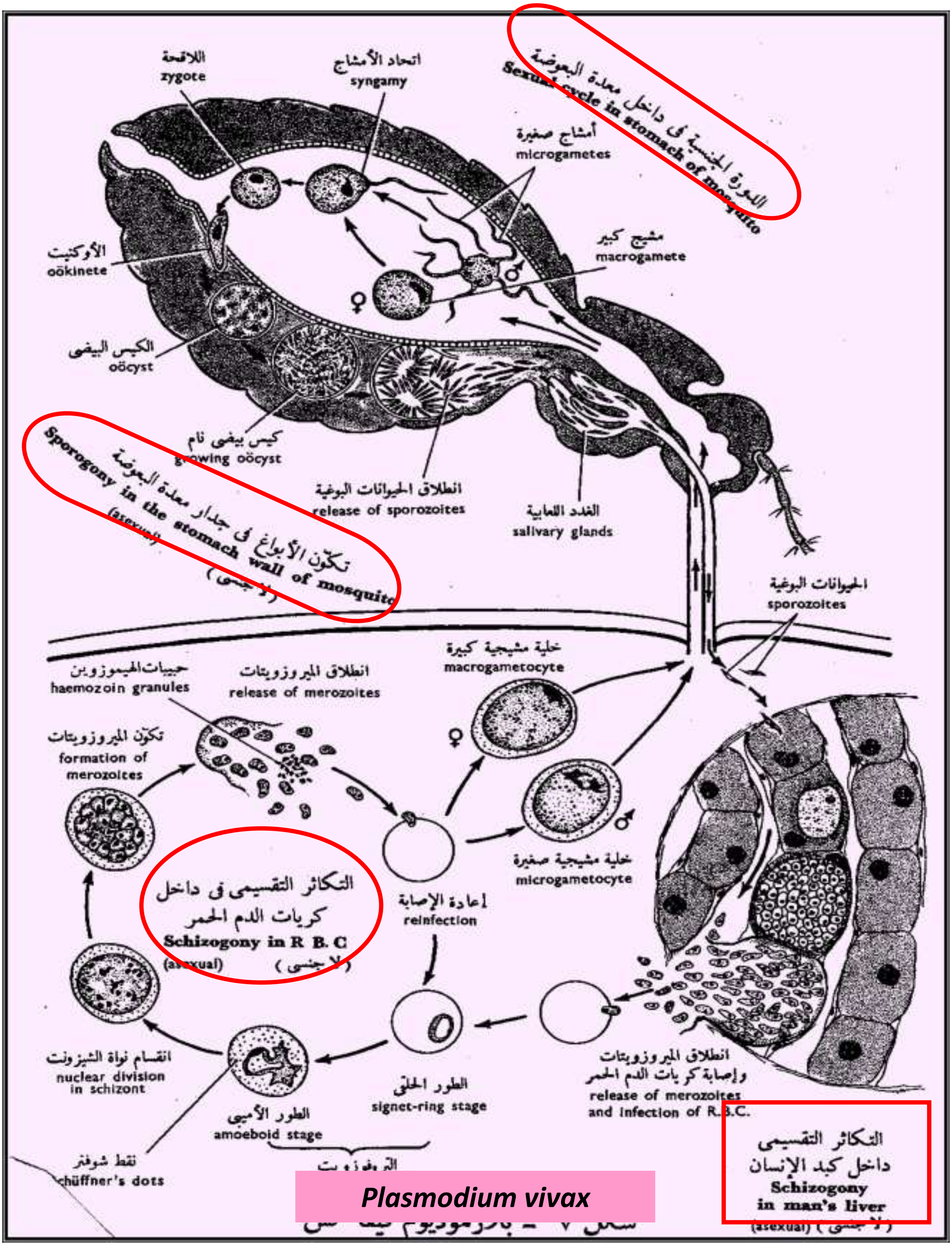
a) In man's liver *:* **sporozoite,** sickle-shaped, in the hepatic cells; **schizont,** rounded and divides **(schizogony)** into about 1000 **merozoites** which are released into the hepatic sinusoids. The merozoites may reinfect hepatic cells or pass into the general circulation.

b) In man's blood *:* **trophozoites,** which are the result of growth of the merozoites inside the red blood corpuscles. A trophozoite is at first disc-like then becomes ring-shaped when a vacuole appears in its middle **(signet-ring stage),** and at last it develops pseudopodia and acquires an amoeboid from **(amoeboid** stage). It then rounds up, enlarges, and upon reaching the optimum size for division it is called a **schizont.** Meanwhile **haemozoin granules** appear in its cytoplasm. The schizont divides by multiple fission or **schizogony** into a limited number of **merozoites** and the blood corpuscle bursts liberating the merozoites and haemozoin granules into the blood. The merozoites attack new red cells to repeat the schizogonic cycle again and again.

Some of the merozoites, however, develop into gametocytes of two types : **macrogametocytes** with small peripheral nuclei and dense cytoplasm loaded with reserve food material, and **microgametocytes** with larger eccentric nuclei and lighter cytoplasm.

c) In mosquito *:* the macrogametocyte is transformed into a single **macrogamete.** The nucleus of the microgametocyte divides into a variable number of nuclei depending on the species, the cytoplasm surrounds each nucleus, giving rise to a number of **microgametes** which are elongate and much smaller than the megagamete. Syngamy occurs and the **zygotes** are formed. The zygote, known then as the **ookinete,** becomes elongate and moves in an amoeboid fashion working out its way through the wall of the stomach to rest between its epithelium and the subepithelial layer. There, it forms a cyst, the **oocyst,** and grows considerably in size. Eventually the nucleus divides by multiple division giving rise to numerous **sporozoites;** this phase of asexual multiplication is called **sporogony. The** sporozoites escape by rupture of the oocyst and reach the salivary glands of the mosquito, whence they are ready to repeat the life-history in man if he is bitten by the infected mosquito.

— In what respects does *Plasmodium* resemble or differ from *Monocystis* ?



Plasmodium vivax

1- *Paramecium*

Several species of *Paramecium* occur in freshwater ponds where decaying organic matter is abundant, feeding on it and on bacteria and other microorganisms. *Paramecium* reproduces asexually by **transverse binary fission,** and sexually by **conjugation** in which a temporary union occurs between two individuals for the purpose of exchanging their nuclear material. After complex nuclear divisions, 8 new paramecia are developed which are full of vigor and can produce better generations. It reproduces sexually also by **autogamy** or self-fertilization.

Examine *Paramecium* (figure 11)and notice its comparatively large size, and slipper shape with a broad anterior end and a more pointed posterior one. *Paramecium,* while moving, rotates on itself in a spiral way, and that on its ventral side there is an oral groove which leads inwards to the mouth.

-The ectoplasm and **endoplasm, food vacuoles, contractile vacuoles oral groove** on the right side of the anterior edge. It leads to a channel-like **vestibule** that extends diagonally across the animal and ends with the **mouth or cytostome. This** opens into the **gullet or cytopharynx** which is a mere cleft in the endoplasm. Note the numerous **cilia** covering the whole surface of the body. They resemble flagella but are much shorter and greater in number. The cilia in the vestibule are somewhat longer, denser, arranged in rows and almost adhere sidewise so as to form something like a membrane whose wave-like undulations (so erroneously described as an **undulating membrane**) help to propel food into the gullet.

— **In the ectoplasm,** distinguish 4 zones : The outermost is a firm **pellicle** with a characteristic surface pattern of **hexagonal depressions,** from each of which comes out a cilium. Below it lie the **basal granules or kinetosomes** of the cilia arranged in longitudinal rows. The granules of each row are connected to a composite fiber or **kinetodesma** (contractile myoneme). A third zone contains spindle-shaped **trichocysts** arranged perpendicular to the surface (defensive and adhesive in function). The innermost zone contains **two contractile vacuoles,** one anterior and the other posterior. the vacuole distends and discharges its contents on to the surface of the body.

— Identify **in the endoplasm,** in the stained preparation, two nuclei: a large oval **mega-or macro-nucleus** (concerned with vegetative functions), and a small **micronucleus** (concerned with reproduction) situated alongside with the former.

2- Vorticella

This is again one of the common ciliates in ponds where it attaches itself to plants (sedentary) .The cilia are concentrated in the adoral area, and an undulating membrane is formed.

— **General body form,** bell-like with a stalk at the base, which can be straightened out or shortened by spiral coiling. The free end of the body, or **disc,** is surrounded by long **cilia,** and on one side of it the **vestibule** opens. the cilia are inserted in a groove, the, **peristome,** which lies between the sides of the disc and the edge of the bell called the **collar.**

— **The vestibule** leads into a short gullet, and contains rows of adherent cilia forming an **undulating membrane.**

— **The ectoplasm** covers the body, bears no cilia other than those described above, and contains no trichocysts but only **myonemes** especially visible in the stalk. There is a single **contractile vacuole** close to the vestibule. It discharges into a **reservoir** opening into the vestibule.

— **The endoplasm has a macro- and a micro-nucleus,** and **food vacuoles.** The undigested food is also passed into the vestibule through a **temporary anus** (figure 12).

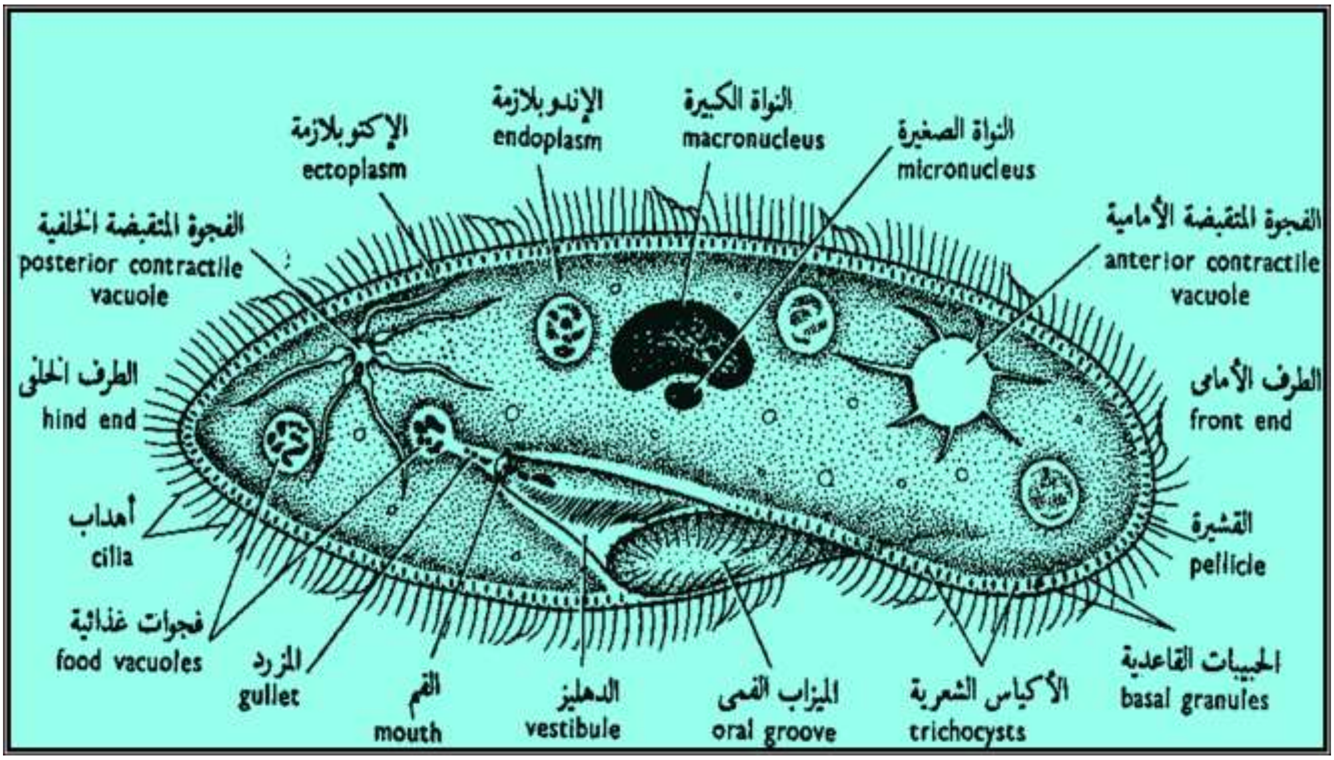
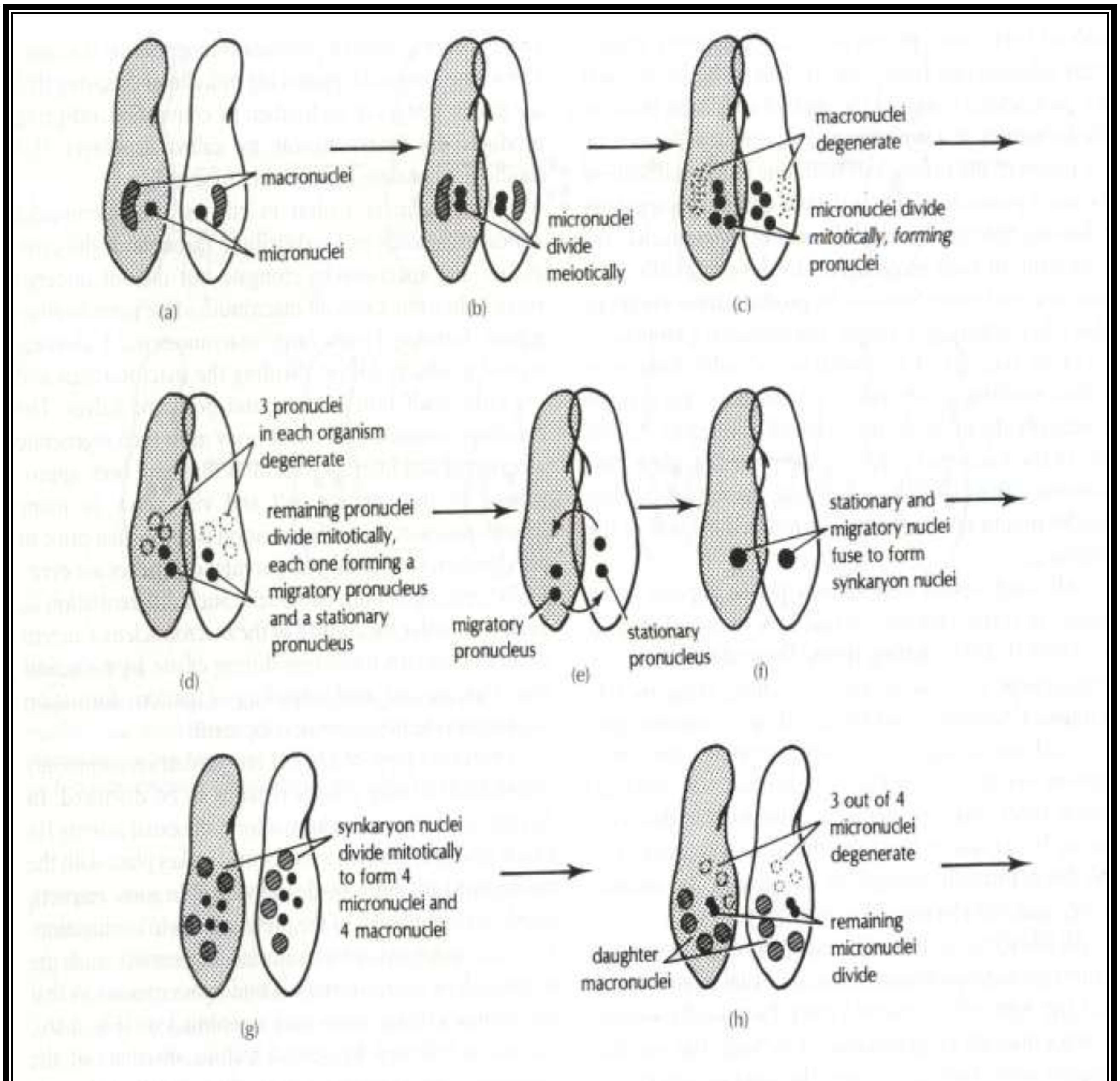


Figure 12: The structure of *Vorticella*



Phylum PORIFERA

The exact position of sponges has till recently been unknown. They were once included as plants, largely because they are sedentary and do not possess a nervous system. Later on., they were included in the animal kingdom with the subkingdom Metazoa. However, sponges show a special low grade of organization unknown among all other Metazoa. Although they are cellular animals (composed of many cells), yet the cells are far less specialized and less dependent upon one another (i.e. they hardly form tissues) than the cells of other Metazoa. Sponges have, thus, been set aside as a separate subkingdom under the name **Parazoa,** which includes only one phylum, the **Porifera.** The Porifera are asymmetrical or radially symmetrical, aquatic (mostly marine) "The Porifera are purely aquatic; they cannot live on land" , sedentary animals, but have a ciliated larva. The body is perforated by numerous **pores** serving for the ingress and egress of water, with a single body cavity (the **paragaster)** lined with peculiar collared cells, and usually with an internal skeleton of various material. Besides having no nervous system or sensory cells, sponges possess no mouth, proper tissues or organs; the cells of the body are capable of de-different-iation, that is, reverting to an undifferentiated condition, but they may then different-iate again into any type of cell found in the body.

Three types of sponges are known, the ascon, sycon and leucon types, according to the structural complexity of the body, the first being the simplest.

A — THE ASCON TYPE (*Leucosolenia*)

Leucosolenia is a simple sponge which grows on rocks near the sea shore in the form of colonies. It has a skeleton of calcium carbonate, deposited mostly in the form of **triradiate spicules.**

a) **External features.**

— **General form of colony,** with numerous horizontal branches over which sprout many vase-shaped individuals, each with a single large opening at its free end, the **osculum.**

— **The body wall** is thin, transparent, perforated by many **tiny inhalant pores or ostia,** and supported by numerous **triradiate spicules** which lie in the wall with two rays towards the osculum and one away from it.

In live specimens, a continuous current of water passes in through the ostia, and out through the osculum.

b) **Internal Structure.**

— **The body wall** is simple, very thin and formed of two layers: i)The **dermal layer,**

which lies to the outside, is formed of an outer layer of flattened covering cells or **pinacocytes,** and an inner skeletogenous layer of numerous scattered cells embedded in a non-living gelatinous matrix. Of these cells note :

— **The scleroblasts** are the most numerous of all, and secrete needle - like **calcareous spicules** in their protoplasm.

— **The amoebocytes** are large wandering cells which can develop into any of the more specialized cells in the body.

—The **porocytes** are tubular cells each of which is pierced by a small central tube that acts as a **pore.**

ii) The **gastral layer,** which lies to the inside, lining the whole of the paragastral cavity, is composed of a single layer of collared flagellate cells or **choaaocytes.** The cells stand side by side, do not touch, and the free end of each cell bears a single **flagellum** encircled at its base by a delicate, contractile, protoplasmic **collar.**

B - THE SYCON TYPE *(S y con)*

Sycon is a sponge of more complexity than *Leucosolenia.* It is a solitary sponge that lives attached to rocks near the sea shore and possesses a skeleton of calcareous spicules.

a) External Features

— **General body form,** vase-shaped, with a large osculum at the free end, encircled by a fringe of large straight monoaxonic spicules. Buds may be seen arising near the base.

— **The body wall** is thick and perforated by numerous ostia, with spicules projecting around them giving the animal a bristly appearance.

b) Internal Structure

—**The paragastric cavity** is large and lined with ordinary pinacocytes, not collared cells.

— **The body wall** has essentially the same structure as that seen in *Leucosolenia* but regularly thrown up into numerous radial, thimble-shaped **flagellated chambers (radial canal)** which are lined with collared cells, open into the paragastric cavity, and their walls are pierced by numerous pores(of porocytes). **Inhalant canals,** lined with pinacocytes, run between the chambers and open on the surface by minute **ostia.** In live specimens, water enters by these ostia into the inhalant canals, passes through the pores into the flagellated chambers **(**radial canal**)**, leaves the latter to the paragastric cavity, and finally passes out through the osculum.

c) The Skeleton

Their is **monoaxonic and triradiate spicules.**

e) The Amphiblastula Larva

Besides reproducing asexually by **budding**, sponges also reproduce sexually by the formation of **germ cells**. These are developed from the **amoebocytes**. Fertilization is followed by cleavage, then a peculiar larva is formed, **the amphiblastula larva**. This is oval in shape, with one half covered by **small flagellated cells,** and the other half by larger **granular** cells. After swimming freely for some time, the amphiblastula settles down to develop into the sedentary motionless adult sponge.

C-THE LEUCON TYPE

The Bath Sponge

Euspongia

The bath sponge, like the vast majority of sponges, belongs to the leucon or the most complex type of sponges in which there is a further increase in the folding of the body wall that results in the formation of a very complex system of canals, the evagination of the choanocyte layer into innumerable small rounded chambers, and the great obstruction of the paragastric cavity. The numerous minute ostia scattered on the surface lead into extensive **subdermal cavities** and **branching inhalant canals** which open into spherical **flagellated chambers.** Larger **exhalant canals** lead out from the flagellated chamber and collect to form a somewhat branched and comparatively small **paragastric cavity,** that opens to the surface by several **oscula.** Different species of *Euspongia* live on rocky sea bottoms fixed to the substratum by a secretion of **spongin,** a horny substance of which the skeleton is formed.

The shape of dried specimen of *Euspongia* is roughly spherical, encrusting or cup-shaped according to species. The skeleton is composed of a complex network of **spongin fibres.** There are some large openings on the surface, the **oscula.** The other smaller openings are the **ostia.**

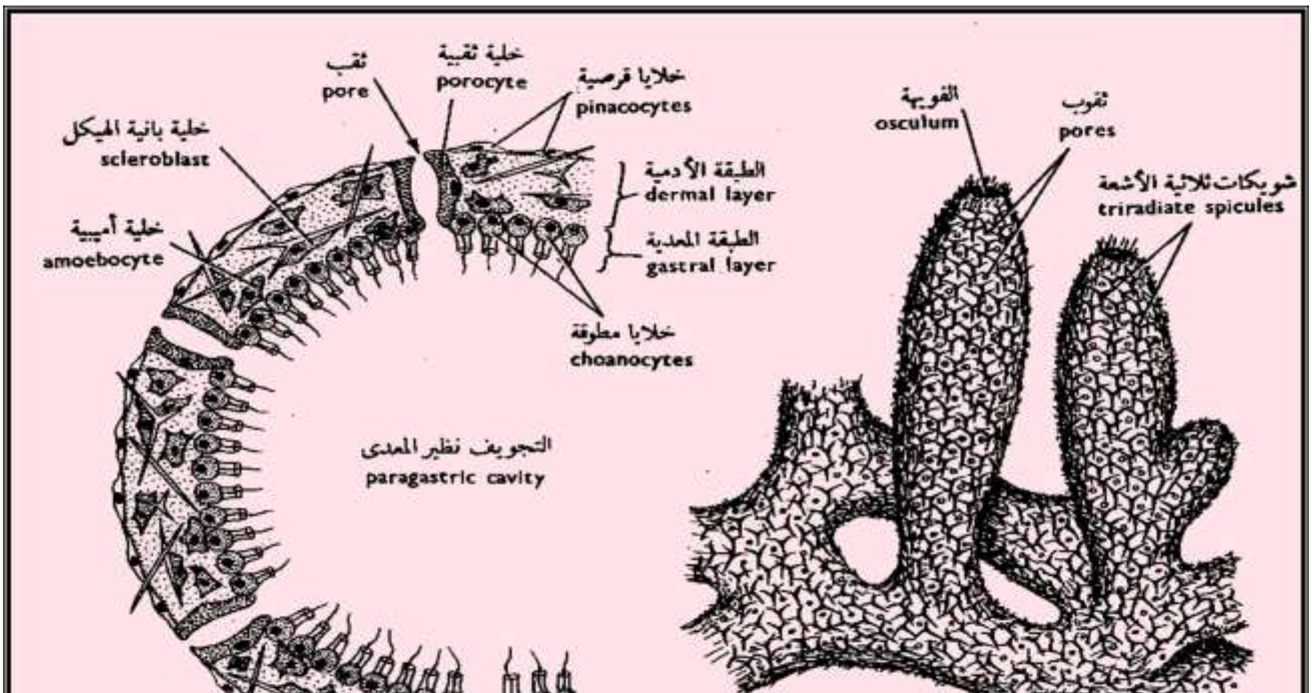


Figure 14: Ascon, Sycon, Lucon types structure

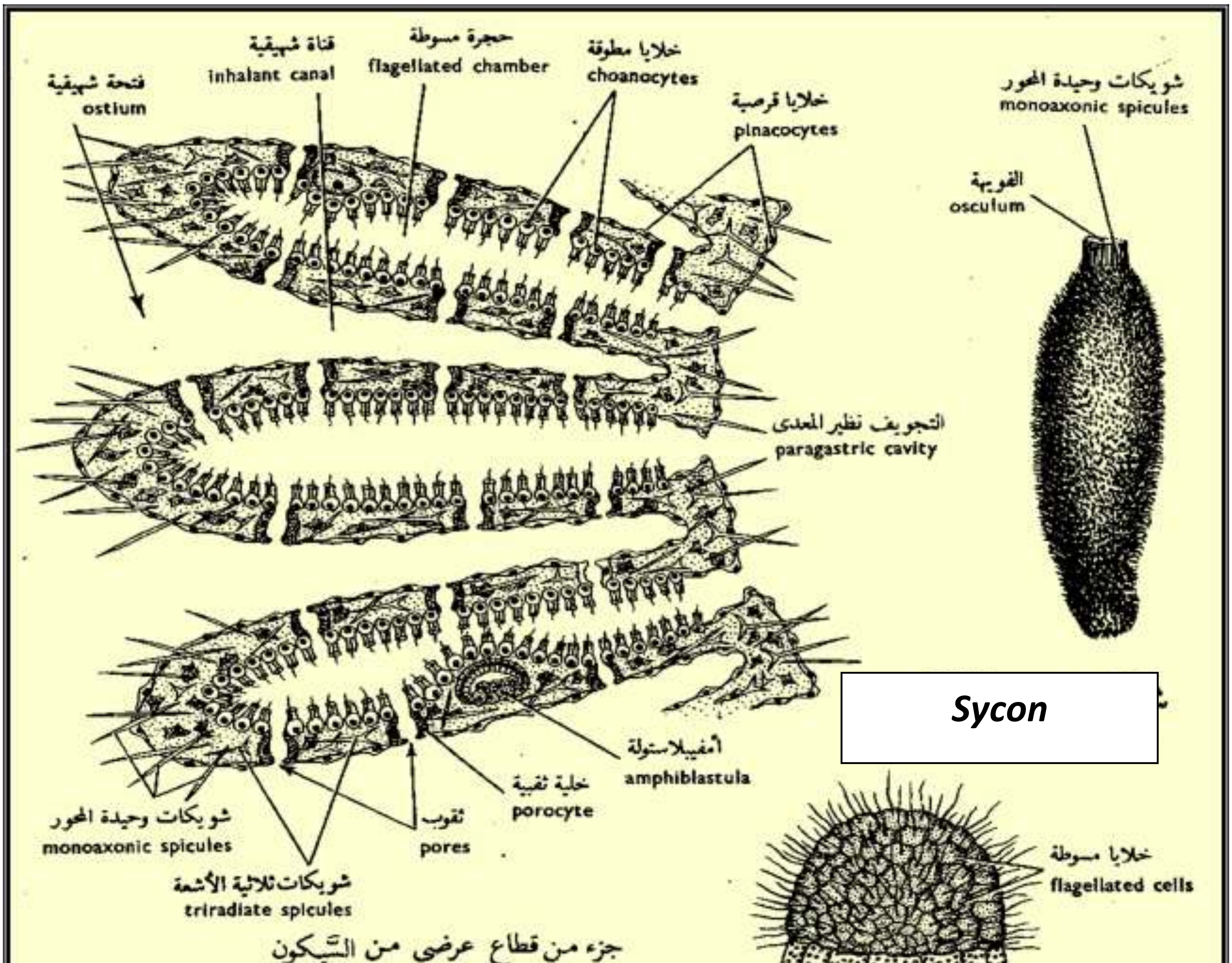


Figure 15: Sycon type structure, Amphiblastula, and spicules

The classes of sponges:

Class Calcarea

Members of this class, known as calcareous sponges, are distinctive in having spicules composed of calcium carbonate. All the spicules are of the same general size and are monaxons or three or four pronged; they are usually separate, Spongin fibers are absent. All three grades of structure, asconoid, syconoid, and leuconoid, are encountered. Many Calcarea are drab, although brilliant yellow, red, and lavender species are known. They are not as large as species of other classes; most are less than 10 cm in height. Species of calcareous sponges exist throughout the oceans of the world, but most are restricted to relatively shallow coastal waters. Genera such as *Leucosolenia*, *Sycon* and *Grantia* are commonly studied examples of asconoid, syconoid and leuconoid sponges respectively .

Class Hexactinellida

Representatives of this class are commonly known as glass sponges. The name Hexactinellida is derived from the fact that the spicules include a triaxons with six points.

The shape is usually cup, vase, or urnlike, and they average 10 to 30 cm in height. The coloring in most of these sponges is pale. There is a well-developed spongocoel, and the single osculum is sometimes covered by a sieve plate—a gratelike covering formed from fused spicules. Basal tufts of spicule fibers implanted in sand or sediments adapt many species for living on soft bottoms.

The surfaces exposed to water are covered not by pinacoderm but by a framework of syncytial strands through which long spicules may project. Another syncytium, containing flagella with collars, lines the flagellated chambers. The flagellated chambers are commonly thimble-shaped and oriented at right angles in parallel planes to the body wall and central spongocoel. Hexactinellids appear superficially to be somewhat **syconoid** in structure. However, there is nothing comparable to syconoid incurrent canals; In contrast to the Calcarea, the Hexactinellida are chiefly **deepwater sponges..**

Species of *Euplectella,* Venus's flower basket display an interesting commensal relationship **with** certain species of shrimp *(Spongicola).* A young male and a young female shrimp enter the spongocoel where they grow and cannot escape through the sieve plate covering the osculum. Thus their entire life :-spent within the sponge, where they feed on plankton. brought in by the sponge's water currents. A spider crab *(Chorilla)* and an isopod *(Aega)* are also found as commensals with some species of *Euplectella.*

Class Demospongiae

This large class contains 90% of sponge species These sponges range in distribution from shallow water to great depths. Coloration is frequently brilliant because of pigment granules located in the amebocytes.. The skeleton of this class is variable, may consist of siliceous spicules or spongin fibers or a combination of both. The genus *Oscarella* is unique in lacking both a spongin and a spicule skeleton. These Demospongiae with siliceous skeletons differ from the Hexactinellida in that their larger spicule are monoaxons or tetraxons, **never triaxons (hexactines)**.

All Demospongiae are leuconoid, and the majority are irregular. Some are encrusting; some have an upright branching habit or form irregular mounds; others are string-like or foliaceous. There are also species, such as *Poterion*. that are goblet- or urn-shaped, and others, such as *Callyspongia*, that are tubular. The great variation in the shapes of members of the Demospongiae reflects, in part, adaptations to limitation of space, inclination of substrate, and current **velocity.**

Regeneration and Reproduction

Many sponges have remarkable powers of regeneration. Regeneration was employed in the propagation of commercial sponges in overfished areas off the Florida coast. Pieces of sponge called cuttings were attached to cement blocks and dumped into the water. Regeneration and several years[1] growth produced a sponge of marketable size. The classic experiment demonstrating the regenerative ability of sponges involves forcing living sponge tissue through a silk mesh. The separated cells quickly reorganize by progressive association of similar cells bounded by pinacocytes, forming themselves into several new sponges. Archeocytcs are essential for reaggregation, as is a minimum number of cells. Calcium and magnesium ions plus some cell surface macromolecules are also necessary for reaggregation. Whether successful reaggregation will occur only with dissociated cells from the same species is still being debated. If an individual of certain sponges, for instance, *Tethya*, is sliced, and a piece from another sponge of the same species is inserted into the wound, host and graft grow together in a short time. In contrast, the host rejects a graft from a different species. There are also certain sponges, such as species of *Halichondria* and the freshwater *Spongilla*, in which developing individuals, following dense larval settlement, fuse and form sponges that are genetic mosaics. On the other hand, grafting experiments with the tropical *Callyspongia diffusa* indicate immunocompetence in some sponges, that is, the species distinguishes self from nonself: an individual accepts grafts that come from itself but rejects those from other members of the same species.

Asexual reproduction by the formation of buds that are liberated from the parent is not common in sponges, although it does occur in some species. Somewhat different from budding is the formation and release of packets of essential cells. Spongillid sponges, as well as some marine species, have such aggregates called **gemmules**. In freshwater sponges, a mass of food-filled archeocytes becomes surrounded by other amebocytes (spongo-cytes) that deposit a hard covering composed of a material similar to spongin. Spicules are also incorporated, so that a thick resistant shell is formed. Gemmule formation takes place primarily in the fall when a large number of these bodies is formed by each sponge. With the onset of winter, the parent sponge disintegrates. The gemmules are able to withstand freezing and drying and thus are able to carry the species through the winter. In spring the interior cells undergo some initial development, and the primordium eventually emerges through an opening (**micropyle)** in the shell. The primordium continues development into an adult .sponge and may attain a large biomass by the end of the summer.

Sexual reproduction and the development of sponges display a number of peculiar features. Both hermaphroditic and dioecious sponge species exist, although most are hermaphroditic, usually producing eggs and sperm at different times. The sperm arise from choanocytes. For example, the choanocytes of an entire flagellated chamber lose their collars and flagella and form spermatogonia, which then undergo meiosis. The cluster becomes surrounded by a cellule wall forming a spermatic cyst. Alternatively, a spermatic cyst may be derived from the division of a single sperm-mother cell.

Eggs arise from archcocytes or choanocytes. Eggs generally accumulate their food reserves by engulfing adjacent nurse cells and are usually located within a cluster of surrounding cells. Gamete production appears to be initiated by changes in water temperature, photoperiod, or cellular regression, depending on the species.

Sperm leave the sponge by means of the exhalant water currents and are taken into other sponges in the inhalant stream. Certain tropical sponges have been observed to release their sperm suddenly in great milky clouds, and sudden sperm release may be characteristic of most sponges.

After a sperm has reached a flagellated chamber, it is engulfed by a choanocyte, which transports the sperm to the egg. Both cells lose their flagella. After the carrier with its sperm has reached an egg (which would be close by in the surrounding mesohyl), the carrier either transfers the sperm nucleus or the earner and sperm nucleus are engulfed by the egg. Fertilization thus occurs *in situ.* Only one species of sponge is known to liberate eggs that are then fertilized externally, outside of the sponge body. This is surprising given the wide occurrence of external fertilization in other marine animals.

In the majority of sponges, development to the larval stage takes place within the body of the parent. Among the Demospongiae, however, there are some species that liberate fertilized eggs, which develop in the sea water.

Cleavage is complete and generally radial. Development leads to a larval stage, which displays various degrees of differentiation. The larva is usually at the blastula stage of development. The majority of sponges possess a parenchymella larva, in which monociliated cells cover all of the outer surface, except, often, the posterior pole . Spicules are often present, and the interior of the larva commonly contains most of the cell types found in the adult, with the usual exception of choanocytes. The parenchymella larva breaks out of the mesohyl, exits through the parent's excurrent canal system, and has a brief free-swimming existence.

A few calcareous sponges, such as *Grantia, Sycon,* and *Leucosolenia,* and among the Demospongiae, *Oscarella,* have an amphiblastula larva . This larva is hollow, and one hemisphere is composed of small flagellated cells and the other of large nonflagellated macromeres.

Following settling and attachment by the anterior pole, the sponge larva undergoes an internal reorganization that is comparable to gastrulation in other animals. In the parenchymella, the external flagellated cells lose their flagella and move to the interior, where they regrow flagella and form choanocytes, and interior cells move to the periphery to form pinacocytes. The parenchymella larva of freshwater sponges and some marine species develops choanocytes before leaving the parent sponge. In these species, the external flagellated cells are sloughed off or move to the interior but are then phagocytized by amebocytes. In the hollow amphiblastula larva, reorganization following settling occurs either by epiboly or by invagination, or by both, but the macromeres overgrow the micromeres in other metazoans the macromeres typically become internal. The macromeres in these sponges give rise to the pinacoderm and the micromeres to the choanocytes; both layers produce the amebocytes of the mesohyl. There is nothing equivalent to endoderm in sponges.

In most animals development proceeds from the establishment of gross form (morphogenesis) to the addition of more and more histological detail. However, given the absence of organs, cell differentiation in sponges precedes much of morphogenesis, that is,the attainment of the definitive sponge form. Moreover, there is a great deal of cell mobility and reversal of cell differentiation.

In many of those calcareous sponges having a leuconoid structure, the final stages of development after attachment of the larva are preceded by stages resembling the asconoid and syconoid structures. In other leuconoid sponges, especially the Demospongiae, the leuconoid condition is attained more directly. The first stage is known as a **rhagon** . It resembles either the asconoid or the syconoid structure except that the walls are quite thick. The leuconoid plan develops directly from the rhagon stage by means of the formation of canals and flagellated chambers.

Some marine sponges live only one year; others live many years. Those in temperate regions are usually dormant in the winter. *Microciona* in Long Island Sound, for example, passes the winter in a reduced state, lacking flagellated chambers and other components of the water canal system. With an increase in water temperature, the sponge redevelops the adult functional condition. Freshwater sponges also overwinter in a regressed state or die, releasing gemmules.

Subkingdom

METAZOA

Phylum: Cnidaria (COELENTERATA)

This phylum and all the following phyla belong to the subkingdom Metazoa. The Coelenterata show a distinct advance in structure over the Porifera. Their cells are much more specialized, with a higher coordination than in sponges, maintained by a simple nervous system in the form of a network. Similar cells, therefore, work together to perform a common function, thus beginning to form **"tissues".** In other words, the Coelenterata have reached the "tissue" grade of organization.

They are **radially symmetrical** animals, mostly marine, solitary or colonial and sedentary or free-swimming. They are also **diploblastic,** that is, their body is built up of two cellular layers only, an outer **ectoderm** and an inner **endorderm,** in between them there is **mesogloea** formed of a jelly-like structure, which in some of the higher forms is traversed by migrating cells or crossed by nerve cell processes. There is a single cavity to the body, the **enteron** (coelenteron) or **gastrovascular cavity,** with one opening to the exterior, the **mouth,** which at the same time acts as an anus. They possess peculiar elaborate defensive structures, the **nematocysts,** which may be also used in numbing the prey. Polymorphism, alternation of generations and skeleton formation are common phenomena in this phylum.

The phylum is divided into 3 classes: the **Hydrozoa** including freshwater polyps, small jellyfishes and hydroids; the **Scyphozoa** comprising large jellyfishes, and the **Anthozoa** including the flower-like sea anemones and most of the stony reef-building corals.

A - Class HYDROZOA

The Hydrozoa comprise solitary or colonial forms, some of the latter are reef-building corals. They often show an alternation of asexual hydroid and sexual medusoid generations, although either generation may be reduced or eliminated.

1- *Hy d r a*

This genus belongs to the **order Hydrida,** and is peculiar in being a common inhabitant of fresh water, particularly in ponds and slow streams. The medusoid stage is absent, while the hydroid stage is solitary and sedentary, although capable of detaching itself from the substratum to change place (figure 16).

Hydra is about 4-10 mm in length, and feeds on small crustaceans such as *Daphnia* and *Cyclops, and* some other small animals.

a) External Features.

— **Body form,** cylindrical with a crown of **tentacles** (6-8 in number) on the free end; the other end, at which the body is narrowed, terminates in the **foot or basal disc.** This secretes sticky mucus for adhesion to the substratum.

— **The oral cone or hypostome,** around which the tentacles are arranged. The **mouth** lies in the middle of this cone.

— **The enteron** extends into the tentacles and has one inlet, the mouth, which at the same time acts as an exit.

— **The body wall** is formed of an outer **ectoderm** and an inner **endoderm,** each of them being one cell in thickness, and in between them there is a lamella, the **mesoglea.** This construction continues into the tentacles.

— **The tentacles,** are covered by protuberances, each carrying a **battery of nematoblasts.**

— The buds, not always present, are of different sizes; they are usually connected to the body of the parent. At first small, a bud then grows in size with an extension of the enteron, develops an oral cone and tentacles, and finally separates from the parent to lead an independent life **(asexual reproduction).**

— The gonads, or organs of sexual reproduction, are merely accumulations of cells arising in definite sites on the body. *Hydra* is either **hermaphrodite (monoecious)** developing both types of gonad in the same individual (but testes develop first and then shed, ovaries developing afterwards — **protandrous hermaphrodite), or uni-sexual (dioecious),** that is, the sexes are separate. The **testes** appear as conical swellings near the oral cone, while the **ovaries** are formed about the middle of the body, and their size depends on their maturity.

b) **Structure of Body Layers (Histology).**

(figure 16)

1- In the ectoderm : — The myo- or musculo-epithelial cells, have broad outer ends which meet and form the surface of the body (hence epithelial). They rest by their narrower inner ends on the mesoglea, where they give off **contractile processes** or **muscle tails** which run parallel to the long axis of the body. When these processes contract equally on all sides the body is shortened.

— The interstitial cells

are small, rounded and lie in the interstices between the musculoepithelial cells. They are not differentiated cells and seem to retain the properties of embryonic cells as they may give rise to any of the other kinds of cells, especially the nematoblasts and germ cells.

— The nematoblasts (cnidoblasts)

Peculiar to the coelenterates, are extremely specialized cells for defense and offense. They appear in groups or **batteries,** particularly numerous on the tentacles. Each has an ovoid body and a basal nucleus. Its distal end is exposed to the surface and from it projects a short sensory bristle, the **cnidocil** or trigger. Inside the cell, there is a peculiar stinging structure called the **nematocyst.** Different types of nematocysts are known in *Hydra*, the largest and most important are the **penetrants.** Each is a pear-shaped capsule with a lid or **operculum** on top. It is filled with a fluid and its outer part is tucked in and produced into a long, hollow, capillary **thread,** which lies coiled up in the capsule. The thread is thickened at its base, where it carries a numbers of **stylets** and numerous small **barbs.** When discharged by chemical and tactile stimuli, the thread is shot out turning inside out, penetrates into the tissues of the prey or enemy, and injects a fluid in it that has a paralyzing effect.

— **The nerve cells are** bipolar and multipolar cells which lie at the base of the ectoderm next to the mesoglea. Each gives off a number of branched processes (nerve fibres) which connect with other processes of adjacent cells forming a **nerve-net.**

— **The sensory cells** are narrow columnar cells. Each has a small projection exposed to the surface and is connected at its base with the nerve-net.

— **The reproductive cells** are found in mature individuals only. They arise from the interstitial cells by cell proliferation and form the gonads, either **testes** or **ovaries.**

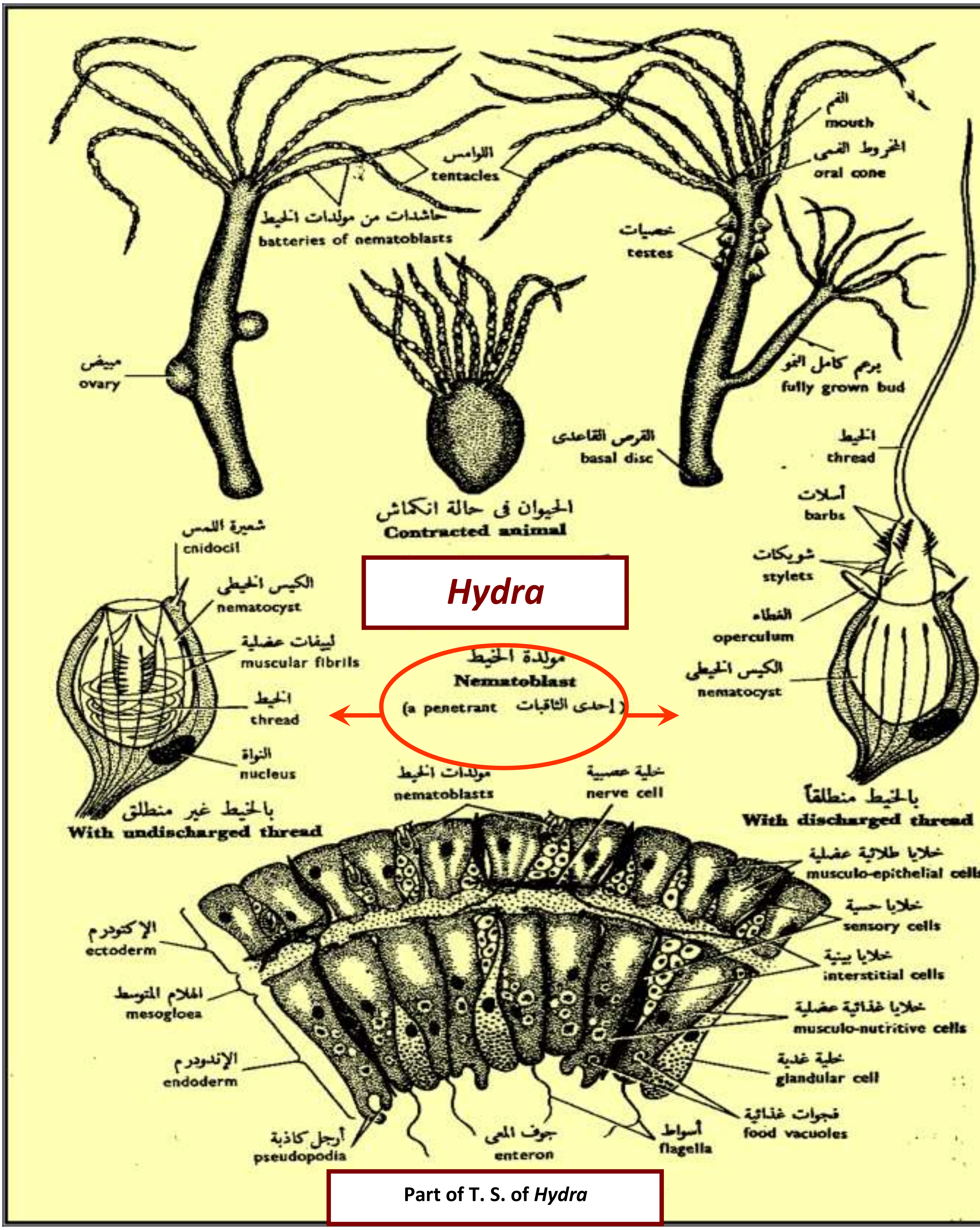
— **The mucous cells** are particularly abundant in the basal disc.

2- **In the endoderm :**

— **The nutritive cells or musculo-nutritive cells** are tall columnar cells drawn out at their bases, towards the mesoglea, into **contractile processes** which run parallel to the circumference of the body. Their contraction causes a lengthening of the animal. Some of these cells carry **flagella** (producing a water current) while others thrust out **pseudopodia, and** both contain **food vacuoles** in which some food particles are digested **(intracellular digestion).**

— **The glandular cells** are wedged in between the musculo-nutritive cells. It pours their enzymatic secretion into the enteron**.**

— Among the endodermal cells there are also sparse **interstitial cells** which migrate from the ectoderm as needed, **nerve cells** which form another nerve-net on the inner surface of the mesogloea, few sensory cells, and some **mucous cells** around the mouth, but no nematoblasts.



Calyptoblastea. It is dimorphic, exhibiting two different forms in the life-cycle, a hydroid and a medusoid. The hydroid form is colonial, sedentary and lives attached to weeds and rocks between tidemarks. It reproduces asexually giving the medusoid form. This is solitary, free-swimming and reproduces sexually giving rise to the hydroid form again, the two forms or generations alternating regularly with one another in the life-cycle (figure 17).

a) **The Colony.**

— **The hydrocaulus or** stem has stalked **polyps or zooids** arising in a cymose fashion on both sides of it. It is fixed to the substratum by a branching root-like portion called the **hydrorhiza.** The stem is in the form of a tube, its cavity being the **enteron** which is continuous with that found in the different zooids and through which the nutritive fluid is distributed. The wall of the tube is built also of the same layers as those of the zooids, namely of an outer **ectoderm,** a thin **mesogloea** and an inner **endoderm,** all forming together the **coenosarc.** The ectoderm secretes a horny flexible outer case (exoskeleton) called the **perisarc** which is continuous over the whole colony. The perisarc is annulated at intervals to allow bending.

— **The hydranth,** is the feeding zooid or polyp and is similar to *Hydra* in many respects. It is protected by a cup-shaped structure, the **hydrotheca,** continuous with the perisarc. The hydranth has a prominent **oral cone or hypostome** with a ring of **tentacles** (about 24) in -the centre of which **the mouth** opens. The body wall is built of the ectoderm, mesogloea and endoderm enclosing the enteron, all continuous with those of the stem. However, *the enteron does not project into the tentacles*, the latter being solid (compare with *Hydra*), with a solid central core of endodermal cells, and carry numerous **nematoblasts** on the surface. A circular **shelf** extends inwards from the hydrotheca at the hydranth base as a diaphragm which narrows the opening into the stalk and prevents the passage of large food particles.

— **The blastostyle is** the reproductive polyp which has lost the tentacles, mouth and capacity to feed, and become specialized for asexual reproduction. Each arises as a hollow extension of the coenosarc enclosed in a vase-shaped extension of the perisarc called the **gonotheca,** with a distal aperture. A blastostyle grows at the base of a branch of the stem carrying a hydranth. Along the sides of the blastostyle **medusae -buds** are formed, which on maturity separate off and leave the gonotheca through its aperture to swim freely away from the colony.

b) The Medusa.

— **The general form,** umbrella-like, with the rim fringed with **tentacles** carrying nematoblasts, with a dorsal convex surface, the **exumbrella,** and a ventral concave one, the **subumbrella.** The **manubrium** hangs down from the centre of the subumbrella and bears the **mouth opening** at its free end. A narrow ridge rich in muscle fibrils, the **velum,** projects inwards around the whole edge of the subumbrella.

— **The gastrovascular cavity (enteron).** The mouth leads through the manubrium into a small **gastric cavity** in the centre of the umbrella from which four **radial canals** branch out and join at their outer ends into a **marginal or circular canal.** All these canals are flagellated and carry the food particles from the manubrium, in which digestion begins. The bases of the tentacles are swollen where digestive juices are also secreted.

— **The statocysts,** 8 in number, two in each inter-radial region, attached to the bases of 8 tentacles.

— **The gonads** are 4 in number. The sexes are separate but not externally distingui-shable. Gonads appear as ectodermal swellings, each hanging below a radial canal, and discharge to the outside.

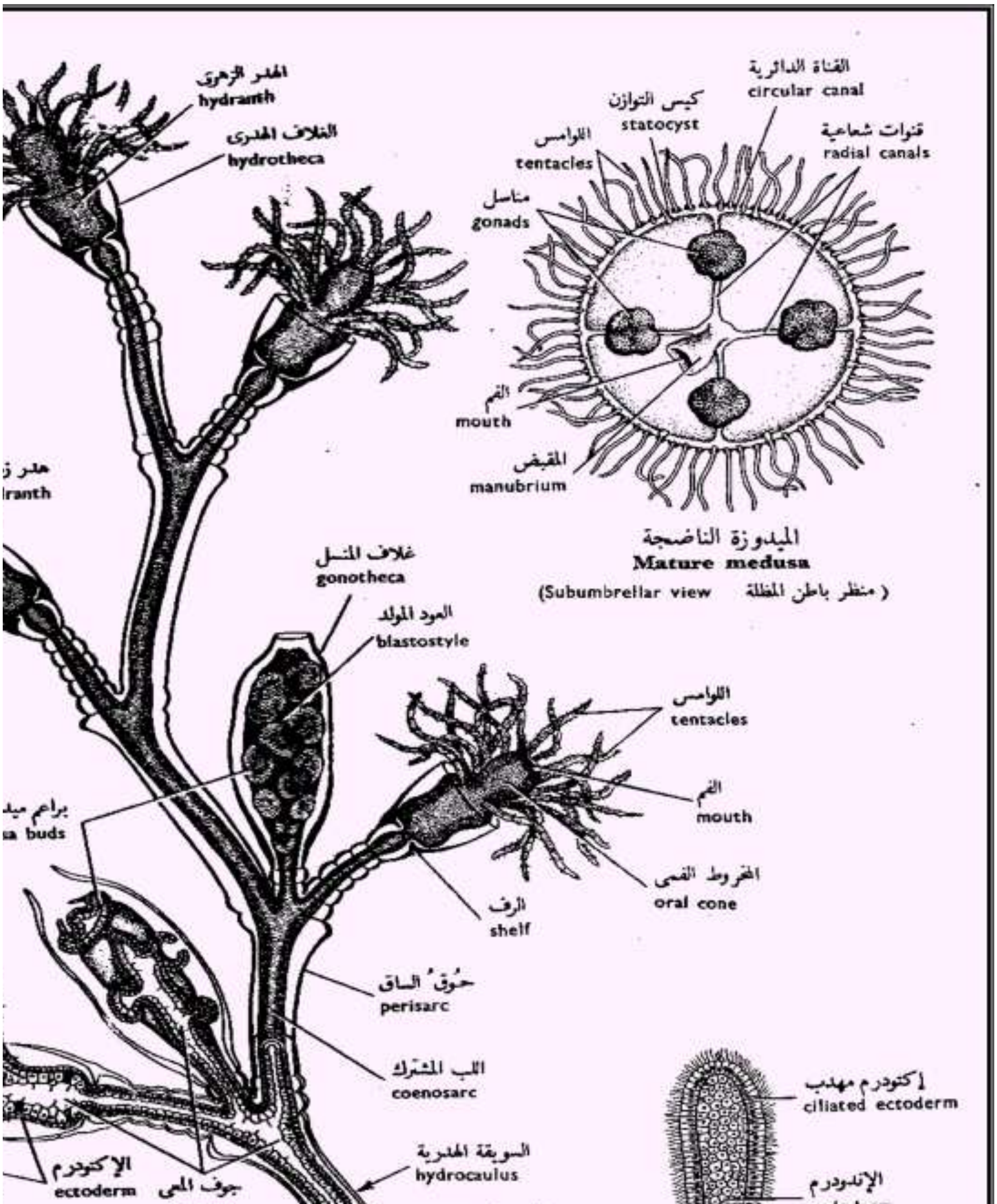


Figure 17: *Obelia* (colony, medusa, planula)

B - Class SCYPHOZOA

This class includes all the larger jellyfishes which are entirely marine animals in which the medusa is the pre dominant phase; the hydroid stage being very much reduced and included in the life-history only as a polypoid larva. Gonads are endodermal and discharge into the enteron. The enteron is divided by ridges into four **gastric pouches** and bears some endodermal tentacles **(gastric filaments).** There is an extensive system of **radial canals.**

A u r e l i a

It is readily recognized by its gelatinous umbrella which is 7-30 cm or more in diameter, and by its 4 pink horse-shoe-shaped gonads which lie near the centre embedded in the jelly (figure 18).

The sexes are separate; fertilization occurs inside the female medusa. A **planula larva** is formed which, after leaving the mother, swims for some time, and then settles down transforming into a polyp known as the **scyphistoma.** This stores food, multiplies asexually and sooner or later it develops a series of horizontal fissions which gradually deepen forming a number of discs, simulating a pile of saucers. The discs separate successively giving rise each to an **ephyra,** which is a small larval medusa (figure 19).

a) **The Medusa**

— **The general form,** umbrella-like but less convex than that of *Obelia.* A very short manubrium hangs from the subumbrella with the four-cornered **mouth** in its centre. The lips at the four corners are greatly elongated forming the **oral lobes** or arms which are deeply grooved and bear nematoblasts along their edges.

— Fringe of numerous short marginal **tentacles** beset with stinging cells (nematoblasts) and set closely together except where they are interrupted by 8 marginal notches, each of which contains a **tentaculocyst** (sensory in function) .

— **The gastro vascular system.** The mouth leads into a small central **gastric cavity** which is extended into four **gastric pouches** (interradial). These contain the gonads, and close inside each gonad ring is a prominent row of **gastric filaments** which carry nematoblasts and digestive gland cells (figure 18).

From each gastric pouch two unbranched **adradial canals** (total 8) lead into a marginal **circular canal**. From the circular canal four branched **interradial canals** lead inwards towards the gastric pouches and four branched **perradial canals** lead inwards towards the gastric cavity.

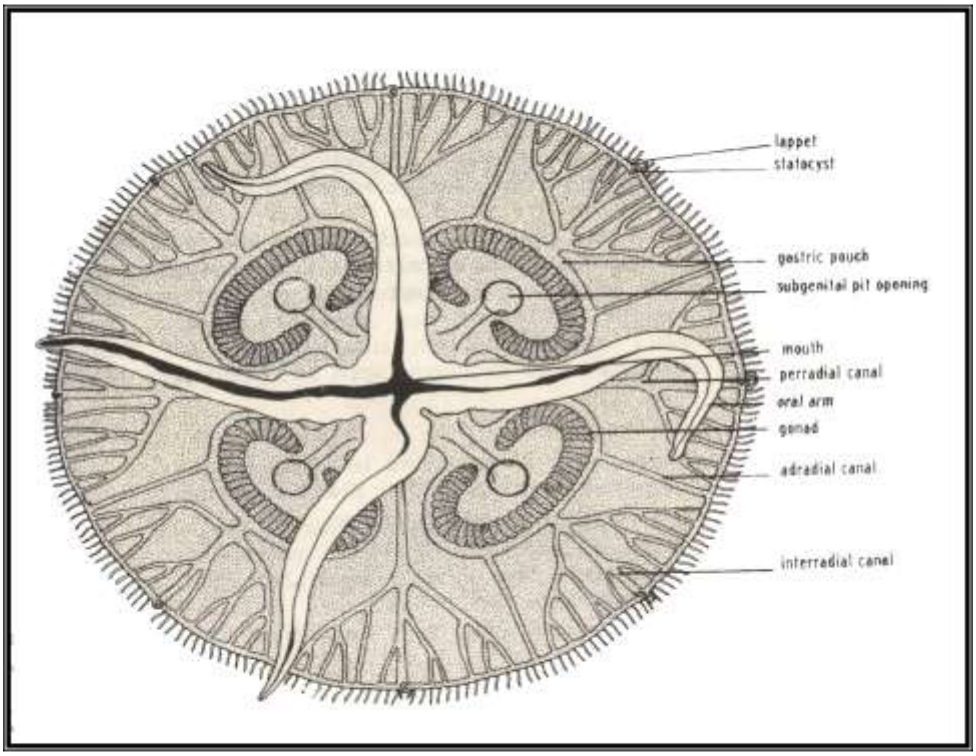
— **The gonads,** either testes or ovaries, are horseshoe-shaped, 4 in number in either case, and lie in the floor of the gastric pouches.

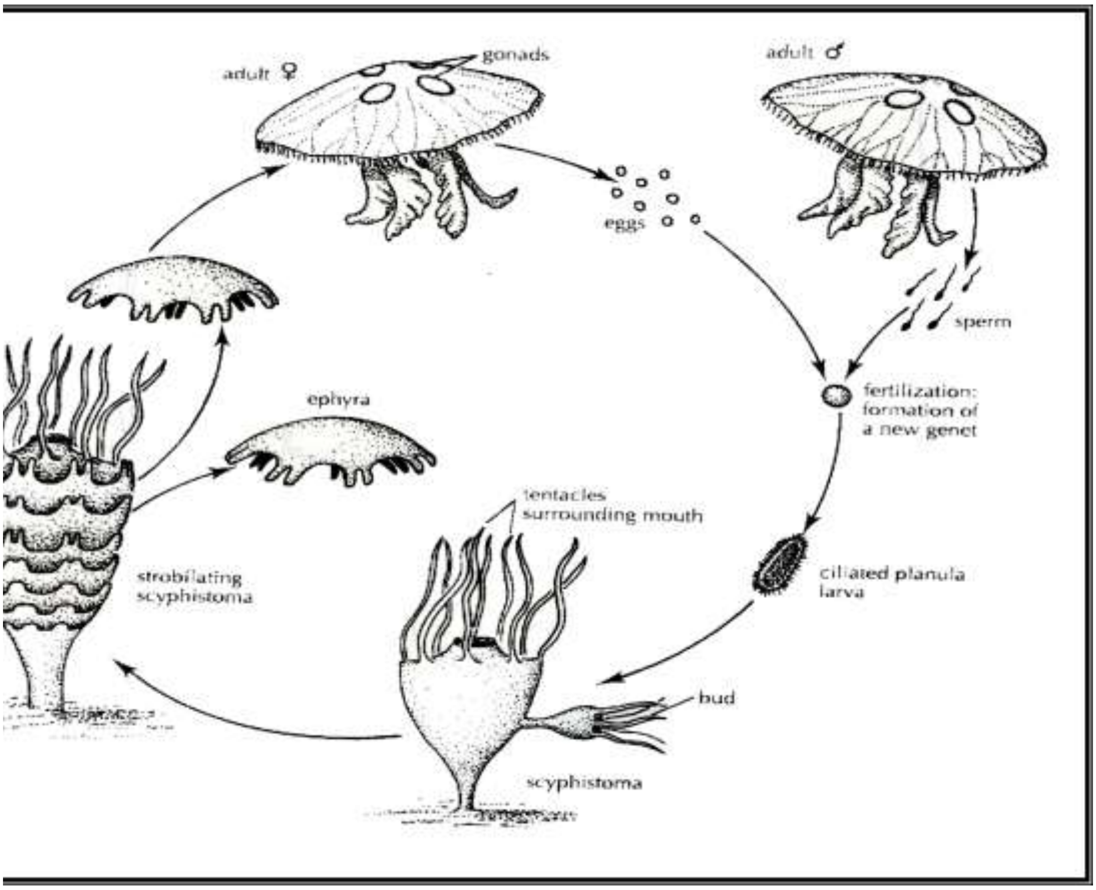
b) **Developmental stages**

— **The planula larva** is ovoid , with ciliated outer ectoderm

— **The scyphistoma** is trumpet-shaped, with a **circle of 16 tentacles and mouth,** but with the gastric cavity divided into four **gastric pouches.**

— **The ephyra** is a small medusa with the umbrella divided into 8 long forked **arms, a manubrium** with the mouth in the middle, **gastric cavity, gastric filaments,** and 8 prominent **tentaculocysts** (figure 19)**.**





C — Class ANTHOZOA

This class comprises the sea anemones and reef-building corals which are entirely marine. They are either solitary or colonial, and *exist only in the hydroid stage, the medusoid one being absent.*

Sea anemones

Sea anemones are belong to order **Zoantharia,** cosmopolitan, marine, solitary and of variable size. *They lack a skeleton*(figure 20).

a) External Features

— **The body form,** cylindrical with a **basal disc** for adhesion to substratum, and an **oral disc** which bears the **tentacles,** arranged in whorls, and has the **mouth** in the centre.

— **The stomodaeum**, has two deep ciliated **siphonoglyphs** which maintain water circulation in the gastro-vascular cavity.

b) **T.S. Through Stomodaeal Region:**

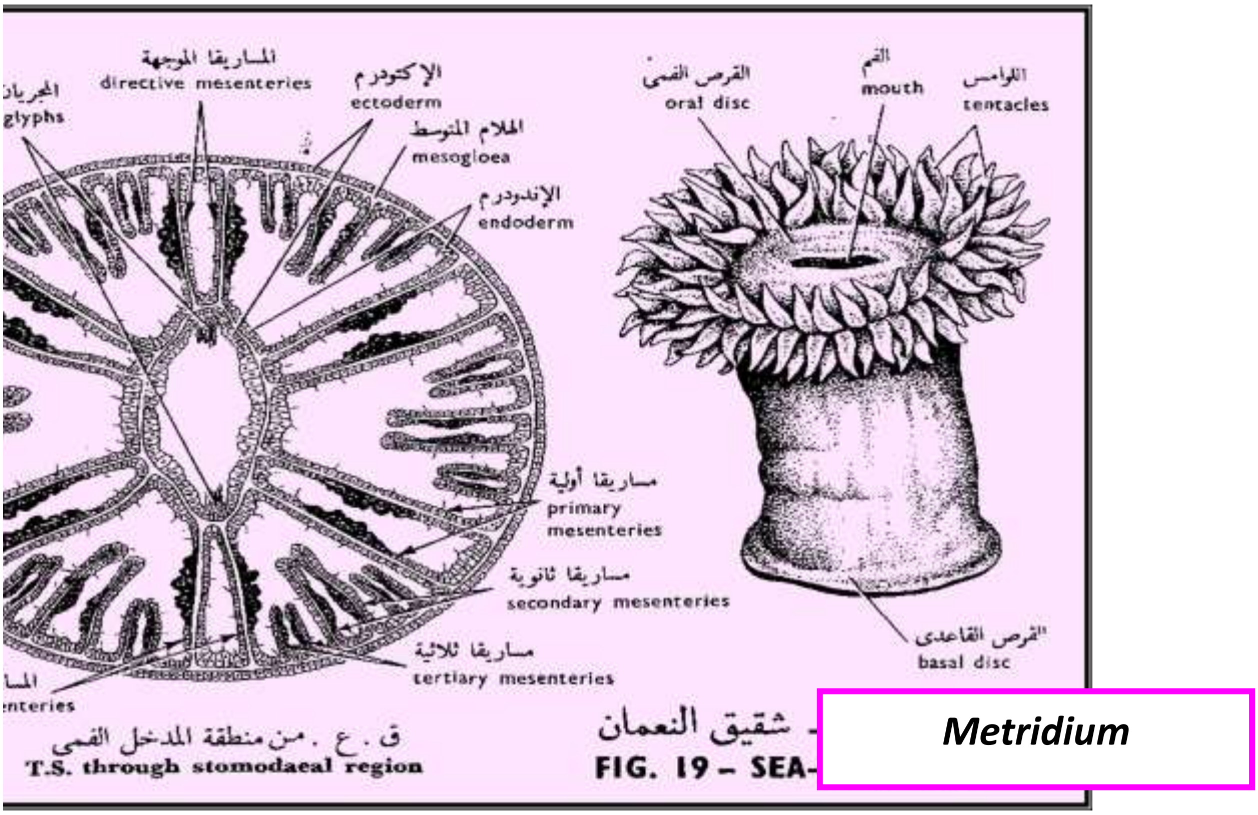
— **The body wall** consists of the **ectoderm** which is rich in mucous cells, the thick **mesoglea** with numerous fibres and wandering cells, and the **endodemm.**

— **The stomodaeum** is lined with ectoderm and has **two siphonoglyphs .**

— **The mesenteries** are of three kinds; primary, secondary and tertiary. The **primary mesenteries** are 6 pairs and extend from the stomodaeum to the body wall dividing the enteron into radial chambers. The **secondary mesenteries** are also 6 pairs but incomplete and shorter than the primary ones. In between these, there are 12 pairs of still shorter **tertiary mesenteries** (figure 20)**.**

c) **T.S. Below Stomodaeum:**

Note same features as in(b) except for the absence of the stomodaeum, the presence of the **septal or mesenteric filaments** which carry nematoblasts and digestive gland cells and appear as trilobed swellings on the inner free edges of the mesenteries, and the presence of the **gonads** on all the larger mesenteries except the directives.



ق . ع . من منطقة المدخل الفمي
T.S. through stomodaeal region

شقيق النعمان
FIG. 19 – SEA-