A MANUAL OF PRACTICAL BOTANY

I BSc.

SECOND SEMESTER

PAPER II

DIVERSITY OF NON- VASCULAR PLANTS MYCOLOGY, PLANT PATHOLOGY, BRYOPHYTES AND PLANT ANATOMY

2019-2020

DEPARTMENT OF BOTANY

BGS Science Academy & Research Centre

Agalagurki, Chikkaballapura

Affiliated to Bangalore North University

Laboratory Instructions

- Do not forget to carry laboratory apron, observation book and other required accessories.
- Handle equipments, microslides, glasswares, chemicals and specimen bottles with proper care.
- Report breakages / damages to the batch incharge or laboratory assistants.
- Keep the laboratory clean and tidy.

PRACTICAL PAPER II

DIVERSITY OF NON- VASCULAR PLANTS MYCOLOGY, PLANT PATHOLOGY, BRYOPHYTES AND PLANT ANATOMY

TOTAL UNITS: 13

1. Identification and classification of fungi members included in theory : **3 units**
   - *Albugo*
   - *Peziza*
   - *Puccinia*
   - *Cercospora*
2. Demonstration of mushroom cultivation, Study of Lichens, Study of Mycorrhiza. **2 units**
3. Study of plant diseases included in theory: **2 units**
   - Koleroga of Arecanut
   - Smut Disease of *Sorghum*
   - Red rot of Sugarcane
   - Coffee Rust
   - Blast Disease of Rice
4. Study of forms of Bryophytes included in the theory: **3 units**
   - *Marchantia*
   - *Anthoceros*
   - *Funaria*
5. Normal and Anomalous secondary growth in stem eg. *Tridax*, *Dracaena* stem and *Boerhaavia* stem. **2 units**
6. Field visit to study pathogen and host interaction **1 unit**
7. Report of Field visit / Project report on mushroom cultivation / Applications of Bio fertilizers/ Mycorrhizal staining. **1 unit**

PRACTICAL QUESTION PAPER II

DIVERSITY OF NON- VASCULAR PLANTS MYCOLOGY, PLANT PATHOLOGY, BRYOPHYTES AND PLANT ANATOMY

Time: 3 hours **Max marks: 35**

1. Identify the specimens **A, B and C** with labelled diagrams and reasons. **3 X 3 = 9 marks**
2. Prepare a temporary safranin stained T.S of the material **D**. Sketch, label and identify with reasons, leave the preparation for evaluation. **4 marks**
3. Write critical notes on **E.** **2 marks**
4. Identify slides **F, G, H and I** with labelled diagrams and reasons. **4 X 3 = 12 marks**
5. Record and submission**.** **5 + 3 = 8 marks**

SCHEME OF VALUATION

1. Two specimens from fungi and one from Bryophyta (**A, B** and **C**- Identification - **1** mark, Labelled diagram with reasons - **2** marks).
2. Any one of the following may be given – stem of *Tridax*, *Dracaena* or *Boerhaavia* (**D**- Staining and Mounting - **2** marks, sketch and labelling - **1** mark, Identification with reasons- **1** mark).
3. One diseased plant / lichens/ mycorrhiza (**E** - Identification **1** mark, Critical points- **1** mark).
4. Two from bryophytes, one from fungi and one from anatomy (**F, G, H** and **I**- Identification and Classification- **2** marks, Labelled diagram with reasons - **2** marks).
5. Class records and Submission of 3 herbarium sheets from Plant Pathology. **5+3** marks.

CONTENTS

MYCOLOGY (Fungi)

Albugo (Cystopus)

Division: Mycota
Class: Phycomycetes
Order: Peronosporales
Family: Albuginaceae
Genus: *Albugo* (derived from a Latin word means white)

INTRODUCTION: Albugo is the only genus of family Albuginaceae is represented by more than 25 species. In India about 18 species of Albugo have been reported. All species are obligate parasites on Brassicaceae members like cabbage, cauliflower mustard, radish etc. *Albugo* causes a disease called 'White Rust'. Some of the common species are *Albugo candida (Syn. Cystopus candidus), A. portulacæ, A. tragopogon.*

The preliminary symptoms of the disease are seen on leaves in the form of white shining pustules. On rupture of epidermis, white powdery mass is seen on the underside of the leaf. The leaves become fleshy and thickened. The flowers and stems, when infected, show enormous hypertrophy (abnormal enlargement of host tissue) or deformed.

VEGETATIVE STRUCTURE:

- Mycelium is intercellular, aseptate, coenocytic.
- It is freely branched and provided with knob- shaped haustoria.
- Haustoria penetrate the host cells and absorb food material

REPRODUCTION:

ASEXUAL REPRODUCTION:

- It takes place by means of conidia.
- The hyphal mass beneath the epidermis produces vertical groups of conidiophores.
- Two conidia are joined with each other by a gelatinous pad known as disjunctor.
- Each conidia is multinucleate, hyaline, smooth and spherical.
- As a result of production of large number of conidia a pressure is exerted on the epidermis, which ruptures releasing them outside.
- Conidia are disseminated by wind and germinate directly to form zoospores.
- The reniform biflagellate zoospores also germinate to form the new mycelia.

SEXUAL REPRODUCTION:

- Sexual reproduction is oogamous. Sex Organs like antheridia and oogonia are produced at the tips of hyphae.
- Oogonium is uninucleate, spherical with a central ooplasm and peripheral periplasm.

- Antheridia are multinucleate club shaped structures. A mature antheridium develops a slender fertilization tube which grows through the oogonial wall into the ooplasm.
- A single male nucleus enters and fuses with the nucleus of oogonium thus effecting fertilization and results to form zygote or oospore.
- The oospore develops a thick, ornamented and three layered wall.
- The nucleus divides meiotically producing 40 to 60 biflagellate zoospores which germinate into a new mycelium.

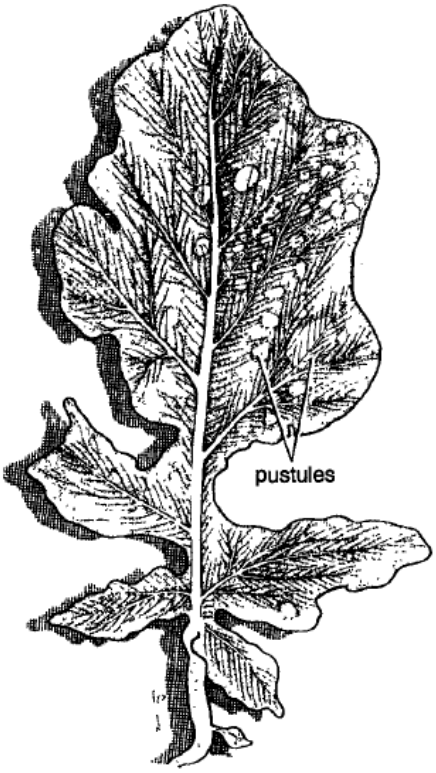
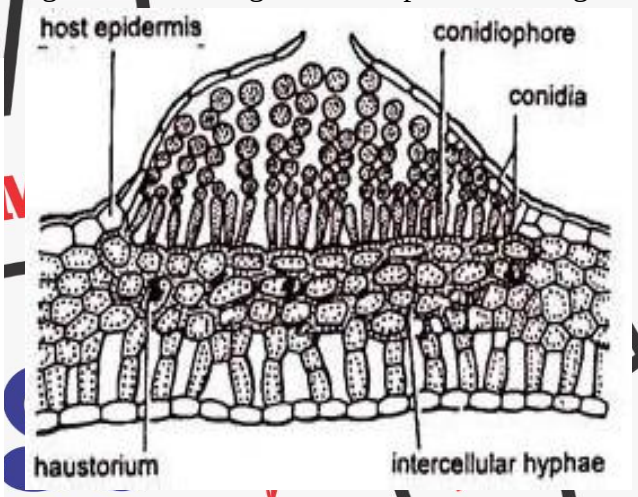
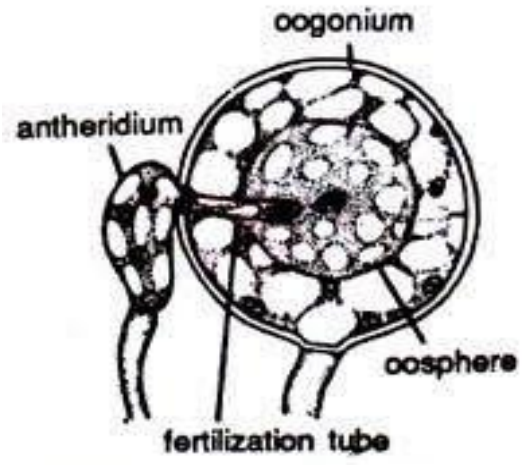


Fig. 1. ***Cystopus.*** Infected leaf of radish (*Raphanus sativus*) showing white pustules.



T/S OF INFECTED LEAF SHOWING CONIDIOPHORES AND CONIDIA



SEX ORGANS IN *Albugo*

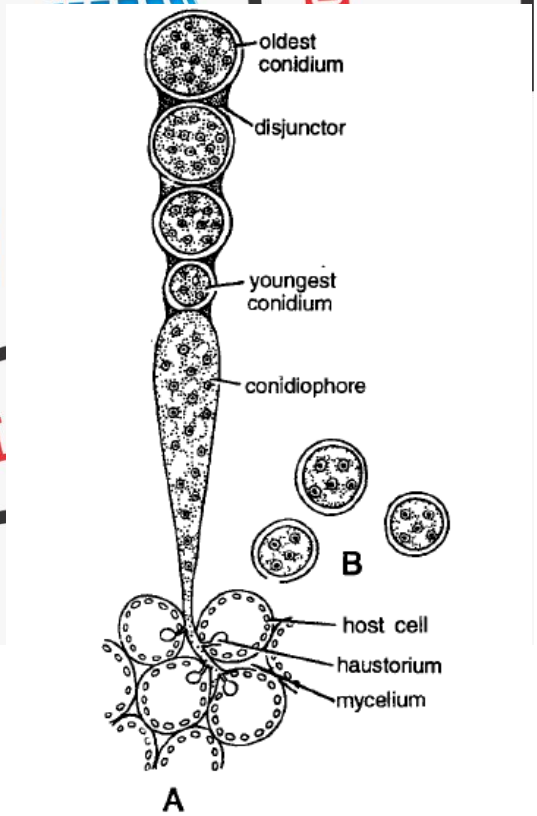


Fig. 6. ***Cystopus.*** **A.** Single conidiophore showing conidia in chain **B.** Conidia.

Peziza (Cup Fungus)

Class: Ascomycetes
Order: Pezizales
Family: Pezizaceae
Genus: *Peziza*

INTRODUCTION:

Peziza genus includes about 160 species, of these 13 species have been recorded from India. Some common species found are *Peziza pustulata*, *P. catinus*, *P. vesiculosa.* It is a common saprophyte growing on rich humus soils and decaying woods. Sometimes it becomes coprophilous (grows on cow dung).

VEGETATIVE STRUCTURE:

- The mycelium consists of profusely branched, septate hyphae and the cells are multi nucleate.
- The vegetative hyphae give rise to dikaryotic ascogenous hyphae from which the fruiting body called apothecium develops.
- Apothecium is a cup like structure and it is fleshy short stalked and dull white in colour.

ASEXUAL REPRODUCTION:

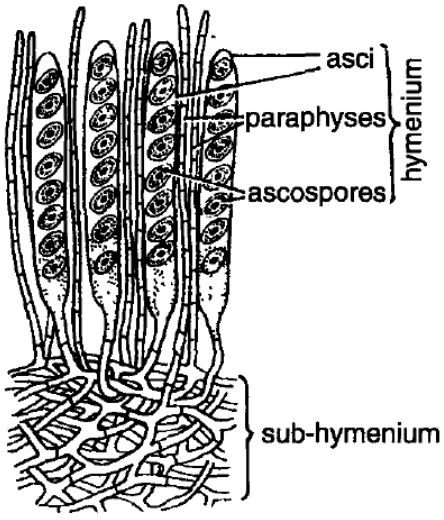
- The conidia are the asexual reproductive structures, produced rarely.
- Conidia are hyaline, lightly colored and elliptical.
- In some species, thick walled and intercalary chlamydospores are produced singly or in series on mycelium.
- Chlamydospores on germination produce the new mycelium.

STRUCTURE OF APOTHECIUM:

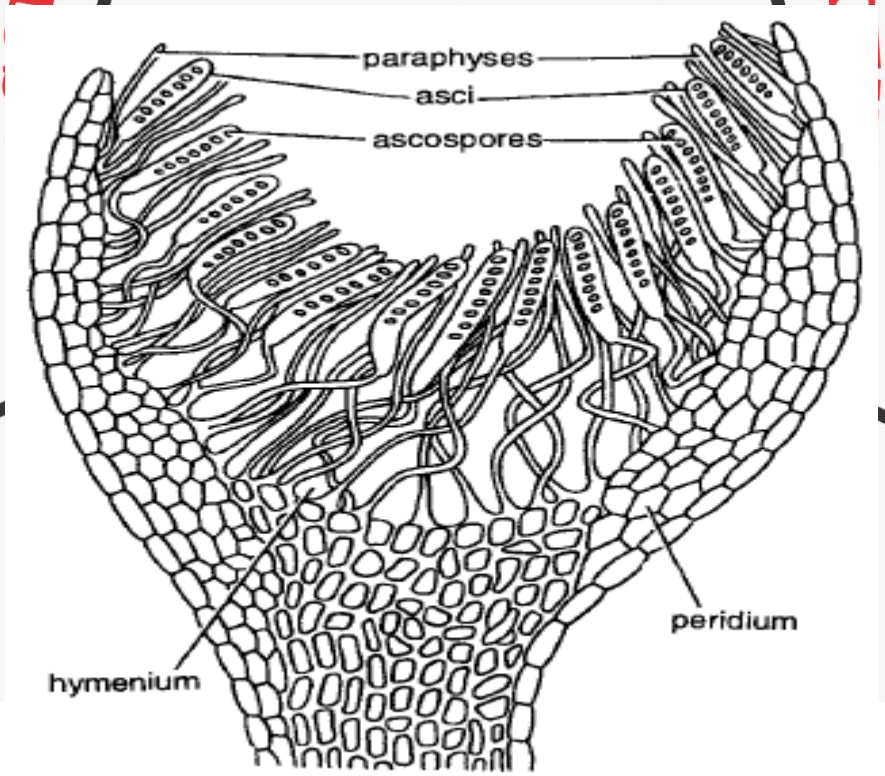
- The ascocarp is an apothecium. It is fleshy and shortly stalked.
- A vertical section of ascocarp shows a cup shaped structure made up of mycelium. It shows 3 regions – hymenium, hypothecium and peridium.
- Hymenium consists of asci (fertile structures) and paraphyses (sterile hair like bodies) arranged vertically in palisade- like layer.
- Sub hymenium/ Hypothecium consists of thin and lightly coloured hyphae that run parallel to hymenium.
- Excipulum/ Peridium forms a basal large part of loosely interwoven hyphae of apothecium.
- Hymenium is encircled by densely interwoven hyphae forming the wall of the apothecium – the peridium.
- Ascus is elongated with a single row of eight ascospores, arranged obliquely.

- Each ascospore is uninucleate, hyaline, elliptical, surface smooth and ellipsoidal. It germinates to form new mycelium.

A: HABIT OF *Peziza*



B: A PORTION OF HYMENIUM ENLARGED



V/ S OF APOTHECIUM

Puccinia

Class: Basidiomycetes
Order: Uredinales
Family: Puccinaceae
Genus: *Puccinia*

INTRODUCTION: Genus *Puccinia* includes about 700 species. Species of *Puccinia* are called Rusts, as the infected portion gives the appearance of a rusted iron. All the species of *Puccinia* are obligate parasites on some of the important cereals of family Graminae (wheat, maize and oat), on millets such as bajra and jowar and on other plants like *Berberis vulgaris* and *Thalictrum* etc. Well known species are *Puccinia graminis var tritici*, *P. recondite*, *P. stiformis*. In heteroceous rusts, uredo and teleuto stages are found on primary host while pycnidial and aecidial stages are found on alternate host.

VEGETATIVE STRUCTURE:

- The mycelium is well developed, branched and septate. It is generally intercellular and sometimes shows globular haustoria also.
- The mycelium is called as monokaryotic when it has only one nucleus in each cell and dikaryotic, when it has two nuclei of different strains in each cell.
- It shows following stages on primary and alternate secondary hosts in its life cycle.

STAGES ON HOSTS:

1. UREDOSORUS STAGE: (RED RUST STAGE)

- It is the first stage found on the primary host wheat, produced from dikaryotic mycelium. The symptoms are observed as red pustules on the leaves and stem.
- The uredosorus in section reveals the ruptured host epidermis due to the pressure of underlying uredospores.
- The (dikaryotic) intercellular, septate and branched mycelium is aggregated beneath the epidermis. The uredospores arise in aggregates at the tips of secondary mycelia.
- Each uredospore is unicellular, binucleate, stalked and rounded or oblong in shape.
- It has an outer exine which is finely echinulate (red pigmented) and an inner smooth intine.
- The uredospores get disseminated by wind and may infect the fresh wheat plant, hence they are called repeating spores.

2. TELEUTOSORUS STAGE: (BLACK RUST STAGE)

- It is the second stage found on the primary host, wheat. The appearance of dark brown patches on the leaf sheath and stem is the characteristic symptom.

- A teleutosorus in a section reveals the (dikaryotic) intercellular, branched mycelium, a bunch of teleutospores and the ruptured host epidermis.
- 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, each cell is dikaryotic.
- The teleutospore has a very thick but smooth exine and delicate thin intine. The exine turns black at maturity.
- The teleutospores are incapable of infecting the primary host (wheat plant). They germinate to form the basidiospores which infect the barberry plant, the alternate host.

3. BASIDIOSPORE STAGE:

- It is the third stage in the life cycle of *Puccinia.* One or both the cells of the teleutospore germinate independently and give rise to four haploid basidiospores in the soil.
- They do not infect the wheat plant they need alternate secondary host like Barberry to continue its life cycle.
- Each haploid basidiospore germinates on barberry leaf by producing mycelium through the epidermal layer and infect the mesophyll region. Later it produces many pycnia cups on the dorsal surface.

THE PYCNIDIAL AND AECIDIAL CUPS ARE FORMED ONLY ON ALTERNATE HOSTS.

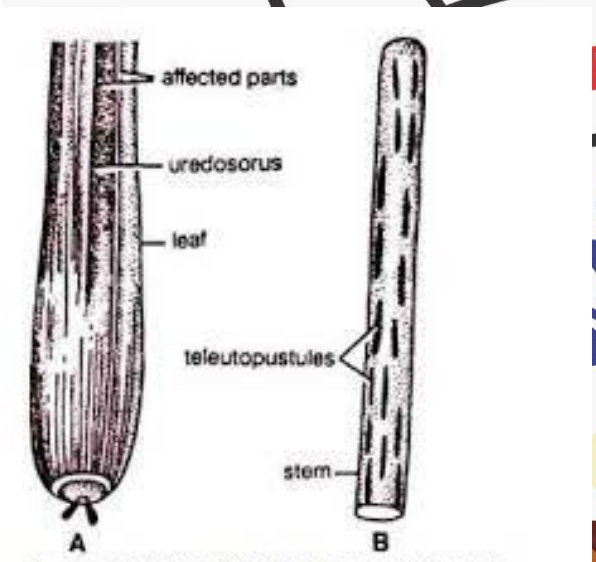
4. PYCNIDIAL STAGE: (SPERMAGONIA)

- It is the fourth stage in the life cycle produced from the basidiospores.
- Each basidiospore germinates on the leaf of alternate host producing the (monokaryotic) mycelium (either of '+' strain or of '-' strain produced corresponding from a '+' or '-' basidiospore) that ultimately forms the pycnidial cup.
- The pycnidial cups are generally present on the upper surface of the leaf. A mature pycnidium is flask shaped with a pore at its apex, known as ostiole.
- The hyphae near the ostiole are unbranched and project out through the ostiole. These are called the paraphyses.
- The cavity of the pycnidium is lined by many elongated and uninucleate fertile hyphae called pycnidiophores.
- The pycnidiophores are arranged in a palisade like layer and each cuts off their ends to give a chain of uninucleate cells called pycnidiospores or spermatia.
- The pycnidiospores on being discharged through the ostiole help in producing the dikaryotic mycelium.

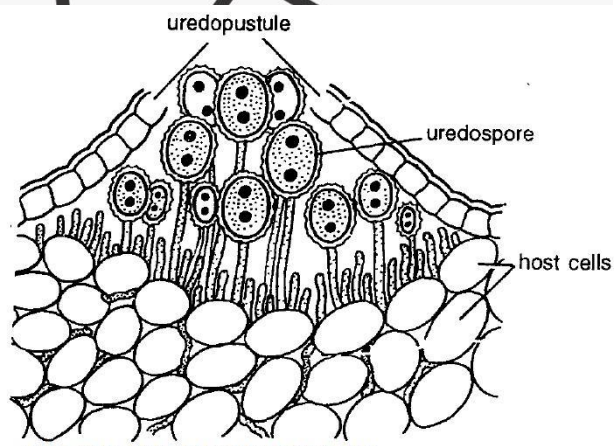
5. AECIDIAL STAGE:

- It is the fifth stage in the life cycle produced from the dikaryotic mycelium.
- It is characterized by yellow circular spots on lower surface of barberry leaf.
- Each aecidium is a cup like structure with an outer protective layer called peridium.
- The developing aecidium elongates and pushes through the host epidermis.

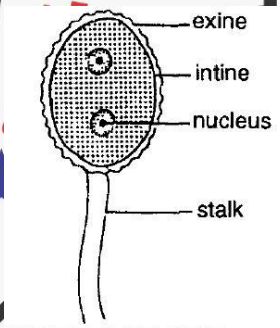
- At the base of the aecidium there are many elongated cells known as sporophores, arranged in a palisade like manner.
- Each sporophore cuts off alternately a small and a large cell. The small cell is the disjunctor whereas the large cell is the aecidiospore.
- Each aecidiospore is a binucleate structure with a thick and smooth wall.
- The aecidiospores are blown away by wind and infect wheat plant and produce dikaryotic mycelium on the wheat plant (primary host). They are not capable of reinfecting the barberry.



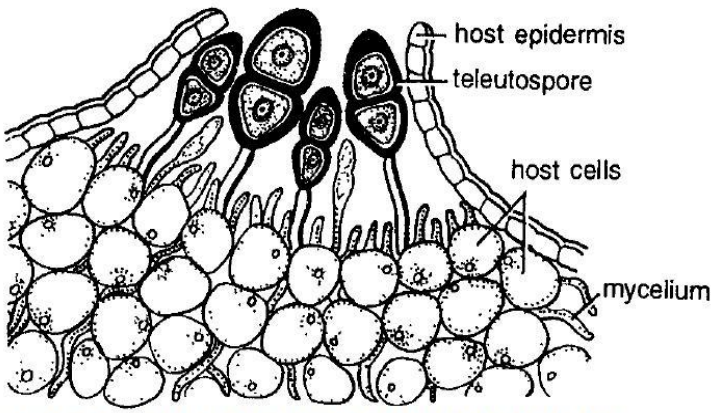
A: INFECTED WHEAT SHOWING UREDOSORI
B: SHOOTS SHOWING TELEUTOSORI



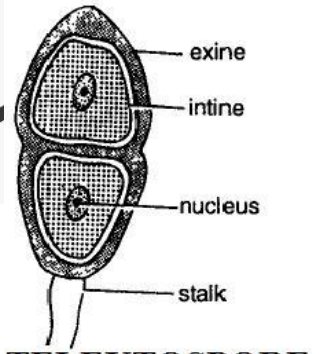
T/S OF INFECTED PART SHOWING UREDOSORUS STAGE



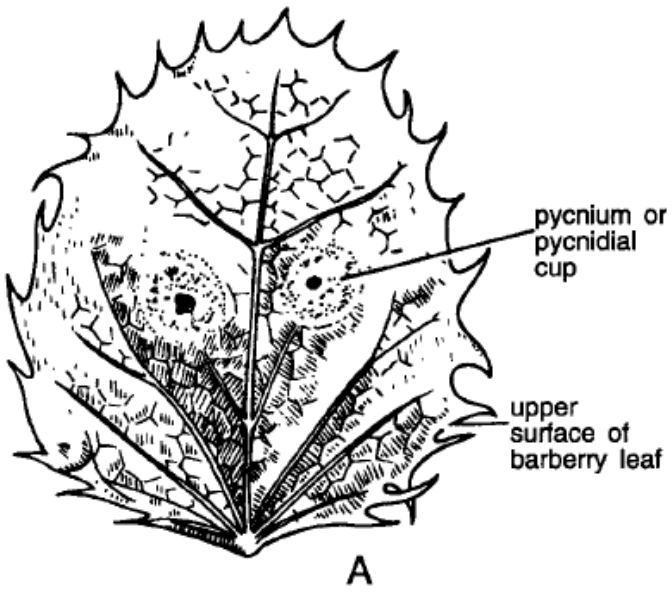
UREDOSPORE



T/S OF INFECTED PART SHOWING TELEUTOSORUS STAGE



TELEUTOSPORE



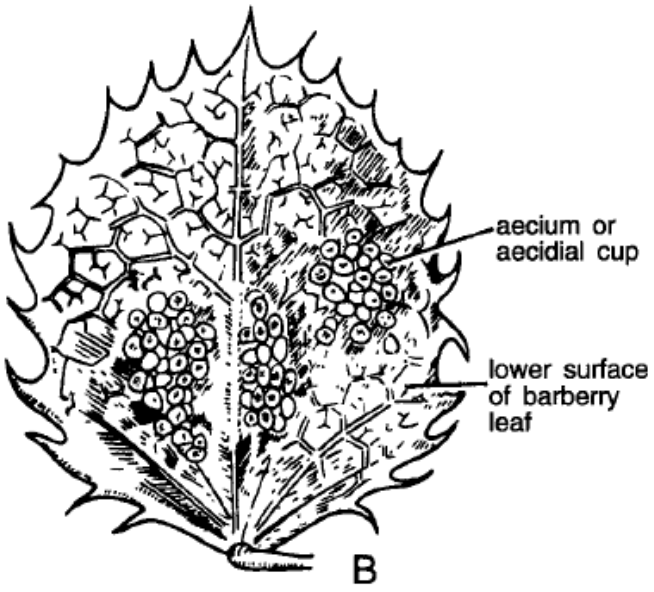
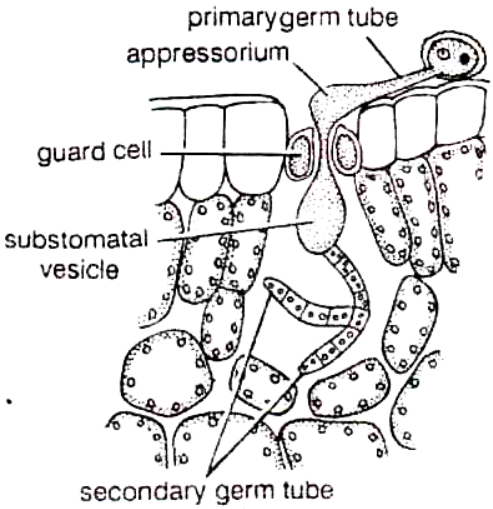
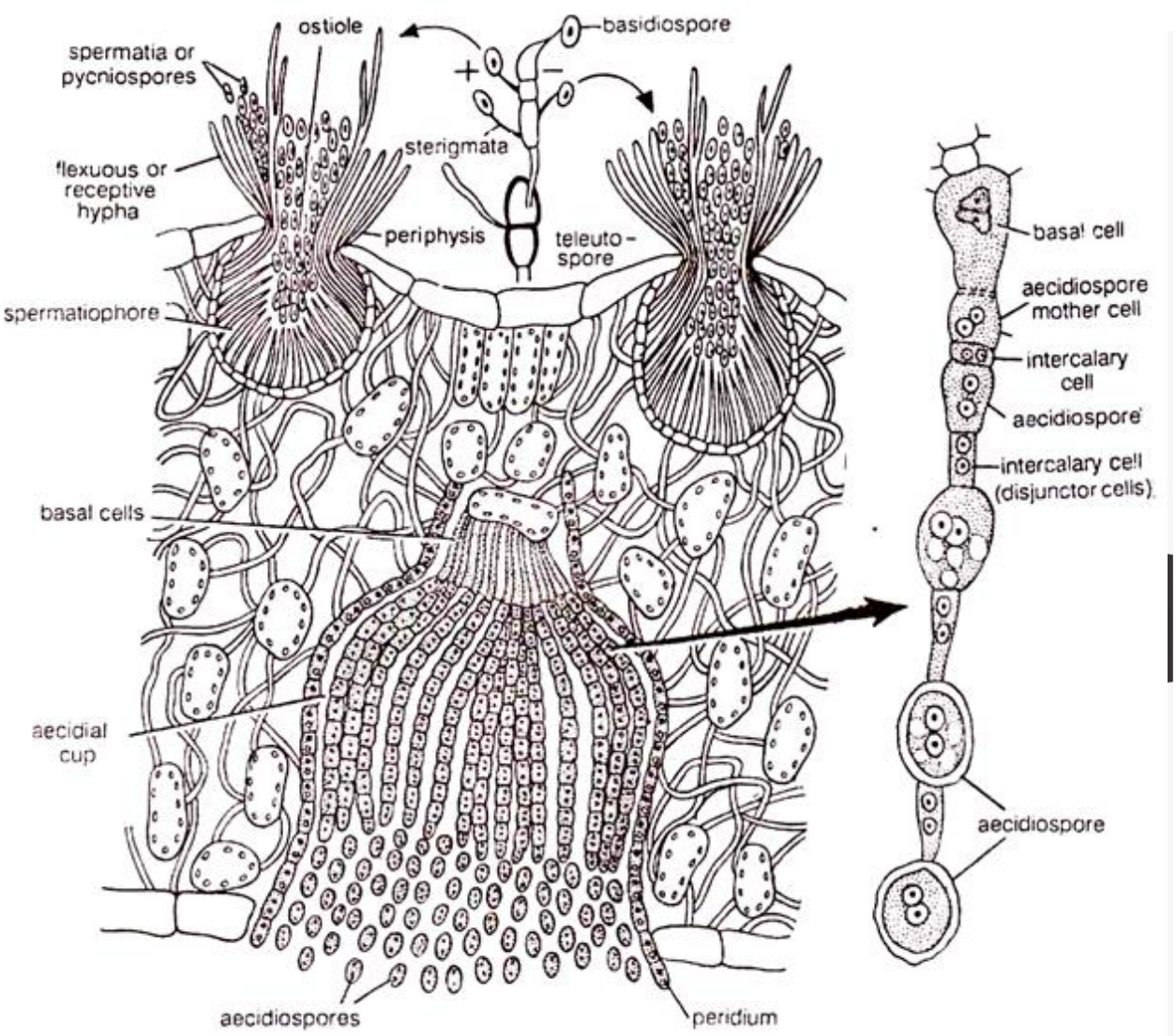


Fig. 9. *Puccinia graminis*. Leaves of barberry showing **A.** Pycnidial cups on upper surface **B.** Aecidial cups on lower surface.



3. *Puccinia* : Germination of uredospore on wheat leaf. Note the formation of appressorium



T/S OF INFECTED BARBERRY LEAF SHOWING PYCNIA AND AECIDIA

Cercospora

Class: Deuteromycetes
Order: Moniliales
Family: Dematiaceae
Genus: *Cercospora*

INTRODUCTION: Genus *Cercospora* includes 3800 species. Majority of the species are facultative parasites causing Leaf Spot Disease. The well-known species are *Cercospora personata*, *C. indica*, *C. hibiscus*, *C. arachidicola* etc. *C. personata* causes a disease on groundnut plant called 'Tikka' Disease.

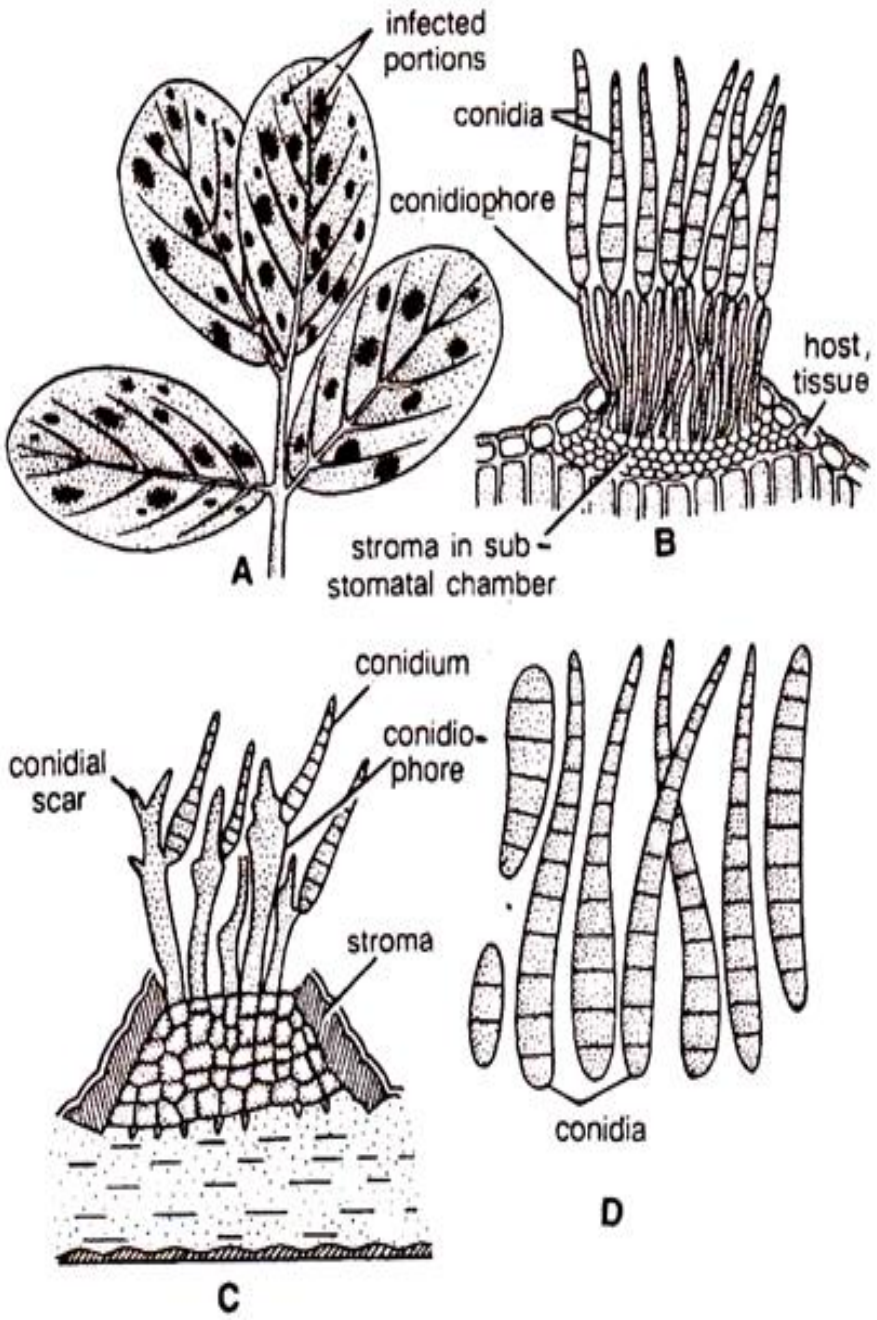
Leaf spot disease produces pale green spots on upper surface of the leaf. These gradually turn yellow and ultimately become brown. The foliage finally dries up and is destroyed when disease is severe and destructive.

VEGETATIVE STRUCTURE:

- Mycelium consists of multicellular, septate and branched hyphae.
- Parasitic hyphae are slender and intra cellular. Inside the host it forms lobed haustoria which penetrate the cells.
- The mycelium reproduces asexually by means of conidia. They are developed on dark coloured, unbranched, aseptate conidiophores.

CONIDIA:

- The hyphal mass is aggregated beneath the epidermis as pseudo parenchymatous stroma.
- A tuft of short, septate, geniculate (knee-like) thin walled and unbranched conidiophores emerge through the epidermis. Mature conidiophores are dark coloured, and somewhat thicker than the rest of the hyphae.
- Conidium is produced at the tip of conidiophore.
- Conidium is inversely clavate (rounded at base and tapering towards apex) and straight or slightly curved. It is generally 4 – 5 septate (at times 12 – 15 septate) and light yellow in colour.



(A–D). *Cercospora*. (A) Leaf spot disease of ground nut, (B) Conidiophore bearing conidia, (C) Logitudinal section of acervulus with geniculate conidiophores, (D) Conidia

MUSHROOM CULTIVATION

Aim: Cultivation of edible mushroom.

Introduction: Mushrooms are referred to the fleshy, spore bearing fruiting bodies of fungi. Mushrooms commonly belongs to Basidiomycotina (*Agaricus campestris*, *A. brunnescens*, *Pleurotus sajor-caju*, *Volvariella volvacea* etc.) and rarely to Ascomycotina (*Morchella conica*, *M. esculenta*). The mushrooms were used as food since long back, probably from 3000 B.C. as per ancient Indian literature. Since that time, the mushrooms are being consumed in different countries like Greece, Egypt, France etc. The Greeks and Romans described mushrooms as "food for the god". During that period, people consumed the mushrooms after collecting them from their natural habitat.

The cultivation was started in the early part of 18th century in France, but it became a thriving industry only by 1850 in Paris. In India, the first successful experimental cultivation of mushroom (*A. bisporus*) was initiated at Solan (Himachal Pradesh) in 1961. But there is no definite test to confirm whether a mushroom is poisonous or edible.

Requirements: Spawn, dried paddy straw, polythene bags, horse gram powder, tap water and distilled water, sprayers, threads, gunny bags, 4% solution of formalin, permanent markers, labels, 70% alcohol, Autoclave, scissors, needle, rack stand.

Procedure:

1. Spawns have to be procured from Biocentre, Hulimavu, or from IIHR (Indian Institute of Horticulture Research), Hesaraghatta or GKVK (Gandhi Krishi Vignana Kendra), Bengaluru.
2. Dried paddy straw was chopped into 1-2 cm Bits.
3. Straw should be soaked in water overnight.
4. Next day excess water has to be drained off and horse gram powder has to be added (8gms/kg of straw).
5. Soaked straw need to be autoclaved for 15 minutes at 121 °C (250 °F) at 100 kPa (**15 psi**) above atmospheric pressure for 15 minutes.
6. Autoclaved straw has to be cooled to room temperature.
7. Clean the hands with alcohol, take a clean polythene bag, into the bag first put the mushroom spawn followed by autoclaved paddy straw (thickness of paddy straw layer should be maintained 3-4 inches).
8. Again put a layer of spawn towards the borders of polythene bag.
9. In the same way 3-4 inoculums and paddy straw should be added.
10. Then polythene bags are tied and using needle, small holes are made at equal distance, all around the bag.
11. The tied bags are kept for incubation in a sterile room at 21°C for 15-16 day to get fructifications.
12. Everyday spraying of distilled water should be done to maintain humidity in the room.

13. When buttons start emerging from the polythene bag, cut the bag on the sides without disturbing from side.
14. After 25 days mushrooms were harvested.

Collection of Spawn

Collection of paddy straw
⇩
Cutting into 1-2 cms.
⇩
Soaking overnight in water
⇩
Mix with horse gram
⇩
Autoclave
⇩
Cool it
⇩
Inoculate in polythene bag
⇩
Tie it in incubation room
⇩
Spray distilled water twice a day
⇩
Harvest the edible mushroom after 25 days

Observation: Observe for the white cottony mycelium over the compost surface and colour of the compost that changes from dark to light brown which is indicative of successful completion of spawn running period. Also observe the beds for mushroom crop which can be expected after 5 to 20 days. Mushrooms mostly appear in flushes and at a temperature of 15°C, it generally takes 7 to 8 days to come to the button stage from the first appearance of the formation of a pin head. There is an interval of 8 to 10 days between flushes. The cap still being tight to its stalk is the right stage to harvest the mushrooms.

Results:

Technical Terms and its definitions

Mycelium – the fungal threads (comparable to plant roots) that sprout the mushrooms.
Spores – miniscule mushroom 'seeds' that are kept safe in the brown gills under the cap of the mushroom (almost impossible to see with the naked eye).
Grain spawn – sterile grain inoculated with mushroom spores. The mycelium sprouts from the spores and retrieves food from the grain.
Compost – a mixture of horse manure, straw, gypsum and chicken manure.
Flush – a cropping cycle of mushrooms, from the moment they pop their heads above the casing.

LICHENS

Lichens represent one of the ingenious creations of nature in coloring and occupying any hostile environment. They form worldwide vegetation with 400 genera and about 16,000 species. They can thrive and multiply in areas where no other vegetation is possible.

SRUCTURE OF THALLUS:

Lichen is not an individual plant, though the plant body looks like that of individual organism. It is the symbiotic association of both algae and fungi. The plant body is composed of algal members belonging to the Class Chlorophyceae (phycobionts) and fungal members to Class Ascomycetes or Basidiomycetes (mycobiont). Based on the mycobiont, lichens are divided into two groups - Ascolichens and Basidiolichens.

Ascolichens are further classified into three types on the nature of thallus namely Crustose lichens, Foliose lichens and Fruticose lichens.

STRUCTURE OF CRUSTOSE LICHENS:

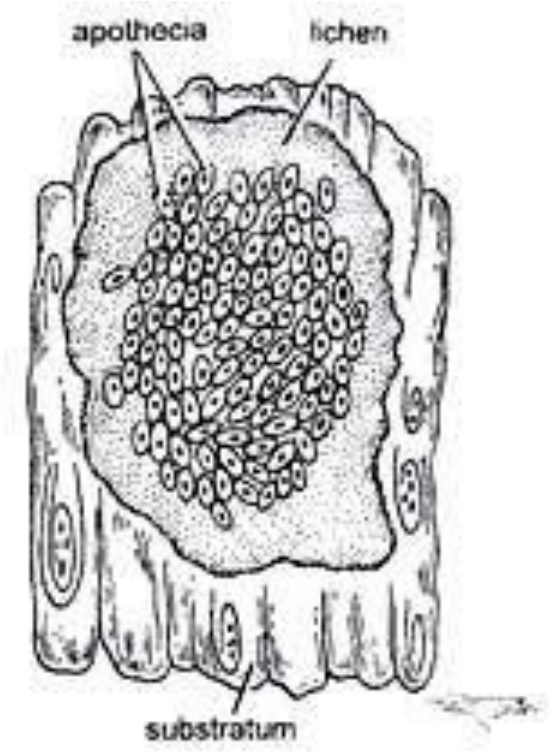
They are usually found growing on rocks or barks of trees. They form thick or thin incrustations on the substratum. The thallus is small lobed dorsiventral. The lower surface secretes a gummy substance called "lichnin" which sticks the thallus to substratum and makes it inseparable. Small cup shaped structures are found on dorsal surface of the thallus and are called apothecia. Eg. *Graphis*.

STRUCTURE OF FOLIOSE LICHENS:

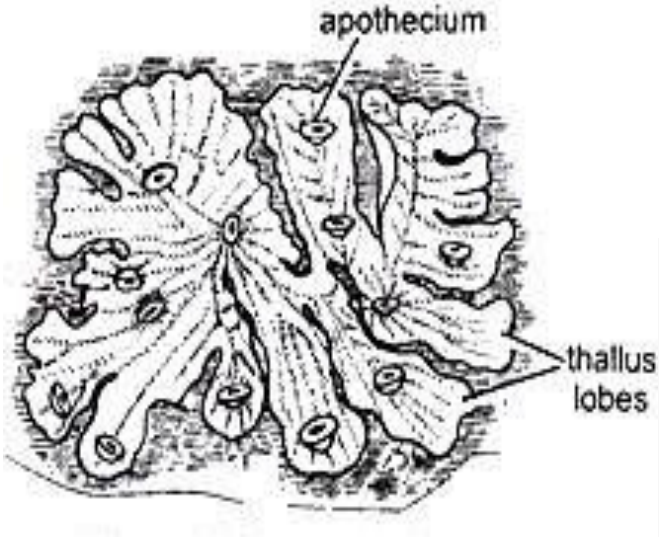
These are found growing on barks of trees and rocks. The lobes are broader than Crustose and thallus is leaf like flattened and it is attached to substratum with the help of rhizoid like outgrowths called rhizines. They develop from the lower surface of the thallus. Many cup like structures called apothecia are visible on dorsal surface. Eg. *Parmelia*.

STRUCTURE OF FRUTICOSE LICHENS:

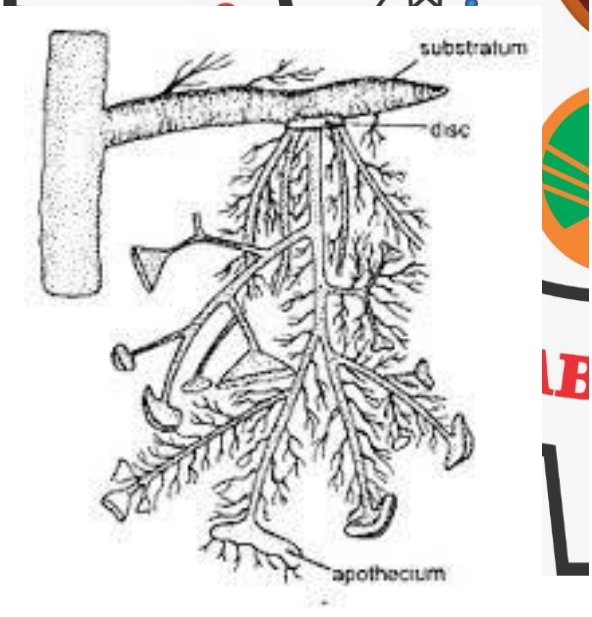
These are found growing on tree trunks and hanging downward or growing erect on soil surfaces. The plant body is attached to the substratum through dense clusters of hyphae. The plant body appears bushy with branched cylindrical thallus. The reproductive structures like apothecia are borne on apices of branches. Eg. *Usnea*.



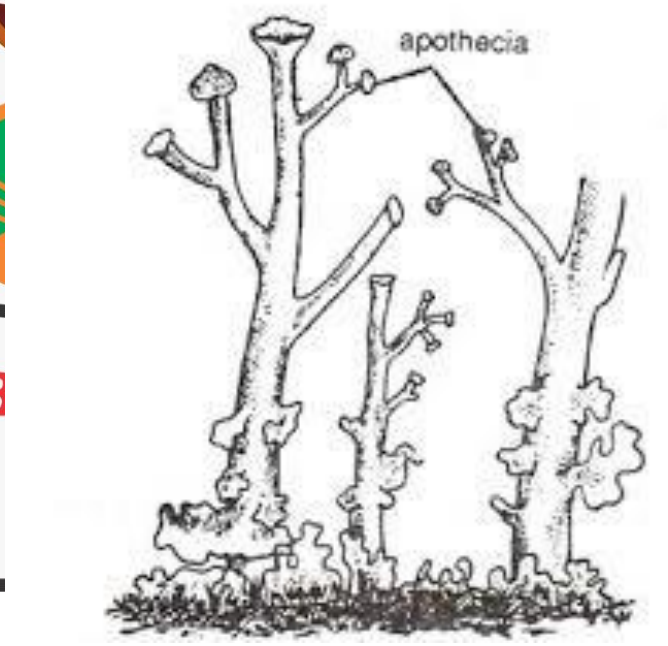
CRUSTOSE LICHEN Eg. *Graphis*



FOLIOSE LICHEN Eg. *Parmelia*



FRUTICOSE LICHEN Eg. *Usnea*



AN ERECT FRUTICOSE LICHEN Eg. *Cladonia*

ANATOMY

T/S OF HOMOISOMEROUS/ HOMOMEROUS THALLUS: In Homoisomerous lichens, the T/S of thallus shows uniformly, loosely interwoven mass of fungal hyphae and algal filament which are present between the upper and lower surfaces.

T/S OF HETEROMEROUS THALLUS: In Heteromerous thallus lichens, the T/S of thallus is differentiated into different zones like cortex, algal zone and medulla.

Upper and **lower** cortexes are made up of closely interwoven fungal hyphae.

Algal zone (Gonidial Layer) found below the upper cortex, in which the algal cells are dispersed with the loosely arranged fungal hyphae. Medulla present above the lower cortex where the fungal hyphae are interwoven. The roots like structures are called rhizines and present on the lower surfaces.

T/S OF THALLUS OF FRUTICOSE LICHENS: It shows three regions like Cortex, Algal zone and Medulla.

Cortex is the outermost zones composed of loosely arranged interwoven fungal hyphae.

Algal zone is present below the cortex, composed of algal cells dispersed with loosely arranged fungal hyphae.

Medulla is the central region in which the mycelia are interwoven with one another.

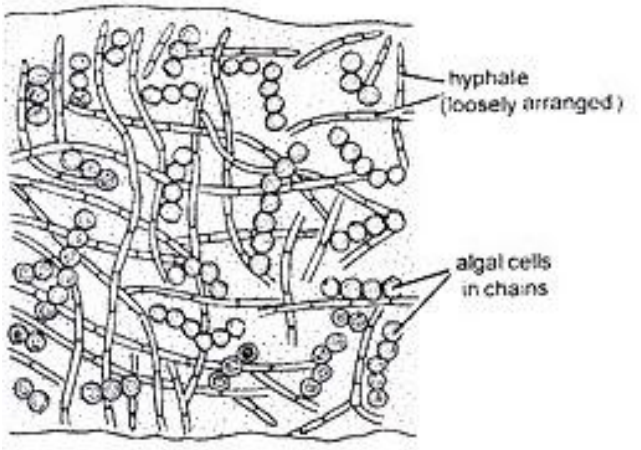
STRUCTURE OF L/S OF APOTHECIUM: The fructification of lichens is called apothecium. It is a cup like or disc like structure, in which the reproductive structures are borne. The L/S of apothecium shows the regions like cortex, algal zone, medulla and hymenium.

Cortex is the outer region and it is made of closely joined fungal hyphae present at lower surface and peripheral sides of apothecium cup.

Algal zone is present below the cortex and composed of loosely arranged algal cells.

Medulla is the central part in which the fungal hyphae are loosely arranged from the lower part of hymenium to the cortex.

Hymenium is the floor of Apothecial cup. It is a layer composed of alternatively arranged Asci and Paraphyses. Paraphyses are hair like sterile structures and asci are sac like fertile structures consist of eight ascospores.



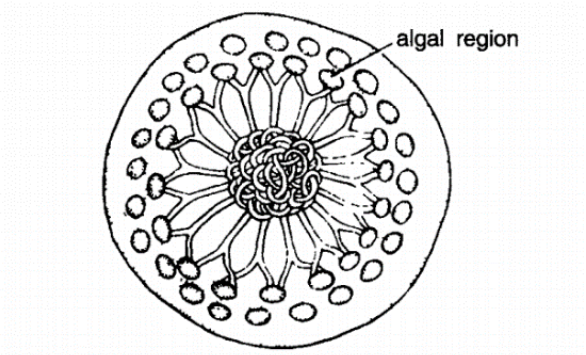
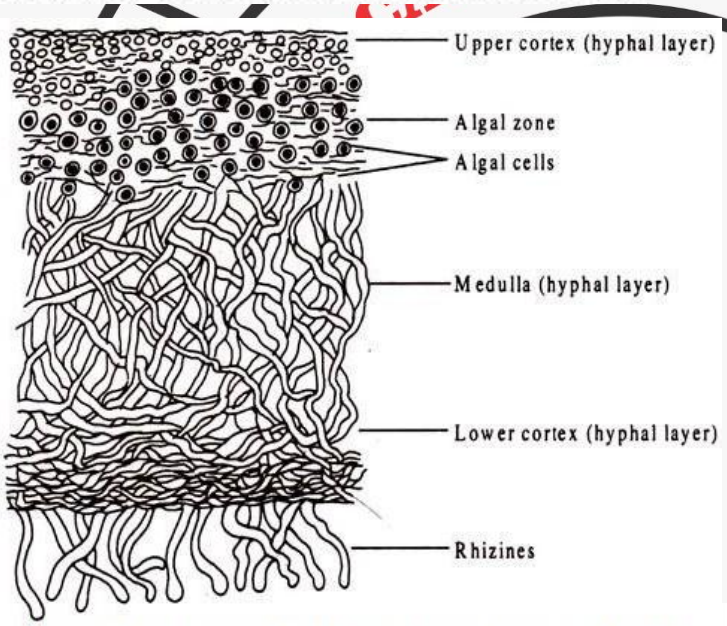
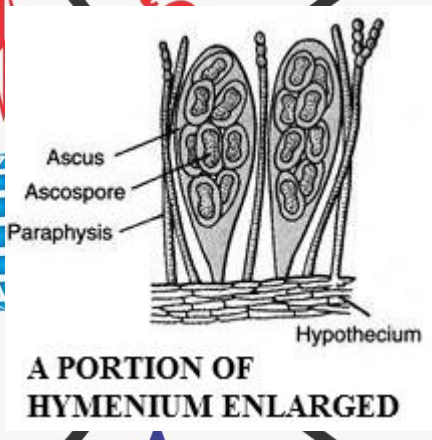


Fig. 10. ***Usnea*** sp. A fruticose thallus. Transverse section to show internal structure.

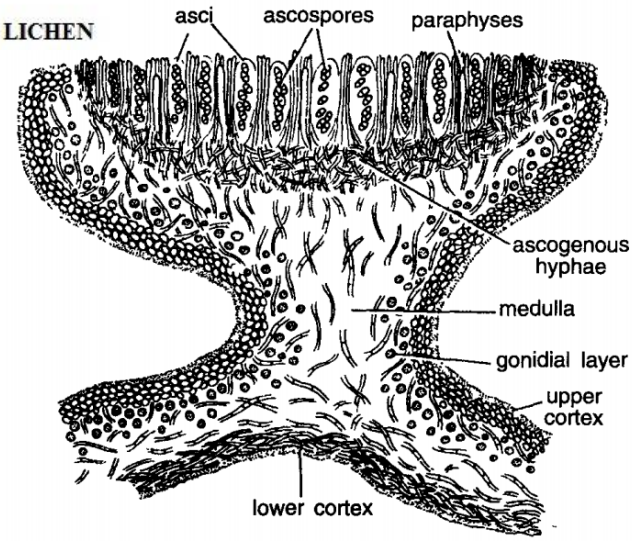
7. Lichens : Transverse section of homoiomerous lichen



VERTICAL SECTION OF HETEROMEROUS FOLIOSE LICHEN



A PORTION OF HYMENIUM ENLARGED



V/S OF LICHEN APOTHECIUM

STUDY OF MYCORRHIZA

A **Mycorrhiza** is a symbiotic association between a fungus and the roots of a vascular host plant. The term Mycorrhiza refers to the role of the fungi in the plants rhizosphere (its root system). Mycorrhiza play important roles in soil biology and soil chemistry.

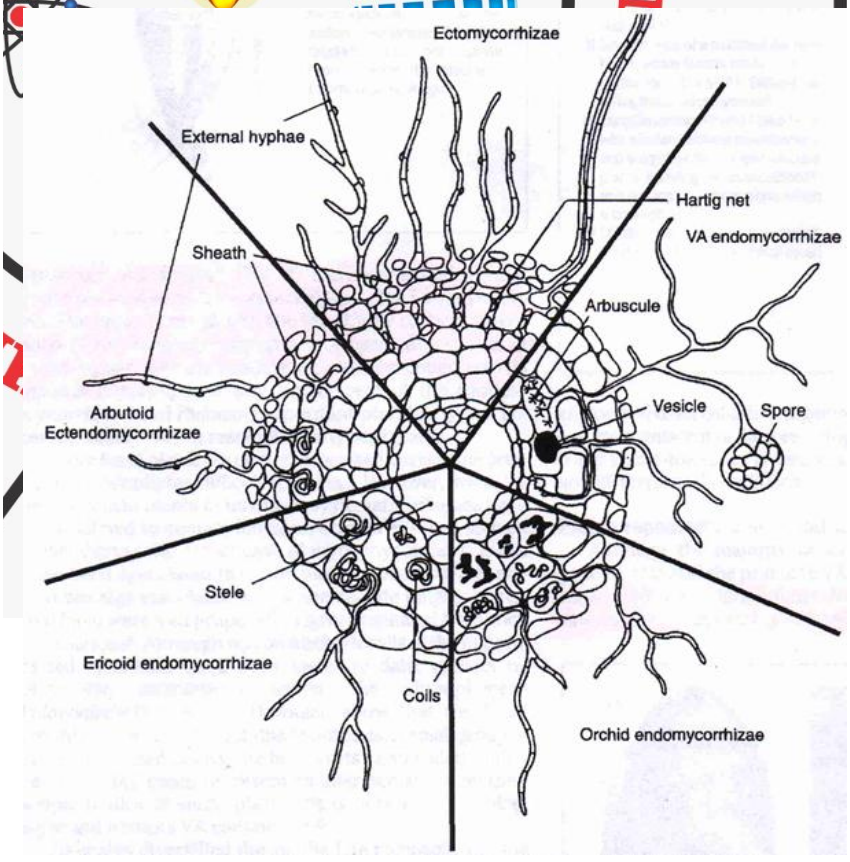
In a Mycorrhizal association, the fungus colonizes the host plant's root tissues, either intracellular as in arbuscular mycorrhizal fungi (AMF or AM), or extracellular as in ectomycorrhizal fungi. The association is generally mutualistic but in particular species or in particular circumstances, mycorrhiza may be variously pathogenic in the host plants.

TYPES:

Mycorrhiza are commonly divided into ectomycorrhiza and endomycorrhiza. The two types are differentiated by the fact that the hyphae of ectomycorrhizal fungi do not penetrate individual cells within the root, while the hyphae of endomycorrhizal fungi penetrate the cell wall and invaginate the cell membrane. Endomycorrhiza includes arbuscular, ericoid, and orchid mycorrhiza, while arbutoid mycorrhiza can be classified as ectoendomycorrhiza.

ARBUSCULAR MYCORRHIZA:

Endomycorrhiza are variable and have been further classified as arbuscular, ericoid, arbutoid, monotropoid, and orchid mycorrhiza. Arbuscular mycorrhiza, or AM (formerly known as vesicular-arbuscular mycorrhiza, or VAM), are mycorrhiza whose hyphae enter into the plant cells, producing structures that are either balloon-like (vesicles) or dichotomously branching invaginations (arbuscules). The fungal hyphae do not in fact penetrate the protoplast (i.e. the interior of the cell), but invaginate the cell membrane. The structure of the arbuscules greatly increases the contact surface area between the hypha and the cell cytoplasm to facilitate the transfer of nutrients between them.

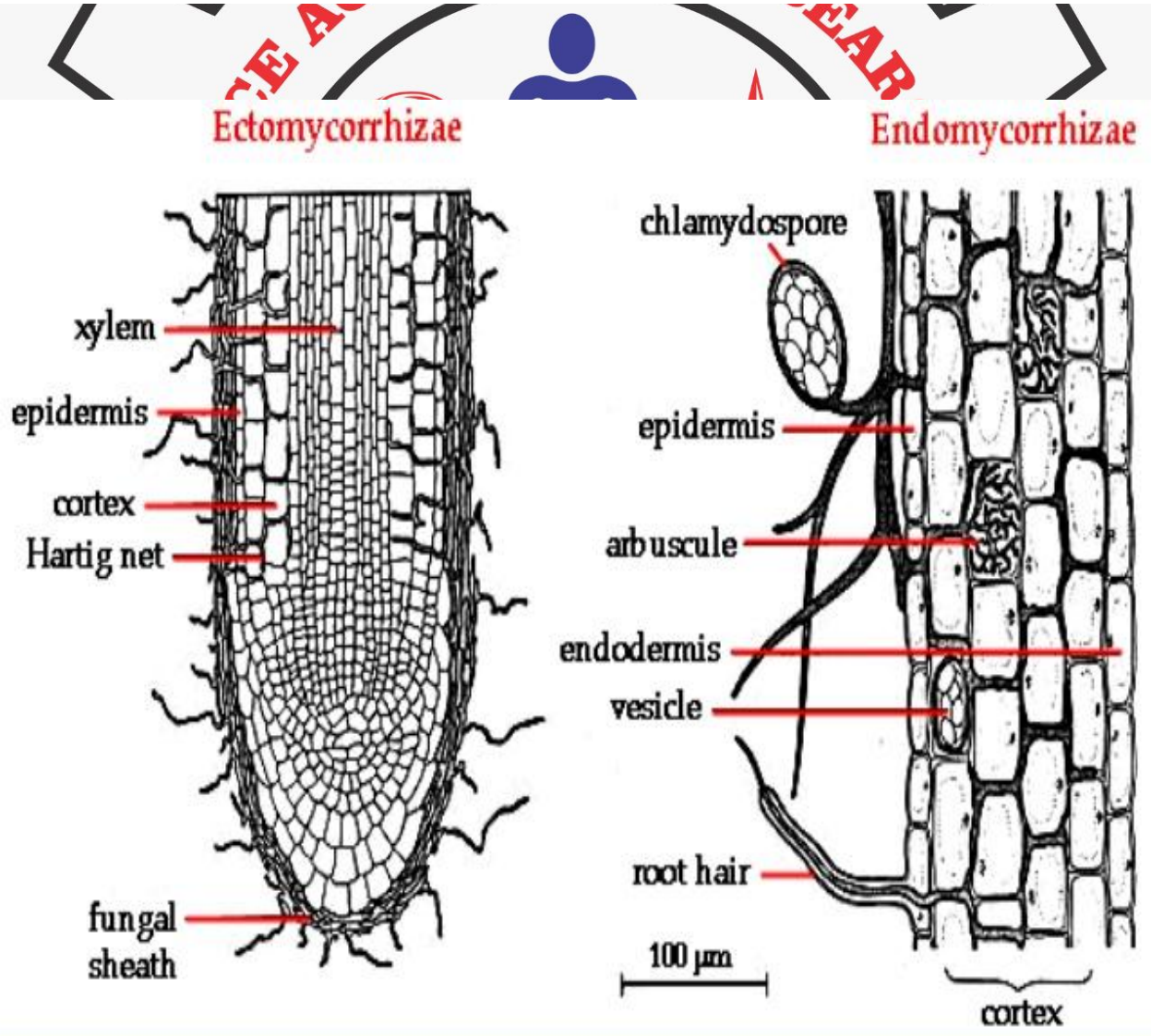


ECTOMYCORRHIZA:

Ectomycorrhizas or EcM are typically formed between the roots of around 10% of plant families, mostly woody plants and fungi belonging to the Basidiomycota, Ascomycota and Zygomycota.

Ectomycorrhiza consist of a hyphal sheath, or mantle, covering the root tip and a Hartig net of hyphae surrounding the plant cells within the root cortex. In some cases the hyphae may also penetrate the plant cells, in which case the mycorrhiza is called an ectendomycorrhiza. Outside the root, Ectomycorrhizal extramatrical mycelium forms an extensive network within the soil and leaf litter.

Nutrients can be shown to move between different plants through the fungal network. Carbon has been shown to move from paper birch trees into Douglas-fir trees thereby promoting succession in ecosystems.



PLANT PATHOLOGY

KOLEROGA OF ARECANUT

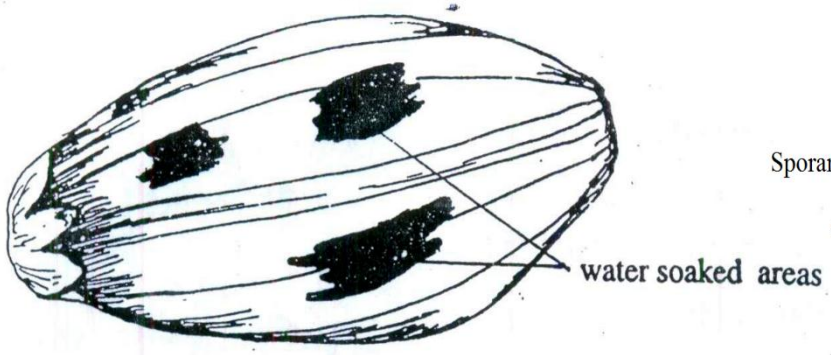
It is also called **Fruit rot** disease or **Mahali** disease caused by a parasitic fungus *Phytophthora palmivora*. It belongs to the
Class: Phycomycetes
Order: Peronosporales
Family: Pythiaceae

VEGETATIVE STRUCTURE: The plant body of *Phytophthera* is the mycelium consisting of branched aseptate coenocytic hyphae. Some of hyphae are larger called sporangiophores. They are branched, erect and bear lemon shaped sporangia.

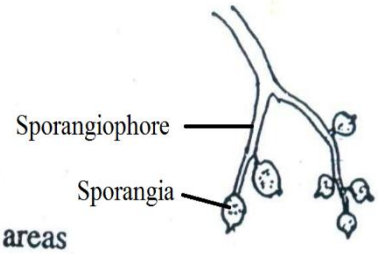
SYMPTOMS: The disease is characterized by the appearance of decolorisation of nuts within the water soaked areas due to development of mycelium as white mantle. Gradually the entire nut gets the infection and drops down. The pericarp of the nut becomes shriveled and the kernel gets destroyed, hence it is called as fruit rot disease.

CONTROL MEASURES:

1. Spraying of Bordeaux mixture to the diseased plant
2. Cleanliness and field sanitation which does not allow water logging will help in controlling the disease to some extent.



Infected Arecanut by *Phytophthera pamivora*



Branched sporangiophore with lemon shaped sporangia

SMUT DISEASE

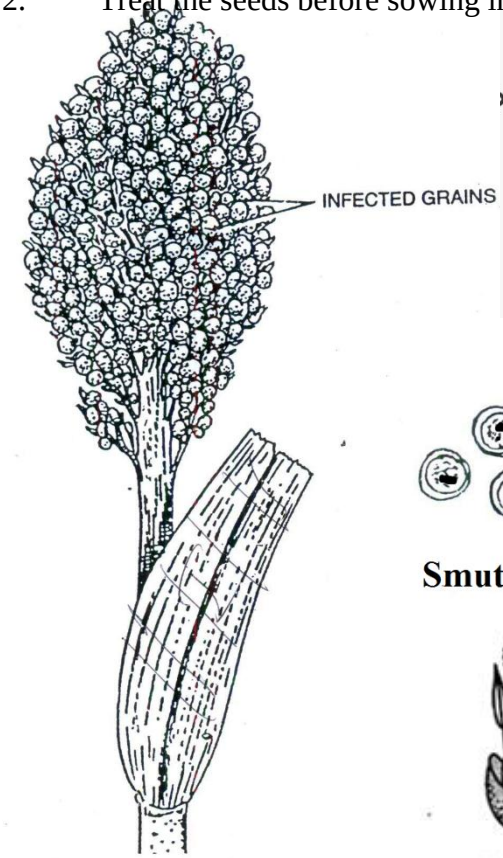
Smut disease of *Sorghum* caused by a parasitic fungus *Sphacelotheca sorghii*. It belongs to the
Class: Basidiomycetes
Order: Ustilaginales
Family: Ustilaginaceae

VEGETATIVE STRUCTURE: The plant body is mycelium. It is inter cellular, septate and it infects the host through spores.

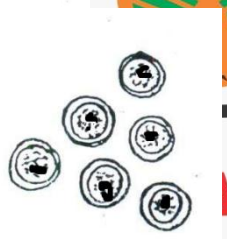
SYMPTOMS: The infected ovaries turn into grayish spore sacs enclosed by the wall made up of fungal hyphae, as a result all the ovaries of an ear turn into smut sori. Each sorus has a central columella made of hard tissue surrounded by a number of minute spores. Spores are spherically dark brown in colour and smooth walled.

CONTROL MEASURES:

1. Seed treatment with organo mercuric compounds yields good results.
2. Treat the seeds before sowing in 3% copper sulphate for 3 to 15 minutes.



Infected Ear of Sorghum by *Sphacelotheca sorghii*



Smut Sorus

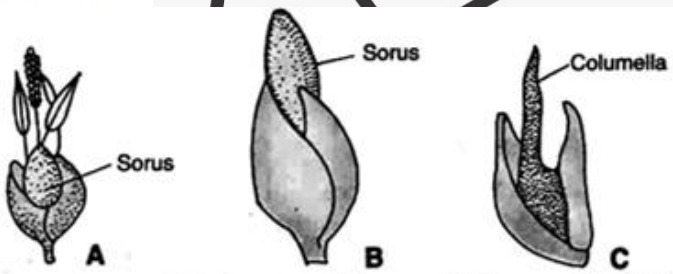


Fig. 14.11. A, A flower of the host in which ovary is being transformed into sorus; B, A grain with sorus; C, Sorus with columella exposed.

RED ROT OF SUGARCANE

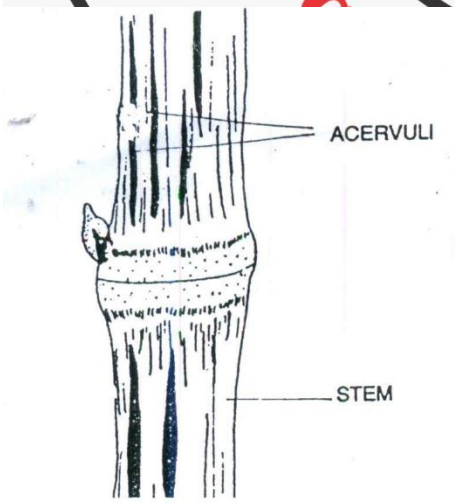
It is caused by a parasitic fungus called *Colletrorichum falcatum.* It belongs to the
Class: Deuteromycetes
Order: Melanconiales
Family: Melanconiaceae

VEGETATIVE STRUCTURE: The plant body is mycelium. It is branched consists of septate, thin hyaline hyphae. They are intercellular in the pith region of stem. The conidia are curved, colourless produced on the tips of conidiophores.

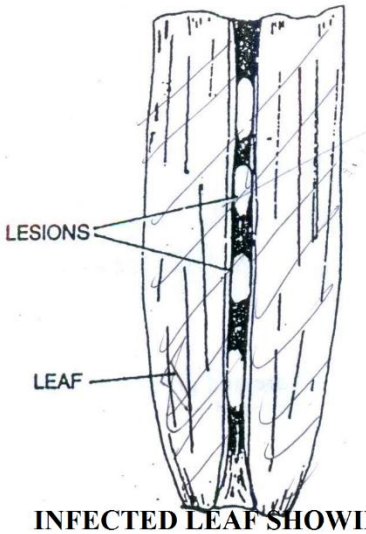
SYMPTOMS: The disease is characterized by the appearance of decolourisation of spots or lesions on leaves. The stem appears like shriveled and longitudinally wrinkled contains red coloured streaks in pith regions.

CONTROL MEASURES:

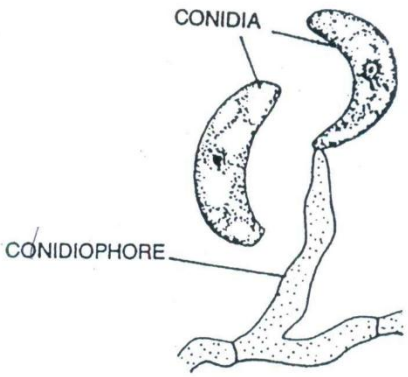
1. Selection of healthy plant to cultivate and growing disease resistant varieties.
2. Before sowing the cut ends should be dipped in 1% Bordeaux mixture to prevent soil borne infection.



INFECTED SUGARCANE STEM BY *Colletotrichum falcatum*



INFECTED LEAF SHOWING SYMPTOMS



CONIDIOPHORE AND CONIDIA

COFFEE RUST

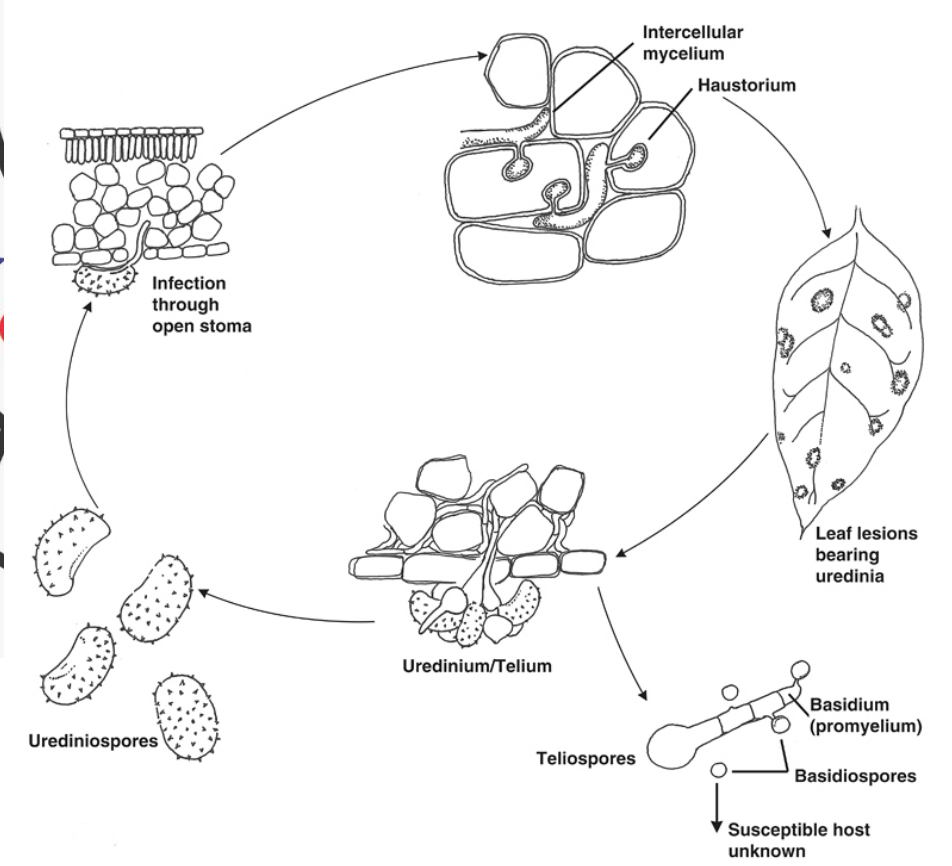
It is caused by a parasitic fungus *Hemileia vastatrix* belongs to the
Class: Basidiomycetes
Order: Uredinales
Family: Pucciniaceae

VEGETATIVE STRUCTURE: The plant body is mycelium. It is intercellular, branched septate hyphae. The hyphae produce haustoria which penetrate the host cells to suck nutrients. The reproductive bodies are borne on the club shaped branches of hyphae, which come out through the stomata.

SYMPTOMS: They appear on the leaf blades and very rarely on the fruits. They are formed as small yellowish spots under the surface of leaves and gradually changes into orange powdery masses of rust spores. On the upper surface of the leaves corresponding to the presence of the rust spots, chlorotic lesions can be seen. As disease advances the leaves dry up and they become dark in colour later drop down.

CONTROL MEASURES:

1. Spraying of Bordeaux mixture at suitable intervals.
2. Maintaining proper field sanitation and growing disease resistant varieties.



BLAST DISEASE OF RICE

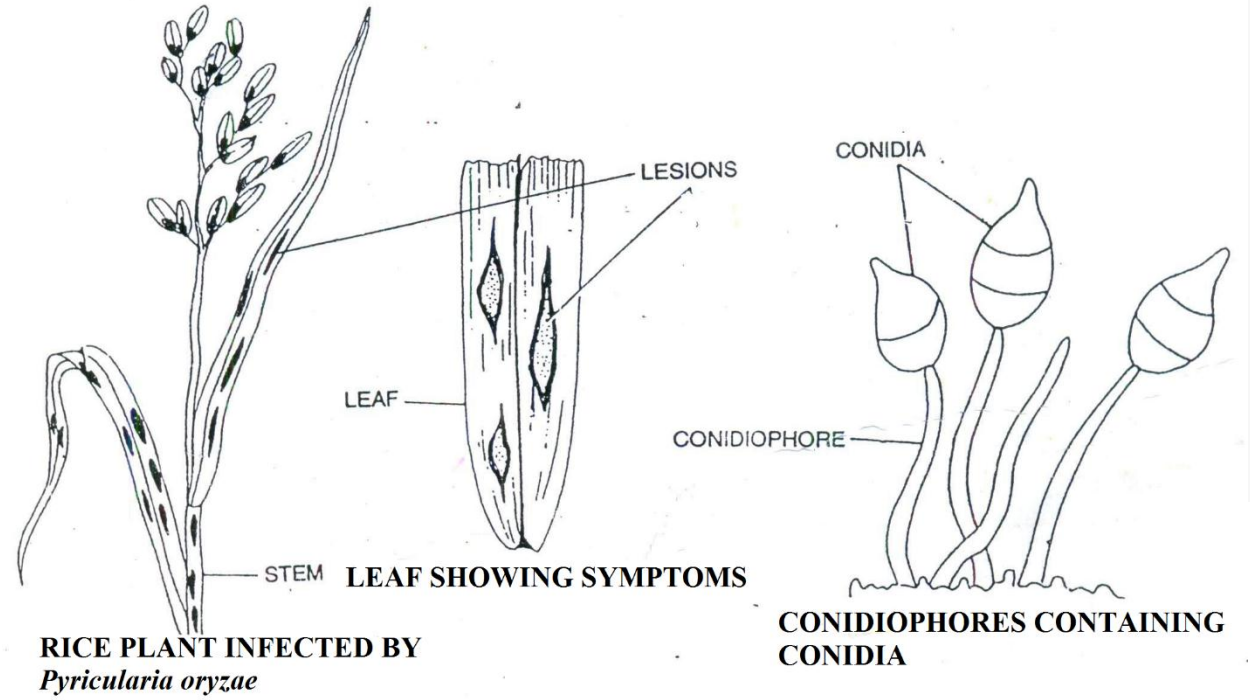
It is also called the 'Rotten Neck Disease'. It is caused by a parasitic fungus *Pyricularia oryzae.* It belongs to the
Class: Deuteromycetes
Order: Moniliales
Family: Moniliaceae

VEGETATIVE STRUCTURE: The plant body is branched, septate multinucleate mycelium. The reproductive bodies are borne on the tips of conidiophores. Conidia are oval in shape and they are three celled with pointed apex.

SYMPTOMS: Mainly found on leaves, petioles, leaf sheath, calyx and stem. The appearance of small blue elongated pustules on young leaves and they become circular on mature leaves. The center of the pustule is grayish green and water soaked. Lesions on maturing peduncle are usually blackish brown. Later the symptom of the disease is the decay of the base of the ear. Due to this the ear collapses, hence it is named as rotten neck disease.

CONTROL MEASURES:

1. Seed treatment with fungicides before sowing will eliminate seed borne infection and also seeds treatment with 1 % copper sulphate before sowing.
2. Cultivate disease resistant varieties.



RICE PLANT INFECTED BY *Pyricularia oryzae*

LEAF SHOWING SYMPTOMS

CONIDIOPHORES CONTAINING CONIDIA

BRYOPHYTES

Marchantia

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

INTRODUCTION: The genus is represented by 65 species, of which nearly 11 species have been recorded groeing in the Himalayas and in the different hills of India. The well-known ones are *M. polymorpha, M. palmate, M.nepalensis and M. simlana.* This Plants usually grow in cool, moist, shady places either on wet open woodland or forest floors, streams, wet rocks etc.,

VEGETATIVE STRUCTURE: The plant body is gametophyte. It is dorsiventrally flattened, dichotomously branched, green coloured thallus. The dorsal surface has furrowed midrib and along the midrib a number of cup like structures called gemma cups are present, which contain gemmae. Ventral surface of the thallus contains a number of unicellular smooth – walled and tuberculated rhizoids. Smooth rhizoids are called simple rhizoids and tuberculated rhizoids are called pegged rhizoids.

Scales are arranged in four rows present on the ventral surface of the thallus. *Marchantia* is a dioecious form, the male plant develops the male sex organs and the female plant develops the female sex organs at the apex of the branches.

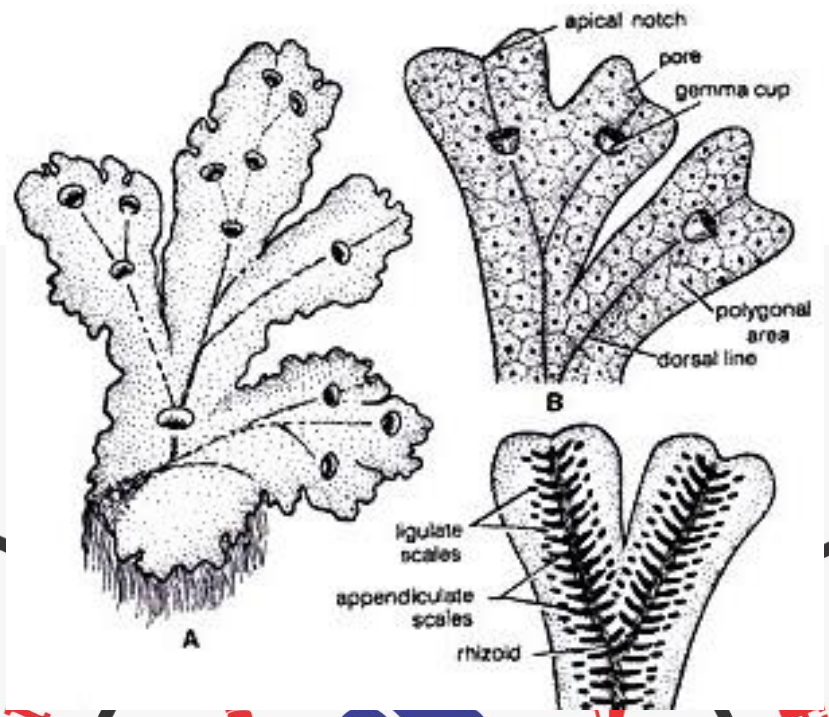
STRUCTURE OF THE T.S OF THALLUS:

The vertical transverse section of the thallus shows three distinct regions like epidermal region, photosynthetic region and storage region.

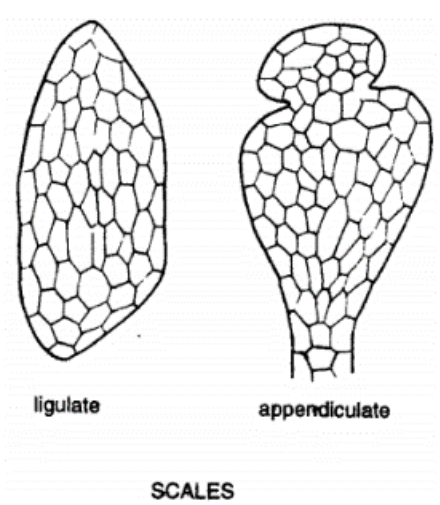
Epidermis is the single layer of cells present on the upper and lower surface of the thallus. The upper epidermis contains a number of barrel shaped air pores. Lower epidermis bears unicellular rhizoids and multicellular scales.

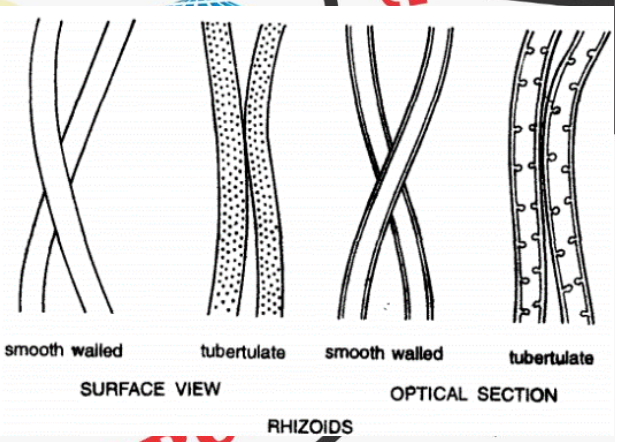
Photosynthetic region is present below the upper epidermis consists of horizontal row of air chambers. They open through air pores and they are separated by means of parenchymatous partitions. Each air chamber contains a number of branched photosynthetic filaments. The cells of filaments are chlorophyllous and constitute the chief photosynthetic tissue of the plant.

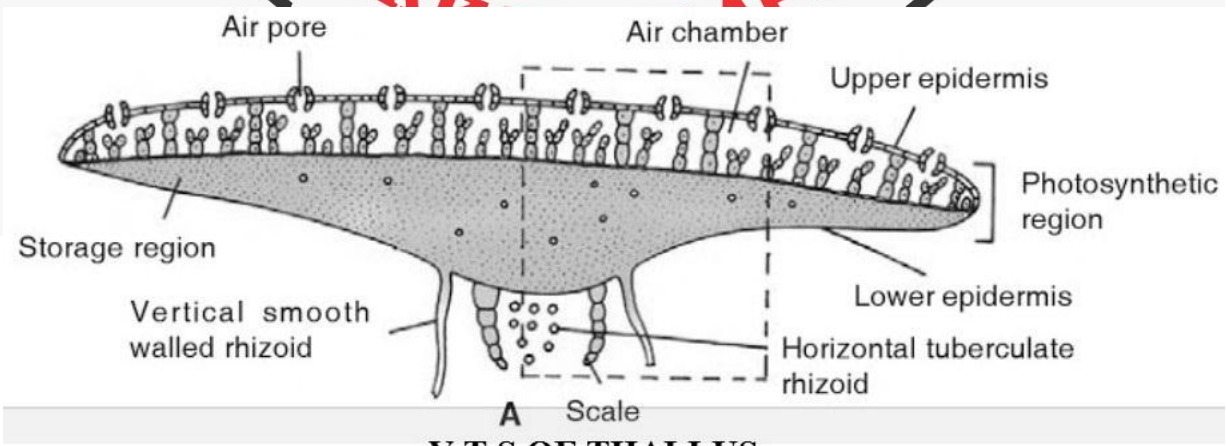
Storage region is present below the photosynthetic region consists of compactly arranged parenchymatous cells. The cells are rich in starch grains. Here and there are some oil and mucilage cells are also present in this region.



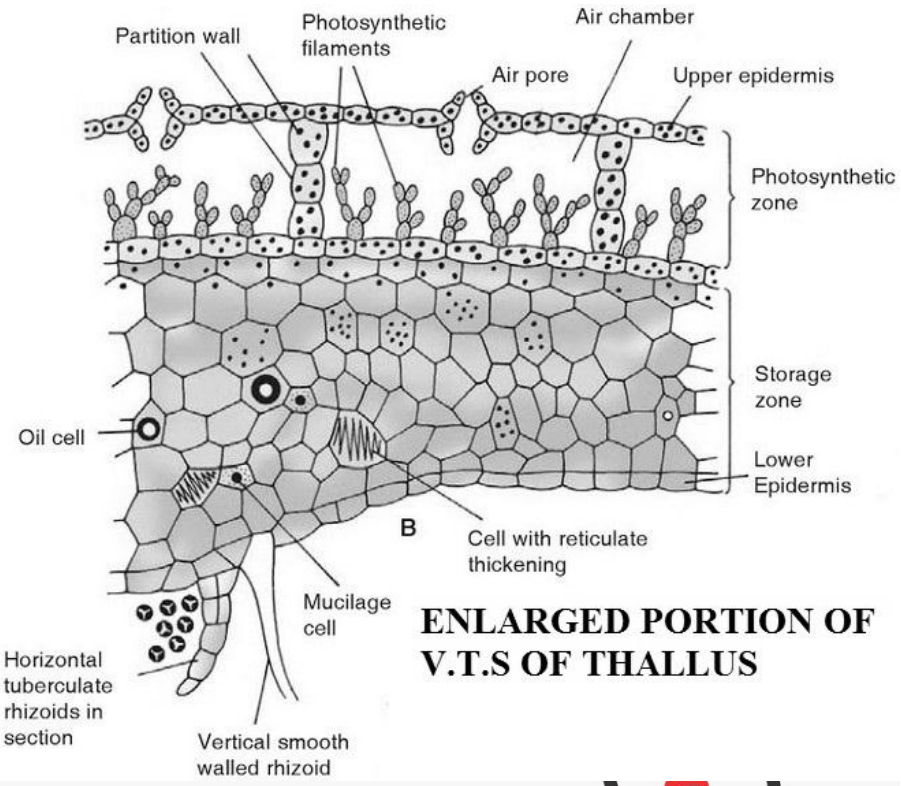
HABIT OF *MARCHANTIA*



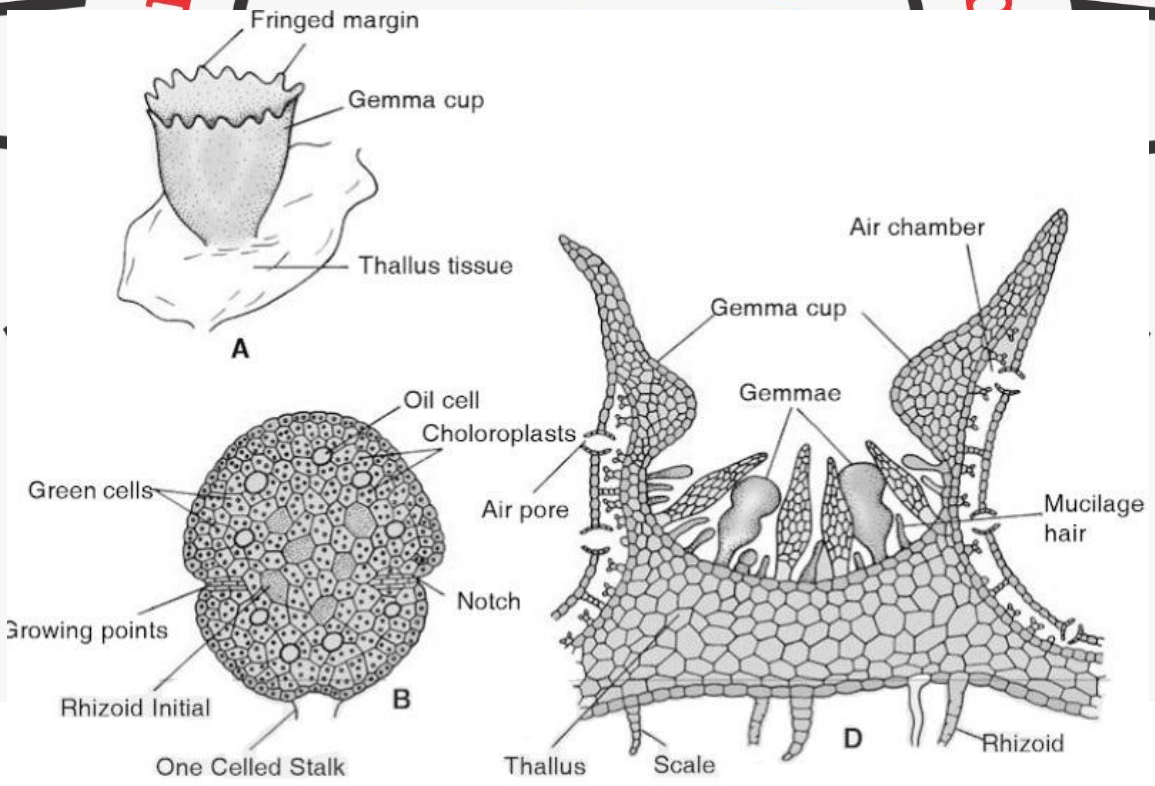




V.T.S OF THALLUS



ENLARGED PORTION OF V.T.S OF THALLUS



A. GEMMA CUP WITH A PART OF THE THALLUS
B. SINGLE GEMMAE
C. V.T.S OF THALLUS PASSING THROUGH GEMMA CUP

V.T.S OF THALLUS PASSING THROUGH A GEMMA CUP:

Shows the following details. It has a fringed margin and is made up of parenchymatous cells. Numbers of gemmae are lined on the floor of cup at different stages of growth. Each gemmae has a single celled short stalk and it is a dumble shaped structure bearing two notches. The growing points are situated in notch regions.

REPRODUCTION:

Marchantia is a dioecious plant. It reproduces sexually by the development of archegonia and antheridia. Antheridia are male reproductive structures borne on the male thallus and female reproductive structures on the female thallus. The reproductive structures are formed on special branches of the thallus called gametophores. The male gametophore is called antheridiophore and the female gametophore is called archegoniophore. They arise at apical notches on different thalli.

STRUCTURE OF ANTHERIDIOPHORE:

It has a cylindrical stalk and a terminal peltate disc. The stalk has two longitudinal grooves called rhizoidal grooves. All along the groove the epidermal cells produce rhizoids.

L.S OF ANTHERIDIAL RECEPTACLE:

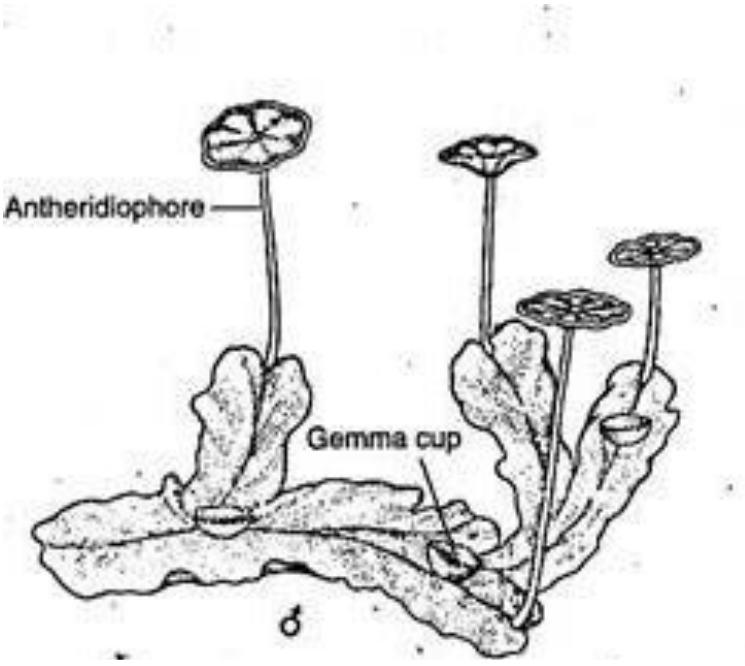
Shows three regions like epidermis, photosynthetic region and storage region. The upper surface of the receptacle is slightly flat or concave. The photosynthetic zone is present below the epidermis consists of number of photosynthetic chambers unlike in the thallus the photosynthetic chambers are alternate with the cavities of antheridial chambers. Each antheridial chamber is a flask shaped cavity opening on the dorsal surface of the disc through an opening called ostiole. Antheridia arise in the acropetalous order. Each antheridial chamber encloses a single antheridium. Antheridium is stalked, spindle shaped body bounded by a jacket layer and it encloses a number of androcytes. The storage region consists of closely packed parenchyma cells with rich starch grains.

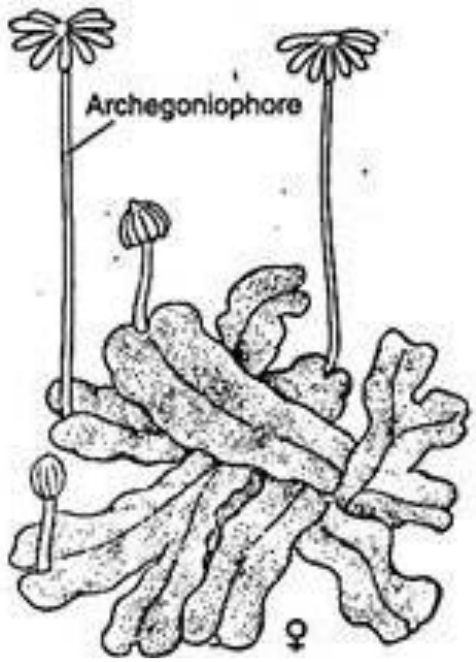
STRUCTURE OF ARCHEGONIOPHORE:

It is borne on the apex of female thallus. It has a cylindrical stalk and terminal receptacle. The receptacle on the ventral surface bears 8 - 9 radial groups of archegonia in pendulous manner.

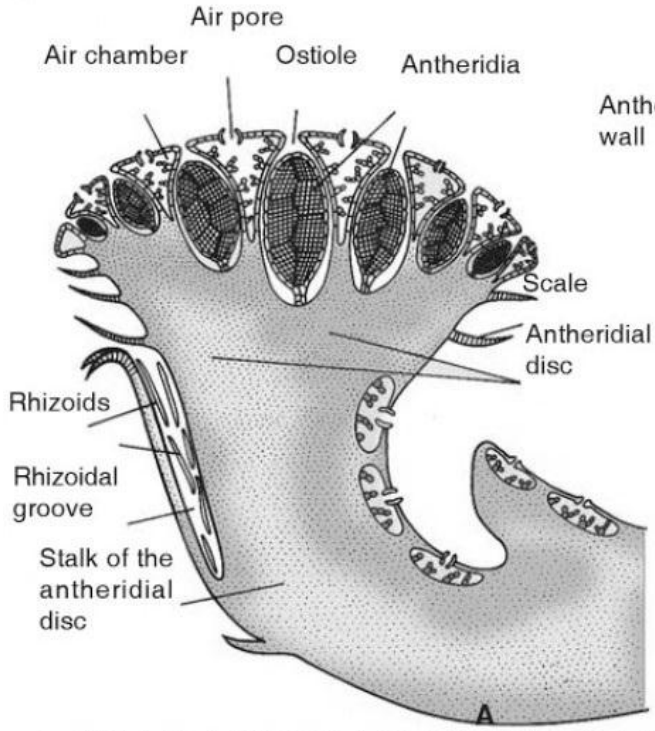
L.S OF ARCHEGONIAL RECEPTACLE:

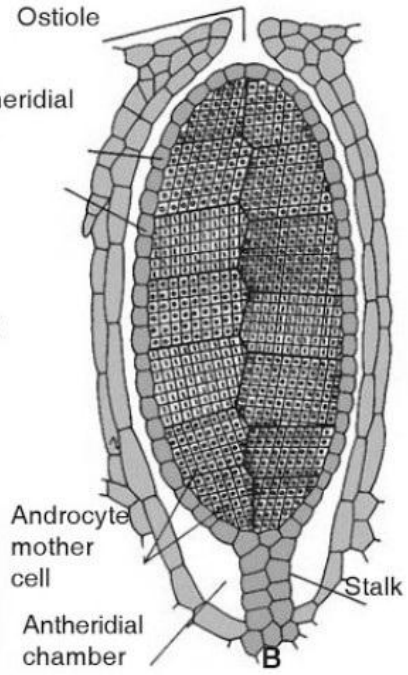
Show three regions epidermis, photosynthetic region and storage region. The upper surface of receptacle is slightly convex. The epidermis is single layer of cells and is interrupted by the presence of air pores. Below the epidermis is the photosynthetic zone consists of number of air chambers bearing photosynthetic filaments. The lowest surface of the receptacle has eight radial groups of archegonia in pendulous manner. They are formed in an acropetal manner and enclosed by a sheath called involucres. Each archegonium is the stalked flask shaped body with basal

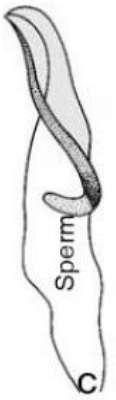




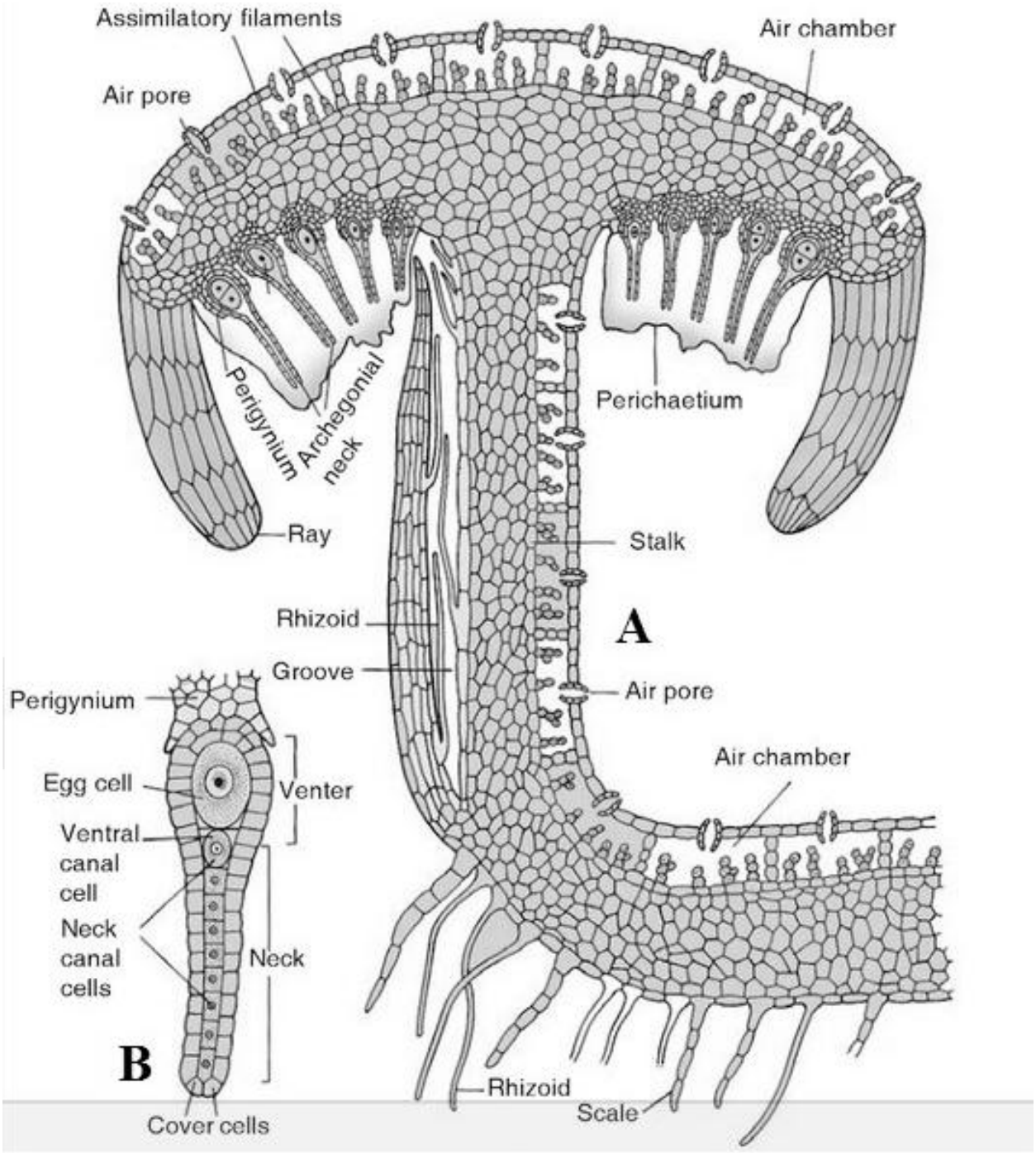
THALLUS BEARING ANTHERIDIOPHORE **THALLUS BEARING ARCHEGONIOPHORE**







A. V.S THROUGH ANTHERIDIOPHORE
B. A SINGLE ANTHERIDIUM
C. BIFLAGELLATE ANTHEROZOID



A. V.S THROUGH ARCHEGONIOPHORE
B. A MATURE ARCHEGONIUM

swollen venter part and upper narrow neck part. Venter part contains a large egg cell and a small venter canal cell. These are surrounded by a single layered venter wall. The neck contains 6 - 8 neck canal cells and they are surrounded by 6 vertical rows of neck cells.

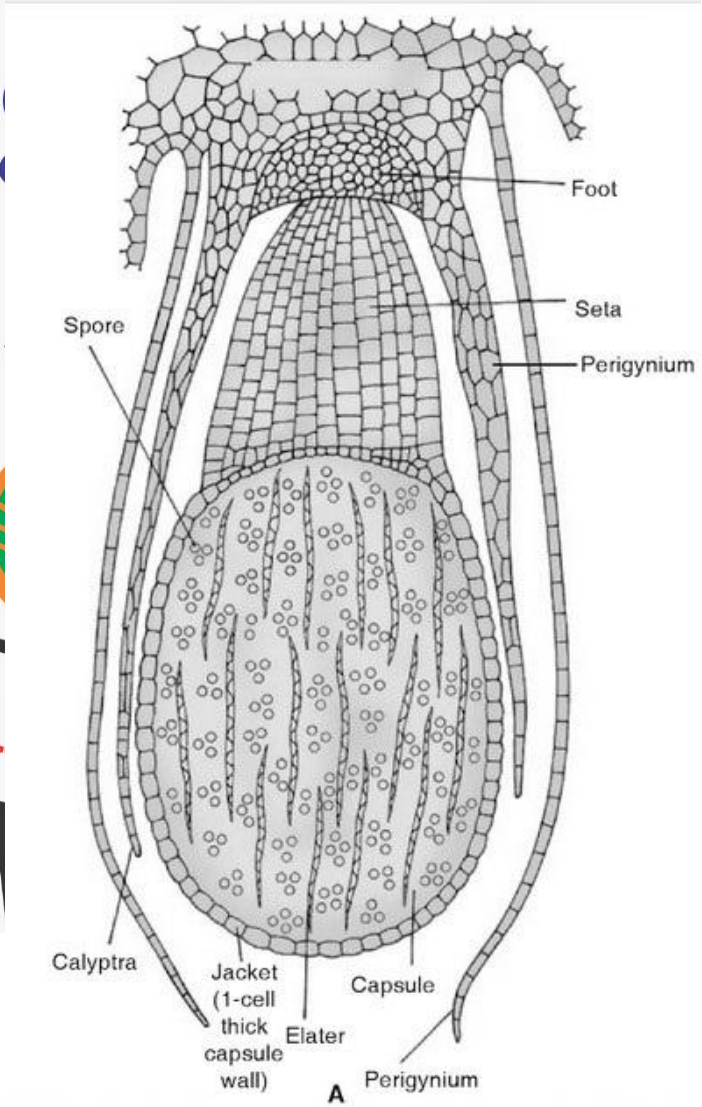
V.L.S OF MATURE SPOROPHYTE:

It shows three regions like foot, seta and capsule.

Foot is the basal swollen structure embedded in the gametophyte tissue of receptacle.

Seta is the middle short stalk connecting the foot and the capsule.

Capsule is terminal; oval shaped consists of an outer single jacket layer enclosing a number of haploid spore tetrads and elaters. Elaters are spindle shaped structure having special thickenings they are hydroscopic and help in the dispersal of the spores. Spores are uninucleate with double layered wall like outer exine and inner intine.



V.L.S OF MATURE SPOROPHYTE

Anthoceros (Horn Wort)

Class: Anthocerotopsida
Order: Anthocerotales
Family: Anthocerotaceae
Genus: *Anthoceros*

INTRODUCTION:

The genus *Anthoceros* is represented by about 200 species. In India about 25 species are found. The well-known species are *A. himalayensis*, *A. erectus*, *A. chambensis*. *A. hallii* and *A. punctatus.* They are usually found growing on moist shady places or on side bunds of rice fields.

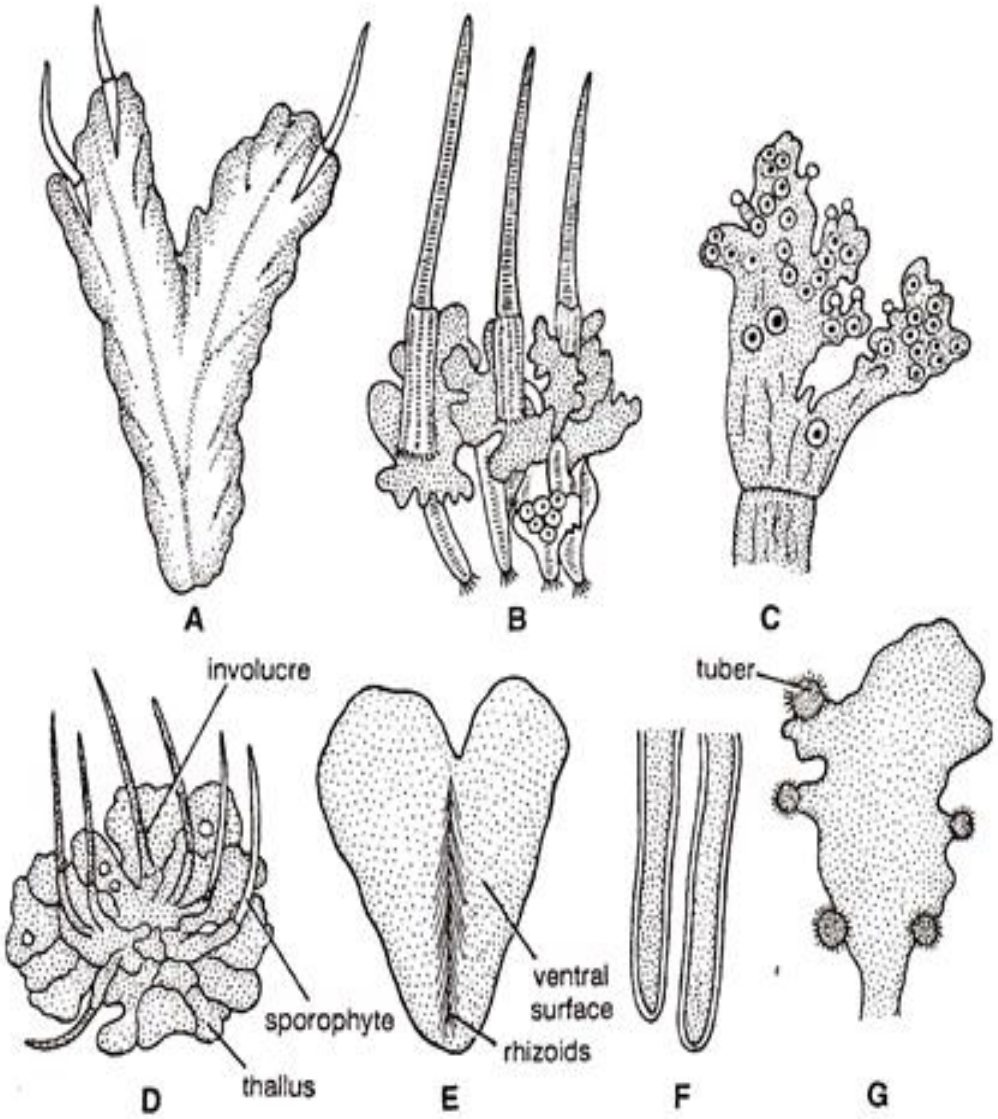
EXTERNAL STRUCTURE:

The plant body is gametophyte. It is green, dorsiventrally flattened, irregularly lobed thalloid structure. The thallus is thick at the center and thin at the margin, lacking a midrib. The dorsal surface of the thallus may be smooth or velvety because of the presence of several lobed lamellae or rough with spines and ridges. It is shining, thick in the middle and without a distinct mid rib. The ventral surface bears unicellular, smooth walled rhizoids only. Many small, opaque, rounded, thickened dark bluish green spots can be seen on the ventral surface. These are the mucilage cavities filled with Nostoc/Anabaena colonies. The mature thalli have erect, elongated and cylindrical sporogonia. These are born like and arise in clusters. Each sporogonium is surrounded by a sheath like structure on its base. It is called involucre. Sex organs are situated on the dorsal surface and are embedded in the tissue of the thallus. The sporophyte, however, is linear, elongated structure, arising from the dorsal side.

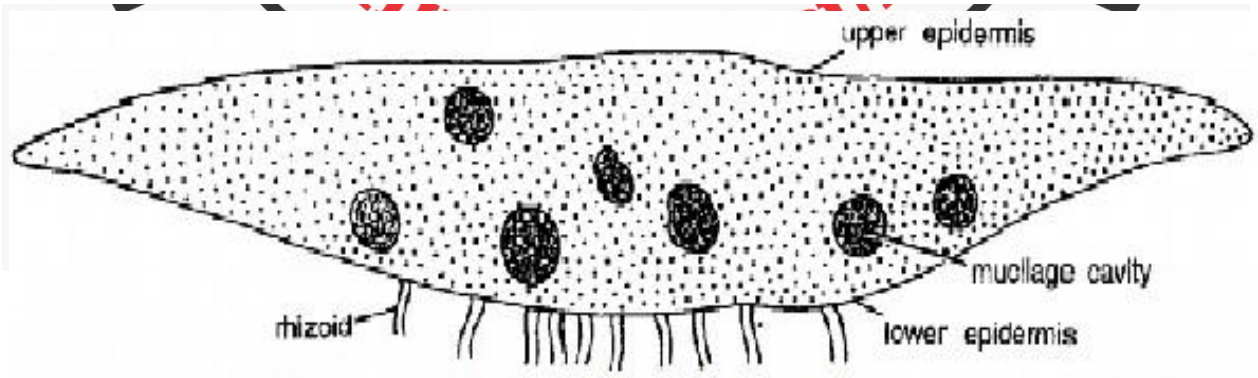
V.T.S OF THALLUS:

Thallus is a few cells in thickness in the middle and becomes thinner towards the margins. Internal structure is homogenous. Air pores and air chambers are absent. Parenchymatous tissue lies between the two epidermises i.e., upper and lower epidermis. A parenchymatous cell has a distinct nucleus and a chloroplast. Each of the cells has a large chloroplast with a single pyrenoid except cells of lower epidermis giving rise to rhizoids. On the ventral surface there are certain mucilage filled cavities which open by slime pores, through the ventral epidermis. The endophytic algae Nostoc or Anabaena present in the mucilage cavities enter through the slime pores.

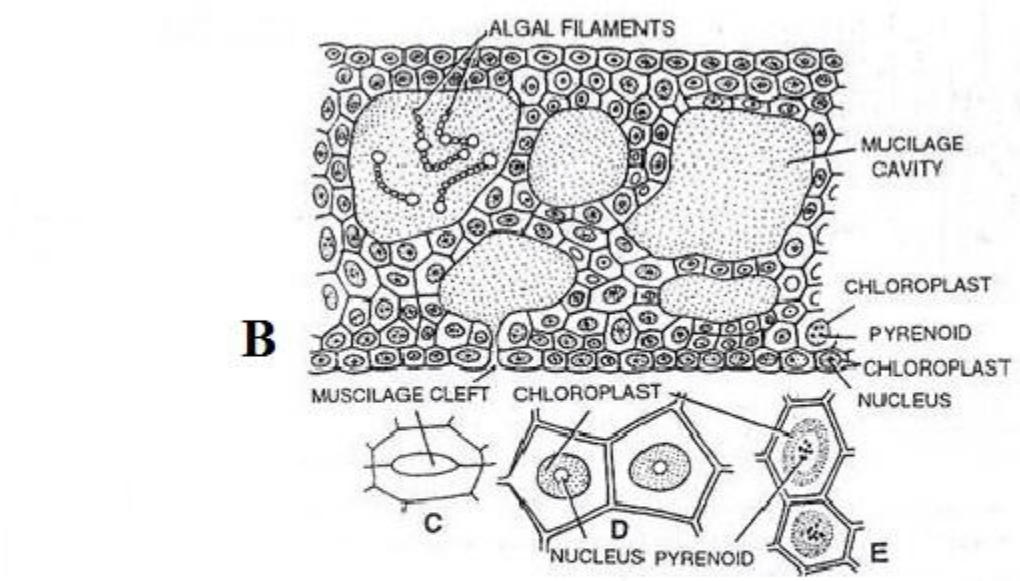
Rhizoids are smooth – walled and arise in the middle region of the thallus from the lower epidermis.



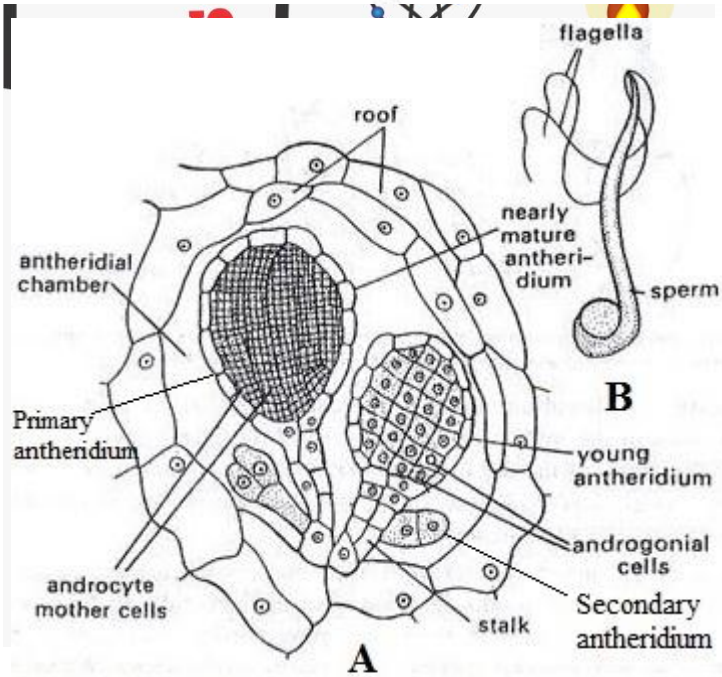
1. (A-F). *Anthoceros.* External features (A) *A. himalayensis*, (B) *A. erectus*, (C) *A. gemmulosus*, *crispulus* (dorsal surface), (E) Ventral surface, (F) Smooth–walled rhizoids, (G) Thallus with tubers.



V.T.S OF THALLUS.



B. A PORTION OF V.T.S OF THALLUS.
C. MUCILAGE CLEFT OF THALLUS
D & E. PARENCHYMA CELLS WITH CHLOROPLAST, NUCLEUS AND PYRENOID



A. V.S OF ANTHERIDIUM
B. BIFLAGELLATED ANTHEROZOID

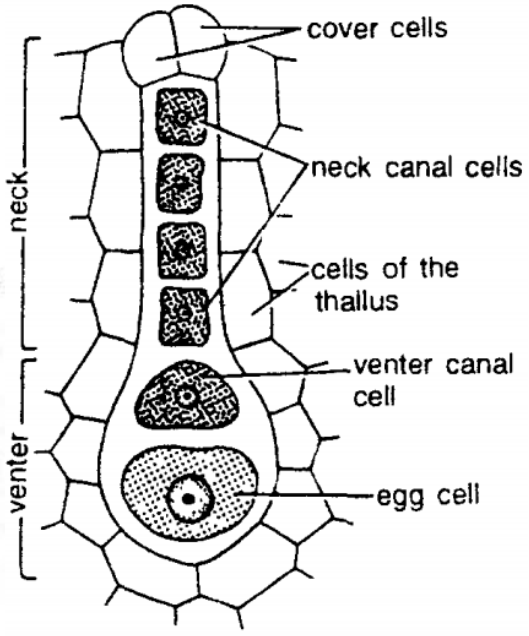


Fig. 7. ***Anthoceros.*** An archegonium.

REPRODUCTION: Vegetative Reproduction takes place by death and decay of the older portion of the thallus or fragmentation, tubers, Gemmae, persistent growing apices, apospory etc.

Anthoceros may be monoecious or dioecious plant. It reproduces sexually by developing in the male and female sex organs. The male sex organs are called antheridia and the female sex organs called archegonia. They are embedded in the dorsal region of the thallus and very close to the apical cells.

STRUCTURE OF THE ANTHERIDIUM:

Antheridia are embedded in the dorsal surface of the thallus in small cavities called antheridial cavities. Each cavity has a roof made up of two layers of cells. Each antheridial cavity contains about 1 - 4 or more primary antheridia. Secondary antheridia bud out from the stalks of these primary antheridia and ultimately there may be 25 in each antheridial cavity.

The mature antheridium is a stalked, club- shaped structure with single layered jacket. The antheridium encloses a large number of androcytes which later develop into antherozoids.

STRUCTURE OF ARCHEGONIUM:

It is a flask shaped structure embedded on the dorsal surface of the thallus. Only cover cells are projected out from the thallus and the rest part is completely embedded in the thallus. Archegonium consists of single egg cell at the venter and one venter canal cell above it. There are 4 – 6 neck canal cells present in the neck part surrounded by gametophytic tissue.

STRUCTURE OF MATURE SPOROPHYTE:

The sporophyte is an erect cylindrical horn like structure present above the gametophyte and it shows three regions like foot, seta and capsule.

Foot is the basal bulbous part completely embedded in the thallus.

Seta is the short middle part connecting the foot to capsule. It consists of actively dividing meristematic cells.

Capsule is the major part of the sporophyte. It is upright green cylindrical body. Internally it shows three regions namely collumella, sporogenous region and capsule wall. Columella is the central core of capsule consists of 16 vertical rows of elongated cells. It gives mechanical support. The sporogenous tissue region present around the columella and it contains of different stages of the development of the spores from base to top. There is a single layer of sporogenous cells at the base. Above the sporogenous cells there are alternatively arranged spore mother cells and elater mother cells. Just above this region there are spore tetrads in between the elaters. At the terminal part of the capsule there are haploid, free spores present between the elaters. The elaters are also called pseudoelaters. The capsule wall is outermost protective layer of the capsule.

The wall of the capsule is made up of 4- 6 layers of cells present around the sporogenous region. The outermost layer of cells is called epidermis and the inner layers of cells consists of chloroplasts constitute the photosynthetic tissue. Some stomata are also present in the epidermal layer.

The T/S of capsule at maturity shows the central collumella surrounded by sporogenous cavity with the presence of number of free spore tetrads and elaters. They are surrounded by 4 – layered capsule wall.

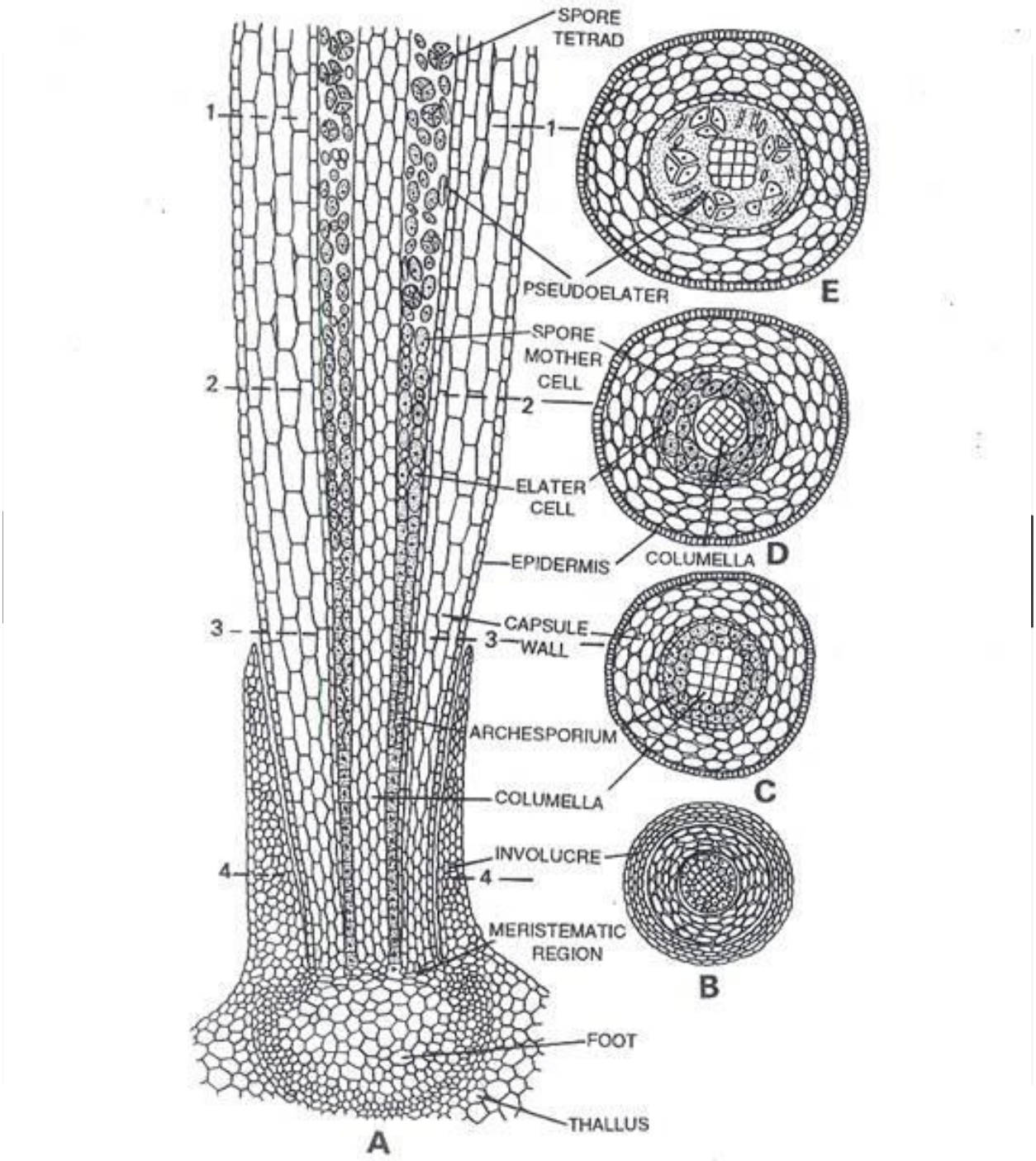


Fig. 22.10. *Anthoceros* sp. A, longitudinal section of sporogonium; B, cross section of sporophyte (A) at 4-4; C, cross section of sporophyte (A) at 3-3; D, cross section of sporophyte (A) at 2-2; E, cross section of sporophyte (A) at 1-1.

Funaria(Moss)

Class: Bryopsida
Order: Funariales
Family: Funariaceae
Genus: *Funaria*

INTRODUCTION:

The genus *Funaria* is represented by 117 species. The well-known species is *Funaria hygrometrica*. Usually grows on damp soil, wet walls etc.

EXTERNAL STRUCTURE:

The main plant body is gametophyte. It is erect, slender and reaches a height of 2 – 4 cms. It has a central axis called stem maybe branched or unbranched, the stem is anchored to the soil with the help of rhizoids. The rhizoids are multicellular with oblique cross walls. The stem is surrounded by a number of spirally arranged leaves or phylloids. The leaves are sessile simple entire wit distinct midrib. They are closely packed towards the upper portion than the lower regions. The apex leaves are called perichaetial leaves. They are very large and radially arranged around the sex organs, hence the apex of the shoots are called moss flowers. In mature female plants the gametophore bearing sporophytes are seen. Sporophyte is a diploid plant body vertically grown upwards, the foot part is embedded in the gametophytic tissue. Some lower leaves bear small, multicelled gemmae on midrib regions. Anatomically the leaf show single layer of chlorophyllous cells, the midrib is made up of central cylinder composed of narrow elongated thin walled dead cells. They are surrounded by few large chlorophyllous cells.

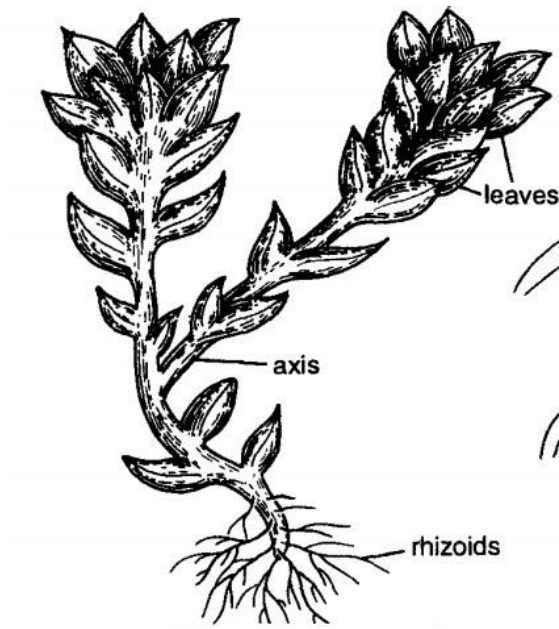
INTERNAL STRUCTURE:

The transverse section (T. S.) of axis can be differentiated into three distinct regions:
(i) Epidermis (ii) Cortex (iii) Central conducting strand or central cylinder.

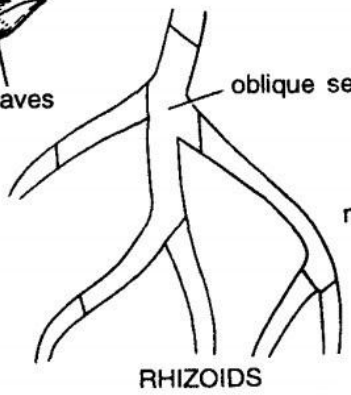
(i) Epidermis:
It is the outer most single layered protective covering consisting of small tangentially elongated chlorophyll bearing cells.

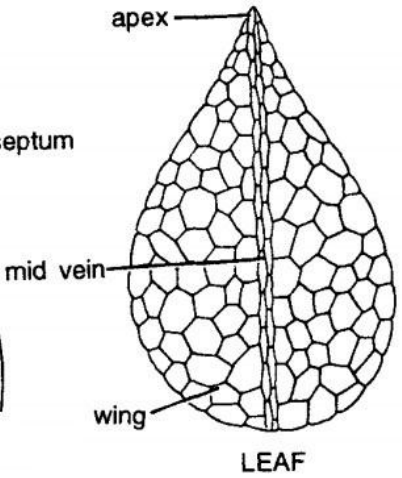
(ii) Cortex:
It is present between the epidermis and conducting tissue. It is made up to parenchymatous cells. Younger part of the cortex contains chloroplasts but in the older part they are lacking.

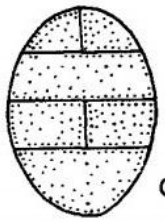
(iii) Central Conducting Strand:
It is made up of long, narrow thin walled dead cells which lack protoplasm. These cells are now commonly called as hydroids. Conducting strand besides providing a certain amount of mechanical support, functions in the upward conduction of water and solutes.



HABIT OF *Funaria* GAMETOPHORE







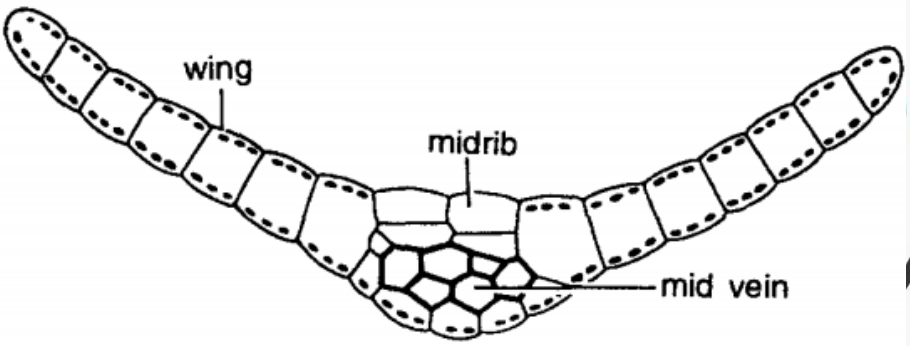


Fig. 3. ***Funaria.*** T.s. leaf (cellular).

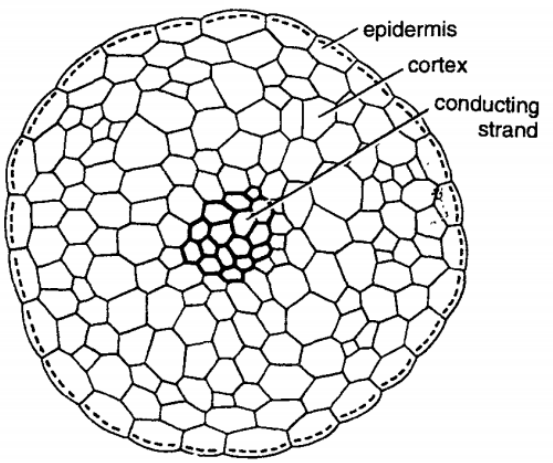
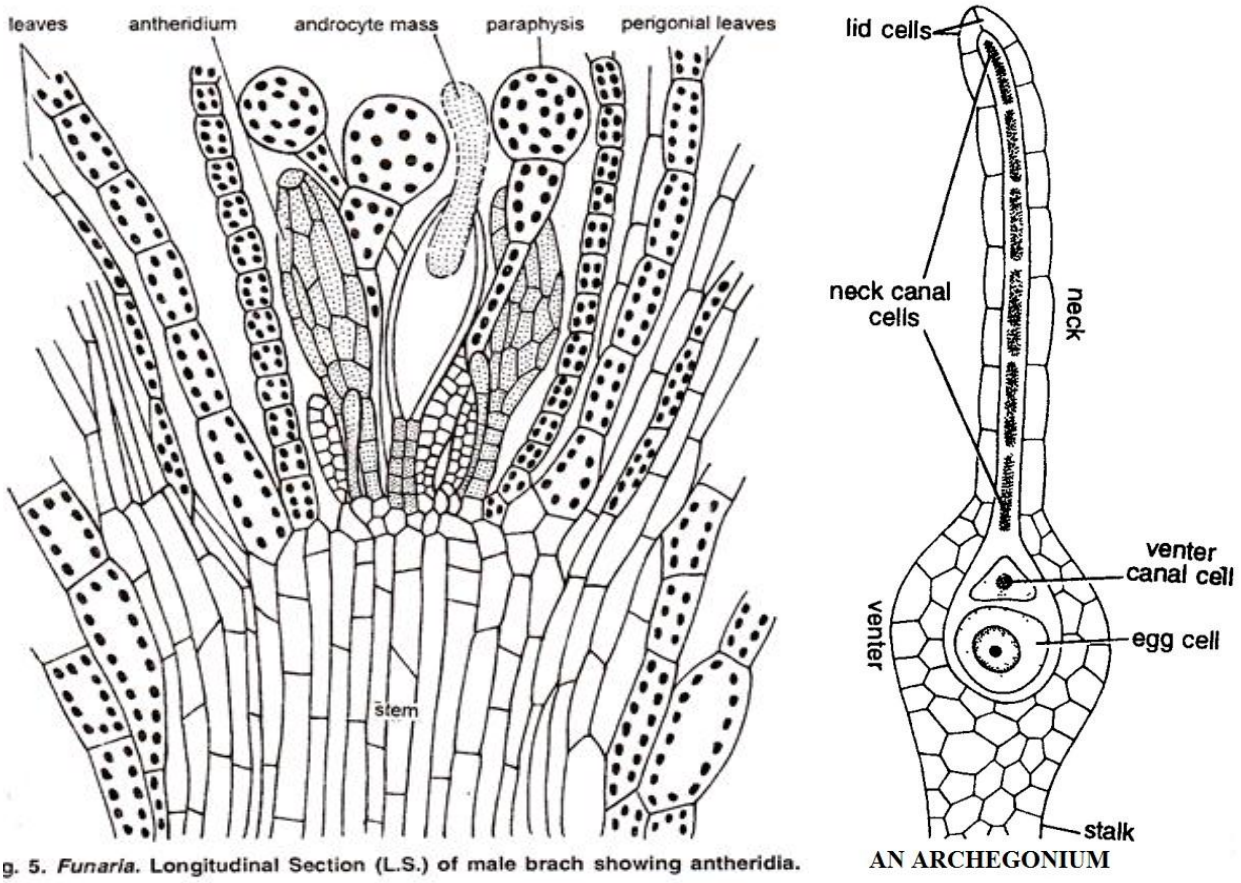


Fig. 2. ***Funaria.*** T.s. axis (cellular).



g. 5. *Funaria*. Longitudinal Section (L.S.) of male brach showing antheridia.

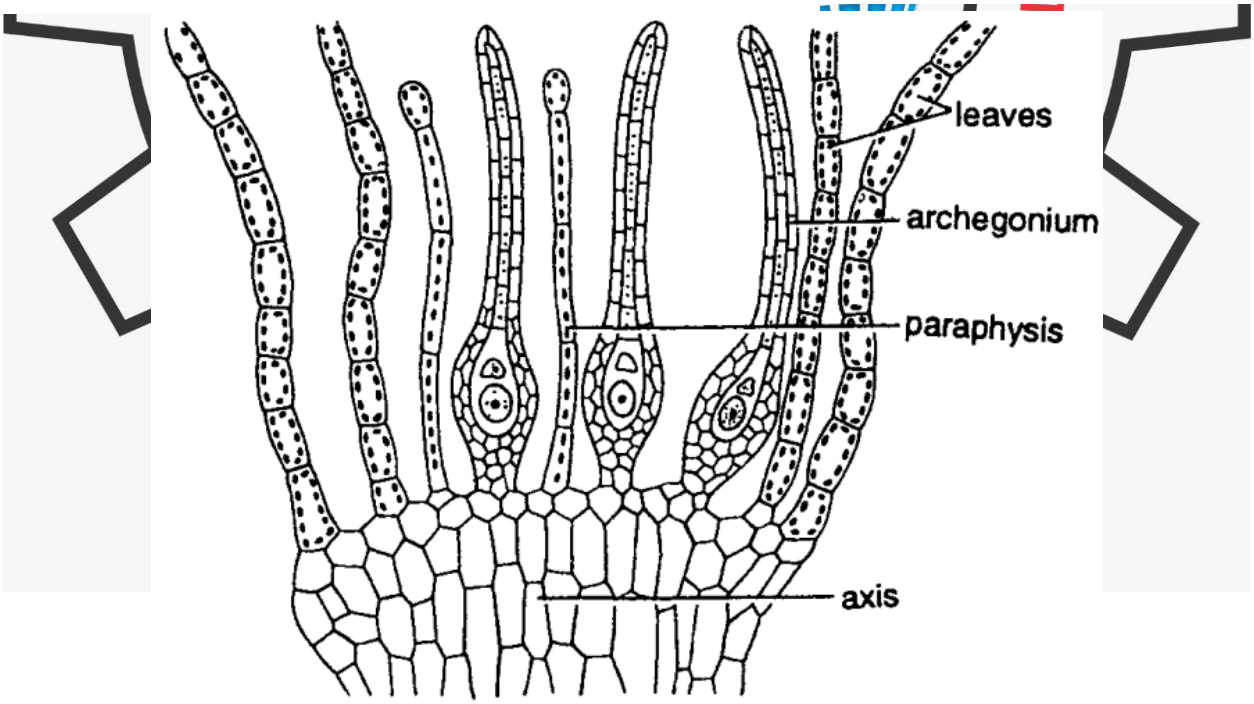


Fig. 5. *Funaria*. L.s. apex of the female branch showing archegonia.

ANATOMY OF LEAF:

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

REPRODUCTION:

Funaria is either monoecious or dioecious. The sex organs are present at the apices of branches. They are enclosed by a group of leaves at the apex.

STRUCTURE OF L/S OF THE APEX OF MALE FLOWER (ANTHERIDIAL BRANCH):

- Intermingled with antheridia are multicellular capitate hairs, known as paraphyses.
- Both antheridia and paraphyses are surrounded by large leaves, known as perichaetial leaves.
- The mature antheridium consists of a 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 jacket is an operculum, which helps in the liberation of antherozoids.
- A dense central mass of androcytes lies within the jacket.

STRUCTURE OF L/S OF FEMALE FLOWER (ARCHEGONIAL BRANCH):

- The archegonia 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.
- The matured archegonium is a multicellular, stalked structure with a broad venter and a 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 a egg cell.

SPOROPHYTE:

EXTERNAL FEATURES:

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. The capsule is slightly oblique and pear shaped. Calyptra covers the apex of the capsule.

INTERNAL FEATURES:

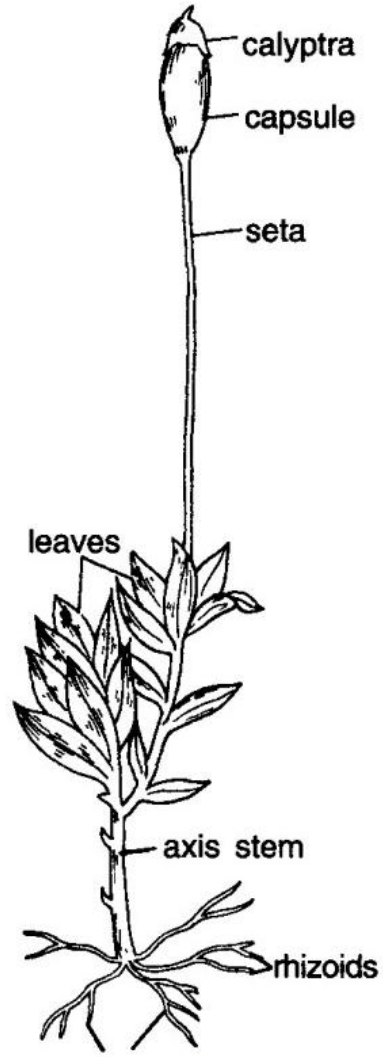
L.S OF THE CAPSULE SHOWS THREE REGIONS:

(i) Apophysis, (ii) theca proper and (iii) upper region.

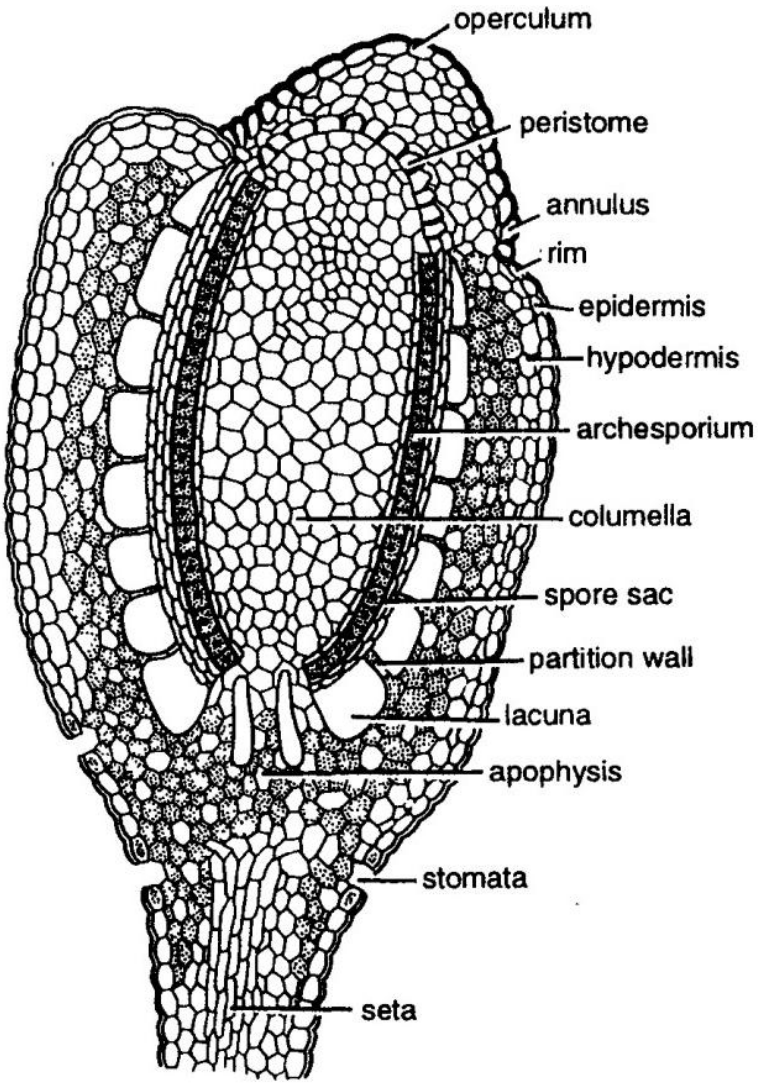
- Apophysis is the basal region. In its centre is a conducting strand in continuation with that of seta.
- Around the conducting strand are few layers of cells with intercellular spaces and chloroplast. The epidermis in this region is ventilated (stomata present)
- The theca proper is the fertile region. It has a central columella, the upper part of which is cone- shaped, projecting into the concavity of the operculum. On the basal end, it is connected with the central tissue of the apophysis.
- Around the columella is a U shaped spore sac, broken at the base, thus separating the two arms of U.
- Spore sac has an outer wall of 3 – 4 layers and an inner of one layer. Between these only spores are present, elaters being absent.
- The spore has an inner hyaline endosporium and a coloured, almost smooth exosporium.
- The wall of the capsule is many layered. Two to three inner wall layers show intercellular spaces while outermost 2 – 3 layers just beneath the epidermis are compact, parenchymatous and colourless.
- The upper region consists of operculum and peristome. It is marked off by a conspicuous constriction, immediately below which is a rim and above the annulus.
- Calyptra caps the capsule. The peristome teeth encircle the operculum. Peristome consists of 2 rows of triangular plate like teeth. Each row has 16 teeth. Hygroscopic movements in the outer peristome teeth assist in the liberation of the spores from capsule.

PROTONEMA:

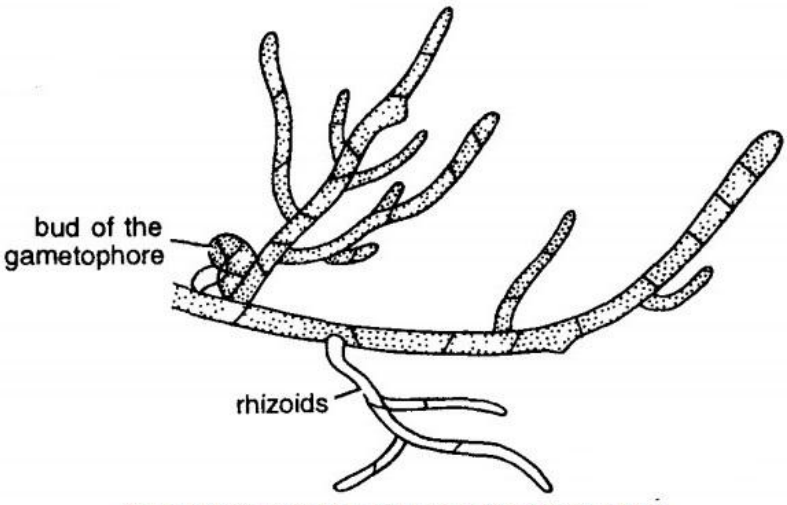
The spore on germination develops into a thalloid like body called primary protonema. The primary protonema has two types of branches they are chloronema (chlorophyllous branches) and rhizonema (rhizoidal branches). Rhizonema penetrates the substratum and helps in fixation. Many lateral buds are formed on the protonema and develop into the erect gametophores.



A GAMETOPHYTE WITH SPOROPHYTE



L/S OF CAPSULE



STRUCTURE OF PROTONEMA

Plant Anatomy

Tridax Stem

Tridax procumbens is a wild growing ephemeral mesophytic prostrate herb. *Tridax* stem may be studied as a best example of dicot stem.

A transverse section shows the three main regions viz., epidermis, cortex and stele.

EPIDERMIS-This is single layered with closely packed regular cells. Above the epidermis there is a well-defined cuticle. Some of the epidermal cells produce multicellular hairs. Occasionally stomata may be seen in the epidermis.

CORTEX- There are two regions in the cortex. The outer cortex (immediately below the epidermis) consists of a few layers of collenchyma whose corner walls are thickened by the deposition of pectin and cellulose. Next to the collenchyma, there is parenchyma constituting the inner cortex. This consists of several layers of parenchyma, some of the outer layers of which are chlorophyllous.

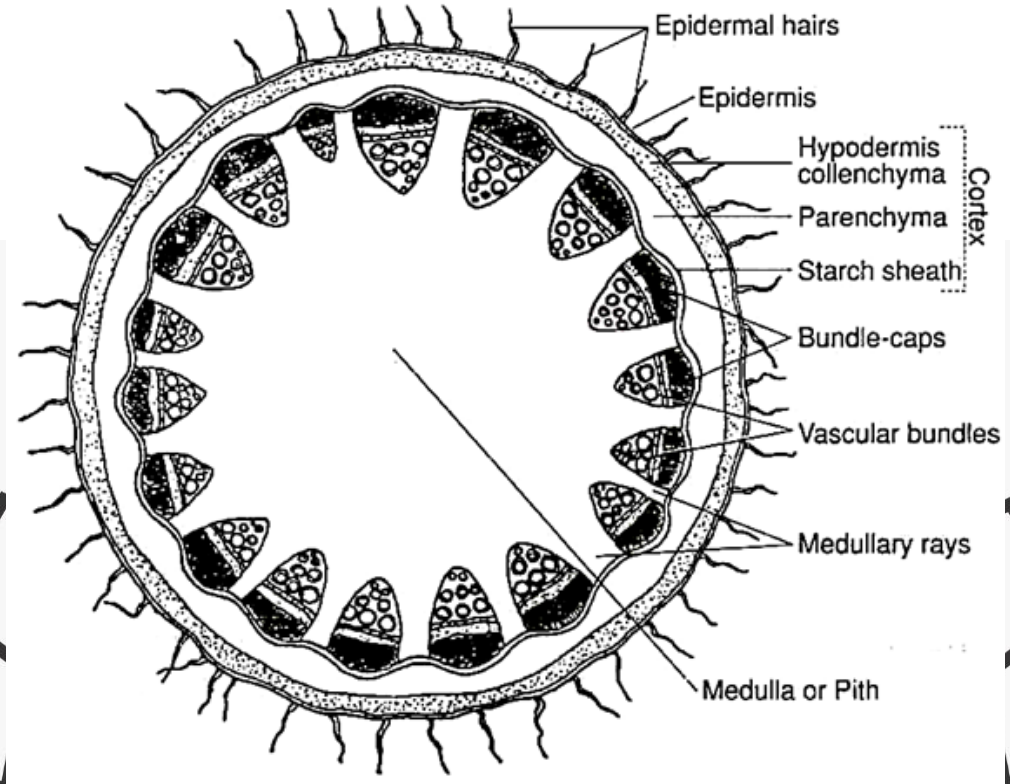
STELE- The outermost layer is the endodermis whose cells are rich in starch grains, hence also known as starch sheath. It has thickening on radial walls called casparian thickenings.

Next to the endodermis is the pericycle. It is represented by patches (cap like) of sclerenchyma present immediately above each vascular bundle.

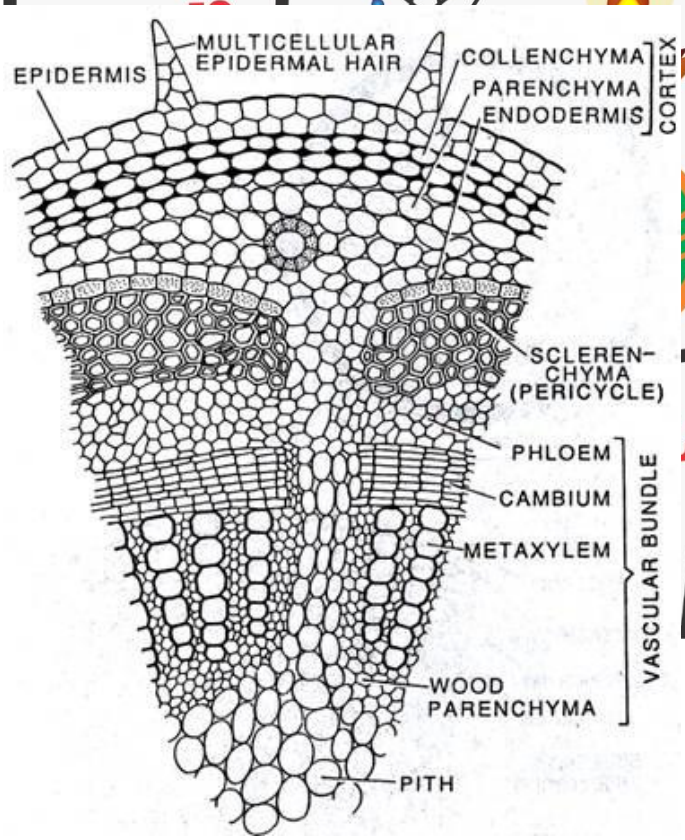
The vascular bundles are many in number arranged in the form of a ring surrounding central pith. Each vascular bundle is conjoint (xylem and phloem combining to form a single bundle), collateral (xylem and phloem on the same radius with x/p arrangement), open (open to secondary growth i.e., cambium present) with endarch (protoxylem pointing towards the pith) xylem.

Phloem consists of sieve tubes, companion cells and phloem parenchyma. In between phloem and xylem is cambium, which is said to be intrafascicular (present within a vascular bundle). The cambial cells are thin walled, rectangular and actively dividing. Next to the cambium, internally is the xylem, with the protoxylem facing the pith. Xylem consists of vessels, tracheids, wood fibers and xylem parenchyma. Between the vessels are found the wood parenchyma.

Between the vascular bundles are present radially elongated parenchyma cells constituting the primary medullary rays. Occupying the central region of the stem is a wide parenchymatous pith.



T/S OF *TRIDAX* STEM GROUND PLAN



A PORTION ENLARGED

ANAMOLOUS SECONDARY GROWTH IN *Boerhaavia* STEM:

Boerhaavia diffusa is a small semi-prostate spreading herb. A transverse section of the stem shows an outermost single layered epidermis. The epidermis bears a number of multicellular hairs. In the primary structure, next to the epidermis there is a hypodermis. The hypodermis is made of 2 – 3 layers of collenchyma, which is followed by parenchymatous cortex having few chlorophyllous cells. Next to the cortex is an indistinct endodermis lining externally 1 – 2 layered pericycle. The stele consists of 3 rings of vascular bundles of which inner ring has two large centrally located medullary bundles, the middle ring is made up of 6- 14 loosely arranged bundles and the outer ring has small 15 - 20 bundles.

Secondary growth is limited in the inner and middle rings. As a result they slightly increase their size. The inter and intrafascicular cambial strips join together to form the cambial ring. The cambial cells produce secondary xylem in the intrafascicular region and lignified conjunctive tissue in the interfascicular region on the inner side and on the outer side secondary phloem facing the secondary xylem and parenchyma opposite the conjunctive tissue.

After the formation of secondary tissue, the cambium ceases its activity and a new cambial ring gets differentiated combining the secondary parenchyma cells opposite to the conjunctive tissue and the cells of pericycle outside the phloem. This accessory cambium functions in a manner similar to the fascicular cambium and produces similar tissues. As a result of this a fourth ring of vascular bundles of secondary origin are produced. Very soon this cambium also stops functioning and one more cambium gets differentiated, which also functions in a similar manner. As a result of these successive cambial differentiations several concentric rings of vascular bundles are formed. These vascular bundles get embedded in the thick conjunctive tissue separated by thin walled parenchyma give the appearance of growth rings.

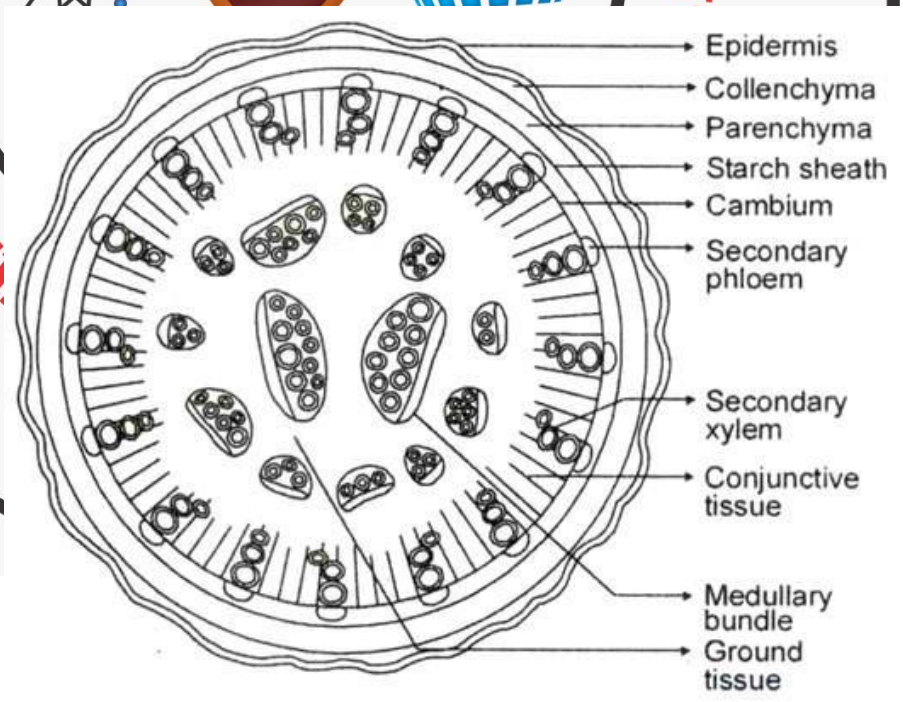


Figure 22.7
Diagrammatic transverse section of *Boerhaavia* stem.

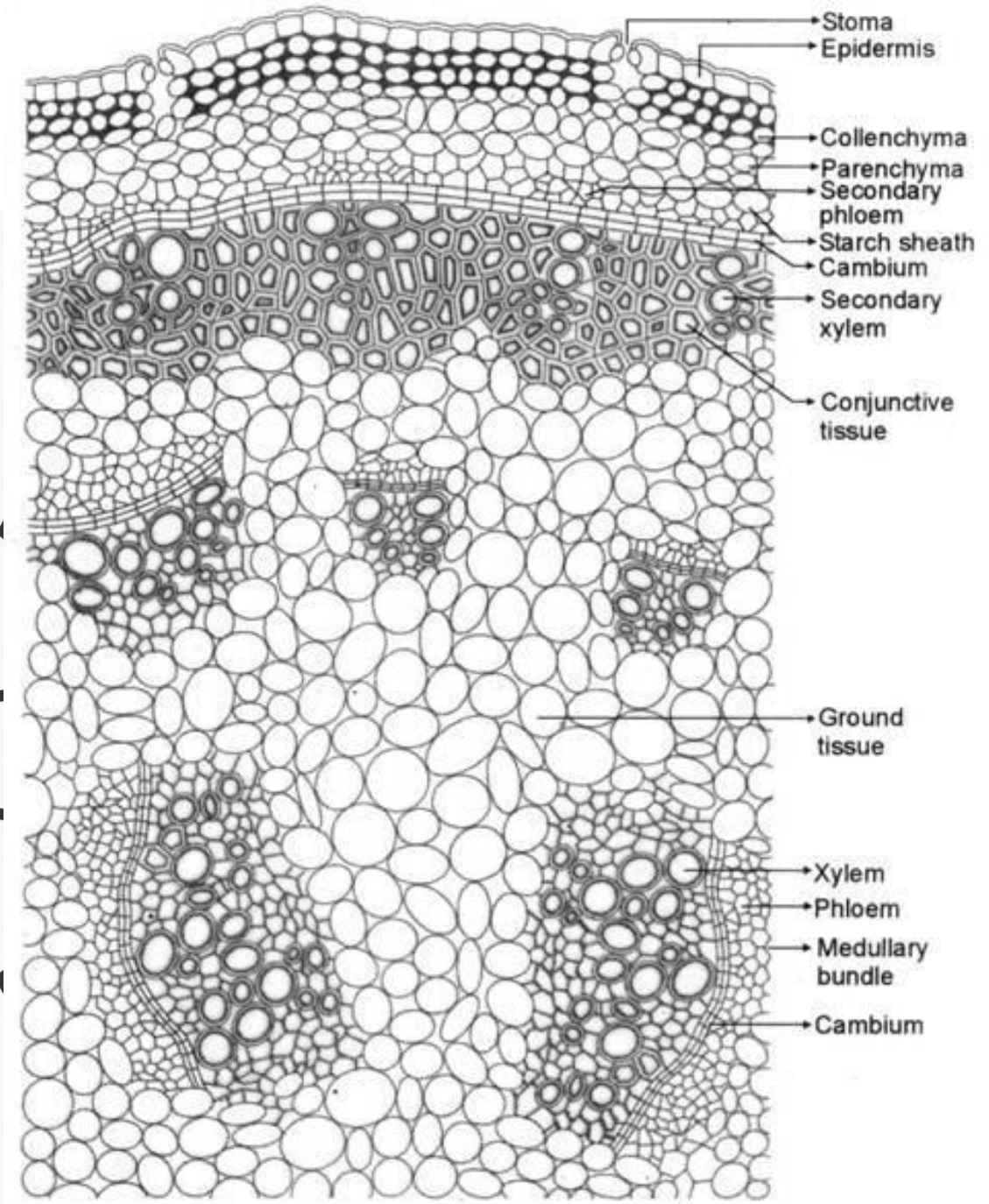


Figure 31.18

A portion of transverse section of *Boerhaavia* stem.

ANAMOLOUS SECONDARY GROWTH IN *Dracaena* Stem

Dracaena is a perennial herb. Generally, in monocots there will be no secondary growth due to the lack of cambium. Abnormally, secondary growth occurs in members like *Dracaena*, *Yucca* etc. The stem of *Dracaena* in its primary structure consists of a normal monocotyledonous structure. It has a number of conjoint, collateral and closed vascular bundles scattered in the ground tissue. Secondary growth is initiated by a multi layered cambium arising outside the primary vascular bundles. This abnormal cambium produces more cells towards its inner face than towards the outer face. The outer derivatives develop into thin walled parenchyma whereas the inner derivatives develop partly into lignified conjunctive parenchyma and partly into secondary vascular tissues. Each cambial cell divides anticlinally to form a row of four cells. Further divisions are irregular, the cells towards the periphery develop into xylem and those toward the center develop into phloem.

After secondary growth, the stem of *Dracaena* shows the following features. Outermost layer is the epidermis. Beneath the epidermis is the cork tissue. Internal to this is the parenchymatous cortex, which is secondary in origin. It is derived from the cambium. Next to the secondary cortex is the cambium. Internal to the cambium are found the secondary vascular bundles embedded in the thick walled conjunctive tissue. The secondary vascular bundles are amphivasal (phloem surrounded by xylem on all the sides). Towards the center of the stem are found the normal primary vascular bundles.

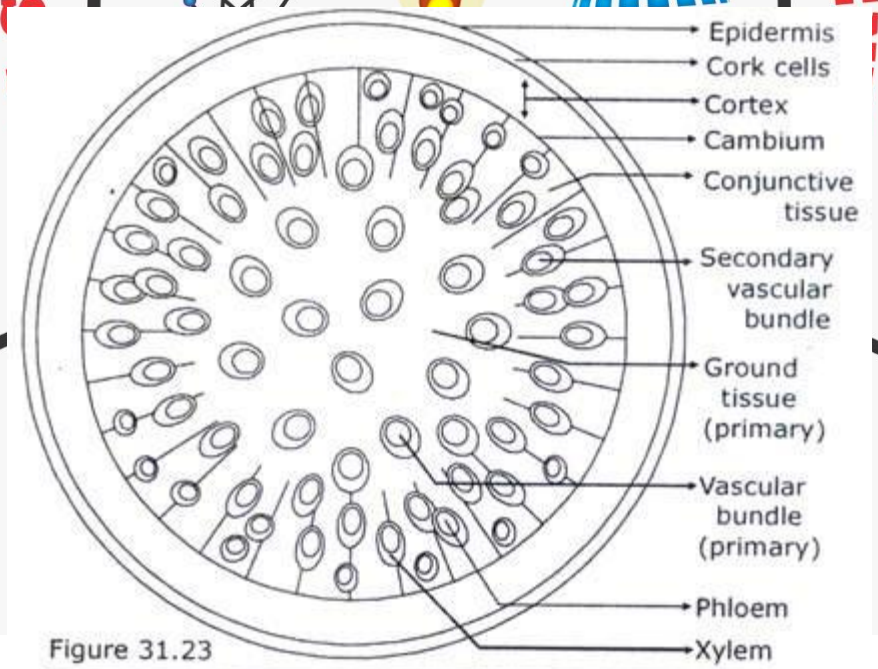


Figure 31.23
Transverse section of stem of *Dracaena* (Diagrammatic).

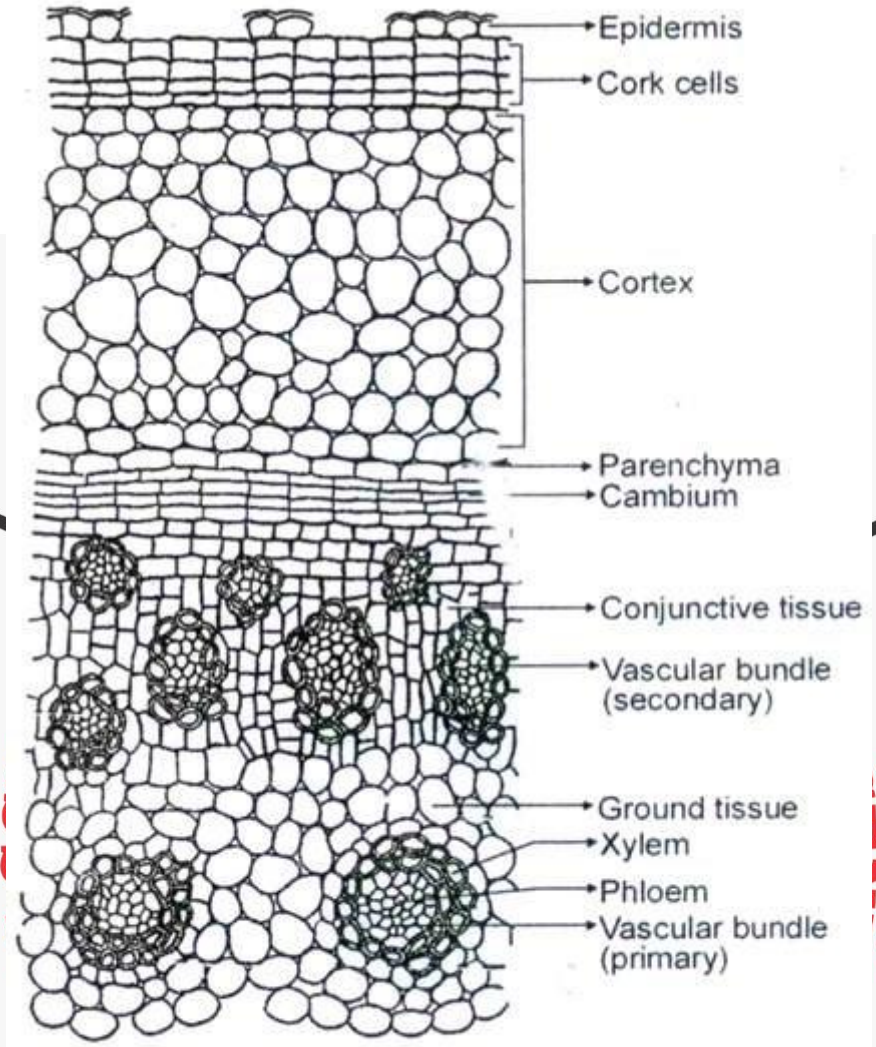
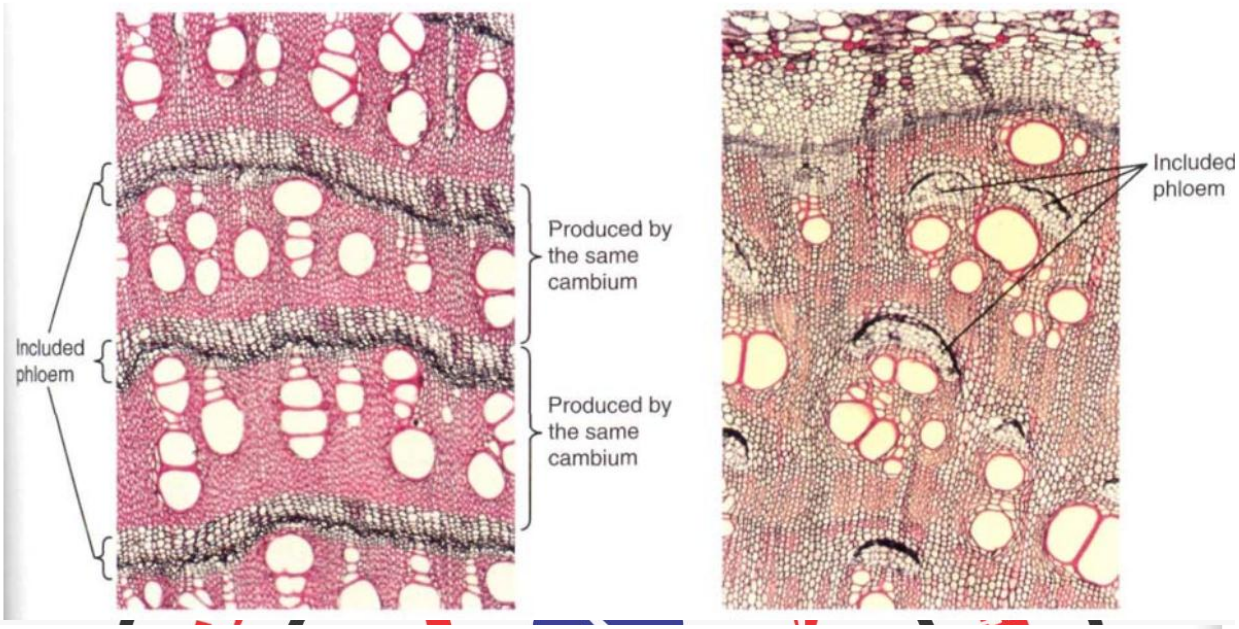
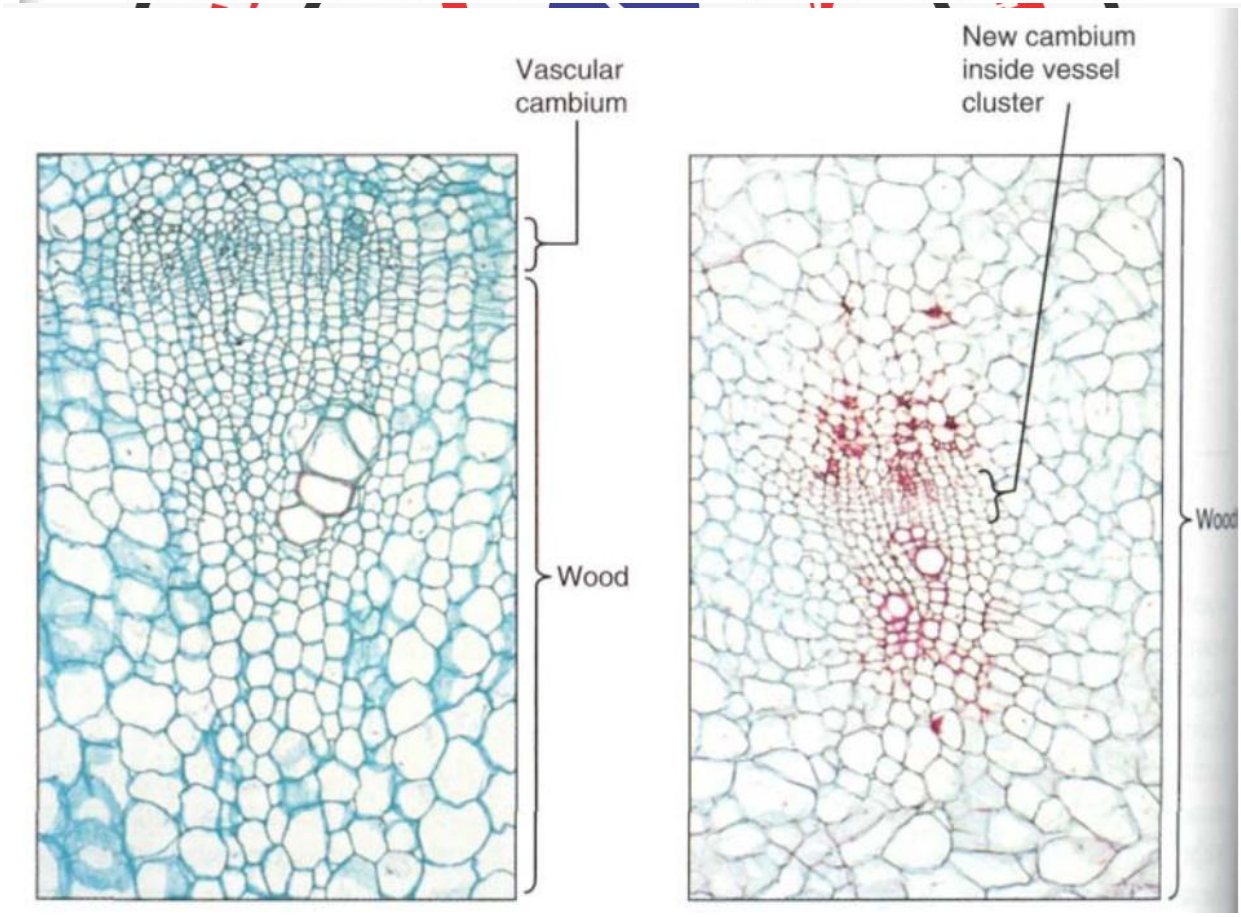


Figure 31.23A

A portion of *Dracaena* stem in cross-sectional view.


Included phloem
Produced by the same cambium
Produced by the same cambium
Included phloem


Vascular cambium
Wood
New cambium inside vessel cluster
Wood