Subject Code: 18BBO23C
CORE PAPER – II ALGOLOGY, BRYOLOGY AND LICHENOLOGY

Unit-II

Detailed study of structure, reproduction and life cycle of the following: *Diatom*, *Dictyota,* and *Polysiphonia.* Economic importance of algae. General account of fossil algae.

UNIT II

ALGALOLY, BRYOLOGY AND LICHENOLOGY

DIATOM (Bacilliriophyceae)

Diatoms are photosynthesising algae, they have a siliceous skeleton (frustule) and are found in almost every aquatic environment including fresh and marine waters, soils, in fact almost anywhere moist. They are non-motile, or capable of only limited movement along a substrate by secretion of mucilaginous material along a slit-like groove or channel called a raphe. Being autotrophic they are restricted to the photic zone (water depths down to about 200m depending on clarity). Both benthic and planktic forms exist. Diatoms are formally classified as belonging to the Division Chrysophyta, Class Bacillariophyceae. The Chrysophyta are algae which form endoplasmic cysts, store oils rather than starch, possess a bipartite cell wall and secrete silica at some stage of their life cycle. Diatoms are commonly between 20-200 microns in diameter or length, although sometimes they can be up to 2 millimeters long. The cell may be solitary or colonial (attached by mucous filaments or by bands into long chains). Diatoms may occur in such large numbers and be well preserved enough to form sediments composed almost entirely of diatom frustules (diatomites), these deposits are of economic benefit being used in filters, paints, toothpaste, and many other applications.

It is a large group of algae consisting of 200 genera and over 10,000 species, out of which 92 genera and about 569 species are reported from India. They are commonly known as Diatoms. The diatoms are the most beautiful microscopic algae due to their structure and sculpturing of their walls.

They occur in various habitats like fresh water, saline water and also in terrestrial condition on or within the soil. Sometimes they also occur as epiphytes along with algae, on the leaf of forest trees, mostly in tropical rain forests. Depending on the mode of nutrition they may be photosynthetic autotrophs or photosynthetic symbionts or heterotrophs.

The important characteristics of the class Bacillariophyceae are:

1. They are commonly unicellular and free- living but some members form colonies of various shapes like filaments, mucilaginous colonies etc.

2. Microscopic cells are of different shapes. They may be oval, spherical, triangular, boat-shaped etc.

3. Plant bodies are either bilateral or radial in symmetry.

4. The cells are surrounded by a rigid cell wall, called frustule, consisting of upper epitheca and lower hypotheca; arranged in the form of a box with its lid.

5. The cell wall is composed of pectic substances impregnated with high amount of siliceous substance.

6. The wall may have secondary structures like spines, bristles etc.

7. Vegetative cells are diploid (2n).

8. The cells generally have many discoid or two large plate-like chromatophores. Some cells possess stellate chromatophore.

9. The photosynthetic pigments are chlorophyll a, chlorophyll c along with xanthophylls like fucoxanthin, diatoxanthin and diadinoxanthin.

10. Reserve food is oil, volutin and crysolaminarin.

11. Some vegetative cells show gliding movement.

12. Motile structure (antherozoid) has single pantonematic flagellum.

Plant body is unicellular, generally moves singly. The cells are of different shapes viz. round, oval, elongated, rod-shaped, triangular, disc-shaped etc. Sometimes they become aggregated and get embedded in a gelatinous matrix, but they do not behave like multicellular organisms.

In colonial form the cells may be present as uniseriate row (e.g., Melosira), like a branched body (e.g., Licmophora flabellate) or other forms also (

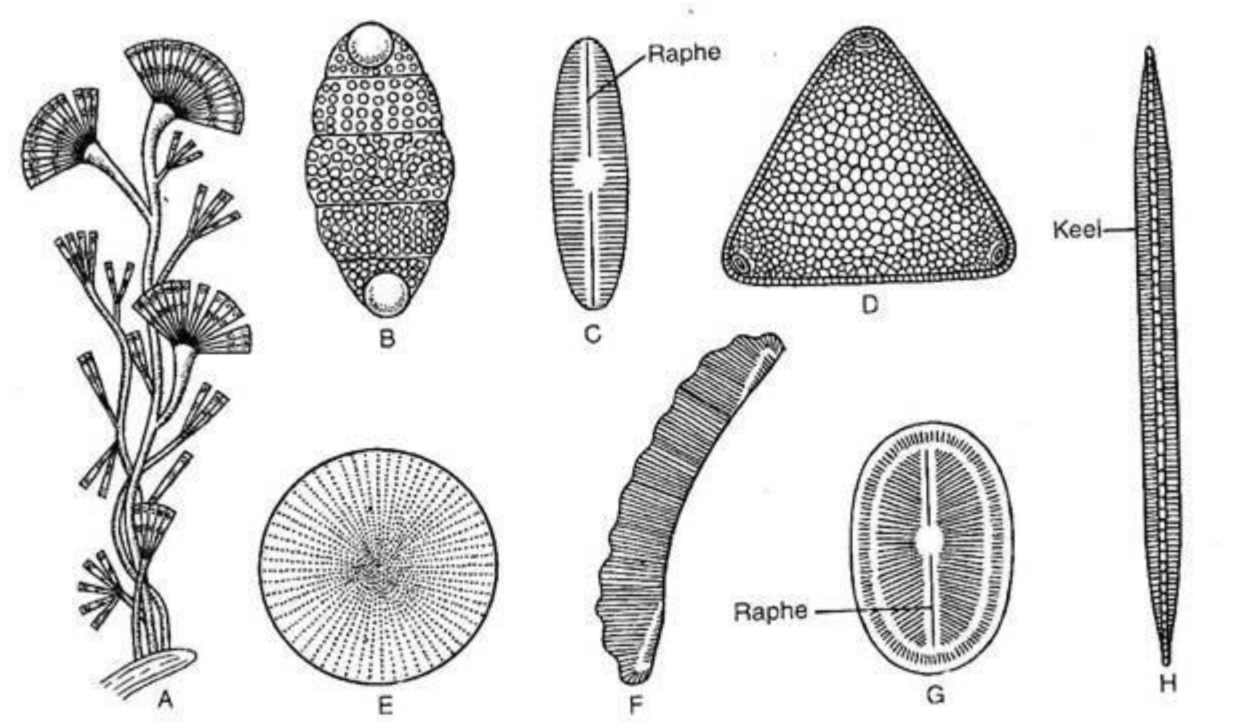


Fig. 3.100 : Different forms of Diatom : A. *Licmophora flabellata*, B. *Biddulphia pulchella*, C. *Achnanthes linearis*, D. *Triceratium planoconcavum*, E. *Cascinodiscus excentricus*, F. *Eunotia* sp., G. *Cocconeis placentula*, and H. *Bacillaria paradoxa*

Cell Structure of Diatoms:

The cell consists of cell wall and protoplast (Fig. 3.101 A, B, C). The cells are covered by a siliceous wall, the frustule. It consists of two overlapping halves, the theca. The upper one is epitheca and lower one is hypotheca.

Both the theca consist of two portions:

(a) Valve — the upper flattened top and

(b) Connecting band or cingulum (pl. cingula) — the incurved region.

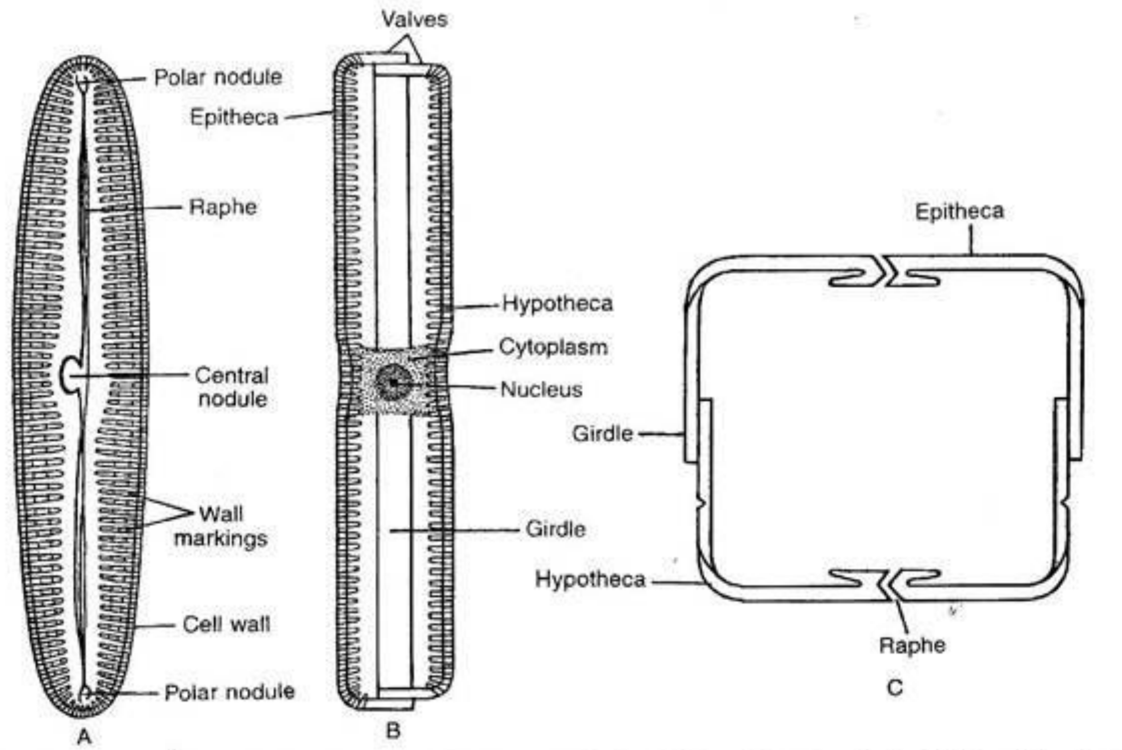


Fig. 3.101 : Cell structure of *Pinnularia viridis* (Pennales) : A. Frustule in valve view, B. Frustule in girdle view, and C. Frustule in transverse section

The common region of the connecting bands, where both the theca remain fitted together, is the girdle. [When the diatoms are observed from the valve side i.e., valve side is uppermost, called the valve view, but when viewed from the connecting band, it is the girdle view]. Depending on symmetry, the cells are divided into two orders: Pennales (bilaterally symmetry) and Centrales (radially symmetry).

In some pinnate diatoms (Cybella cistula, Pinnularia viridis etc.) an elongated slit is present on their valves, called raphe. The raphe is interrupted at its midpoint by thickening of the wall called central nodule. Similar thickening is also present at the ends called polar nodules. Some members like Tabellaria fenestrate etc. of the order Pennales, do not have raphe, called pseudoraphe.

Besides raphe or pseudoraphe, the cell walls have other types of openings, called pores and locules.

Based on electron microscopic studies, Hendey (1971) observed four basic types of secondary structures. These are: Punctae (small perforations on valve surface), Canaliculi (tubelike narrow channels which run through the valve surface), Areolae (large boxlike depressions) and Costae (riblike structures on the valve surface).

The cell wall is mainly made up of pectic substances, impregnated with silica. The content of silica varies from 1% (Phaeodactylum tricornutum) to about 50% on the basis of dry weight of the cell.

Protoplast:

The entire content present inside the cell wall is the protoplast. The cell membrane encloses a large central vacuole surrounded by cytoplasm. The cytoplasm contains single nucleus, mitochondria, golgi bodies and chloroplasts. The chloroplasts may be of different shapes like stellate, H-shaped, discoid etc. In some species the chloroplasts contain pyrenoids.

The photosynthetic pigments are chlorophyll a, c_1 and c_2, β-carotene, fucoxanthin, diatoxanthin and diadinoxanthin. The latter two are present in small quantity. (The golden-brown colour of diatom cells is due to the presence of xanthophylls like fucoxanthin, diatoxanthin and diadinoxanthin.

The term diatomin is used for the mixture of chlorophyll and carotenoids, particularly carotene and several brown xanthophylls pigments.) The reserve food of diatoms is chrysolami- narin and oil droplets (they do not store in the form of starch).

Locomotion:

All diatoms with raphe are motile. Most of the members of the order Pennales contain raphe and perform gliding movement. The gliding movement is caused by the circulation of cytoplasm within the raphe by the release of mucilage. The rate of movement varies from 02-25 µm/sec. The locomotion is affected by temperature, light etc.

Reproduction of Diatoms:

Diatom reproduces by vegetative and sexual means.

1. Vegetative Reproduction:

Vegetative reproduction performs with the help of cell division (Fig. 3.102). It takes place usually at midnight or in the early morning.

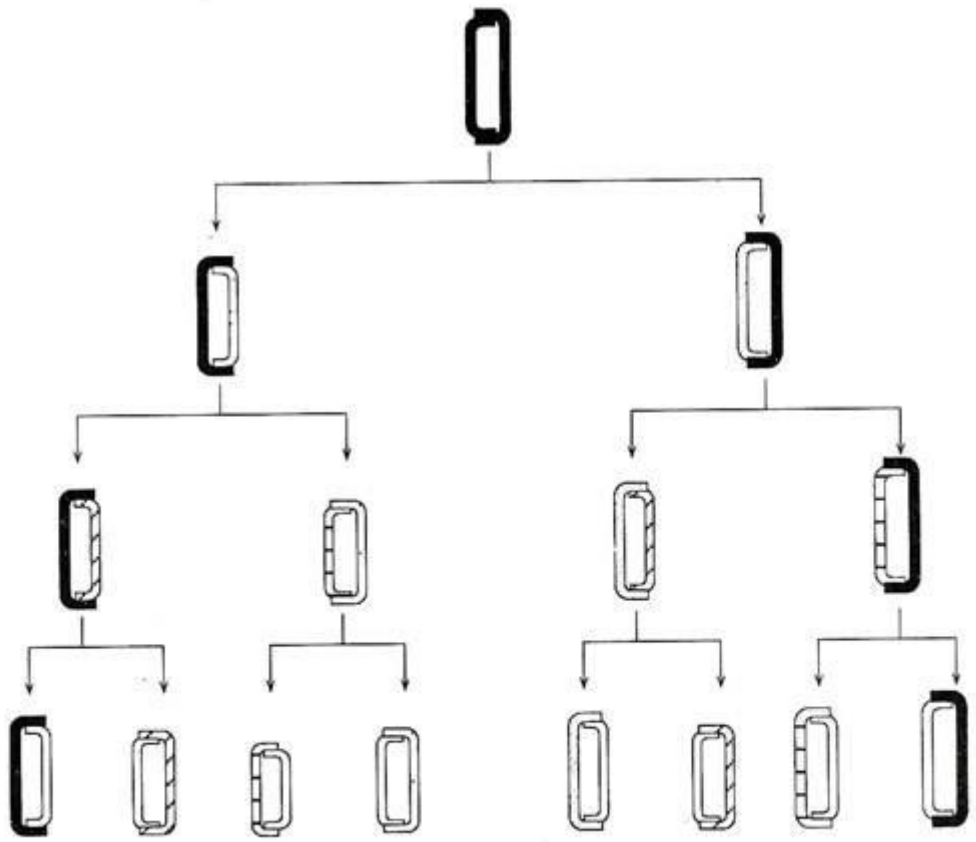


Fig. 3.102 : Cell division in diatoms (diagrammatic) showing reduction in cell size in successive generations except one (extreme right)

During cell division the protoplast of the cell enlarges slightly, thus the cell increases in volume and slightly separates both the theca (epitheca and hypotheca). Then the protoplast undergoes mitotic division and gets separated along the longitudinal axis through the median line.

Thus one half of protoplast remains in epitheca and the other one in hypotheca. One side of the protoplast thus remains naked. Now both the theca i.e., epitheca and hypotheca of mother cell behave as epitheca of the daughter cells.

Thus new silicious valves are deposited towards the naked sides of the protoplast and always behave as hypotheca of the daughter cells. Connecting bands are developed between the theca. Later on, the daughter cells get separated.

During cell division, both the theca i.e., epitheca and hypotheca of the mother cell behave as epitheca of the daughter cells. So at the side where the hypotheca behaves as epitheca, the cell becomes reduced in size. Thus with continuous cell division some cells gradually become reduced in size.

2. Sexual Reproduction:

The pattern of sexual reproduction differs in both orders — Pennales and Centrales. During this process, auxospore is formed in both the groups. During cell division, those cells become reduced in size, are able to regain their normal size through the formation of auxospore, so it is a "restorative process" rather than multiplication.

Auxospore Formation in Pennales:

It takes place through gametic union, autogamy and parthenogenesis.

These are of the following types:

1. Production of one auxospores by two conjugating cells. In this process two uniting cells come very close to each other (Fig. 3.103) and become covered by a mucilaginous sheath. The diploid nucleus of each cell undergoes meiosis.

Out of four nuclei, three degenerate and only one survives. The surviving nucleus behaves as gamete (n). The gametes come out from the parent frustules and unite together, to form a zygote (2n).

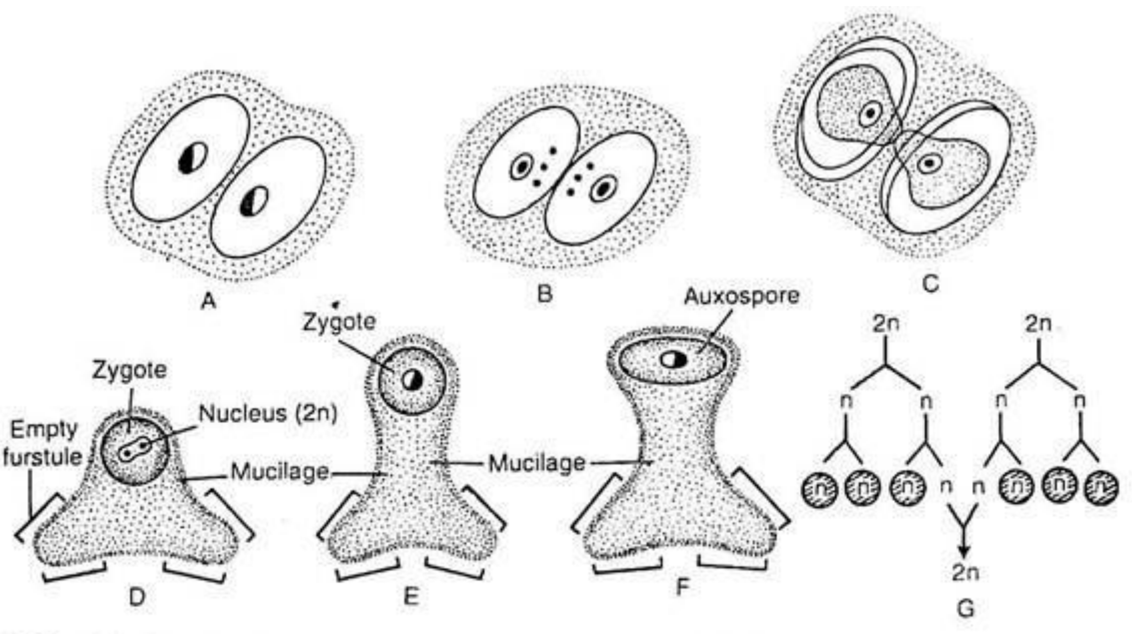


Fig. 3.103 : A-F. Production of one auxospore by two conjugating cells of *Cocconeis placentula*, and G. Nuclear behaviour during reproduction

After a short period of rest the zygote elongates considerably and functions as an auxospore. The auxospore projects out from the parent frustules along with mucilage and elongates in a plane parallel to the long axis of the parent diatom.

The auxospore is enclosed in a pectic membrane, the perizonium. The auxospore then develops new frustule inside the perizonium. Thus new diatom cell is formed which regains the normal size. It is found in Cocconis placentula, Surirella saxonica etc.

2. Production of Two Auxospores by Two Conjugating Cells:

This is a very common process of auxospore formation. In this process the conjugating cells come very close to each other and get enclosed by mucilage (Fig. 3.104). The nucleus (2n) of each cell undergoes meiotic division and forms four nuclei.

Out of four nuclei, two degenerate, the rest two survive. The cytoplasm then divides either equally or unequally and along with one nucleus they behave as gametes. Thus two gametes are formed in each cell.

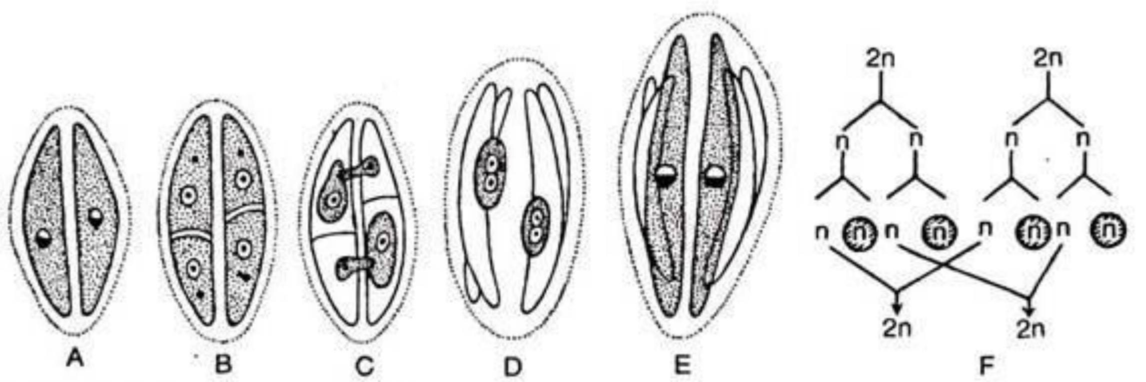


Fig. 3.104 : *Cymbella lanceolata* : A-E. Production of two auxospore by two conjugating individuals, and F. Nuclear behaviour during reproduction

The pattern of union between the gametes varies from species to species. Both the gametes of a cell may be active and fuse with the gametes of other cell, thus two zygotes are produced in a single cell or out of two, one becomes active and fertilises with the opposite one and thus one zygote is produced in each cell.

The zygotes elongate and function as auxo- spores. The auxospores develop the perizonium around themselves and both of them develop new frustules on their outer sides i.e., inside the perizonium. Thus two diatom cells of normal size are formed. It is found in Cymbella lanceolata, Gomphomema parvulum etc.

3. Production of One Auxospore by One Cell:

This process of auxospore formation is called Paedogamy (Pedogamy). In this process the diploid nuclei of a vegetative cell undergo meiosis and form four haploid nuclei. Out of the four nuclei two partially degenerate. Each of the rest two along with the cytoplasm and one partially degenerated nucleus, behaves as gamete. Later on, the union between the two sister gametes takes place and forms the zygote.

The zygote comes out from the parent frustule and behaves as an auxospore. The auxospore then gets covered by perizonium and develops wall inside the perizonium. Thus one diatom cell of normal size is formed.

4. Production of One Auxospore by Autogamy:

In this process the diploid nucleus undergoes first meiotic division. Thus two haploid nuclei are formed. The two nyclei in the protoplast come side by side, fuse together and form diploid (2n) nucleus. This is called autogamous pairing.

The protoplast along with diploid (2n) nucleus comes out from the parent frustule and behaves as an auxospore. The auxospores are then covered by perizonium. New wall develops on the auxospore inner to the perizonium. Thus a new individual of normal size is developed. This is found in Amphora normani.

5. Production of Auxospore by Parthenogenesis:

The diatom cells come together and are covered by a common mucilage envelop (Fig. 3.105). The diploid nucleus undergoes two sequential mitotic divisions. Meiotic division does not take place here. One nucleus in each mitotic division degenerates. Thus only one diploid (2n) nucleus along with protoplast remains, and comes out from the mother cell and behaves as an auxospore.

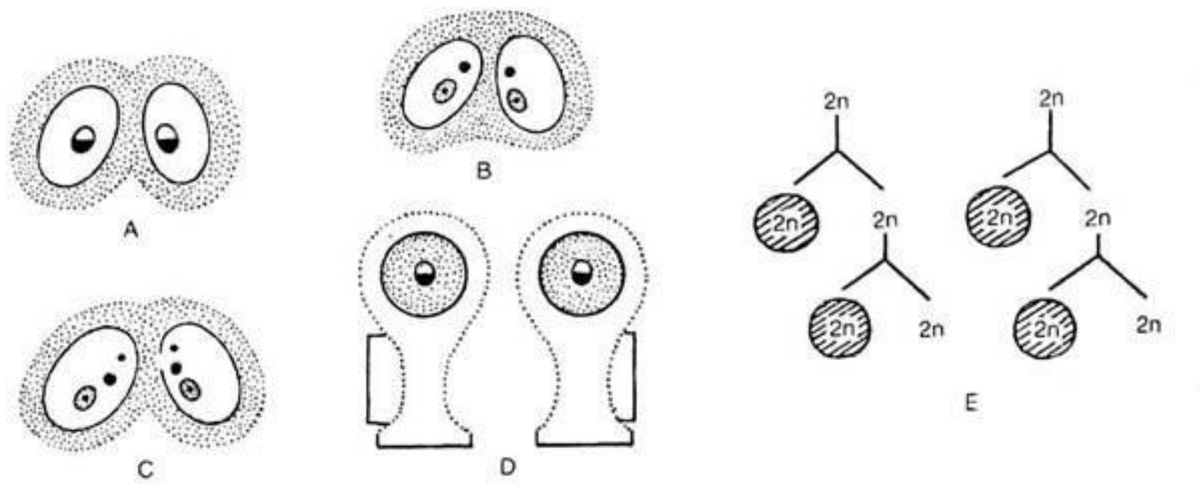


Fig. 3.105 : A-D. Production of auxospore by parthenogenesis in Pennales, and E. Nuclear behaviour during reproduction

The auxospore is then covered by perizonium and secretes new wall around itself. Thus normal size cell is formed.

6. Production of Auxospore by Oogamy:

In this process (Fig. 3.106) the nucleus (2n) of female cell which behaves as oogonium, undergoes meiosis and forms four nuclei. The protoplast is also divided into two unequal parts, each containing two nuclei.

The lower half is larger and behaves as functional ovum and the upper smaller one as non-functional ovum. The functional ovum contains one functional nucleus and one non-functional nucleus, which gradually degenerates at maturity.

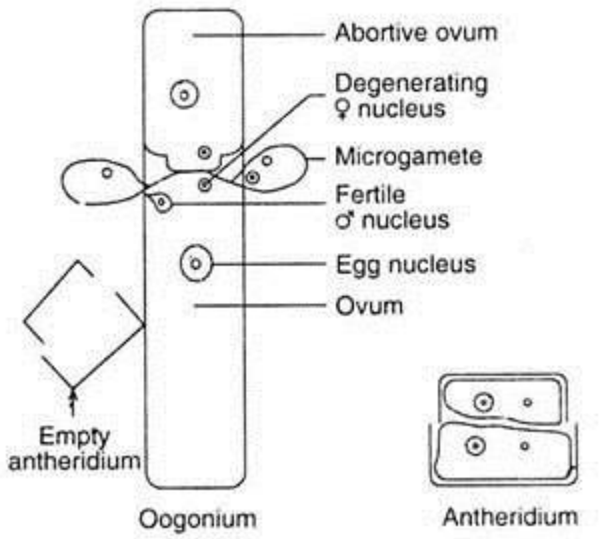


Fig. 3.106 : Production of auxospore by oogamy in Pennales

The male cell (2n) behaves as antheridium, also undergoes meiosis and forms four nuclei. The protoplast also divides into two parts. Thus two microgametes are formed. Each of which contains two nuclei, of which one is functional and other is non-functional. The microgametes are naked, globular and non-flagellate.

After coming out, the male gamete fertilizes the egg and forms the zygote (2n). Later it functions as an auxospore and forms new individual of normal size. It is found in Rhabdonema adriaticum.

Auxospore Formation in Centrales

It takes place by autogamy and oogamy:

1. Auxospore Formation by Autogamy:

The protoplast of the vegetative cell (Fig. 3.107) secretes mucilage which separates both the theca. The nucleus (2n) then undergoes meiosis and forms four nuclei. Of the four nuclei two degenerate and the other two undergo fusion to form diploid (2n) nucleus again.

This is called autogamy. The protoplast with 2n nucleus functions as an auxospore. The auxospore forms fresh frustule inside the perizonium covering and forms cell of normal size. It is found in Melosira nummuloides.

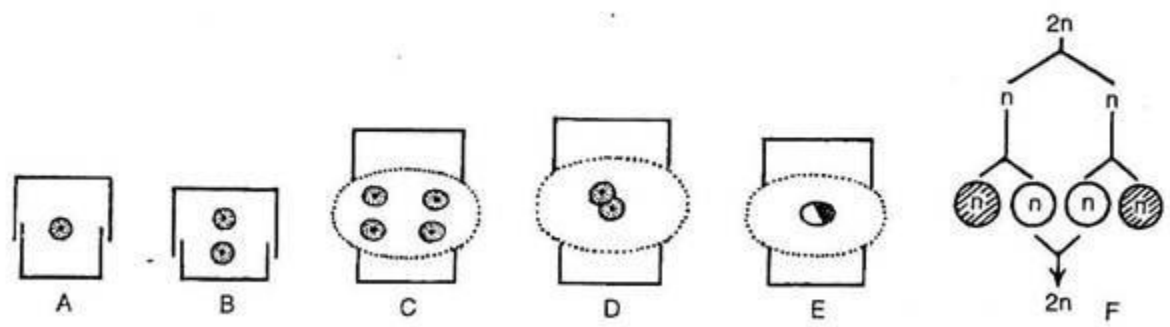


Fig. 3.107 : A-E. Auxospore formation by autogamy in Contrales, and F. Nuclear behaviour during reproduction

2. Auxospore Formation by Oogamy:

Oogamy takes place by the fusion of egg and sperm developed inside the oogonium and antheridium respectively (Fig. 3.108).

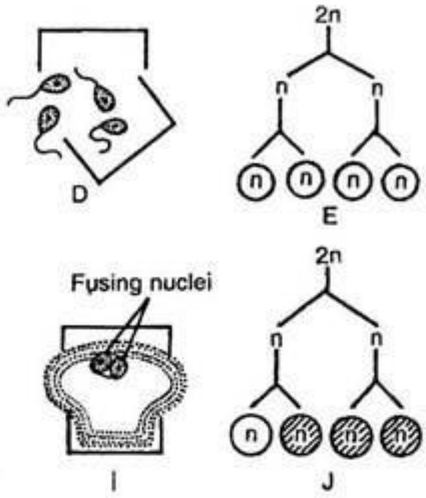


Fig. 3.108 : Auxospore formation by Oogamy in Centrales : A-D. Formation of sperms, E. Nuclear behaviour during sperm formation, F-G. Formation of egg, (F. Single oogonium, G. Sperm approaching oogonium), H. Male nucleus entered inside the oogonium, I. Fusing male and female nuclei and J. Nuclear behaviour during Egg-formation

Oogonium:

Single vegetative cell behaves as an oogonium. The protoplast of oogonium undergoes meiotic division and forms four nuclei. Of the four nuclei three degenerate and the remaining one functions as an egg.

Antheridium:

The pattern of development of sperms varies in different species. In species like Melosira varians the protoplast undergoes meiotic division and forms four haploid nuclei. Each haploid nucleus with some protoplast metamorphoses into an uniflagellate (tinsel type) sperm. In others the number of sperms may go up to 8 or even 128.

Fertilisation:

After coming out of the antheridium only one sperm enters inside the oogonium and fertilises the egg. The resultant zygote undergoes mitotic division but one nucleus degenerates in each division. The remaining nucleus with its protoplast behaves as an auxospore. The auxospore then develops new wall inside the perizonium covering and forms new cell of normal size like the mother. It is also called firstling cell.

From the above processes of sexual reproduction in both pennales and centrales, it becomes clear that the sexual process in diatom does not lead to multiplication but is to regain the normal size.

3. Resting Spores:

These spores are formed during unfavourable conditions. Some members reproduce by the formation of thick-walled resting spores, the cysts or statospores. They are formed in Melosira.

Economic Importance of Diatoms:

The diatoms are used in various purposes either directly or indirectly.

The different uses of diatoms are:

1. Diatomite:

After the death of diatom cells the outer coverings i.e., the silicified walls become accumulated at the bottom of water. The accumulation may be thicker during favourable conditions. These deposits are called diatomaceous earth, diatomite or keiselghur.

It is very suitable for use in different industries:

a. **As Filter:**
b. It is used as filter in different industries like sugar (to filter microorganism), oil and chemical industry. Diatomite is also used as filter for battery boxes.

c. **b. As Insulator:**
d. It is used as insulator in boilers and blast furnaces for its heat- resistant ability.

e. **c. As Absorbent:**
f. It is used as absorbent of liquid nitroglycerine.

g. **d. Other Uses:**
h. Diatomite is used as abrasive (i.e., capable of rubbing or grinding down) substance for the manufacture of metal paints, polish, varnish, toothpaste etc. It is also used with bake-lite for electrical fuse and switch boxes.

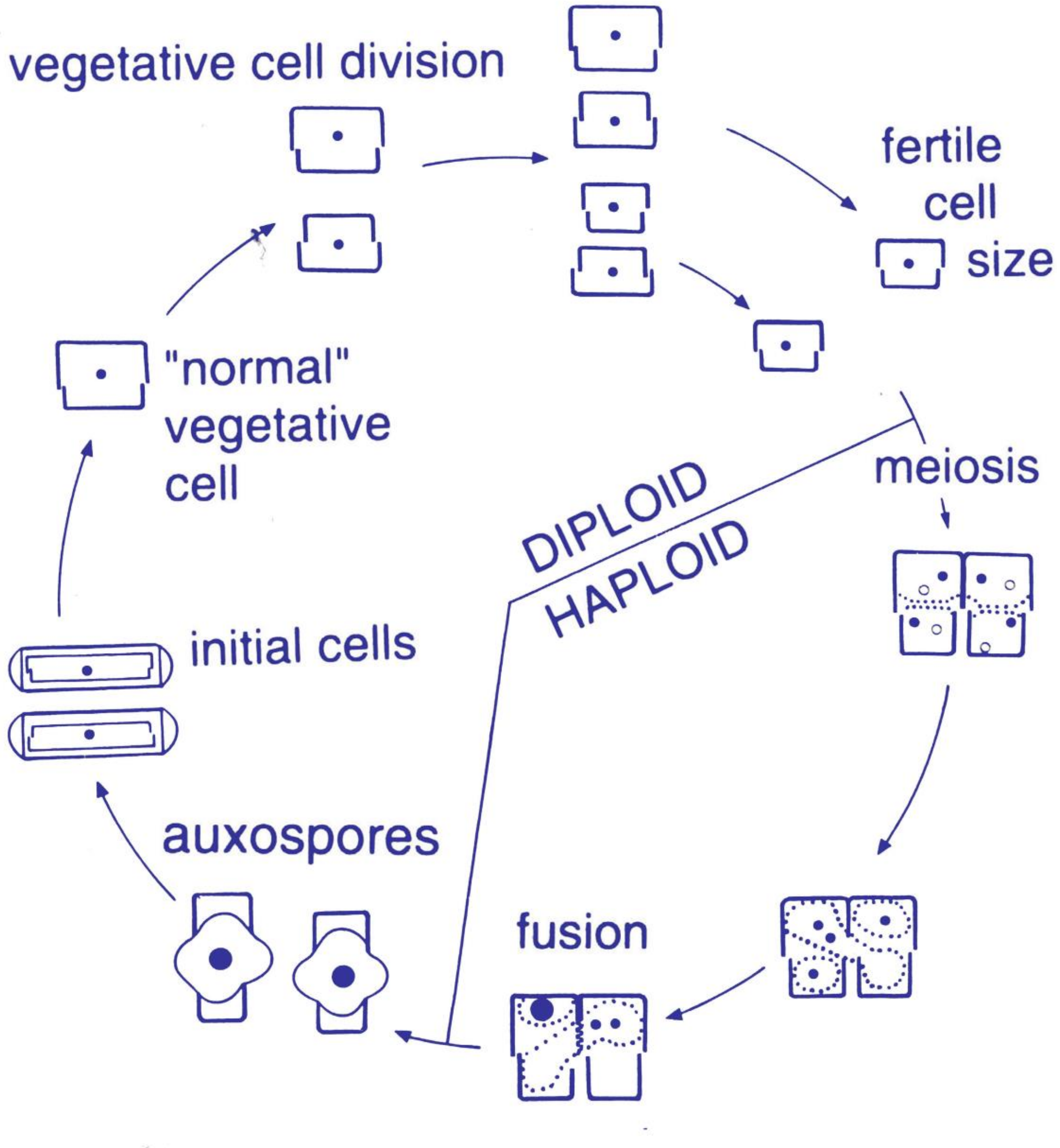
i. **2. Petroleum:**
j. Much of the petroleum is considered to be of diatom origin as they are found in association with large oil deposits.

k. **3. Food:**

l. Due to their great abundance in the different seas and their use as food by marine animals, they are called the ‘grasses of the sea’. Those animals may be consumed as food by man and maintain the food chain.

m. **4. Testing of Microscopic Lenses:**

n. Due to the fine markings on shell, the diatom cells are used to test microscopic lenses



https://upload.wikimedia.org/wikipedia/commons/a/a7/Diatom_pennate_life_cycle.jpg

Dictyota

Classification

Class: Phaeophyceae
Order: Dictyotales

The plant body of *Dictyota* is long, dichotomously branched, flattened, and brown in color. The apical portion of the frond is acute and has an entire margin. The short life cycle (less than 3 months) of *Dictyota* has three overlapping alternation of generations. The gametophyte forms sex organs in the male and female sori; female sori are deep brown, appearing as spots on both sides of the thallus, containing 25–50 oogonia arranged in rows with sterile oogonia at the margins. Each oogonium contains one egg cell, is fertilized externally, and develops to form the sporophyte. Haploid aplanospores or tetraspores are usually produced on mature sporophytes.

It is a ribbon shaped dichotomously branched marine brown alga that grows in shallow waters. Frond is flat, dichotomously branched. The surface of the frond bears hair and unilocular sporangia. Unilocular sporangia produce haploid tetra spores.

Each tetraspore produces haploid gametophytic thallus that is similar in morphology to sporophytic thallus. Sex organs are borne in clusters or sori. Male sex organs or antheridia produce uniflagellate sperms. Fertilization produces diploid zygote which germinates to produce diploid plant body.

Genus DICTYOTA (like a mat)

Occurrence. This genus has about 35 species. They are widely distributed in warm seas of tropics. *Dictyota dichotoma* is common around the coast of Britain growing in the pools between the lines of high and low tides. Usually they remain attached to rocks in tide pools by a basal **holdfast.** It seems likely that light conditions are involved in the case where single tidal periods are involved.

Morphology. The plant body consists of a strap-like thallus ten to twenty cm., long. The thallus branches repeatedly, each division giving rise to two equal branches. This type of branching is known as **dichotomous.** The basal portion of the thallus forms a disc-like branched holdfast by which the thallus remains attached to the solid substrata.

The strap-like thallus consists of rectangular cells arranged in a single layer, with a superficial layer of smaller cells on each side of the thallus. Small tufts of hairs develop from scattered groups of these surface cells. Viewed in transverse section the thallus is seen to be composed of three layers, a central one of large cells and an upper and lower epidermis of small assimilatory cells from where groups of mucilage hairs arise.

Apical growth. The growth is restricted to the ends of branches. There is a large biconvex apical cell on each branch, which cuts off derivatives at its posterior face. Each derivative divides asymmetrically. This division is always in a plane parallel to the surface of the thallus. The larger of the two daughter cells also divides in the same plane asymmetrically. There are no further divisions parallel to the thallus surface and therefore, thallus does not become more than three cells in thickness.

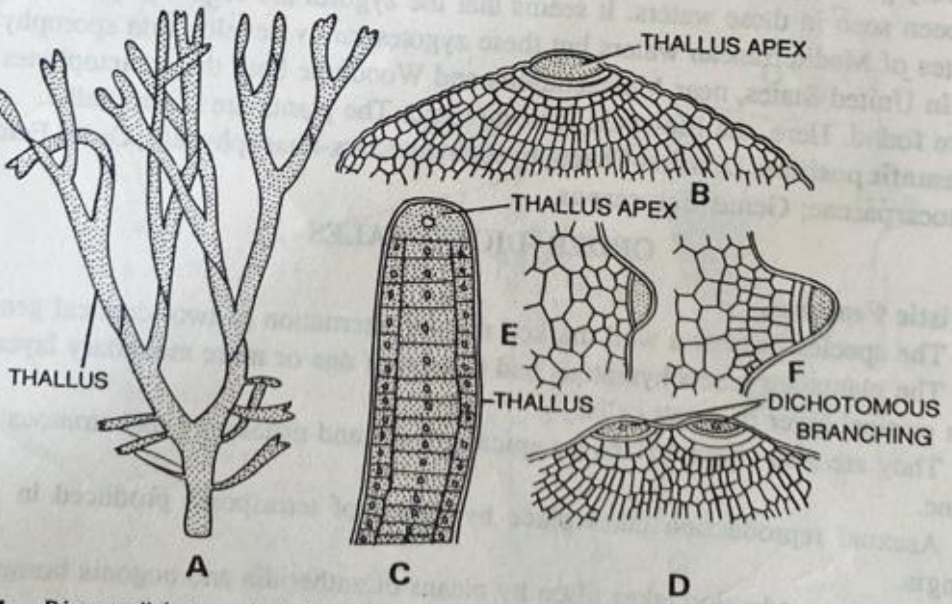


Fig. 7.7. *Dictyota dichotoma*. A, thallus; B, surface view of thallus apex; C, vertical section of thallus apex; D, thallus apex with beginning of dichotomy; E-F, early stages in the formation of lateral adventitious branches.

The thallus branches repeatedly dichotomously. Growth takes place by means of one large apical cell on each branch, which divides vertically into two equal halves when dichotomous branching is about to take place. Each of the two daughter cells functions as an apical cell and cuts off derivatives at its posterior face. After continuous growth the dichotomy becomes distinct.

and the two apical cells become far apart from each other.

Reproduction. The reproduction takes place by vegetative, asexual and sexual methods. They are as follows :

Vegetative reproduction. It takes place by the decay of the older parts resulting in the separation of the branches of the thallus. Each such part develops into a new plant. In certain species gemmae like vegetative structures have also been recorded which develop into new plants after detaching from the parent thallus.

Asexual reproduction. The asexual reproduction takes place by means of **tetraspores** produced within the **tetrasporangia.** The tetrasporangium arises from a superficial cell of the thallus, which grows out into a small globular outgrowth from the thallus. The nucleus enlarges in size and divides meiotically producing four haploid nuclei, simultaneously the cytoplasm divides into four portions. No separation walls are formed and the four haploid non-flagellate spores liberate by a breakdown of the sporangial wall. These non-motile spores are known as tetraspores.

On germination, a tetraspore produces a new *Dictyota* plant which resembles the parent plant from which the tetraspores were developed. Two of the tetraspores produce male plants and two female plants.

Development of tetrasporangia. During development of a tetrasporangium, a superficial thallus cell grows out and elongates vertically two to three times its original height and then divides by a transverse division. The lower cell becomes the stalk cell and does not divide further, while the upper cell enlarges in size forming a rounded sporangium. The single nucleus of young sporangium divides meiotically producing four haploid nuclei. The cytoplasm also divides into four and thus four nonflagellate tetraspores are formed. The aplanospores or tetraspores liberate by an apical rupture of the wall of sporangium. There is segregation of sex at time of meiosis and therefore, two of the tetraspores germinate into male gametophytes and two into female gametophytes (Schreiber, 1935).

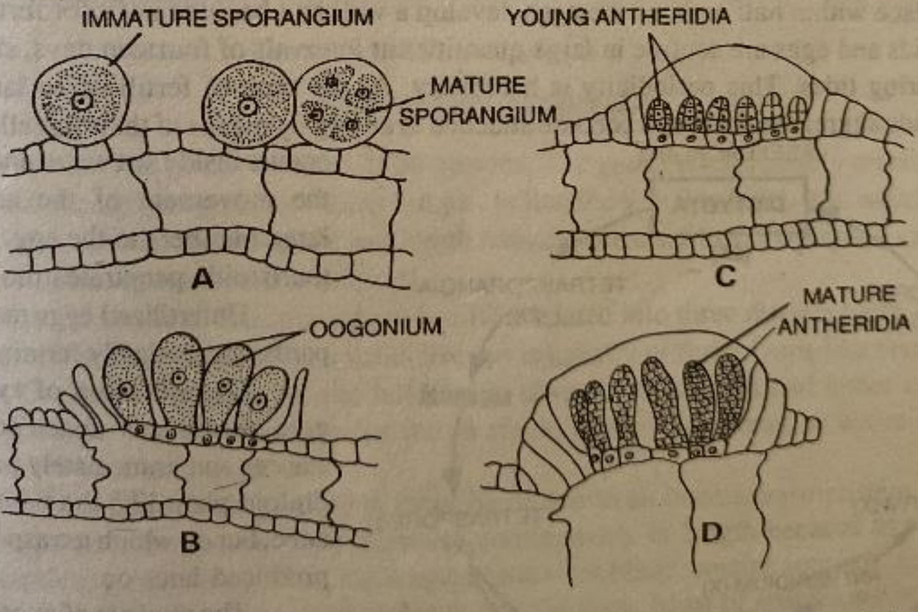
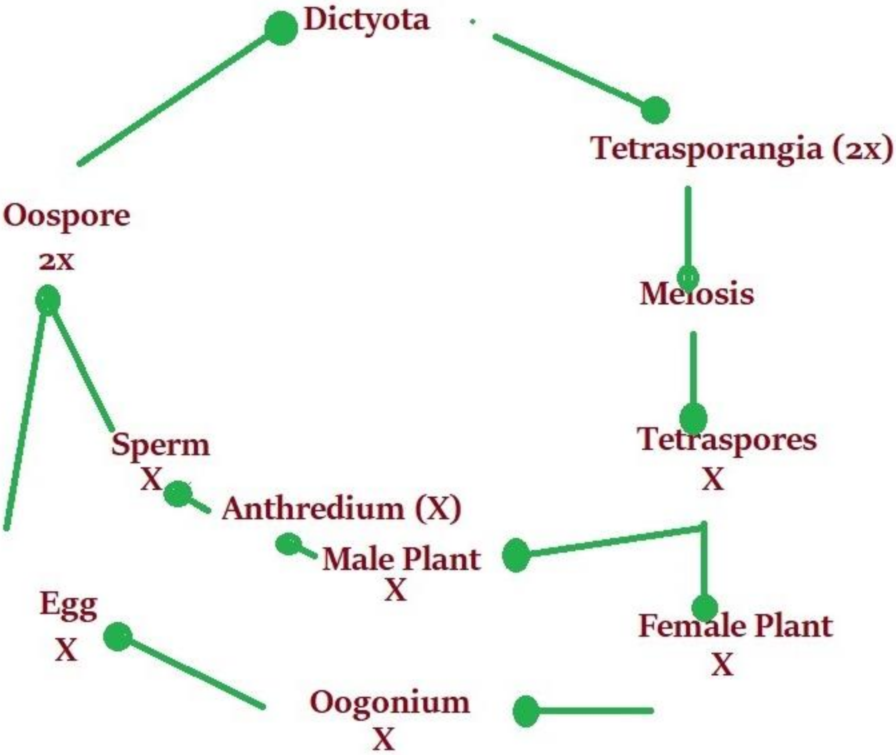


Fig. 7.8. *Dictyota dichotoma*. A transverse section through a portion of sporangial sorus showing immature and mature sporangia; B, transverse section through an oogonial sorus showing oogonia; C, transverse section through antheridial sorus showing young antheridia; D, transverse section through antheridial sorus showing mature antheridia.

Sexual reproduction. The sexual reproduction is oogamous. The sex organs are known as antheridia and oogonia. The antheridia and oogonia are found to be arranged on surface of the


Dictyota
Tetrasporangia (2x)
Meiosis
Tetraspores
X
Female Plant
X
Male Plant
X
Anthredium (X)
Sperm
X
Oospore
2x
Egg
X
Oogonium
X

POLYSIPHONIA

(Rhodophycease)

Occurrence of Polysiphonia:

The genus Polysiphonia (Gr. poly — many; siphon — tube) is represented by more than 150 species, out of which about 16 species are reported from India. They grow in marine habitat and are cosmopolitan in distribution.

Commonly they are found in littoral and sublittoral zones. In India they are found in western and southern coasts. Commonly, they grow as lithophytes i.e., on rocks or stones (e.g., P. elongata), some species like P. urceola, P. terulacea grow as epiphytes on Laminaria. P. fastigiata grows as semiparasite on Ascophyllum nodosum.

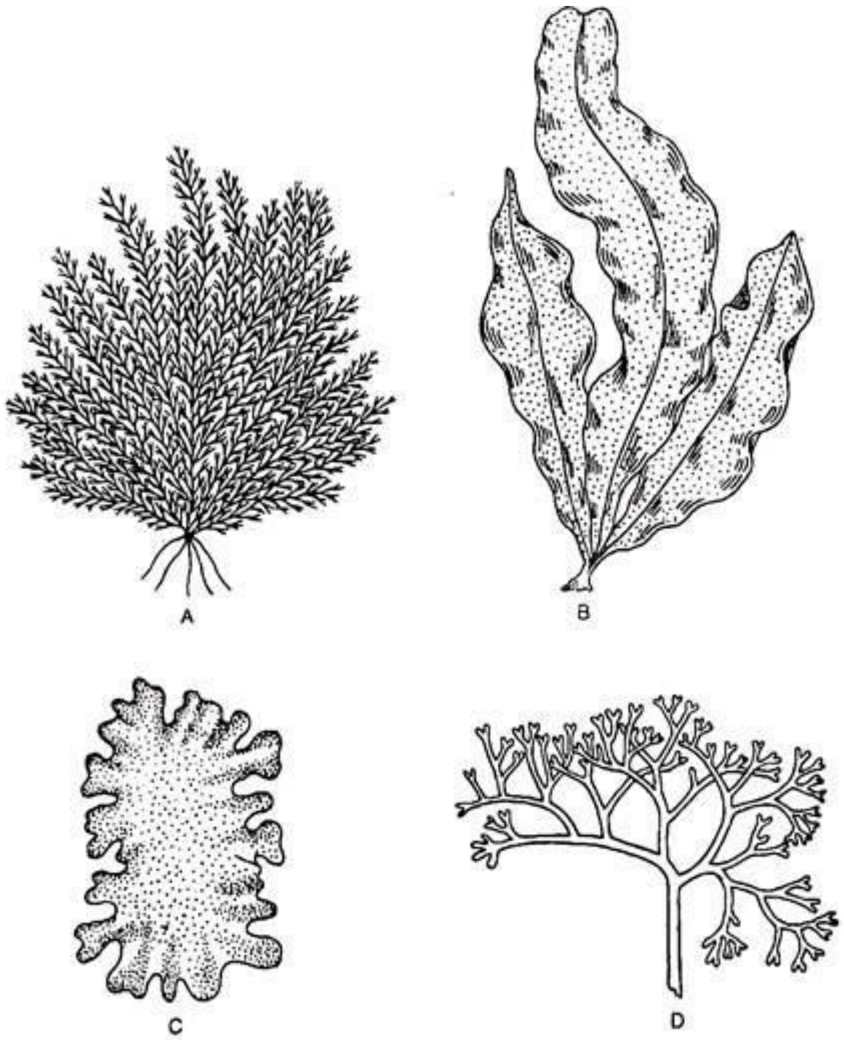


Fig. 3.130 : Types of red algae : A. Feathery thallus of *Polysiphonia*. B. Leaf like thallus of *Grinnellia*, C. Flat thallus of *Porphyra* and D. Branched thallus of *Chondrus*

Plant Body of Polysiphonia:

Plant body is multiaxial well branched thallus of dark brown, reddish or bluish red colouration appearing as a very small bush (Fig. 3.131 A). The height of the bush varies from a few to several centimeters.

Most of the species are heterotrichous in habit, consisting of prostrate and erect systems.

Prostrate System:
It may be multiaxial and well developed. From the lower side of the prostrate system many unicellular rhizoids are developed (Fig. 3.131B, C). The rhizoids are much lobed at the apex and form definite attachment discs (e.g., P. urceolata, P. nigrescens).

[In P. elongata and P. violacea, the prostrate system is absent and many rhizoids develop from the lowermost cells of the erect system and by aggregation they form massive attachment disc (Fig. 3.131C).]

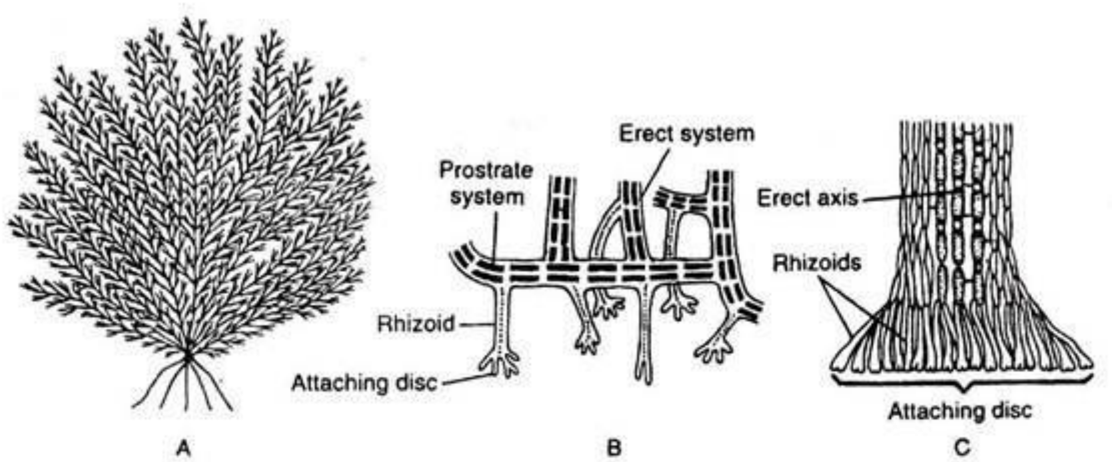


Fig. 3.131 : *Polysiphonia* sp. : A. Habit of Plant body, B. Lower portion of thalus with attaching disc and some erect filament developed on it, and C. Lower portion of *P. violacea* with a massive attaching disc

Erect System:
The erect filaments develop from the prostrate system. The erect system consists of main axis and many branches (Fig. 3.132A). The branches are of two types: long branch and short branch

The long branches are called branches of unlimited growth or long lateral branches and the short branches i.e., branches of limited growth are called trichoblasts. The long branches develop in a spiral or radial symmetry. The trichoblasts are spirally arranged, dichotomously branched, colourless and mostly annual structures bearing sex organs. The trichoblasts may develop both from main axis and long branches.

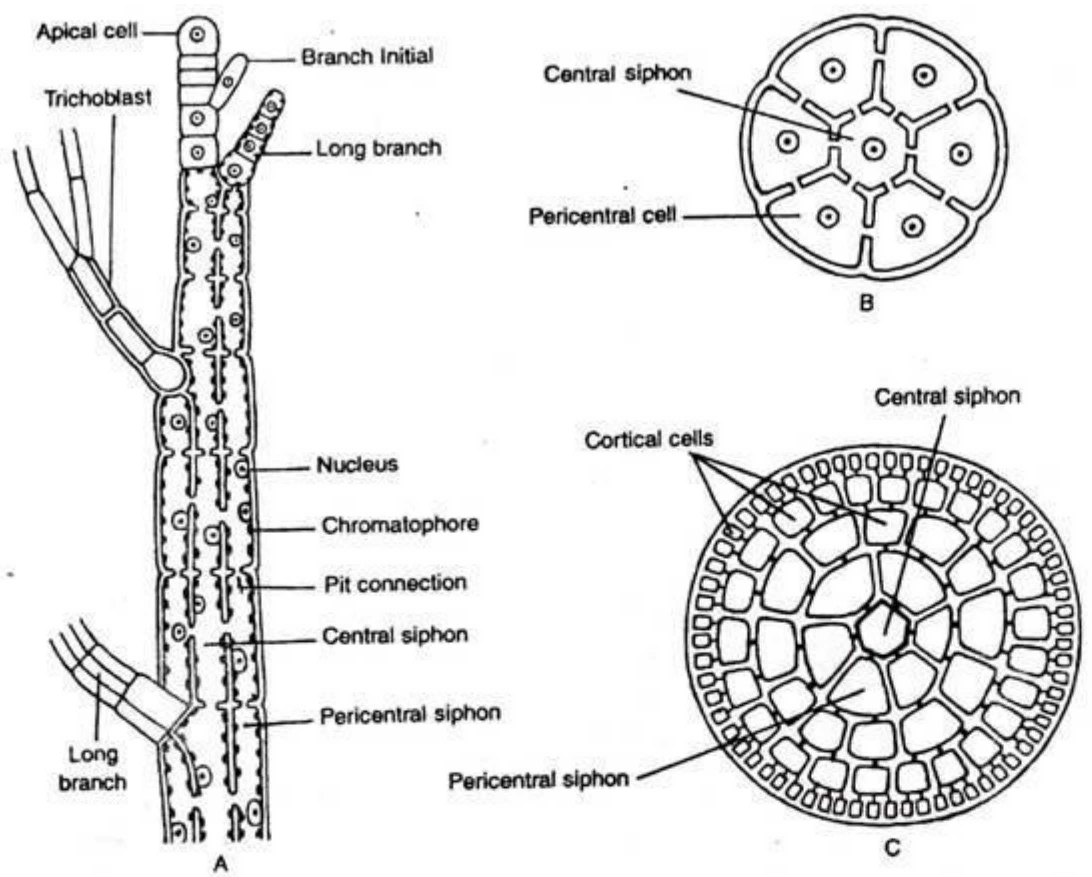


Fig. 3.132 : *Polysiphonia* sp. : A. Apical portion of a plant body showing central siphon, pericentral siphon, long branch and trichoblast, B. T.S. of thallus showing central siphon, surrounded by pericentral cells, and C. T.S. of old thallus showing cortical cells in addition to central and pericentral siphons

The main axis and long branches consist of a central siphon of many elongated cylindrical cells situated in vertical row (Fig. 3.132B, C). It is surrounded by 4-20 peripheral siphons. So the plant body is polysiphonous and named Polysiphonia. Only the central siphon is present at the apical region of both main axis and the long branches.

In most of the species, pericentral siphon is covered by 3 layers of cortical cells formed due to periclinal and anticlinal divisions of the cells of pericentral siphon. All cells of the plant body are connected with each other by pit connections (cytoplasmic connections). The short branches or trichoblasts are monosiphonous.

Cell Structure of Polysiphonia:

The cells have thick wall, differentiated into outer pectic and inner cellulosic layers. The cells are uninucleate with many discoid chromatophores without pyrenoids. Neighbouring cells are connected by pit connections. The cells contain large central vacuole. Reserve food is floridean starch.

Important Features of Polysiphonia:

1. Plant body is polysiphonous.

2. Apical growth takes place by single dome- shaped apical cell.

3. Sexual reproduction is of advanced oogamous type.

4. Post-fertilisation stage is much elaborate.

5. Cystocarp is well-developed.

Reproduction in Polysiphonia:

Polysiphonia reproduces both asexually and sexually. Sexual reproduction is of oogamous type. In the life cycle of Polysiphonia three kinds of plants are recognised.

These are:

1. Diploid tetrasporophyte,

2. Haploid gametophyte, and

3. Diploid carposporophyte (Fig. 3.138).

1. Diploid Tetrasporophyte:

It develops on direct germination of carpospore (2n = 40), thus the plant is diplsid (2n). It is an independent plant which, instead of developing sex organs develops tetrasporangia. The diploid nucleus of tetrasporangia undergoes meiosis and develops four (4) haploid (n = 20) tetraspores.

2. Haploid Gametophyte:

It develops on direct germination of tetraspore (n); thus the independent plant is haploid (n). Most of the species are heterothallic, thus the spermatangia (male sex organ) and carpogonia (female sex organ) are developed on different plants.

3. Diploid Carposporophyte:

This stage is diploid (2n) and dependent on haploid gametophytic plants. The union between haploid (n) spermatium (developed inside spermatangium) and haploid female gamete (developed inside carpogonium) forms diploid (2n) nucleus inside the carpogonium.

Further development of diploid nucleus forms diploid carposporophyte. Later carpospores are formed by mitotic division of carposporangium. The carpospore on direct germination forms diploid tetrasporophyte plant.

Asexual Reproduction:
Asexual reproduction takes place by haploid non-motile tetraspores.

The carpospores (2n) on direct germination develop diploid tetrasporophytic plants. The plants are independent and polysiphonous. Some pericentral cells of the thallus near apical region develop sac-like tetrasporangia. The diploid nucleus of tetrasporangium undergoes meiosis and forms four tetraspores. The spores are arranged tetrahedrally (Fig. 3.133A).

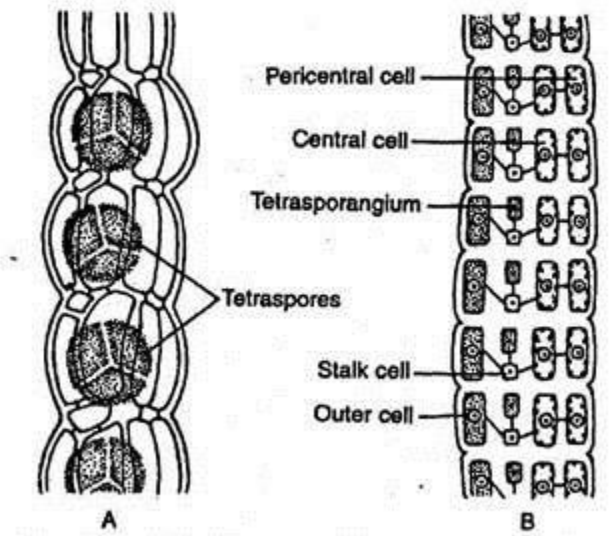


Fig. 3.133 : *Polysiphonia* sp. : A. Portion of tetrasporophytic plant (2n) with tetraspores, and B. Portion of tetrasporophytic plant showing development of tetraspores

Development of Tetraspores:
Tetraspores are produced in tetrasporangia. Single pericentral cell of each tier, towards apical region functions as tetrasporangial initial (Fig. 3.133B). This initial cell is smaller than other pericentral cells of any particular tier. This initial cell divides vertically into inner and outer cells.

The inner cell functions directly into sporangial mother cell and the outer cell further divides and forms two or more cover cells. The sporangial mother cell divides transversely into lower stalk cell and upper tetra- sporangial cell.

The latter undergoes further enlargement and develops into a tetrasporangium. The diploid nucleus of tetrasporangium undergoes meiosis and forms 4 tetraspores or meiospores. The tetraspores are arranged tetrahedrally inside the tetrasporangium.

The mature tetraspores are liberated by rupturing the wall of the sporangium. On germination they develop gametophytic polysiphonous plant. Being heterothallic, out of four tetraspores, two produce male and the remaining two produce female gametophytic plants.

Sexual Reproduction:

Sexual reproduction is of oogamous type. Plants are commonly dioecious. The male sex organs i.e., spermatangia and female sex organs i.e., carpogonia, are developed on male and female plants, respectively.

1. Male Reproductive Organ:

It is called spermatangium or antheridium.

Initially male trichoblast develops as side branch on the plant body (Fig. 3.134A). It becomes branched. In some species both the branches become fertile, but in others only one remains fertile and the rest undergo repeated dichotomy to form dichotomous sterile structure.

The monosiphonous fertile branch(es) of male trichome bears many unicellular and spherical spermatangia. Each spermatangium is a uninucleate structure which produces single spermatium, the male gamete.

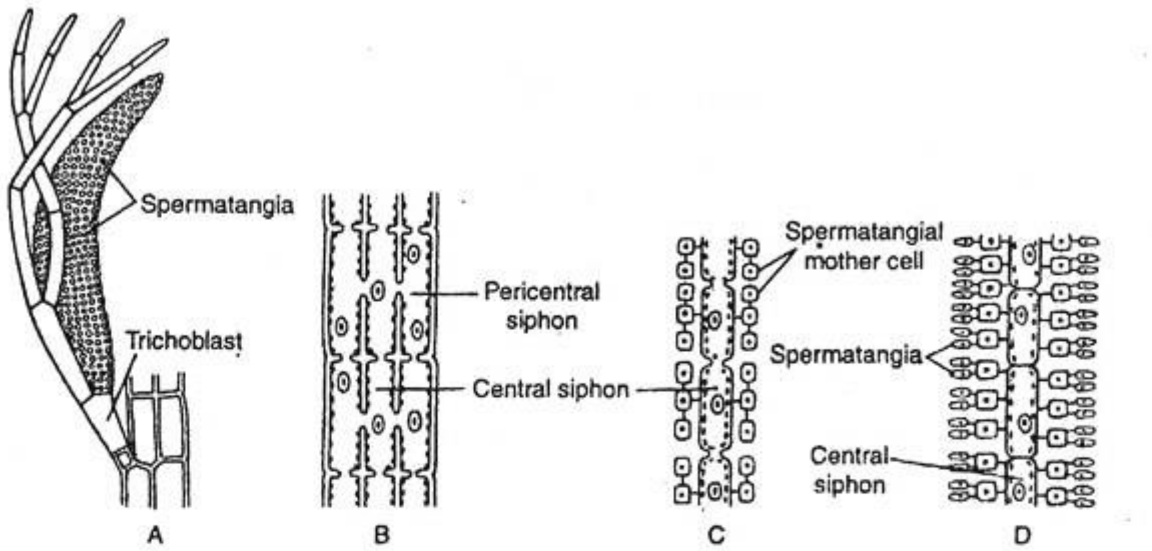


Fig. 3.134 : *Polysiphonia* sp. : Development of male reproductive organ. A. Portion of thallus with antheridial branch, and B-D. Sequential development of spermatangia

During development of spermatangium (Fig. 3.134B-D), all cells except a few basal cells, divide periclinally and form pericentral cells on both the sides. Each pericentral cell undergoes several divisions and forms spermatangial mother cells. Each one cuts off 2-4 unicellular bodies, the spermatangia. Each spermatangium develops into a single non-motile male gamete, the spermatium.

The spermatia are liberated from the spermatangium, through a narrow apical slit on the wall. The spermatia are dispersed through water.

2. Female Reproductive Organ:

The female reproductive organ is called carpogonium.

The carpogonium develops at the top of 2-5 celled carpogonial filament (Fig. 3.135). The carpogonial filament develops on the female trichoblast. The carpogonium is a flask-shaped body, with a basal swollen region containing an egg and an upper elongated neck region, the trichogyne.

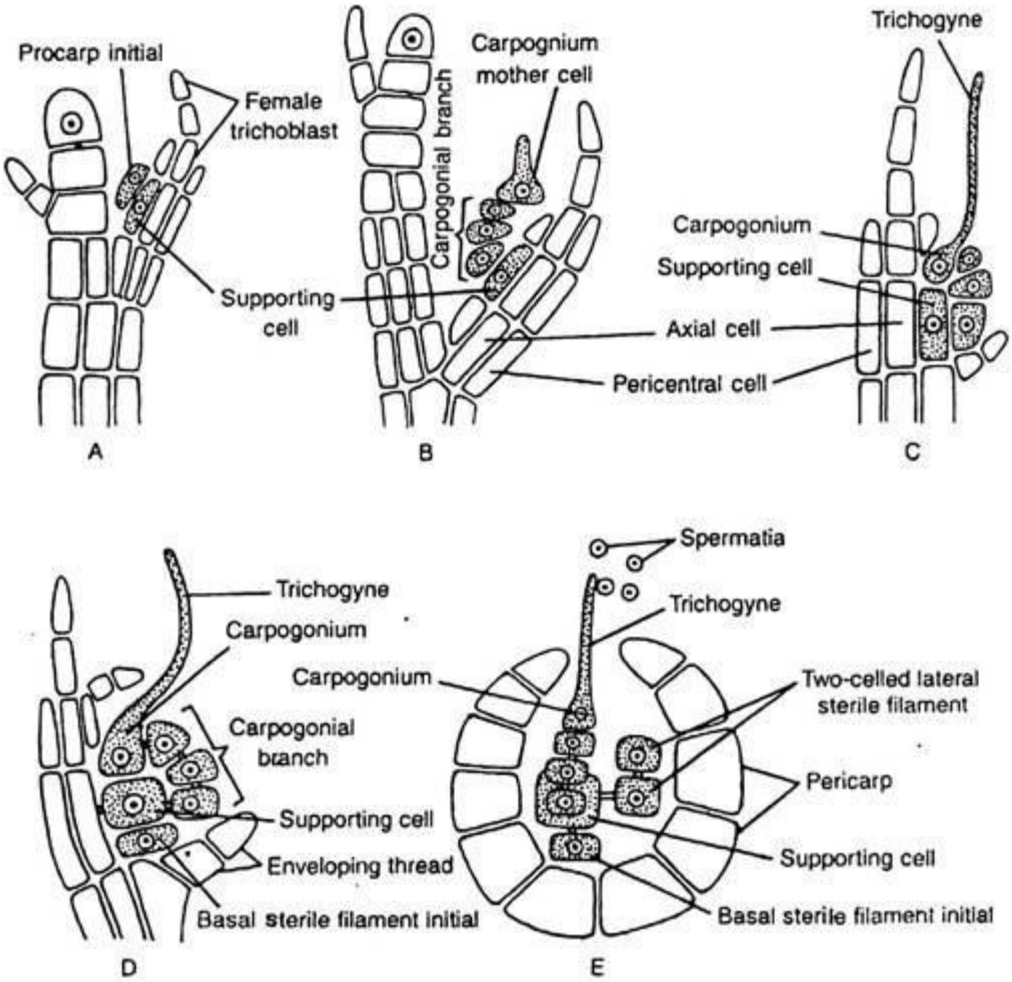


Fig. 3.135 : *Polysiphonia* sp. : A-E, Development of carpogonium

During development of carpogonium, initially a female trichoblast initial is developed on central siphon, a few cells (3-4) below the apical cell. The female trichoblast initial, then undergoes repeated divisions and forms a female trichoblast of 5-7 cells. The lowermost three cells of the female trichoblast divide vertically and form three tiers of pericentral cells.

Any one of the pericentral cells of the middle tier towards the mother axis becomes the supporting cell. The supporting cell cuts off a small initial at its outside, the procarp initial (Fig. 3.135A). The procarp initially undergoes repeated divisions and forms a 4-celled branch, the procarp or carpogonial filament (branch) (Fig. 3.135B).

The apical cell of the carpogonial filament functions as carpogonium mother cell. The cell further develops into a carpogonium. The carpogonium has a swollen basal region containing egg and an elongated tubular region, the trichogyne (Fig. 3.135C).

At the later stage, the carpogonium develops two initials from the supporting cell, one at the base, the basal sterile filament initial (Fig. 3.135D) and another at the lateral side, the lateral sterile filament initial. The lateral sterile initial divides transversely and forms two-celled lateral sterile filament (Fig. 3.135E).

The carpogonium is ready for fertilisation at this stage. The pericentral cell adjacent to the supporting cell starts growing to cover the fertilised carpogonium. Later on they form sheath (the protective covering) around the fruit body, called as pericarp.

Fertilisation:

The spermatia are dispersed with the help of water. A few spermatia become attached at the tip of the. receptive trichogyne. Out of many, only one becomes successful. The common wall of successful spermatium and trichogyne dissolves at the point of contact and the male nucleus passes to the female nucleus present at the base of the carpogonium. The fusion between the nuclei results in the formation of zygote.

Post-Fertilisation Changes:

At the starting of this phase, an auxiliary cell is developed from the supporting cell situated just below the basal region of the carpogonium (Fig. 3.136A). Simultaneously, the lateral,.sterile filament increases in length (4-10 celled) by cell division as well as elongation and the basal sterile initial divides to form a two (2)-celled filament. The auxiliary cell has a single haploid nucleus.

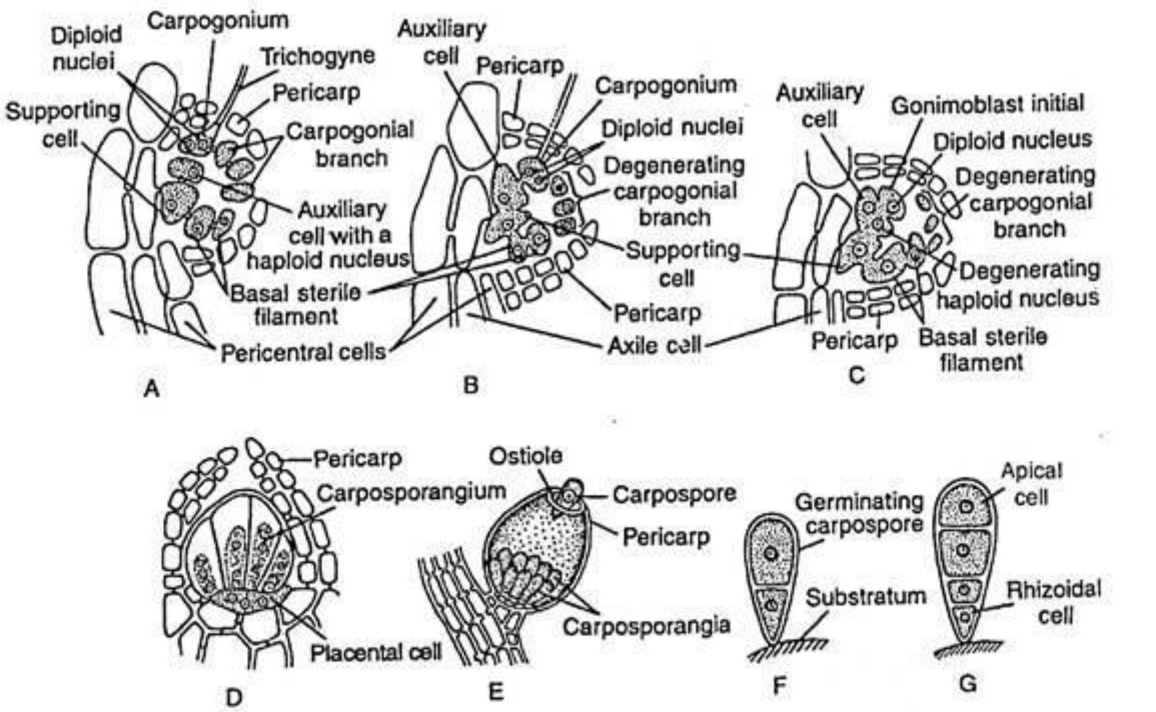


Fig. 3.136 : *Polysiphonia* sp. Post-fertilization changes : A. Fertilised carpogonium, B. Continuity between auxiliary cell and carpogonium, C. Degeneration of carpogonial filament, D. Formation of carposporophyte, E. Liberation of carpospore from mature cystocarp, F & G. Germination of carpospore

A tubular connection is then developed between the auxiliary cell and carpogonium (Fig. 3.136B). The carpogonial nucleus (2n) divides mitotically into two nuclei, of which one is transported to the auxiliary cell and the other one remains in the carpogonium. Thus the auxiliary cell contains one haploid and one migrated diploid nuclei. The haploid nucleus (n) is degenerated. Gradually the trichogyne shrivels (Fig. 3.136B).

Many vegetative filaments then develop from the adjacent vegetative pericentral cells, which gradually develop the total covering. The diploid nucleus of auxiliary cell then divides mitotically and forms two nuclei. One of them then migrates into the outgrowth developed on the auxiliary cell.

This outgrowth after separating by a partition wall forms gonimoblast initial (Fig. 3.136C). In this way many gonimoblast initials can develop on auxiliary cell. Each initial by repeated mitotic divisions forms gonimoblast filament. The terminal cell of the gonimoblast filament develops into carposporangium, which forms single diploid carpospore inside (Fig. 3.136D, E).

During this development the auxiliary cell, supporting cell, carpogonium and some cells of basal and sterile filaments fuse together and form an irregular cell, the placental cell (Fig.

3.136D). The haploid nuclei (n) of the placental cell gradually degenerate and have simply a nutritive function.

The placental cell, gonimoblast filament and carpogonia are covered by many vegetative filaments and form an urn-shaped structure, the cystocarp (Fig. 3.136E, 3.137). The outer covering of cystocarp is called pericarp. The diploid part of the cystocarp represents the carposporophyte. Some cells of basal and sterile filament along with some cells of carpogonial filament gradually degenerate.

The carposporangium develops single diploid carpospore. After liberating from the carpogonium they come out through the ostiole of cysto- carp (Fig. 3.137).

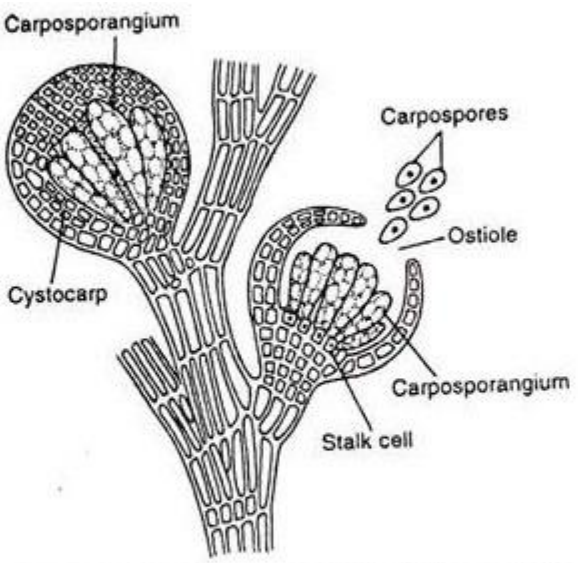


Fig. 3.137 : *Polysiphonia* sp. : A branch bearing cystocarps

Germination of Carpospore:

Coming in contact with any solid surface, the diploid carpospore gets attached and then undergoes first mitotic division and forms large upper and small lower cells (Fig. 3.136F, G). Both the cells undergo mitotic division and form 4 celled stage.

The lower most cell forms the rhizoid, the upper one functions as apical cell and the rest cells undergo further development and form the polysiphonous body. This plant body is diploid i.e., the tetrasporophytic plant, which later develops the tetraspores and complete the cycle.

Life Cycle of Polysiphonia:

Life cycle of Polysiphonia consists of three distinct phases: diploid tetrasporophyte, haploid gametophytes and diploid carposporophyte.

Out of 4 tetraspores produced in tetrasporangia on diploid tetrasporophytic plant, two tetraspores develop haploid (gametophytic) male and other two haploid (gametophytic) female plants. The male gametophytic plants develop male gametes inside spermatangia and female gametophytic plants develop female gametes inside carpogonigia.

Zygote develops inside carpogonium after gametic fusion. With gradual development gonimoblast filament, carposporangia and carpospores are developed inside a composite structure, the cystocarp. It is the carposporophytic stage. Diploid carpospore on germination produces the diploid tetrasporophytic plant again.

Thus the life cycle is triphasic and haplo- diplobiontic type (Fig. 3.138).

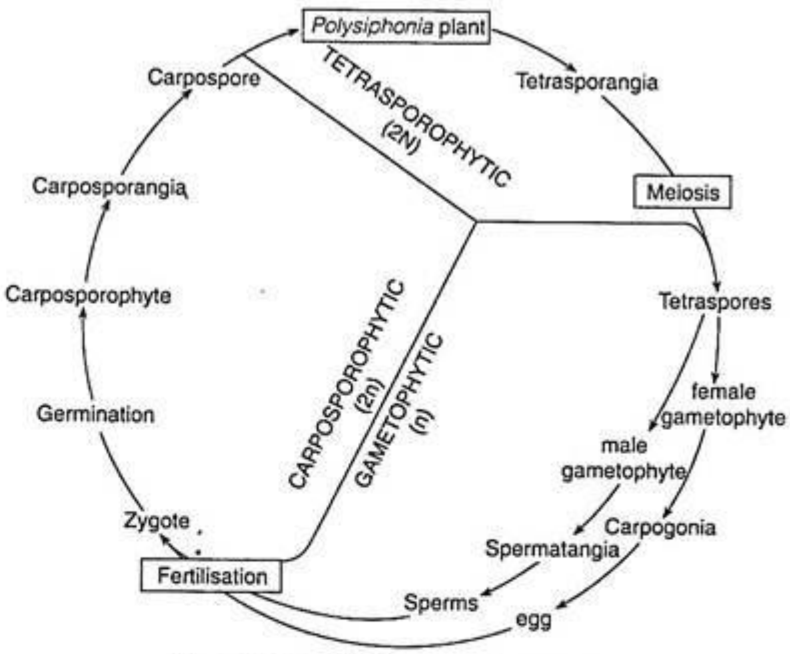


Fig. 3.138 : Graphic life cycle of *Polysiphonia* sp.

Indian Species:

Polysiphonia tuticorinensis, P. sertularioides, P. platicarpa, P. suotilissima, P. unguiformis etc.

ECONOMIC IMPORTANCE OF ALGAE

These eukaryotic marine organisms have no roots, flowers, and stem. It plays important role in alkaline reclaiming which is used as a soil binding agent. They are economically important in a variety of ways which are discussed below:

Alga is a term that includes a large group of eukaryotic, photosynthetic life forms, which are incredibly diverse. These organisms do not share a common ancestor and, therefore, are not interrelated. The habitat distribution of the Algae can be determined by their pigment. Although the majority of the Algae are found in aquatic habitats that might be in freshwater or marine water. They are economically important in a variety of ways which are discussed below:

Food source: Most species of marine algae are edible, such as Porphyra, Sargassum and Laminaria. Chlorella and spirulina are protein-rich. They are thus used as food supplements. These are a healthy source of carbohydrates, fats, proteins, and vitamins A, B, C, and E as well as the minerals like iron, potassium, magnesium, calcium, manganese.

Commercial importance: Agar is used in jelly and ice-cream preparations. Agar is derived from Gracilaria and Gelidium. Carrageenan is used in chocolates, paints, and toothpaste as an emulsifier. Its source is red algae. Algae are also used as liquid fertilizer which helps in the repairing level of nitrogen present in the soil.

Medicines: Lots of red algae like Corallina are used to treat worm infections.

Biological indicator: Water pollution is checked with the help of Algae like Euglena and Chlorella.

Pisciculture: In fish farming, Algae plays a very important role because it helps in the production process. That algae are fruitfully utilized in fish culture can very well be indicated from the successful culture of the Siamese fish, Tilapia mossambica which is voracious feeder of filamentous algae. This particular fish has been successfully introduced in different parts of India. A culture of Scenedesmus is often exclusively used as a daily dose of fish meal for the culture T. mossambica.

Algae Constitute the Link of Food Chain

Algae is Useful in Fish Culture

Algae is Used for Recreational Purposes

Algae is Useful in Sewage Treatment Plants

Algae and Water Supplies

Algae as the Origin of Petroleum and Gas: That algae are fruitfully utilized in fish culture can very well be indicated from the successful culture of the Siamese fish, Tilapia mossambica which is voracious feeder of filamentous algae. This particular fish has been successfully introduced in different parts of India. A culture of Scenedesmus is often exclusively used as a daily dose of fish meal for the culture T. mossambica.

Algae and Limestone Formation

Algae is Used in Space Research and Other Fundamental Studies: In recent years Chlorella is being used in space research. Chlorella has been found very suitable for keeping the air in space vehicles pure on long interplanetary flights. The stale air in which the carbon dioxide has been concentrated is fed into a flood-lit container containing a mixture of water and nutrient chemicals and Chlorella.

The alga restores oxygen into the space vehicle by its photosynthesis. Again species of Chlorella, Chlamydomonas, and Acetabularia are used as tools for solving fundamental biochemical and genetical problems.

Algae is Used as Fodder

Algae is Used as Fertilizers

Algae is Used as Medicine

Industrial Utilization of Algae: **(i) Kelp Industry:**

Industrial utilization of seaweeds in Europe had its principal early development in the production of ‘kelp’, a name that originally referred to the ash, rich in soda and potash, derived from burning marine plants. Kelp production was begun sometimes in the seventeenth century by French peasants and spread to other parts of North-West Europe.

Drift-weeds were first used, but cutting was later resorted to Laminaria and Saccorhiza in North Britain as of major importance.

But Fucus and Ascophyllum were also widely used, and in some areas Himanthalia and Chorda. The kelp ash from these plants was widely bought by early industrialists for use in manufacture of soap, glass and alum. During the eighteenth and early nineteenth centuries the demands became considerable, and enormous quantities of seaweeds were handled in areas of rich algal growth.

Kelp extract contains a number of chemical elements, notably potassium and iodine. About 25 per cent, of the dry weight of kelp is potassium chloride. Many species of kelp are used as food for man, especially in the Orient. In Northern Europe they also serve as food for domestic animals, such as sheep and cattle.

(ii) Algin Industry:

Algin is the general term designating the hydrophilic, or water-loving derivatives of alginic acid. The most commonly known algin is sodium alginate, but other commercially important compounds are the potassium, ammonium, calcium, and propylene glycol alginates, as well as alginic acid itself.

With the exception of alginic acid and calcium, alginate, the algin products offered commercially arc soluble in water to form vis-Sous solutions.

Algin occurs generally throughout the brown algae (Laminaria, Macrocystis, Sargassum and Fucus) as a cell wall constituent. It has remarkable water-absorbing qualities that make it useful in numerous industries in which a thickening, suspending, stabilizing, emulsifying, gel-forming, or film-forming colloid is required.

Thus, algin provides ice cream with a smooth texture by preventing the formation of ice crystals. In automobile polishes it suspends the abrasive; in paints, the pigments; also in pharmaceuticals, the drugs and antibiotics. As a stabilizing agent it serves in the processing of rubber latex .and in the printing of textiles. As an emulsifier it is widely used in such products as water-based paints, French dressings, and cosmetics.

The algin industry has become so important to such a wide variety of industries that extensive survey of kelp-bed ecology is an effort to guard against loss of this important resource. Harvesting methods are now carefully regulated, and a huge amount of money is being spent on kelp-bed research throughout the world.

Experimental studies are continuing on the relation of pollution to kelp survival and on kelp-bed grazing organisms.

(iii) Agar Industry:

The outstanding use of the red algae, however, is in the production of agar. This is a dried and bleached gelatinous extract obtained from red algae—Gelidium nudifrons, G. pusillum, G. robustum, and Gracilaria verrucosa. Agar is used extensively in medicine, chiefly as laxative, since it is not digested and increases greatly in bulk with the absorption of water.

More important than this medicinal utilization is its use as an essential ingredient in the preparation of medium for the growth of bacteria and fungi. As such it is indispensable in bacteriological laboratories, because no adequate substitute for agar is known.

Since the introduction of agar into bacteriology in 1881, the agarphytes have become increasingly industrialized and the technical uses of agar enormously expanded. Modern industry has developed such a multitude of applications that only a fraction of them can be noted here. Large quantities of agar are used as a food adjunct.

Agar serves widely as a substitute for gelatin, as an anti-drying agent in breads and pastry, in improving the slicing quality of cheese, in the preparation of rapid-setting jellies and desserts, and in the manufacture of frozen dairy products. The use of agar in meat and fish canning has greatly expanded, and hundreds of tons are utilized annually.

Agar has proved effective as a temporary preventive for meat and fish in tropical regions, due to the inability of most purifying bacteria to attack it.

Early industrial uses of agar in the Orient included sizing fabric, water-proofing paper and cloth, and making rice paper more durable. Modern industry has refined and expanded these uses to meet new needs in the manufacturing of such items as photographic film, shoe polish, dental impression molds, shaving soaps, and hand lotions.

In the tanning industry agar imparts a gloss and stiffness to finished leather. In the manufacture of electric lamps, a lubricant of graphite and agar is used in drawing the hot tungsten wire.

The increasing applications have called for wide expansion of the collection of agarphytes, and since Japan supplied most of the world’s markets before World War II, when those supplies were cut off, a great amount of hurried research was conducted in an attempt to develop domestic agar supplies not only in the United States, but in South Africa, Australia, New Zealand and Russia.

(iv) Diatomaceous Earth Industry:

The Diatoms are equally important in comparison with other algae that have industrial utilization. Most species of Diatoms are marine, and when these minute plants die, they fall to the sea bottom and, because of their siliceous nature, the cell walls are preserved indefinitely. Great deposits of this material, known as diatomaceous earth, are found in many parts of the world.

The largest beds in the United States, some 1400 feet thick, are in California. The beds are sedimentary deposits originally laid down on the floor of the ocean and later raised above the level of the sea.

Because diatomaceous earth is inert chemically and has unusual physical properties, it has become an important and valuable material in industry. It makes an excellent filtering agent, which is widely used to remove colouring matters from products as diverse as petrol and sugar.

As a poor conductor of heat it is used in soundproofing. It is used in the manufacture of paints and varnishes, of phonograph records, and as a filler for battery boxes. Because of its hardness, it is used as an abrasive in scouring and polishing powders.

Reclaiming Alkaline: Blue-Green Algae helps in the reduction of a high concentration of alkalinity in the soil.

Binding Agent: Algae act as binding agents against natural processes such as erosion.

Biological indicator: Algae are very sensitive. If there is a slight change in the environment their pigments changes or might get died. Water pollution is checked with the help of Algae like **Euglena and Chlorella**.

FOSSIL ALAGE

Stromatolites the oldest known Fossil algae stating that approximately more than 3 million years. They are in the form of colonial structure formed by photosynthesizing cyanobacteria and other microbes. Cyanobacteria are prokaryotes which are primitive organisms. Stromatolites in freshwater environment. They are chlorophyllous having simple thallus body They are responsible for the changing of the Earth atmosphere. They are dominated as the primary life on earth over 2 million years. Presently stromatolites nearly extinct.

The Fossil algae originated from the lower plant variety of algae some are green and some have brown red are blue colour. They are unicellular or multicellular non filament filament and branch branch microscopic structures. They are formed in the PROTEROZOIC ROCKS and perfectly preserved in the precambrian rocks.

Algae are important group of fossils typically studied under microscope because they are very small and tend to break up into small fragments two main types of algae exist in the Fossil record as Rock Builders the red algae and the green algae. These two groups are responsible for producing large volume of carbonate sediment which is deposited on the sea floor and later become limestone.

The devonian period was rich in red algae but was not ugly lacking in green algae compared to other times in the geologic record. Both Red and Green algae tend to be most successful in warm Clear Water ecosystem typically within the photic zone. Devonian red algae are commonly found as interesting organisms in research deposits alongside Stromatophoroides.

The origin of the promo fight and they remained unknown the Crypto are and Revolutionary any there is no Fossil records available the Fossil record for the algae is not nearly as complete as it is for land plants and animals red algae fossils are the oldest known algal Fossil microscope experiment algae that resembles the living genus Porphyridium are known from North America. That resemble modern tetraspores are also known from Australia the best characterized fossils are the coralline red algae representative in Fossil with since the precambrian time. Fossil dinophyceae date from the silurian period the Chromaphyta have the shortest Fossil history among the major algae groups the oldest Chromophyta brown algae are approximately 400 million years old. The Chrysophyceae, bacillariophyceae and Dictyochophycease dates from hndred million a year ago. Most species become extinct in cretaceous period.