COURSE NAME-BIOLOGY AND DIVERSITY OF ALGAE, BRYOPHYTA AND PTERIDOPHYTA (PAPER CODE: BOT 502)

Unit -4 & 5 : Life Histories of Some Genera of Chlorophyta

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Introduction

Chlorophyceae generally includes green algae. The pigments are same (chla,chlb, carotene, xanthophyll) as in the higher plants and are located in chloroplasts. Starch is the reserve food. Plant body may be unicellular or multicellular with motile reproductive structures. Flagella are 2, 4 or more but always anterior and are whiplash type only. The gametes are produced, in unicellular non jacketed sex organs.

The name chlorophyceae (chloros= green, phyceae=algal organization) was coined by Fritsch. Most of the fresh water forms belong to green algae. The members of this class are distributed in variety of habitats; in fresh water or marine, terrestrial, on ice, etc. It includes more than 20,000 species

Salient features of Chlorophyta

- The members of class Chlorophyta are primarily aquatic and about 90% members are found in freshwater. Some members are terrestrial while few are found in brackish water.
- Chlorophyta are also known as “Green Algae” due to green appearance of their thallus. This green appearance is due to the abundance of pigments chlorophyll a and b in their plastids. Other pigments commonly found in these members are lutein, siphonoxanthein and siphonein.
- Thallus organization in this class ranges from unicellular motile, non-motile, coccoid, palmelloid, filamentous, heterotrichous, siphonaceous, folioceous, to complex habit.
- The cell wall is chiefly made up of cellulose, however, in some members xylans and mannons are also found.
- The chloroplast of these members is usually associated with the pyrenoids. Inside the chloroplast, the thylakoids are grouped always more than two and up to the five in numbers. The chloroplast is without the layer of chloroplast endoplasmic reticulum.
- The pyrenoids are present in the chloroplasts and are surrounded by the starch-sheath.

- The photosynthetic product starch is formed with in the chloroplast. The chemical composition of starch consists of amylase and amylopectin, similar to the higher plants.
- In motile forms, the flagella are usually two or in multiple of two and there are usually apically inserted to the cell.
- Vegetative reproduction occurs by fragmentation while asexual reproduction takes place by motile zoospores, non-motile aplanospore, autospores, and by formation of akinete,
- Sexual reproduction is isogamous, anisogamous and oogamous type.
- Mostly the members are haploid, but some are diploid.
- Life cycle may be haplontic, diplontic or diplohaplontic.

Haematococcus

Occurrence: The genus occurs in puddles of rainwater, aquaculture ponds, sometime in saline water ponds and salt pans, which they usually color blood-red.

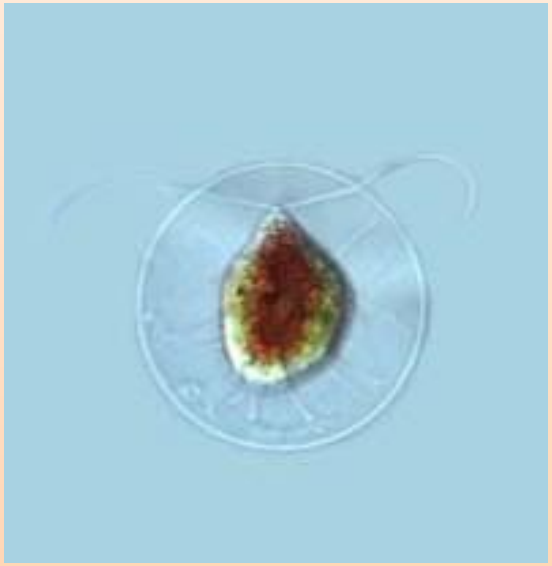


Fig.*Haematococcus pluvialis*

Thallus structure: The cells are usually blood red in colour due to the abundance of the pigment haematochrome or astaxanthein lying in the cytoplasm. The thallus is unicellular, ovoid, ellipsoid or nearly globose in shape. The major part of the protoplasm lies at some distance from the cell wall. Some delicate strands of the protoplasm radiate out from the cell into the layer of mucilage. From the anterior end of the cell two flagella arise and penetrate the cell wall. The chloroplast is usually cup-shaped with 1-2 to several pyrenoids and a large eye spot. Nucleus lies centrally in the depression of the chloroplast. The genus contains many contractile vacuoles in the cell.

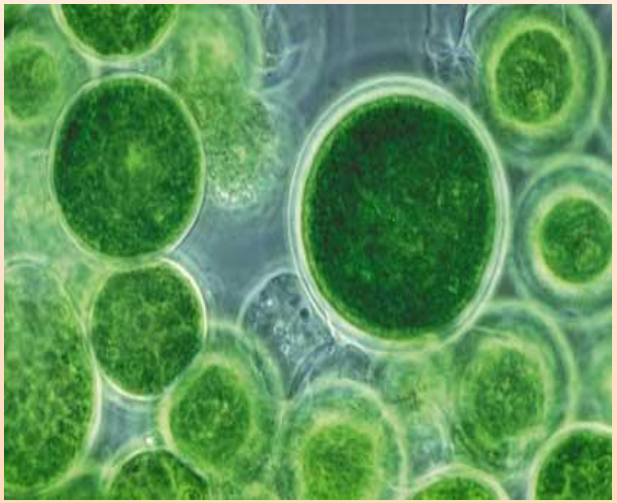
Reproduction

- Asexual reproduction takes place by formation of zoospores in favorable condition. During unfavorable condition, the cells develop thick-walled aplanospores which later on produce 4-8-or 16 zoospores.
- Sexual reproduction is isogamous type. Gametes are biflagellate which after fusion form quadriflagellate zygote. This zygote remains motile for some time and later it loses its flagella and secrete thick cell wall. It undergoes zygotic meiosis and produce 4 vegetative cells which grow in to the adult cells.

Chlorella

Occurrence

It is found in freshwater usually in stagnant water or on soil. Some species are found in brackish water while some are marine. *Chlorella* can also occur as endosymbiont in *Paramecium*, gastrovacular cavities of *Hydra* and in some sponges. Some species of *Chlorella* like *C. lichina* associates with fungal partner to form lichen.



Chlorella

Thallus structure It is unicellular alga which may form a colony like structure. The cells are spherical, sub-spherical, or ellipsoid with or without mucilage, 2-10 µm in diameter and are without flagella. It contains single parietal chloroplast with pyrenoid which is surrounded by starch grains. The cell wall of *Chlorella*, besides cellulose consists of sporopollenin-like substance which is also found in pollen grains of the higher plants.

Reproduction

Chlorella reproduces asexually by **Autospore** formation. Each mother cell produces four autospores which are like miniature of the parent cell. It does not produce zoospores or gametes for sexual reproduction.

Economic Importance

Chlorella is of great economic importance. It has high nutritional value. It contains 50% protein, 20% carbohydarates and 20% lipids. It contains all the essential amino acids and dried biomass of the Chlorella is used as single cell protein. *Chlorella* also contains Vitamin A, riboflavin, biotin, folic acid and minerals like Iron and Calcium. It contains an antibiotic chlorelline. The growth of the *Chlorella* is very fast and it is an efficient Oxygen producer hence it is used in spacecrafts to absorb the CO_2 and is also used in oxidation ponds for sewage treatment plants.

Volvox

Occurrence

Volvox is freshwater **planktonic** alga which is usually found in stagnant water like pools and ponds during spring and rainy season. On the water surface, its colony appears green, small pin head like structure which are visible to the naked eyes.

Volvox colony

Thallus structure

The colony of *Volvox* is composed of many small vegetative cells which form the **coenobia**. A definite number of cells form the globular structure which is held together by highly viscous gelatinous sheath. The coenobia of different species may consist of 500-50,000 cells including reproductive cells or gonidia which are embedded in gelatinous sheath. The individual cells in their general morphology appear like the cell of *Chlamydomonas*. Each cell is ovate in shape having broad posterior and narrow apical end with two apically inserted flagella which are equal in size. Eye spot and two or more contractile vacuoles are present in the anterior region near the base of flagella. The chloroplast is cup-shaped with pyrenoid. Cells are uninucleate. In most of the species, individual cells are held together by prominent cytoplasmic strand. In the coenobium, the cells of the posterior region are usually larger than the anterior end.

Reproduction

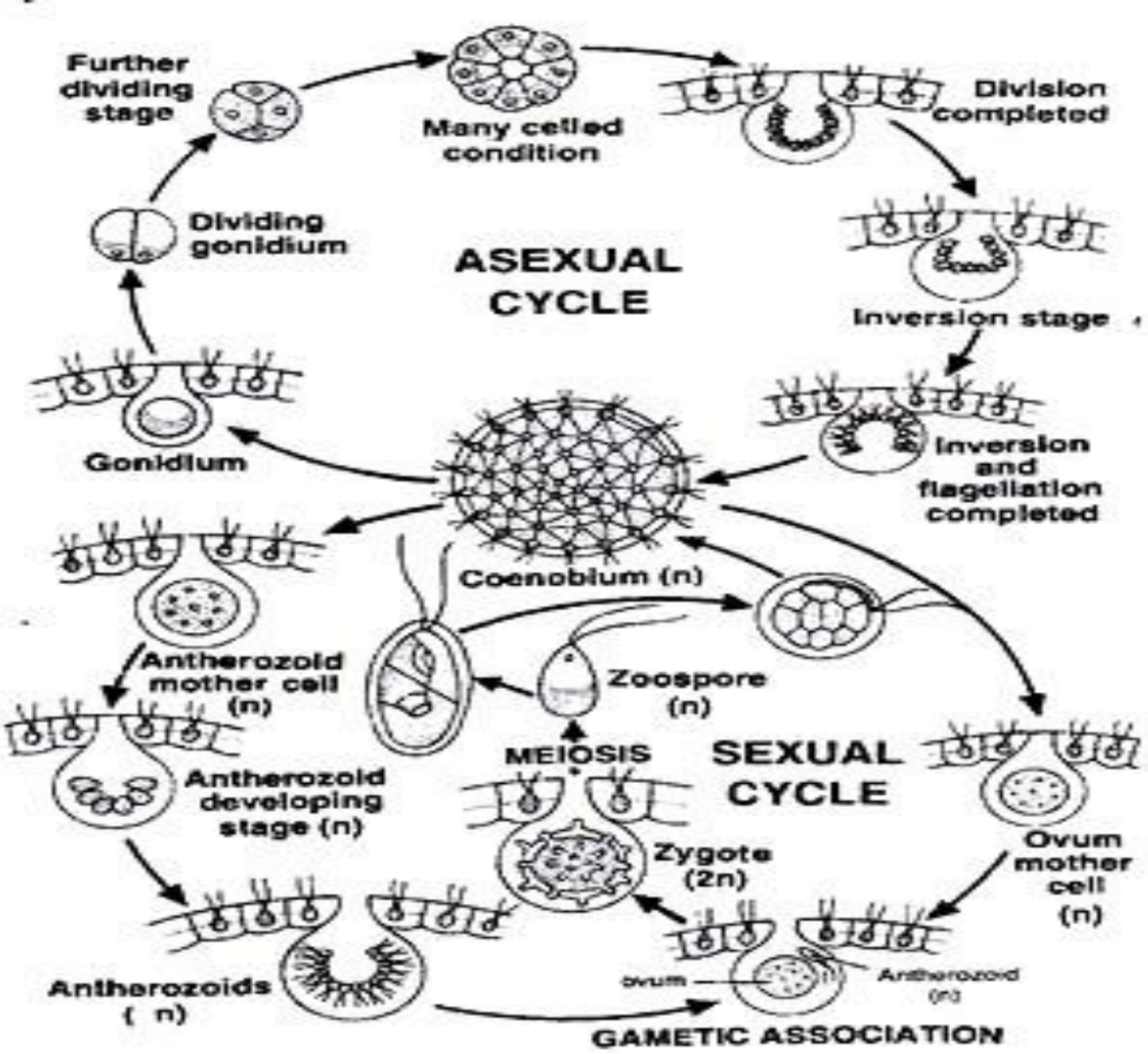
During asexual reproduction, some cells of the posterior region withdraw the flagella, become larger in size and differentiate into asexual reproductive cell called **gonidium.** In a coenobium 2-50 gonidia may be produced. The gonidium divides mitotically several times mostly longitudinally. The group of 8 daughter cells form a curved plate like structure called **Plakea stage**. After the 16-celled stage, the cells are arranged at the periphery of a hollow sphere having an opening called **phialopore.** When the cell division stops, the cells of sphere turn inside out passing through the phialopore by the inversion process. Now the individual cells develop flagella and become the part of a new colony. This new colony may or may not escape from the parent colony.

In *Volvox*, the sexual reproduction takes place during unfavourable season. It is strictly oogamous type. Depending on the species, the coenobia may be monoecious or dioecious. Monoecious species like *V. globator* produce male and female sex organs in same colony. The monoecious species are protandrous. In dioecious species like *V. aureus*, the male and female sex organs produce in two different colonies. Gametes develop specially from the posterior half of the coenobia. The potential egg cell loses its flagella and enlarges in size during development.

It is distinct from the gonidia being flask-shaped, denser and darker than the later.

The cell forming male gametangium or antheridium divide successively forming many (16-512) spindle-shaped biflagellate antherozoids similar in manner the development of zoospore, passing through Plakea-stage and by inversion process through the phialopore.

During fertilization, the entire mass of the antherozoids are liberated from the colony which reaches to the egg cell of another coenobium. There individual antherozoids are set free and one of them fuses with the egg cell and form zygote which is called **oospore**. The oospore subsequently, secretes the three-layered wall which may be smooth or spiny depending upon the species. It also accumulates the haematochrome which imparts it orange-red colour. Oospore is released by the rupture of the colony. It is perennating body of the *Volvox*. After a period of rest, During germination, the oospore divide meiotically to form four nuclei, out of which three degenerate while remaining one divides and re-divides mitotically to form the new coenobium.



Volvox: Life cycle

Hydrodictyon

Occurrence

Hydrodictyon is also known as “water net” alga. It is found growing in freshwater ponds and lakes, rivers in free-floating condition usually in spring or summer season. Sometimes, it becomes so abundant that it may cover entire surface of the water body. *H. reticulatum* is the common species of the India.

***Hydrodictyon* colony**

Thallus structure

The thallus of *Hydrodictyon* is macroscopic non-motile coenobium. The coenobia form large cylindrical nets which have few hundred to several thousand cells and may reach upto one meter or more in length. Each coenobium consisting of a network of pentagons or hexagons. Each corner of the polygon is made up of fusion of ends of the three large cylindrical cells. These cylindrical cells may be up to 1 cm long. The young cells are uninucleate and have a parietal band-shaped chloroplast with pyrenoids but mature cells become multinucleated. The cytoplasm of the cell is restricted to the periphery of the cell by a large vacuole.

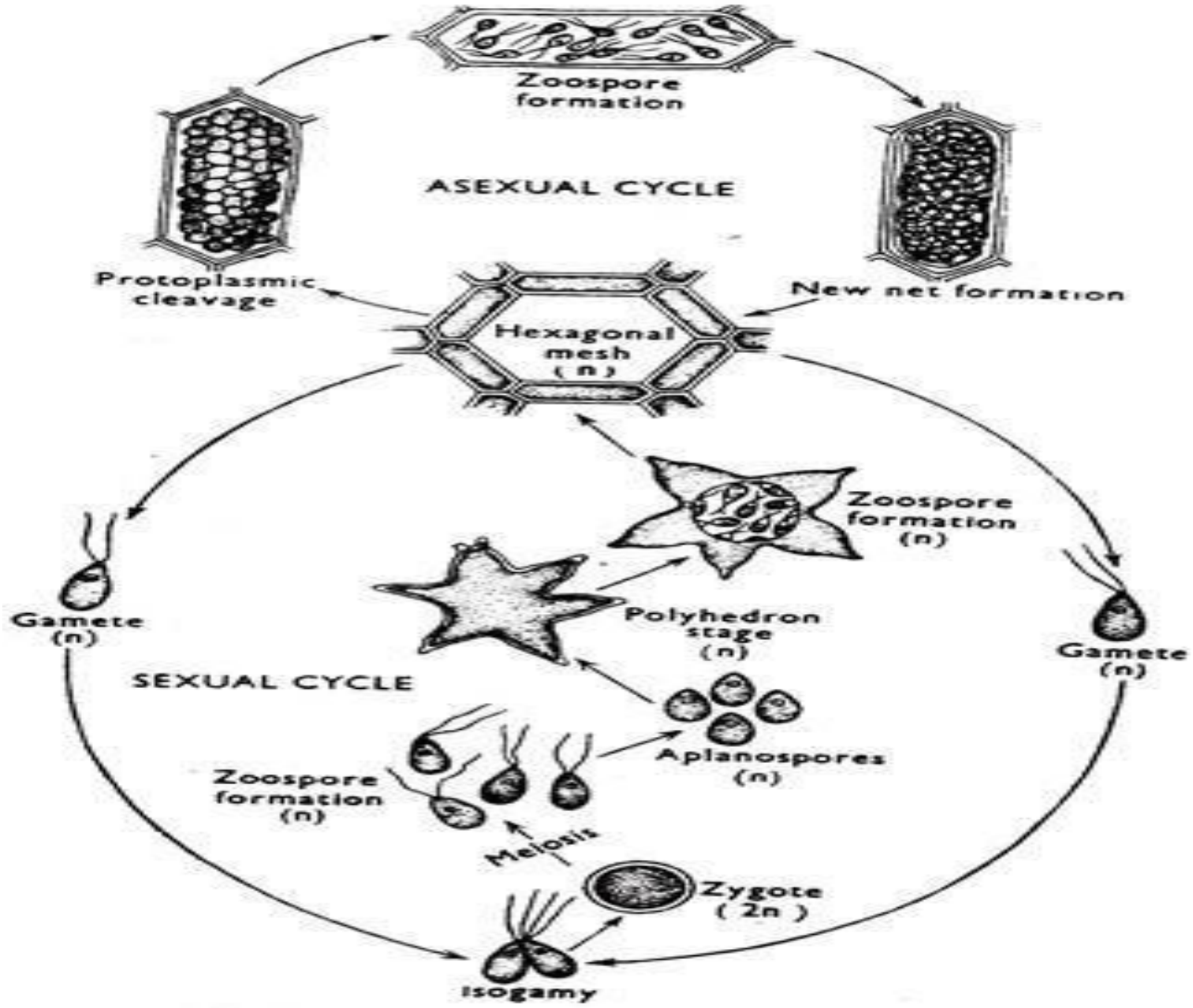
Reproduction

Asexual reproduction takes place by **autocolony** formation. The cytoplasm divides up into many uninucleate protoplasts and these lie close together so that each has a polygonal outline. Each protoplast develops into biflagellated zoospore. A single cell of coenobium may form up to 20,000 zoospores, which get associated laterally to each other and thus produce a new net like colony. Each zoospore develops in to cylindrical uninucleate cell and subsequently grow to become the large multinucleate cells of the mature colony. The young colony of the newly formed water net is liberated through the disintegration and dispersion of the parent cell wall.

In some cases, the zoospores instead of assembling to form a new young colony, get liberated from the parent cell and swim freely for some time, then come to rest and surround themselves with the thick wall and turn into a hypnospore. This hypnospore germinate by forming new zoospore. This zoospore settle down into a **polyeder** which is an irregularly shaped cell bearing pointed projections. The content of this polyeder divides into zoospores which are then discharged into a vesicle. Within the vesicle, the zoospores arrange themselves into a spherical net called ‘germination net’.

Each cylindrical cell of the germination net subsequently produces a daughter net, by the same developmental process described above. As each daughter net takes on the cylindrical shape of the cells in which they are formed, now the daughter net acquires the original cylindrical water net shape of the colony.

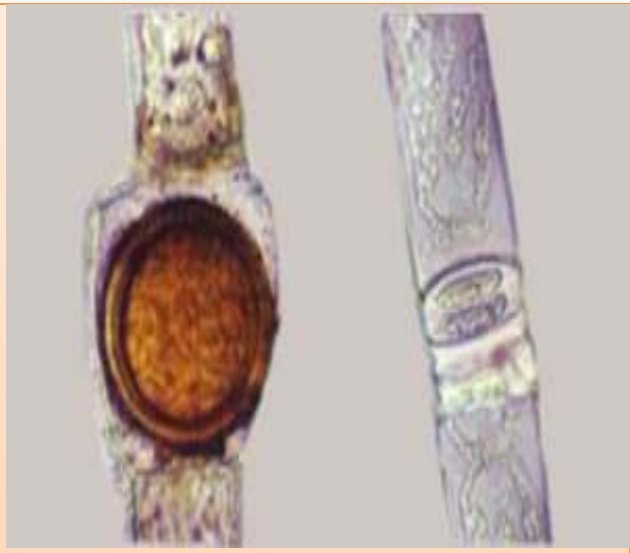
Sexual reproduction is isogamous type. The genus is monoecious. The gametes arise in the same way as zoospores but are smaller. The gametes are liberated from the parent cell wall through the hole. The fertilization occurs in water. The zygote undergoes for a period of rest and later divide mitotically into four haploid zoospores. Zoospores escape from the zygote wall and develop in to a non-motile polyhedral cell. This polyhedral cell divides and re-divides to produce numerous zoospores which arrange themselves into a fashion like the *Hydrodictyon* net.



Life cycle of Hydrodictyon

Oedogonium

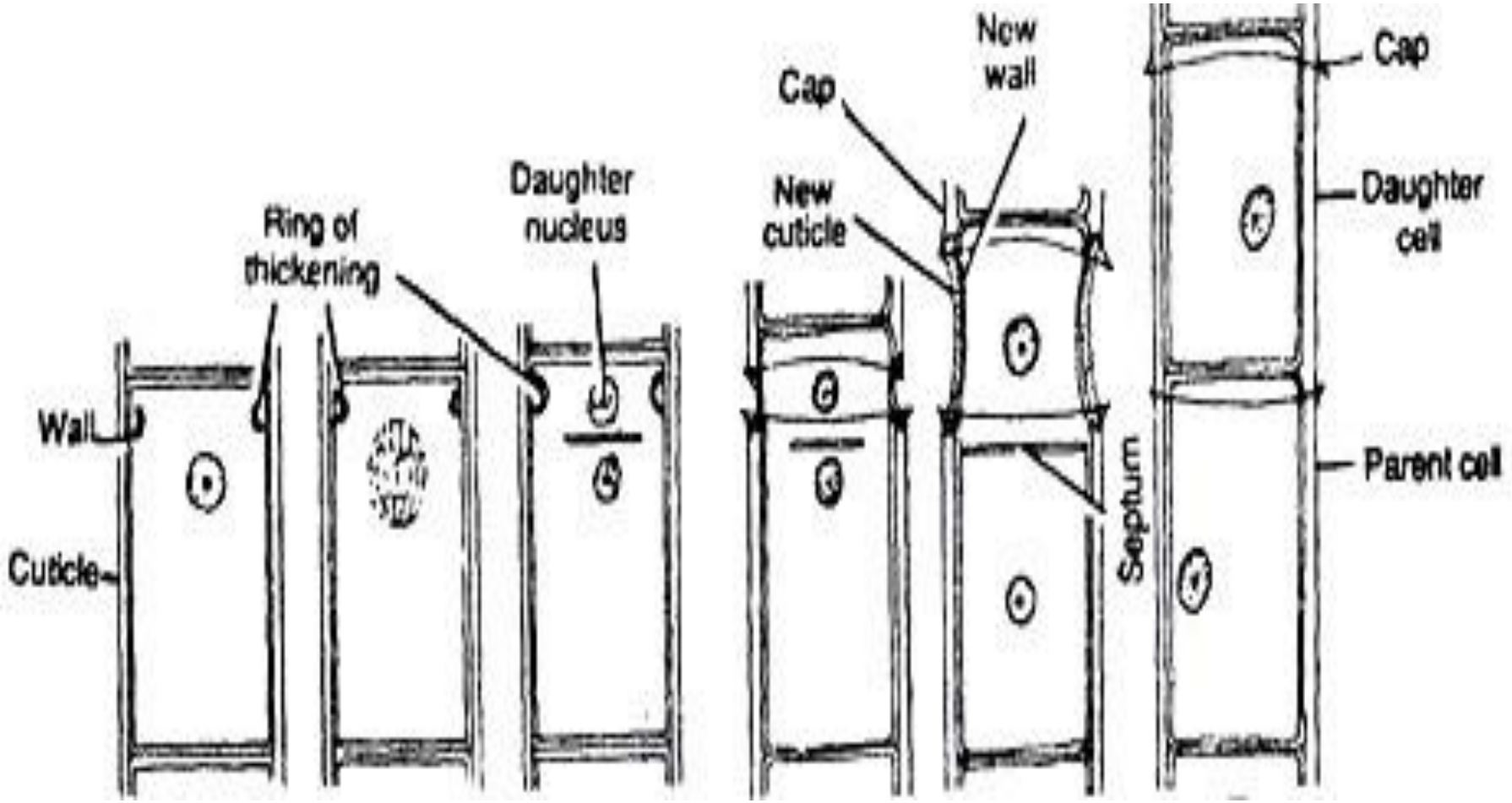
Occurrence - It is a common freshwater filamentous unbranched alga and is found attached with the different substrates like stones, wood, leaves of aquatic plants.
In the young stage filaments are attached to the substratum with the help of basal holdfast which later may become free. Few species are terrestrial like *O. terrestre*.



Oedogonium : Female and male filaments

Thallus structure - Cell wall of this genus is made up of three layers, inner cellulosic, middle pectic and outer chitinous layer. The terminal cell of the filaments is generally rounded and intercalary cells show apical-basal polarity. Most of the cells at distal end possess annular striations at the apical end which are known as **cap cells**. The cells of the filament are cylindrical, uninucleate contain parietal, reticulate chloroplast with several pyrenoids. Mature cells contain a central vacuole.

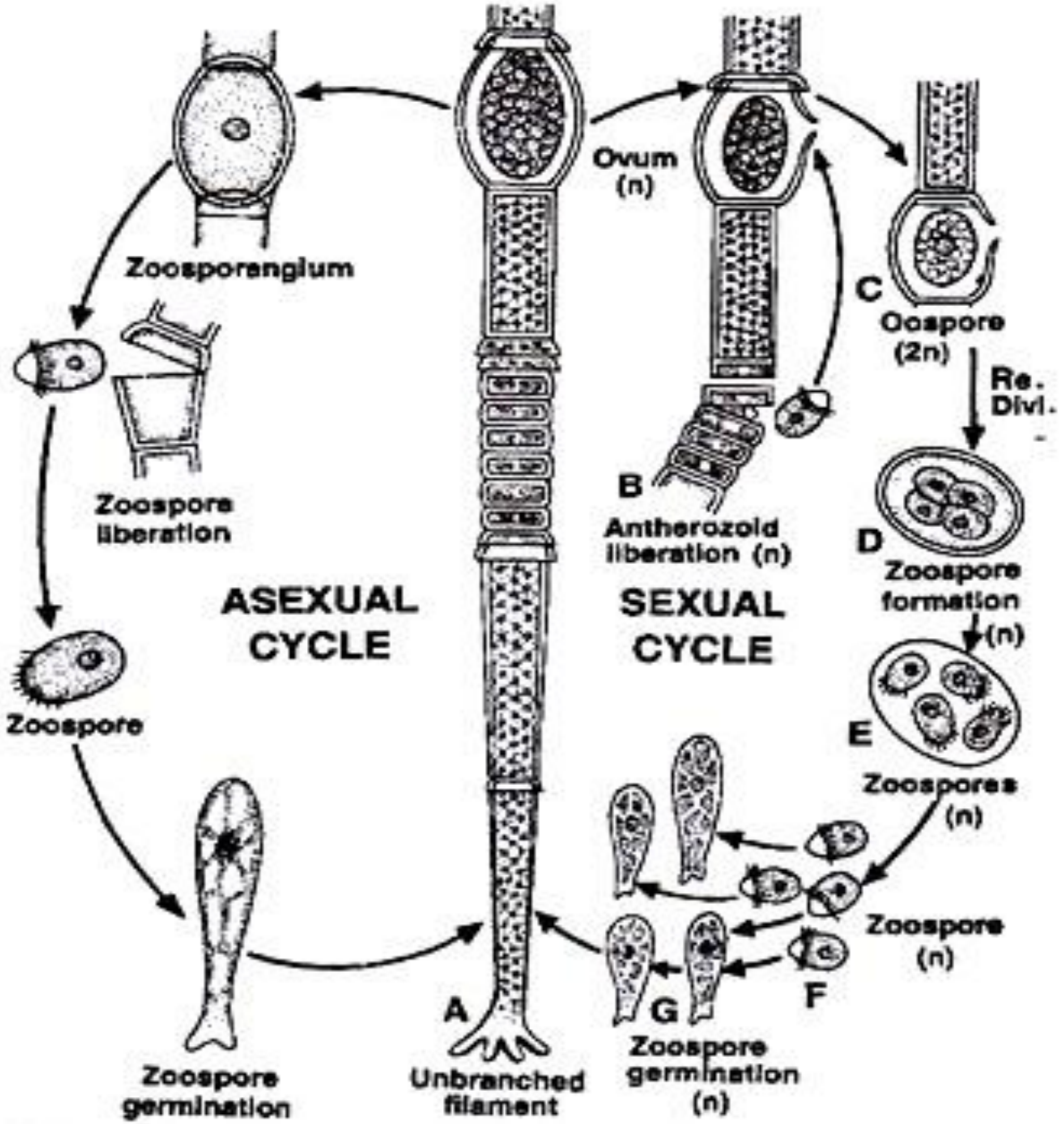
The process of cell division in *Oedogonium* is unique. Each cell division results in to formation a new cap cell. During cell division the nucleus migrates from middle to distal end and it divides mitotically there. In the early stages of mitosis, just below the apical end of the cell, a ring containing cell wall material develops from the inner cell wall layer. Along with progress in to the cell division this ring grows, thickens and forms a groove like structure which appears like two tubercles. After nuclear division, an unattached floating septum is formed between the two daughter nuclei. The middle and outer cell wall layers external to the ring situated at apical end of the cell ruptures, permitting free elongation of the ring which forms the new cell wall. Now the floating septum moves upward and become fixed near the terminal end of the old cell wall. The membranous striations of the ruptured cell wall at the anterior end of the upper daughter cell becomes the cap and the cell bearing it is called cap cell. The number of caps present on the cell indicated the number of cell divisions that has taken place.



Cell division in *Oedogonium*

Reproduction : Vegetative reproduction takes place by fragmentation but under unfavourable condition the *Oedogonium* may produce akinetes also.

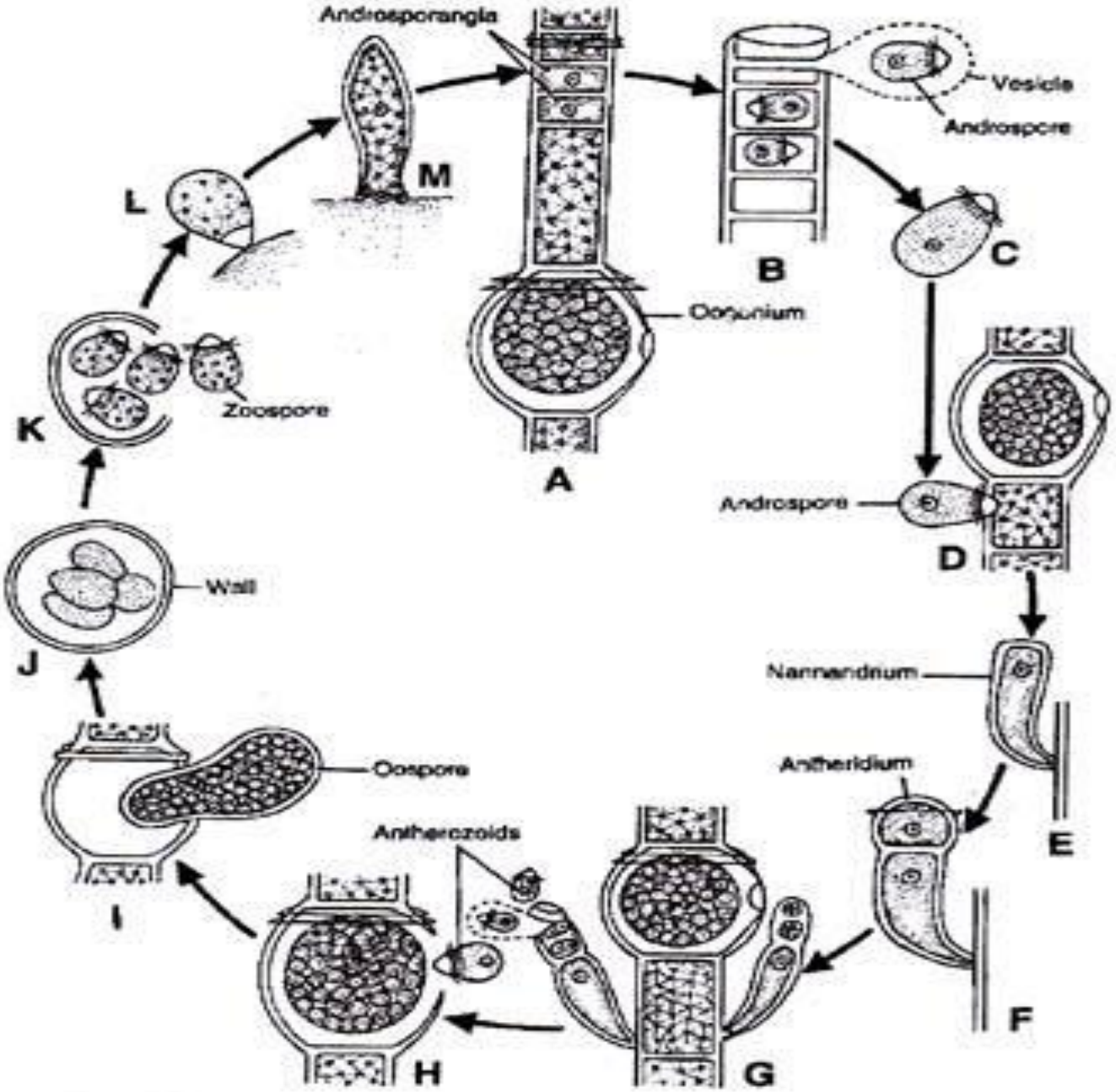
Asexual reproduction takes place by formation of multiflagellate zoospores. Zoospore formation usually occurs in cap cell. In this process the whole content of the cell gradually metamorphoses in to a single pear-shaped zoospore having a hyaline area at the apex. Surrounding the hyaline area, a ring of flagella develops in the zoospore. Such zoospores are called **stephanokont** zoospores. The zoospore is liberated enveloped in a hyaline sheath from the parent cell through a hole in cell wall. The vesicle soon disappears and the zoospore swim freely for some time and attaches to the substratum by their anterior end. Thereafter, the flagella are withdrawn and the zoospore elongates considerably. The attached end differentiates into holdfast subsequently grow into a new filament.



Life cycle of macrandrous speceis of *Oedogonium*

Sexual reproduction is oogamous type. Some species are monoecious while others are dioecious. In dioecious species two different categories are found. (i) **macrandrous** type with antheridia produced on normal filament and (ii) **nannandrous** type in which antheridia are produced on dwarf male filament i.e., nannandrium. In monoeciuous species, antheridia are formed in a series by vegetative cells. Protoplasm of each antheridium forms two multiflagellate antherozoids. Oogonia are formed by the division of oogonial mother cell into lower supporting cell or **suffultory cell** and upper oogonium. Oogonium after development enlarges into oval or rounded ball-like structure. A small colorless area appears at one side of the oogonium through which antherozoids enter into the oogoium and reaches up to the egg. After fertilization, zygote develops into the oospore. Oospore secretes the thick wall around it and undergoes a period of rest. It later divides mitotically into four haploid zoospores. In dioecious macrandrous species, out of four, two zoospores form male filament and two form the female filament.

In nannandrous types, the dwarf male filaments are produced from a special type of zoospores called **androspores** which are formed in the **androsporangium**. Androspores are of size between zoospores and antherozoids. Usually the androsporangia are produced on the filaments bearing oogonia and such filaments are called **gynandrosporous** type. In some species, the androsporangia are formed on different filaments which are called **idioandrosprorous** type. The oogonial mother cell of *O. donnellii* produces a pheromone called **circein** which affects the behavior and development of the androspore of *O. donnellii*. Androspores after liberation from androsporangium get attached to the oogonial wall and germinate to form the 2 to 3 celled dwarf male filaments which bear the antheridia. Each antheridium forms two multiflagellated antherozoids which escape from the antheridium and enter into the oogonium through the aperture. Further process of development and germination are similar to the macrandrous species. If the androspores are subjected to the nitrogen-rich environment it forms a vegetative male thallus that cannot be distinguished from the one which originally released the androspore.



Life cycle of nanandrous species of *Oedogonium*

Ulva

Occurrence - It is a marine alga and grows attached to loose shells, rocks and stones in the intertidal zone. It is mainly found in warmer seas, estuaries and coastal areas.

Ulva thallus

Bistromatic thallus

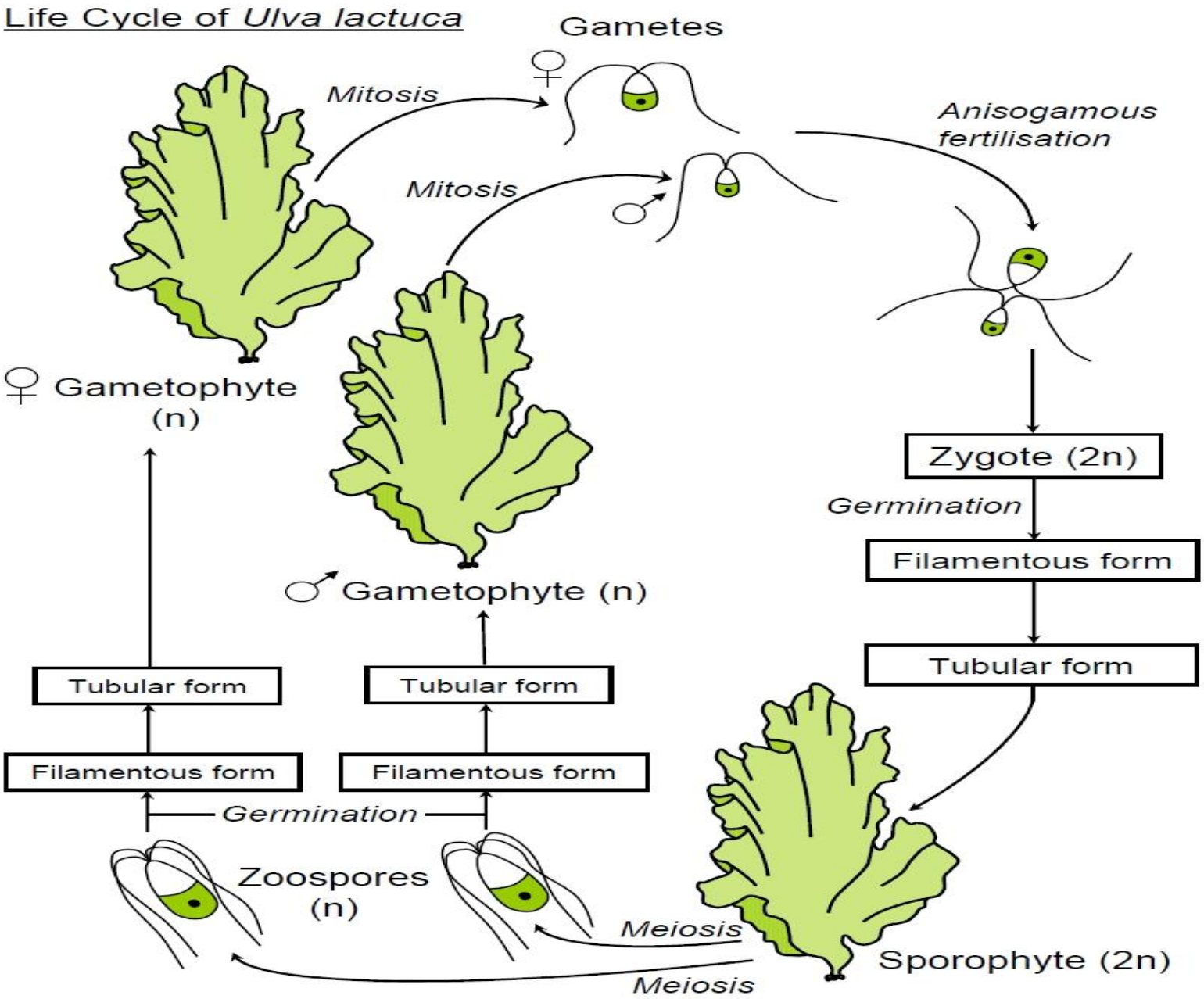
Thallus structure - The thallus is leaf-like or green sheet like which is highly polymorphic and attached to the substratum by means of club-shaped rahizoidal cells which fuse to form the attachment disc. The expanded leaf-like part of the thallus is called blade. Thallus *U. curvata* has curved margins while *U. neapolitana* has narrow, lanceolate ribbon-like blades. The margins of *U. lactuca* are entire and undulate. The shape and arrangement of the cells differ from the basal to middle to apical regions of the blade.

In most of the species the thallus is bistromatic i.e. made up of two cell layers. The individual cells are parenchymatous, somewhat isodiametric and polygonal. Cells are uninucleate. Chloroplast is parietal, cup-shaped with one or two pyrenoids. In *U. lactuca* and *U. curvata* there is one pyrenoid per cell while in *U. rigida* most of the cells have 2-4 pyrenoids per cells in middle and apical region of the thallus. The chloroplast may also be notched or have irregular margins. The growth of the thallus is diffused.

Reproduction - Vegetative reproduction takes place by fragmentation of the thallus. In *Ulva* the dominant phase of life cycle is sporophyte.

Asexual reproduction takes place by quadriflagellated zoospores which are formed by the meiosis. The fertile cells are situated at the margin of the thallus. These zoospores germinate and develop into gametophyte which are morphologically similar to sporophyte.

The gametophyte produces iso-or anisogametes which fuse to form the zygote. This diploid zygote first develops into filamentous form to tubular form and eventually gives rise to leafy sporophyte. Thus, *Ulva* exhibits isomorphic alternation of generation.



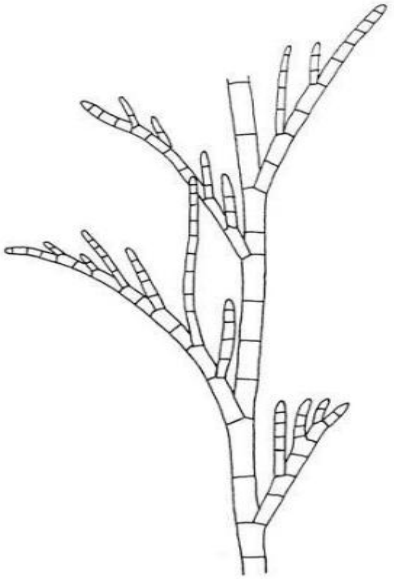
Life cycle of *Ulva*

Cladophora

Occurrence - *Cladophora* occurs in diverse habitats like in freshwater, brackish water and in marine habitats either free-floating or attached to rocks or as epiphyte or attached on shells of molluscs. Some species of *Cladophora* grow so profusely that they form dense mat-like structures while some others form a hollow ball-like structure called as '**aegagropiloid habit**'. *C. glomerata* is a typical, most abundant freshwater alga which is found in streams throughout the world. The excessive growth of the alga may cause nuisance due to cultural eutrophication of the water bodies.

Thallus structure – The thalli are dark green, entangled aggregates which may grow up to 4 cm in diameter. The filaments are branched which usually grow attached with long horizontal branches. The branching is usually dichotomous and they arise below the septa. The branching is usually lateral but appears dichotomous due to pushing aside of the original axis of the branch. This process is called **evection**. Cells are elongated with thick, stratified cell wall. Each cell consists of many discoid chloroplasts at periphery which unit to form a reticulate structure with numerous pyrenoids. Cells are multinucleate.

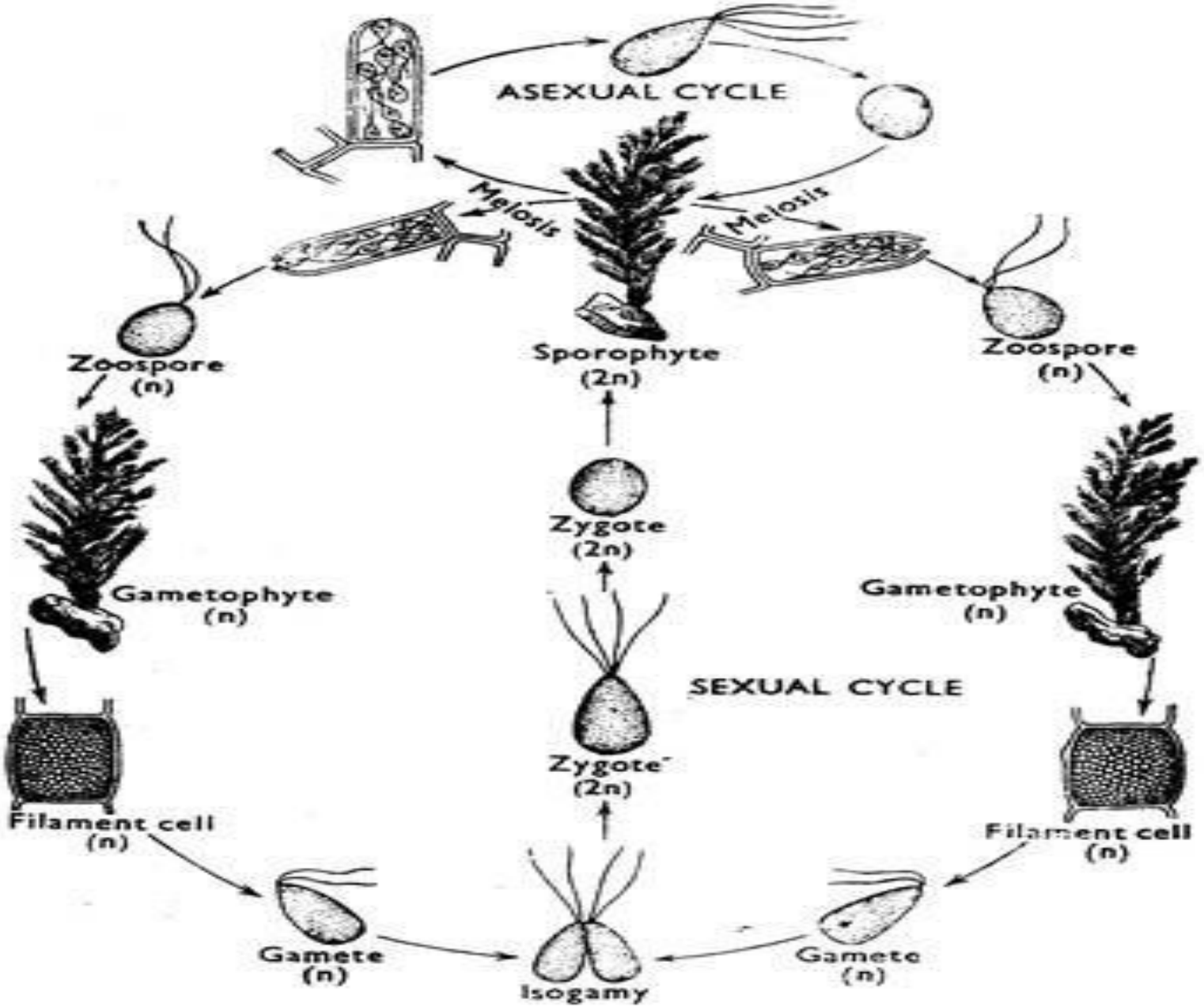
***Cladophora* : Aegagropiloid habit**



***Cladophora:* Pattern of branching of thallus**

Reproduction - During unfavourable condition, the rhizoidal branches act as perennating organ which grow into new plant after advent of favourable condition. Some freshwater species also tide over the unfavourable condition by forming akinetes. Asexual reproduction takes place by formation of quadriflagellated zoospores which are formed in zoosporagium situated usually at terminal branches. After liberation from zoosporangium the zoospores germinate to form new filament.

During sexual reproduction, zoospore like isogametes are formed from the two different thalli in gametangium which fuse to form the zygote. Zygote, without undergoing a period of rest germinate and grow to form the diploid sporophytic thallus. The diploid sporophytic thallus of the *Cladophora* produces haploid zoospores after the meiosis which develop to produce the haploid gametophytic thalli, which are morphologically similar to the diploid sporophytic thalli. Thus, *Cladophora* exhibits isomorphic alternation of generation. However, in *C. glomerata*, both gametes and zoospores are produced on diploid thalli but meiosis occurs only during gamete formation. Hence in this species the life cycle is diplontic type.



Life cycle of *Cladophora*