B.Sc. I Spotting Slides and specimens 2016-17

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e-learning section

Algae

Ocillatoria

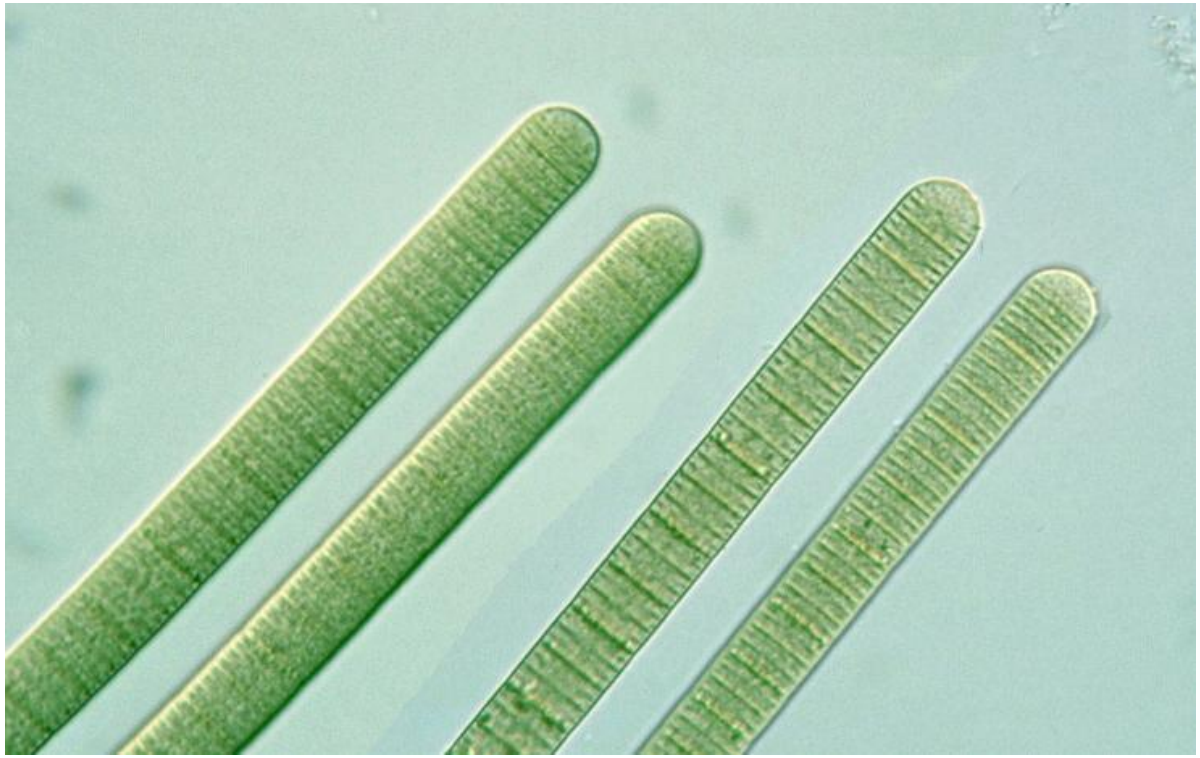
Division : Cyanophyta

Class: Cyanophyceae

Order: Nostocales

Family: Oscillatoriaceae

Genus : ***Oscillatoria***

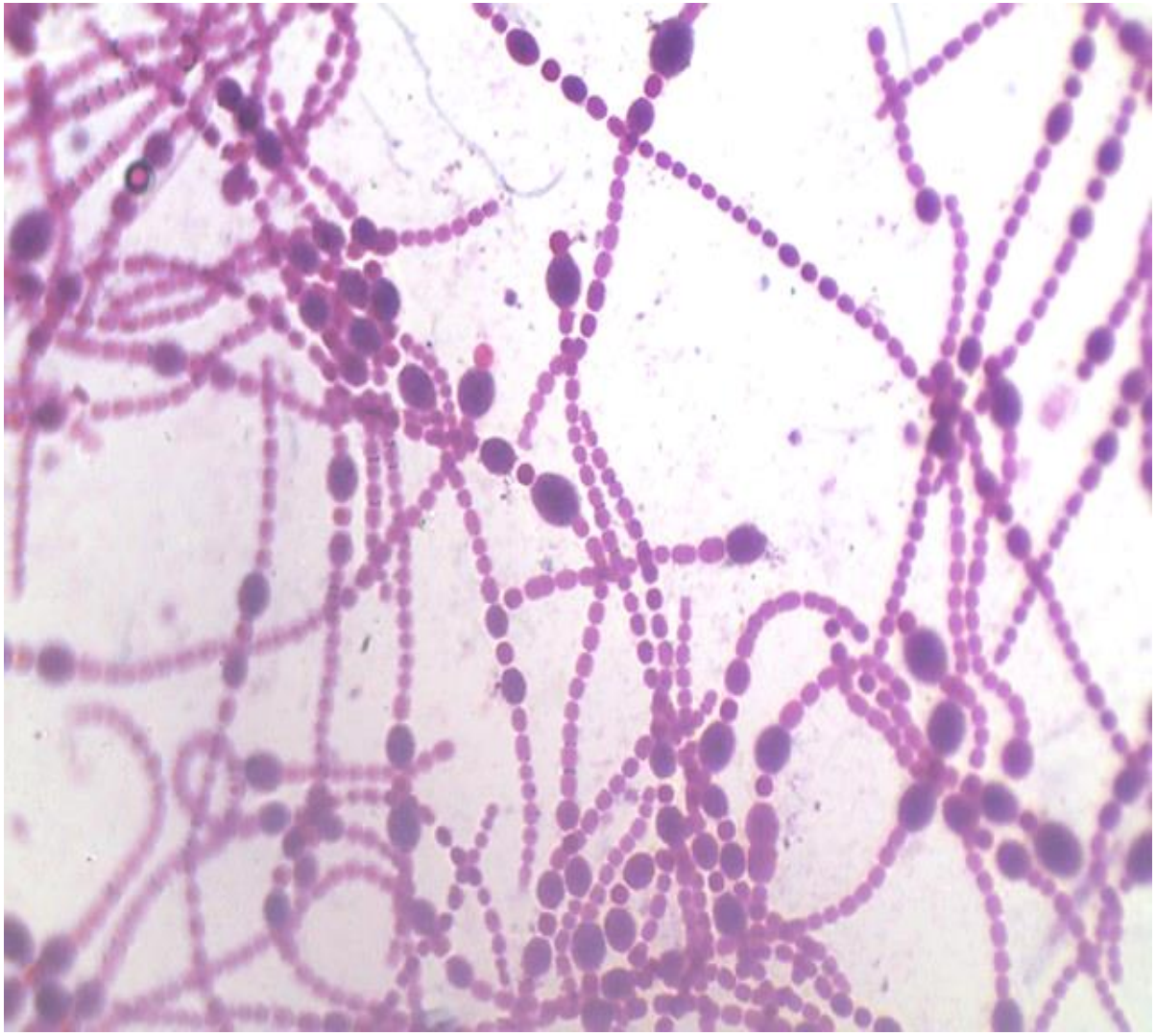


- The plant body is filamentous
- The filament occur singly or large number intervoven to form spongy sheet
- The filaments are unbranched.
- All cells are alike except the terminal on which may be conical , rounded, pointed.
- Freshly mounted specimen show **oscillating movement**

Nostoc

Division : Cyanophyta
Class: Cyanophyceae
Order: Nostocales
Family: Nostocaceae
Genus : ***Nostoc***

- *Nostoc* is colonial and grows in form of mucilaginous balls.
- The filament is unseriate and unbranched.
- Each filament consist of a large number of spherical cells which give it a moniliform beaded appearance.
- The filament possess **terminal or intercalary heterocyst.**



Division : Chlorophyta

Class: Chlorophyceae

Order: Volvocales

Family: Volvocaceae

Genus : ***Volvox***

Volvox daughter colonies

- *Volvox* are aquatic and free floating.
- The plant body is multicellular, motile coenobium.
- The coenobia are spherical or oval in shape.
- The coenobium is hollow in the centre.

Hydrodictyon

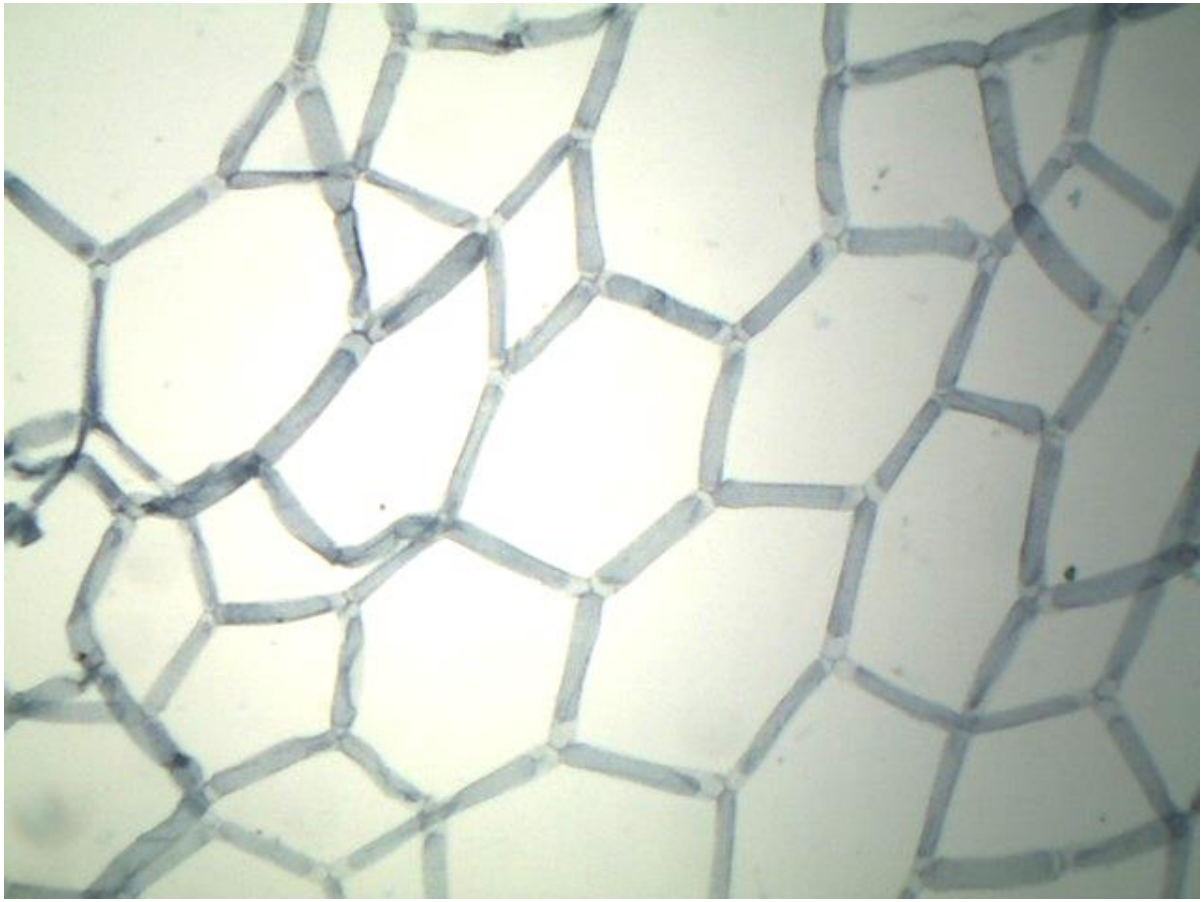
Division : Chlorophyta

Class: Chlorophyceae

Order: Chlorococcales

Family: Hydrodictyaceae

Genus : ***Hydrodictyon***

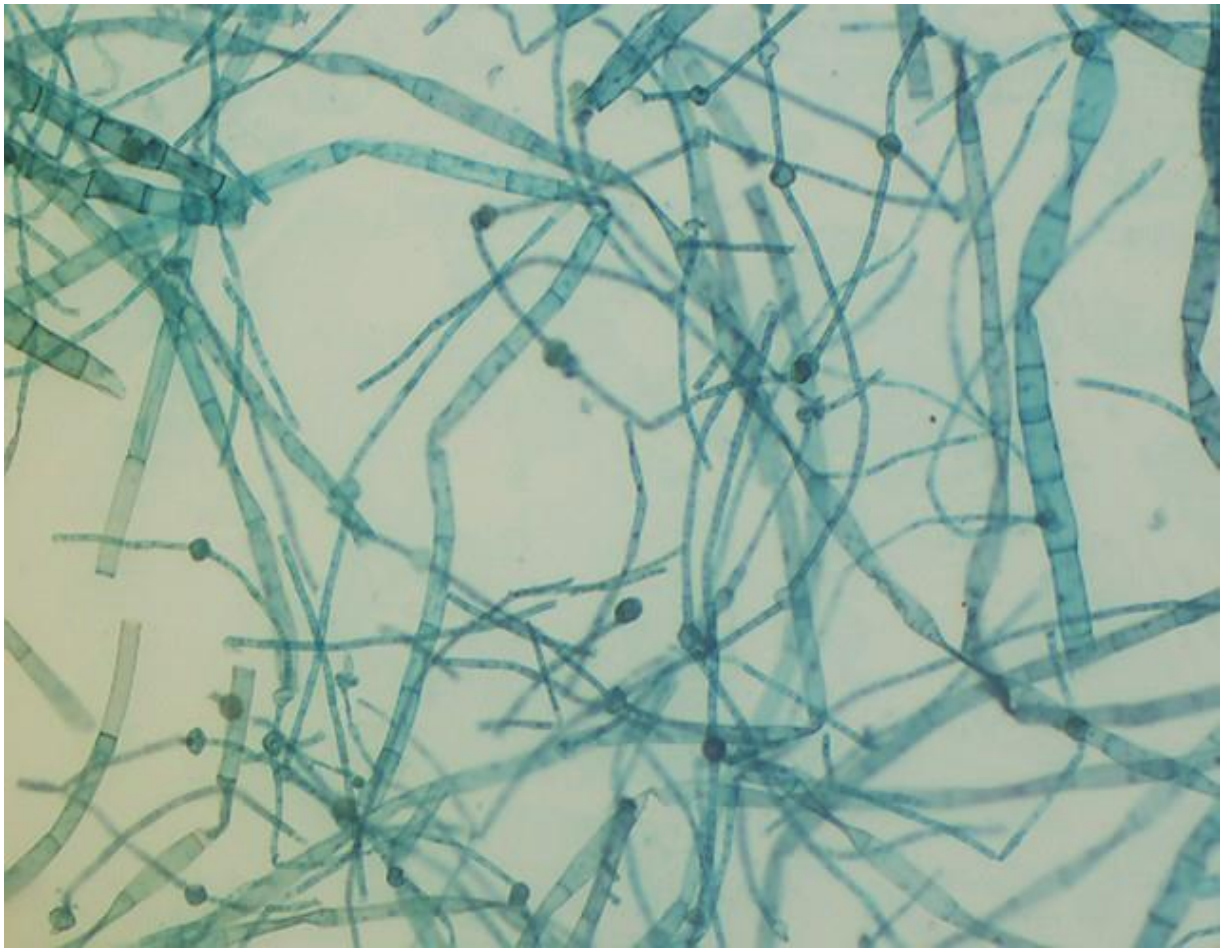


- The plant body is multicellular non motile coenobium.
- Coenobium forms hollow and cylindrical sac like net work closed at either end.
- Each perforation, net or mesh is bounded by 5 or 6 cells.

Oedogonium- Oogonial

Division : Chlorophyta
Class: Chlorophyceae
Order: Oedogoniales
Family: Oedogoniaceae
Genus : ***Oedogonium***

- The plant body is multicellular, filamentous, long and unbranched.
- The filament is attached to substratum by means of long hyaline, basal holdfast.
- Apical cell of filament is generally rounded at it free surface.



The oogonium is swollen, rounded or oval structure which encloses single egg or oosphere.

Division : Chlorophyta

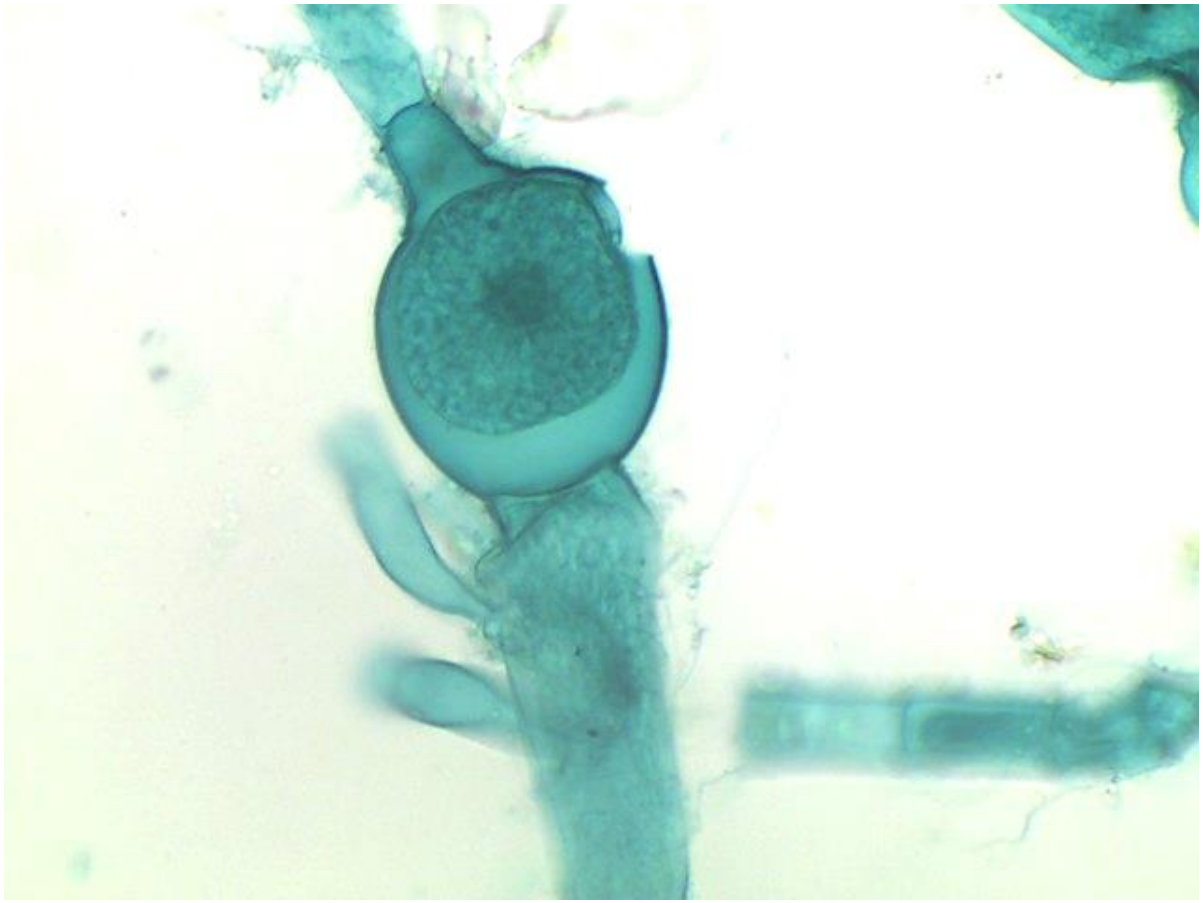
Class: Chlorophyceae

Order: Oedogoniales

Family: Oedogoniaceae

Genus : ***Oedogonium***

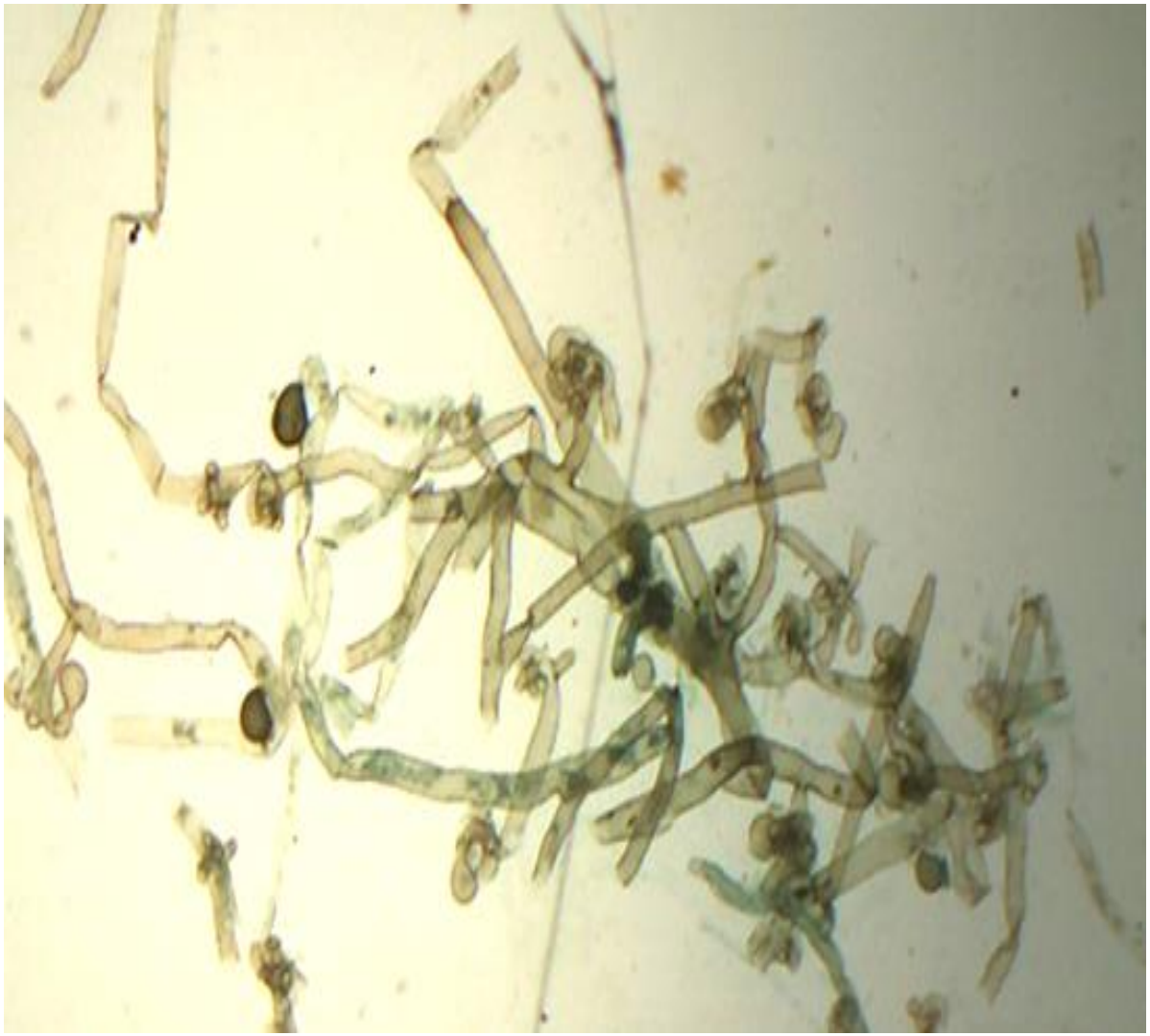
Oedogonium dwarf male



- Nannandrous species are always dioecious.
- The antheridia are borne on special filament called dwarf male or nannandrium

Vaucheria

Division : Xanthophyta
Class: Xanthophyeae
Order: Heterosiphonales
Family: Vaucheriaceae
Genus : ***Vaucheria***

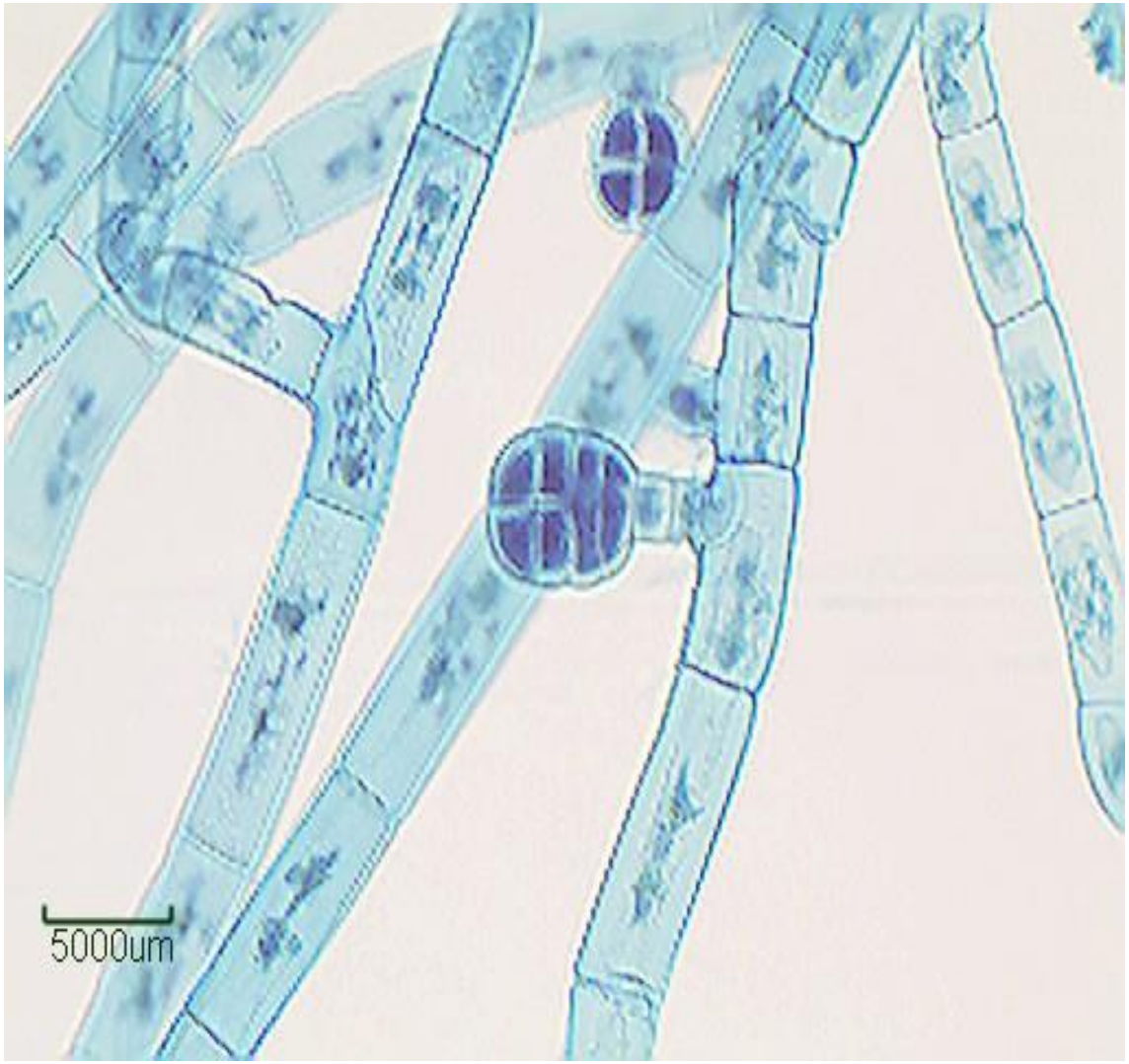


- The plant body is filamentous, branched multinucleate and acellular coenocytic
- The branching is lateral but looks dichotomous
- The filament is cylindrical and aseptate.

Division : Phaeophyta
Class: Phaeophyceae
Order: Ectocarpales
Family: Ectocarpaceae
Genus : ***Ectocarpus***

Ectocarpus unilocular

- The plant body is multicellular, macroscopic, filamentous, branched.
- The unilocular sporangia are always found in sporophytic (diploid) plant.
- Unilocular sporangium is globose to ellipsoidal in shape, situated at apex of short lateral branch.



Division : Phaeophyta
Class: Phaeophyceae
Order: Ectocarpales
Family: Ectocarpaceae
Genus : ***Ectocarpus***

Ectocarpus plurilocular

- The plant body is multicellular, macroscopic, filamentous, branched.
- The plurilocular sporangia are elongated, cone shaped, ovate or siliquose. They are borne laterally on lateral branches.
- They may be shortly stalked or sessile.

Division : Phaeophyta
Class: Phaeophyceae
Order: Fucales
Family: Fucaceae
Genus : ***Fucus***

Fucus female conceptacle

- There are numerous flask shaped female conceptacle present towards the periphery on all the receptacles..
- Each conceptacle open outside by an ostiole which is guarded by several hair like periphyses.
- Several sterile and unbranched paraphyses originate from the wall of conceptacles. The stalked oogonia are singly attached to the inner layer of conceptacles.

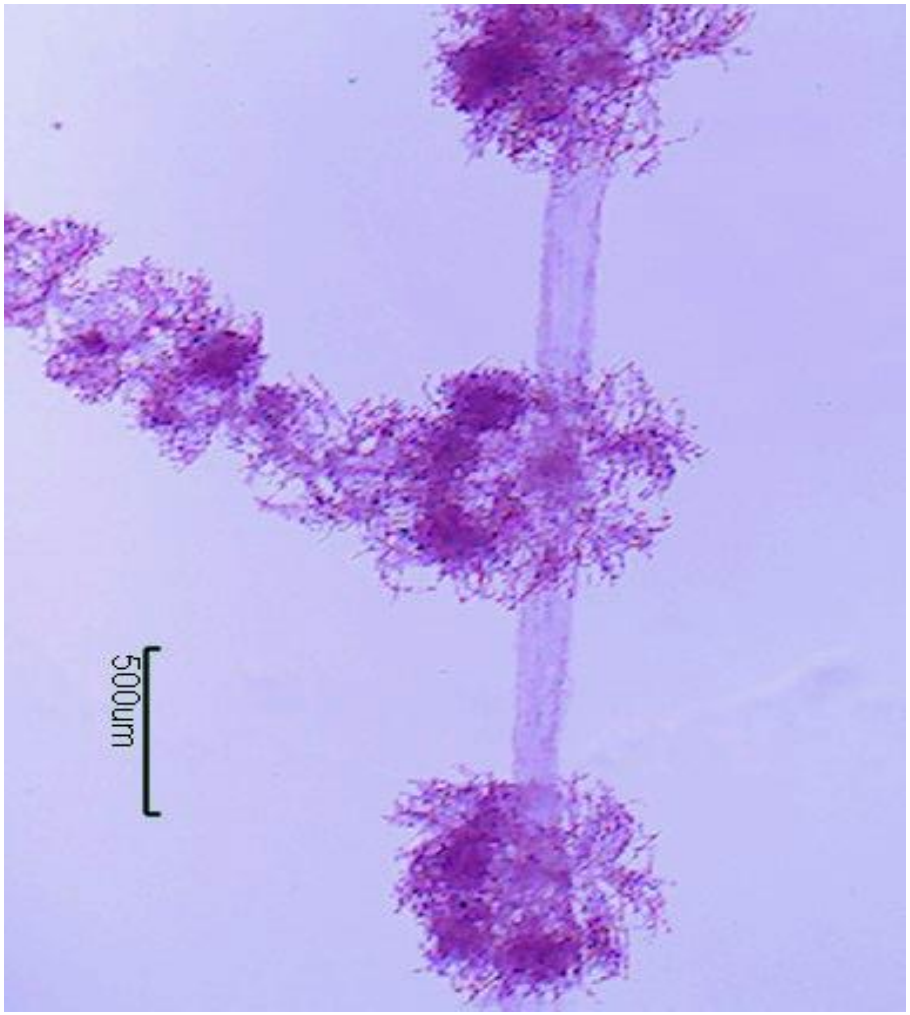
Division : Phaeophyta
Class: Phaeophyceae
Order: Fucales
Family: Fucaceae
Genus : ***Fucus***

Fucus male conceptacle

- There are numerous flask shaped female conceptacle present towards the periphery on all the receptacles.
- Each conceptacle open outside by an ostiole which is guarded by several hair like periphyses.
- Several sterile and unbranched paraphyses originate from the wall of conceptacles. Fertile paraphyses arebranched and bear number of antheridia

Division : Rhodophyta
Class: Rhodophyceae
Order: Nemalionales
Family:Batrachospermaceae
Genus:
Batrachospermum

Batrachospermum (frog spawn)

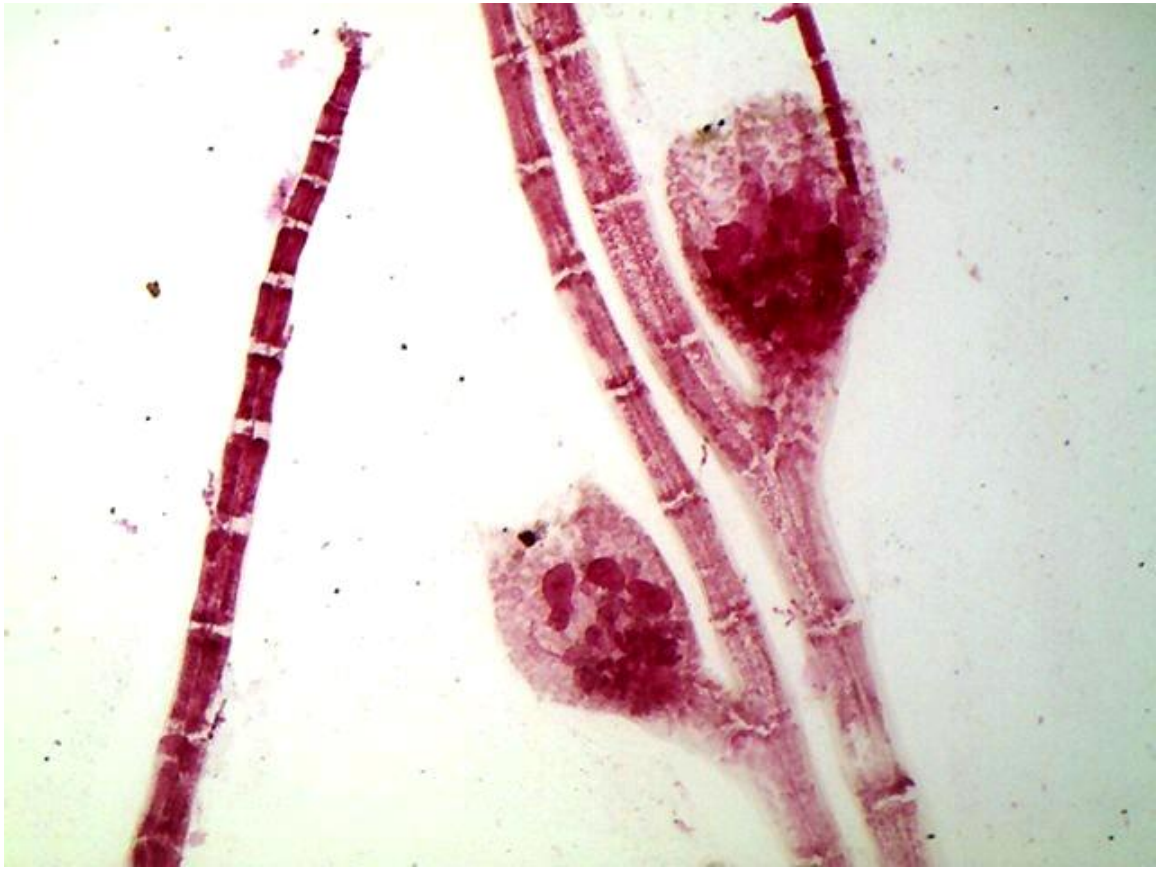


- The plant body is mucilagenous, multicellular, filamentous, branched and heterotrichous
- The branched thallus appear as chain of beaded filaments
- The main axis consist of uniseriate row of long, cylindrical axial cells.
- The lateral branches arise monopodially from 4-6 lateral basal cells near septa(node).
- Two types of branch: limited growth and unlimited growth

Division : Rhodophyta
Class: Rhodophyceae
Order: Ceramiales
Family:Rhodomelaceae
Genus: ***Polysiphonia***

Polysiphonia cystocarp

- The plant body is multicellular, filamentous, branched and heterotrichous
- The thallus is characteristically polysiphonous.
- Cystocarps are produced on female gametophytes as a result of post fertilization changes in the female sex organ



Polysiphonia tetrasporophyte

Polysiphonia tetrasporophyte

Division : Rhodophyta

Class: Rhodophyceae

Order: Ceramiales

Family:Rhodomelaceae

Genus: ***Polysiphonia***

- The diploid plant body produced by germination of carpospores is called tetrasporophytes.
- It is similar to the gametophytic plant body.
- The thallus is free living. It consist of central siphon enriched by pericentrat siphons.

Polysiphonia antheridia

Polysiphonia antheridia

Division : Rhodophyta

Class: Rhodophyceae

Order: Ceramiales

Family:Rhodomelaceae

Genus: ***Polysiphonia***

- The spermatangia are borne on male gametophyte
- They are produced on special fertile trichoblasts called male trichoblasts near the apices of male gametophyte.
- They are produced in large number densely packed in a cone shaped structure.
- Each spermatangium is spherical or oblong, unicellular, uninucleate and produces single non-motile, naked, colourless spermatium.

Fungi

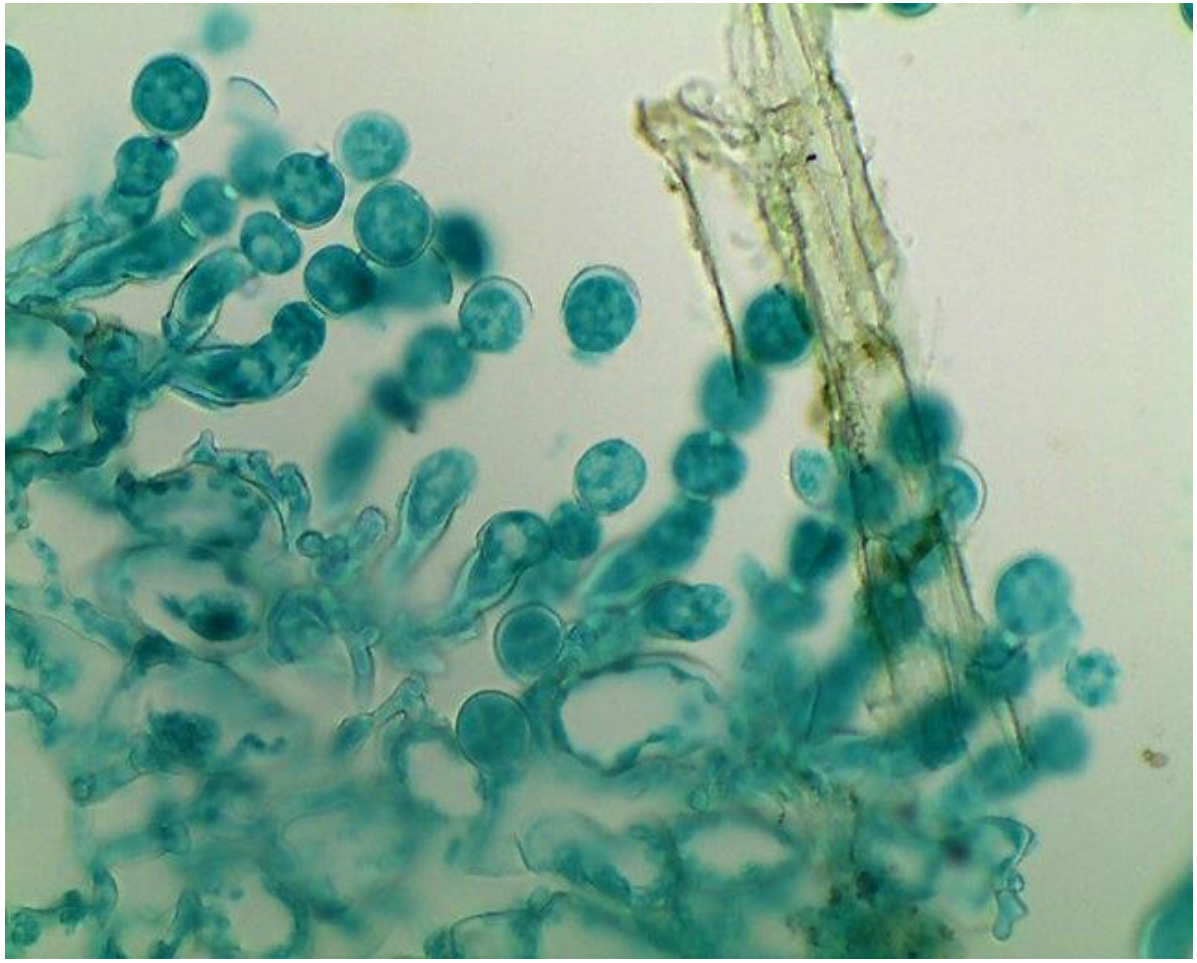
Division : Eumycota
Sub-division: Mastigomycotina
Class: Oomycetes
Order: Peronospoales
Family: Albuginaceae
Genus: ***Albugo***

Hypertrophied inflorescence of *Brassica*

- The disease is caused by *A. candida* in plants of family cruciferae.
- Symptoms of the disease first appear on leaves in form of shinning white, smooth, irregular blisters. Gradually the pustules become powdery.
- It is followed by twisting of stems, deformation of flowers, swelling and gall formation and hypertrophy in the inflorescence axis. .
- Hypertrophy and distortion of the particular organ (viz., stem, flower or inflorescence) indicate presence of sex organs in underlying tissues.

Division : Eumycota
Sub-division: Mastigomycotina
Class: Oomycetes
Order: Peronospoales
Family: Albuginaceae
Genus: ***Albugo***

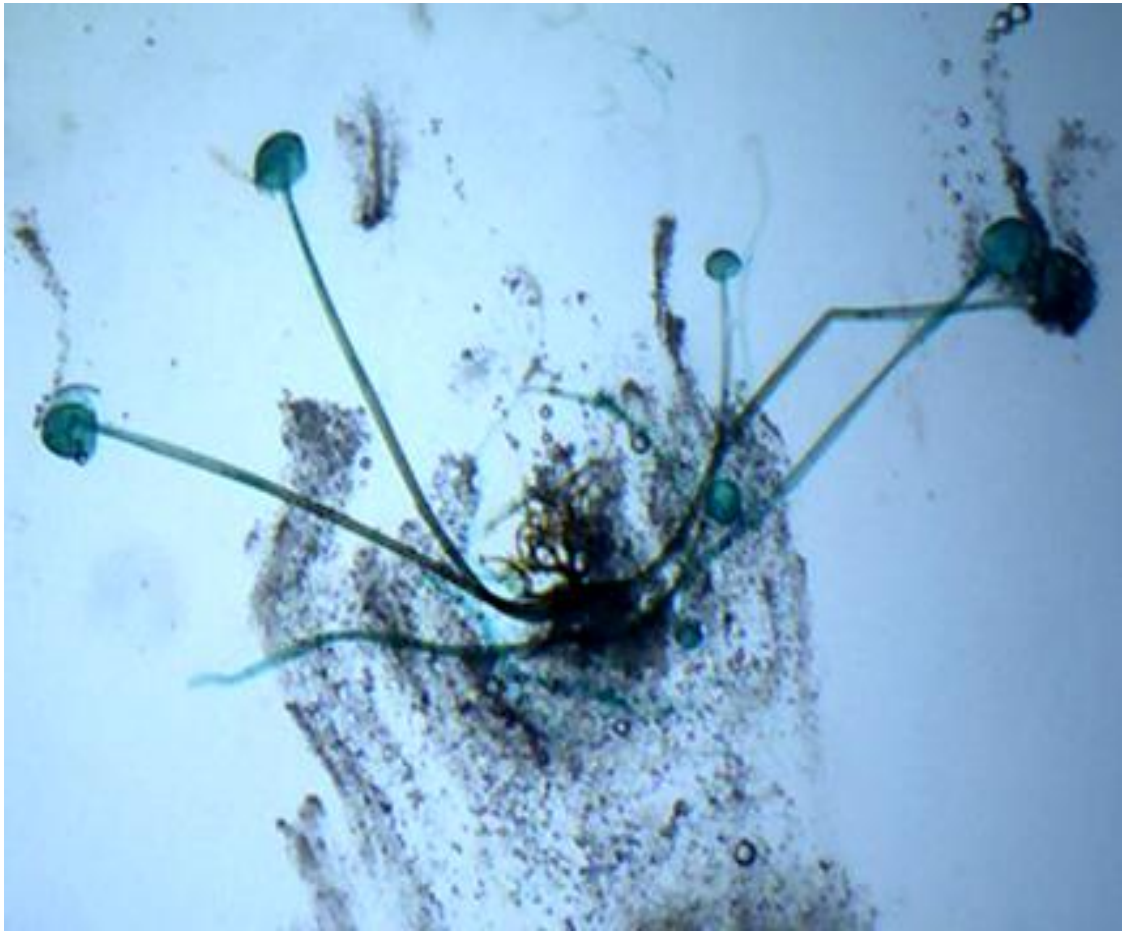
Cystopus conidia



- It causes **white rust of crucifers.**
- The mycelium is non septate present in the intercellular spaces
- Conidiophore are club shaped, parallel arranged.
- Conidia are arranged in basipetal succession

Division : Eumycota
Sub-Division: Zygomycotina
Class: Zygomycetes
Order: Mucorales
Family: Mucoraceae
Genus : ***Rhizopus***

Rhizopus



- Mycelium aseptate.
- Sporangiophore develops in group.
- Single sporangium is formed at the apex of sporangiophore.
- Sporangium are dehiscence become umbrella shaped.

Morchella

Division : Eumycota
Sub-Division: Ascomycetes
Class: Discomycetes
Order: Pezizales
Family: Helvellaceae
Genus : ***Morchella***

- The ascocarp or fruiting body is an **apothecium**. The size of ascocarp ranges from 2.5 cm to 12 cm.
- The colour varies from grayish white to dark brown.
- The ascocarp was differentiated into thick stalk called **stipe** and an apical cap like head called **pileus**.
- The stalk or stipe is fleshy and hollow in centre.
- The fertile portion of pileus is conical in shape and hollow in centre and looks like cap.
- The outer surface of pileus show ridge and depression which give pitted appearance.
- The ridges are sterile. The depressions or pits are fertile area constituting the hymenium. They are irregular in shape and brown in colour.

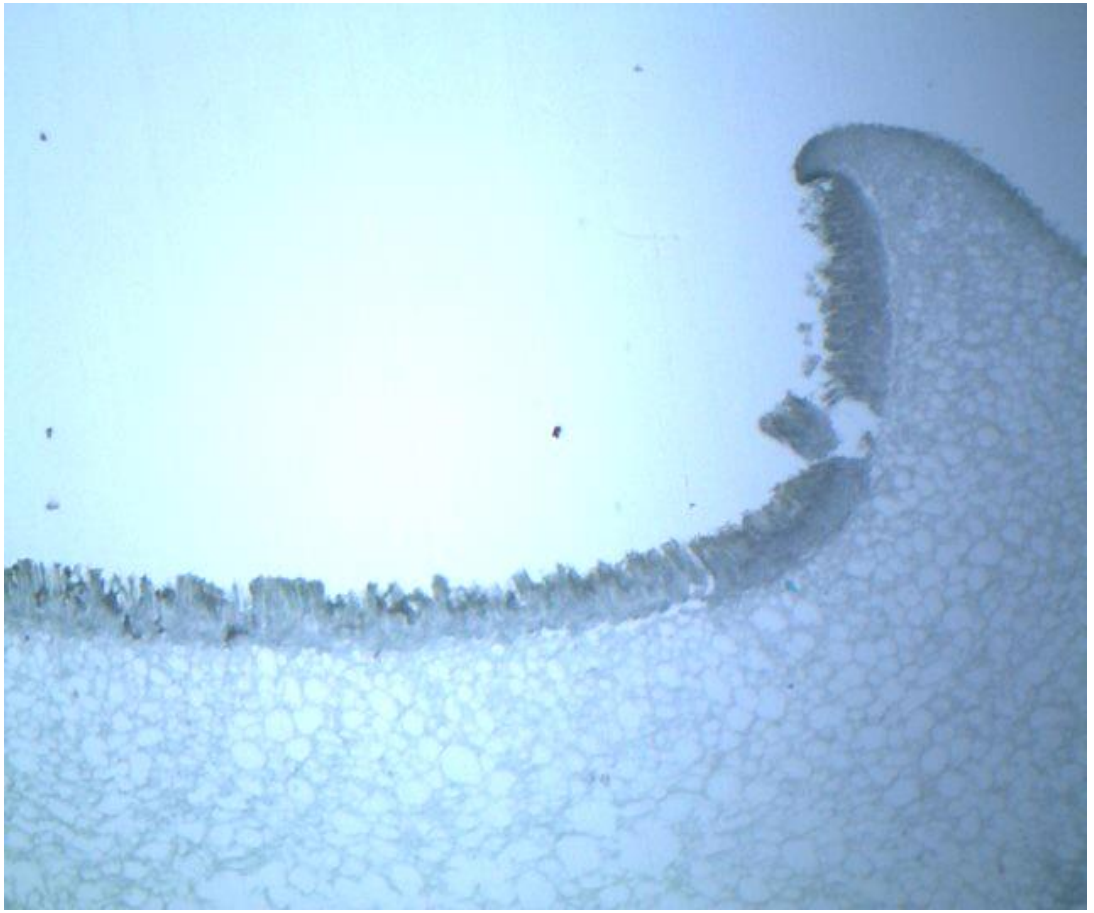
Division : Eumycota
Sub-Division: Ascomycotina
Class: Discomycetes
Order: Pezizales
Family: Pezizaceae
Genus : ***Peziza***

Peziza cups

- The fungus remains in substratum in form of much branched mycelium.
- The ascocarp or fruiting body is an **apothecium**.
- The apothecia are large, fleshy about 5 cm in diameter, sessile or subsessile cup shaped bodies.
- The cups are white or buff coloured from outside and interior of cups are brown or bright red in colour.
- The inner lining of apothecium is called Hymenium which consist of large number of asco intermixed with sterile paraphyses.

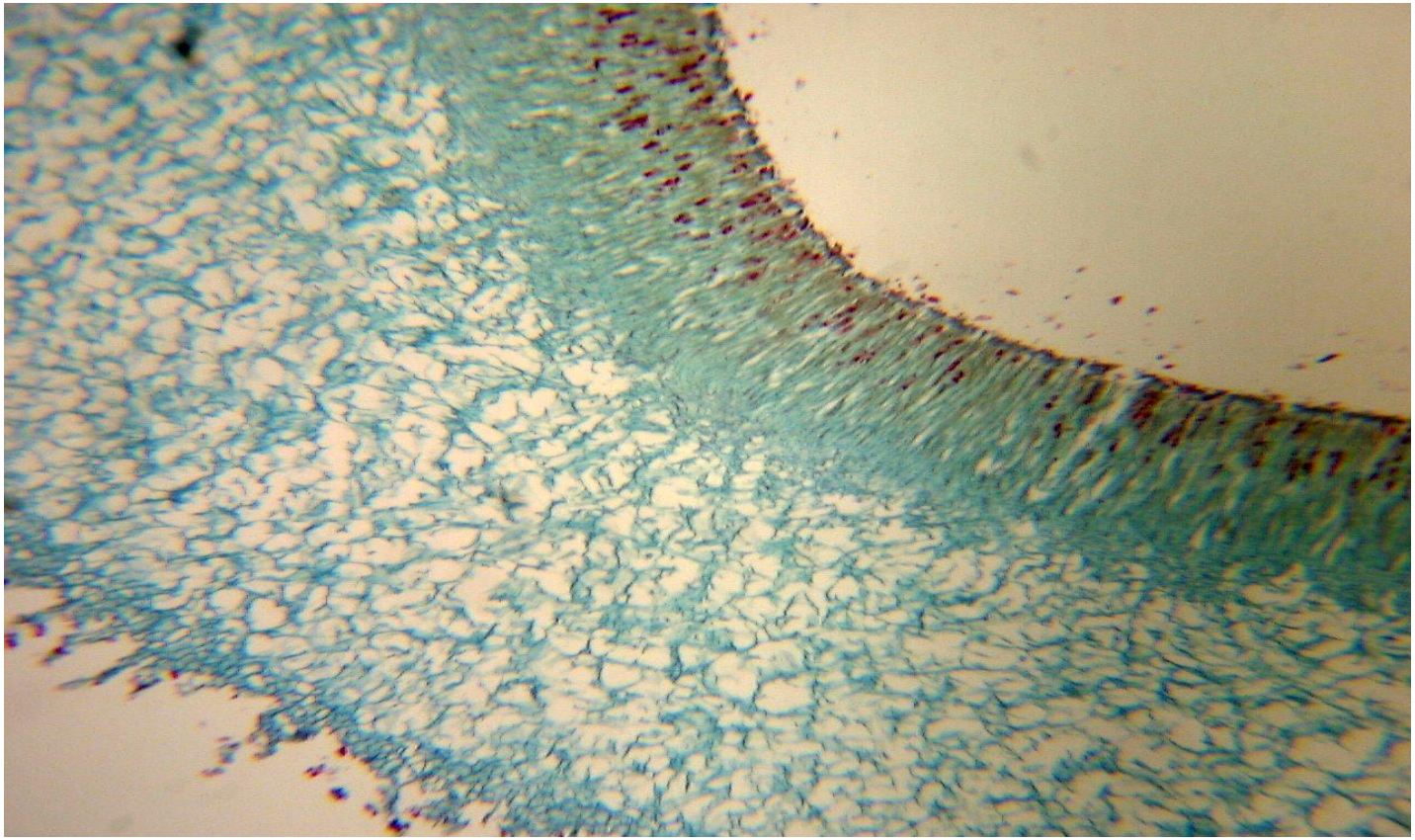
Division : Eumycota
Sub-Division: Ascomycotina
Class: Discomycetes
Order: Pezizales
Family: Pezizaceae
Genus : ***Peziza***

Peziza apothecium (V.T.S.)



- The vertical section of an apothecium show cup shaped structure consisting of mycelium
- The basal portion of apothecium is called **hypothecium** which is made up of loosely packed mycelium.
- The inner lining of apothecium is called **hymenium** layer which consist of large number asci arranged in layer in palisade like manner

Peziza apothecium



Agaricus

Division : Eumycota
Sub-Division: Basidiomycotina
Class: Hymenomycetes
Order: Agaricales
Family: Agaricaceae
Genus : ***Agaricus***

- The basidiocarp is the fruiting body which develops in rainy season.
- The young basidiocarp is small, oval or pear shaped structure which arise on rhizomorphic potion and called Button stage.
- The mature basidiocarp is an umbrella shaped structure, differentiated into upper expanded, circular head called **pileus** and lower short, fleshy stalk called **stipe.**
- The upper surface of pileus is smooth, flesh coloured. The underside bear large number of lamellae or gills.
- The stipe is short, fleshy elongated axis.

Division : Eumycota
Sub-Division: Basidiomycotina
Class: Teliomycetes
Order: Ustilaginales
Family: Ustilaginaceae
Genus : ***Ustilago***

Loose smut of wheat

- The disease is caused by *U. tritici* on wheat.
- The fungus is present in form of secondary mycelium in the whole plant but symptoms only appear in the “ears”.
- The disease ‘ear’ contain black powderey mass of teleutospores which are covered by a thin silvery membrane in beginning but exposed due to its rupture before the emergence of ear.
- Once diseased ear exposed all sores are dispersed leaving behind a naked rachis.

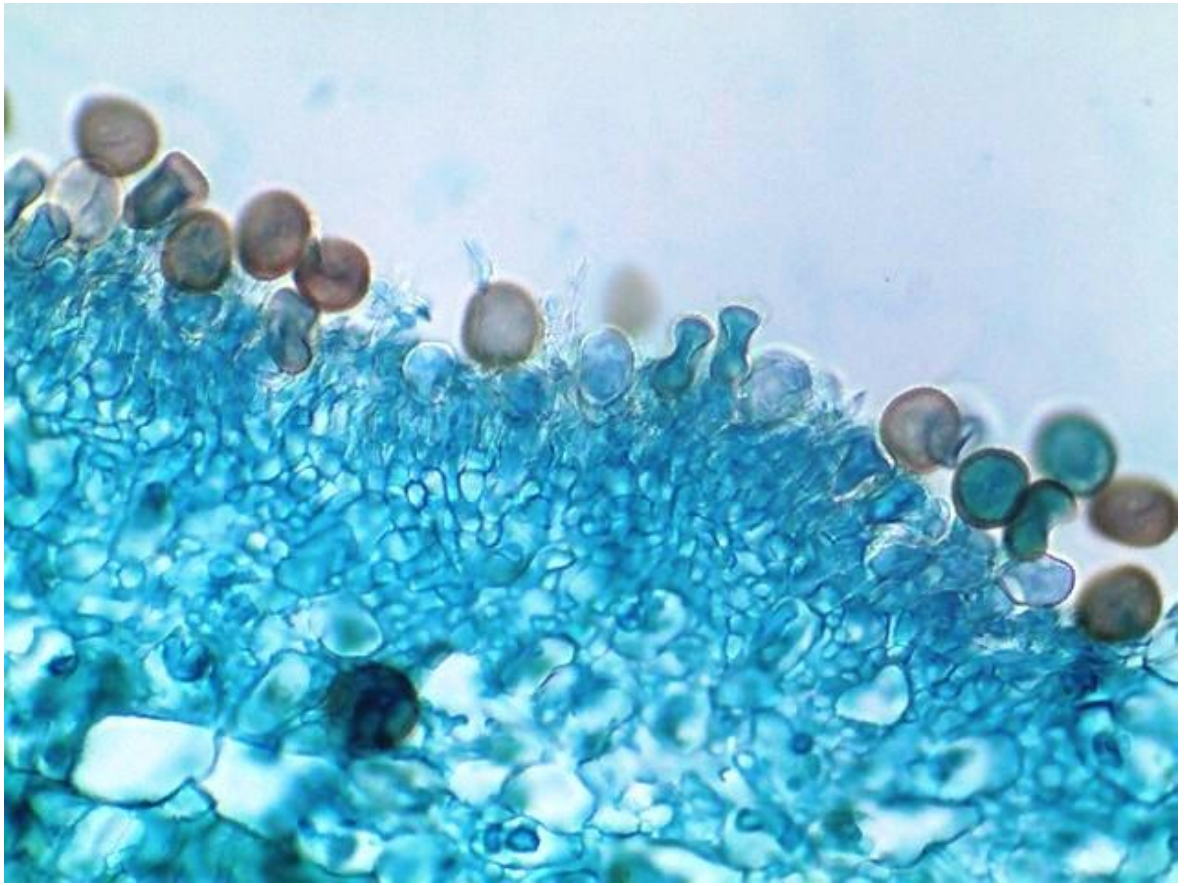
Division : Eumycota
Sub-Division: Basidiomycotina
Class: Teliomycetes
Order: Ustilaginales
Family: Ustilaginaceae
Genus : ***Ustilago***

Covered smut of *Barley*

- The disease is caused by *U. hordei* on barley.
- The fungus is present in form of secondary mycelium in the whole plant but symptoms only appear in the “ears”.
- Some of the grain are completely filled with black coloured smut spores which are enclosed inside the wall.
- The sporulation occurs inside the ovaries making use of internal tissues except ovary wall.
- Since the spores are covered in the membranous wall and not visible outside, disease is called **covered smut**.

Division : Eumycota
Sub-Division:
Basidiomycotina
Class: Teliomycetes
Order: Uredinales
Family: Pucciniaceae
Genus : ***Puccinia***

Puccinia uredospore



- The section of host through uredosorus show ruptured epidermis.
- A cluster of Uredospores is seen projecting out through pustules. These are attached to the underlying mycelium with small stalk.
- Each uredospore is binucleate, oval or rounded in shape and possess a double layered thick wall..

Division : Eumycota
Sub-Division: Basidiomycotina
Class: Teliomycetes
Order: Uredinales
Family: Pucciniaceae
Genus : ***Puccinia***

Puccinia teleutospore

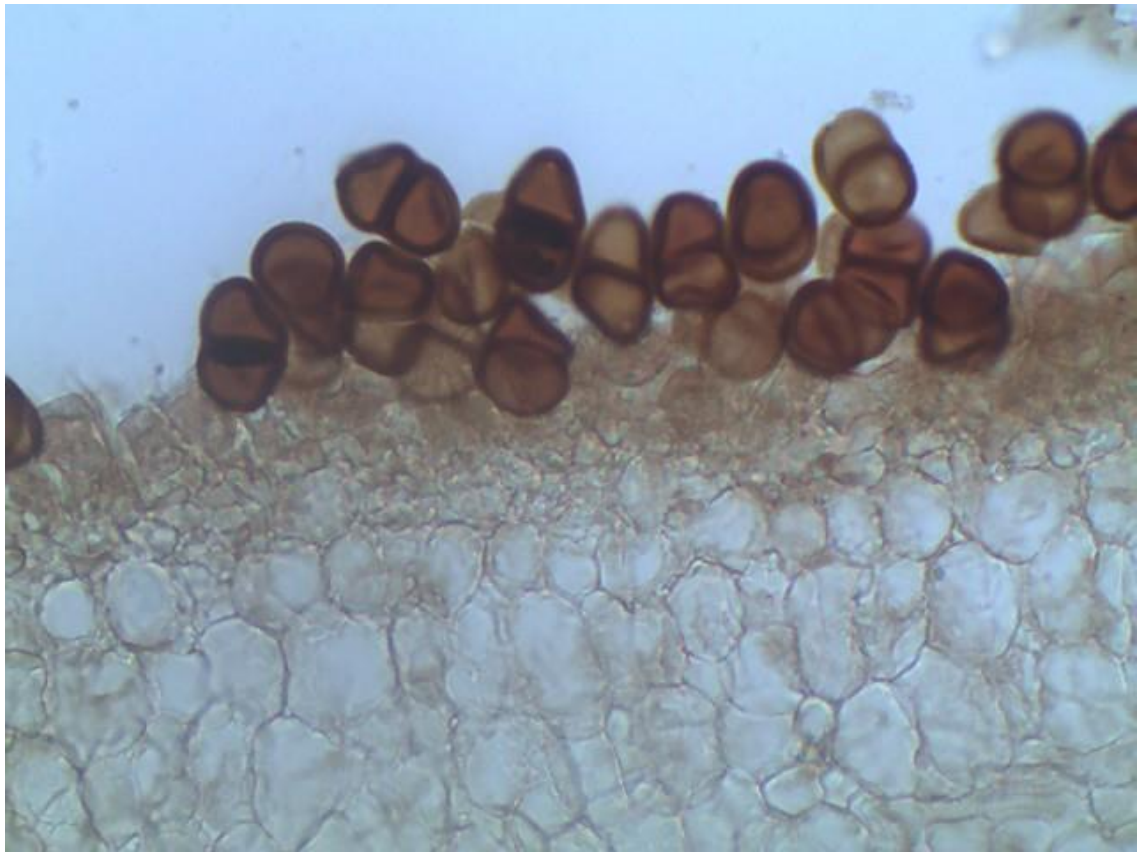
- The section of host through teleutosorus show ruptured epidermis.
- A cluster of teleutospores is seen projecting out through pustules.

Continued in next slide

Puccinia teleutospore

Continued from previous slide

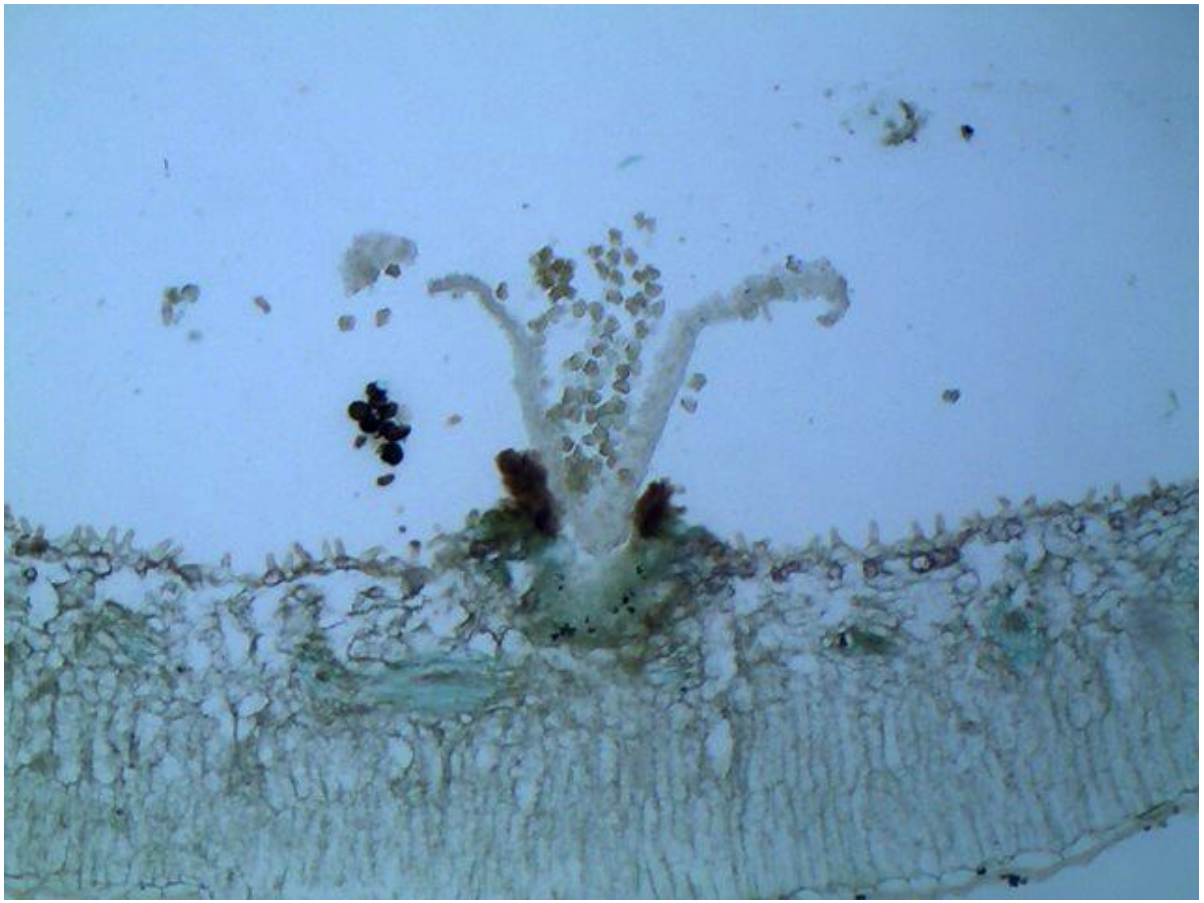
- Each teleutospore is elongated or spindle shaped shaped, bicelled (two cells attached to each other forming one spore) structure attached to the mycelium with the single celled stalk.



Division : Eumycota
Sub-Division: Basidiomycotina
Class: Teliomycetes
Order: Uredinales
Family: Pucciniaceae
Genus : ***Puccinia***

Puccinia acediospore

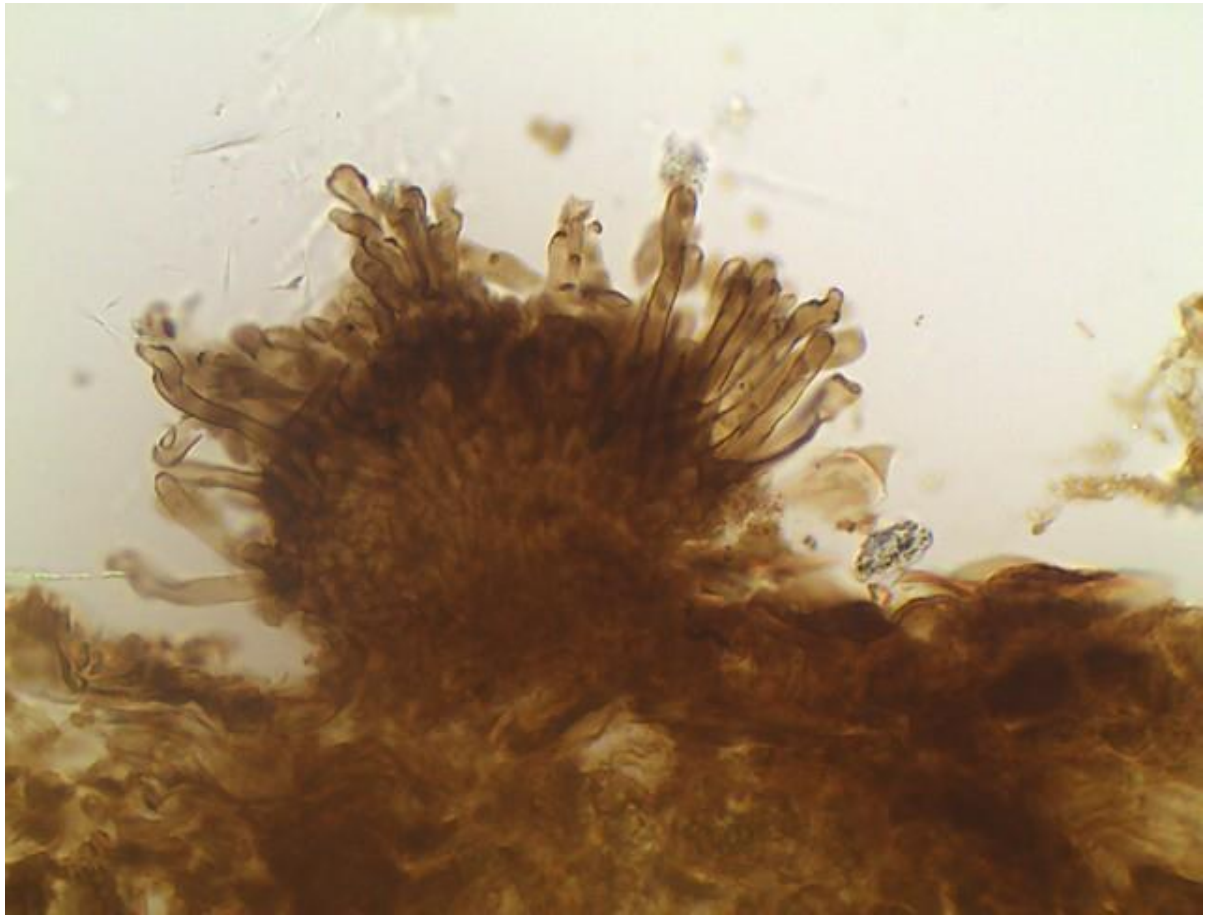
- The mature aecidium looks like bell or cup shaped structure.
- The peridium is broken towards lower surface.
- The aecidiospore are formed at the tip of basal cell towards the lower side .



Cercospora conidia

Division : Eumycota
Sub-Division: Deuteromycotina
Class: Hyphomyycetes
Order: Moniliales
Family: Dermatiacea
Genus : ***Cercospora***

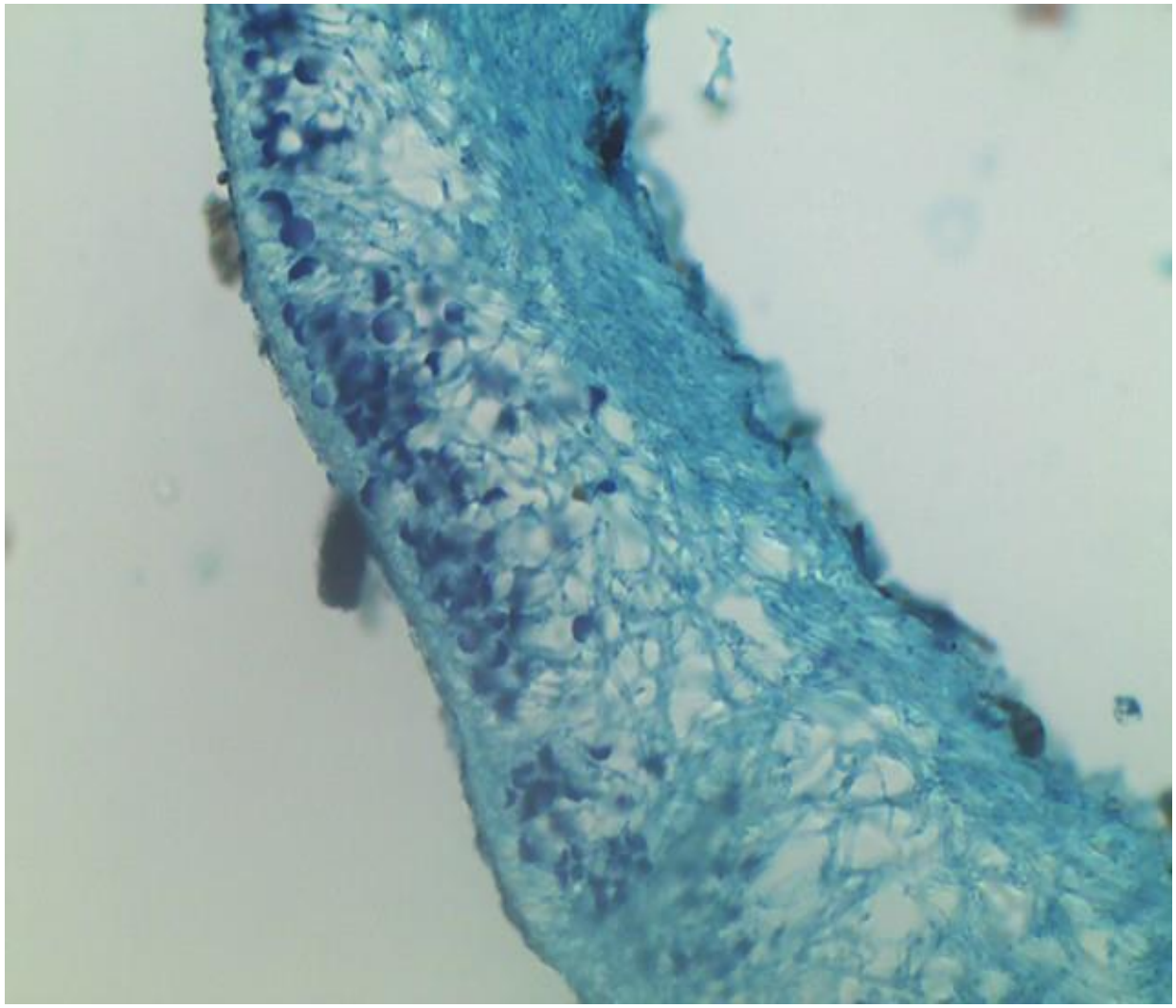
- It causes leaf spot disease.
- The mycelium consist of coloured, branched and septate hyphae.
- The conidiophores are seen protruding out in tuffs from epidermis.
- The conidiophore are dark colored, aseptate and show sympodial branching



Each conidiophore produce single conidium at apex

Lichen thallus V.S.

- The thallus differentiated into 4 regions.
- The **upper cortex** consist of compact hyphae with or without intercellular spaces.
- The **algal layer** consist of loose hyphae mixed with algal cells.
- **Medulla** occupies central portion consisting loosely interwoven hyphae.
- Lower cortex: compact hyphae.



Bryophyta

Riccia thallus

Division : Bryophtya

Class: Hepaticopsida

Order: Marchantiales

Family: Ricciaceae

Genus : ***Riccia***

- Gametophytic plant body of *Riccia* grows in small rosettes.
- Each thallus is small dark green in colour, prostrate, dorsiventral, ribbon like, fleshy and dichotomously branched.

Riccia sporophyte

Division : Bryophtya

Class: Hepaticopsida

Order: Marchantiales

Family: Ricciaceae

Genus : ***Riccia***

- The sporogonium is embedded centrally in the tissue of gametophytic plant body.
- It is more or less rounded, represented by only spore sac– the capsule.
- The foot and seta are absent. Spore attached in tetrads.
- The sporogonium of *Riccia* is most primitive type.

Marchantia thallus with Gemma cup

Division : Bryophtya

Class: Hepaticopsida

Order: Marchantiales

Family: Marchantiaceae

Genus : ***Marchantia***

- The plant body is gametophyte, which is thalloid, prostrate, flat, dorsiventral and dichotomously branched.
- They are dark green in colour.
- The dorsal surface show median longitudinal furrow which deepens at the apex of branch forming notch. Dorsal surface show certain cup like borne along midrib called **Gemma cup** which encloses numerous gemma.

Marchantia Anthrediophore

Division : Bryophtya

Class: Hepaticopsida

Order: Marchantiales

Family: Marchantiaceae

Genus : ***Marchantia***

- Each antheridiophore is differentiated into a long stalk and a lobed disc.
- The antheridiophore arises as an erect and stalked branch from apical notch of male thallus.

- The disc is usually 8 lobed. Each lobe represent a branch
- Upper surface of mature disc is slightly concave.

Marchantia anthrediophore V.T.S.

Division : Bryophtya

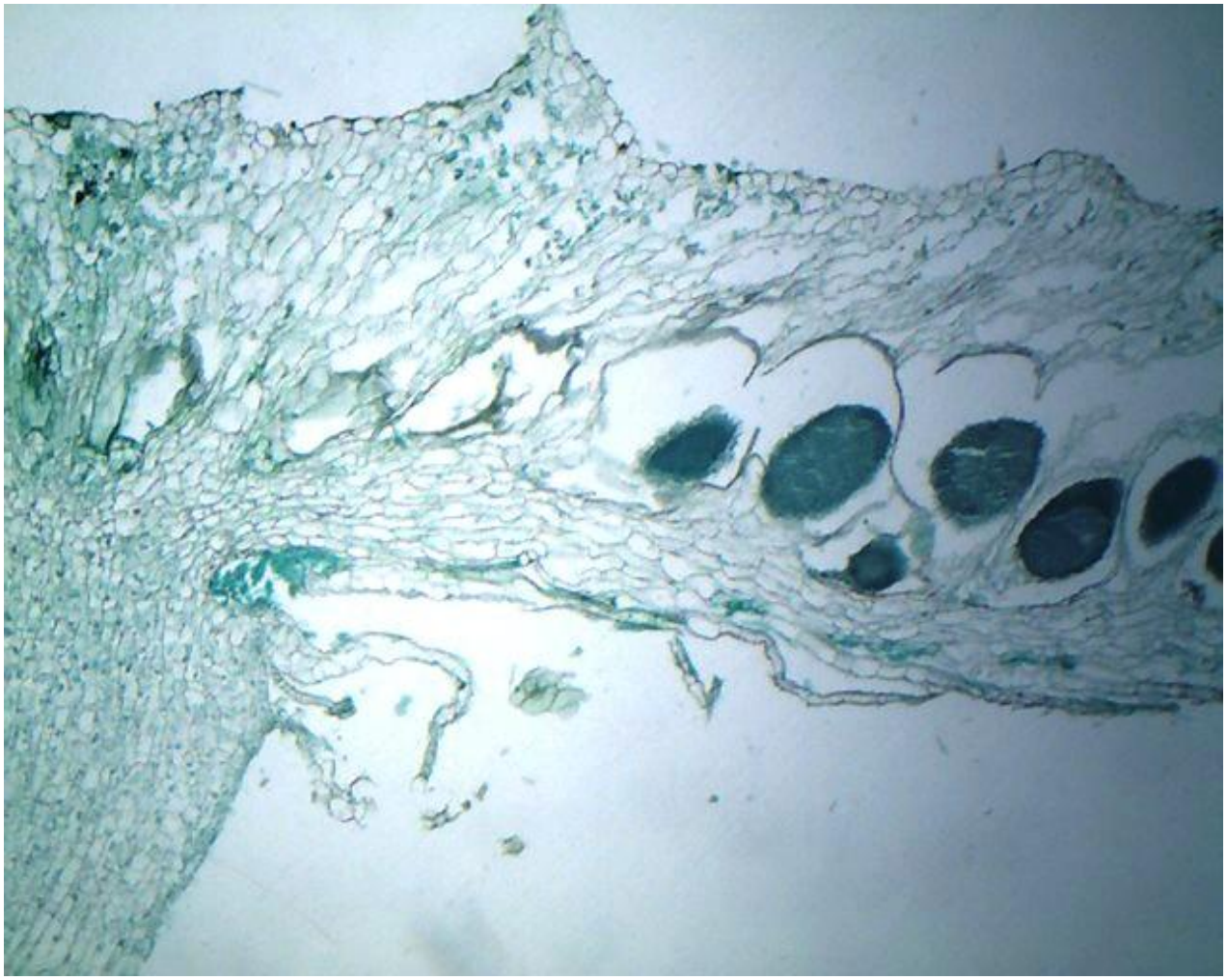
Class: Hepaticopsida

Order: Marchantiales

Family: Marchantiaceae

Genus : ***Marchantia***

- The disc of antheridiophore is modified thallus branchs , it s internal structure resembles to that of thallus.
- The upper zone consist of air chambers alternating with antheridial chambers.



- The antheridia are borne in acropetal succession in each branch.

Marchantia archaegoniophore

Division : Bryophtya

Class: Hepaticopsida

Order: Marchantiales

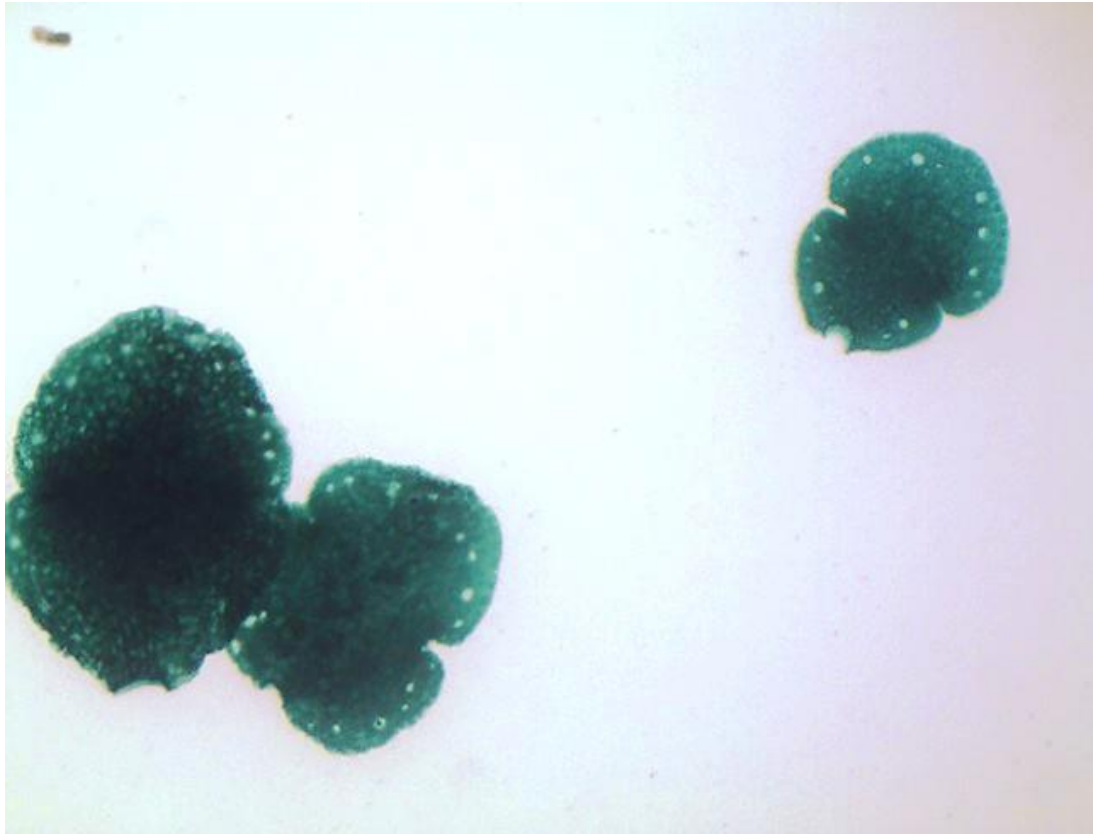
Family: Marchantiaceae

Genus : ***Marchantia***

- Each archegoniophore arise at apex of thallus.
- It is differentiated into two parts: stalk and body
- The stalk is short and elongates after fertilization.
- The disc is eight lobed.
- The rays curve downward giving the disc a shape of umbrella
- The group of archegonia arranged in radial rows. The archegonia are inverted.

Division : Bryophtya
Class: Hepaticopsida
Order: Marchantiales
Family: Marchantiaceae
Genus : ***Marchantia***

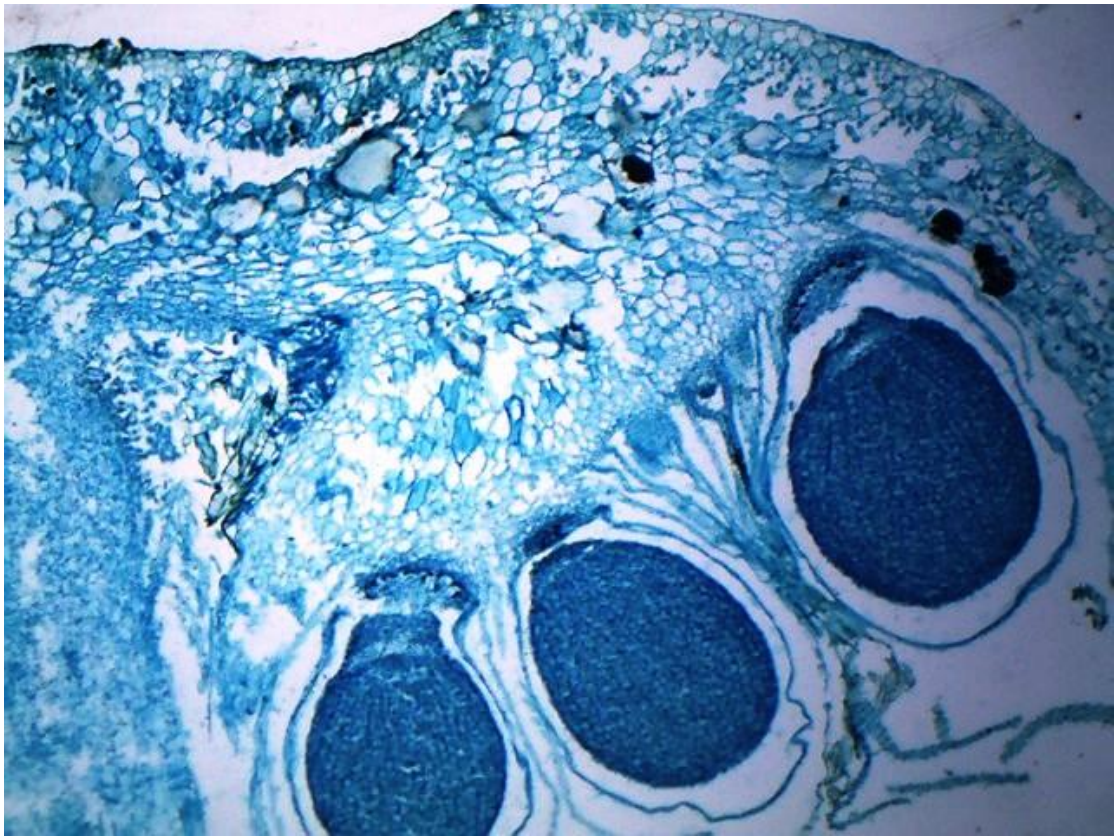
Gemmae



- The most common method of vegetative propagation is by specialised asexual multicellular bodies, known as gemmae.
- They are borne in large numbers in small receptacles called gemma cups present on the dorsal surface of the thallus in the midrib region.
- Each gemma is vertically attached to the base of the gemma cup by a one-celled stalk .
- The gemmae are multicellular, biconvex, discoid bodies constricted at the middle.
- The two notches in the constriction possess a row of apical cells showing two growing points.

Division : Bryophtya
Class: Hepaticopsida
Order: Marchantiales
Family: Marchantiaceae
Genus : ***Marchantia***

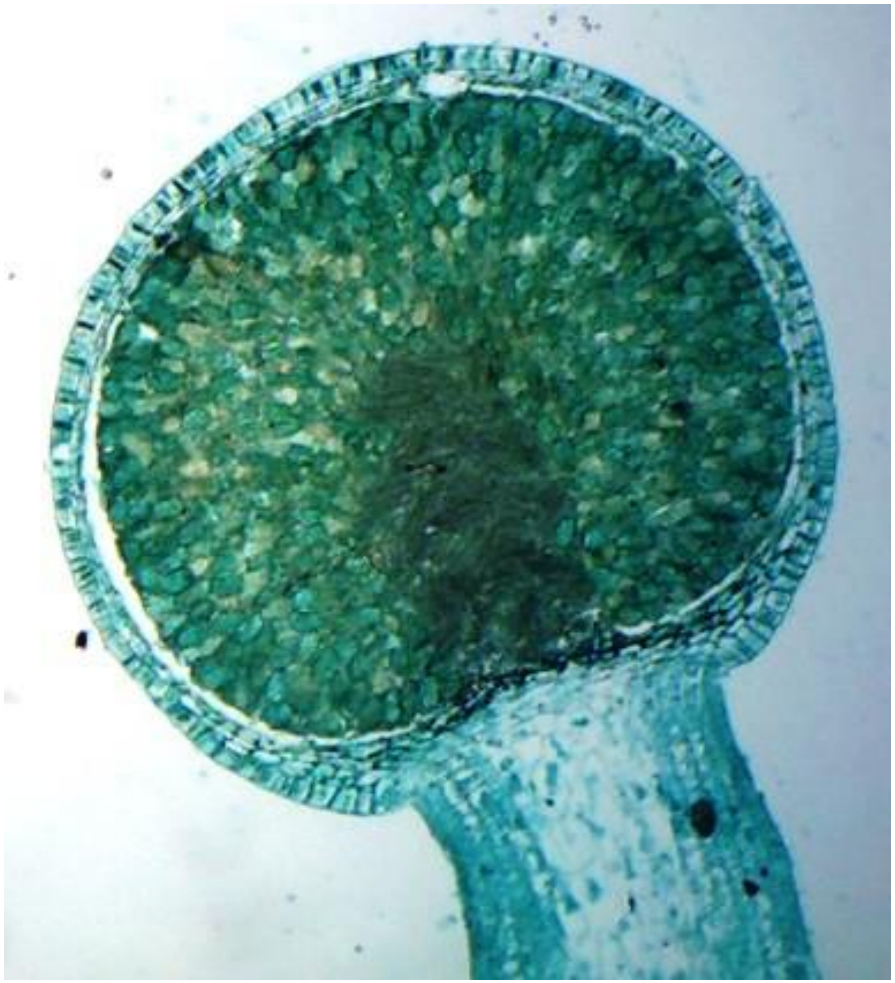
Marchantia young sporophyte



- The mature sporophyte of *Marchantia* is differentiated into three parts — foot, seta and capsule.
- It is enclosed within a protective covering called calyptra.
- Foot is an expanded bulbous mass of cells at the base of the sporogonium.
- Seta is slightly elongated stalk that connects the foot to the capsule.
- Capsule is a yellow-coloured spherical structure, contains numerous spores and elaters.

Division : Bryophtya
Class: Hepaticopsida
Order: Jungermanniales
Family: Pelliaceae
Genus : ***Pellia***

Pellia sporophyte



- The mature sporophyte of *Pellia* is differentiated into three parts — foot, seta and capsule.
- When young sporogonium is under protective covering called calyptra and involucre.
- Foot is conical project like collar surrounding seta
- Seta is long consist.
- Capsule is spherical surrounded by two or more layers
- Elaterophore are present at base of capsule.
- Spore and elaters present

Division : Bryophtya

Class: Hepaticopsida

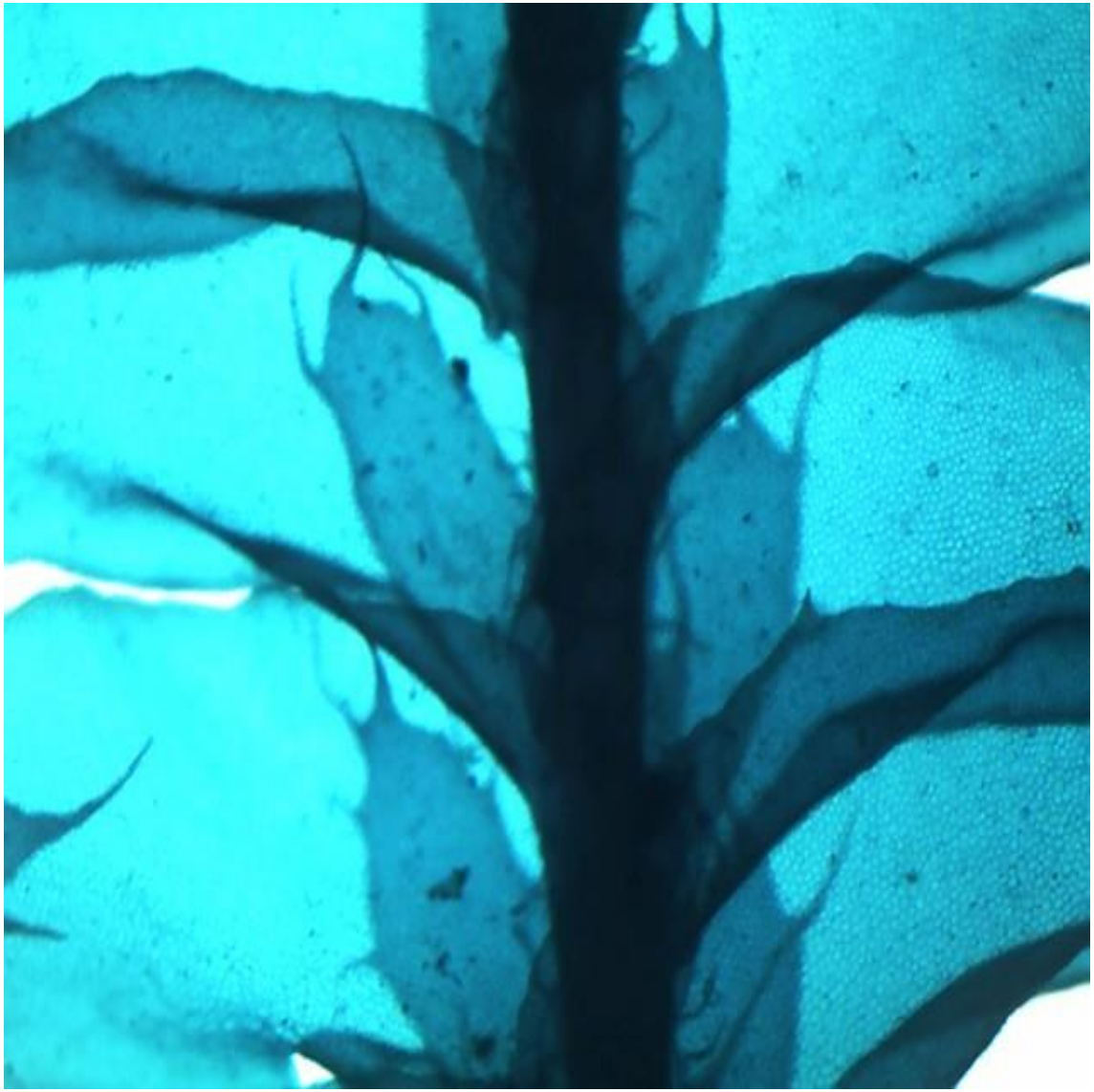
Order: Jungermanniales

Family: Porellaceae

Genus : ***Porella***

- The plant body is a leafy axis.
- The leaves are arranged in three rows: two lateral and a ventral row
- The dorsal surface of plant body show central axis and two rows of lateral leaves.
- Third row of ventral leaves seen only on ventral surface.
- Lateral leaves are bilobed divided into two unequal lobes.

Porella wm



Division : Bryophtya

Class: Hepaticopsida

Order: Jungermanniales

Family: Porellaceae

Genus : ***Porella***

Porella sporophyte

- The mature sporophyte of *Porella* is differentiated into three parts — foot, seta and capsule.
- When young sporogonium is under protective covering called calyptra and perianth.
- Foot is bulbous and indistinct.
- Seta is short consists of vertically elongated cells. Foot and seta not clearly demarcated.
- Capsule is spherical and encloses short elaters and spores.

Division : Bryophtya

Class: Bryopsida

Order: Sphagnales

Family: Sphagnaceae

Genus : ***Sphagnum***

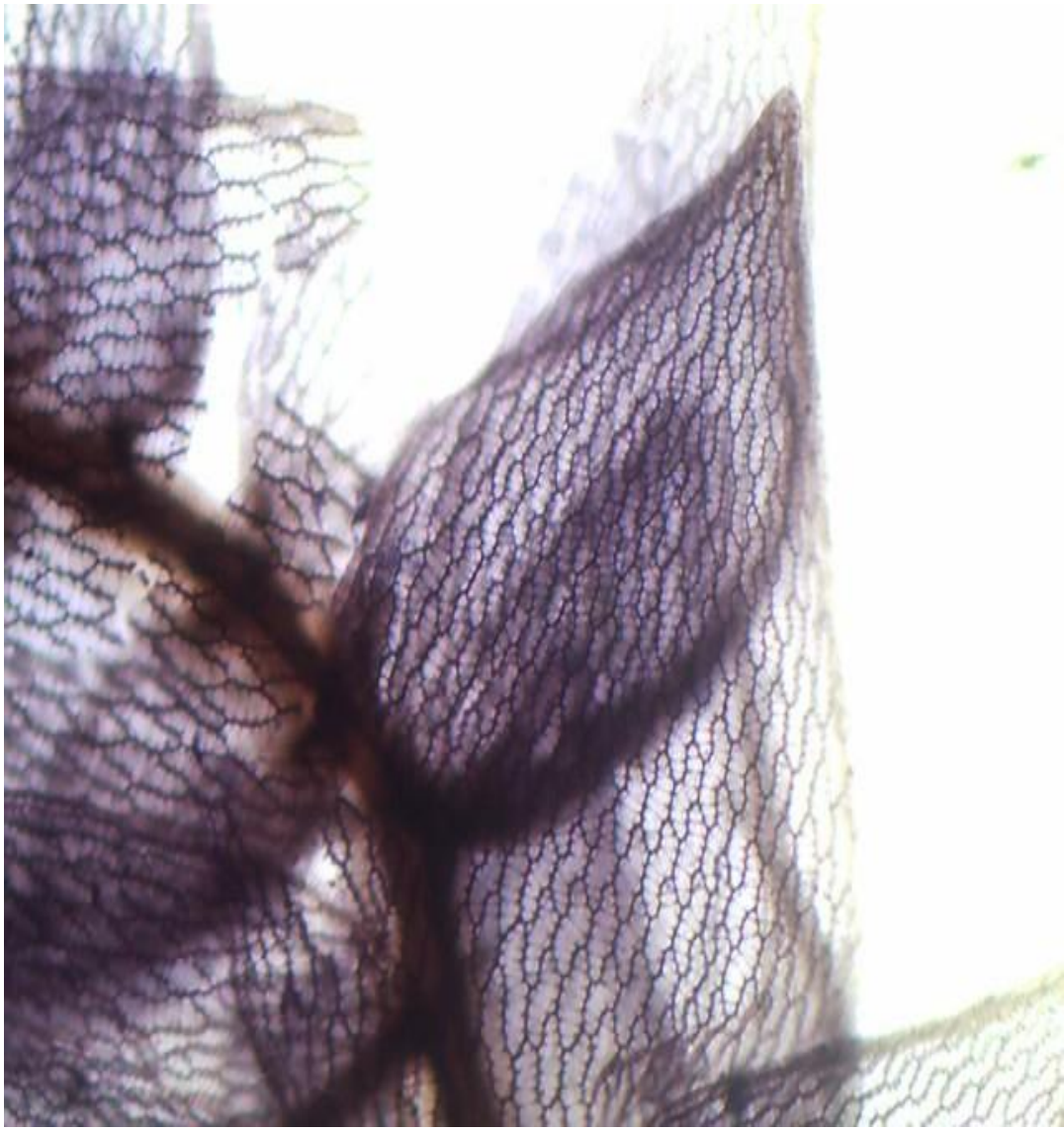
- The plant body is erect, branched and differentiated into stem, leaves and lateral leafy branches.
- Rhizoid present in young gametophyte but absent in adult plant.
- The lateral branch on main axis arise in tufts from the axile of every fourth leaf. There are 3-8 lateral branches in each tuft.

Sphagnum wm

Division : Bryophtya
Class: Bryopsida
Order: Sphagnales
Family: Sphagnaceae
Genus : ***Sphagnum***

Sphagnum leaf

- Leaf of Sphagnum is entire, sessile, unistratose (one cell thickness) and devoid of midrib.
- Surface veiw of leaf show two type of cells: narrow, living, chloroplast containing assimilatory cells called **Chlorophyllose cells** and large, dead, rhomboidal **hyaline cells** which show annular and spiral wall thickening which is for mechanical support.



Division : Bryophtya
Class: Bryopsida
Order: Sphagnales
Family: Sphagnaceae
Genus : ***Sphagnum***

- The gametophyte is a long 1-3 cm in height and differentiated into rhizoids, axis (stem) and leaves.
- Rhizoids: Multicellular, colourless root-like structures with oblique septa. The axis and its branches covered with spirally arranged leaves.
- The sporogonium of *Funaria* is photosynthetic, hence semi-parasitic on gametophore. It differentiates into foot, seta and capsule.

Funaria with capsule

The foot embedded in the female receptacle and absorbs inorganic nutrients. Seta is a long stalk with a pear-shaped capsule by its tip.

Division : Bryophtya
Class: Bryopsida
Order: Sphagnales
Family: Sphagnaceae
Genus : ***Sphagnum***

Peristome teeth

- Capsule has 3 parts-basal apophysis, central theca and terminal operculum.
- Greater number of species have capsules with teeth or hairs around the mouth. The teeth are called **peristome teeth** and there may be one ring or two rings of teeth around the margin of the mouth.
- Each ring of peristome possesses 16 teeth. The teeth of outer ring (exostome) are conspicuous, red with thick transverse bands whereas the inner rings (endostome) are comparatively small, colourless and soft.
- The dispersal of spores is due to hygroscopic movements of exostome of peristomial teeth. The inner ring of peristomial teeth do not show hygroscopic movement.

Pteridophytes

Division : Lycophyta

Class: Eligulopsida

Order: Lycopodiales

Family: Lycopodiaceae

Genus : ***Lycopodium***

Lycopodium phlegmaria

- This species grow as epiphytic on tree trunk.
- The stem are pendulous, dichotomously branched and terminate into strobili.
- The root arise from basal portion of stem.
- The leaves are small , isophyllous and spirally arranged on the stem.
- The sporophylls are smaller than the vegetative leaves.

Division : Lycophyta

Class: Eligulopsida

Order: Lycopodiales

Family: Lycopodiaceae

Genus : ***Lycopodium***

Lycopodium clavatum

- The plant body consists of creeping rhizome which give rise to aerial branches. The branching is dichotomous.
- The adventitious root arise from creeping leafy axis.
- The distinct strobili are borne on special modified branches.
- The sporophyll are small and closely appressed around cone axis.

Lycopodium cernuum

Division : Lycophyta

Class: Eligulopsida

Order: Lycopodiales

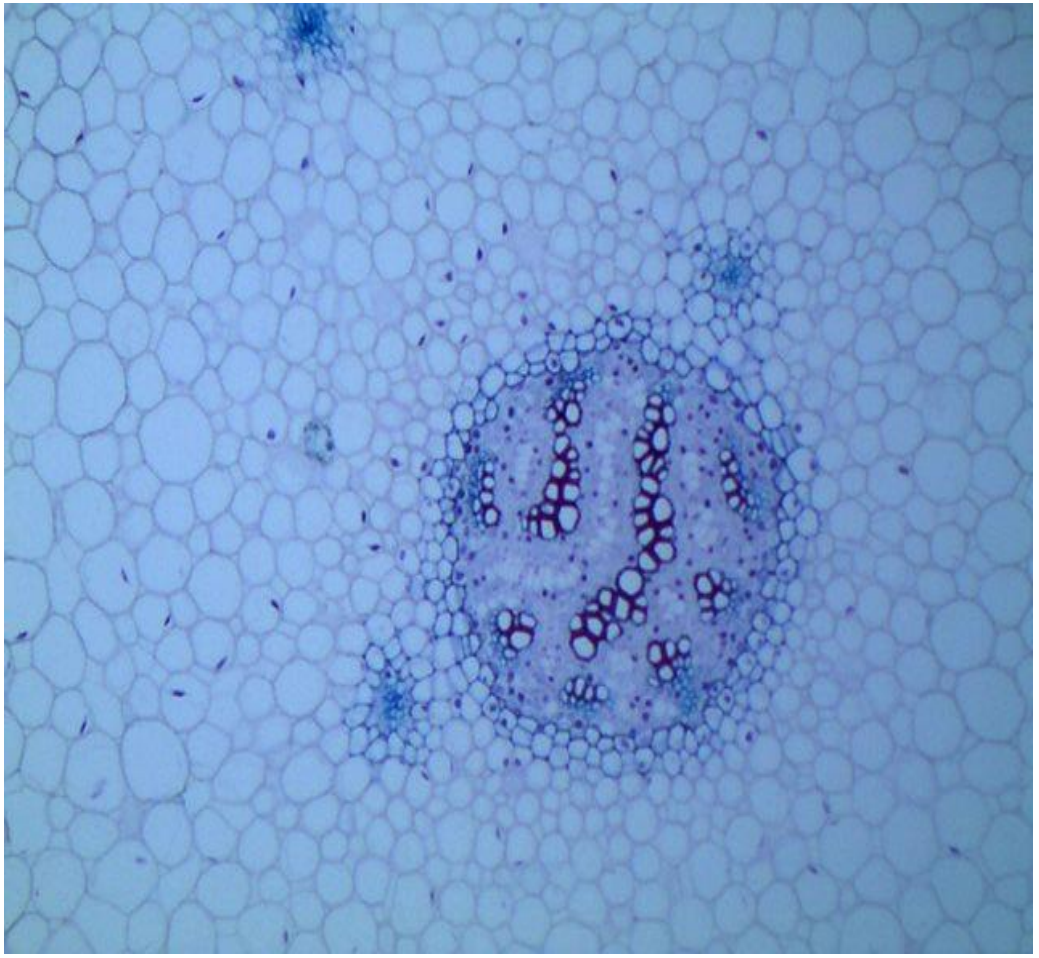
Family: Lycopodiaceae

Genus : ***Lycopodium***

- The plant body consists of creeping rhizome which give rise to aerial branches.
- The branching is dichotomous but looks monopodial.
- All foliage leaves are alike and arranged in whorl.
- The strobili are comparatively small and sessile and borne on tips of aerial branches.

Division : Lycophyta
Class: Eligulopsida
Order: Lycopodiales
Family: Lycopodiaceae
Genus : ***Lycopodium***

Lycopodium clavatum stem TS

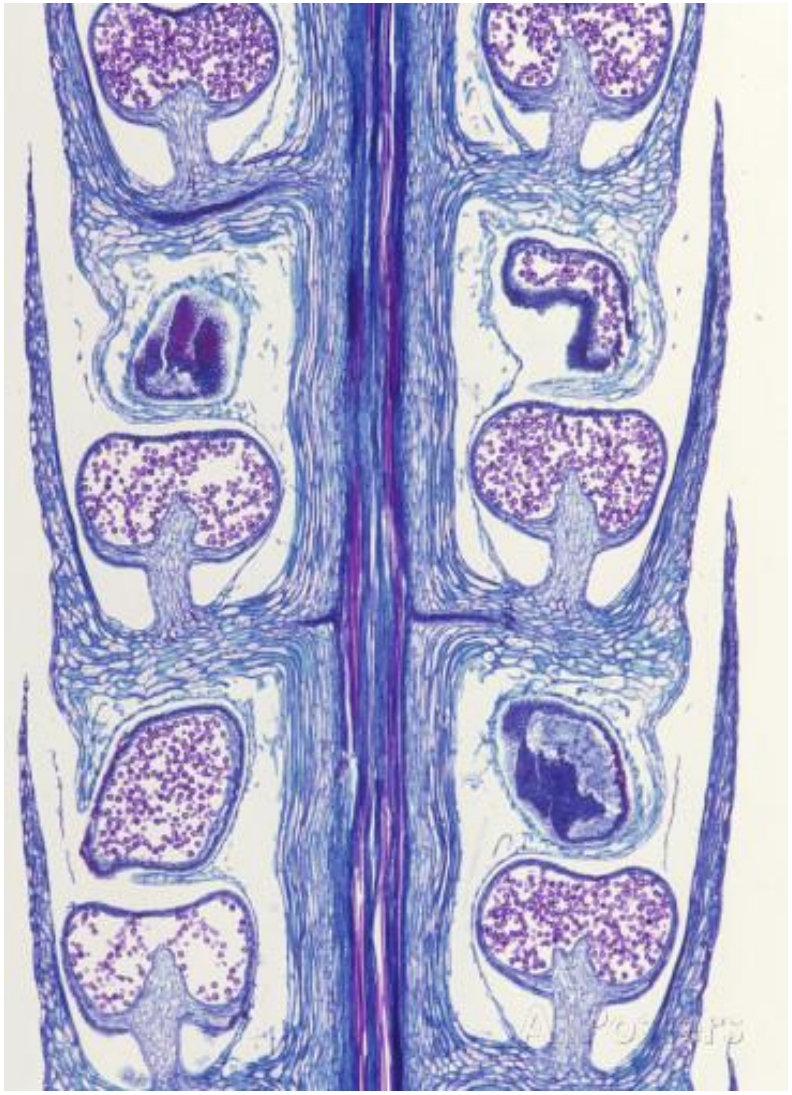


- The epidermis is cutinised on the outer side and interrupted at places by the presence of stomata.
- The cortex is differentiated into outer and inner sclerenchymatous cells and middle parenchymatous cells .
- Next to the cortex is present a single layer of well-defined cells known as endodermis which is followed by pericycle .
- The xylem is in form of seperate plates or bands. This stele is known as plectostele

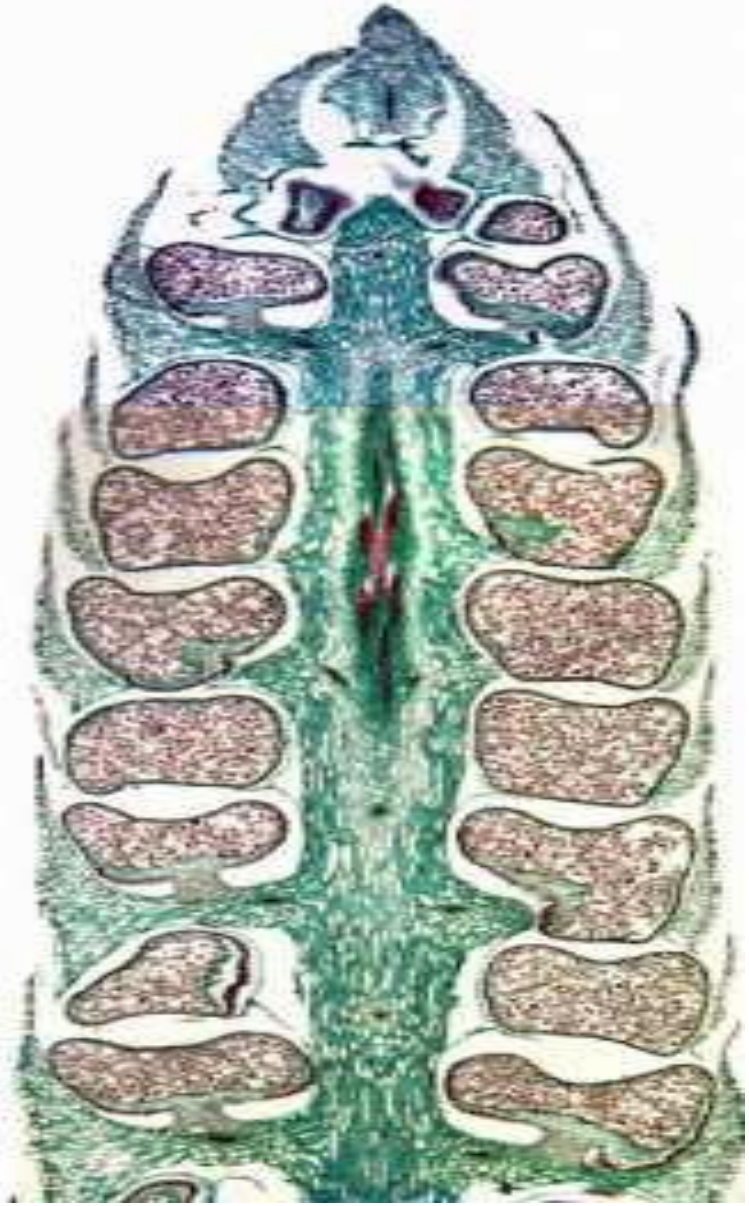
Division : Lycophyta
Class: Eligulopsida
Order: Lycopodiales
Family: Lycopodiaceae
Genus : ***Lycopodium***

Lycopodium strobilus LS

- It consist of long central axis around which sporophylls are arranged spirally.
- The sporangia may be axillary or epiphyllous.
- Each sporophyll bears only one sporangium.
- All the sporangia are arranged acropetally in a strobilus.
- Sporangia are sac-like structures but usually kidney shaped in appearance attached to sporophyll with help of a short massive stalk.
- The sporangia are homosporous filled with one type of spores. Spores arranged in tetrad.



Lycopodium strobilus LS



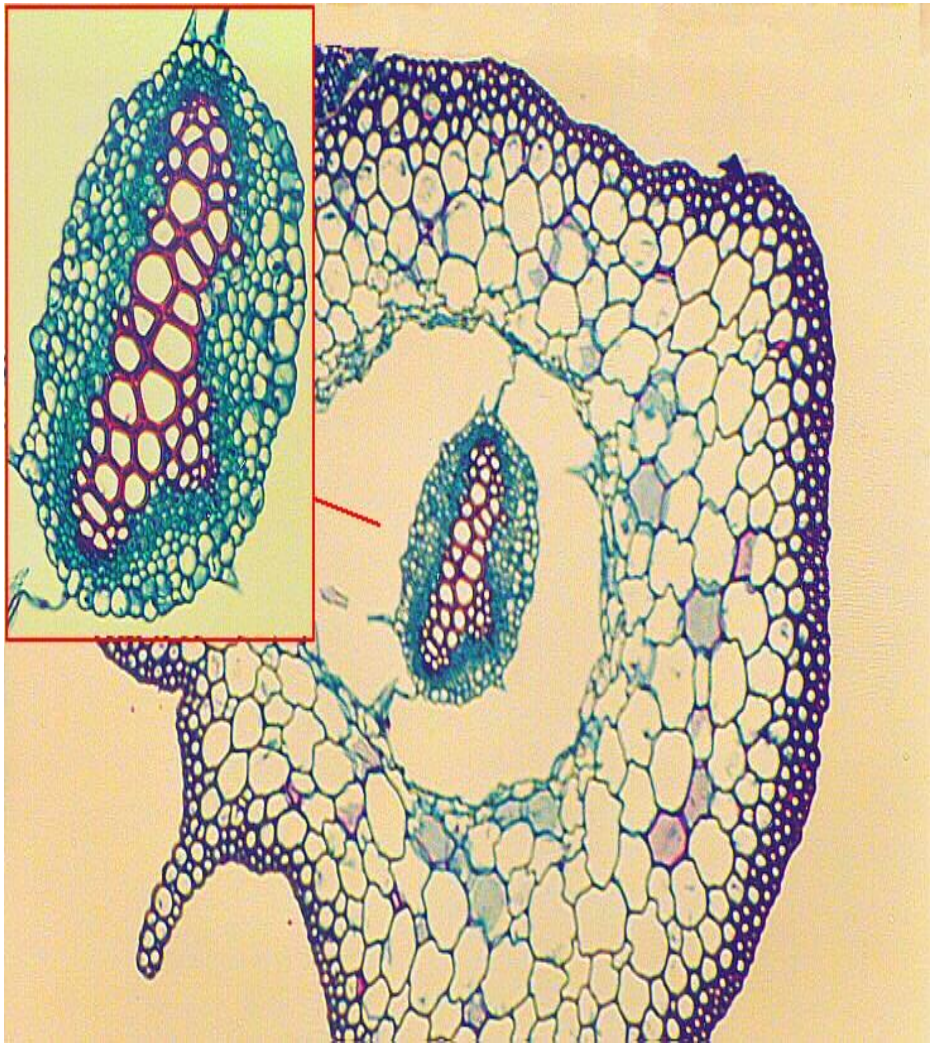
Division : Lycophyta
Class: Ligulopsida
Order: Selaginellales
Family: Selaginellaceae
Genus : ***Selaginella***

Selaginella plant

- The sporophytic plant body is prostrate and creeping on ground. It is differentiated into root, rhizophore, stem and leaves.
- The stem is slightly dorsiventral, flat dichotomously branched.
- The stem give rise to a prop like, leafless cylindrical struture called rhizophore from point of dichotomy.
- The leaves are dimorphic. Two rows of large dorsal leaves and two small ventral leaves.

Division : Lycophyta
Class: Ligulopsida
Order: Selaginellales
Family: Selaginellaceae
Genus : ***Selaginella***

Selaginella stem ts

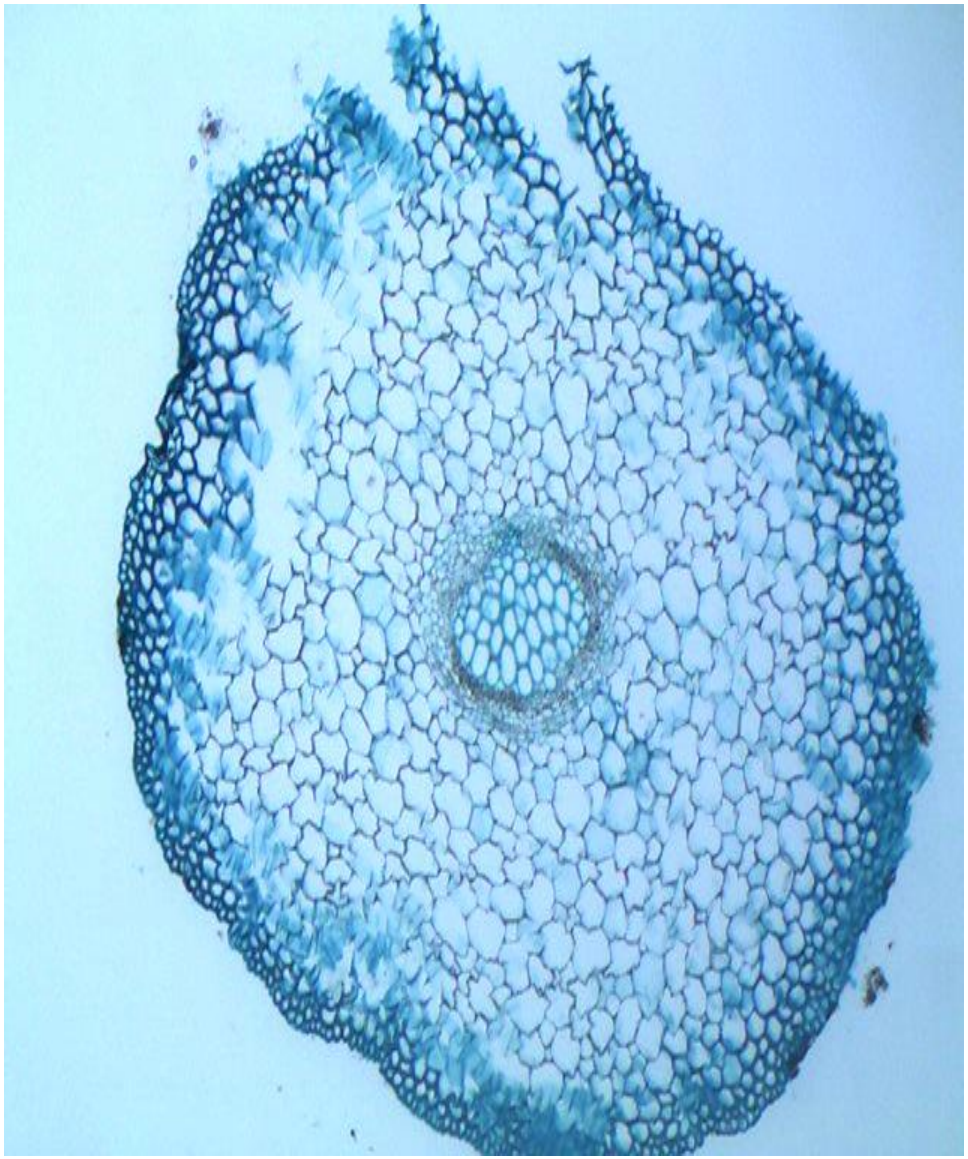


- The outline of section is wavy.
- The outer cell walls of the epidermis are cutinised. It is devoid of stomata and hairs.
- It is followed by schlerenchymatous hypodermis.
- The cortex is of compactly arranged angular parenchymatous cells without intercellular spaces.
- The centre is occupied by one or many steles.
- The stele is set off from the cortex by a few radially elongated endodermal cells desig-nated as trabeculae.
- The stele is protostele.

Division : Lycophyta
Class: Ligulopsida
Order: Selaginellales
Family: Selaginellaceae
Genus : ***Selaginella***

Selaginella rhizophore

- The epidermis is single-layered and highly cutinised.
- The cortex is extensive and may be differentiated into an inner thin-walled parenchymatous and outer thick-walled sclerenchymatous zone (hypodermis)
- The stele is protostelic and surrounded by a layer of endodermis.
- The xylem is monarch and exarch.



Division : Lycophyta
Class: Ligulopsida
Order: Selaginellales
Family: Selaginellaceae
Genus : ***Selaginella***

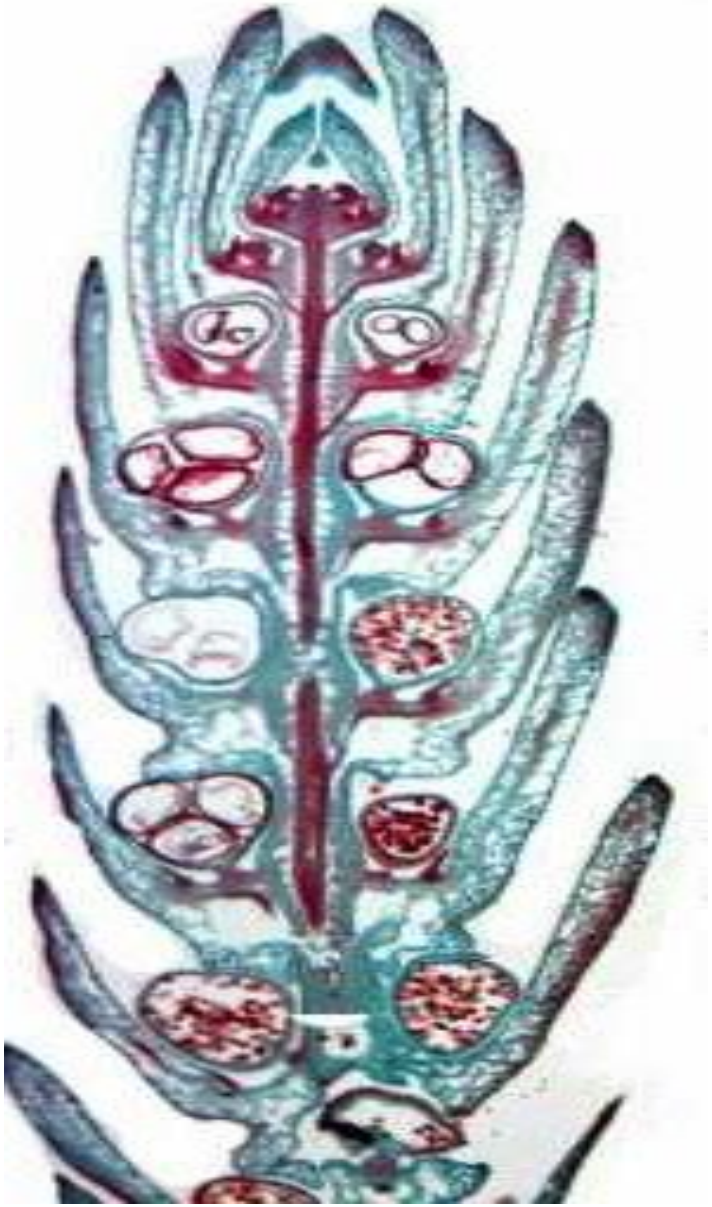
Selaginella micro & mega spore

- The strobili are borne at the apices of main stem or on lateral branches.
- They vary in size and shape in different species.
- *Selaginella* is heterosporous and, therefore, sporangia are of two types viz., microsporangia and megasporangia.
- The sporophylls associated with these two types of sporangia are designated as microsporophylls and megasporophylls respectively.
- Strobili either consists entirely of microsporangia or of megasporangia.

Division : Lycophyta
Class: Ligulopsida
Order: Selaginellales
Family: Selaginellaceae
Genus : ***Selaginella***

Selaginella apex LS

- It consist of long central axis around which micosporophylls and megasporophylls are arranged spirally.
- Each sporophyll bears only one sporangium. The sporophyll possesses a ligule
- The microsporangia is small attached to microsporophyll. It has two layered wall. Outer layer is thick while inner is thin. It is filled with numerous microspore.
- The megasporangium is four lobed in shape and large in size. It usually contain 4 megaspores.



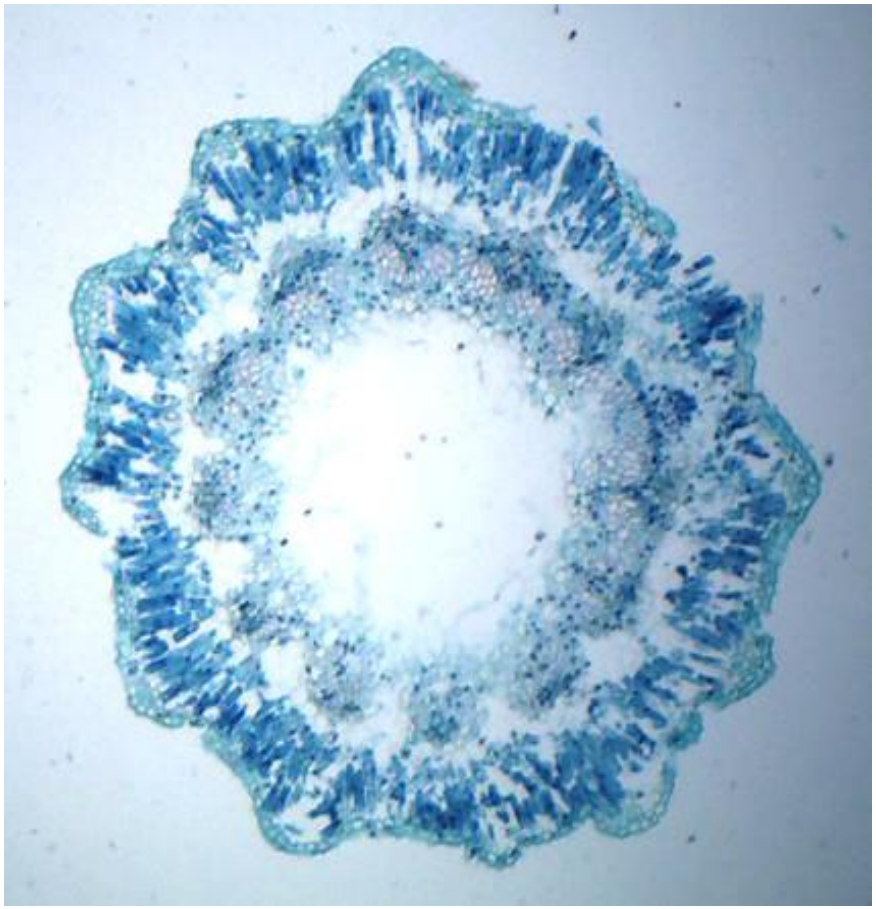
Division : Sphenophyta
Class: Calamopsida
Order: Equisetales
Family: Equisetaceae
Genus : ***Equisetum***

Equisetum plant

- The sporophytic plant body is bushy perennial herb, differentiated into root, stem and leaves.
- The stem of Equisetum has two parts: perennial, underground, much-branched rhizome and an erect, usually annual aerial shoot.
- The branching is monopodial, shoots are differentiated into nodes and internodes.
- The primary root is ephemeral. The slender adventitious roots arise endogenously at the nodes.
- The leaves are small, simple, scale-like and isophyllous; they are attached at each node, united at least for a part of the length and thus form a sheath around the stem.

Division : Sphenophyta
Class: Calamopsida
Order: Equisetales
Family: Equisetaceae
Genus : ***Equisetum***

Equisetum stem T.S



- In T.S., the stem of *Equisetum* appears wavy in outline with ridges and furrows.
- The epidermal cell walls are thick, cuticularised and have a deposition of siliceous material.
- The outer cortex is chlorenchymatous, while the inner cortex is made up of thin-walled parenchymatous cells.
- There is a large air cavity in the inner cortex corresponding to each furrow and alternating with the ridges, known as **vallecular canal**.
- The vascular bundles are arranged in a ring which lies opposite to the ridges in position and alternate with the vallecular canals of the cortex.
- Vascular bundles are conjoint, collateral and closed. In the mature vascular bundle, protoxylum is disorganised to form a **carinal cavity** which lies opposite to the ridges.

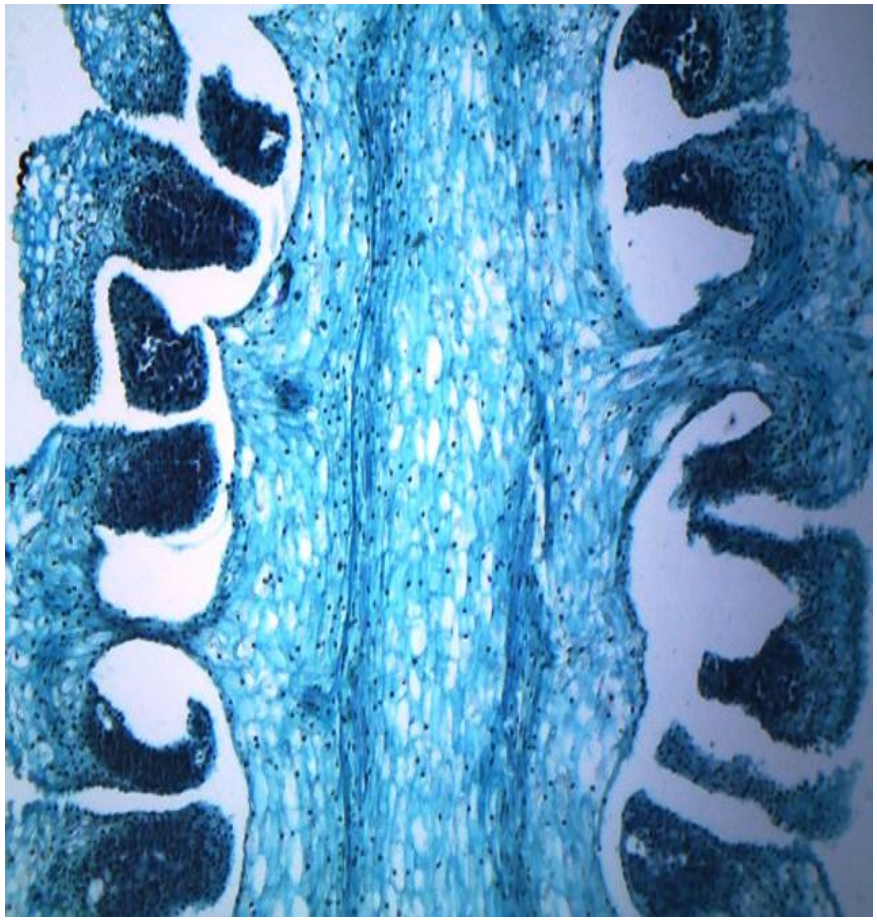
Division : Sphenophyta
Class: Calamopsida
Order: Equisetales
Family: Equisetaceae
Genus : ***Equisetum***

Equisetum cone

- The strobilus are terminal in position and generally are borne terminally on the chlorophyllous vegetative shoot
- The strobilus is composed of an axis with whorls of sporangiophores.
- Each sporangiophore is a stalked structure bearing a hexagonal peltate disc at its distal end.
- On the under surface of the sporangiophore disc 5-10 elongate, cylindrical hanging sporangia are borne near the periphery in a ring.
- The flattened tips of the sporangiophores fit closely together which provide protection to the developing sporangia.
- The axis bears a ring-like outgrowth, the so-called annulus immediately below the whorls of sporangiophores which provide additional protection during early development.

Division : Sphenophyta
Class: Calamopsida
Order: Equisetales
Family: Equisetaceae
Genus : ***Equisetum***

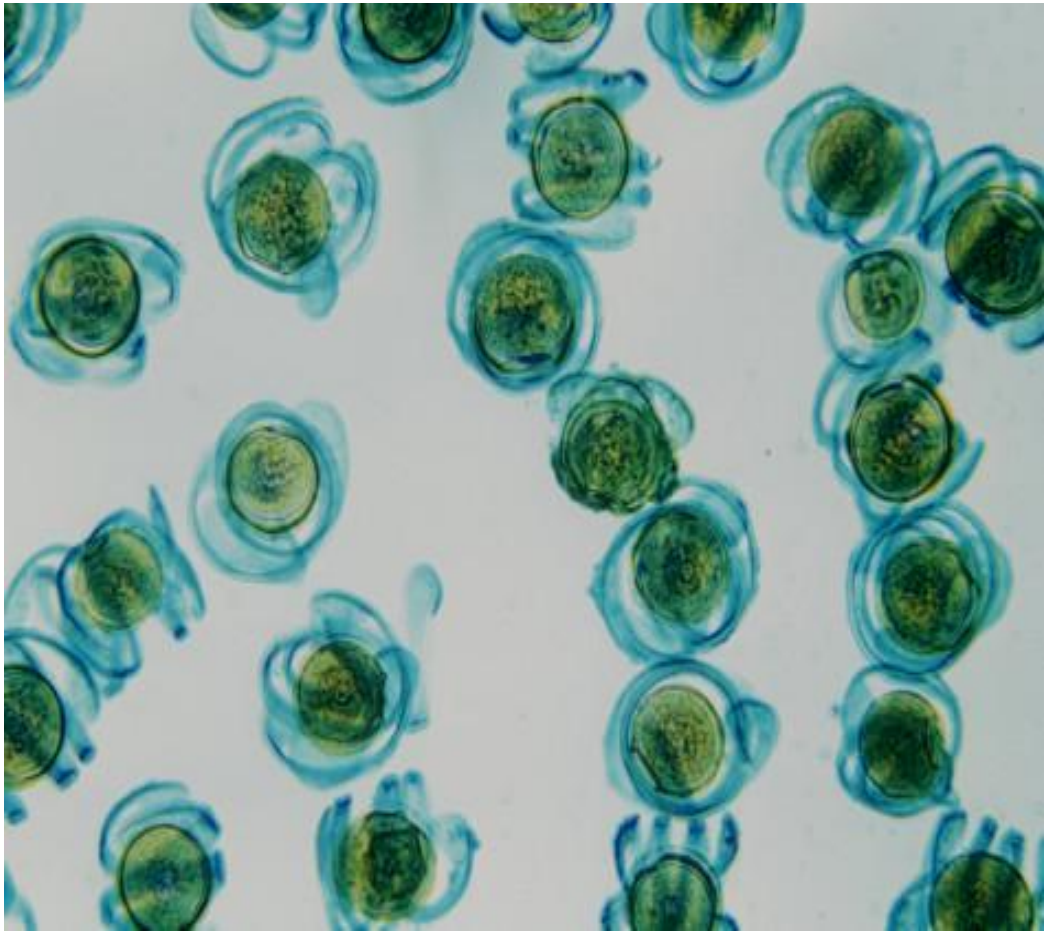
Equisetum cone



- The centre of section is occupied by a cone axis.
- A leaf like annulus is present at the base of cone.
- The sporangiophore are attached on the cone axis opposite to each other.
- Each sporangiophore is attached to axis by slender stalk which terminates into a peltate disc.
- The underside of peltate disc bear elongated, cylindrical sac like sporangia.
- Each sporangium is surrounded by single layered jacket enclosing a large number of homosporous spores.

Division : Sphenophyta
Class: Calamopsida
Order: Equisetales
Family: Equisetaceae
Genus : ***Equisetum***

Equisetum spores



- The spores are spherical and filled with densely packed chloroplasts. The spore wall is laminated and shows four concentrate layers.
- The outer two layers i.e., cuticular layer and epispore are derived due to the disintegration of the nonfunctional spore mother cells and tapetal cells.
- At maturity, the epispore (the outermost layer) splits to produce four ribbon like bands or strips with flat spoon-like tips.
- These bands are free from the spore wall except for a common point of attachment and remain tightly coiled around the spore wall until the sporangium is fully matured.

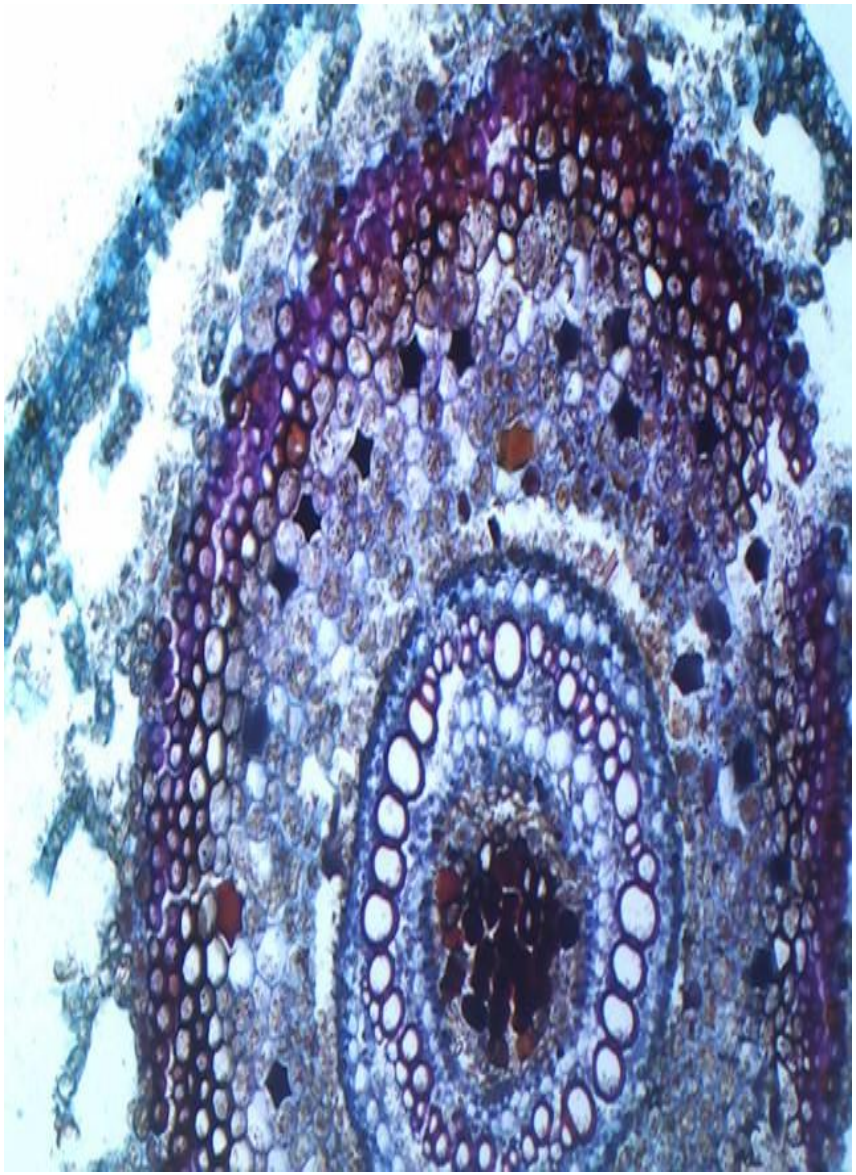
Division : Filicophyta
Class: Leptosporangiopsida
Order: Marsileales
Family: Marsileaceae
Genus : ***Marsilea***

Marsilea plant

- The species of *Marsilea* are generally aquatic or amphibious in nature with their roots embedded in mud or damp soil.
- The sporophytic plant body of *Marsilea* shows differentiation of stem, leaves and roots
- The stem is long, slender and freely-branched rhizome of indefinite growth
- The leaves are long petiolate and palmately compound, each having four leaflets in many species, but sometimes the number of leaflets varies from 3-8.
- The primary roots are short-lived (ephemeral) and are replaced by adventitious roots.

Division : Filicophyta
Class: Leptosporangiopsida
Order: Marsileales
Family: Marsileaceae
Genus : ***Marsilea***

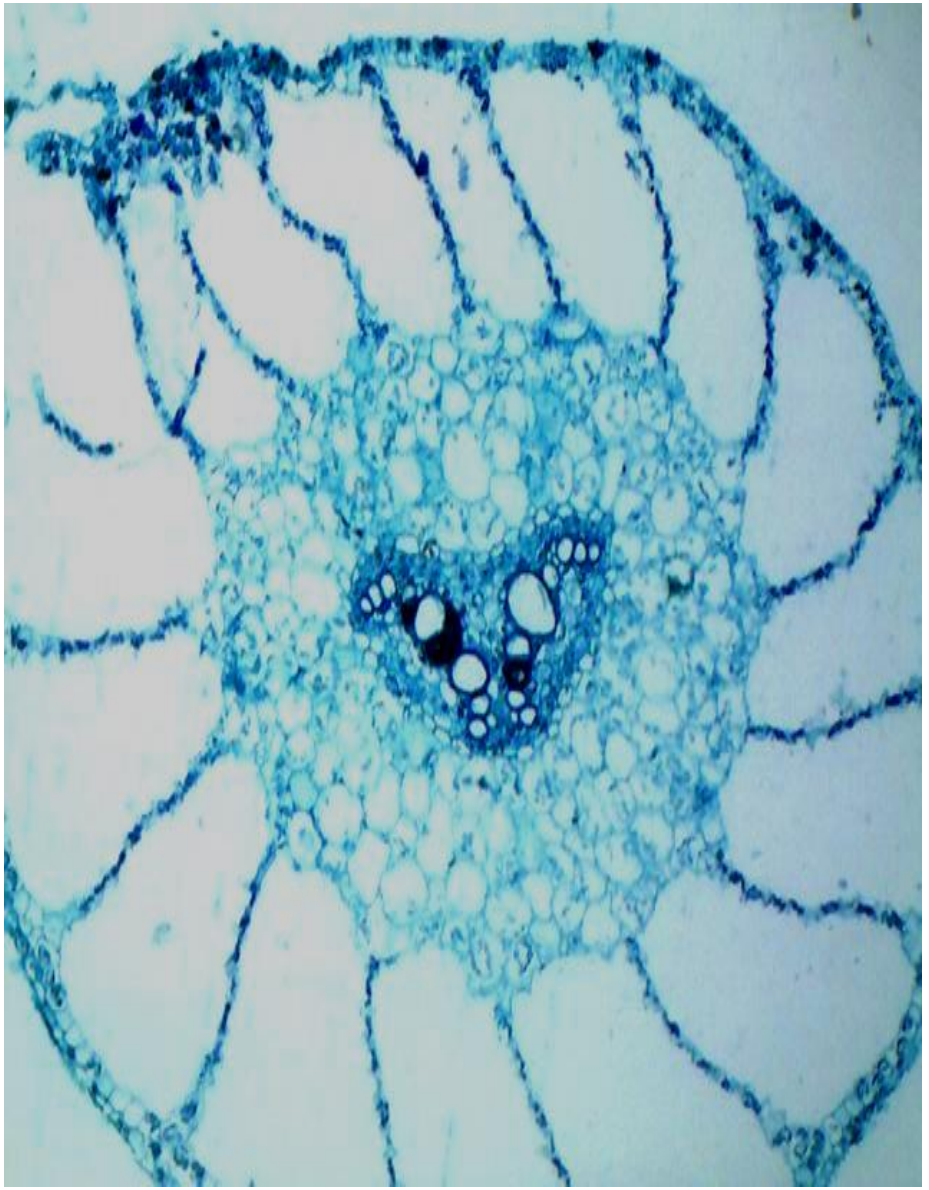
Marsilea rhizome



- A T.S. of the rhizome (stem) shows epidermis, cortex and the stele from periphery to the centre .
- The outermost layer is epidermis, composed of compactly arranged thick-walled cells and are devoid of stomata.
- The cortex is extensive and differentiated into three layers viz., outer cortex, middle cortex, and inner cortex. The outer cortex is parenchymatous with large air spaces.
- The middle cortex is sclerenchymatous, while the inner cortex is made up of compactly arranged parenchymatous cells.
- The stele is amphiphloic solenostelic which occupies the centre of the rhizome. Xylem occurs in the form of a ring and is surrounded on either side by phloem.

Division : Filicophyta
Class: Leptosporangiopsida
Order: Marsileales
Family: Marsileaceae
Genus : ***Marsilea***

Marsilea petiole ts



- In T.S., the petiole differentiates into epidermis, cortex and stele. The epidermis is cutinised and composed of a single-layered rectangular cells.
- The cortex is differentiated into outer and inner cortex. The outer cortex consists of aerenchyma having many air-cavities separated by one-celled thick septa.
- The stele is protostelic with diarch and exarch xylem.
- The xylem has two large metaxylem elements at the centre and protoxylem elements at each end towards the peri-phery.
- Phloem bands are present on either side.

Division : Filicophyta
Class: Leptosporangiopsida
Order: Marsileales
Family: Marsileaceae
Genus : ***Marsilea***

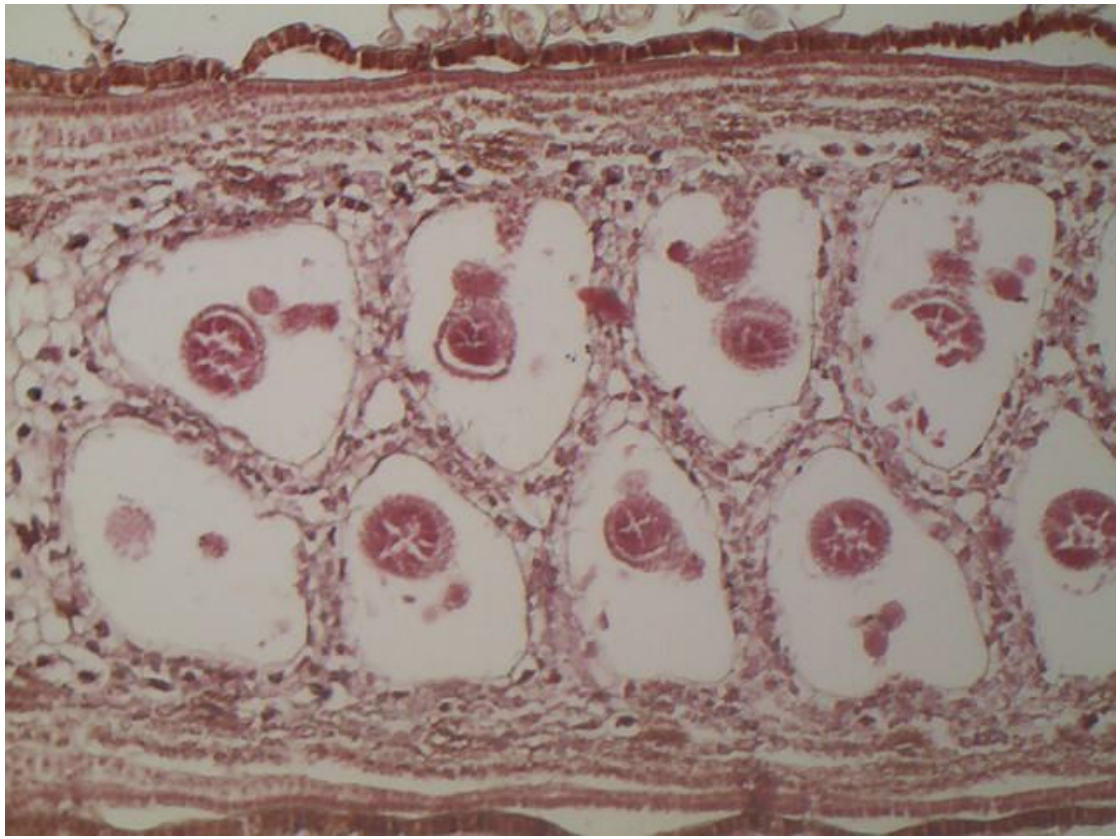
Marsilea sporocarp H.L.S

- The sporocarp wall is hard, thick, thus resistant against mechanical injury.
- Anatomically, the wall is differentiated into three layers. The outer layer is epidermis made up of single-layered cuboidal cell with sunken stomata.
- The middle layer is made up of radially elongated compactly arranged thick-walled palisade cells. This is followed by second palisade layer which is comprised of more elongated thin-walled palisade cells.
- A vertical longitudinal section (VLS) in the plane of the stalk shows that a single strong vascular strand enters the sporocarp near the lower horn and continues forward all along the dorsal or upper side of the sporocarp thus forming a midrib

- A vertical longitudinal section (VLS) of sporocarp away from the plane of the stalk reveals many sori arranged in vertical rows.
- In this plane of section either megasporangia or microsporangia are visible. Each sorus is surrounded by an indusium.

Marsilea sporocarp H.L.S

A horizontal longitudinal section (HLS) cuts each sorus transversely and it is seen that each sorus is an elongated structure, covered by a delicate indusium.



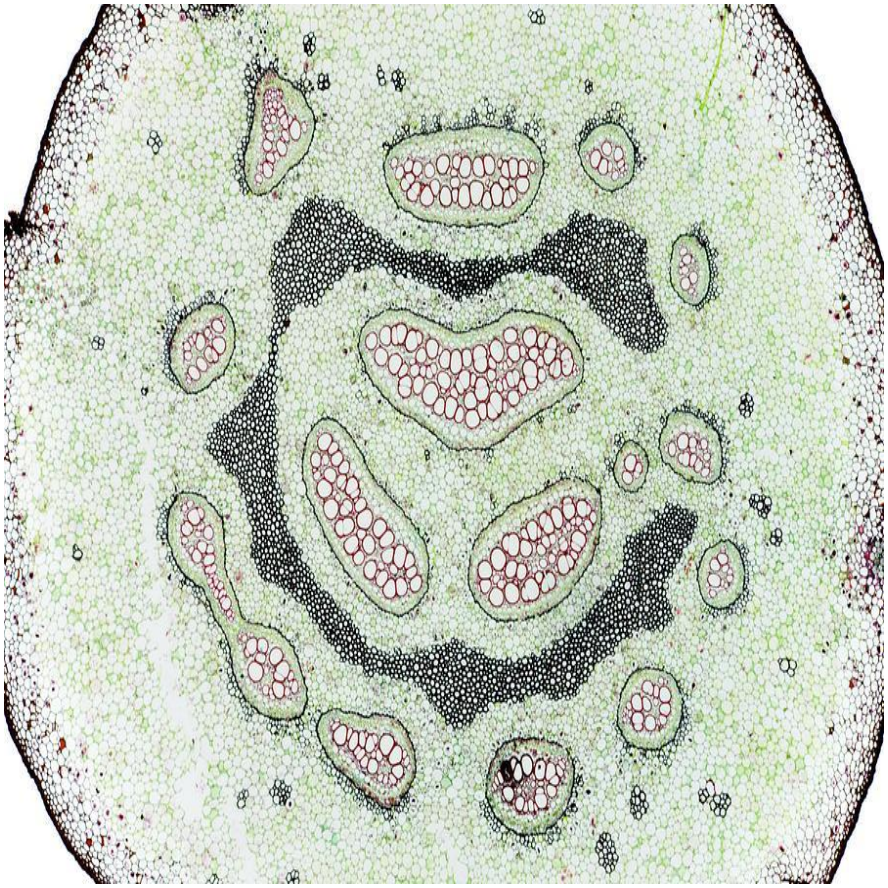
Fern plant

Division : Filicophyta
Class: Leptosporangiopsida
Order: Filicales
Family: Polypodiaceae
Genus : ***Pteridium***

- The mature plant body is sporophytic and can be differentiated into rhizome, roots and leaves .
- Stem grows horizontally, 8-12 cm. beneath the surface of the soil. It is long, slender and branched. The branching is first dichotomous.
- The rhizome is differentiated into nodes and internodes.
- In mature sporophyte, adventitious roots arise in acropetal succession .
- On nodes, the young leaves appear alternately on the dorsal surface. Young leaves are circinately coiled and are separated by long internodes.
- Each leaf is tripinnately compound. Each pinna is sessile.

Division : Filicophyta
Class: Leptosporangiopsida
Order: Filicales
Family: Polypodiaceae
Genus : ***Pteridium***

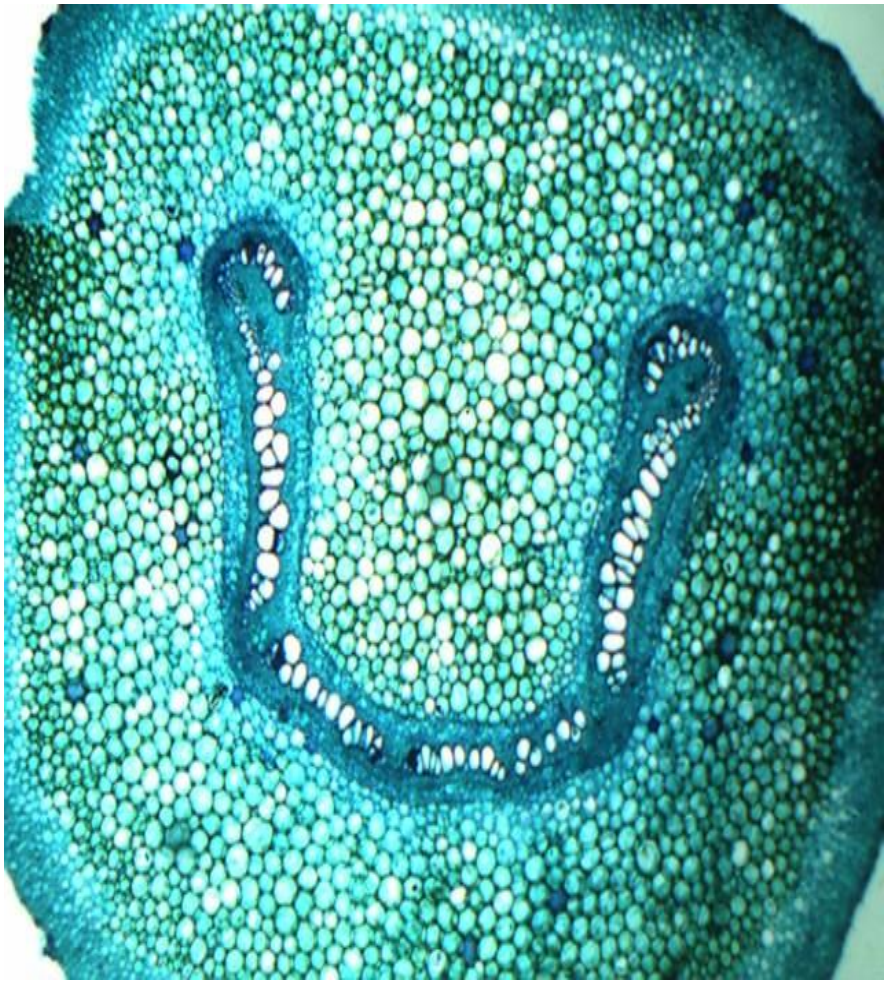
Fern rhizome TS



- It can be differentiated into three zones: epidermis, cortex and stele.
- **Epidermis:** It is the outermost layer. Its cells are narrow, thin or thick with thickened brown outer walls.
- Epidermis is followed by cortex. Many layers just below the epidermis are thick walled (scelerenchymatous) and are called hypodermis.
- Rest of the space inside the hypodermis is occupied by thin walled (parenchymatous) ground tissue in which are embedded many **meristeles.**
- In between the meristeles two patches of sclerenchymatous tissue are present. One patch lies above and one lies below the inner meristeles.

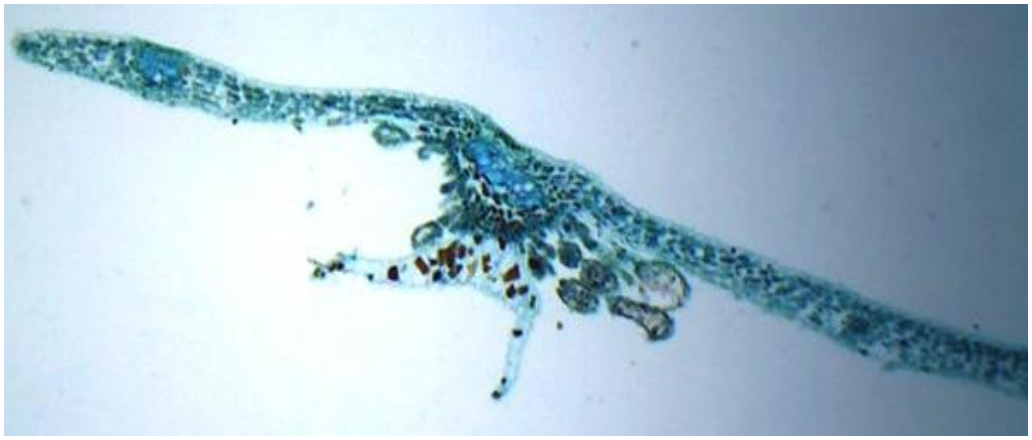
Fern rachis ts

- It can be differentiated into three zones: epidermis, cortex and stele.
- **Epidermis:** It is the outermost layer. Its cells are narrow, thin or thick with thickened brown outer walls.
- Epidermis is followed by cortex. Many layers just below the epidermis are thick walled (scelerenchymatous) and are called hypodermis.
- Rest of the space inside the hypodermis is occupied by thin walled (parenchymatous) ground tissue in which are embedded many **meristeles.**
- In between the meristeles two patches of sclerenchymatous tissue are present. One patch lies above and one lies below the inner meristeles.

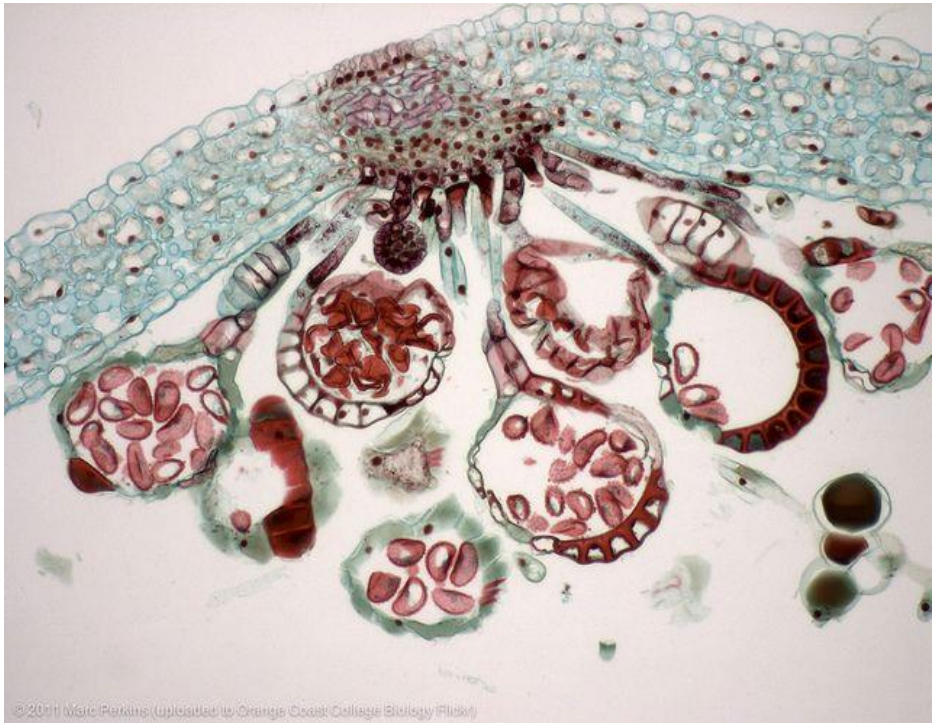


Division : Filicophyta
Class: Leptosporangiopsida
Order: Filicales
Family: Polypodiaceae
Genus : ***Pteridium***

Fern true indusium



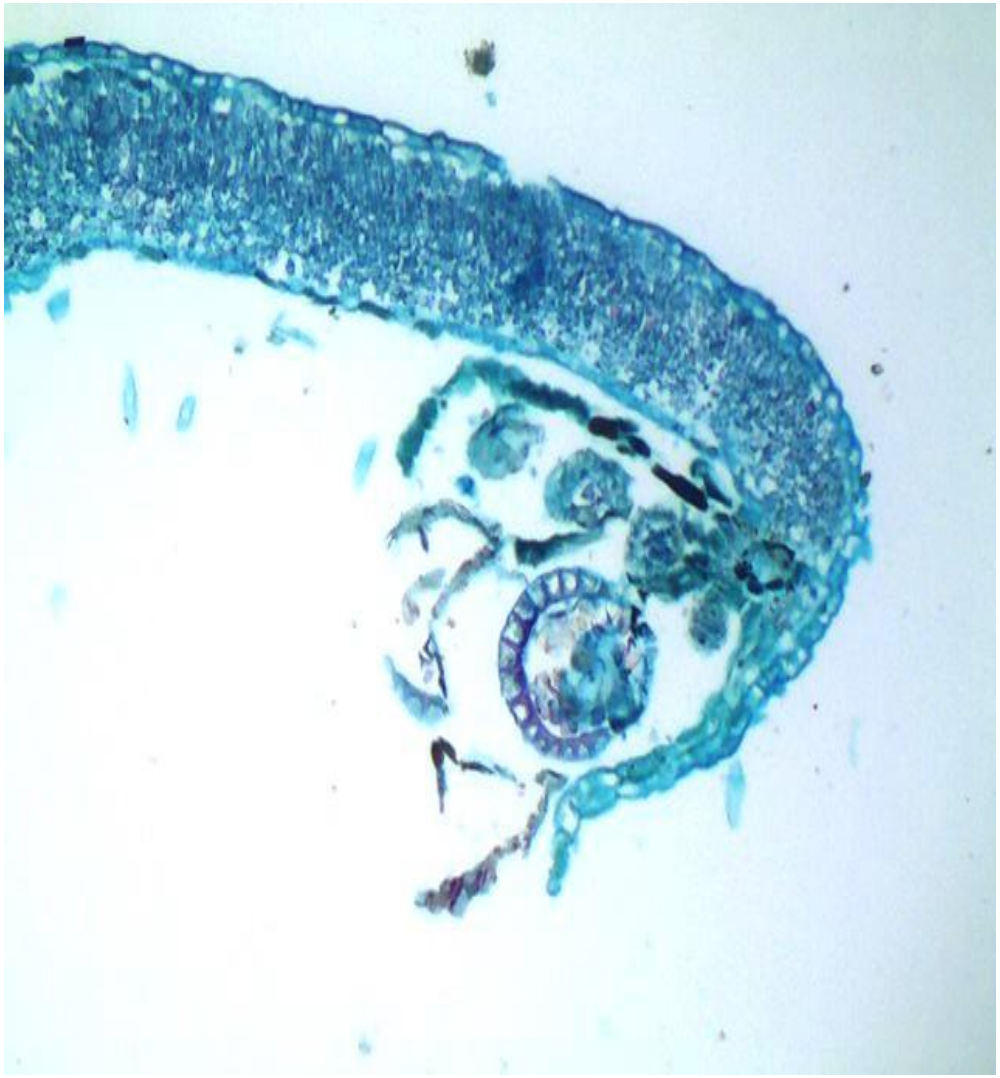
- Transverse section of fertile pinnule is similar to that of sterile pinnule with the exception that fertile pinnule bears many stalked sporangia (coenosorus) along the lower margins.
- The coenosorus is surrounded by two well-formed indusial lips between which lies the receptacle.
- The inner indusial lip is ill developed. It consists of a sheet one cell in thickness and lies adjacent to receptacle. It is the outgrowth of placenta and is called **true indusium**



Division : Filicophyta
Class: Leptosporangiopsida
Order: Filicales
Family: Polypodiaceae
Genus : ***Pteridium***

False indusium

- Transverse section of fertile pinnule is similar to that of sterile pinnule with the exception that fertile pinnule bears many stalked sporangia (coenosorus) along the lower margins.
- The coenosorus is surrounded by two well-formed indusial lips between which lies the receptacle.
- The outer indusial lip is well developed. It is formed by the reflexed margin of the pinnule. It overlaps the coenocorus and its sporangia. It is called **false indusium.**



Division : Filicophyta
Class: Leptosporangiopsida
Order: Filicales
Family: Polypodiaceae
Genus : ***Pteridium***

Fern Prothallus

- The prothallus is small, green and heart shaped. It is flat dorsiventral and show an apical notch.
- The central portion is thick. It is called **cushion.**
- A large number of rhizoids arise from lower surface of prothallus**.**
- All cells of prothallus bear chloroplast.
- Archegonia are borne on cushion towards apical notch and antheridia are towards base.
- The young sporophyte is attached to prothallus and gets food and water.
- It develop inside the calyptra and starts germination

Gymnosperms

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas

- The mature plant body is sporophytic and can be differentiated into roots , stem and leaves . It resembles angiospermic palms
- Roots in Cycas are of two types, i.e., normal tap roots forming a tap root system, and coralloid roots.
- The stem is thick, woody and usually unbranched. It is tuberous when young but columnar, erect and stout at maturity. Branching in stem is rare.
- The aerial part of the trunk remains covered by a thick armour of large and small rhomboidal leaf bases.
- Two types of leaves are present in *Cycas*. These are green, assimilatory ox foliage leaves, and scaly leaves or cataphylls.

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas coralloid root

- From the normal roots develop some lateral branches near the ground surface. These lateral roots get infected with some bacteria, fungi and algae, and are called **coralloid roots.**
- They are negatively geotropic.
- They grow first horizontally in the soil and become swollen at their tips.
- They divide repeatedly to form big bunches of greenish or brownish structures, which are coral like in appearance.
- They divide dichotomously, come out of the soil on the ground surface and are phototrophic in nature.
- Young plants bear more coralloid roots than the older ones.

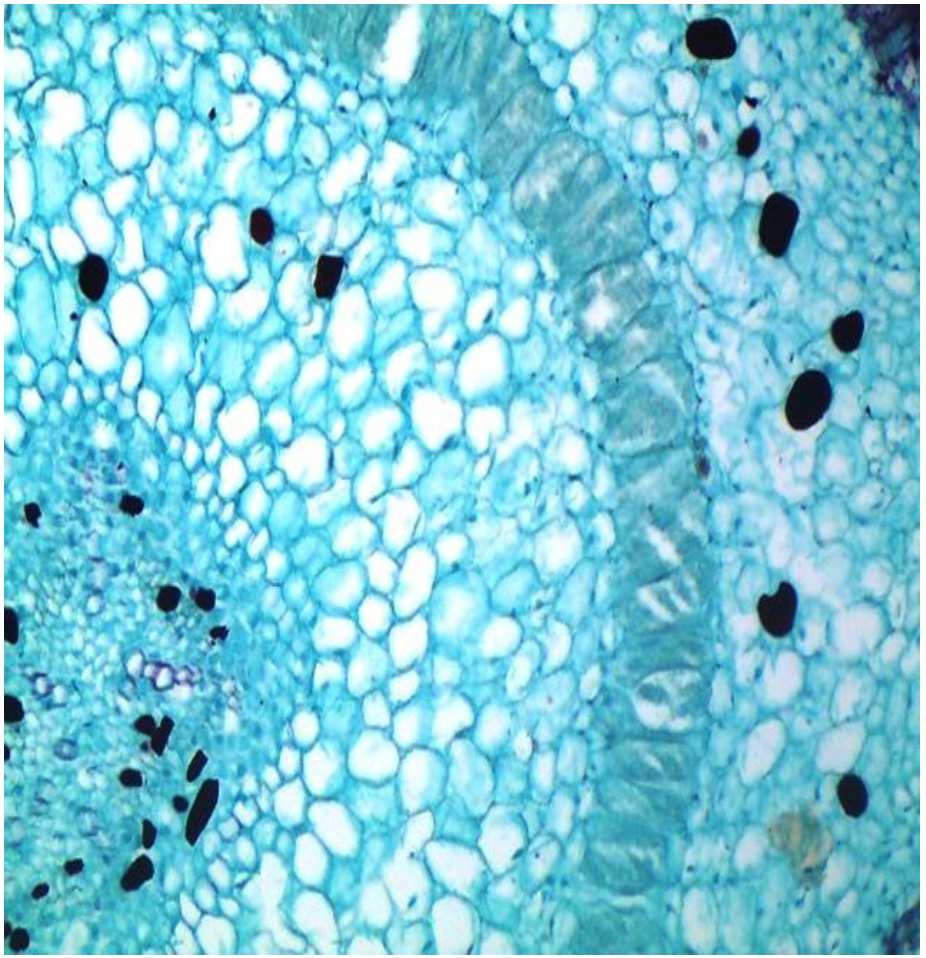
Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas coralloid root TS

Anatomically, the coralloid roots resemble

normal roots except some under mentioned differences:

1. The secondary vascular tissue in coralloid roots is either totally absent or poorly developed.
2. The cortex is wider in comparison with the normal root.
3. Presence of a greenish algal zone in the middle of the cortex. Algal zone consists of radially elongated, large, thin walled cells having large intercellular spaces occupied by algae.
4. The cortex is followed by single layered endodermis and multilayered pericycle.



5. The vascular bundles are radial. Xylem is diarch, triarch or polyarch.
6. Centre is small parenchymatous pith.

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
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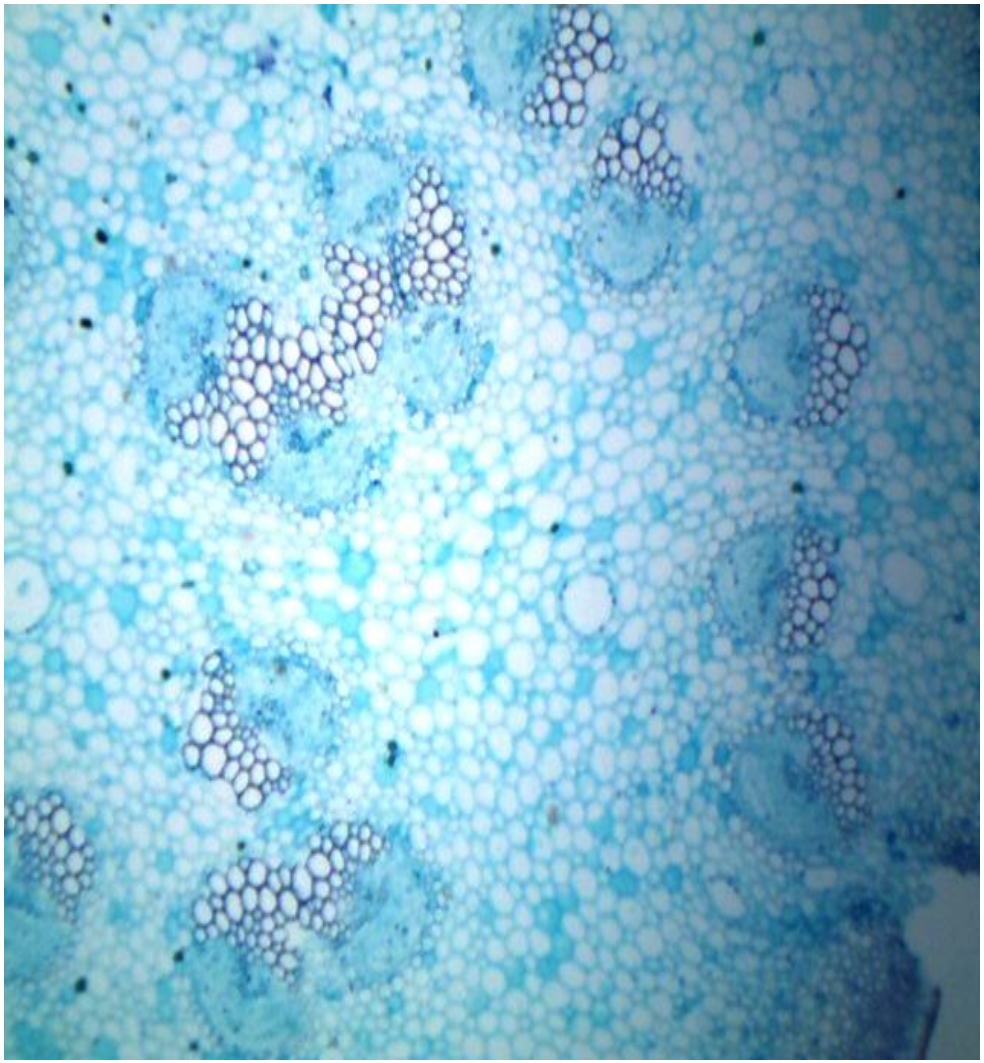
Genus : ***Cycas***

Cycas rachis ts

- The outline of transverse section is rhomboidal in the basal region of the rachis, biconvex in the middle cambium and roughly cylindrical at the tip region or at the apex of the rachis.
- Epidermis is the outermost layer of the rachis consisting of thick walled cells. It is heavily circularized.
- Hypodermis is present below the epidermis.
- Ground tissue is a large region consisting of thin walled, parenchymatous cells. Many mucilaginous canals and vascular bundles are present in this region.
- Vascular bundles are arranged in the shape of an inverted Greek letter Omega (Ω).



Each vascular bundle remains surrounded by a bundle sheath. It is conjoint, collateral and open

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas leaflet

- *Cycas* leaflets are large, tough, thick and leathery. In a vertical section the leaflet is differentiated into a swollen midrib portion and two lateral wings.
- Epidermis is the outermost layer consisting of thick walled cells. It is surrounded by a thick layer of cuticle.
- Hypodermis is sclerenchymatous and present below the epidermis and absent lower side.
- A continuous layer of palisade is present below the sclerenchymatous hypodermis.
- Transfusion tissue consists of two small groups of short and wide tracheid like cells with reticulate thickenings or bordered pits on

Vascular bundle is one, and present in the midrib region of the leaflet. It is conjoint, collateral, open and diploxylic.
The triangular centrifugal xylem is well developed with endarch protoxylem.

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas Megasporophyll

True female cone or strobilus is absent *Cycas*. Female reproductive organs are present in the form of megasporophylls.

Many megasporophylls are present around the apex of the monopodial trunk of the female plant above each crown of foliage and scaly leaves

Each megasporophyll is considered a modification of foliage leaf. It is a flat body consisting of an upper dissected or pinnate leafy portion, middle ovule bearing portion and proximal petiole. Petiole varies in length in different species.

The middle part is comparatively wider than petiole and bears ovules arranged in two pinnate rows. The number of ovules varies between 2-12 in different species.

The ovules are green when young but at maturity they are fleshy and bright orange or red coloured structures.

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
Family: Cycadaceae
Genus : ***Cycas***

Cycas male cone

- The male cone or male strobilus is a large, conical or ovoid, compact, solitary and shortly stalked structure, which is generally terminal in position.
- It sometimes attains a length of as much as 1.5 metre. In the centre of the cone is present a cone axis
- Several perpendicularly attached microsporophyll's are arranged around the cone axis in closely set spirals.
- At the base of male cone are present many young leaves. All the microsporophyll's in a male cone are fertile except a few at its basal and apical parts.
- The terminal growth of the stem is checked for sometime when a male cone appears at its apex.

Division : Cycadophyta
Class: Cycadopsida
Order: Cycadales
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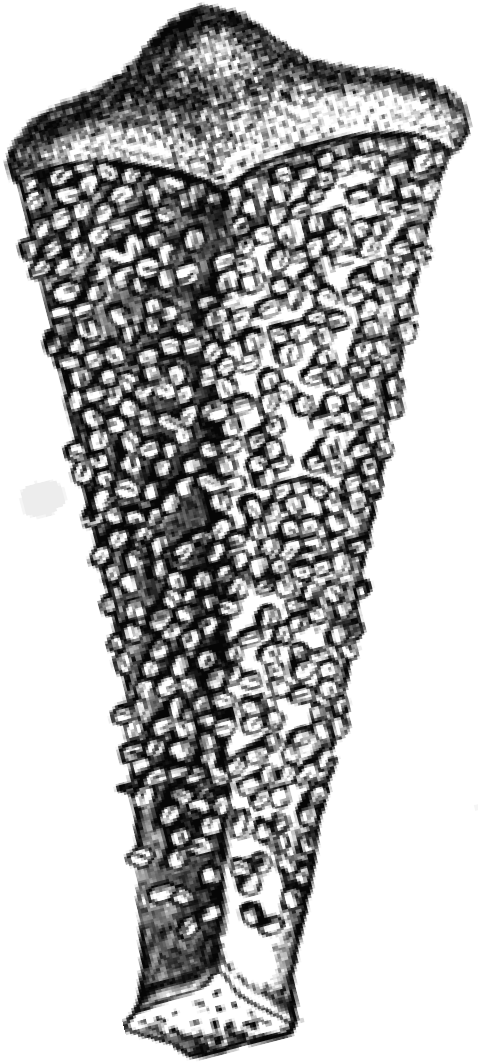
Genus : ***Cycas***

Cycas microsporophyll

- Microsporophyll's are flat, leaflike, woody and brown coloured structures with narrow base and expanded upper portion.
- The upper expanded portion becomes pointed and is called apophysis. Narrow base is attached to the cone axis with a short stalk.
- Each microsporophyll contains two surfaces, i.e. an adaxial or upper surface and an abaxial or lower surface. On the adaxial surface is present a ridge like projection in the middle and an apophysis at the apex .
- On the abaxial surface are present thousands of microsporangia in the middle region in the groups of 3-5.
- Each such group is called a sorus. In between these groups are present many hair like structures, which are very soft and one or two celled structures.



Division : Cycadophyta
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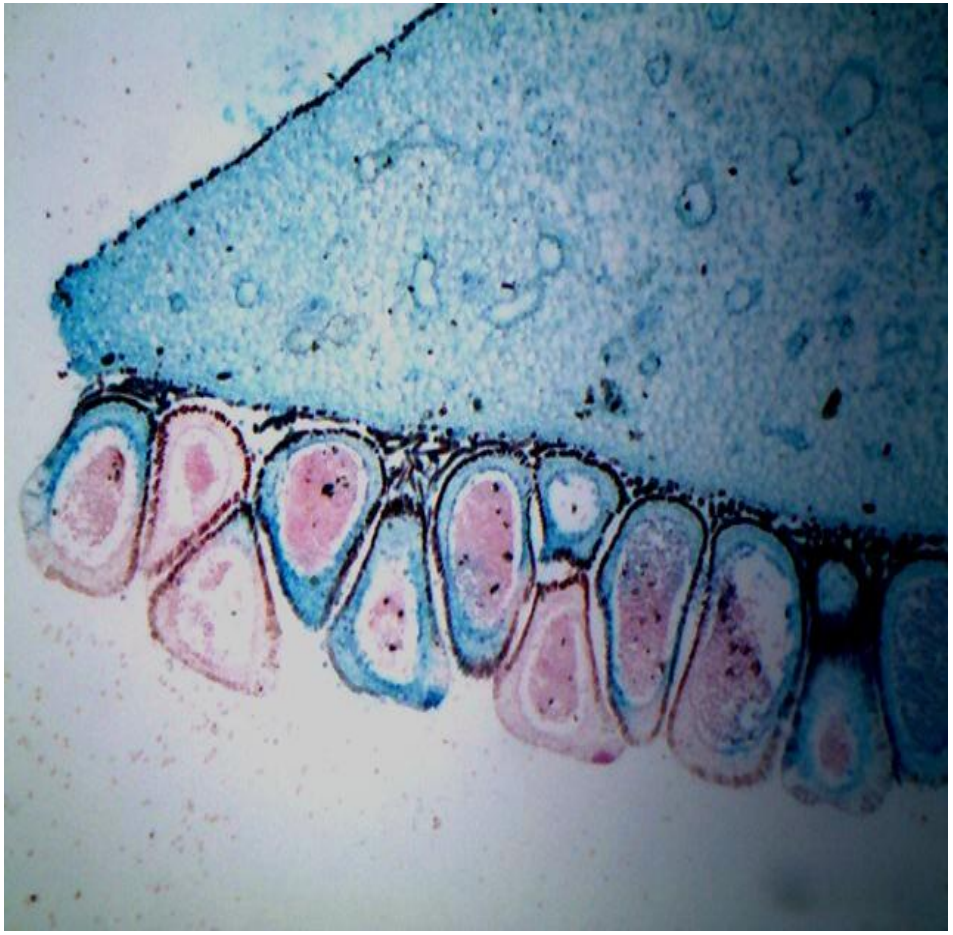
Cycas microsporophyll



- In T.S. of a microsporophyll, there are present many microsporangia on the abaxial side . Each shortly stalked, oval or saclike microsporangium is surrounded by 5-6 layers.
- The wall layers of each sporangium include an outer thick epidermis or exothecium, middle zone of thin walled cells and an innermost layer of tapetum.
- Many pollen grains or microspores are present in each sporangium.
- In the expanded region of microsporophyll are present many mucilaginous canals and vascular bundles. Each sporangium is provided with a radial line of dehiscence, which helps in the dispersal of spores.

Division : Coniferophyta
Class: Coniferopsida
Order: Coniferales
Family: Pinaceae
Genus : ***Pinus***

Pinus plant

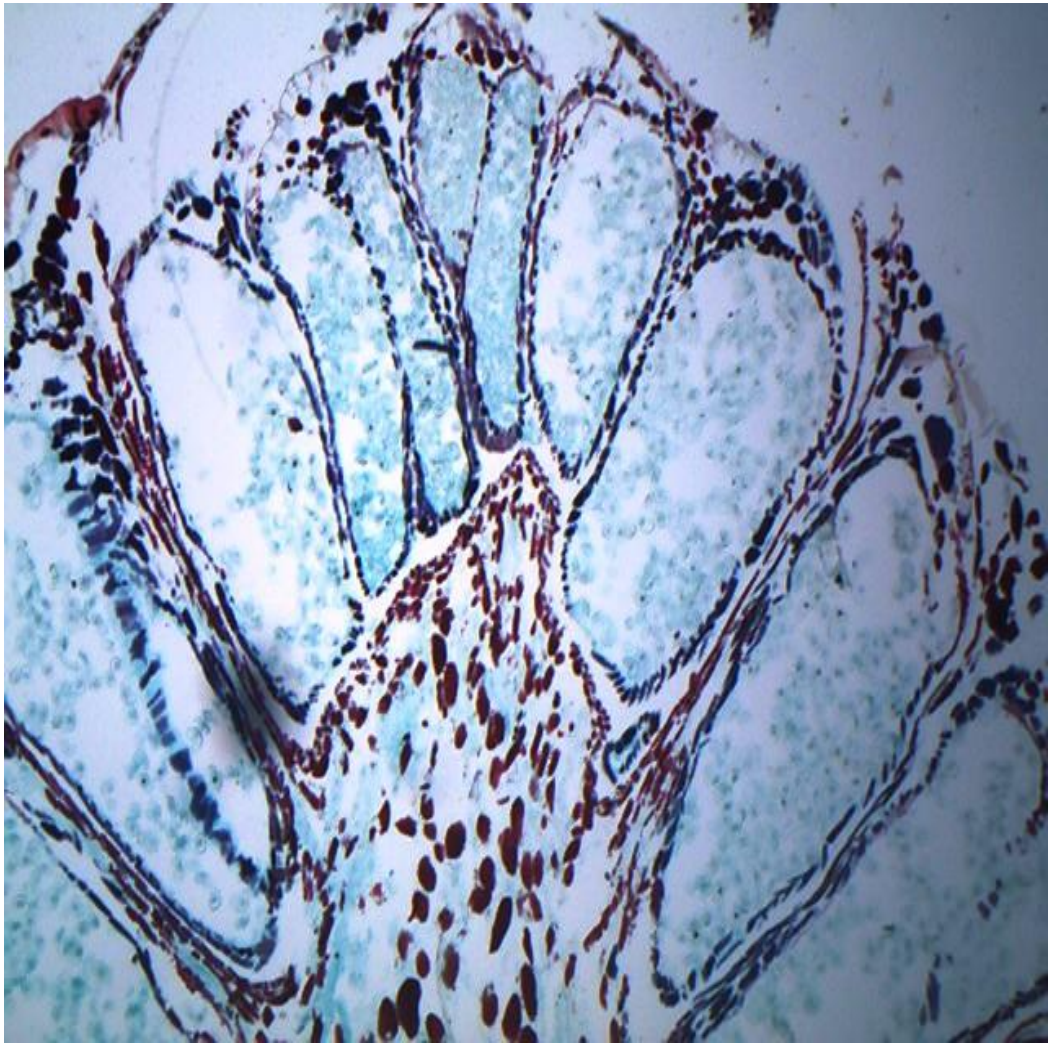
- *Pinus* is a large, perennial, evergreen plant.
- Branches grow spirally and thus the plant gives the appearance of a conical or pyramidal structure.
- Sporophytic plant body is differentiated into roots, stem and acicular (needle like) leaves
- Two types of branches are present: long shoots and dwarf shoots. These are also known as branches of unlimited and limited growth, respectively.
- Long shoots contain apical bud and grow indefinitely. Many scaly leaves are present on the long shoot.
- Dwarf shoots are devoid of any apical bud and thus are limited in their growth.
- The leaves are of two types, i.e., foliage and scaly.

Pinus male cone

- *Pinus* is monoecious, and male and female flowers are present in the form of cones or strobili on the separate branches of the same plant.
- The male cones develop in clusters in the axil of scaly leaves on long shoot.
- They replace the dwarf shoots of the long shoot.
- Each male cone is ovoid in shape and ranges from 1.5 to 2.5 cm. in length.
- A male cone consists of a large number of microsporophylls arranged spirally on the cone axis.
- Each microsporophyll is small, membranous, brown coloured structure.
- Two pouchlike microsporangia (= pollen sacs) are present on the abaxial or undersurface of each microsporophyll. In each microsporangium are present many microspores

Division : Coniferophyta
Class: Coniferopsida
Order: Coniferales
Family: Pinaceae
Genus : ***Pinus***

Pinus male cone LS



- The centre of cone is occupied by broad cone axis.
- The microsporophylls arise at right angle from the axis.
- Few microsporophylls at there base are sterile whereas other bear microsporangia at lower surface.
- The upper sterile apophysis of microsporophylls is curved upward.
- Each microsporangium is sessile, elongated, sac like structure.
- The cavity of microsporangium filled with number of winged pollen grains.

Division : Coniferophyta
Class: Coniferopsida
Order: Coniferales
Family: Pinaceae
Genus : ***Pinus***

Pinus female cone

- Female cone develops either solitary or in groups of 2 to 4.
- They also develop in the axil of scaly leaves on long shoots like male cones.
- Each female cone is an ovoid, structure when young but becomes elongated or cylindrical at maturity.
- Each female cone takes three year to mature.
- The young female cone is small, reddish-green in colour and show compact structure
- The old female cone is large and consist of loosely separated ovuliferous scales arranged spirally around the cone axis.

Division : Coniferophyta
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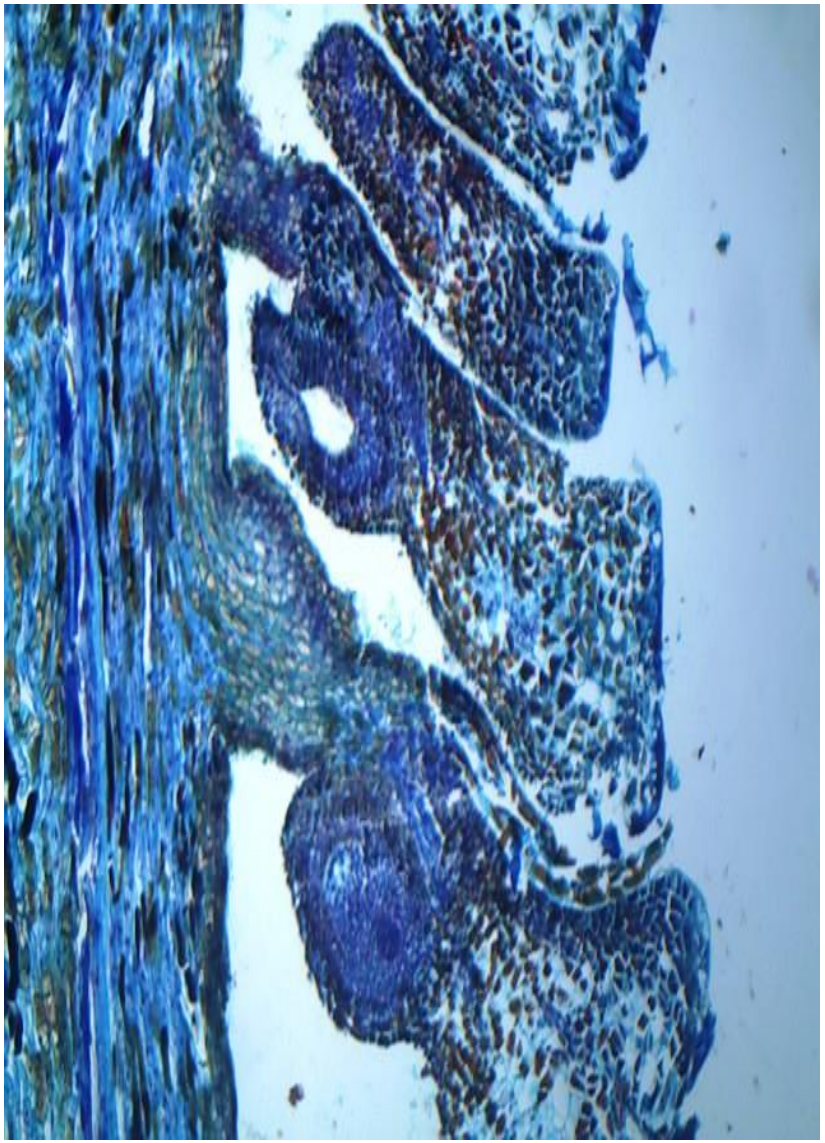
Genus : ***Pinus***

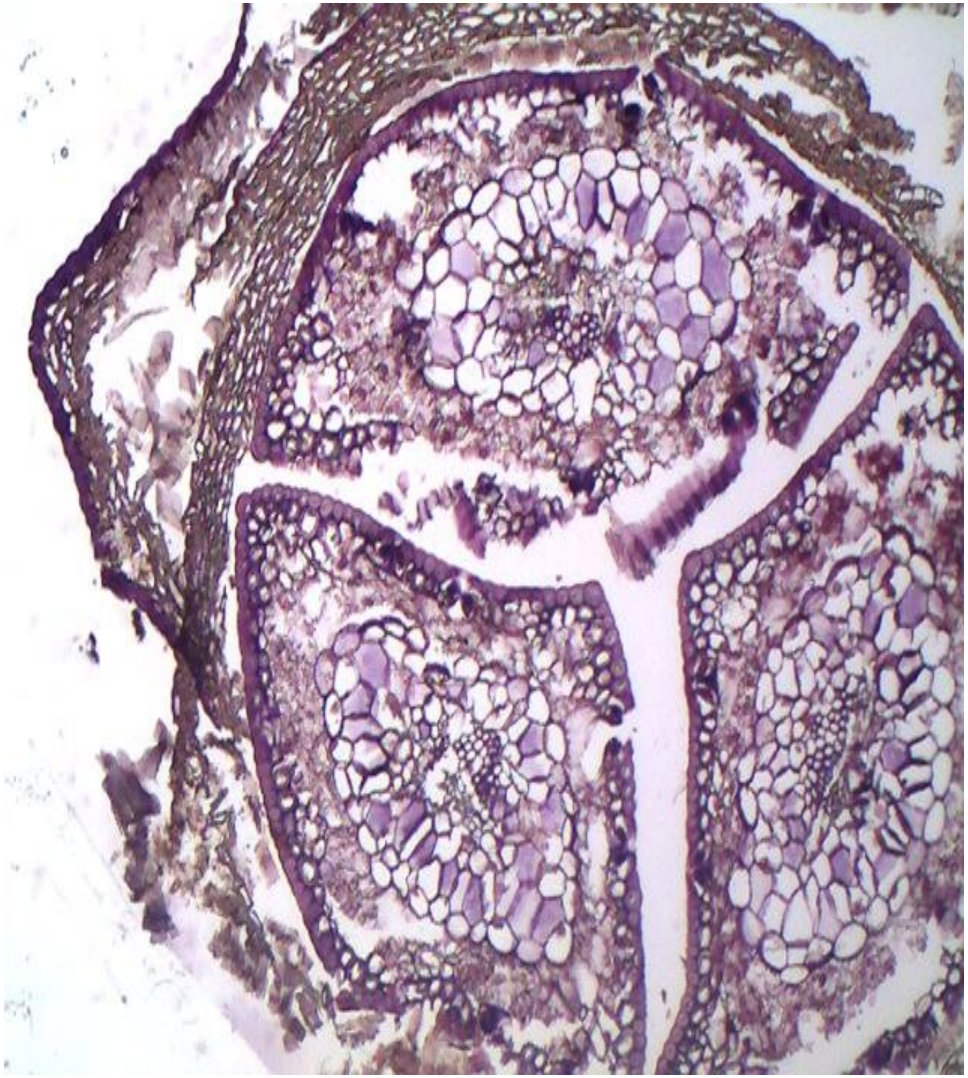
Pinus female cone LS



- In the centre is present a cone axis to which sporophylls are attached on both side.
- Each megasporophyll consists of two types of scales, known as bract scales and ovuliferous scales.
- Bract scales are thin, dry, membranous, brown coloured structures having fringed upper part. These are also called carpellary scales.
- An ovuliferous scale is present on the upper surface of each bract scale.
- Each ovuliferous scale is large, triangular and bear two ovules on its upper surface.
- A broad sterile structure, with pointed tip, is present at the apex of these scales. This is called apophysis.

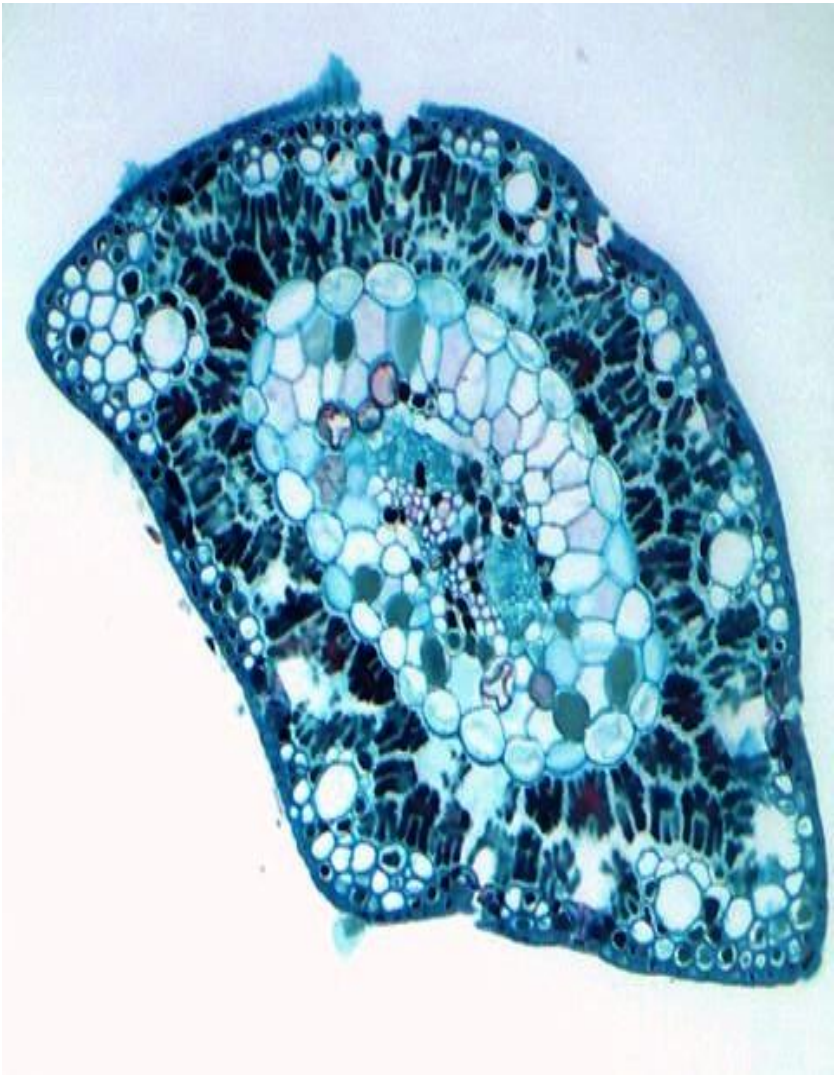
Pinus dwarf shoot

- The outline is neatly circular but rough and wavy sdue to cataphylls.
- Epidermis single layered composed of thick walled cells. Stomata are absent
- Epidermis followed by 1-2 layered hypodermis.
- The cortex is broad, multilayered and parenchymatous. There are about six resin duct present in cortex.
- Endodermis and pericycle indistinguishable.
- The is ectophloic siphonostele. Vascular bundle are generally 6 in number arranged in ring.
- Vascular bundle is conjoint, collateral, open and endarch.



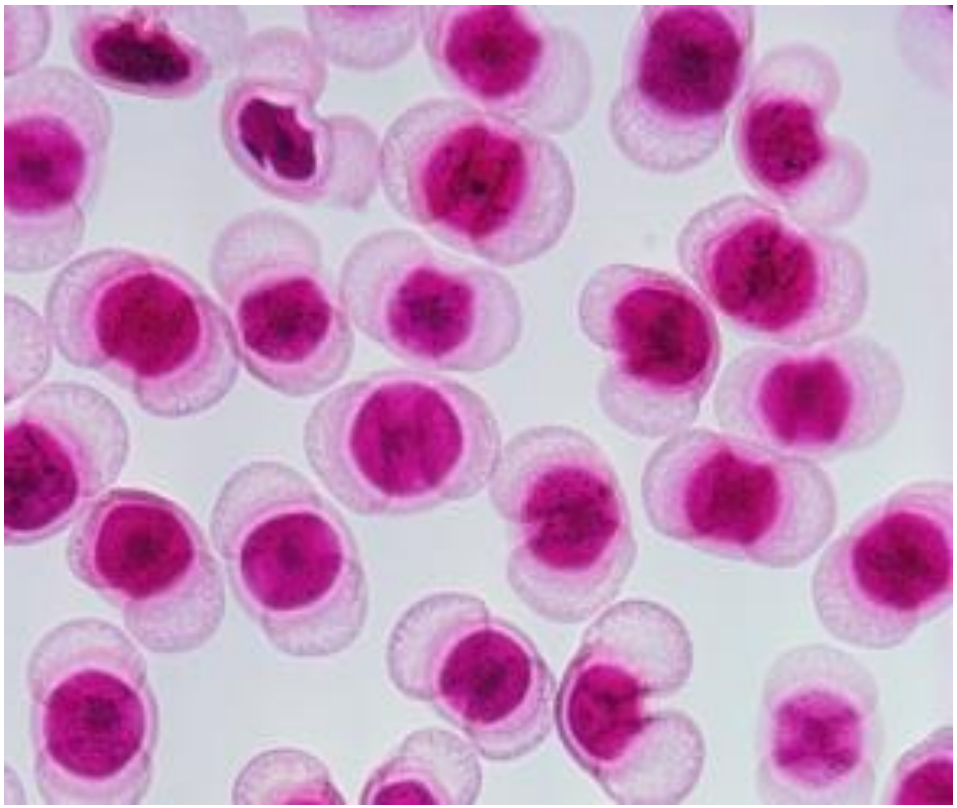
Pinus needle

- The outline is triangular in *P. longifolia, P. roxburghii,* etc.
- Outermost layer is epidermis, which consists of thick walled cells. It is covered by a very strong cuticle.
- Many sunken stomata are present on the epidermis.
- Below the epidermis are present a few layers of thick walled sclerenchymatous hypodermis. It is well developed at ridges.
- In between the hypodermis and endodermis is present the mesophyll tissue. Few resin canals are present in the mesophyll, adjoining the hypodermis.
- Cells of the mesophyll are polygonal and filled with chloroplasts. Many peg like infoldings of cellulose also arise from the inner side of the wall of mesophyll cells.
- Two conjoint and collateral vascular bundles are present in the centre. These are closed. Xylem lies towards the angular side and the phloem towards the convex side of the needle.



Pinus pollen grains

- Each microspore or pollen grain is a rounded and yellow coloured, light, uninucleate structure with two outer coverings, i.e., thick outer exine and thin inner intine.
- The exine protrudes out on two sides in the form of two balloon shaped wings.
- Wings help in floating and dispersal of pollen grains.



Pinus winged seed

- The ovuliferous scale of *Pinus* is hard, woody and stout.
- It is triangular in shape and brownish in colour
- Each ovuliferous scale bear two ovules on its dorsal side near the base. Both the ovules of each ovuliferous scale develop into seeds.
- Each seed contains a large membranous wing formed from the ovuliferous scale.
- The wings help in dispersal.

Fungi, Bacteria viruses and lichens specimens

Citrus canker disease

- The disease is caused by a short bacillus bacterium called *Phytomonas citri (Xanthomonas citri)* on citrus.
- The symptoms of the disease appear on almost all the above ground parts of the host plant, especially on leaves, twigs, young branches and fruits.
- Infected organs show the presence of crust like lesions or scabby spots and small **cankers**
- Cankers on leaves first appear as small, dark green raised protuberances on ventral surface.

- The lesions on fruits are similar to those of leaves.

Lichens crustose

- These lichens have poorly defined thallus.
- They grow on bare rock, trees or soil and form crust like appearance.
- The thalli are partially or wholly embedded in the substratum.
- They are variously coloured.
- Common examples: *Graphis scripta*

Lichens foliose

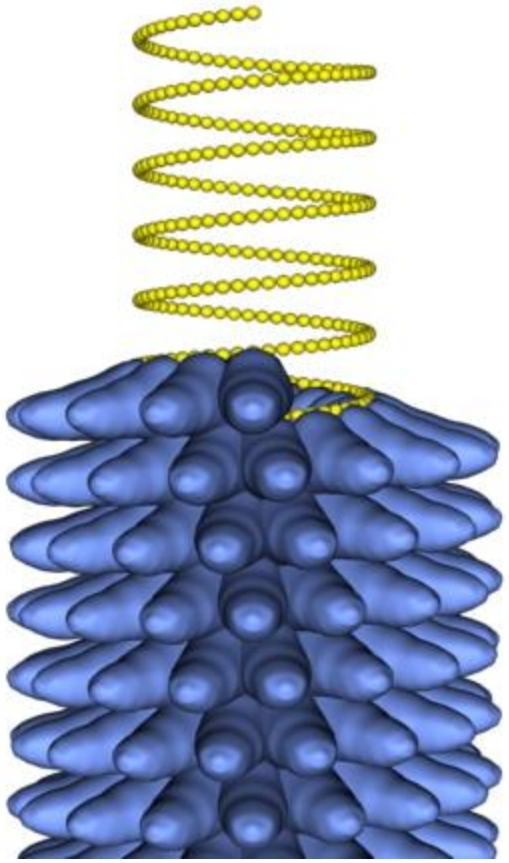
- They have flat , leaf like, dorsiventral thalli. The thalli may be lobed or irregular margins.
- The thallus attached to substratum by small portion through rhizoids like outgrowths called rhizines.
- The foliose lichen are usually brownish or greyish in colour.
- Common examples: *Parmelia, Peltigera*

Lichen fruticose

- The fructicose lichens are branched, slender, cylindrical or ribbon shaped thalli.
- The branches are bushy in appearance.
- Some species show erect branches whereas other shows pendant or tassel like branches.
- Common examples: *Usnea, Cladonia, Ramalina ,etc.*

TMV model

- Tobacco mosaic virus (TMV) is a positive-sense single stranded RNA virus that infects a wide range of plants, especially tobacco and other members of the family Solanaceae.
- Tobacco mosaic virus has a rod-like appearance. Its capsid is made from 2130 molecules of coat protein and one molecule of genomic single strand RNA, 6400 bases long.
- The coat protein self-assembles into the rod-like helical structure (16.3 proteins per helix turn) around the RNA which forms a hairpin loop structure.

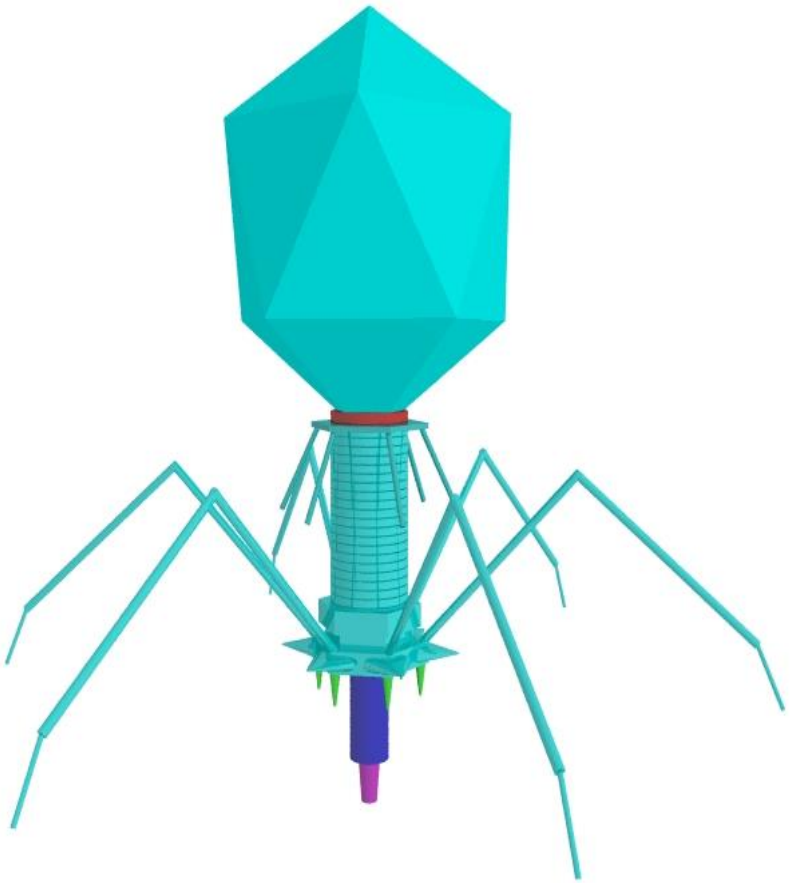


Bacteriophage

A **bacteriophage** _is a virus that infects and replicates within a bacterium.

The term is derived from"bacteria" and "to devour".

Bacteriophages are composed of proteins that encapsulate a DNA or RNA genome, and may have relatively simple or elaborate structures.



Root nodules

- The root of leguminous plants bear large number of small, granular, pink nodules on their branches.
- The nodules vary in size and shape.
- The nodules are formed due to penetrations of bacteria- ***Rhizobium*** sp and resultant stimulation of cell division in cortical cells.
- The host plant supplies the nodule bacteria with organic carbon and in return the bacteria supplies usable nitrogen to the host. Such association is known as **Symbiosis**.
- The invaded cells of nodules contain a reddish pigment called **leghaemoglobin**