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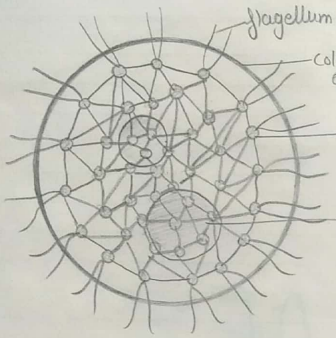
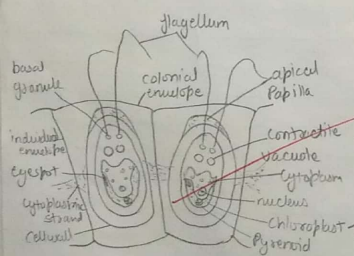
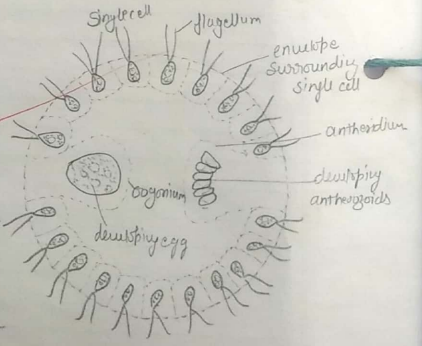
ALGAE



Volvox : Parent colony with daughter colonies.



A part of colony (arrangement of cells)



Colony with antheridium and oogonium

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[VOLVOX]

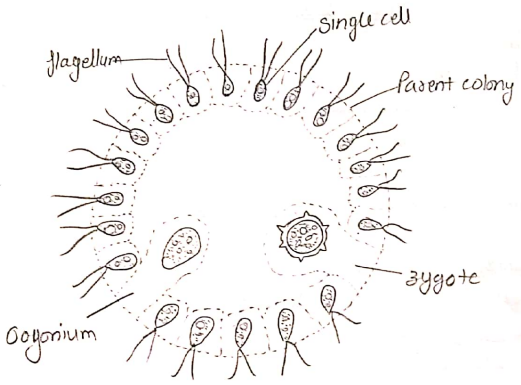
Classification

Sub division - Algae
Class - Chlorophyceae
Order - Volvocales
Family - Volvocaceae
Genus - volvox.

Occurence :- Volvox is highly evolved coenobial alga both in its morphology and Reproduction. The genus has about 20 species, represented in India by five species of these V. globator, V. aureus, V. prolificus & V. africanus are fairly common.

Thallus :- Thallus is multicellular, motile and a coenobial colony.

- Colonies are mostly spherical, rounded or oval in shape.
- It is hollow in the centre and cells are arranged in a single layer towards the periphery.
- layers of cell is surrounded by a gelatinous mass & no. of cells in colony varies from 500 - 6,500 / ccc" to the species.
- Each cell of the colony is connected with a few of the neighbouring cells by thin & delicate cytoplasmic strands.
- Each cell is enveloped by an individual gelatinous sheath.
- Each vegetative cell is biflagellate, motile and ovoid. Two flagella are anteriorly inserted. A contractile vacuole is situated one each at the base of a flagellum.



A colony with a zygote

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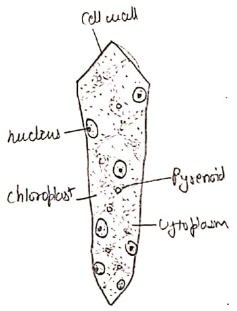
Asexual Reproduction :-

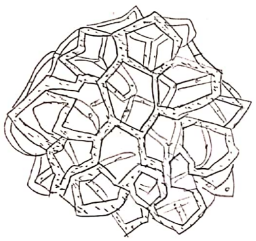
- Asexual reproduction takes place by the formation of daughter colonies.
- Daughter colonies are formed mostly in the posterior part of the parent colony.
- Many small daughter colonies remain embedded in the parent colony. These appear similar to parent colony except its smaller size.
- Daughter colonies are liberated by the gelatinization of wall of the parent colony.

Sexual Reproduction :-

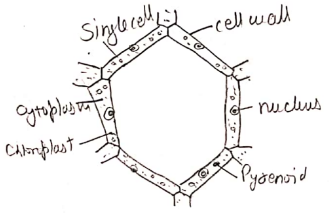
- Colonies may be monoecious or dioecious.
- Sexual reproduction is oogamous.
- Antheridia and oogonia are developed mostly in the posterior part of the colony.
- Antheridium produces biflagellate antherozoids while non-motile oogonium develops a single egg.
- As a result of fertilization oospore or zygote is produced.
- Zygote is orange-red in colour because of the presence of haematochrome.
- Zygote is thick walled structure. The wall is made of two or three layers. Outermost layer is thick and may be smooth or ornamented.



Hydrodictyon: A single cell.



Hydrodictyon: A part of saccate thallus



Hydrodictyon: A part of reticulum

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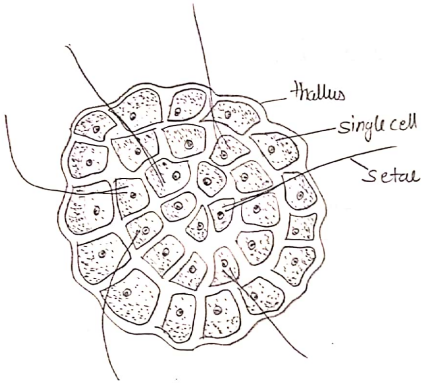
[Hydrodictyon]

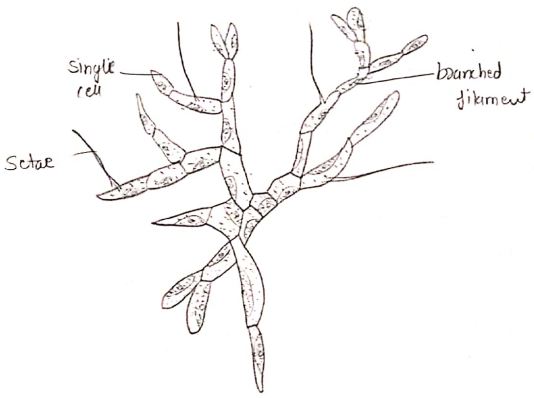
Sub-division - Algae
Class - Chlorophyceae
Order - Chlorococcales
Family - Hydrodictyaceae
Genus - Hydrodictyon.

Thallus and a single cell.

- The thallus is a multicellular colony forming a net-like str.
- Colony is a hollow and sac-like or saucer like, cylindrical network, closed at both the ends.
- The spaces of the reticulum are bound by five or six cells which form a pentagonal or hexagonal structure.
- The cells are cylindrical. End walls are angular to facilitate the formation of a mesh.
- A cell has a large central vacuole.
- Cytoplasm lies towards the periphery.
- Cells are multinucleate. The young cells are however, uninucleate
- Cell is called a coenocyte because of its multinucleate nature and presence of large central vacuole.
- Young cells have zonate or entire chloroplast, little mature cells possess reticulate chloroplast, older stages discoid shape and diffuses throughout the cytoplasm.
- Chloroplast contains large no of pyrenoids.



Coleochaete - Discoid thallus



Cushionoid thallus

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[Coleochaete]

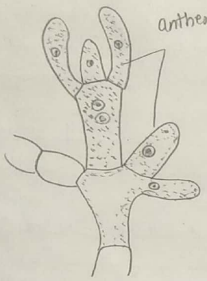
Sub division - Algae
Class - Chlorophyceae
order - Chaetophorales.
Family - Coleochaetaceae
Genus - Coleochaete.

Thallus Structure

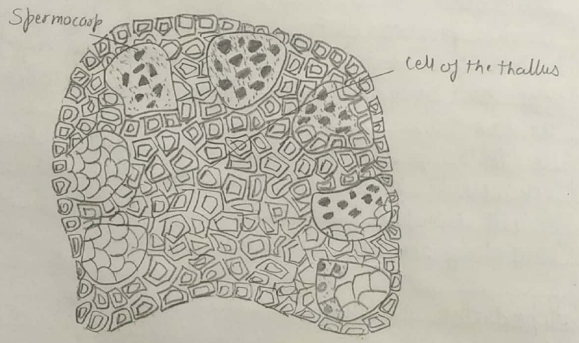
- Thallus is multicellular heterotrichous either of disc shaped str. or cushionoid or filamentous.
- In disc like disc represents only the prostrate system while a few setae or hair, represent erect system.
- Filamentous thallus exhibits typical heterotrichous habit with a branched prostate system and a branched projecting system.
- In both cases a few cells possess a cytoplasmic outgrowth-setae. Setae are surrounded partly or wholly by a gelatinous sheath at the base.
- The thallus is distinctly enveloped by a gelatinous sheath or mucilage.
- Each cell is uninucleate. It has single, large, laminate and parietal chloroplast with a single pyrenoid. Rest of the cell is occupied by the cytoplasm.

Reproductive Structure

- Thalli may be homothallic or heterothallic.
- Sexual reproduction is oogamous.
- Antheridia are generally borne at the tips of filamentous species &



Thallus bearing antheridia



Thallus with spermocarps

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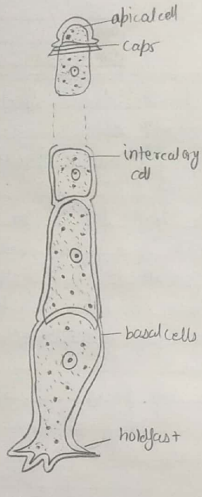
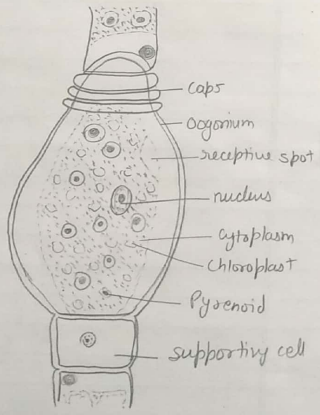
in the middle or peripheral region in the discoid species.
- Antheridia appear as a group of small cells.
- Oogonia are also borne terminally in filamentous species and towards periphery in the discoid species.
- Oogoniam is a flask-shaped structure with long tubular trichogyne.
- The fertilization results in the formation of a zygote which remain embedded inside the wall of the oogoniam. It is a thick walled sto.
- Zygote known as spermocarp remains enveloped in a parenchymatous tissue formed by the development of neighbouring cells. It is conspicuously reddish-brown in colour.
- Spermocarp remains dormant for a long period.



Oedogonium: A filament



Oedogonium: Filament showing mature oogonium

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[Oedogonium]

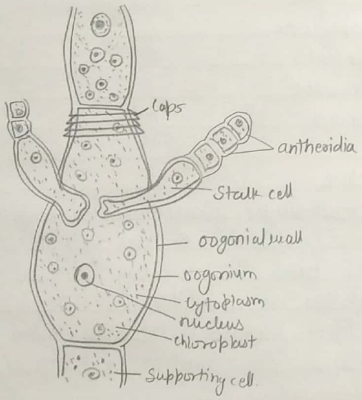
Sub-division - Algae
Class - Chlorophyceae
Order - Oedogoniales
Family - Oedogoniaceae
Genus - Oedogonium.

Thallus structure

- Thallus is multicellular, filamentous and unbranched.
- A filament is differentiated into three types of cells according to their position : (i) basal (ii) intercalary (iii) apical.
- basal cell functions as a holdfast.
- A cell at the tip of filament is known as apical cell.
- The cells present b/w basal cell and apical cell are intercalary cells.
- A typical cell is cylindrical, cell wall is thick & three layered, cells are uninucleate, mature and old cells show 'cap cells' at their upper end. These are characteristic of the members of oedogoniales.

Oogonium

- oogonia are intercalary or terminal in position.
- Oogonium may be solitary or occur in a row of 2-3 or even more.
- Oogonium generally show one or more cap cells at its upper end, indicating its upper end, indicating its development form a comparitively older cell.
- It is mostly spherical or oval in shape and larger than a vegetative cell.
- At the base of each oogonium lies a small and flat daughter cell.



Oedogonium: Oogonium with two dwarf males attached to it.

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known as supporting or suffultory cell.
- Oogonium encloses a single large ovum.
- The wall of oogonium has a small pore on one side known as receptive pore.
- Just opposite to receptive pore, Protoplast of oogonium has a hyaline area - receptive spot.
- Uninucleate protoplast is rich in reserve food.

Antheridium

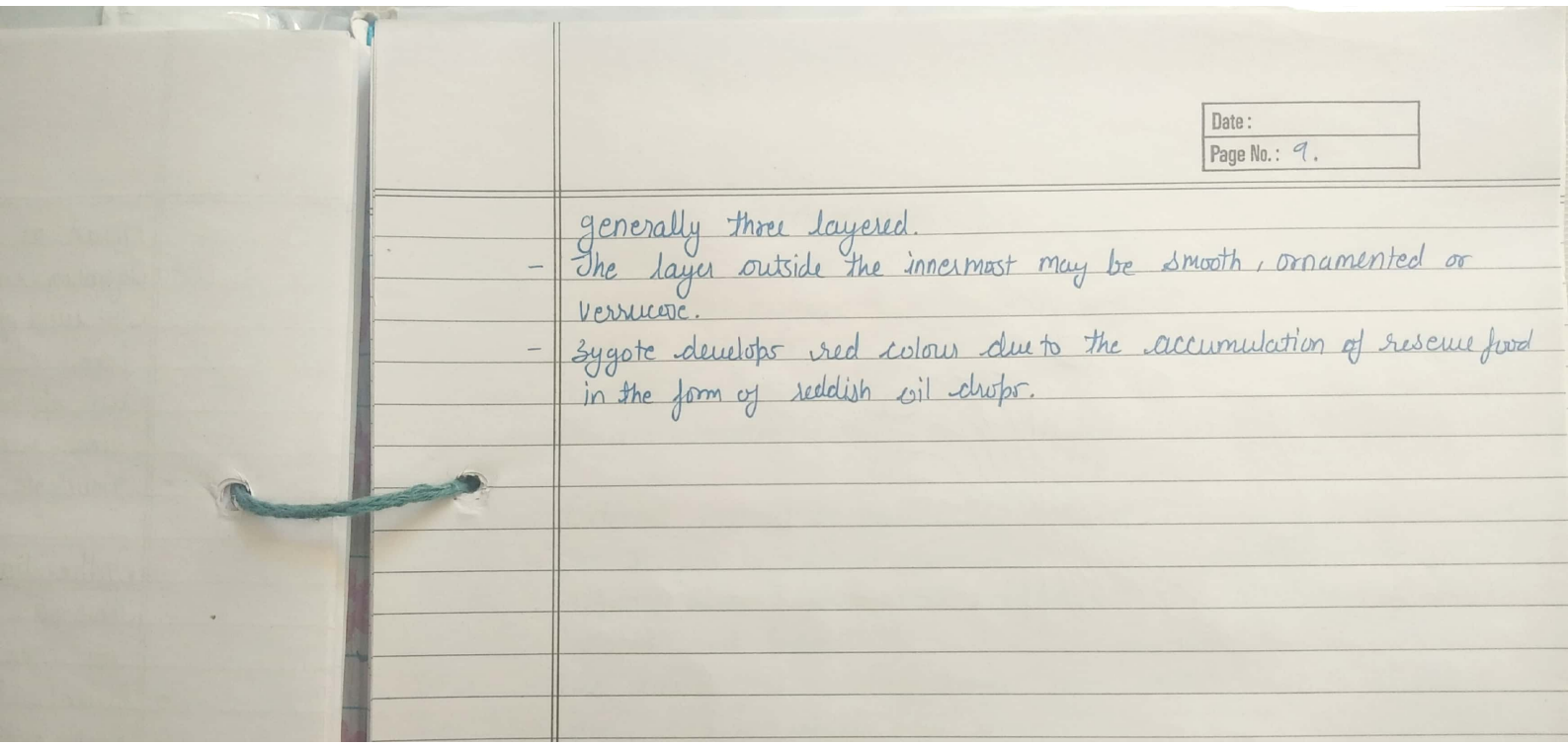
- These are intercalary in position and numerous antheridia form a long chain being arranged in a series.
- An antheridium is a small and flat cell.
- Each antheridium has two nuclei lying side by side, surrounded by dense cytoplasmic contents.

Dwarf male or nannandrium

- The dwarf male is a characteristic of nannandrus species & these are produced by the germination of androspore.
- A dwarf male is made of a stalk cell and a terminal row of 2-3 cells.
- Stalk cell is at the base by which the dwarf male is attached to the filament.
- The terminal row has 2-3 small, flat and narrow antheridia.
- Each antheridium has two multiflagellate antherozoids.

Zygote

- Zygote is thick walled post fertilization structure. The wall is



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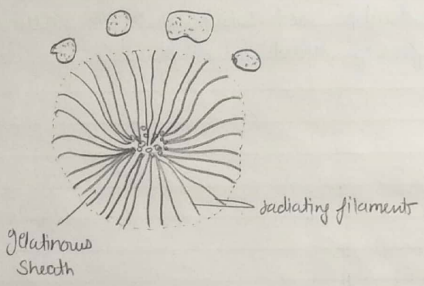
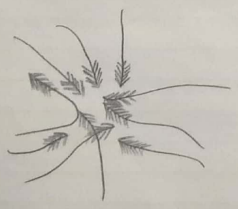
generally three layered.
- The layer outside the innermost may be smooth, ornamented or verrucose.
- Zygote develops red colour due to the accumulation of reserve food in the form of reddish oil drops.





Gloeotrichia : A few colonies.

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[Gloeotrichia]

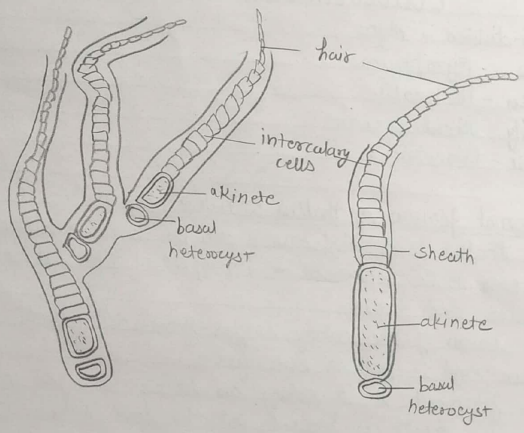
Sub-division - Algae
Class - Myxophyceae
Order - Nostocales
Family - Rivulariaceae
Genus - Gloeotrichia.

External features of thallus & heterocyst.

- The thallus is colonial surrounded by large mucilage. The shape appears to be spherical or hemispherical. The old colony becomes inflated and hollow.
- The colour of the colony ranges from dull brown to blackish green and is seldom blue green.
- The filaments in a colony are loosely arranged in radial fashion.
- Colourless sheath is present at the base where it is firm and gradually gelatinizes outwards.
- Trichomes may be unbranched or more or less false branched.
- The trichomes show a typical & distinct trichothallic growth.
- A single spherical heterocyst with a single polar granule is present at the base of the trichome.
- Each cell show a typical cyanophycean structure.

Hormogonia and the Spores.

- Reproduction takes place by hormogones and spores or akinetes
- Sexual reproduction is not known.
- Hormogonia formation is common. These occur singly or in series.
- Spores are common in occurrence occur at the base of trichome



Gloeotrichia : A filament to show heterocyst and akinete.

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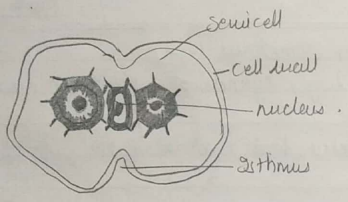
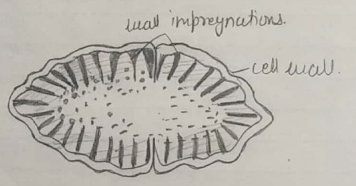
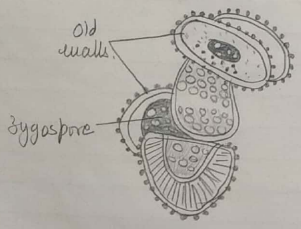
generally singly, sometimes more.
- Each spore is long, cylindrical, smooth or ornamented and thick walled.
- It's rich in reserve food material in the form of cyanophycean granules.
- Akinetes are the major organs of perennation.



Cosmarium - cell content



Cell surface structure.



Stage of Conjugation.

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[Cosmarium]

Classification

Domain - Eukaryota
Kingdom - Plantae
Division - Charophyta
Class - Zygnematophyceae
Order - Desmidiales
Family - Desmidiaceae
Genus - Cosmarium.

- Cosmarium is a common free floating freshwater placoderm desmide found in ponds, lakes, ditches and other reservoirs, though some species are found in brackish water.
- Cosmarium is the largest desmid genus and is very widespread.
- Plant body unicellular and divided into two semi-cells which is joined by isthmus.
- The walls of semicells are frequently ornately sculptured, and this together with the clear brilliant green of chloroplasts make them very attractive.
- Pyrenoids are present in the chloroplast. Each cells contains a single nucleus located in the isthmus region.
- Cosmarium is non-motile, freshwater member of division Chlorophyceae.
- Asexual reproduction takes place by simple cell division.
- Elongation of isthmus region and mitotic division of nucleus into two semi-cells each containing a nucleus.

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- Sexual reproduction takes place by conjugation.
- Interaction of two conjugating cells gives out a thin conjugation tube. Formation of spherical zygospore which after period of dormancy divides reductionally forming four nuclei where two nuclei degenerates.
- The protoplast divides into two daughter cells, each receiving a daughter nucleus.

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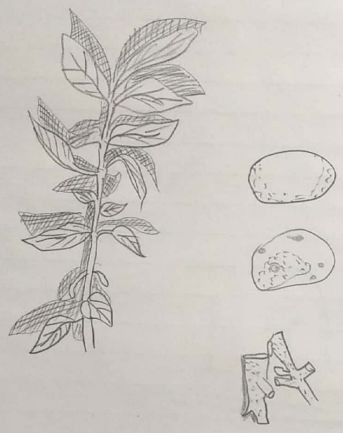
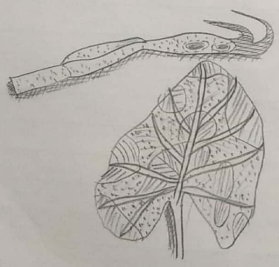


Phytophthora : Infected turnip tubers



Phytophthora : Inflorescence & leaf of Colocasia infected by P. colocasiae

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[Phytophthora]

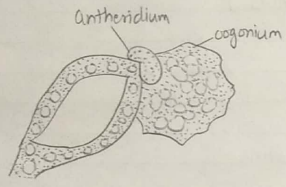
Classification

Division - Eumycota
Sub-division - Mastigomycotina.
Class - Oomycetes
Order - Peronosporales
Family - Pythiaceae
Genus - Phytophthora.

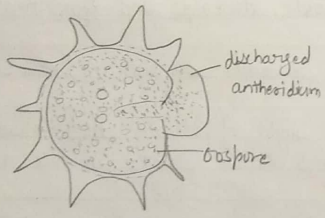
[Study of hosts, diseases and symptoms]

- Some of the diseases common in India are as follows.

1. Late or Irish blight of Potato → host → Solanum tuberosum
- The epidemics cause damage in hills and are not common to plains.
- Symptoms. → on leaves small black patches which increase in size with time. Infection soon spreads to the stem also and the entire shoot falls off in a few days if environmental conditions are suitable.
- Later infection spreads in tubers also, so that entire tubers turns brown and decays giving off pungent odour.



Phytophthora : Sex organs



Phytophthora - Oospore.

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[Vegetative Structure].

- Phytophthora is eucarpic, inter or intracellular parasite.
- The young mycelium is profusely branched and non septate but old hyphae at the time of reproduction is septate.
- Hyphae vary in diameter and develop finger like haustoria which enter the cells of the host.

[Asexual reproductive structures - Sporangia]

- Asexual reproduction takes place by sporangia or conidia.
- In a diseased patch, certain septate hyphae form the conidiophores which grow out from the stomata on the underside of the leaf.
- The conidiophore produces ovoid or lemon-shaped, multinucleate Papillate conidia which are at first terminal but become lateral later on, due to the sympodial branching of conidiophore.
- Each conidium forms many biflagellate zoospores which emerge through papilla. Each zoospore germinates to form a new mycelium.

[Sexual reproductive structures - oogonia and antheridia].

- The sexual reproduction is of oogamous type.
- The antheridium may either be paragynous i.e. at the side of the oogonium.

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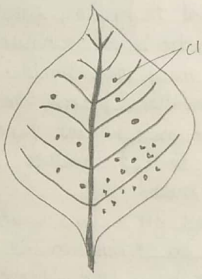
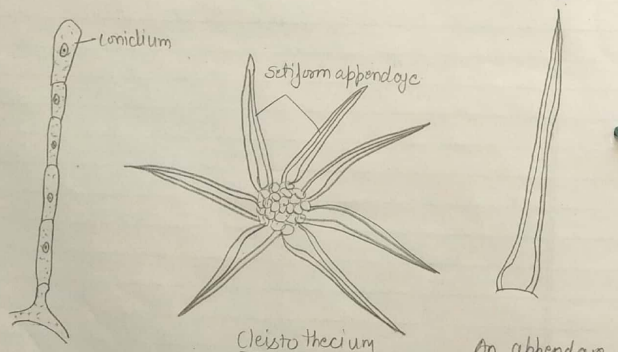
- The oogonium is spherical to pyriform, smooth and hyaline to yellowish. In the centre is an uninucleate oosphere.
- The antheridium has many male nuclei.
- At maturity, the antheridium pierces the oogonium by a fertilization tube. One male nucleus passes into the ooplasm.
- Male and female nuclei unite to produce oospore which develops a thick wall around itself.
- Oospore undergoes a rest for a few weeks or months. It gives out a germ tube on germination. It either develops into new mycelium or may form sporangium at its tip.



Phyllactinia: leaf of Dalbergia sisso showing cleistothecia



Phyllactinia: A conidiophore with conidium.

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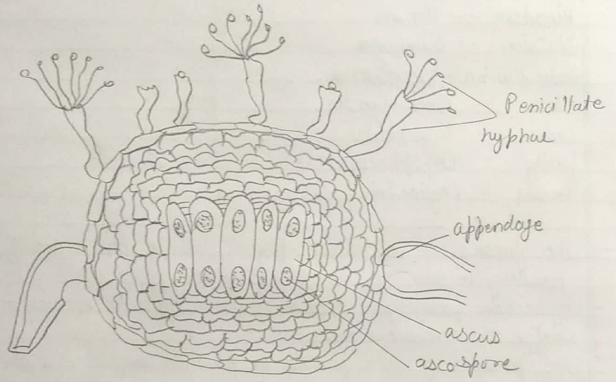
[Phyllactinia]

Kingdom - Mycota
Division - Eumycota
Sub-division - Ascomycotina
Class - Plectomycetes
Order - Erysiphales
family - Erysiphaceae
Genus - Phyllactinia.

- The fungus is a hemiendophytic parasite and commonly causes powdery mildew.
- Phyllactinia parasitizes leaves of over hundered species of Plants, chiefly the deciduous trees.
- The presence of white powder on the host surface. It is the result of profuse extramatrical mycelium spreading on the host surface. The disease is air borne.

[Vegetative structure]

- The mycelium which spreads over the surface of the host possesses septate hyphae with uninucleate cells.
- The saccate haustoria are formed in the mesophyll cells bordering the sub-stomatal chamber by 6-7 celled hyphal branches of limited growth. The mycelium is thus hemiendophytic.



Phyllactinia V.S cleistothecium

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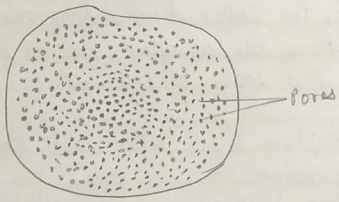
[Asexual Reproductive structures].

- Conidia are the asexual reproductive structures formed on conidiophores, the latter develop from the superficial mycelium.
- The conidiophores are abundant, first on both the surfaces of the leaves but later become restricted only to the lower surface.
- Each conidiophore is 3-4 celled erect branch terminating into a single conidium.
- Each conidium is clavate, thin walled and uninucleate.
- The conidia are disseminated by wind. These germinate into a new mycelium under favourable conditions.

[Ascocarp, asci and ascospores]

- The ascocarp or the fruiting body is cleistothecium provided with long, unbranched setiform and rigid appendages.
- The appendages has bulbous base which helps in release of ascospores after freeing the cleistothecium from hyphal mat.
- Besides the appendages, there is an apical crown of Penicillately branched hyphae over the cleistothecium. These hyphae give out a slimy substance which helps fruiting body to get attached to the host surface.
- The asci get exposed and the ascospores are liberated, only after the rupture of the cleistothecial wall.
- Asci are clavate, arranged more or less in parallel manner on the floor of ascocarp.
- Each ascus contains two ascospores. Each is ovate to elliptical and uninucleate.



Polyporus : Basidiocarp

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[Polyporus]

Classification.

Kingdom - Mycota
Division - Eumycota
Sub-division - Basidiomycotina
Class - Hymenomycetes
Sub-class - Holobasidiomycetidae.
Order - polyporales
Family - Polyporaceae
Genus - Polyporus.

- Many species of the genus are destructive parasites and cause disease in forest and other shade trees. Many other grow on lumber and destroy it.

[Vegetative structure]

- The mycelium is well developed, branched and septate.
- Generally the mycelium grows within and below the bark but in case of severe attacks, it completely invests the central wood cylinder.

[basidiocarp, basidia and basidiospores]

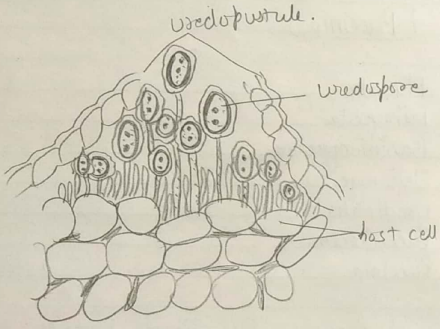
- The mycelium forms a more or less flat fruiting body, the basidiocarp.

- The basidiocarp is characteristically shelf-like, shortly stalked and arises from the tree trunks.
- It is leathery, corky or woody, whitish or slightly greyish or brownish in colour.
- The upper surface is generally smooth, sometimes rough, often undulating, while the lower surface is porous. In some species the upper surface is distinctly striated.
- The section of basidiocarp shows an outer context, trama, Pores and hymenium.
- The context is the outer fibrous part made up of thick walled hyphae.
- The trama is a loose mass of much branched, septate and anastomosing hyphae.
- The pores or tubes extend from below the context to the lower surface.
- The hymenium is made up of a distinct layer of basidia, lining each pore or tube.
- The basidia are club-shaped, somewhat larger than the Steile cells of the hymenium and project slightly into the cavity of the pore.
- The large no. of basidospores dischayed in the pore.
- Each basidospore is small, oval and is uninucleate.
- The basidiospore on germination gives rise to mycelium.

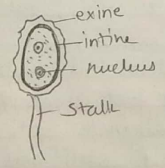
Puccinia

Kingdom - Mycota
Division - Eumycota
Sub-division - Basidiomycotina
Class - Teliomycetes
Order - Uredinales
Family - Pucciniaceae
Genus - Puccinia.

- All the species of Puccinia are obligate parasites on some of the important cereals eg. wheat, maize and oat, on millets as bajra and jowar and on other plants as Berberis and Thalictrum etc.
- All the species of puccinia are polymorphic. some species such as P. graminis are heteroecious, while others such as P. Butleri are autoecious.
- In almost all the heteroecious rusts, uredo-and teleutostages are found on primary host while pycnidial and aecidial stages are found on alternate host.
- P. graminis tritici and P. striiformis infect wheat, the primary host and barberry, the alternate host. They cause Black rust or stem rust and yellow or stripe rust respectively on wheat.
- The symptoms of the disease are seen on leaves, leaf sheaths and sometimes on stem also. The floral organs are gen not affected. In Black or stem rust, dark brown or black,



Puccinia : T.S of infected leaf through uredopustule



Puccinia : Urediospore

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Oblong to linear lesions are produced on leaves, leaf sheaths and stems which in case of severe infection, coalesce to form large patches.

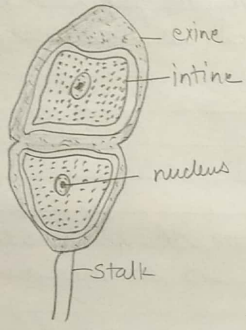
- Yellow or Stripe rust is chiefly confined to leaves but if the attack is severe it may also spread to leaf sheaths and stalks. As such the green colour of leaves fades, producing long streaks on which small oval and lemon yellow lesions are found.

[Vegetative Structures]

- The mycelium is well developed, branched and septate. It is generally intercellular and sometimes shows globular haustoria also.
- The mycelium is called dikaryotic because it possesses two nuclei of different strains in each cell.

[Uredosorus and urediospores]

- The uredosori or uredopustules appear as red, oval or lemon shaped lesions on the leaves and leaf sheaths.
- The uredosorus in section reveals the ruptured host epidermis due to the pressure of underlying urediospores.
- The intercellular and branched mycelium is aggregated beneath the epidermis.



Puccinia : Teleutospore

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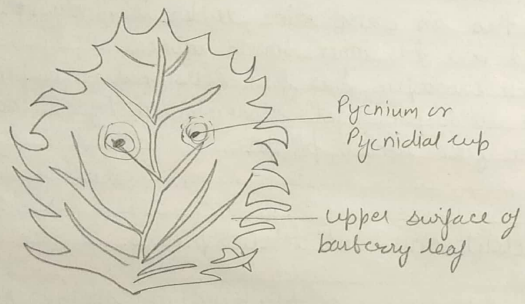
- The uredospores are produced in massive groups from this mycelium.
- Each uredospore is binucleate, stalked and rounded or oblong in shape.
- It has an outer exine which is finely verrucose or echinulate and an has inner smooth intine.
- Each uredospore has four equatorial germ pores.
- The uredospores get disseminated by wind and infect the fresh wheat plants.

[Teleutosorus and teleutospores].

- The teleutosori or teleutopustules appear on leaves, leaf sheaths and stem as black, oval pustules that fuse to form patches in case of severe infection.
- A teleutosorus in a section reveals the intercellular, branched mycelium, a bunch of teleutospores and the ruptured host epidermis.
- The host epidermis is ruptured due to the pressure of underlying teleutospores.
- The teleutospores are formed by the same mycelium which earlier produced uredospores.
- Each teleutospore is borne terminally by the mycelium. It is stalked, elongated and bicelled structure.



Pycnidial cups on upper surface

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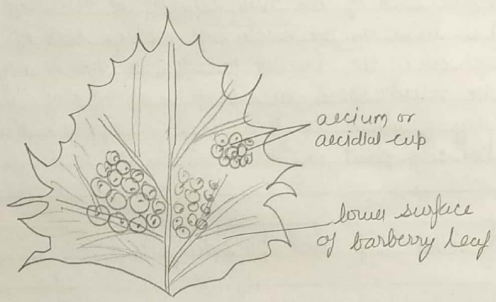
- The apex of the teleutospore may be rounded or pointed as in P. graminis or it may be nearly flat as in P. reconcilita and P. Striiformis.
- The teleutospore has a very thick but smooth exine and delicate thin intine. The exine turns black at maturity.
- At first each of the two cells of the teleutospore is binucleate but later on, the nuclei fuse making each of them uninucleate.
- Each cell of the bicelled teleutospore has a single germ pore.
- The teleutospores are incapable of infecting the primary host. They germinate to form the basidiospores which infect the barberry plant or Thalictrum etc. the alternate host.

Pycnidial cup and pycnidiospores

- Each basidiospores germinates on the leaf of alternate host producing the mycelium, that ultimately forms the pycnicial cup or pycnidium.
- The pycnidia are gen present on the upper surface of the leaf and may be best studied in a ts of the host leaf.
- A mature pycnidium is flask shaped with a pore known as ostiole at its apex.
- The hyphae near the ostiole are unbranched pointed and orange coloured. These are called periphysis and project through the ostiole.
- Some of the periphyses are branched and thin walled. These are called receptive hyphae. They project through



Puccinia : Aecidial cups on lower surface

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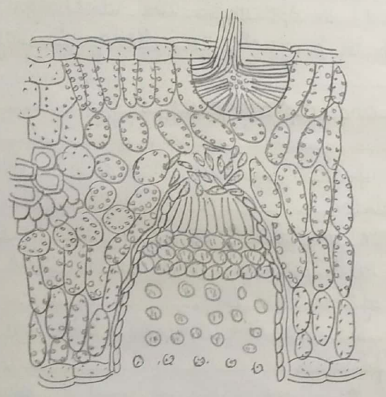
the ostiole far beyond the periphyses.
- The cality of the pycnidium is lined by many elongated and uninucleate pycnidiophores or spermatophores.
- The pycnidiophores are arranged in a palisade like layer and each cuts off a chain of pycnidiospores or spermatia.
- The pycnidiospores or spermatia are discharged through the ostiole and help in producing the dikaryotic mycelium.

[Aecidial cup and aecidiospores]

- The aecidial cup or aecidium can only be formed by a dikaryotic mycelium.
- The aecidia are generally present on the lower surface of leaf and thus both pycnidia and aecidia can be seen in the same section of the host leaf.
- Each aecidium is cup-like structure with an outer protective layer called peridium.
- The developing aecidium elongates and is pushed through the host epidermis.
- At the base of aecidium there are many elongated cells known as sporophores, arranged in a palisade like manner.
- Each sporophore cuts off alternately, a small and a large cell. The small cell is a disjunctor whereas the latter is the aecidiospore.
- In younger conditions, aecidiospores are hexagonal and are held in chains by the disjunctor cells. The spores round off as soon as they get separated.



Puccinia : T.S of infected leaf of Berberis showing pycnidial and aecidial cups on upper and lower epidermis respectively.

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- Each aecidiospore is a binucleate structure with a thick and smooth wall.
- The aecidiospores are blown away by wind and infect wheat plant. They are not capable of reinfecting barberry

[Puccinia butleri.]

- It is an autoecious rust, hence all the stages are found on a single host ie, Launea sp. member of family Compositae. In this case there is no alternate host.

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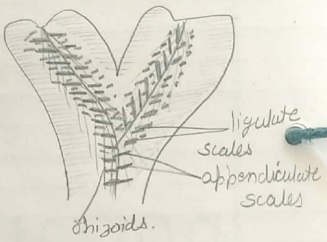
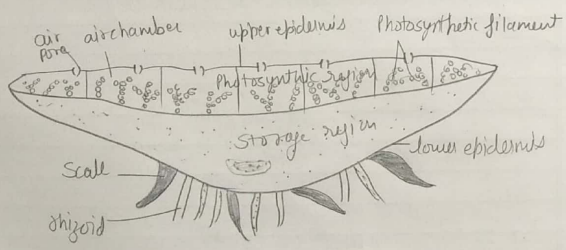
BRYOPHYTA

Dorsal view of thallus



Ventral view of thallus



Marchantia: V.L.S of thallus.

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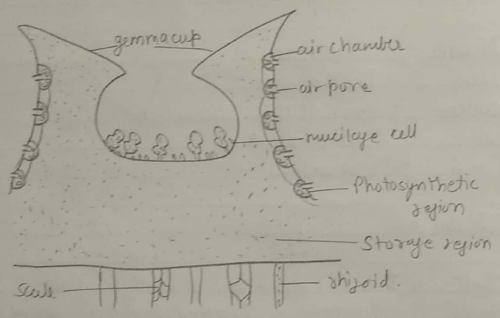
[Marchantia]

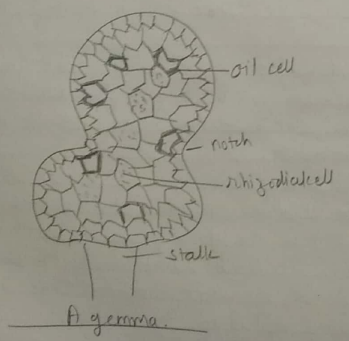
Division - Bryophyta
Class - Hepaticopsida
Order - Marchantiales
Family - Marchantiaceae
Genus - Marchantia.

[Thallus]

- Plants are thalloid, dorsi-ventral and prostrate.
- Thallus is dichotomously branched and the apex of each branch is notched.
- Dorsal side has a conspicuous midrib and many polygonal areas.
- certain cup-like structures present along the midrib are known as gemma cups. These contain gemmae, the vegetative reproduction bodies.
- The ventral surface bears scales and rhizoids along the midrib.
- Scales are arranged in two to four rows on either side of the midrib. Scales of two types (i) simple or ligulate (ii). appendiculate.
- The rhizoids are of two types (i). smooth walled (ii) tuberculate.
- The genus is dioecious, male and female thalli being different.
- The sex organs are present on the stalked male and female receptacles. The male receptacle is known as antheridiophore and the female as archegoniophore. These structures arise from the growing apices of the thallus.



V.L.S of thallus through gemma cup

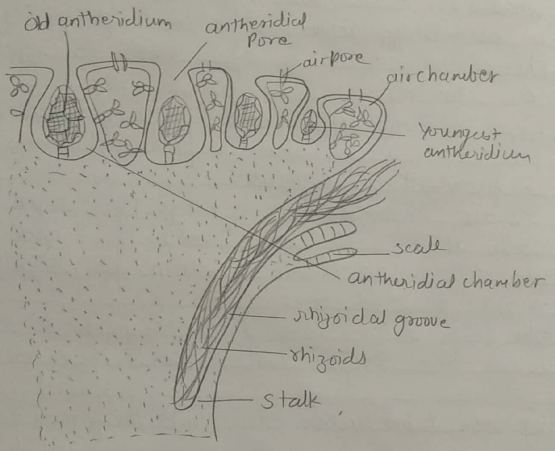


[Anatomy of thallus]

- Thallus is dorsiventrally differentiated into an upper photosynthetic or assimilatory region and a lower storage region.
- Photosynthetic region is differentiated into upper epidermis and air chambers.
- Upper epidermis is interrupted by compound, barrel shaped air pores, each air chamber is filled with many branched assimilatory or photosynthetic filaments.
- Storage region consists of compactly arranged parenchymatous cells. A few cells are filled with oil bodies and mucilage.
- The cells in the midrib or centre are slightly thickened to serve for conduction.
- The lower surface of the thallus is bound by the lower epidermis which bears scales and rhizoids in the middle region.

[Vegetative reproductive structure : the gemma cup]

- Outline is goblet-shaped with an outer wall and central cavity.
- The outer wall shows outer photosynthetic region and inner storage region.
- The internal structure of photosynthetic region and storage region is similar to that of thallus.
- From the floor of the central cavity arise numerous discoid gemmae.
- Intermingled with gemmae are many mucilage hairs or cells.



A part of L.S of antheridiophore.

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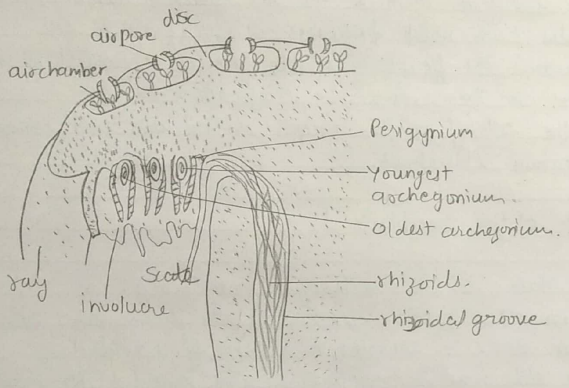
- The gemma cup arises as a part of the thallus. It remains attached with the thallus by its base.
- Gemmae is one-celled, stalked structure. The stalk keeps gemma attached to the base of the gemma cup.
- The disciform gemma has two shallow notches on both the lateral sides. Each notch possesses a row of apical cells.
- Towards the periphery of the gemma colourless oil cells are present. Inner to them are the rhizoidal cells.
- All the cells of gemma except the oil cells and rhizodial cells contain chloroplast.

[Stalk of the receptacle]

- The stalk is dorsiventrally symmetrical.
- It shows 2 rhizoidal grooves on the lower side, situated one on either side. It contains two types of rhizoids.
- Upper side has photosynthetic region divided into many air chambers. It is similar to photosynthetic region of the thallus.
- Stalks of both male & female receptacles are similar in structure.

[Male sex organs]

- The antheridiophore consists of 0.5 to 2.0 cms long stalk, bearing at its apex one eight lobed disc.
- The peltate disc is slightly convex. The internal structure resembles with that of the thallus.



A part of L.S of archegoniophore

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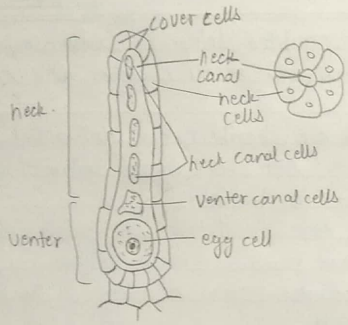
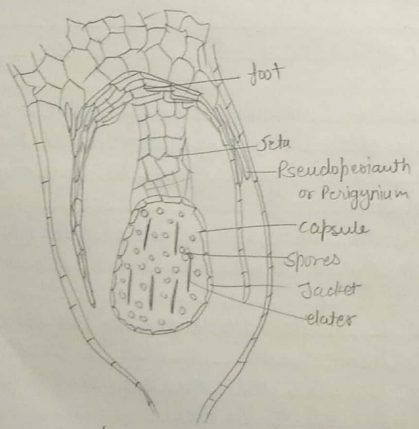
- Epidermis is interrupted below by barrel-shaped air pores, each opening below, into an air chamber with branched assimilatory filaments.
- Alternating with air chambers, are antheridial cavities. Each antheridial cavity, that opens by an antheridial pore, has a single globular antheridium.
- The antheridia are acropetally arranged ie. oldest is nearest the centre and youngest nearest margins.
- It has a multicellular stalk attached to the base of the antheridial cavity.
- The globular body has a single sterile jacket layer. Many androcytes or antherozoids occupy the space inside the jacket.

[Female sex organs]

- It is a stalked structure, possessing a nine-rayed stellate disc at the apex. Groups of archegonia are found in btw the rays. In each archegonial group, the archegonia are borne in radial rows.
- After fertilization, sporophyte is formed in the same archegonium.
- The peltate disc is convex. The internal structure is similar to that of thallus.
- outer most is epidermis, interrupted by air pores. These open into air chambers with branched photosynthetic filaments.
- In a young receptacle, archegonia are acropetally arranged on the upper side of the disc.



An archegonium.



L.s of mature sporophyte

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- Due to growth in the centre of the disc archegonia finally become shifted towards the lower side.
- The nearly mature archegonium has swollen venter and a long neck.
- The venter encloses an egg cell and a venter canal cell, while the neck has 4-8 neck canal cells surrounded by six vertical rows of jacket cells.
- The cover cells are not much distinct.
- After fertilization periauth and involucre are developed.

(Sporophyte)

- Sporophyte develops in the same place as archegonium after it fertilization. Therefore, capsules are seen in a disc of mature archegoniophore, on the lower side. only one sporophyte develops in one involucre.
- Sporophyte is enclosed by three coverings (i). calyptera (ii) Perigynium (iii) Perichaetium. It is differentiated into a foot, seta and capsule.
- Foot is basal and bulbous. Seta is middle and short and the capsule is spherical, occupying the distal end of the Sporophyte.
- Capsule has a single layered jacket, inside which lie many spores and elaters. Spores are arranged in tetrahedral tetrads.
- A spore has an outer thick sculptured exine and a thin uniform intine. Every spore is uninucleate with rich cytoplasm.

- The spores are very small in size.
- Elaters are spindle shaped and each possess 2 spiral thickening bands. These are hygroscopic and help in dispersal of spores.

Gametophytic thallus.

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[Notothylas]

Classification.

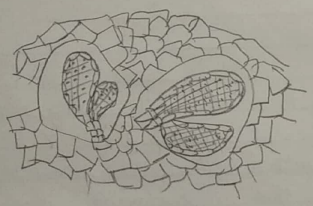
Kingdom - Plantae
Division - Anthocerotophyta
Class - Anthocerotopsida
order - Notothyladales
family - Notothyladaceae
Genus - Notothylas.

[General Characters]

- Notothylas is a genus of hornwort in the family notothyladaceae.
- The genus is found globally but is usually overlooked. It is the smallest of all the hornwort, with a yellow-green gametophyte thallus that is seldom more than a centimeter, and usually much smaller.
- The genus Notothylus is also unusual among hornwort in that the sporophyte is bullet-shaped and does not grow very tall.
- It is generally found in damp, shady places, either on moist soil or on rocks. Sometimes it also grows on the walls and floor of old buildings.

[Gametophyte of Notothylas.]

- The plant is thallose and prostate with an orbicular or sub-orbicular form. It is thin and delicate, dichotomously branched, having a light green or yellowish colour.



Section through thallus showing Antheridium

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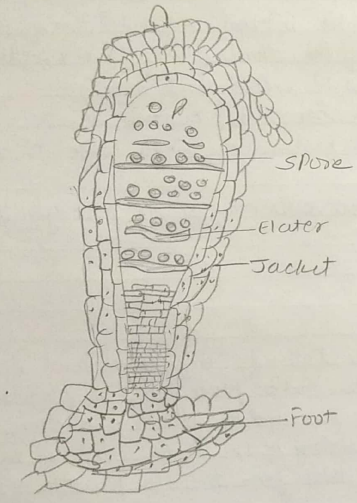
- On the ventral surface it bears only smooth-walled rhizoids.
- The pegged rhizoids as well as the scales are entirely absent.
- The thallus has little internal differentiation of tissues.
- The middle region of the thallus may be 6-8 cells in thickness, whereas margin is 1-3 celled thick.
- The epidermal cells are conspicuously smooth.
- Each epidermal cell contains a single large chloroplast with a pyrenoid.
- Some of the internal cells may contain mucilage and harbour.

Reproduction.

- Notothylas reproduces both by vegetative and sexual methods.
- vegetative reproduction takes place by the progressive growth of the apical portion followed by death and decay of the older one behind the dichotomy of the thallus. Later on two lobes separate out and thus form the older plant two new individuals are produced.
- The plant body is either monoecious or dioecious. Some are protandrous also.
- The antheridia grow close to the growing point of the thallus and they develop endogenously in groups of 3 or 4 in chambers.
- These chambers develop in the hypodermal region of the thallus.
- Each chamber is over-arched by a wall, two-celled in thickness.
- A mature antheridium is shortly stalked, somewhat oval or orange or red in colour.



L.S through capsule

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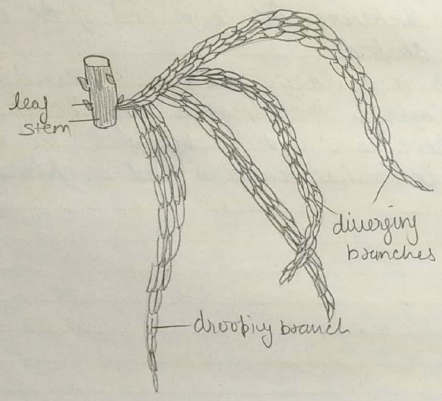
- The antherozoids are typically biflagellate. They are liberated after the disintegration of the antheridial chambers.
- The archegonia develop singly close to the apex of thallus. They are usually grow embedded in tissue of the gametophyte.
- A mature archegonium has 3-5 neck canal cells. The canal of the neck is wide and may be as wide as venter. within a venter, a venter canal cell and an egg are found.
- There are 4 cover cells at the apex of the archegonial neck. At maturity, the neck canal cells and the venter canal cells disintegrate thereby forming a passage for the entrance of the antherozoids.
- Fertilization takes place by union of an antherozoid with an egg.
- The entery of the former into the archegonium is facilitated by the presence of a thin film of water.
- The fertilized egg surrounds itself by a wall and forms the oospore, which almost completely fills the cavity of the venter.
- with fertilization and formation of oospore, the sporophytic or diploid generation begins.
- Oospore by divisions and redivisions forms an embryo consisting of three tiers of cells.
- The cells of the uppermost tier divide periclinally forming an outer amphithecium and inner endothecium.
- Sporangium at maturity becomes more or less cylindrical, sometimes tapering at both ends. borne horizontaly along the margins of the thallus, either singly or in pairs.
- The jacket of the capsule is more than one cell in thickness. and its outermost layer is highly cutinized forming epidermis.

- The sporogenous tissue differentiates into alternate transverse bands of sterile and fertile cells.
- Sterile cells ultimately form the pseudoelaters, while the fertile cells form spore tetrads by reduction divisions. With reduction and formation of spores, the gametophytic or haploid generation begins.
- The capsule is bi-valved with well developed sutures for dehiscence, in most cases the spores are liberated by the decay of the capsule wall.
- The spores are tetrahedral and dark-brown in colour.
- A spore, on germination and subsequent development, gives rise to a new gametophyte.



Sphagnum plant showing tuft of branches.

[Sphagnum]

Classification.

Division - Bryophyta
Class - Bryopsida
sub-class - Sphagnidae
Order - Sphagnales
Family - Sphagnaceae
Genus - Sphagnum.

External features of thallus :-

→ The plants are aquatic, growing about the margins of small lakes and ponds or growing on dripping rocky banks in the range from 3.7 to 4.9.
→ The size of the plant varies from a few inches to a maximum of 7 ~~the~~ inches.
→ The plant is erect, branched and differentiated into stem and the leaves. The colourless rhizoids are formed at the base but soon disappear. Hence, there are no rhizoids on mature gametophores.
→ At the apex of the gametophore there are a number of short branches densely crowded in a cluster called coma.
→ In the posterior part of the stem, the branches arise in tufts in the axil of every fourth leaf and in each tuft in axil.

→ These branches are of two types :- (i) diverging branches
(ii) drooping branches

→ The leaves lack a midrib an exception to mosses.

Anatomy of axis :-

→ The outermost layer is cortex, made of compactly arranged cells.
→ At maturity these cortical cells lack protoplast, become hyaline and dead.
→ The cells inner to cortex are prosenchymatous. These give mechanical support to the stem. The region is also known as hadrome.
→ The innermost region is known as medulla. The cells are colourless, parenchymatous and somewhat vertically elongated.

Leaf : external features :-

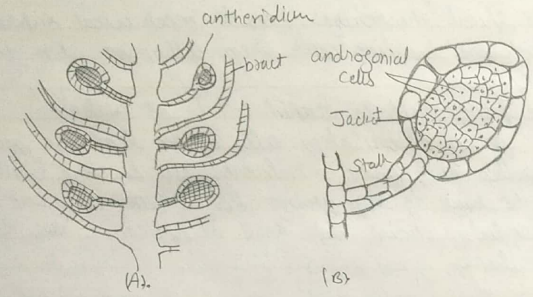
→ The mature leaf is sessile, entire, acute and one celled thick.
→ The leaf lack a midrib and the surface view shows two kind of cells (i) The narrow, chlorophyll containing assimilatory cells, and (ii) the large, dead, rhomboidal hyaline cells with spiral thickenings and pores.

→ The spiral thickenings provide mechanical support and keep the hyaline cells from collapsing when they are empty.
→ The pores help in rapid intake of water.
→ The green assimilatory cells of the leaf are joined together and form a network with sinuous walls.
→ At the base of very young leaf there are one or more glandular hairs but these disappear as the leaf matures.

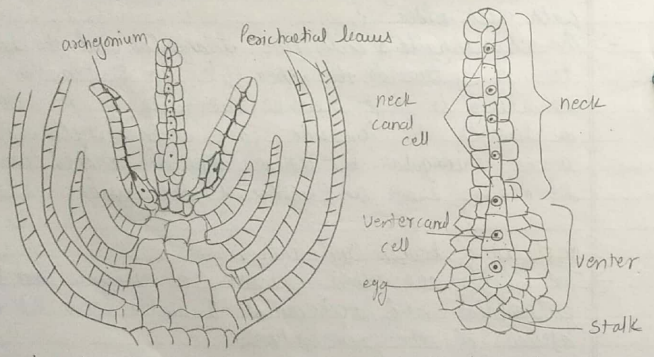
Leaf anatomy:-

→ In a cross section, the leaf appears like a beaded structure with hylaline and chlorophyllous cells alternating with each other.
→ The chlorophyllous cells are triangular and the base of triangle is towards the upper side. In S. tenellum the conditions is just reverse. the base of the triangle is towards the lowerside. The chlorophyllous cells are not triangular but appear spindle-shaped and are hemmed in, above and below, by the hyaline cells.

Antheridial branch and antheridium:-
→ The Plants are either monoecious or dioecious and both antheridial and archegonial branches occur at the apices of the gametophores.



Sphagnum : (A) Portion of antheridial branch to show position of antheridia (B) Single antheridium



L.S of archegonial branch. Single archegonium

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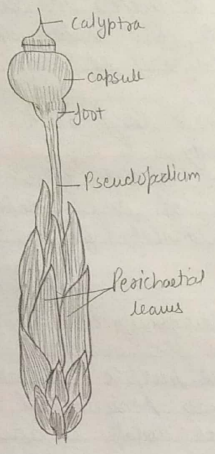
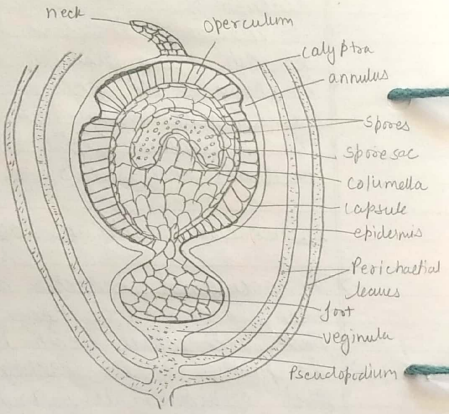
→ The catkin-like antheridial branches are either red, brown or yellow in colour with club-shaped appearance.
→ The antheridia present in the axil of leaf are arranged acropetally.
→ The mature antheridium has a long stalk, 2 cells in breadth and a globular body.
→ The body of the antheridium consists of single-layered jacket surrounding number of androgonial cells.
→ The androgonial cells ultimately form the biciliate antherozoids.

Archegonial branch and archegonium :-

→ The archegonial branches are purple coloured. These bear large leaves known as perichaetial leaves.
→ Each archegonial branch has usually 3 archegonia.
→ The position of the archegonium is acrogynous the first archegonium is formed by the apical cell and is known as the primary archegonium, whereas the other two archegonia are developed from the last two segments cut off by the apical cell and are known as secondary archegonia.
→ The structure of both types of archgonia is similar. A mature archegonium is a stalked structure with a broad venter and a long twisted neck.
→ The venter as well as lower portion of neck are 2-4 cells in thickness.



External feature of sporophyte



L.S sporophyte.

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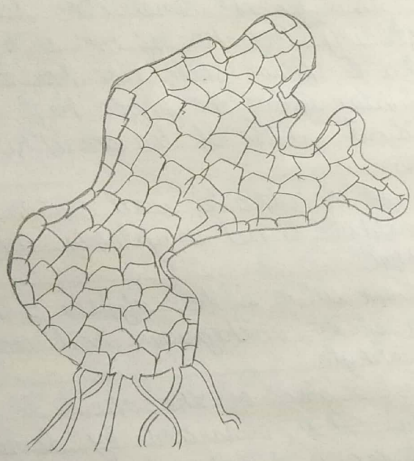
Sporophyte :

- It consists of a large bulbous foot and a nearly spherical, black coloured capsule. Seta is absent and occurs as a small constriction between foot and capsule.
- At maturity, the apex of the archegonial branch elongates to form stalk-like portion called pseudopodium.
- The calyptra covers the upper part of the mature capsule.
- Longitudinal section of the sporophyte shows following characters.
- All cells of the capsule wall contain chloroplasts, hence the sporophyte is not completely dependent on the gametophyte.
- Over the operculum is the calyptra which arises from the venter of the archegonium and completely covers the sporophyte.
- The central region of the capsule is occupied by the columellas. It is overarched by dome-shaped spore etc.
- The spore sac is filled only with spores, elaters being altogether absent. Each spore has an outer exine and inner intine.
- A mature saprophyte is situated at the top of an elongated archegonial branch, the pseudopodium.
- The apex of the pseudopodium is enlarged which together with the basal portion of calyptra is known as veginula.



Sphagnum: Thalloid lobed protonema.

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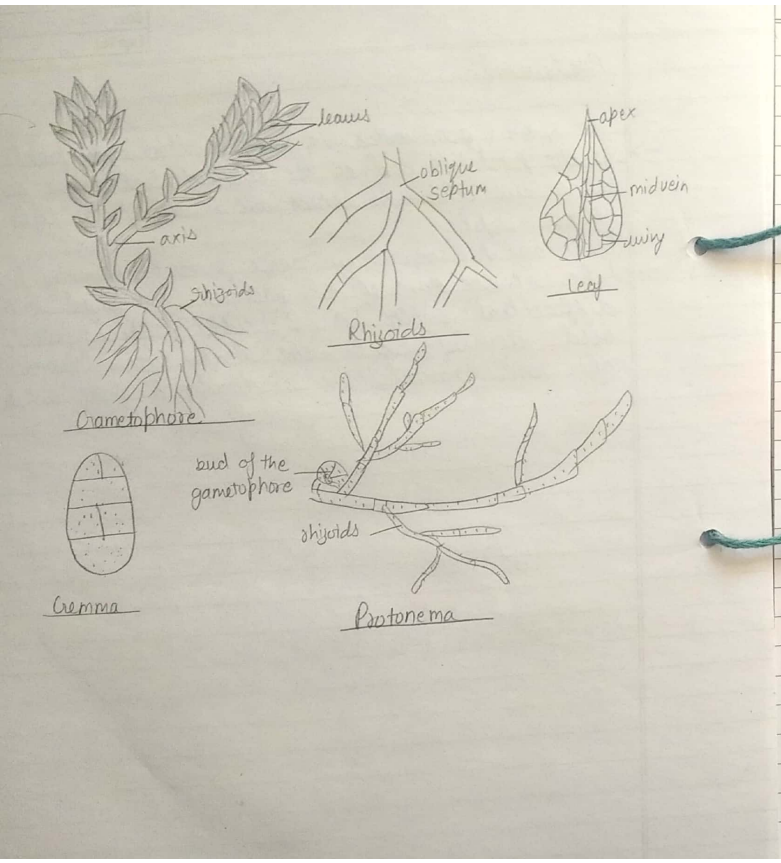
Protonema:-

-> The spore germinates, to form a thalloid protonema.
-> At the posterior end of the thalloid protonema are borne the rhizoids which are multicellular with oblique septa.
-> Secondary protonema may arise from the primary protonema.
-> Later, at the base of the protonema a singal bud is differential with a 3-sided apical cell. This bud develops into the leafy gametophore. Thus only one gametophore is developed from one protonema.

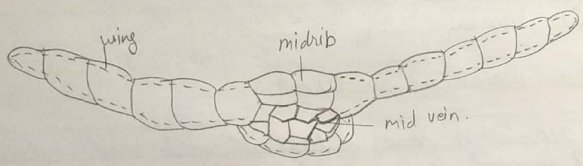


Funaria

Division - Bryophyta
Class - Bryopsida
Sub-class - Bryidae
Order - Funariales
Family - Funariaceae
Genus - Funaria.

External features of gametophyte:

-> The gametophyte shows a prostrate underground protonema and an erect leafy gametophore.
-> The gametophore that arises from protonema is differentiated into (i) rhizoids (ii) axis or stem (iii) leaves.
-> Many rhizoids are present at the base. These are slender, branched and multicellular. The septa are oblique.
-> The axis is erect and branched. It is 1-3 cms high. The branches arise below a leaf and are thus extra-axillary
-> The stem and branches are covered with small, simple, sessile and spirally arranged leaves with 3/8 Phyllotaxy
-> The leaves at the apex of the gametophore are crowded to form a bud-like head
-> Each leaf is nearly ovate in shape and bears a clear midrib except when young.
-> Sex organs are borne at the apices of the axis.



T.S leaf

Anatomy of the axis:

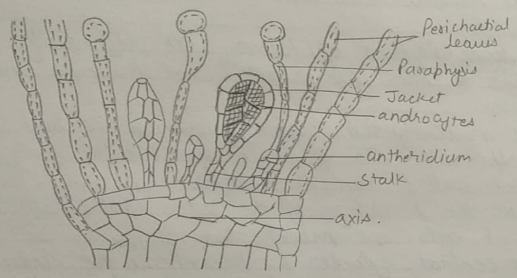
→ It is differentiated into (i) an epidermis, (ii) cortex (iii) central cylinder.
→ The single-layered epidermis, with tangentially elongated cells ~~is~~ has chloroplasts and bounds the underlying cortex.
→ The multilayered cortex surrounds central cylinder. Peripherals cells of the mature cortex are slightly thick walled than the rest.
→ Near the periphery of the cortex, small leaf traces with blind ends are present.
→ The central cylinder is present in the centre. The cylinder takes part in the conduction of water and food materials.

Anatomy of leaf:-

→ The leaf consists of a single layer of cells containing chloroplast except in the middle where it forms a distinct midrib.
→ The centre of the midrib is occupied by a small strand of narrow and slightly thick-walled cells.

Gemmae:-

→ These are vegetative reproductive structures.
→ Multicellular and green gemmae are produced on stem and leaves. on detachment, these germinate to give rise to new plants.
→ Gemmae, when grew on rhizoids, became brown in colour and



apex of male branch showing antheridia

are then known as bulbils.

→ Each gemma is composed of 8-12 cells. It is transversely and vertically septate.

Antheridial branch and antheridium :-

→ The sex organs are present at the apices of branches. These are enclosed by a group of leaves at the apex.

→ At the tip of stem is an antheridial branch or 'male flower'- a cluster of antheridia.

→ Intermingled with antheridia are multicellular capitate hairs, known as paraphyses.

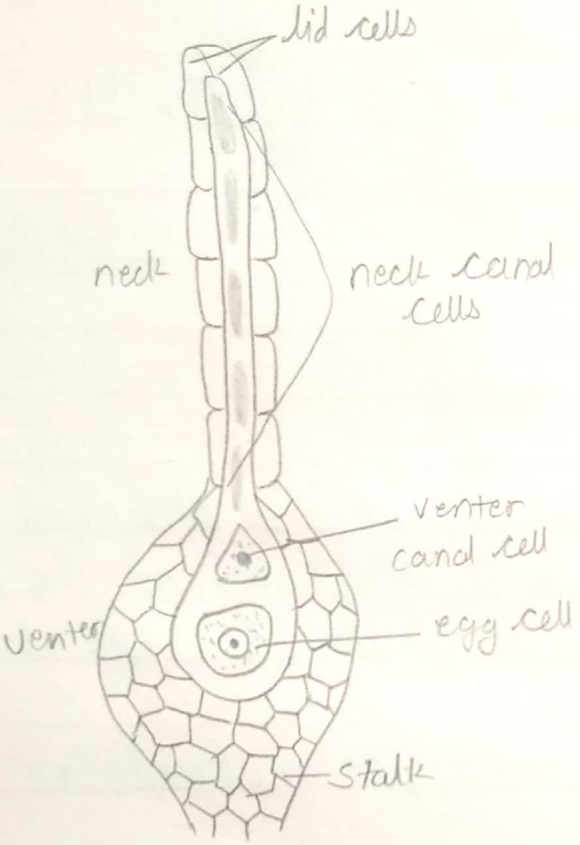
→ Both antheridia are paraphyses are surrounded by large leaves, known as perichaetial leaves.

→ In the antheridium consists of massive stalk and a club-shaped body.

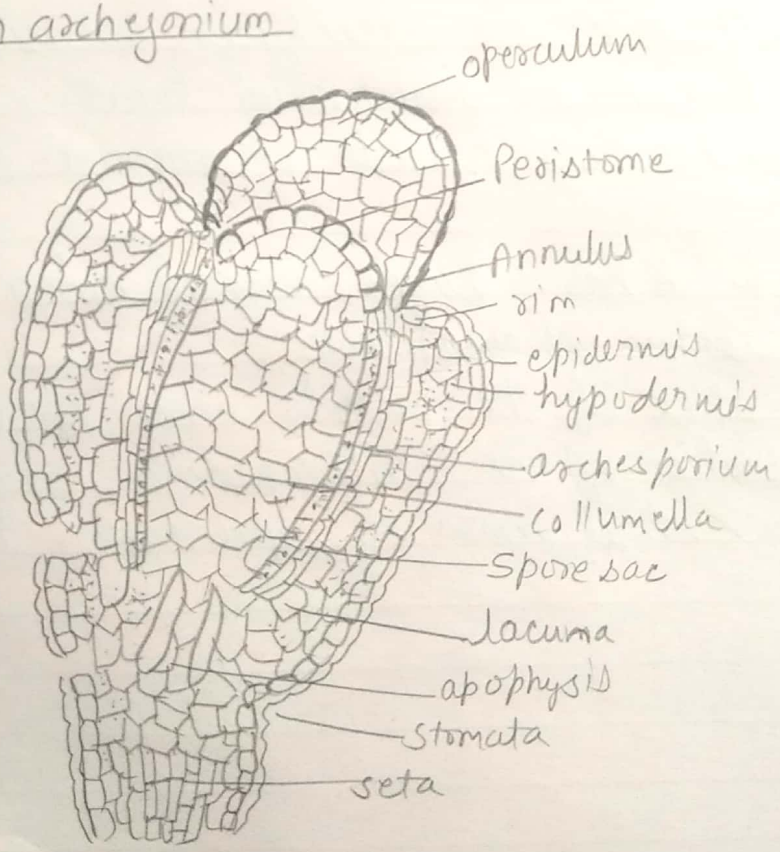
→ The body has a single layered outer jacket, the cells of which contain chloroplasts.

→ At the apex of the jackets is an operculum, which helps in liberation of an antherozoids.

→ A dense central mass of androcytes lies within the jackets.



An archegonium



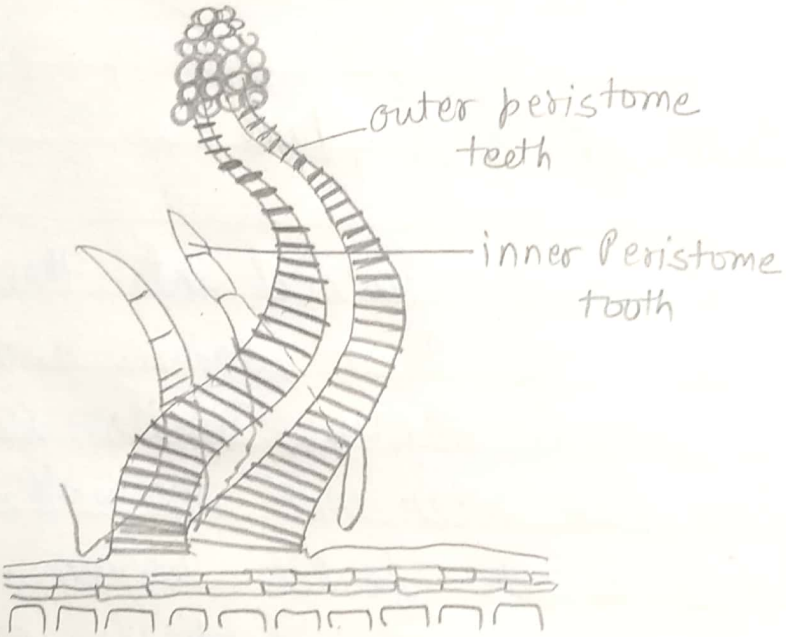
Capsule

Archegonial branch and archegonium :-

→ The sex organs are situated at the apices of branches inside the cluster of leaves.
→ The archegonia also arise in clusters at the apex of the archegonial branch.
→ Intermingled with archegonia are paraphyses.
→ The archegonia and paraphyses are surrounded by closely folding, unmodified leaves.
→ All the archegonia of this cluster are almost of the same age and developmental stage
→ The nearly mature archegonium is a multicellular, stalked structure, with a broad venter and narrow twisted neck.
→ The wall of the venter is double layered. The neck consists of six longitudinal rows of cells surrounding a central canal.
→ In the neck there are six or more neck canal cells and the venter has one venter canal cell and one egg cell.

External features of sporophyte :-

→ A gametophyte shows a sporophyte attached to it.
→ The sporophyte is developed at the apex of the archegonial branch.
→ A mature sporophyte shows three parts (i) foot, (ii) seta and (iii) capsule
→ Foot is poorly developed and is embedded in the apex of the archegonial branch.
→ Seta is long, slender and twisted. It bears a capsule at the top.



Peristome

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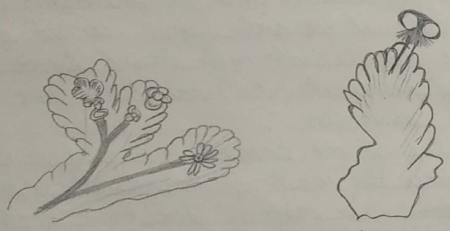
Peristome :-

→ The peristome consists of 2 rows of curved triangular plate-like teeth. Each row has 16 teeth.
→ Outer peristomial teeth are ornamented with thick transverse bands and are spirally twisted to the left.
→ Inner peristomial teeth are colourless, shorter and comparatively more delicate
→ The bases of inner peristome teeth are directly covered by the teeth of the outer peristome, but as they move away from the base, they curve, thus narrowing the slits between outer peristome teeth.
→ Hygroscopic movements in the outer peristome teeth assist in liberation of spores from capsule.



(A) (B)

Male & female gametophyte

(Plagiochasma)

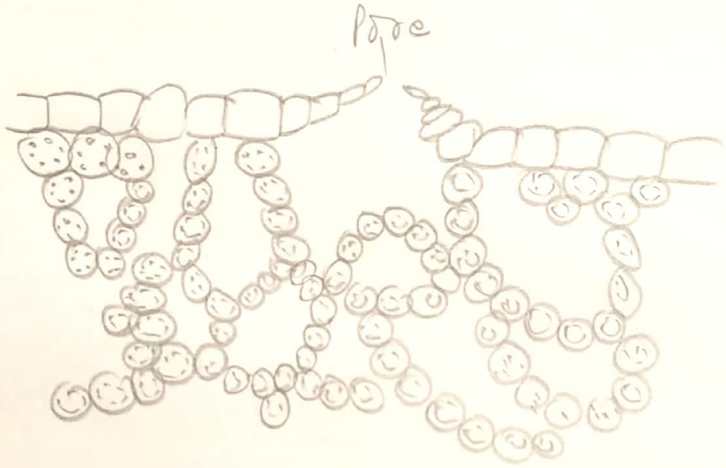
Kingdom - Plantae
Division - Marchantiophyta
Class - Marchantiopsida
Order - Marchantiales
Family - Aytoniaceae
Genus - Plagiochasma.

Vegetative Structure.

- Thallus is long, lobed, and flat, dorsiventraly differentiated, dichotomously branched and with undulated margins.
- Apex of thallus is notched.
- Dorsal surface is dark green.
- Ventral surface is purplish and bears scales and rhizoids.
- Midrib is inconspicuous and gradually passing into the lamina.

T.S of thallus.

- Upper epidermis with simple pores.
- Dorsal air chambers.
- Parenchymatous cell zone.
- Ventral layer with multicellular scales and rhizoids which are unicellular, smooth-walled and tuberculate.



Section through gametophytic thallus.

Reproductive structure.

- Plants are monoecious. Receptacles are always located at apex to begin with, becoming dorsal by the formation of apical adventitious shoots.
- Male receptacle is formed one after another, or a male receptacle may be followed by a female receptacle.
- Male receptacle is sessile, horse-shoe shaped and surrounded by linear scales.
- Air chambers with simple pores lies btw the antheridia.
- Female receptacle is also sessile when young, but at maturity stalked.
- The stalk arise from the dorsal side of the thallus, and is devoid of rhizoidal furrow, but has scales at base and apex.
- Female receptacle is more or less concave on the dorsal surface, with barrel shaped pores and is 2-9 lobed.
- It is surrounded by involucres which are large, inflated, bivalved and margin folded inwardly. Each involucre contains one archegonium.

Sporangium.

- with capsule, short seta and a foot capsule is spherical with single layered jacket.
- Spores are yellowish and reticulate-lamellate.
- Elaters are short and bi-or trispiral.

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PTERIDOPHYTA

Date :
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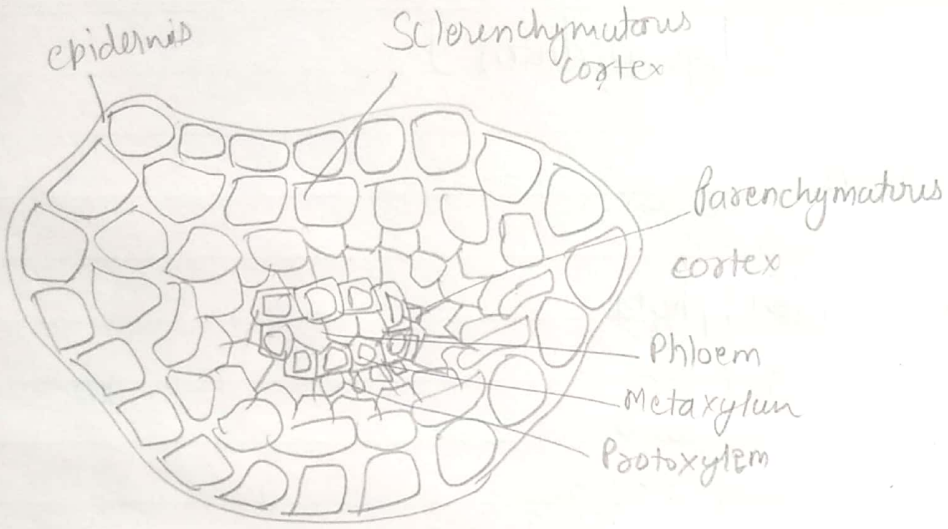
[Lycopodium]

Classification

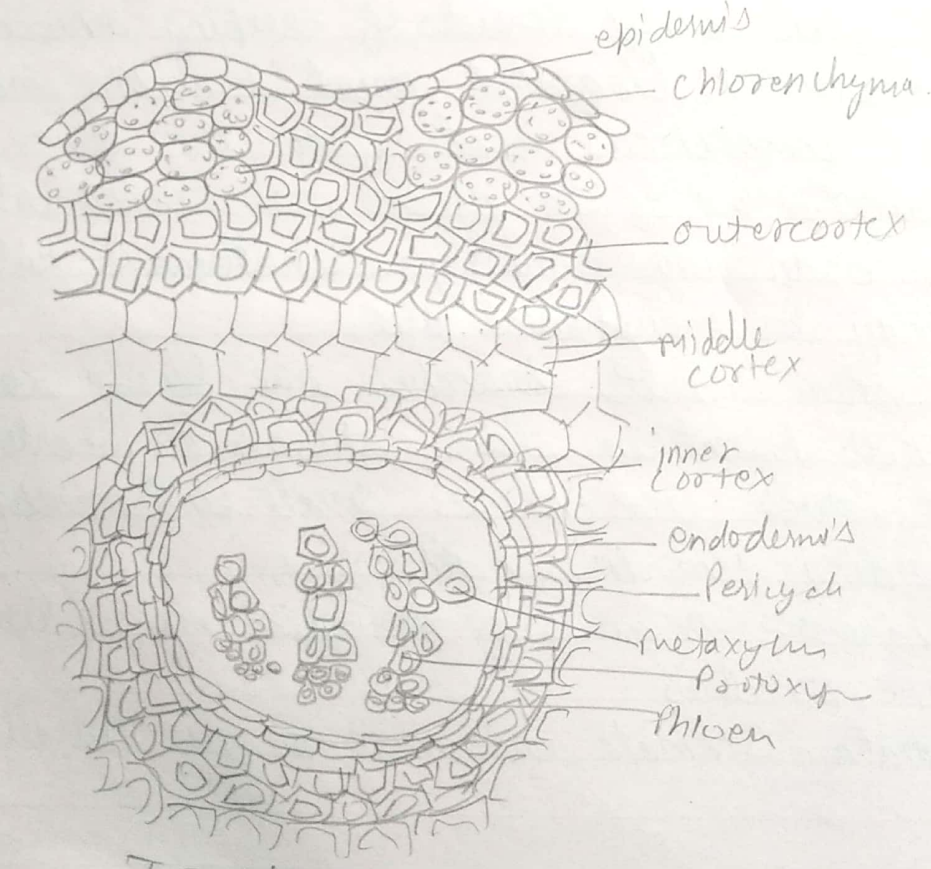
Division - Pteridophyta
Sub-division - Lycopsida
Order - Lycopodiales
Family - Lycopodiaceae
Genus - Lycopodium.

External morphology :-

→ The plant body consists of creeping rhizome which gives off slender, elongated aerial branches from the upper side and adventitious roots from the lower.
→ Habitat. Most of the species are terrestrial.
→ The branching is mostly dichotomous but in some species it may be monopodial also.
→ The stem and its branches are densely covered with small leaves present in close spirals or whorls.
→ The leaves are entire, small and membranous, rarely, exceeding 1cm in length.
→ Epidermis. The walls of the epidermal cells of the leaf are sinuous.
→ Stomata. Stomata are more or less parallel to the midrib



T.S root



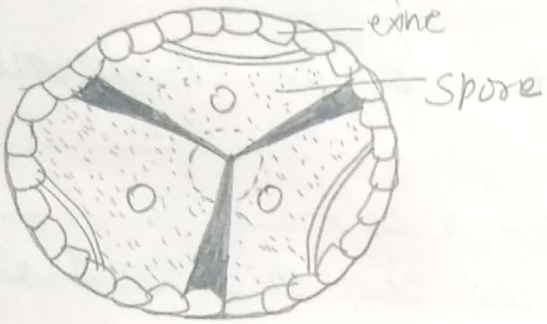
T.S stem.

Anatomy of root :-

→ The root is differentiated into an epidermis, cortex and the stele.
→ The epidermis is single layered.
→ The cortex is several layered and in older roots a few of the outer layers became sclerified.
→ The stele ranges from monarch to tetrarch but generally it is diarch with two protoxylem masses.
→ The phloem is present in between the arms of xylem.

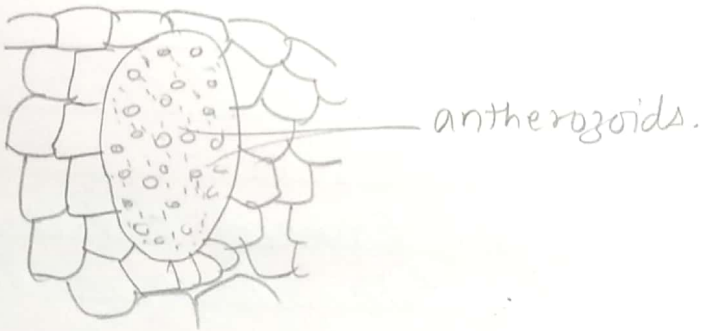
Anatomy of stem :-

→ Epidermis is single layered and is provided with stomata.
→ The stem has certain ridges and grooves chlorenchyma is present in the ridges.
→ Cortex. The structure varies from species to species.
→ Endodermis. It is single layered and lies inner to cortex.
→ Pericycle. The endodermis is follows this layer which is composed of 3 to 6 cells.
→ The xylem is exarch.
→ The tracheids in metaxylem are scalariform while in protoxylem they are spiral or annular.

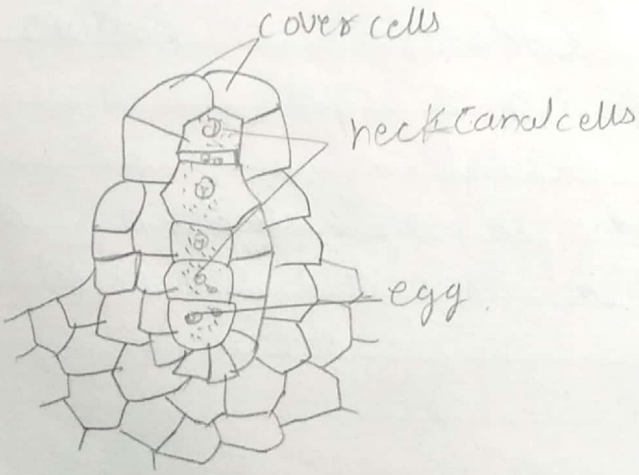


Spore tetrad

A spore



Mature antheridium



Mature archegonium

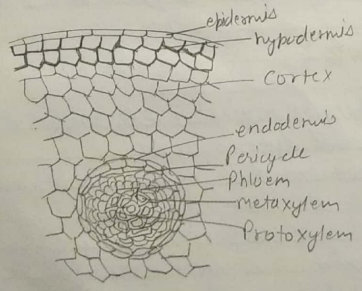
Spore producing organ :

-> External features of strobilus. Sporangia are the spore producing organs. These are grouped to form strobili which are situated at the apices of branches.
-> L.S of the strobilus shows a central strobilar axis with spirally arranged sporophylls.
-> Each sporophyll bears a sporangium near its base on the adaxial side
-> A sporangium is a black, kidney shaped structure, with a long or short massive stalk.
-> The wall of sporangium is several layered thick. Tapetum forms the innermost layer.
-> The cavity has many spores.
-> The spores germinate to form the prothallus.

Gametophyte :-

-> The gametophytes may be subterranean or sub-aerial.
-> The sub-aerial type is green.
-> The subterranean type is non-green and is bigger as compared to the sub-aerial type.
-> The prothallus is monoecious and the sex organ.
-> The antheridium is spherical with a single layer of jacket containing within, a number of antherozoids or antheraid mother cells.

External features



T.S rhizophore

Date :
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[Selaginella]

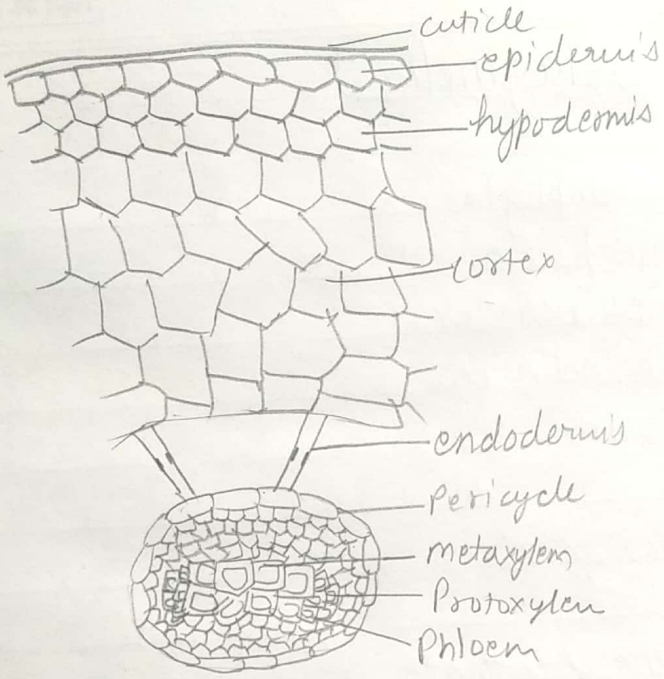
Division - Pteridophyta
Sub-division - lycopsida
Order - Selaginellales
Family - Selaginellaceae
Genus - Selaginella.

External features of the plant :-

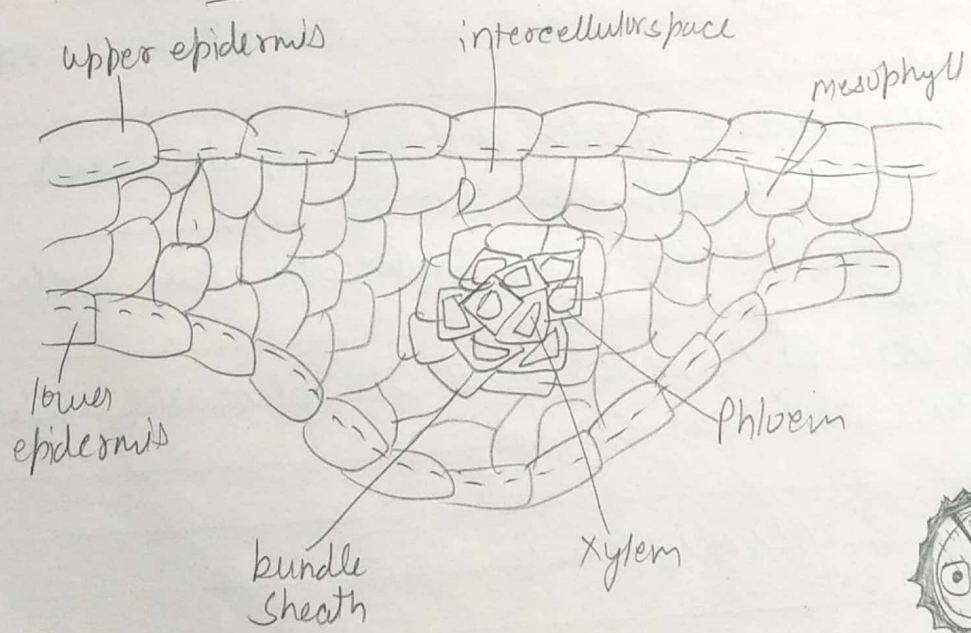
-> Many species are prostrate, creeping on the ground.
-> The plant body is divided into root, stem and leaves.
-> The primary root is short lived and all other roots are adventitious.
-> On the basis of nature of stem and form of the leaves, the genus is sub-divided into two sub-genera.
-> The body of the ligule has parenchymatous cells with dense protoplasm.
-> Certain vertical branches from the stem are reproductive in nature and bear strobili.

Anatomy of rhizophore :-

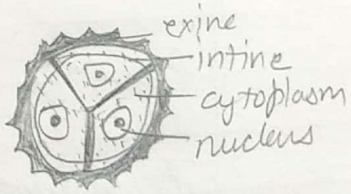
-> The outline of the section is almost circular.
-> The section shows epidermis, hypodermis, cortex, endodermis and stele.
-> The epidermis is cuticularised.



T.S stem



T.S leaf



Microspore tetrad

Anatomy of the Stem :-

→ The outline of the section appears slightly wavy.
→ The section shows epidermis, cortex and the stele.
→ Epidermis is the outermost layer. It is cuticularised and lack stomata.
→ The stele is generally a protostele.
→ The protoxylem masses of the two steles point in opposite.

Anatomy of leaf :-

→ The section shows a slightly bulged midrib in the centre and the wings.
→ It shows definite upper and lower epidermis, usually undifferentiated mesophyll and a central vascular bundle.
→ The vascular bundle is concentric with xylem surrounded by phloem and is bounded by a bundle sheath.
→ The mesophyll is usually not differentiated into palisad.

Spore producing organs :-

→ The spore producing organs are sporangia, aggregated in strobili which are generally present at the apices.
→ L.S. of the strobilus shows a strobilar axis, around which sporophylls are spirally arranged.
→ The sporangia are of two types, borne in the axils of the sporophylls, attached either strictly to the axils or to the axis

Date :
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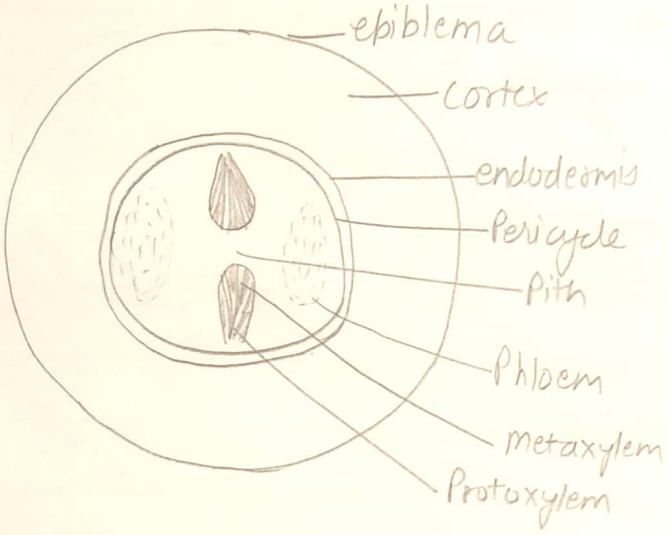
GYMNOSPERMS

[Cycas]

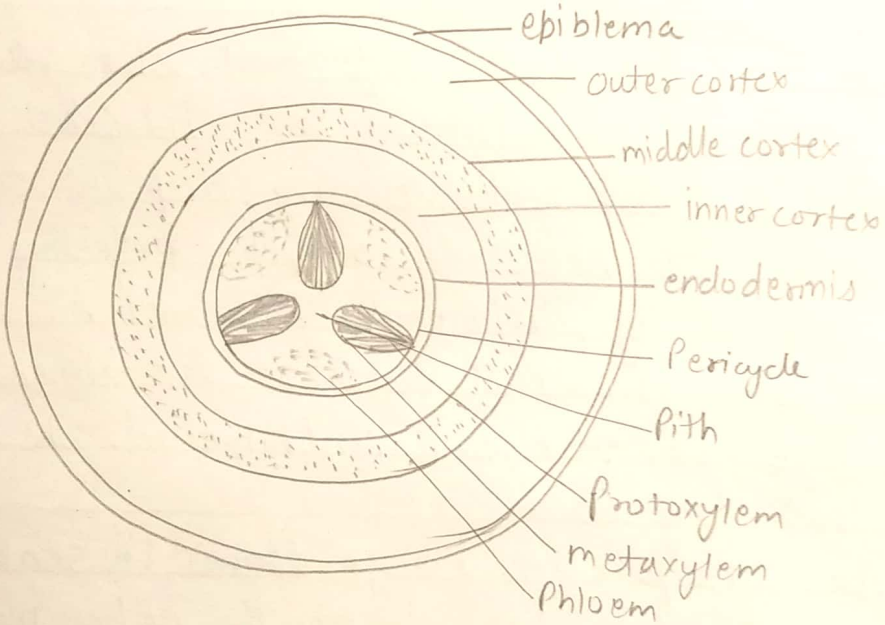
Division - Gymnosperm
Class - Cycadopsida
Order - Cycadales
Family - Cycadaceae
Genus - Cycas.

[External features]

- Plant body is differentiated into root, stem and leaves.
- Roots are of two types (i). Primary root (ii) Coralloid root.
- Primary root is a tap root, growing deep into soil.
- Coralloid roots are negatively geotropic projecting above the soil surface, repeatedly dichotomously branched.
- The young stem is almost tuberous but when grows old, it becomes thick, columnar and unbranched. The trunk is covered by persistant leaf bases.
- Leaves are dimorphic (i). foliage leaves (ii) scale leaves.
- Cycas is dioecious bears terminally, either male cone or female reproductive structures.
- The sporophylls are smaller than the foliage leaves. They are brown or light brown in colour and are densly covered with woody hairs.



normal root.



Coralloid root.

[Young tap root]

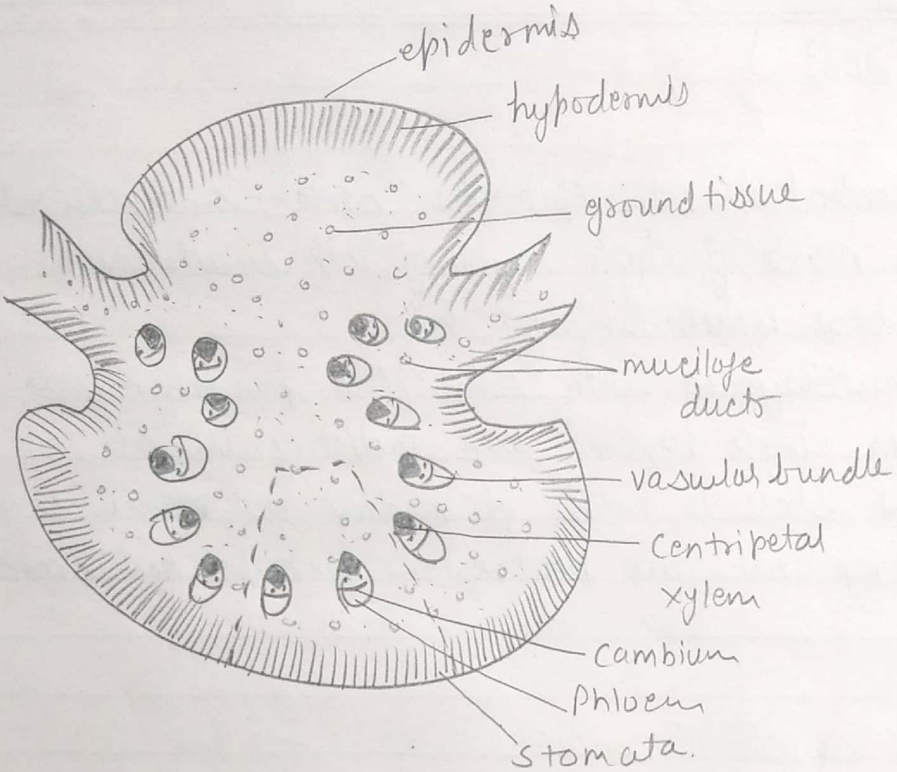
- It is differentiated into epiblema, cortex and centrally located stele.
- Epiblema is made of single layer of thin walled cells. Some of these cells bear unicellular root hairs.
- Cortex is multilayered with starch filled parenchymatous cells.
- Endodermis is single layered and indistinguishable.
- The central stele is made of radial and exarch vascular bundles. There are two protoxylem groups and condition is diarch.

Anatomy of coralloid root :-

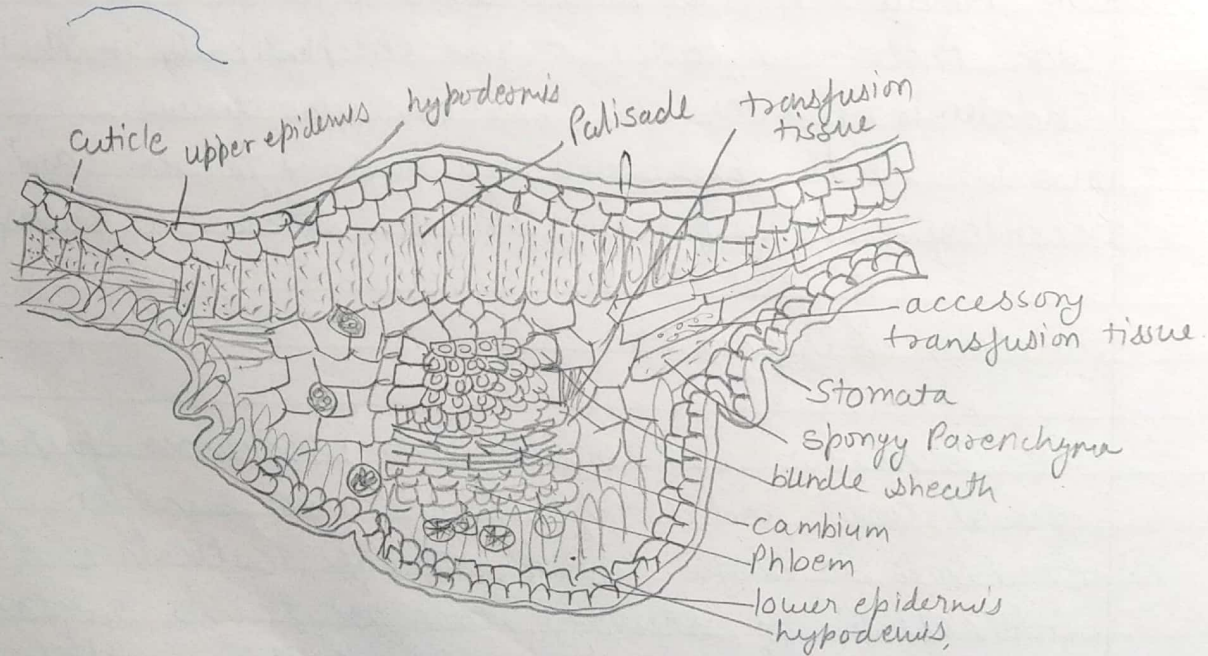
- Epiblema is outermost and single layered.
- Cortex is divisible into three regions - outer, middle and inner.
- The middle cortex is also called algal zone. A blue green alga Anabaena cycadae occurs endophytically in these cells.
- Endodermis separates cortex and vascular tissues.
- Vascular bundles are radial and xylem is triarch and exarch.
- Secondary growth is generally absent, if present it is very less.

Anatomy of rachis :-

→ The rachis is differentiated into epidermis, hypodermis, ground tissue and a ring of vascular bundles.
→ Epidermis is single layered, thickly cuticularized and is interrupted by stomata throughout its surface.
→ Hypodermis is mainly composed of thick-walled cells.



rachis



T.S of leaflet.

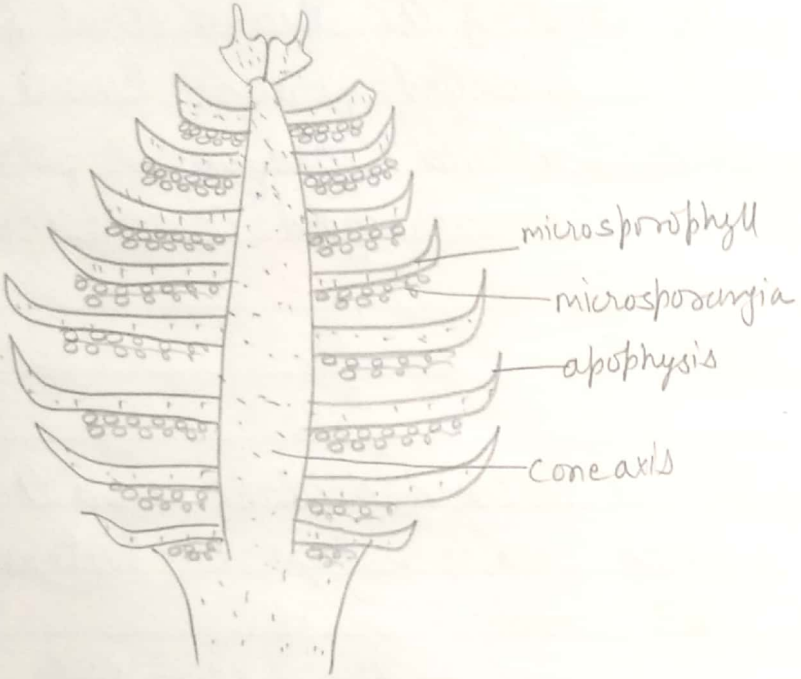
→ Ground tissue → The rest of the tissue that forms most part of the section is called ground tissue.
→ Mucilage ducts are scattered throughout the ground tissue
→ The vascular bundles are arranged in an inverted omega (Ω).

Anatomy of leaflet :-

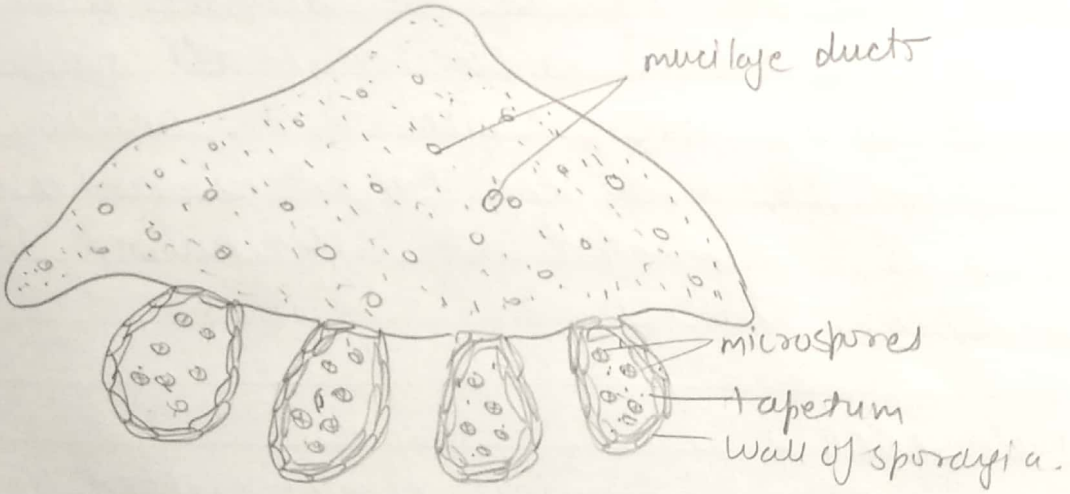
→ The leaflet shows a distinct midrib and the wings.
→ The midrib is swollen, while wings on lateral sides are narrower and flattened.
→ Upper epidermis is present on the upper side. It is thickly cuticularized and single-layered.
→ Stomata are very much sunken in the lower epidermis.
→ Lower epidermis bounds the leaflet from lower side.
→ The vascular bundle is similar in all respects to that found in the upper region of the rachis.
→ Mesophyll lies below the hypodermis and is well developed It is differentiated into upper palisade layers and lower of spongy parenchyma

Male cone :-

→ The male cone is terminal, shortly stalked, compact, large and oval or conical in shape and consist of a central cone axis around which numerous microsporophylls are spirally arranged.
→ The cone itself consists of a central cone axis with many microsporophylls.



male cone



Microsporophyll

Each microsporophyll is attached to the cone axis. The part of microsporophylls away from the axis is upcurved and is called apophysis

→ The upper surface of the microsporophyll is sterile.

→ The lower surface of the microsporophyll is fertile and bears many microsporangia in groups.

→ Microsporophylls in the middle part of the cone are largest and get gradually smaller towards the base and the apex.

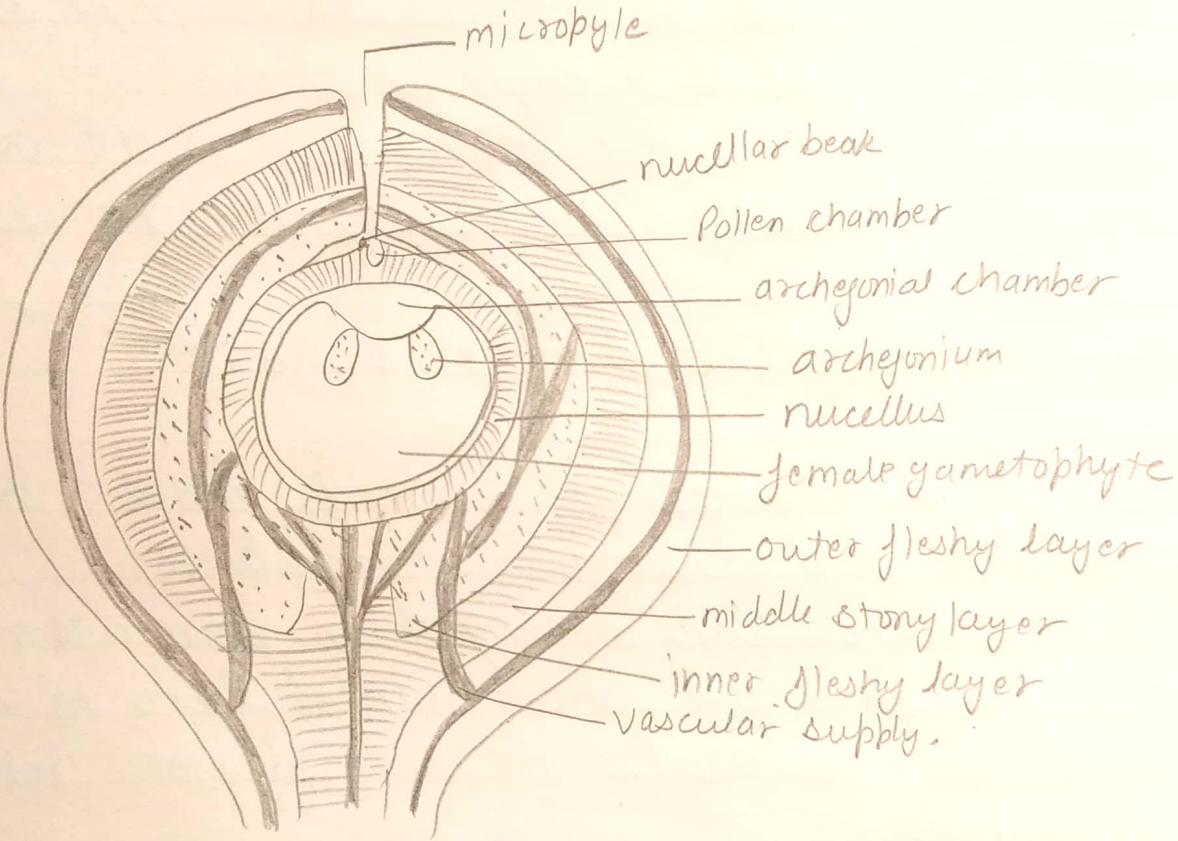
Microsporophyll and microsporgia :-

→ A single microsporophyll is woody, more or less horizontally flattened and triangular structure.

→ Microsporangia are arranged in sori around central papilla. Sporangia show radial lines of dehiscene. Many hairs are distributed on this surface mixed with sporangia.

→ A mature microsporangium has three layered wall. The outermost layer is thick and cutinized, termed as exothecium. The remaining inner layers are thin and are collectively known as endothecium and enclose a tapetum.

→ Numerous microspores remain enclosed inside the wall of the microsporangium.



Ovule

Megasporophyll :-

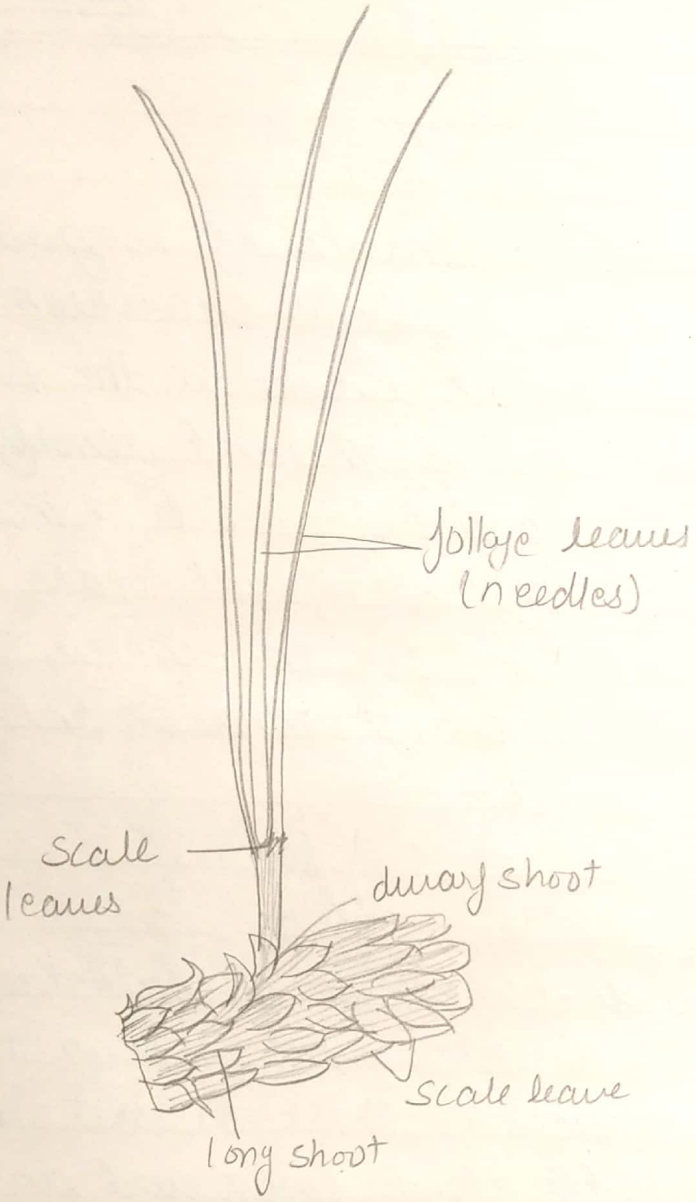
→ Female reproductive body consists of megasporophyll arranged spirally and arising in acropetal succession on the stem.
→ They have their persistent bases on the stem.
→ Each megasporophyll is leaf-like and densely covered with brown hair. It varies in size from 6 to 12 inches.
→ The middle portion of sporophyll bears ovules which are borne in two rows, one on eighter side.
→ Ovules are generally yellow or orange or dark green coloured shortly, oval and smooth.

Mature ovule :-

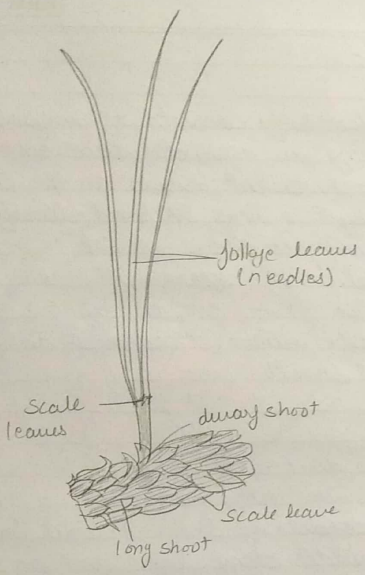
→ The section shows that the ovule is orthotropous.
→ It is unitegmic. The integument is very thick.
→ The integument consists of three distinct layers an outer fleshy layer, middle stony layer and an inner fleshy layer
→ The nucleus lies just below the integument and forms a nucellar beak in the region of the micropyle
→ Archegonial chamber. Just above the archegonia is the archegonial chamber.

L.S of seed :-

→ It shows seed coat, nucellus, embryo and the female gametophyte
→ Nucellus is papery and is situated inside the seed coat
→ Endosperm and female gametophyte form the inner part of seed



A part of stem showing two type of branches.



A part of stem showing two type of branches.

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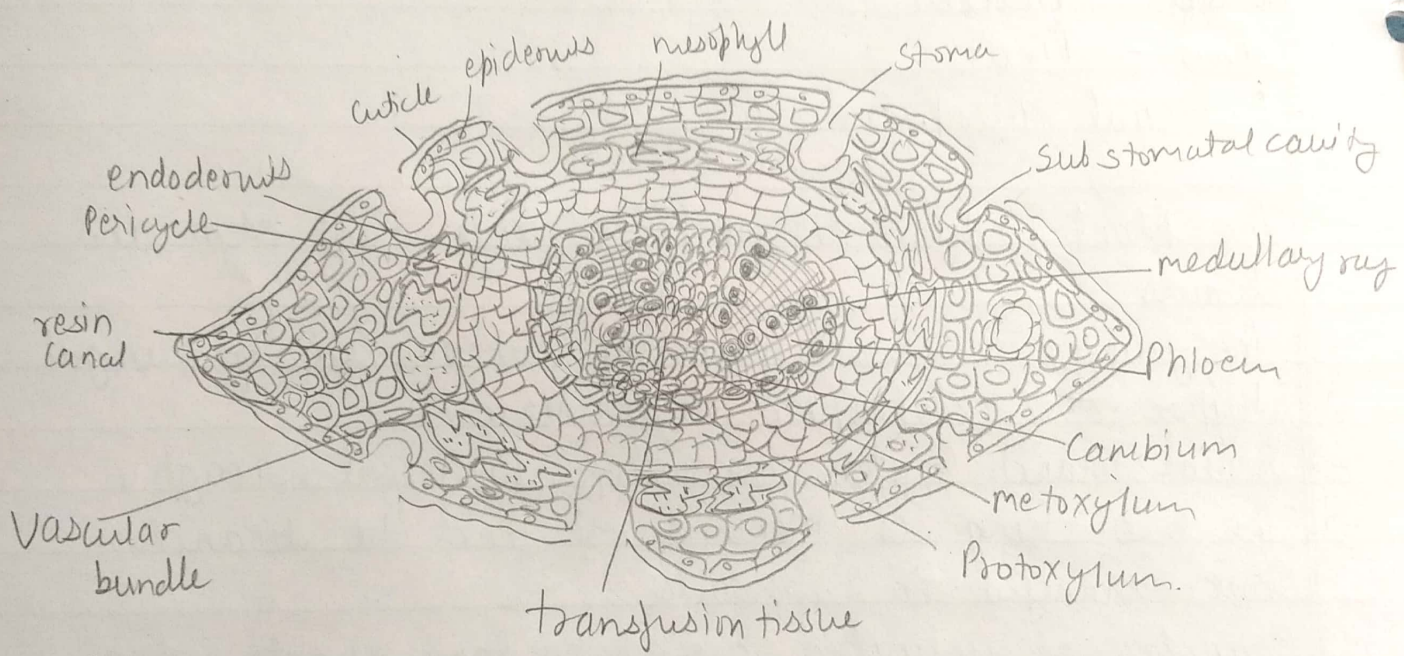
(Pinus)

Division - Gymnosperms
Class - Coniferopsida
Order - Coniferales
Family - Pinaceae
Genus - Pinus

External morphology :-

-> The plant body is differentiated into root, stem and leaves.
-> The younger roots are generally surrounded by fungal hyphae - the ectotrophic mycorrhizae.
-> Aerial branch system consist of cylindrical, rough.
-> The branching is monopodial and the branches are arranged in whorls.
-> Branches of unlimited growth or long shoots are present on the main trunk.
-> The leaves are also dimorphic scale leaves and foliage leaves.
-> Scale leaves are brown, membranous and small.
-> Foliage leaves are green, acicular and needle like. They are born only by the dwarf shoots.
-> The male cones are borne on lateral branches of unlimited growth.
-> The female cones are borne terminally on branches of unlimited growth.



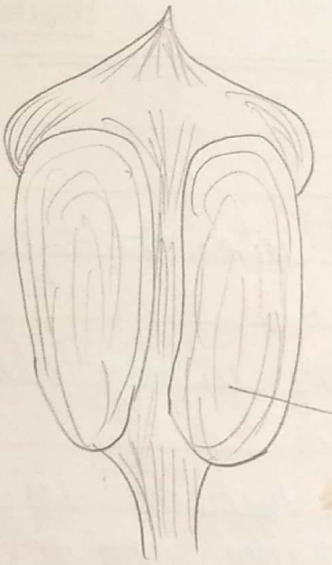
T.S of needle

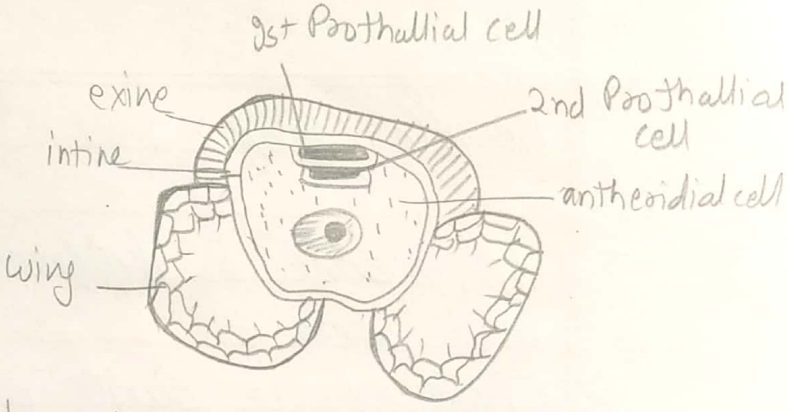
needle (leaf) :-

→ The needle is differentiated into epidermis, mesophyll and stele.
→ Epidermis is single with tangentially elongated and thickly cuticularized cells.
→ Epidermis is followed by hypodermis. It is few layered thick at the corners and 1-2 layered in other parts.
→ Resin canals generally occur in the sclerotic hypodermis but also occur in the mesophyll tissue.
→ Endodermis is conspicuous. Cells are barrel-shaped and tangentially thickened.
→ Generally two vascular bundles remain surrounded by this tissue.
→ The vascular bundles are seperated from one another by a T-shaped thick walked transfusion tissue.
→ Each vascular bundles is conjoint, collateral and open. Protoxylem faces adaxial side. Phloem is located on the abaxial side

Male cone, microsporophylls and microsporangia :-

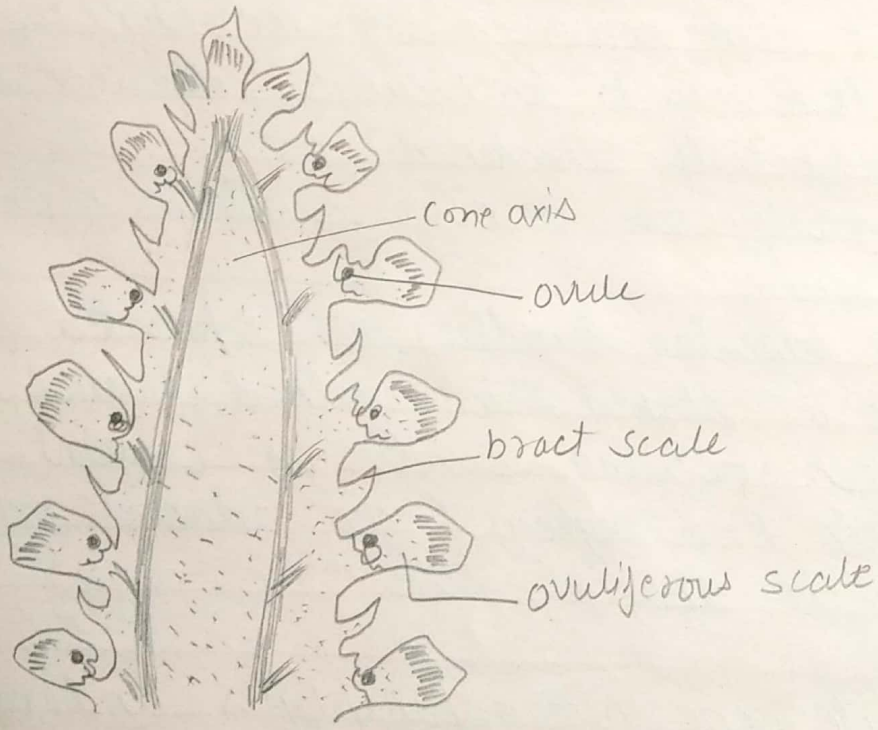
→ Male cones are grouped in clusters on the shoots of the same year only.
→ Each male cone has single centrally located cone axis around which many scaly microsporophylls are arranged.





Old microspores

A microsporophyll with two microsporangia.

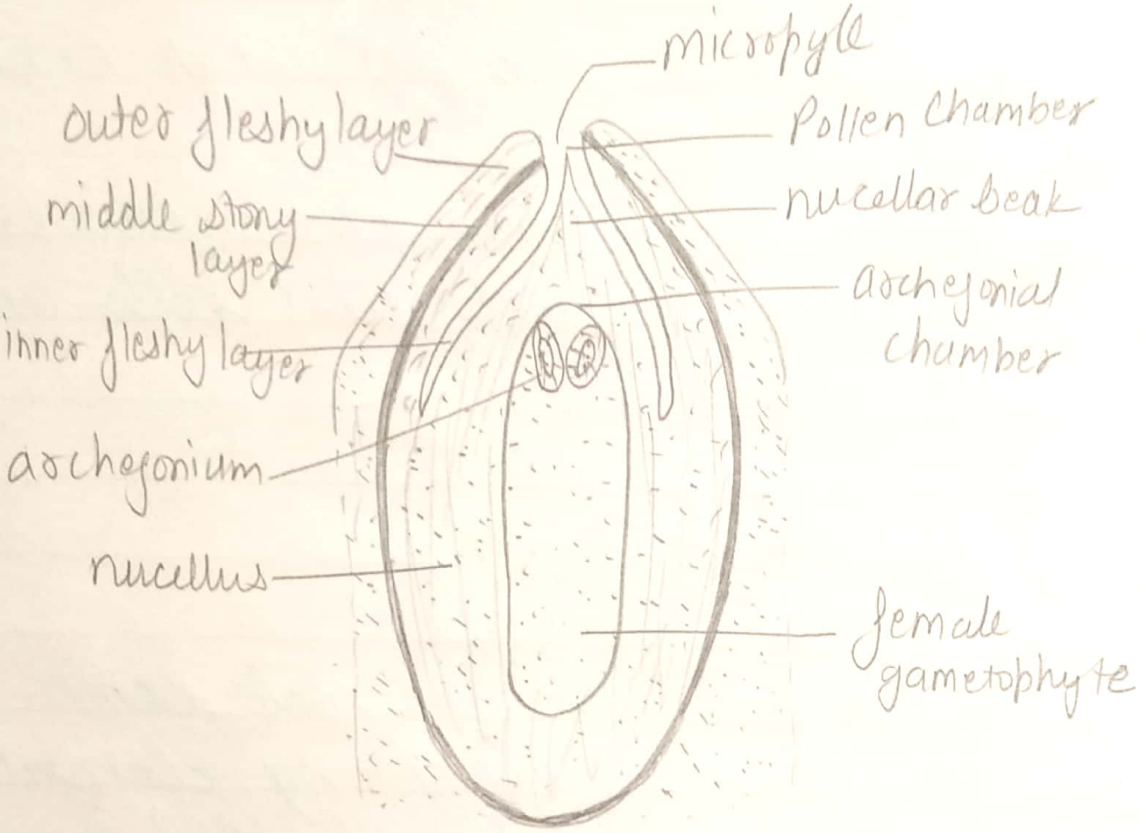


female cone.

→ Each microsporangium has its own wall which encloses many microspores.
→ A mature microspore or pollen grain shows two cell layers - exine and intine, 2 prothallial cells and an antheridial cell.

Morphology of the female cone :-

→ Female cones are larger than the male cones. They are borne at the apices of the young elongated shoots, replacing the shoot of unlimited growth.
→ Single shoot may bear one to four female cones which are reddish-green in colour and mature in three years.
→ In the first year, cones are compact and sporophylls are closely arranged.
→ The second year cones are large in size and woody in nature but sporophylls are still compactly arranged.
→ In the third year, cone becomes loose. Sporophylls separate from one another due to elongation of the cone axis.
→ Each female cone consists of many sporophylls, arranged spirally around the cone axis.
→ Female cone is made of centrally located cone axis and spirally arranged sporophylls.
→ Each sporophyll consists of two kinds of paired scales : (i) bract scale or cone scale
(ii) ovuliferous scale or seminiferous scale.



L.S of ovule

Seed

→ At the base of this expanded, triangular part, two naked and sessile ovules are present.
→ The terminal part of the ovuliferous scale is broad and sterile and is known as apophysis.

Ovule :-

→ Ovule is elongated in shape.
→ It is unitegmic and the integument is three layered. The outermost layer is thin.
→ Nucellus is fused with inner layer of the integument, except at its tip where it forms an elongated and slender.
→ Female gametophyte is differentiated from nucellus. About 2-5 archegonia are situated in this region at the micropylar end near the base of chamber.

Seed :-

→ Fertilized ovules get transformed into seeds which are situated on the adaxial side of the ovuliferous scale at its base near the cone axis.
→ Seeds are small, elongated and winged. The wing is a thin layer of tissue which splits off from the adaxial face of the ovuliferous scale.
→ The seed is covered with red and brown testa.
→ The nucleus is present as a thin layer and forms a nucellar cap at the micropylar end
→ Inner fleshy layer of the integument still persists. It is membranous, thin and papery, termed as tegmen

Plant showing shrubby habit