

# **BOTANY**

## **Lab Manual**

***BSc.-I Medical***

**Semester I**

## Syllabus

### Botany I-A

**Algae:** General characters, classification and economic importance, important features and life history of Chlorophyceae–*Volvox*, *Oedogonium*, *Coleochaete*, Xanthophyceae–*Vaucheria*; Phaeophyceae–*Ectocarpus*, *Sargassum*; Rhodophyceae–*Polysiphonia*.

**Viruses, Bacteria and Fungi:** General account of viruses and mycoplasma; bacteria–structure, nutrition, reproduction and economic importance; general account cyanobacteria. General characters, classification and economic importance of Fungi. Important features and life history of Mastigomycotina–*Pythium*, *Phytophthora*; Zygomycotina–*Mucor*, Ascomycotina–*Saccharomyces*, *Eurotium*, *Chaetomium*. *Peziza*; Basidiomycotina–*Puccinia*, *Agaricus*; Deuteromycotina–*Cercospora*, *Colletotrichum*; general account of Lichens.

### Botany I-B

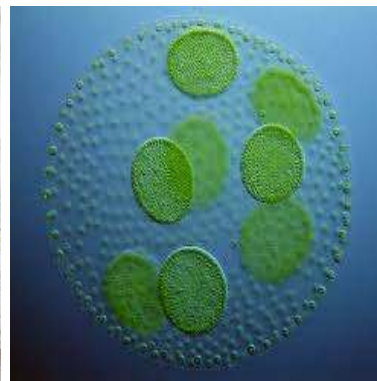
**Bryophyta:** Amphibians of plants kingdom displaying alternation of generations; structure, reproduction and classification of Hepaticopsida (e.g. *Marchantia*); Anthocerotopsida (e.g. *Anthoceros*), Bryopsida (e.g. *Funaria*).

**Pteridophyta:** The first vascular plant; important characteristics of Psilopsida, Lycopsida, Sphenopsida and Pteropsida; structure, reproduction in *Rhynia*, *Lycopodium* *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*.

## 1. Algae

### 1.1. General Information

1. Algae are a very large and diverse group of eukaryotic organisms, ranging from unicellular genera such as *Chlorella* and the diatoms to multicellular forms such as the giant kelp. Most are autotrophic and lack many of the distinct cell and tissue types found in land plants such as stomata, xylem and phloem.
2. There is no generally accepted definition of algae. One definition is that algae "have chlorophyll as their primary photosynthetic pigment and lack a sterile covering of cells around their reproductive cells". Other authors exclude all prokaryotes and thus do not consider cyanobacteria (blue-green algae) as algae.
3. Algae constitute a polyphyletic group. They exhibit a wide range of reproductive strategies, from simple asexual cell division to complex forms of sexual reproduction.
4. Algae can be grown using water resources such as brackish, sea and wastewater unsuitable for cultivating agricultural crops. When using wastewater, such as municipal, animal and even some industrial runoff, they can help in its treatment and purification, while benefiting from using the nutrients present.
5. Most microalgae grow through photosynthesis – by converting sunlight, CO<sub>2</sub> and a few nutrients, including nitrogen and phosphorous, into material known as biomass This is called "autotrophic" growth. Other algae can grow in the dark using sugar or starch (called "heterotrophic" growth), or even combine both growth modes (called "mixotrophic" growth).



## 1.2. Algae Classification

The classification of algae into taxonomic groups is based upon the same rules that are used for the classification of land plants, but the organization of groups of algae above the order level has changed substantially since 1960. Research using electron microscopes has demonstrated differences in features, such as the flagellar apparatus, cell division process, and organelle structure and function that are important in the classification of algae. Similarities and differences among algal, fungal, and protozoan groups have led scientists to propose major taxonomic changes, and these changes are continuing.

The classes are distinguished by the structure of flagellate cells (e.g., scales, angle of flagellar insertion, microtubular roots, and striated roots), the nuclear division process (mitosis), the cytoplasmic division process (cytokinesis), and the cell covering. Many scientists combine the Micromonadophyceae with the Pleurostrophyceae, naming the combined group the Prasinophyceae. “Phylum” and “division” represent the same level of organization; the former is the zoological term, the latter is the botanical term.

S.No	Taxonomic Group	Chlorophyll	Carotenoids	Bilo proteins	Storage products	Flagellation & Cell structure
1.	Bacillariophyta	a, c	β-carotene ± -carotene rarely fucoxanthin..		Chrysolaminarin oils	1- apical flagellum in male gametes: cell in two halves with elaborate markings.
2.	Chloro phycophyta (green algae)	a, b	β-carotene, ± -carotene rarely carotene and lycopene, lutein.		Starch, oils	1,2,4 to many, equal, apical or subapical flagella.

3.	Chrysophycophyta (golden algae)	a, c ,	$\beta$ -carotene, fucoxanthin		Chrysolaminarin oils	1 or 2 unequal, apical flagella, in some, cell surface covered by characteristic scales.
4.	Cyanobacteria (blue green algae)	a,c	$\beta$ -carotene, phycobilins			
5.	Phaeo- phycomphyta (brown algae)	a,c	$\beta$ -carotene, $\pm$ fucoxanthin, violaxanthin		Laminarin, soluble carbohydrates, oils	2 lateral flagella
6.	Dinophyta (dinoflagellates)	a,c	$\beta$ -carotene, peridinin, neoperididin dinoxanthin, neodinoxanthin.		Starch, oils	2 lateral, 1 trailing, 1 girdling flagellum, in most, there is a longitudinal and transverse furrow and angular plates.
7.	Rhodo- phycomphyta (red algae )	a, rarely d	$\beta$ -carotene, zeaxanthin $\pm \beta$ carotene	Phyco- erythrin phyco- cyanin	Floridean starch oils	Flagella absent

## Division - Chlorophyta

The green algae are a diverse group of eukaryotic organisms classified in the phylum Chlorophyta. They are considered eukaryotic because individual cells possess a prominent structural feature known as a nucleus, which houses the chemicals responsible for heredity and metabolic regulation. The phylum is one of several algal phyla in the kingdom Protista, where algae are grouped based upon pigmentation, carbohydrate storage reserves, and cell wall composition. Green algae are found in moist soils and fresh-water and saltwater habitats; most are believed to be freshwater-dwelling. The phylum consists of at least eight thousand species. Some estimates place this number at seventeen thousand species. Several shared characteristics support the hypothesis that these organisms and terrestrial plants derived from a common ancestor.

Phylum	Pigment	Photosynthetic product(s)	Cell wall	Flagellum	Cell nucleus	Form	Note
Green algae (Chlorophyta)	chlorophyll a and b, $\alpha$ , $\beta$ -carotene, lutein	starch	cellulose	biflagellate; equal in length; apical	Yes	unicellular, colonies or multicellular	Widely distributed; both terrestrial and marine, ca. 1,200 species worldwide.

### Members to be studied:

1. *Volvox*
2. *Coleochaete*
3. *Oedogonium*



## 1. Volvox

### A. Classification

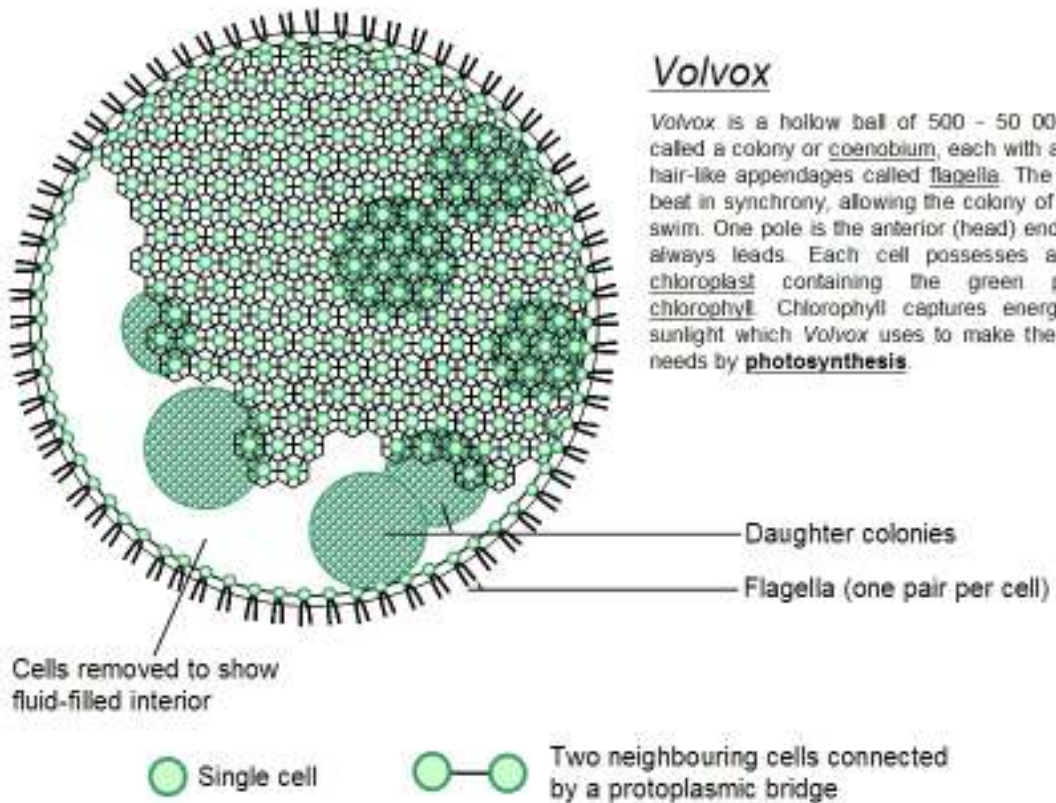
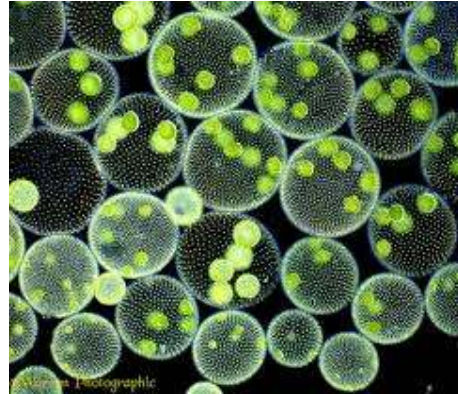
Division: Chlorophyta

Class : Chlorophyceae

Order : Volvocales

Family : Sphaerellaceae

Genus : *Volvox*

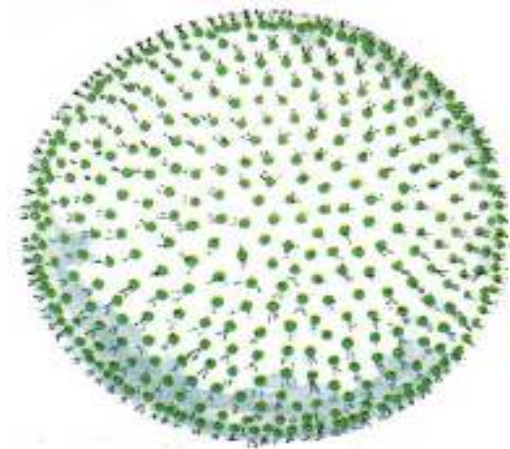


## Specimen to be studied:

### **Volvox Coenobium**

- Each mature Volvox colony is composed of numerous flagellate cells similar to Chlamydomonas, up to 50,000 embedded in the surface of a hollow sphere or coenobium.

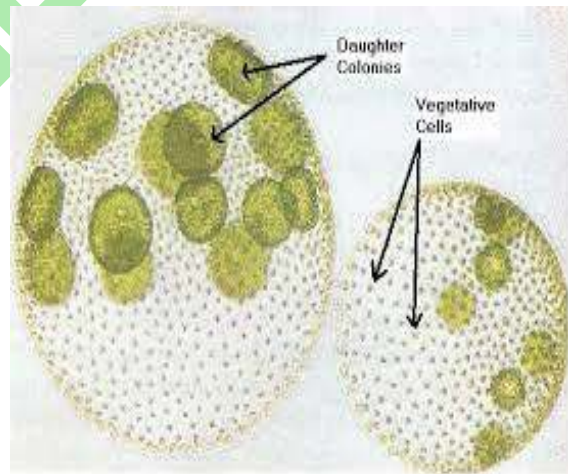
- The vegetative cells comprise a single layer with the flagella facing outward. The cells swim in a coordinated fashion, with distinct anterior and posterior poles. The cells have eyespots, more developed near the anterior, which enable the colony to swim towards light. - The individual algae in some species are interconnected by thin strands of cytoplasm, called protoplasmates.



### **Daughter Colonies**

- Once the young coenobium attains maturity, a few cells in the posterior half are pushed back into the hollow cavity. These cells withdraw their flagella and increase in size and become round in shape. These are called Gonidia.

- The protoplasm of each gonidia divides by successive longitudinal and horizontal divisions and form daughter coenobium.





## 2. *Coleochaete*

### A. Classification

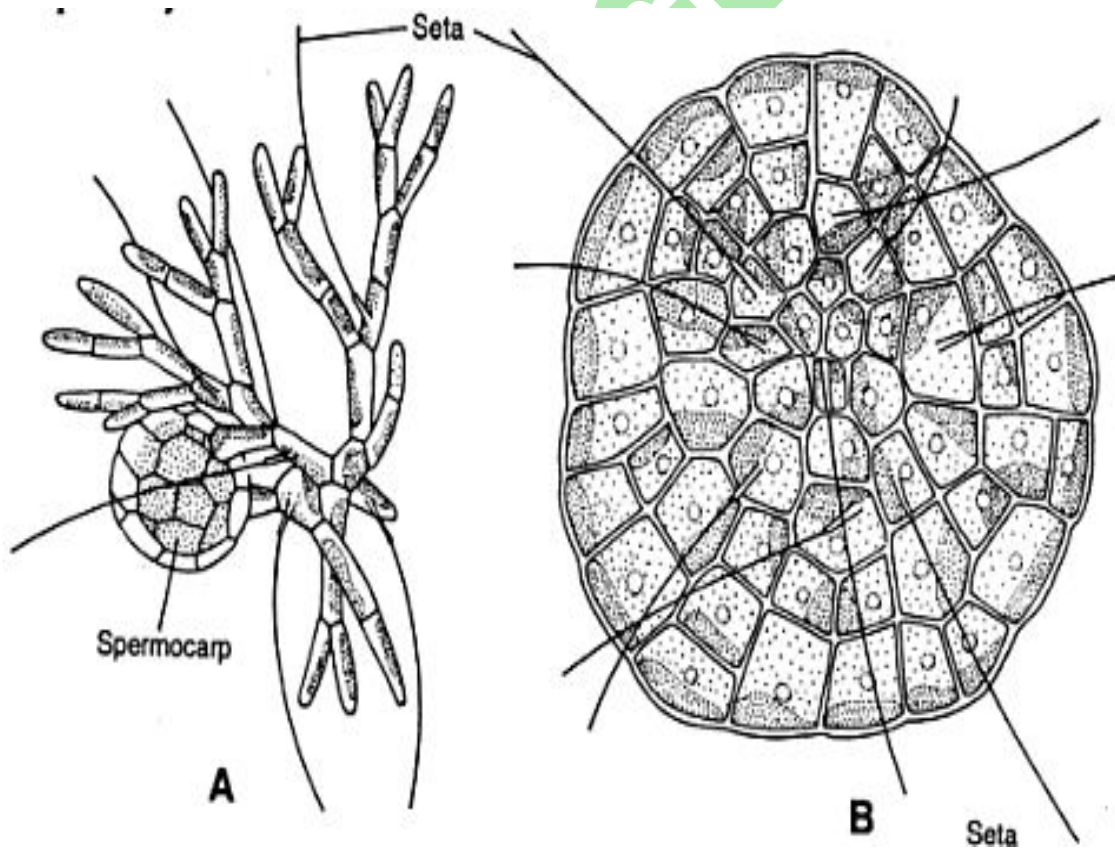
Division: Chlorophyta

Class : Chlorophyceae

Order : Chaetophorales

Family : Coleochaetaceae

Genus : *Coleochaete*

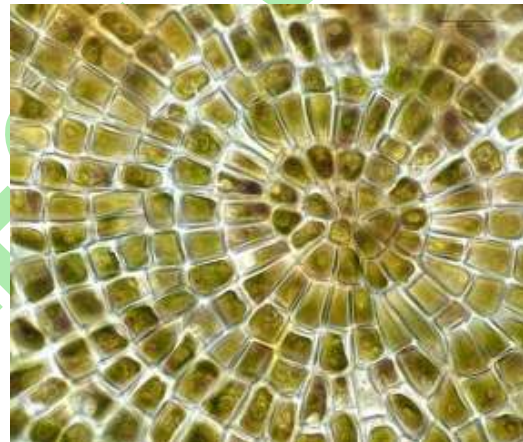


## Specimen to be studied:

### *Coleochaete* Heterotrichous Habit

Prepare a slide by first isolating a discoid or cushionoid thallus from aquatic weed by scratching out the thallus with needle. Stain it with safranin, wash with water and then mount in glycerine. Study the structure of thallus and also a cell.

1. Thallus is multicellular and **heterotrichous**.
2. It is either a disc-like structure in majority of the species (e.g. *C. scutata*) or cushionoid or filamentous (e.g. *C. pulvinata*) in others.
3. If thallus is disc-like, the disc represents only the prostrate system while a few setae or hair, represent erect system.
4. Filamentous thallus exhibits typical **heterotrichous habit** with a branched prostrate system and a branched projecting (erect) system.
5. In both the cases a few cells possess a cytoplasmic outgrowth—setae. Setae are surrounded partly or wholly by a gelatinous sheath at the base.
6. The thallus is distinctly enveloped by a gelatinous sheath or mucilage.
7. In discoid species cells of the thallus are joined end to end to form branches. These branches are laterally apposed to one another to form a pseudoparenchymatous disc.



### *Coleochaete* spermocarp

- After fertilization, the zygote which remains inside the oogonium, increases in size and secretes a thick wall around itself to become a oospore.

- At the same time there is an up growth of branches from the cell below the oospore and from the neighbouring cells to form a parenchymatous layer that completely encloses the oogonium. It later on becomes reddish brown and is termed spermocarp.

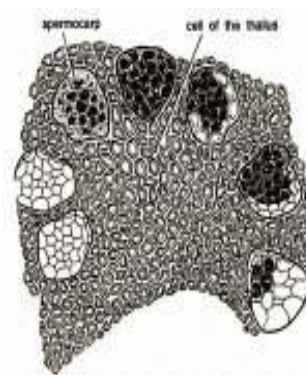
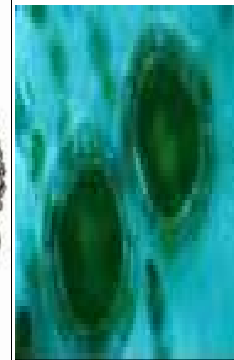


Fig. 4. *Coleochaete* sp. Thallus with spermocarp.



### 3. *Oedogonium*

#### A. Classification

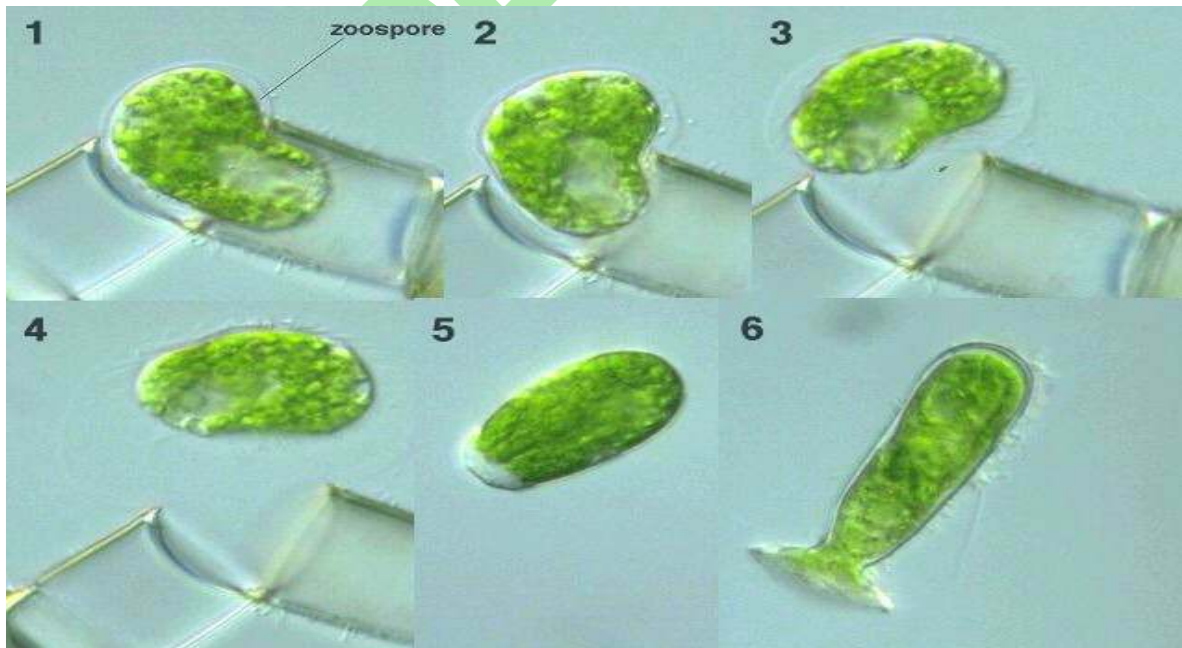
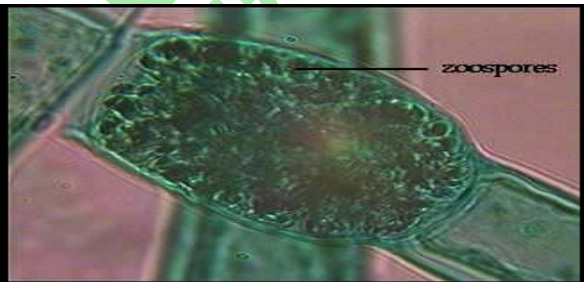
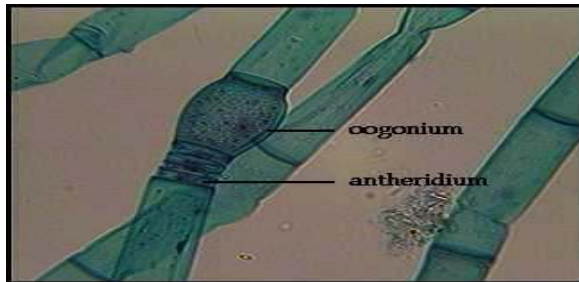
Division: Chlorophyta

Class : Chlorophyceae

Order : Oedogoniales

Family : Oedogoniaceae

Genus : *Oedogonium*





## Specimen to be studied:

### *Oedogonium* Filament

Thallus is multicellular, filamentous and unbranched.

A filament is differentiated into three types of cells according to their position : (i) basal, (ii) intercalary and (iii) apical.

The basal cell of filament functions as a holdfast. The lower part of the holdfast is either disc-like or finger-shaped. The upper part is mostly broad and rounded. The basal part of cell generally lacks green pigment and, therefore, is non-green unlike other cells of the filament.

A cell at the tip of the filament is known as apical cell. It is rounded at its free surface.

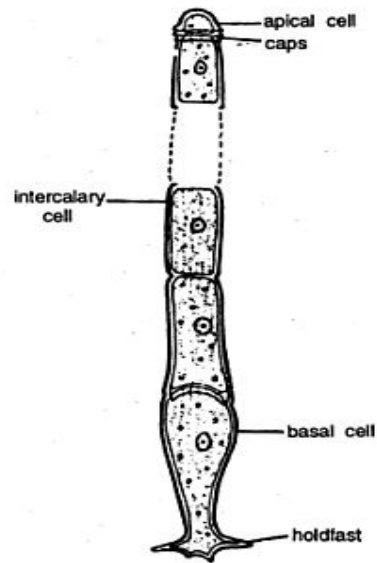


Fig. 1. *Oedogonium*. A filament.

### *Oedogonium* Oogonium

1. Oogonia occur in intercalary or terminal positions.
2. Oogonium may be solitary or occur in a row of 2-3 or even more.
3. Oogonium generally shows one or more cap cells at its upper end, indicating its development from a comparatively older cell.
4. It is mostly spherical or oval in shape and larger than a vegetative cell.

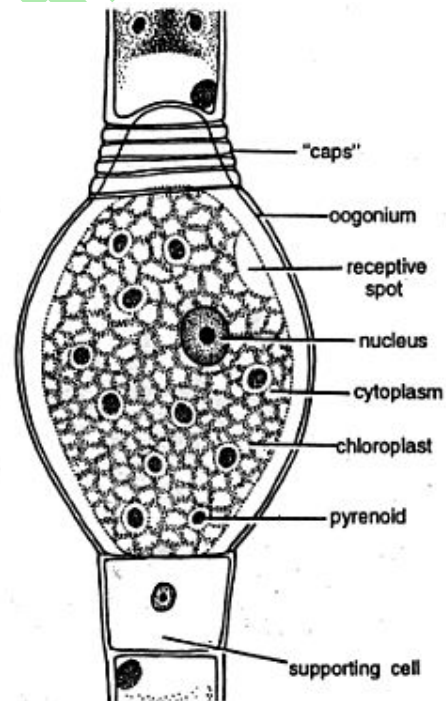
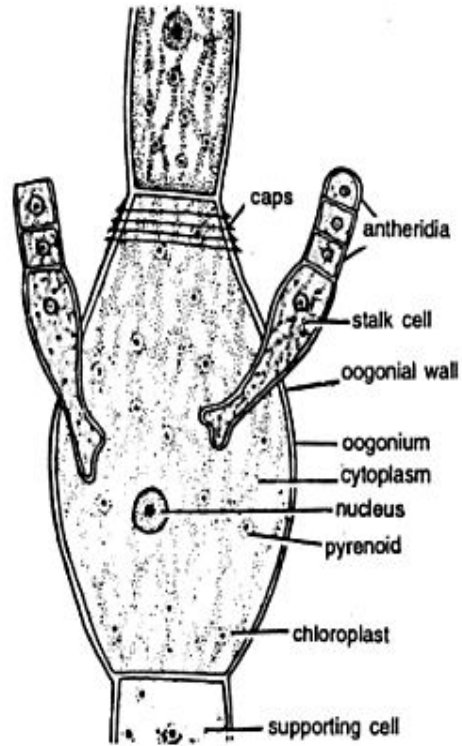


Fig. 2. *Oedogonium*. Filament showing a mature oogonium.

### **Oedogonium Dwarf Male**

1. The dwarf male (or nannandrium) is characteristic of nannandrous species.
2. The dwarf male is produced by the germination of androspore.
3. Androspores are formed inside the androsporangia.
4. Androsporangia form a long chain of small and flat cells in intercalary position in the filament.
5. Each androsporangium develops a single multiflagellate androspore (in contrast, per antheridium two antherozoids are produced).
6. Androspore germinates to produce a dwarf male or nannandrium which remains attached either to the wall of the oogonium or to the suffultory cell.
7. A dwarf male is made of a stalk cell and a terminal row of 2-3 cells.
8. Stalk cell is at the base by which the dwarf male is attached to the filament. It has a disc-like or finger-like structure at its base.
9. The terminal row has 2-3 small, flat and narrow antheridia.
10. Each antheridium has two multiflagellate antherozoids.



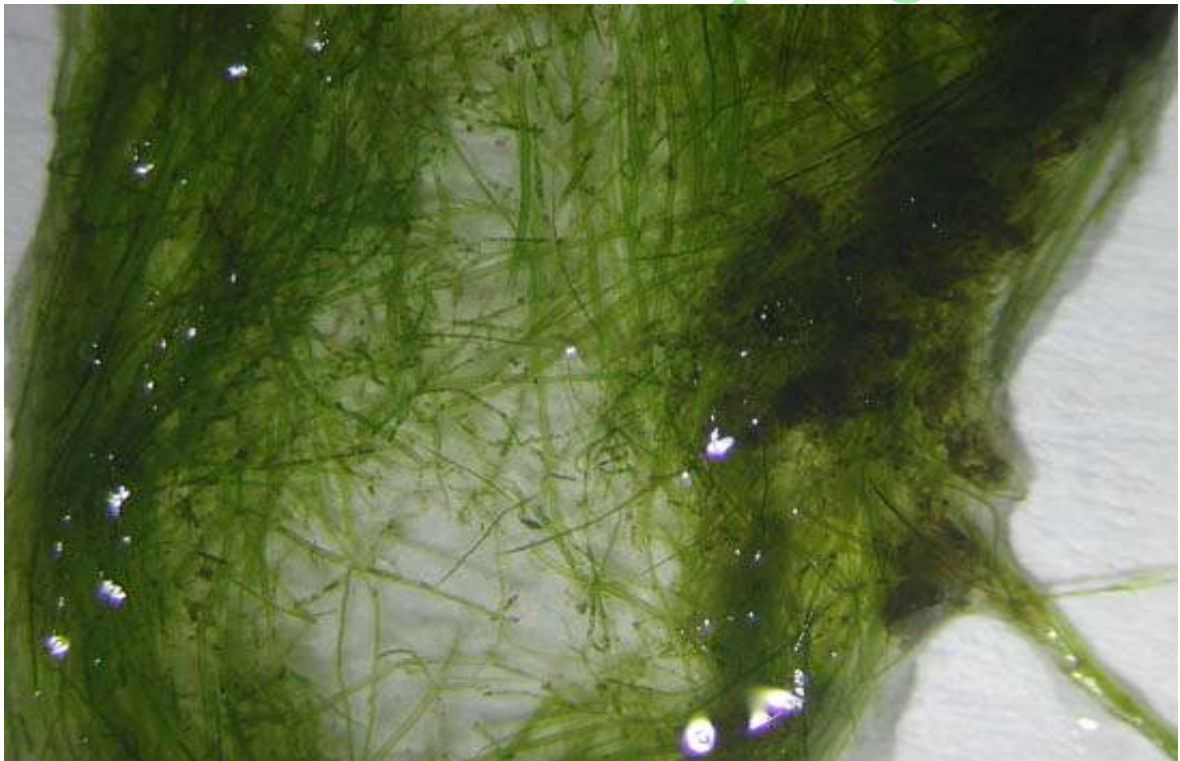
DAV COLLEGE



## Division - Xanthophyta

### General Characters

1. Commonly known as yellow-green algae
2. All the members except a few are fresh water forms. Some are terrestrial or subaerial.
3. The thallus organization can be unicellular motile, palmelloid, coccoid, filamentous, siphonous.
4. The cell wall is chiefly made up of pectic substances. Cellulose may be occasionally present.
5. Starch is absent. The reserve food material is oil, chrysolaminarin and leucosin.
6. Pigment found are chlorophyll a, e and beta-carotenes.



### Members to be studied:

1. *Vaucheria*

## 1. *Vaucheria*

### A. Classification

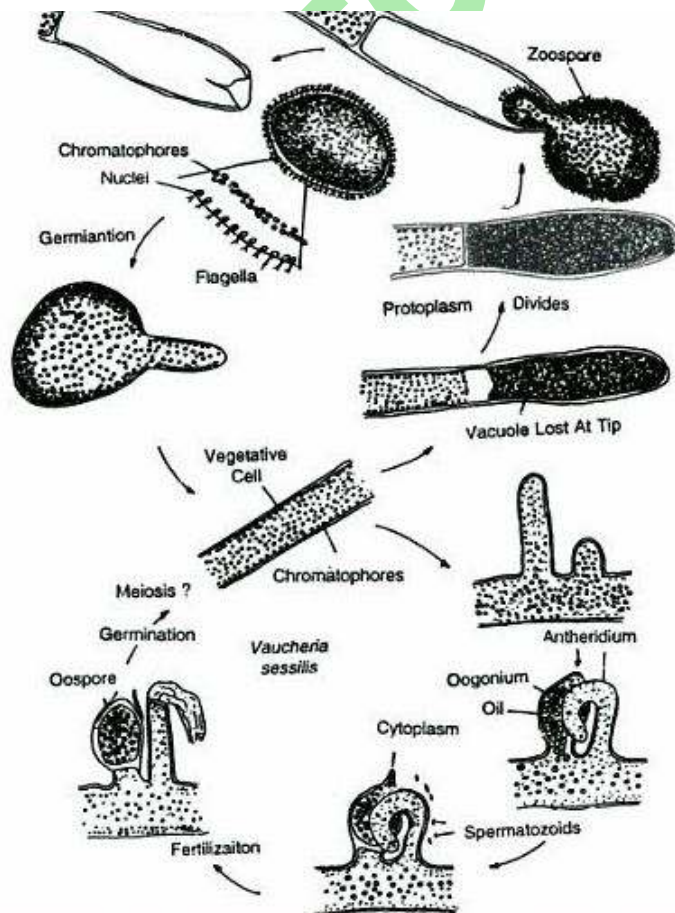
Division: Xanthophyta

Class : Xanthophyceae

Order : Heterosiphonales

Family : Vaucheriaceae

Genus : *Vaucheria*



*Vaucheria* life cycle

### ***Vaucheria* Thallus**

- Thalli are multinucleate and known as coenocytic.
- The cytoplasm contains numerous small, discoid chromatophores.
- The pyrenoids are absent.
- The chromatophores are arranged in the peripheral layer of the cytoplasm.
- A large number of nuclei are arranged next to chromatophores towards central vacuole.



### ***Vaucheria* sessile sex organs**

- The sessile organs are directly formed on the main filament
- The antheridia and oogonia are born close to each other, but they are sessile.
- Antheridia are terminal. These are strongly curved, hook like and cylindrical.
- Antheridia are cut off from the main filament by a transverse septum at its base.



### ***Vaucheria* geminata sex organs**

- The sex organs are borne on certain special branches.
- These branches are short and bear terminal antheridium and lateral group of oogonia.
- Antheridial development begins slightly earlier than oogonia.



## Division - Phaeophyta

### General Characters

1. Commonly known as brown algae
2. Mostly marine except a few like *Bodanella*, *Pleurocladia*..
3. The thallus organization ranges from heterotrichous filamentous to highly differentiated multicellular and sessile forms.
4. The cell wall is made up of inner layer of cellulose and outer mucilaginous layer containing fucinic acid and alginic acid.
5. Reserve food material is laminarin and mannitol..
6. Pigment found are chlorophyll a, Chlorophyll c.



### Members to be studied:

1. *Ectocarpus*
2. *Sargassum*

## 1. *Ectocarpus*

### A. Classification

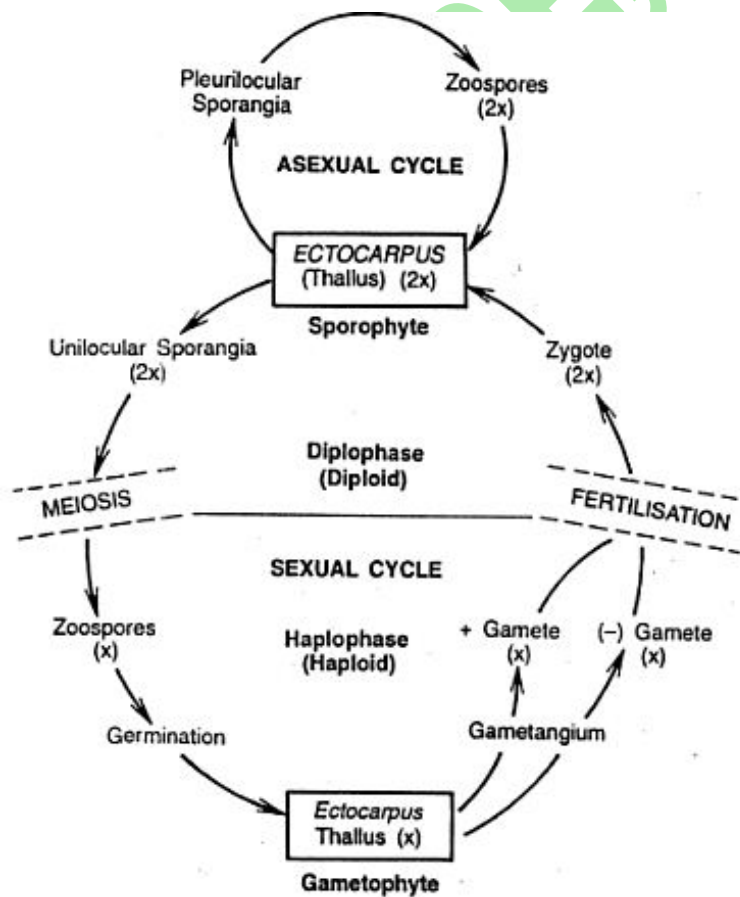
Division: Phaeophyta

Class : Phaeophyceae

Order : Ectocarpales

Family : Ectocarpaceae

Genus : *Ectocarpus*





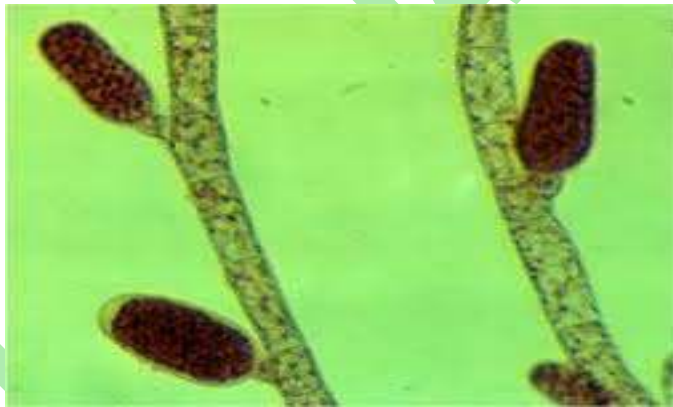
### ***Ectocarpus* Thallus**

- Cells are small, cylindrical and uninucleate.
- Growth of ectocarpus is apical in prostrate system while diffuse in erect system.
- The cells also contain fucosan vesicles.
- Laminarin and mannitol are food reserves.



### ***Ectocarpus* Unilocular Sporangia**

- These are oval in shape and one celled thick.
- These are short stalked.
- Spores are formed by meiotic divisions.
- Each meiozoospore is pyriform, uninucleate and biflagellate.



### ***Ectocarpus* Pleurilocular Sporangia**

- These are multichambered sporangia.
- These may be stalked or sessile.
- Spores are produced by mitotic divisions.
- These are also called neutral sporangia.

### **Spore**



## 2. *Sargassum*

### A. Classification

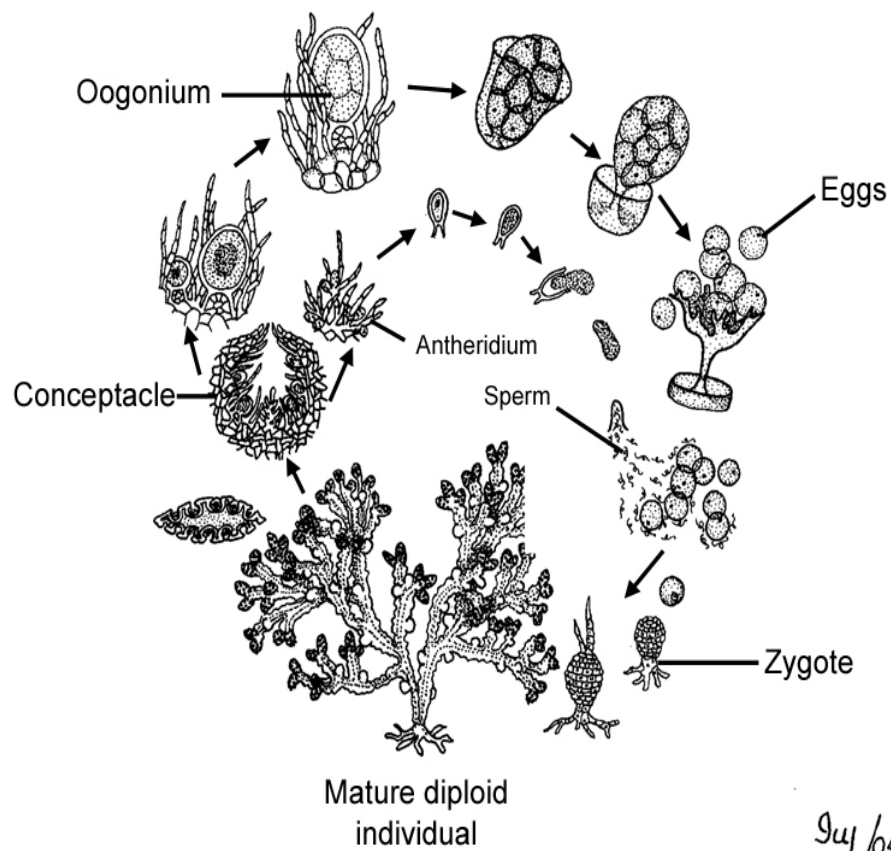
Division: Phaeophyta

Class : Phaeophyceae

Order : Fucales

Family : Sargassaceae

Genus : *Sargassum*



Livingstone ©BIODIDAC

Life cycle of *Sargassum*

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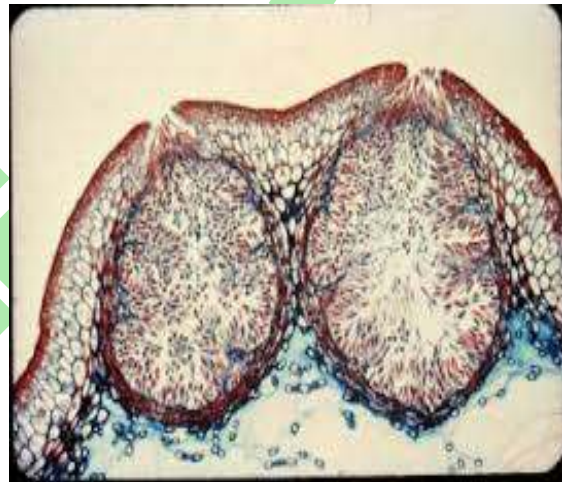
### ***Sargassum* vegetative structure**

- The plant body is perennial, erect and bushy in habit.
- There is holdfast and main axis.
- The main axis bear primary laterals or branches in spiral phyllotaxy.
- Primary laterals bear leaf like branches called secondary laterals.
- Leaves bear cup shaped sterile cavities called cryptostomata or sterile conceptacles.



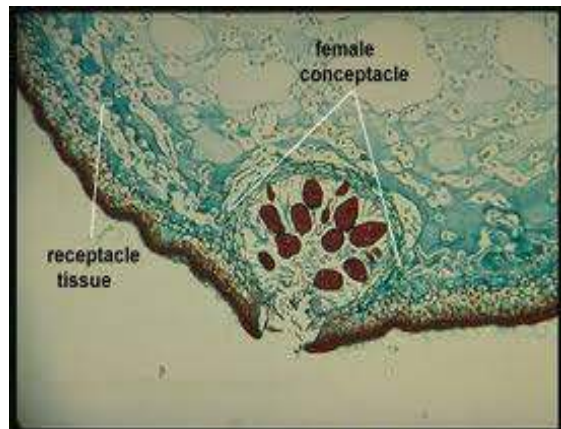
### ***Sargassum* male conceptacle**

- Conceptacle bearing antheridia are called male conceptacles.
- Each antheridium is small, oval body.
- It contains 64 biflagellate structures.
- Antheridium are interrupted in between by sterile filaments called paraphyses.



### ***Sargassum* female conceptacle**

- Conceptacle bearing antheridia are called male conceptacles.
- Oogonium is single celled structure, which is sessile and remains embedded in female conceptacle.
- At maturity, it is discharged through ostiole.



## Division – Rhodophyta

### General Characters

1. Commonly known as red algae
2. Mostly marine upto a depth of 30-90 meters.
3. The thallus organization ranges from unicellular, palmelloid, uniaxial filamentous branched, uniaxial pseudoparenchymatous forms, multiaxial filamentous branched forms to multicellular pseudoparenchymatous thallus.
4. The cell wall is two layered made up of inner layer of pectin and outer layer of cellulose.
5. Reserve food material is floridean starch.
6. Pigment found are chlorophyll a, Chlorophyll d, r-phycoerythrin and r-phycoeyanin.



### Members to be studied:

1. *Polysiphonia*



## 1. Polysiphonia

### A. Classification

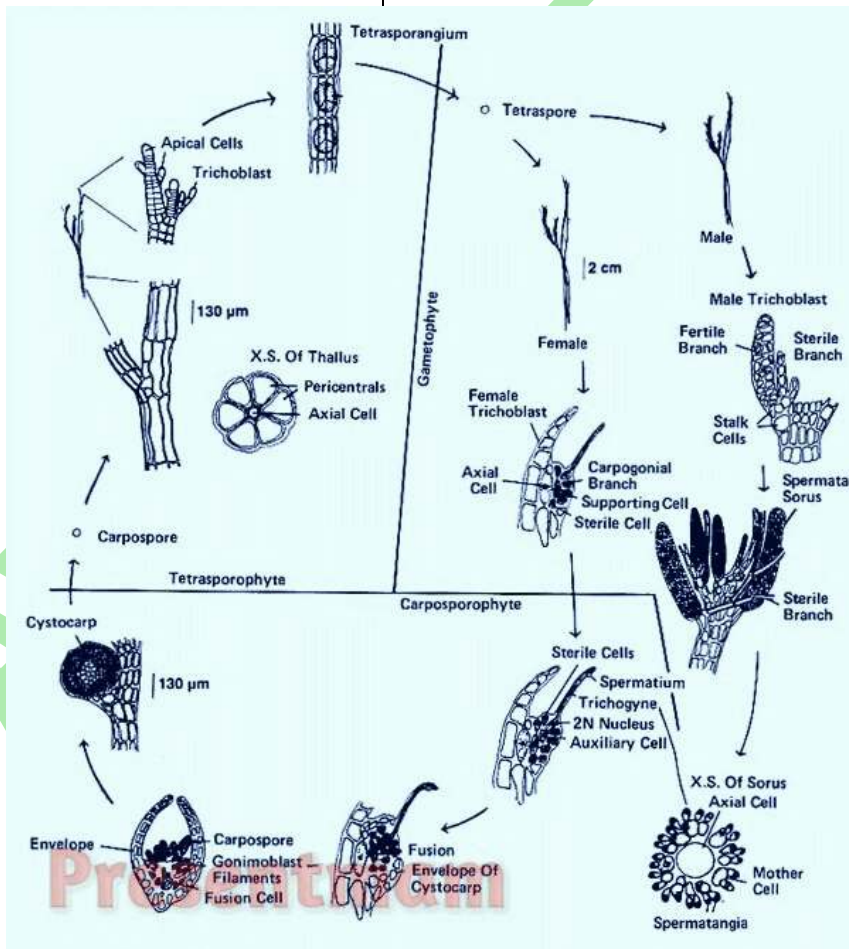
Division: Rhodophyta

Class : Rhodophyceae

Order : Ceramiales

Family : Rhodomelaceae

Genus : *Polysiphonia*

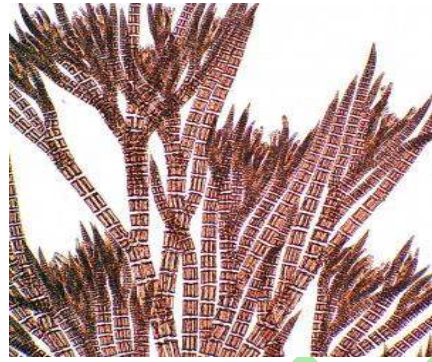


*Polysiphonia* life cycle



### ***Polysiphonia thallus***

- The plant body is bushy or feathery appearance.
- It reaches upto 25 cm in length.
- The thallus is multi-axial, filamentous, branched and heterotrichous.
- Rhizoids are also present to fix plant to substratum.



### ***Polysiphonia spermatangia***

- The male sex organs are called spermatangia (antheridia).
- These are borne in clusters on special trichoblasts.
- Pericentral cell divides to form spermatangial mother cells which in turn give rise to spermatangia.



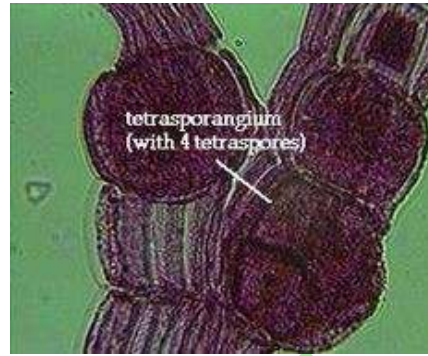
### ***Polysiphonia cystocarp***

- After fertilization, a fruiting body is formed which encloses gonimoblast initial, carposporangia and carpospores.
- It encloses a diploid carpospores.
- It is oval or urn shaped attached to main axis.
- It has an opening called ostiole.



***Polysiphonia* tetrasporophyte**

- It is independent, free living plant body developed from carpospores.
- It is responsible for the production of haploid tetraspore.
- These tetraspores are released to give rise to male and female gametophytic thallus.



DAV COLLEGE, JALANDHAR

## 2. Fungi

Fungi are the eukaryotic, achlorophyllous, and unicellular or multicellular organisms, which may reproduce by asexual and sexual spores.

1. All are eukaryotic - Possess membrane-bound nuclei (containing chromosomes) and a range of membrane-bound cytoplasmic organelles (e.g. mitochondria, vacuoles, endoplasmic reticulum).
2. Most are filamentous - Composed of individual microscopic filaments called hyphae, which exhibit apical growth and which branch to form a network of hyphae called a mycelium.
3. Some are unicellular - e.g. yeasts.
4. Protoplasm of a hypha or cell is surrounded by a rigid wall - Composed primarily of chitin and glucans, although the walls of some species contain cellulose.
5. Many reproduce both sexually and asexually - Both sexual and asexual reproduction often result in the production of spores.
6. Their nuclei are typically haploid and hyphal compartments are often multinucleate although, the oomycota and some yeast possess diploid nuclei.
7. All are achlorophyllous - They lack chlorophyll pigments and are incapable of photosynthesis.
8. All are chemoheterotrophic (chemo-organotrophic) - They utilise pre-existing organic sources of carbon in their environment and the energy from chemical reactions to synthesize the organic compounds they require for growth and energy.
9. Possess characteristic range of storage compounds - e.g. trehalose, glycogen, sugar alcohols and lipids.
10. May be free-living or may form intimate relationships with other organisms i.e. may be free-living, parasitic or mutualistic (symbiotic).

## 2.1. *Pythium*

**Division :** Eumycota

**Class :** Oomycetes

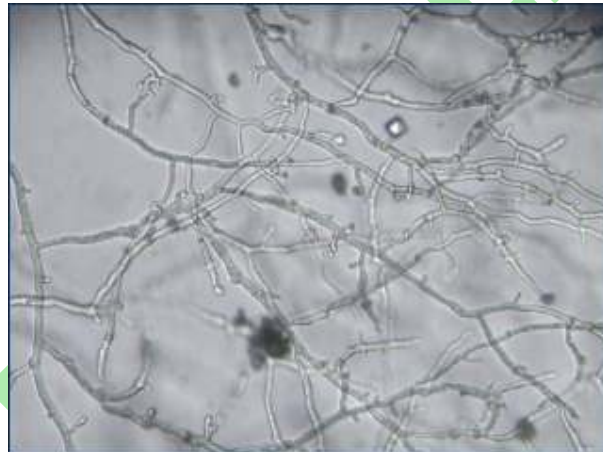
**Order :** Peronosporales

**Family :** Pythiaceae

**Genus :** *Pythium*

### **Pythium vegetative structure**

- The vegetative plant body consists of long, filamentous, branched, aseptate and multinucleate hyphae.
- It shows acellular coenocytic habit.
- Septa appear during differentiation of sex organs.
- When parasitic mycelium is both intercellular and intracellular, but no haustoria is produced.
- The hyphal cell wall is made up of cellulose impregnated with chitin.



### **Damping off disease**

- It is the most common disease of seed beds and nurseries.
- It causes damping off disease of tobacco, tomato, mustard, chillies and cress seedlings.
- Damping off disease may be pre-emergence or post-emergence.
- In pre-emergence, the radical and plumule of the germinating seed got rot and killed before its emergence above the ground.
- In post emergence, the basal part of the stem or hypocotyls of seedlings become soft and droop and get killed.





## 2.2. *Phytophthora*

**Division :** Eumycota

**Class :** Oomycetes

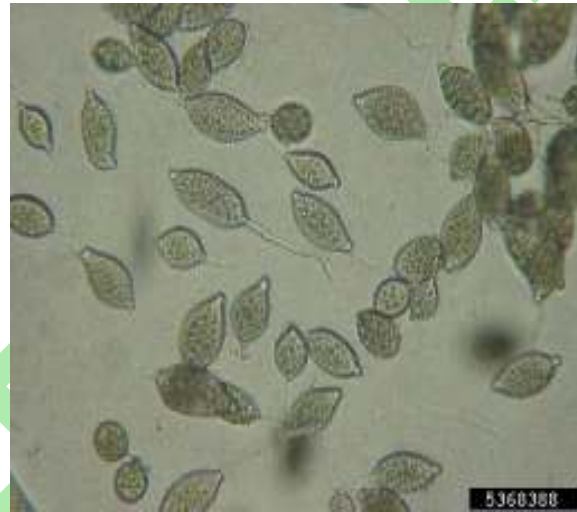
**Order :** Peronosporales

**Family :** Pythiaceae

**Genus :** *Phytophthora*

### ***Phytophthora* vegetative structure**

- The vegetative plant body consists of long, filamentous, branched, aseptate and multinucleate hyphae.
- It shows acellular coenocytic habit.
- Septa appear during differentiation of sex organs or in older hyphae.
- Mycelium is both intercellular and intracellular, it produces short, simple, curved and cylindrical haustoria.



### **Late blight of potato**

- But it is quite common in hills above 6000 feet.
- This disease is not very common in plains due to high temperature and drought in potato growing season.
- The disease appears as hydrotic spots at the margins and tips of lower leaves.
- These spots become necrotic and turn brown to black in colour.
- The diseased tubers become wrinkled and turns black.



### 2.3. *Mucor*

Division : Eumycota

Class : Zygomycetes

Order : Mucorales

Family : Mucoraceae

Genus : *Mucor*

#### *Mucor* vegetative structure

- Also known as bread mould.
- Mycelium is branched, filamentous, slender, stout and coenocytic.
- Early mycelium forms white colony while later on it turns coloured due to appearance of reproductive bodies.
- The hyphae are aseptate and coenocytic.
- Septa appear at the time of sex organ formation and in older hyphae.
- 



## 2.4. *Saccharomyces* (Yeasts)

**Division :** Eumycota

**Class :** Hemiascomycetes

**Order :** Saccharomycetales

**Family :** Saccharomycetaceae

**Genus :** *Saccharomyces*

### Yeast vegetative structure

- The yeasts are ubiquitous and found almost everywhere wherever there is sugary substratum.
- These are unicellular organisms.
- These cells stick in chains and form pseudomycelium or false colonies.
- They are generally spherical, oval, elliptical and elongated.



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## 2.5. *Aspergillus* (*Eurotium*)

**Division :** Eumycota

**Class :** Plectomycetes

**Order :** Eurotiales

**Family :** Eurotiaceae

**Genus :** *Eurotium*

### *Eurotium* vegetative structure

- It is a well developed mycelium.
- The mycelium is hyaline, pale or brightly coloured and consists of slender, tubular, profusely branched, septate hyphae.
- Each septum is perforated with a simple pore.
- The cells are thin walled, multinucleate and contain granular protoplasm with oil globules.





## 2.6. *Penicillium* (Green bread mould)

**Division :** Eumycota

**Class :** Plectomycetes

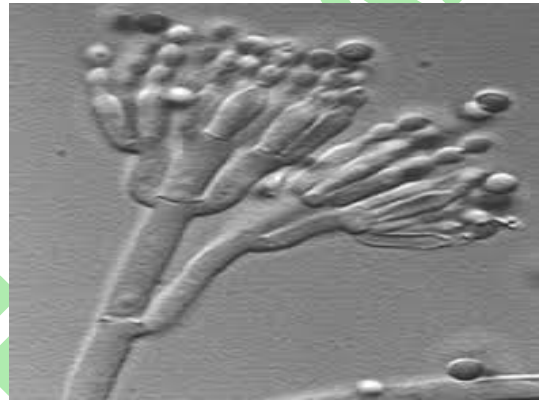
**Order :** Eurotiales

**Family :** Eurotiaceae

**Genus :** *Penicillium*

### *Penicillium* vegetative structure

- It is a well developed mycelium which forms a compact mass called sclerotium.
- The mycelium is hyaline, pale or brightly coloured and consists of slender, tubular, profusely branched, septate hyphae.
- Each septum is perforated with a simple pore.
- The cells are thin walled, short and uni-bi or multinucleated.



## 2.7. *Chaetomium*

**Division :** Eumycota

**Class :** Pyrenomycetes

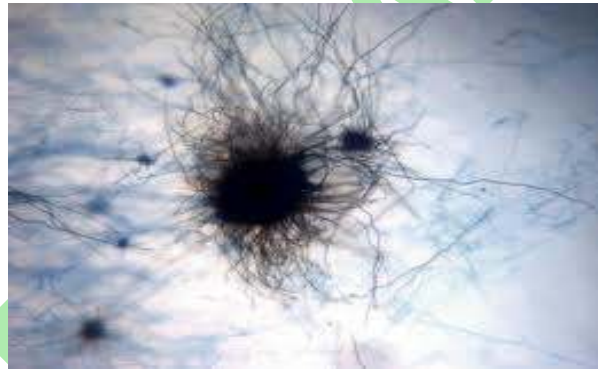
**Order :** Chaetomiales

**Family :** Chaetomiaceae

**Genus :** *Chaetomium*

### *Chaetomium* vegetative structure

- Mycelium is well developed profusely branched and septate.
- It yields an antibiotic called chaetomin.
- It reproduces both by asexual and sexual methods.
- It develops its food from rotten organic matter.



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## 2.7. *Peziza* (cup fungi)

**Division :** Eumycota

**Class :** Discomycetes

**Order :** Pezizales

**Family :** Pezizaceae

**Genus :** *Peziza*

### ***Peziza* vegetative structure**

- The mycelium is branched, filamentous hyphae.
- The hyphae are septate and septa are perforated with simple centrally located pore.
- Each cell is uninucleate.
- A cup shaped fruiting body is produced called apothecia.



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## 2.8. *Puccinia*

Division : Eumycota

Class : Teliomycetes

Order : Uredinales

Family : Pucciniaceae

Genus : *Puccinia*

### *Puccinia* Uredospores

- Uredospore is one celled, oval, binucleate and heteronuclear structure.
- It is thick double layered.
- These are also called repeating spores.
- They develop on wheat leaves.



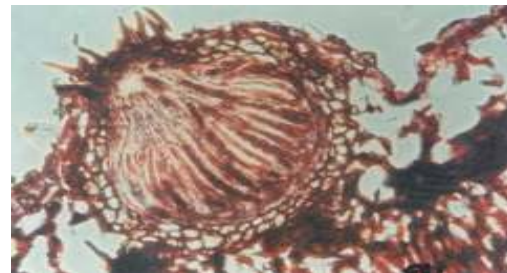
### *Puccinia* Teleutospores

- Teleutospore is bicelled, spindle shaped with rounded or conical apex.
- Also known as teliospores.
- Each cell of teliospore possesses a germ tube.
- They cannot germinate on wheat plant.



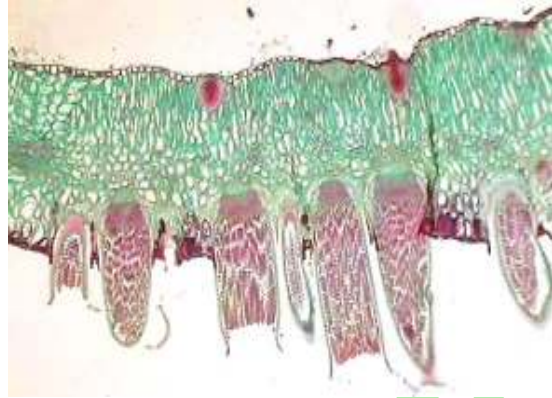
### *Puccinia* Pycnium

- Mycelium on barbery leaf develops spermogonia on its upper surface.
- Each spermogonium is flask shaped structure.
- It produces small rounded pycniospores.



***Puccinia* Aecidiospores**

- The hyphal branches from the base of spermogonium extend and collect below the lower epidermis.
- It differentiates into protoaecidium.
- From this aecidiospores are produced from lower surface of barberry leaf.



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## 2.9. *Agaricus*

**Division :** Eumycota

**Class :** Hymenomycetes

**Order :** Agaricales

**Family :** Agaricaceae

**Genus :** *Agaricus*

### ***Agaricus* vegetative structure**

- Vegetative mycelium of fungus is of three types i.e., primary, secondary and tertiary.
- The primary mycelium develops from uninucleate basidiospores.
- Dikaryotic cells of primary mycelium divide to produce secondary mycelium.
- The complex mass produces a fruiting body called tertiary mycelium.



## 2.10. *Cercospora*

**Division :** Eumycota

**Class :** Hyphomycetes

**Order :** Moniliales

**Family :** Dimatiaceae

**Genus :** *Cercospora*

### ***Cercospora* vegetative structure**

- Hyphae are colored branched and septate.
- Hyphae kill the cells they infect.
- Asexual reproduction occurs by conidia.



### **Tikka disease of Ground nut**

- The spots appear as small pale areas on the surface of older leaves.
- Spots later on turn brown.
- The foliage finally dries up and results defoliation.



## 2.11. *Colletotrichum*

**Division :** Eumycota

**Class :** Coelomycetes

**Order :** Melanconiales

**Family :** Melanconiaceae

**Genus :** *Colletotrichum*

### ***Colletotrichum* vegetative structure**

- Mycelium is endophytic and grows within the epidermal cells.
- The mycelium consists of slender, much branched, septate and colourless or dark coloured hyphae.
- The hyphae contain characteristic oil droplets.



### **Red rot of Sugar cane**

- First symptom appears after rainy season.
- The cane starts shriveling, the rind shrinks and becomes wrinkled.
- The mid rib region of leaves shows dark-reddish areas which spread lengthwise forming blood red lesions.



### 3. Bryophytes

The term "bryophyte" comes from Greek βρύον, bryon, "tree-moss, oyster-green" + φυτόν - phyton "plant".

1. Bryophyte is a traditional name used to refer to all embryophytes (land plants) that do not have true vascular tissue and are therefore called "non-vascular plants".
2. Some bryophytes do have specialized tissues for the transport of water; however, since these do not contain lignin, they are not considered to be true vascular tissue.
3. As of 2014, it is uncertain whether bryophytes are a natural monophyletic group or a paraphyletic group, but the name is convenient and remains in use as a collective term for mosses, hornworts, and liverworts.
4. Bryophytes produce enclosed reproductive structures (gametangia and sporangia), but they produce neither flowers nor seeds, reproducing via spores.

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### 3.1. *Marchantia*

Division : Bryophyta

Class : Hepaticopsida

Order : Marchantiales

Family : Marchantiaceae

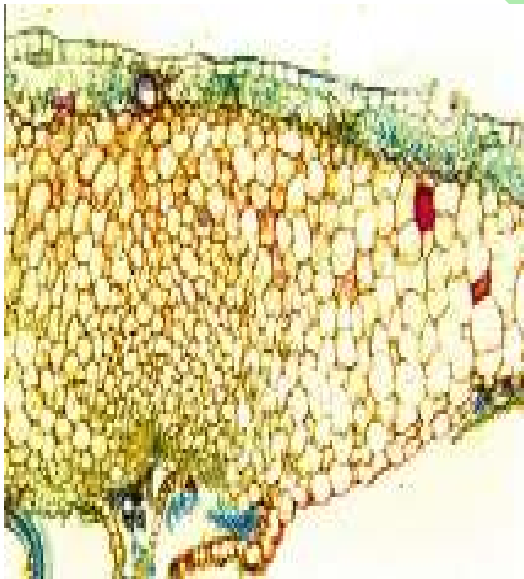
Genus : *Marchantia*

#### ***Marchantia* Thallus**

- Dorsal surface is dark green.
- Midrib is marked by shallow groove having gemma cups over it.
- Anatomical details show photosynthetic chambers alternate with air chambers.
- On ventral surface are present rhizoids and scales for anchorage.



WM Thallus

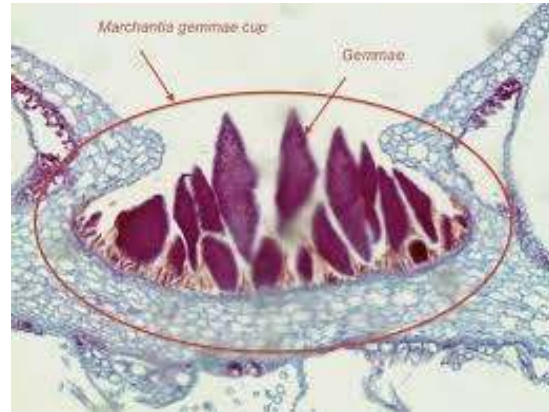


VS Thallus



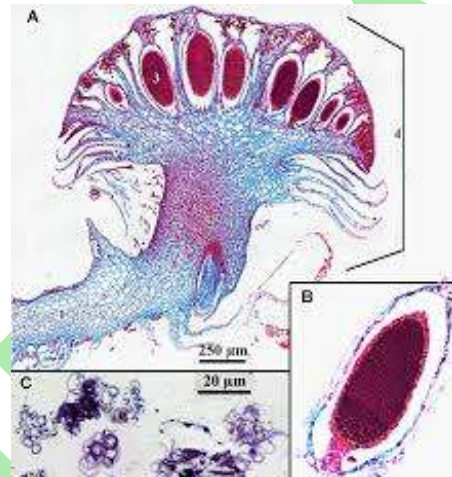
### Gemma Cup

- Gemma cups are found on the dorsal surface of the thallus.
- They are crescent shaped.
- Mature gemmae are found attached at the base of gemma cup.
- Gemma are intermingled with mucilage hairs.
- They are means of vegetative reproduction.



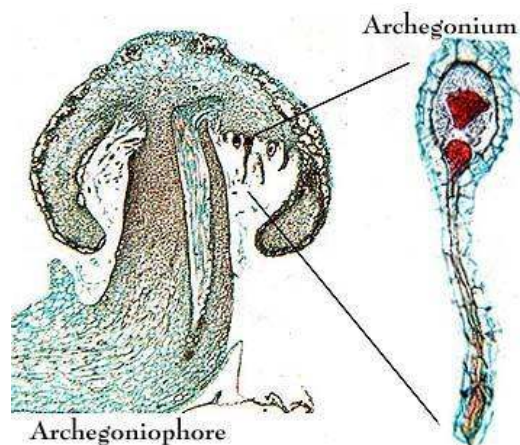
### Antheridiophore

- Antheridia are produced on special erect branches called antheridiophores.
- It consists of 1-3 cm long stalk and a lobed disc at top.
- Disc is usually 8 lobed.
- Lobed disc is a result of repeated dichotomies.
- Antheridia arise in the disc in acropetal succession.
- Each antheridium produces numerous antherozoids.



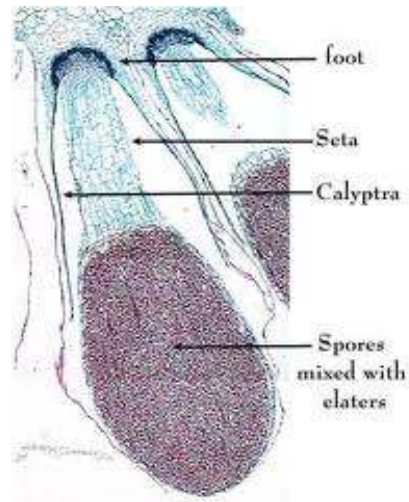
### Archegoniophore

- Archegonia are produced on special erect branches called archegoniophores.
- It consists of 1-3 cm long stalk and a lobed disc at top.
- It is usually longer than antheridiophore.
- Lobed disc is a result of repeated dichotomies.
- Archegonia arise in the disc in acropetal succession.
- Rays alternate with lobes.



### Sporogonium

- It consists of foot, seta and capsule.
- Foot is embedded in the parent tissue and absorbs nutrition and water.
- After fertilization, the archegonial inversion takes place.
- Capsule are protected by perichaetium.
- Spores are present in capsular region along with elaters.
- Spores are double walled and haploid in nature.



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### 3.2. *Anthoceros*

Division : Bryophyta

Class : Anthocerotopsida

Order : Anthocerotales

Family : Anthocerotaceae

Genus : *Anthoceros*

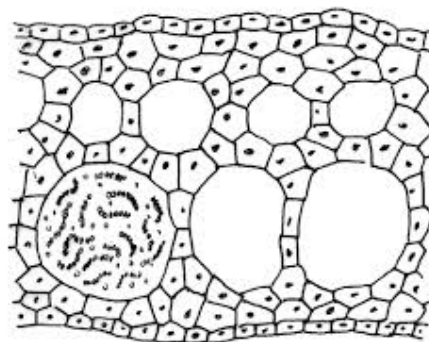
#### *Anthoceros* Thallus

- Dorsal surface is green and smooth.
- Mid rib is not distinct.
- Ventral surface bears unicellular, smooth walled rhizoids.
- Tuberculated rhizoids, scales or mucilaginous hair are absent.
- Bluish green spots are visible on ventral side.
- These spots contain Nostoc colonies and are filled with mucilage.
- Nostoc colonies help in nitrogen fixation.



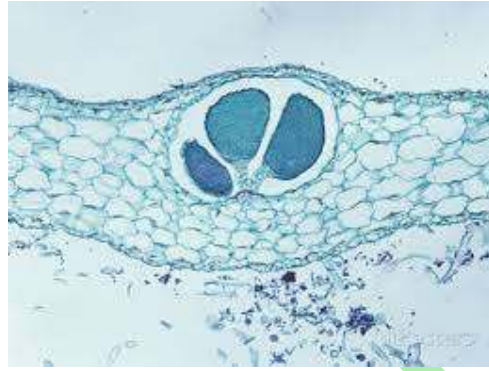
#### T.S of *Anthoceros* Thallus

- It lacks particular zonation.
- It is uniformly composed of thin walled parenchymatous cells.
- The outermost layer is upper epidermis.
- Each cell contains a single large chloroplast.
- Each chloroplast is having a single pyrenoid.



### **Androecia**

- The antheridia are produced in a group of 2-3 in enclosed structures called androecia.
- Each antheridium is having a stalk and a pouch like body.
- Young antheridia are green while as they mature they turn into orange-reddish in colour.



### ***Anthoceros sporogonium***

- It consists of foot, seta and capsule.
- Capsule appears horn shaped, hence anthoceros is also known as hornworts.
- The central portion of the capsule is a thick celled stalk known as columella.
- Archegonium is present between columella and capsule wall.
- It extends from base to top of the capsule.
- Spores are present in top region of the capsule alongwith pseudoelaters.



### 3.2. *Funaria*

**Division :** Bryophyta

**Class :** Bryopsida

**Order :** Funariales

**Family :** Funariaceae

**Genus :** *Funaria*

#### ***Funaria* Thallus**

- *Funaria* is represented by two stages i.e., juvenile primary protonema and leafy gametophores.
- The adult gametophyte is differentiated into stem, leaves and rhizoids.
- Rhizoids arise from base of the axis.
- Leaves are borne in 1/3 phyllotaxy which becomes 3/8 at maturity.



#### **Male Head**

- Antheridia are borne at the top of branch in group.
- Mature antheridium is club shaped.
- Antheridium has a single, sterile jacket of polyhedral cells.
- Jacket encloses a large number of androcytes.
- At maturity, the operculum absorbs moisture and sets free numerous antherozoids.





### Female Head

- Archegonia are borne in groups at top of the archegonial branch.
- It is surrounded by perichaetial leaves.
- Mature archegonium consists of venter, neck and egg cell.
- Venter wall is two layered and encloses a venter canal cell and egg cell.
- Venter canal cell is situated below the neck canal cell.



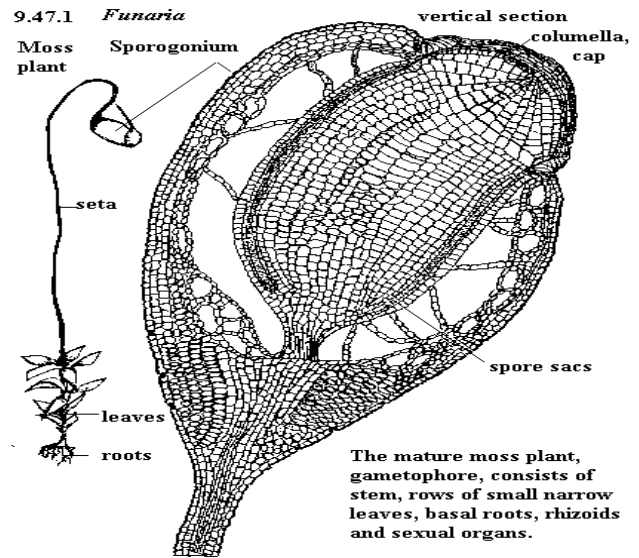
### Peristome teeth

- Two rows of peristome teeth are present in the operculum region of capsule in sporogonium of Funaria.
- Inner and outer row of teeth are distinguishable from each other in morphological details.
- Outer row of teeth have striations all over it.
- Inner row of teeth are smoother.



### Sporogonium

- The sporogonium of *Funaria* consists of foot, seta and capsule.
- The capsule is further differentiated into apophysis, theca and operculum.
- Columella is present in the central part of theca region.
- Operculum is the upper region of the capsule.
- Two rows of peristome teeth are also present for dispersal of spores.



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#### 4. Pteridophytes

##### General Characters

1. Majority of pteridophytes are terrestrial and prefer to grow on cool, moist and shady places.
2. Most of pteridophytes are herbaceous but a few are perennial and tree like.
3. Plant body is sporophytic and can be differentiated into root, stem and leaves.
4. Roots are adventitious in nature and can be monopodial or dichotomous.
5. Leaves may be small, thin, scaly, simple and sessile.
6. Vascular tissue is present in stem and root. Xylem consists of tracheids only and phloem has only sieve tubes.
7. The stele varies from protostele to siphonostel, dictyostele or polycyclic.
8. Cambium is absent, hence they do not show secondary growth.
9. Reproduction takes place by means of spores which are produced inside sporangia.
10. The development of sporangium may be leptosporangiate or eusporangiate.
11. Antheridia and archegonia are developed on prothalli.
12. Antherozoids are unicellular, biflagellate or multiflagellate and motile.

#### 4.1. *Lycopodium*

**Division :** Pteridophyta

**Class :** Eligulopsida

**Order :** Lycopodiales

**Family :** Lycopodiaceae

**Genus :** *Lycopodium*

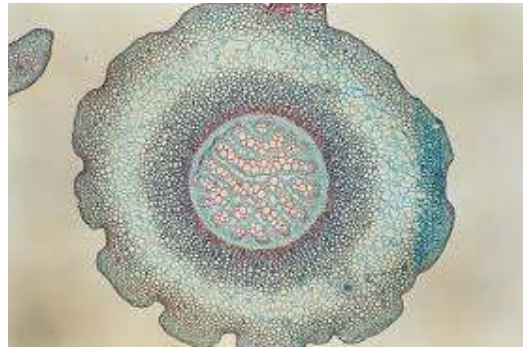
##### ***Lycopodium* Thallus**

- *Lycopodium* is commonly called club moss.
- Most of the species are epiphytic.
- Leaves may be homophyllous or heterophyllous.
- Roots are adventitious.
- Stem may be unbranched or dichotomously branched.



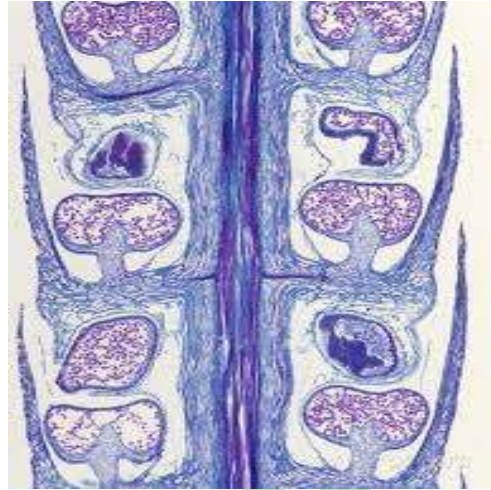
##### **T.S. of Stem**

- Epidermis is cutinized on outer side.
- Epidermis is followed by wide cortex which is made up of parenchymatous or sclerenchymatous cells.
- Stele is pletostele.
- The protoxylem is exarach.



### Strobilus

- Plant is homosporous.
- Male and female spores are different and are produced in respective sporangia.
- Microsporophylls produce male sporangia carrying microspores.
- Megasporophylls produce female sporangia carrying megaspores.
- These micro and megaspores are aggregated to form a specilia structure called strobilus.



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## 4.2. *Selaginella*

**Division :** Pteridophyta

**Class :** Ligulopsida

**Order :** Selaginellales

**Family :** Selaginellaceae

**Genus :** *Selaginella*

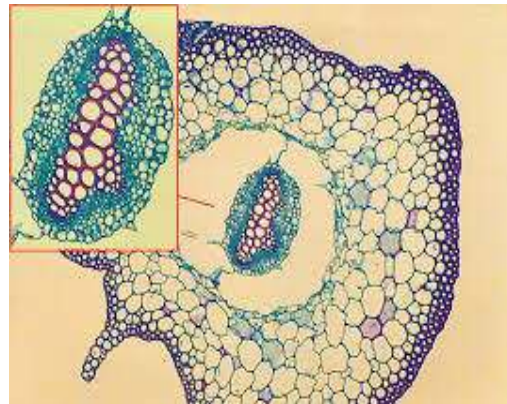
### *Selaginella* Thallus

- Also known as spike or small club moss.
- The sporophyte is evergreen, delicate herb.
- They can be few centimeters to 20 meters.
- They can be isophyllous or heterophyllous.
- Leaves have ligule.
- Sporophylls aggregate to form strobilus.



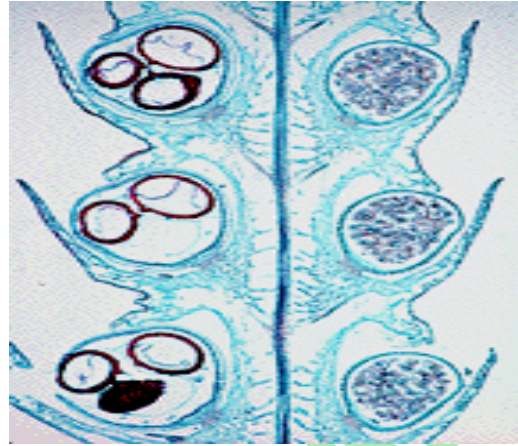
### *Selaginella* T.S. of Stem

- The outline is not circular.
- Epidermis is cutinized.
- Outer cortex can be sclerenchymatous while inner cortex is parenchymatous.
- Endodermis is having casparian strips.
- Trabaculae are seen due to radial elongation of endodermal cells.
- The stele is either monostelic or distelic.



### ***Selaginella* Strobilus**

- *Selaginella* fertile sporophylls are aggregated to form strobilus.
- Two different types of spores are produced i.e., micro and megaspores.
- Fertile leaves alternate with sterile leaves. This condition is known as Selago condition.
- Microsporangium and megasporangium follow a definite pattern on strobilus.



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### 4.3. *Equisetum*

**Division :** Sphenophyta

**Class :** Calmopsida

**Order :** Equisetales

**Family :** Equisetaceae

**Genus :** *Equisetum*

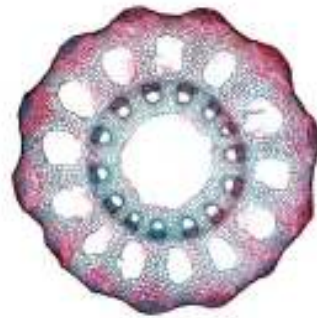
#### ***Equisetum* plant body**

- Also known as horse tails, pipes or scouring rushes.
- The sporophyte is perennial herb.
- Plant body is differentiated into rhizome, aerial branches, roots and leaves.
- At nodes are present, whorls of small leaves.



#### ***Equisetum* T.S of Stem**

- Outline is wavy due to presence of ridges and furrows.
- Epidermis is single layered and thick. It is interrupted by stomata.
- Broad cortex is present.
- Single layered endodermis is followed by single layered pericycle.
- The stele is eustele.
- Vallecular canals are present in cortex.



### ***Equisetum* Strobilus**

- Each strobilus consists of thick central axis.
- Around central axis are attached sporangiophores.
- Sporangiphore is umbrella shaped, differentiated into slender stalk and expanded disc.
- Sac like sporangia are present under the disc.



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#### 4.4. *Pteris*

**Division :** Filicophyta

**Class :** Leptosporangiopsida

**Order :** Filicales

**Family :** Polypodiaceae

**Genus :** *Pteris*

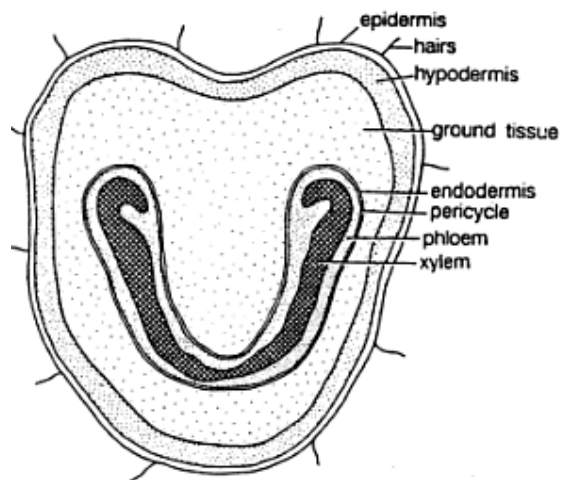
##### ***Pteris* Thallus**

- The main plant body is sporophytic differentiated into root, stem and leaves.
- Stem is modified into underground rhizome.
- Roots are adventitious.
- Leaves are macrophyllous. They are pinnately compound to decomound.
- Each pinna is sessile and traversed by a central midrib.



##### ***Pteris* T.S. of Rachis**

- Rough in outline.
- Epidermis is thickly cutinized.
- Hypodermis is sclerenchymatous.
- Vascular strand is horse-shoe shaped.
- Inner to endodermis is present single layered pericycle.
- Central part of vascular strand is occupied by xylem elements.
- Mesarch condition is seen.





### Coenosorus of *Pteris* leaf

- Sori are borne on special leaves called sporophylls.
- The sporangia occur in group on the lower surface of pinna.
- Sori are continuous along the margin of leaves.



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#### 4.5. *Marsilea*

**Division :** Filicophyta

**Class :** Leptosporangiopsida

**Order :** Marsileales

**Family :** Marsileaceae

**Genus :** *Marsilea*

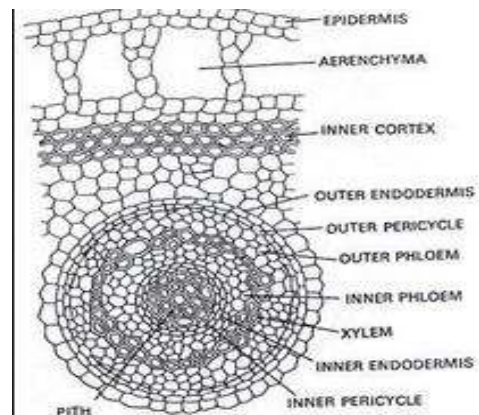
##### ***Marsilea* plant body**

- Also called pepper wort or water fern.
- The mature sporophyte is herbaceous.
- Plant body is differentiated into rhizome, leaves and root.
- Rhizome creeps on or just below the soil.
- Young leaves show circinate vernation.
- Leaves also show sleeping movement.
- Roots are adventitious.



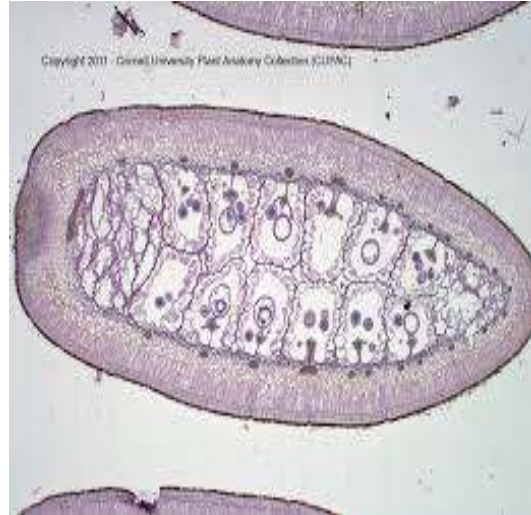
##### ***Marsilea* Rhizome**

- Epidermis is the outermost limiting layer.
- It is differentiated into outer, middle and inner cortex.
- Outer cortex is parenchymatous, middle cortex is aerenchymatous and inner cortex is parenchymatous.
- Stele is amphiphloic siphonostele.



### **Marsilea sporocarp**

- Each sporocarp is oval or bean shaped biconvex, flattened structure.
- It is green and soft when young but turns hard and brown at maturity.
- It is divided into short stalk called peduncle and body.
- The point of attachment of peduncle with body is called raphe.
- Two protuberances called tubercles are also present.
- Sporocarp carries micro and megasporangium.



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## 5. Lichens

Lichen is a composite organism that emerges from algae living among filaments of a fungus in a mutually beneficial (symbiotic) relationship. It is of following types.

### Foliose lichen

- A sandwich of fungal layer with algal mat in middle
- Circular growth, lobes
- Small rootlets called rhizines attach it to substrate
- Top and bottom layers different



### Crustose lichen

- Edges flat, unlobed and closely attached to substrate
- Hard to remove without damaging substrate or lichen
- Algae usually dispersed



### Fruticose lichen

- Round branches with its fungal layer outside, its algal layer within
- No rhizines
- Vertical growth pattern
- Odd-shaped structures such as globets; threads
- Fruticose lichens are either shrub-like small mounds, growing up from the ground, or beard-like, small tangles looking a bit like spanish moss when hanging down, attached to the substrate only at their bases, and usually with a circular cross-section.

