

# **LYCOPODIUM**

**Sub- Division- Lycopsidea**

**Order- Lycopodiales**

**Family- Lycopodiaceae**

# LYCOPODIUM

## Distribution and Occurrence

- Commonly called:
  - Club moss
  - Ground pine
  - Trailing over green
- Represented by 400 species, worldwide in distribution
- In India, represented by 33 species
- Eg.- *L.cernuum*, *L. clavatum*, *L.serratum*, *L.volubile*, *L. inundatum*, *L. phlegmaria*, *L. selago*

# Habit

- Found in open woodlands, in moist and acidic soils
- Epiphytic eg.- *L. phlegmaria*
- Erect and shrubby eg.- *L. clavatum*
- Creeping forms eg.- *L. cernuum*- Gives out erect branches at intervals
- Erect branches highly branched and bushy

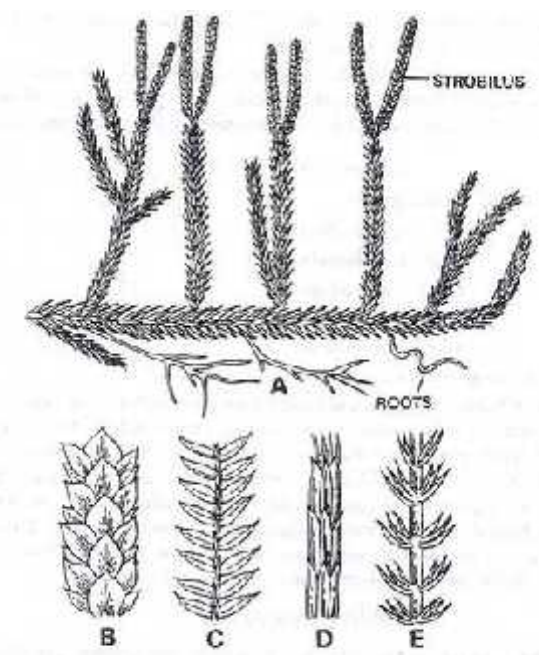
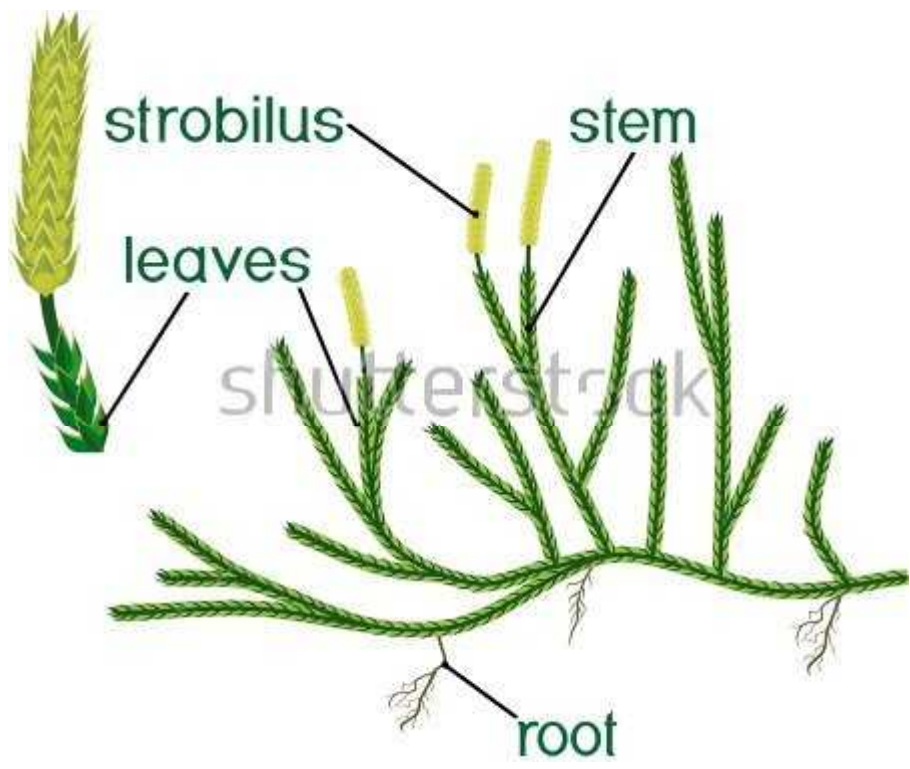


Fig. 27.1. *Lycopodium*. A, part of a plant of *L. obscurum* showing strobili; B-E, leaf form and arrangement in *Lycopodium*. B, *L. reflexum*; C, *L. volatile*; D, *L. complanatum*; E, *L. cernuum*.



*Lycopodium clavatum*



*Lycopodium volubile*



*Lycopodium phlegmaria*



*Lycopodium serratum*



*Lycopodium inundatum*

## *Lycopodium cernuum*



**Stem-** Dichotomously branched- branches grow equally or unequally



# LYCOPODIUM

## External Morphology

- Plant body is the sporophyte
- Differentiated into root, stem and leaves
- Considering the variation in habit of different species, Pritzel (1900) divided the genus *Lycopodium* into two sub-genera:
  - *Urostachya*
  - *Rhopalostachya*

# LYCOPODIUM

## UROSTACHYA

- Erect or pendant stem
- Stem-Dichotomously branched
- Roots arise only from base of stem
- Leaves and sporophylls almost same size
- Vegetative reproduction by bulbils
- Eg. *L. compactum*, *L. selago*, *L. phlegmaria*

## RHOPALOSTACHYA

- Prostrate stem with upright branches
- Dichotomy noticed in first formed branches; later monopodial
- Adventitious roots along entire length of stem
- Sporophylls smaller than foliage leaves
- Sporophylls arranged to form cones or strobili
- Eg. *L. cernuum*, *L. clavatum*, *L. densum*



# LYCOPODIUM

- Root:
  - First formed root is ephemeral. Older plants have adventitious roots; they arise from the pericycle or endodermis
- Stem:
  - Weak, slender and rhizomatous
  - Erect or pendant; creeping in others
  - Branched- basically dichotomous; sometimes monopodial
  - Stem and branches covered with leaves

# LYCOPODIUM

## Leaf

- Simple, sessile, scale like or small with median vein- Microphylls
- Spirally arranged and dense on stem
- Decussate or whorled arrangement



# LYCOPODIUM

## Leaf

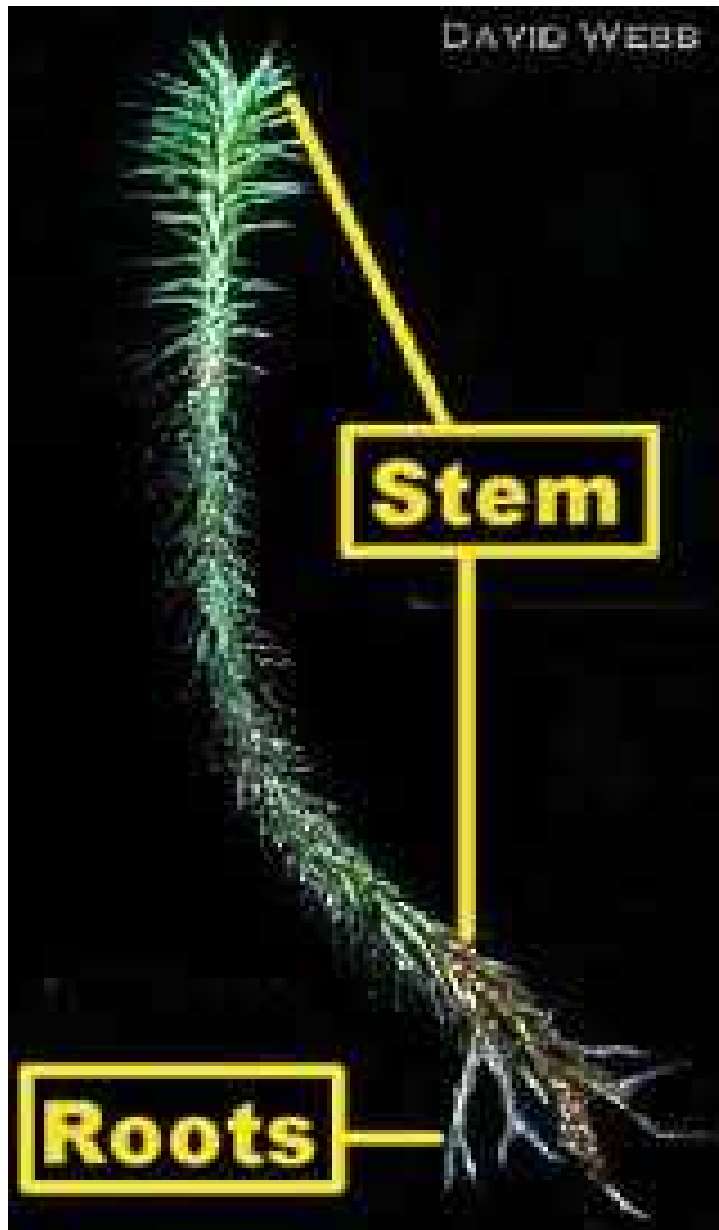
### **Isophyllous**

- All leaves are of the same type

### **Anisophyllous**

- Different types of leaves
- In *L. volubile*, 4 rows of leaves
  - 2 lateral rows of large and falcate leaves
  - 1 ventral row of small hair-like leaves
  - 1 dorsal row of medium sized acicular leaves

DAVID WEBB



# ANATOMY OF ROOT

- Cross section shows three distinct regions:
  - Epidermis- single layered, thin walled cells; sometimes with unicellular hairs
  - Cortex- Composed of parenchymatous cells; older roots have thick walled cells for mechanical support
  - Stele- Protostele; monarch (one protoxylem), diarch (two protoxylem) or triarch (three protoxylem)
  - Xylem is curved and phloem lies in between the arms of xylem

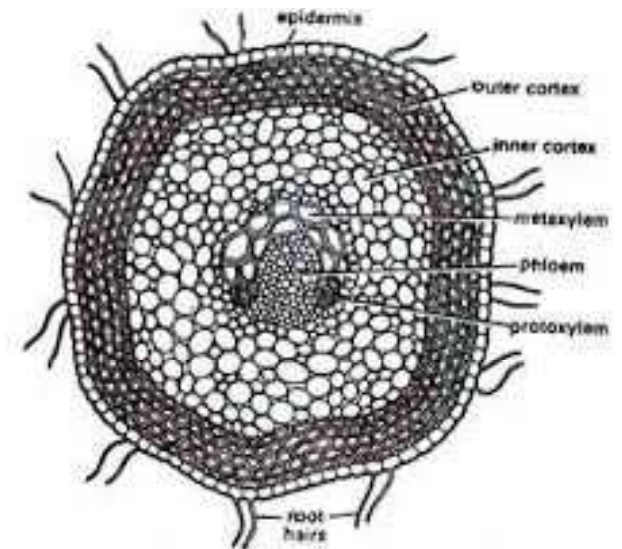


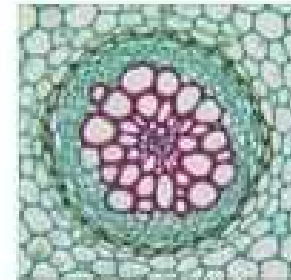
Fig. 230. Lycopodium. T.S. aerial root.

# Anatomy of Stem

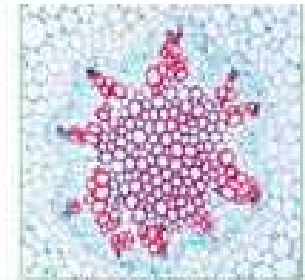
- Three zones:
  - Epidermis: Protective layer; cells with thick outer wall with cuticle
  - Cortex: Nature varies with species and stem diameter
    - Homogenous: Cortex is entirely parenchymatous
    - Heterogenous: Three zones: outer chlorenchymatous, middle parenchymatous and inner sclerenchymatous
  - Endodermis – distinct in young stems
  - Stele: Protostele

# STELE

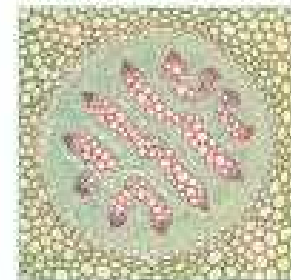
- Has only primary xylem and primary phloem
- Stele is a protosteles- there is no pith at the centre
- Xylem forms the central core surrounded by phloem
- Xylem is exarch
- 3 types of protosteles
  - Actinosteles- Xylem Star shaped, phloem between arms of xylem (*L. selago*, *L. serratum*)
  - Plectosteles- Xylem in the form of plates (*L. clavatum*, *L. companulatum*)
  - Mixed protosteles- Xylem and phloem uniformly distributed in T.S. (*L. cernuum*)



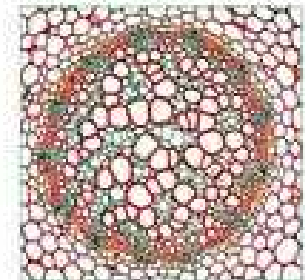
Haplostele (*Lycopodium*)



Actinosteles (*Psilotum*)



Plectosteles  
(*Lycopodium clavatum*)



Mixed Protosteles  
(*Lycopodium cernuum*)

# Anatomy of Leaf

- Leaf is triangular in outline
- Outer epidermis covered by a thick cuticle
- Stomata are present on both surfaces- amphistomatous
- In *L. companulatum* and *L. volubile*, stomata are hypostomatous- confined to lower surface
- Mesophyll is undifferentiated ; made of chlorophyllous cells
- A median concentric vascular bundle with xylem surrounded by phloem

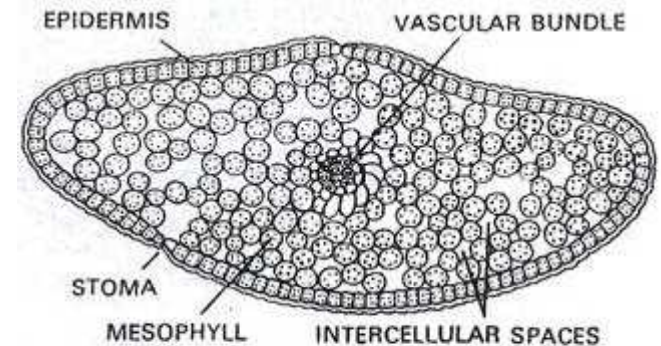


Fig. 27.5. *Lycopodium clavatum*. Transverse section of leaf.



# REPRODUCTION

- **Vegetative Reproduction**
  - Gemmae or Bulbils
  - Fragmentation
  - Formation of Resting Buds
  - Formation of Root tubercles
  - Formation of Adventitious Buds
- **By Spores**
  - **Homosporous condition**

# Vegetative Reproduction

- Gemmae or Bulbils
  - Lateral outgrowths from the stem, takes the place of leaves
  - Consists of a short reduced axis surrounded by thick fleshy leaves with stored food material
  - Falls on the ground and grows into a new plant



# Vegetative Reproduction

- Fragmentation
  - Death and decay of older parts of the stem leads to separation of younger branches which grow into new plants
- Formation of resting buds
  - Tips of apical buds of rhizome and branches store food material and is surrounded by a bunch of leaves. In winter, rest of the plant dies and the resting bud develops into new plants.

# Vegetative Reproduction

- Formation of root tubercles
  - Group of cells with stored food material and protected by thick walls- germinates into new plants
- Formation of Adventitious Buds
  - In the leaves epidermal cells proliferate near the base and grow into buds. These buds are capable of germinating into new plants.

# Strobilus in Lycopodium

- In Urostachya, every leaf on the plant is a sporophyll
- In Rhopalostachya, the leaves near the apices bear sporangia and are called sporophylls
- Sometimes sporophylls are distinctly smaller than the foliage leaves
- Aggregation of sporophylls is called strobilus
- A strobilus has a central axis on which spirally arranged sporophylls are present

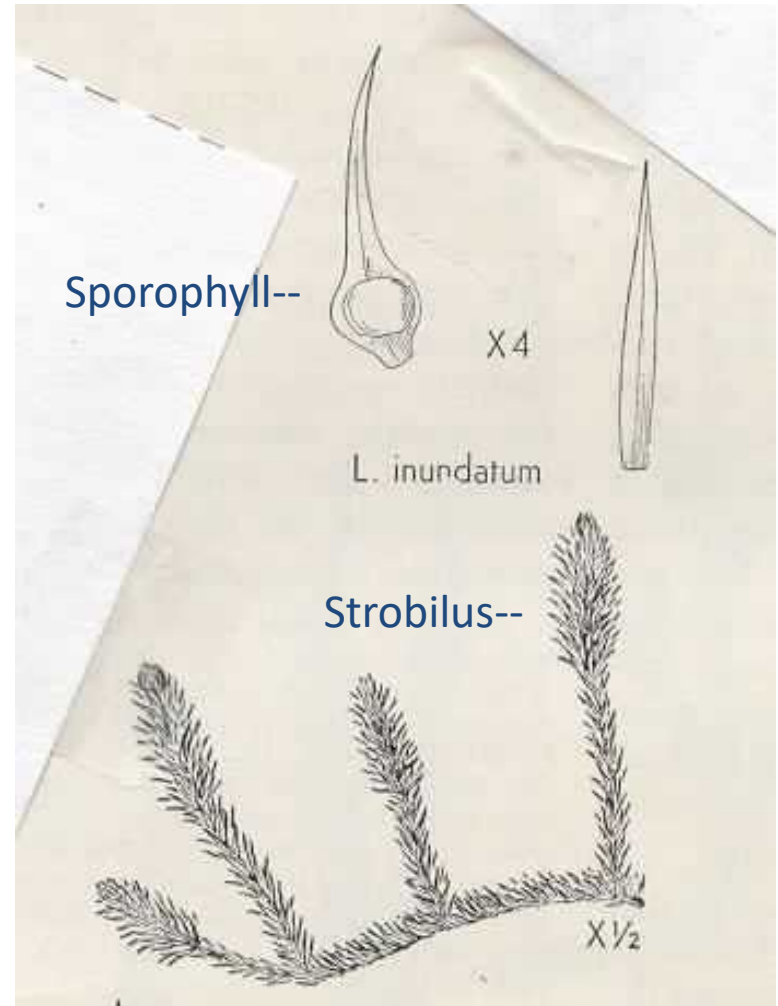


# Position of Sporangium on Sporophyll

- Axillary in position
  - L. selago, L. phlegmaria
- On the dorsal side of the sporophyll-epiphyllous
  - L. cernuum, L. clavatum
- Sub-foliar, not on the sporophyll but a little towards the sporophyll
  - L. squarrosum

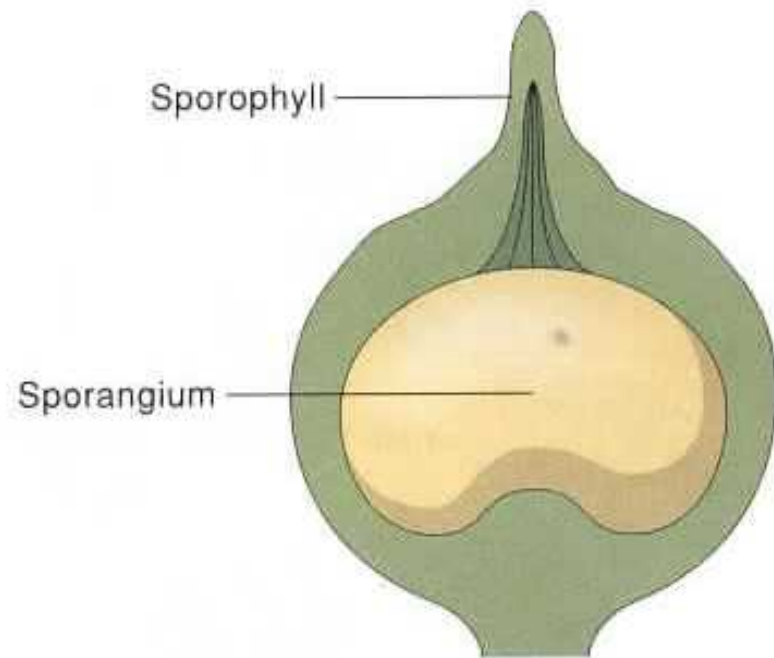
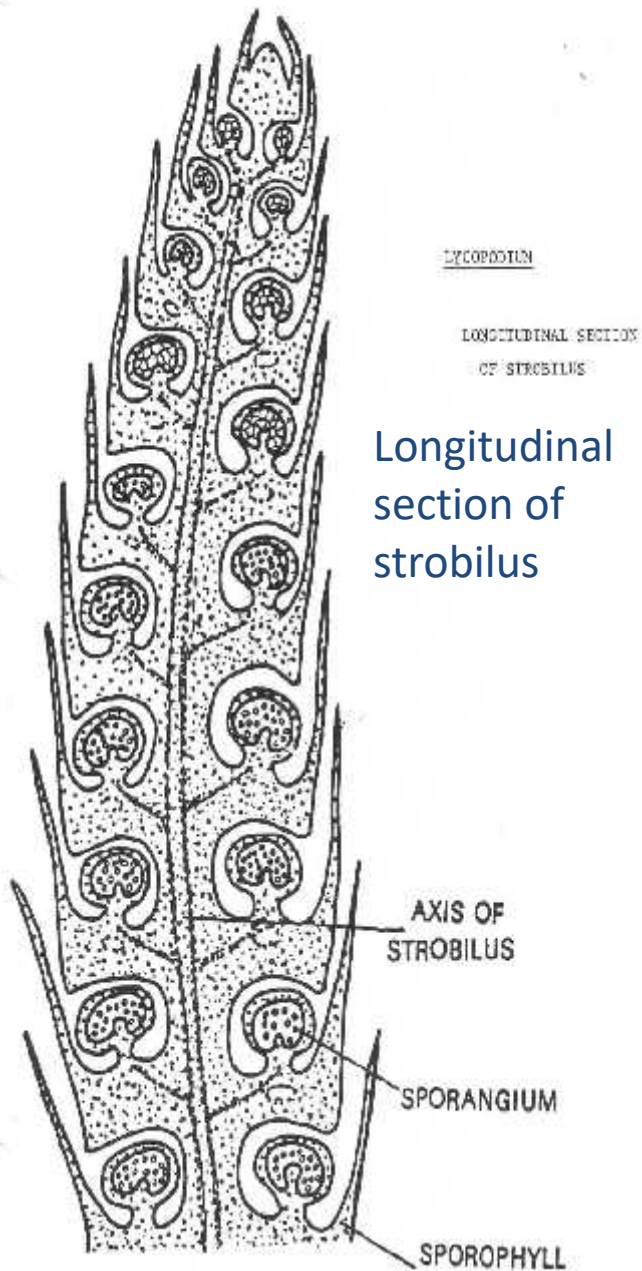


***Lycopodium obscurum***





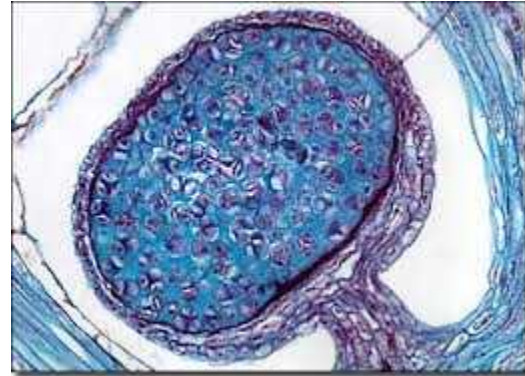
# *Lycopodium* - Strobilus, Sporophylls and Sporangia



Upper (adaxial) side of sporophyll

# Structure of Sporangium

- Reniform or Kidney shaped
- Has a stalk and a capsule
- Capsule is unilocular
- Sporangial wall is three layered
- Innermost layer is the tapetum
- Inside sporogenous mother cells undergoes meiosis and produce tetrads of spores
- Sporangia are homosporous



# Structure of the Spore

- Lycopodium is **homosporous**
- Occur in tetrads
- Tetrahedral in shape with rounded or semicircular base
- Unicellular and range in size from 0.03-0.05mm diam.
- Has a triradiate ridge, 2 layers of cell wall
- Spore wall may be smooth or variously sculptured
- Has a single haploid nucleus
- Cytoplasm filled with reserve food material



# Dehiscence of Sporangium

- Elongation of the internodes of strobilus
- Sporophylls spread out exposing sporangia
- A line of cells are differentiated on the sporangial wall called stomium
- Inner walls of cells of stomium are thick and lignified
- Exposed sporangia lose water and dry
- Split appears in the stomium and sporangia open into two valves
- Air disseminates the spores

# Germination of the Spore

- Time taken for germination varies from a few days to several years after their liberation from the sporangium
- Quickly germinating spores produce aerial short lived and green prothalli
  - *L. cernuum*, *L. inundatum*
- When spores take longer time to germinate, they get buried under the soil and produce colourless subterranean prothalli that are large, tuberous and long lived

# Germination of the Spore

- The spore germinates to produce the gametophyte
- The gametophyte is called the prothallus
- It produces the antheridia and archegonia
- It is free living independent of the sporophyte
- 2 regions- lower region attaches to the soil
- Upper region- Generative zone containing antheridia and archegonia

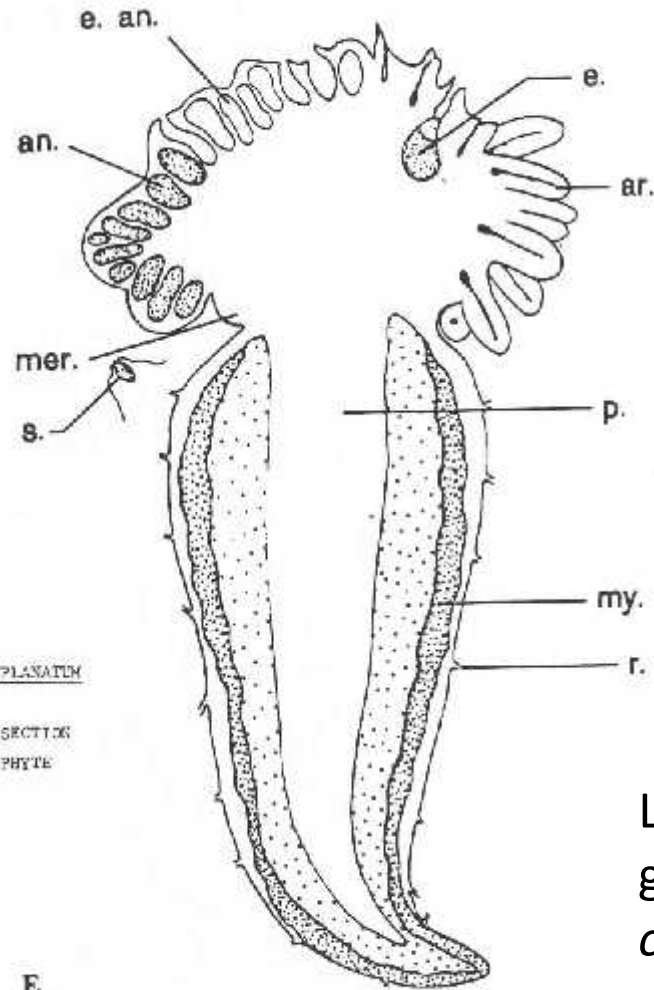
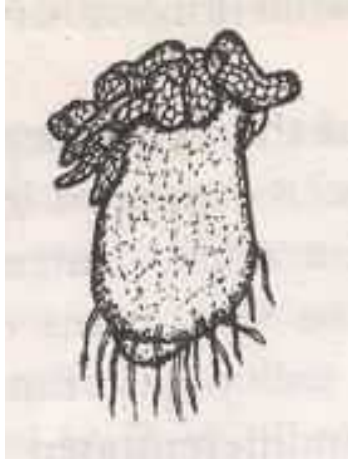
# Gametophyte

- Three types of Prothalli are present in Lycopodium
  - **Cernuum Type**
  - **Clavatum Type**
  - **Phlegmaria Type**

# CERNUUM TYPE

- *L. cernuum*, *L. inundatum*
- Erect cylindrical body, 2-3 mm long
- Grows on the surface of the ground
- Colourless basal portion buried in the soil
- Lobed generative zone-green and bearing sex organs at the base of the lobes
- Rhizoids restricted to lower buried portion
- Endophytic fungus is present in the basal portion
- Meristematic tissue present as a rim around upper part
- Prothallus is independent and prepares its own food





LYCOPEDIUM COMPLANATUM

LONGITUDINAL SECTION  
OF GAMETOPHYTE

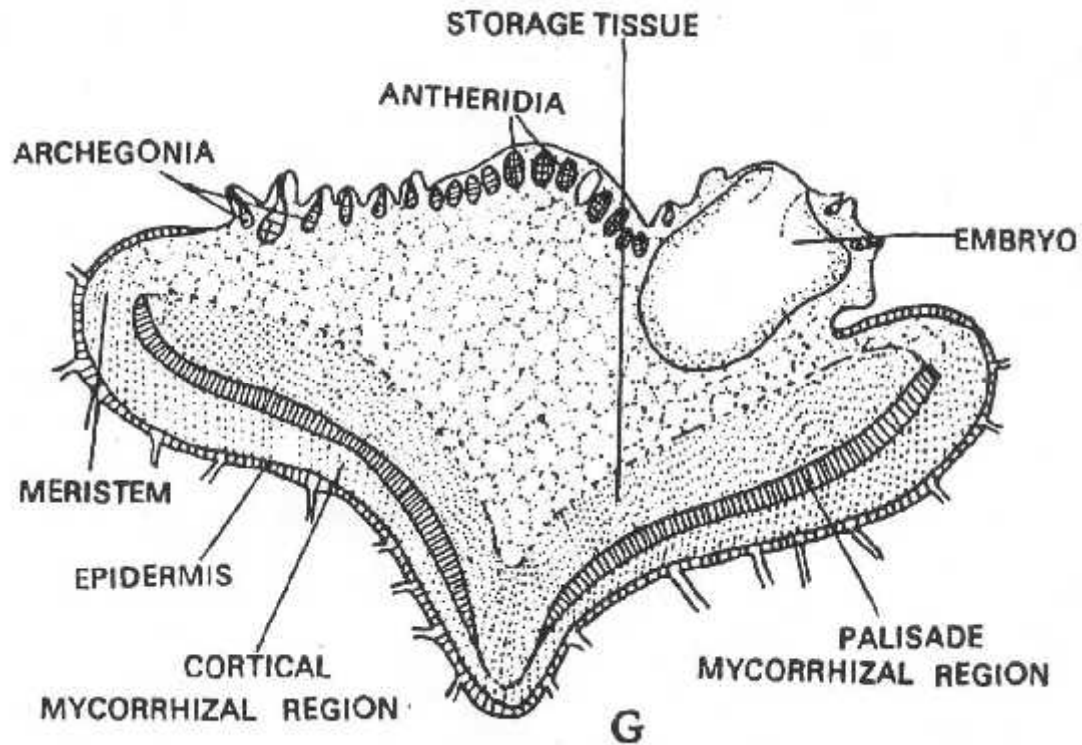
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Longitudinal section of subterranean gametophyte of *Lycopodium complanatum*

# CLAVATUM TYPE

- **Spore germination is delayed for a long time (one to many years), thus the prothallus has a longer lifespan.**
- **Here the prothalli are fleshy, non-green, totally saprophytic and completely subterranean and perennial in nature.**
- Development takes place beneath the surface of the ground or within a layer of humus.
- The prothalli are large and may be up to 2 centimeters in length. They may be top-shaped with a convolute margin or carrot shaped
- The top of the prothallus are lobed and the sex organs and the growing embryos are located on these lobes.
- All the gametophytic cells are parenchymatous

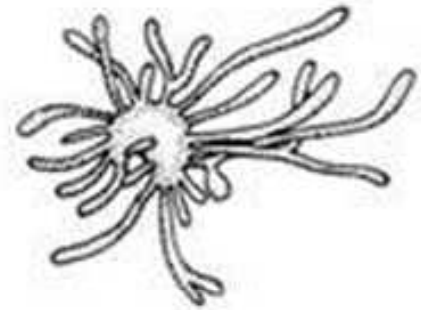
## Second type of Prothallus



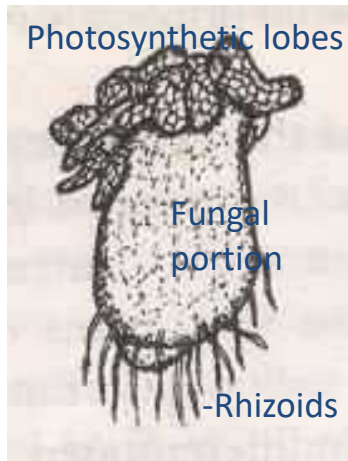
Longitudinal section of subterranean gametophyte of *Lycopodium clavatum*

# PHLEGMARIA TYPE

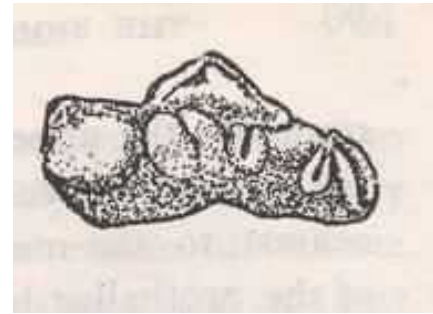
- The pro-thalli are aerial but **saprophytic in nature**, grow on tree trunks below a coating of humus.
- This type is found in epiphytic species of Lycopodium (e.g., *L. phlegmaria*).
- Here the **spore germination is immediate and the gametophyte grows for only one season.**
- The prothallus consists of a short, tuberous central part from which a number of colourless, slender and cylindrical branches develop in an irregular fashion.
- These branches bear sex organs and they are usually surrounded by glandular hairs called paraphysis.



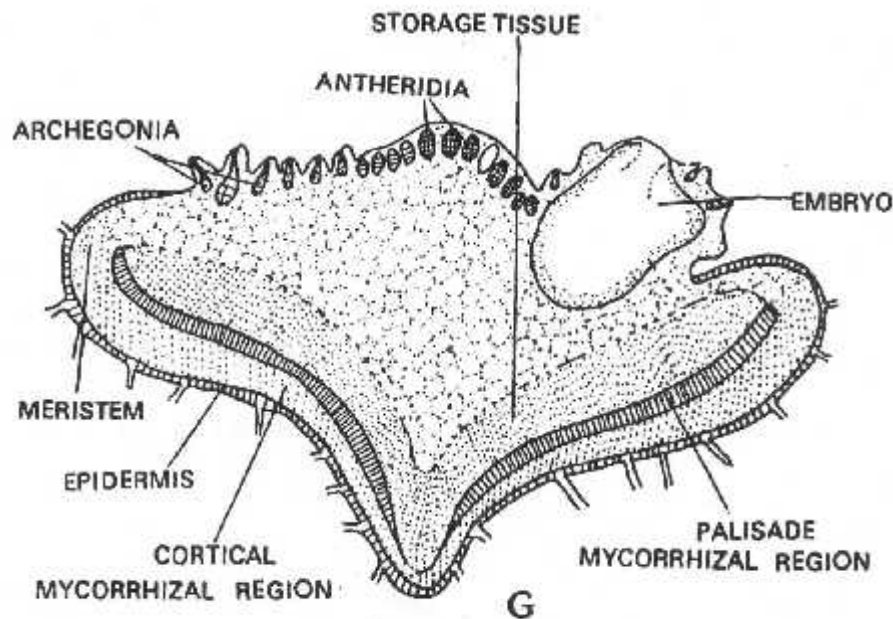
# Gametophyte diversity in *Lycopodium* spp.



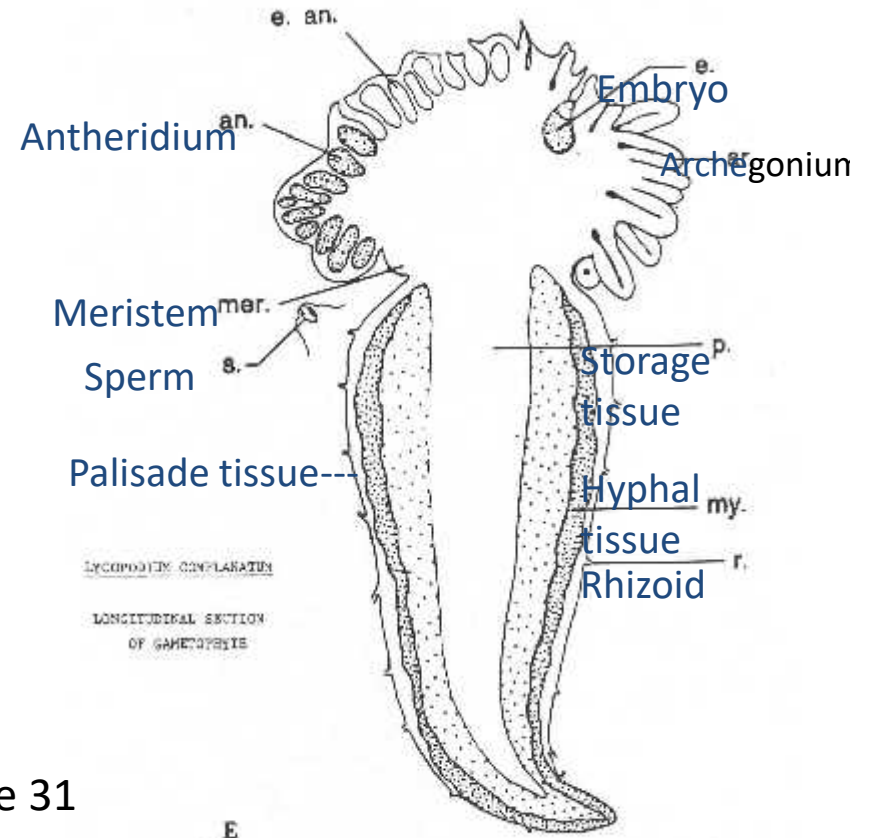
Gameto-  
phyte of *L. inundatum*



Subterranean gametophyte of *L. annotinum*



Longitudinal section of subterranean gametophyte of *Lycopodium clavatum*



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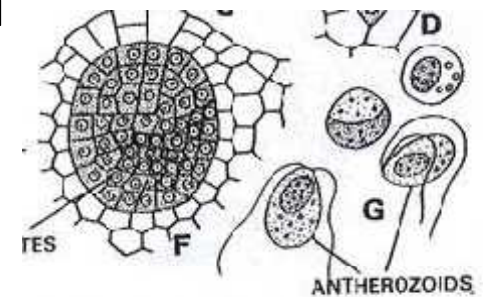
Longitudinal section of subterranean gametophyte of *Lycopodium complanatum*

# Vegetative Reproduction of the Prothallus

- By formation of gemmae
  - Borne on branches of prothallus
  - Singly or in clusters
  - Thick walled and stores food materials
  - Capable of perennation
- By progressive death and decay of older parts
- Adventitious buds arise from injured parts of the lobes

# PROTHALLI

- Prothalli are monoecious- male antheridia and female archegonia are borne on the same thallus
- ANTHERIDIUM
  - Usually sunken in the prothallus; position visible by a small bulge
  - Has a single layered jacket; an operculum cell
  - As water enters, jacket rupture and biflagellate antherozoids are liberated



Development of antheridium. A-E, successive stages in the early antheridium with androcytes; G, androcytes and mature biflagellate antherozoids.

# PROTHALLI

- ARCHEGONIA

- Flask shaped, having basal venter and a neck
- Has 4-8 neck canal cells
- Venter has a venter canal cell and an egg cell

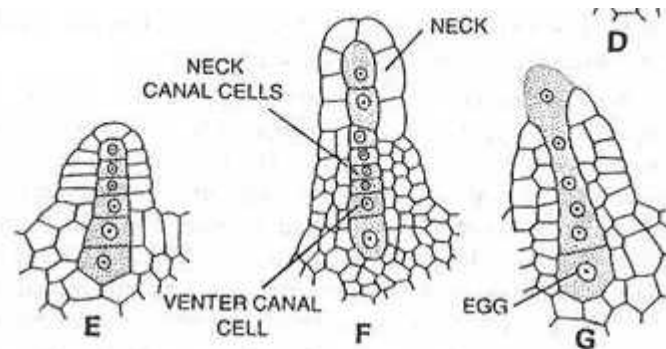


Fig. 27.21. *Lycopodium*. Development of archegonium. A, division of archegonial initial into primary neck cell and inner cell; B, vertical division of primary neck cell and transverse division of inner cell forming basal and central cells; C, central cell divides to form primary canal cell, and primary ventral cell; D-E, later stages showing basal cell, primary ventral cell and four neck canal cells; F, nearly mature archegonium with egg, venter canal cell and neck canal cells; G, mature archegonium with egg and open neck canal.

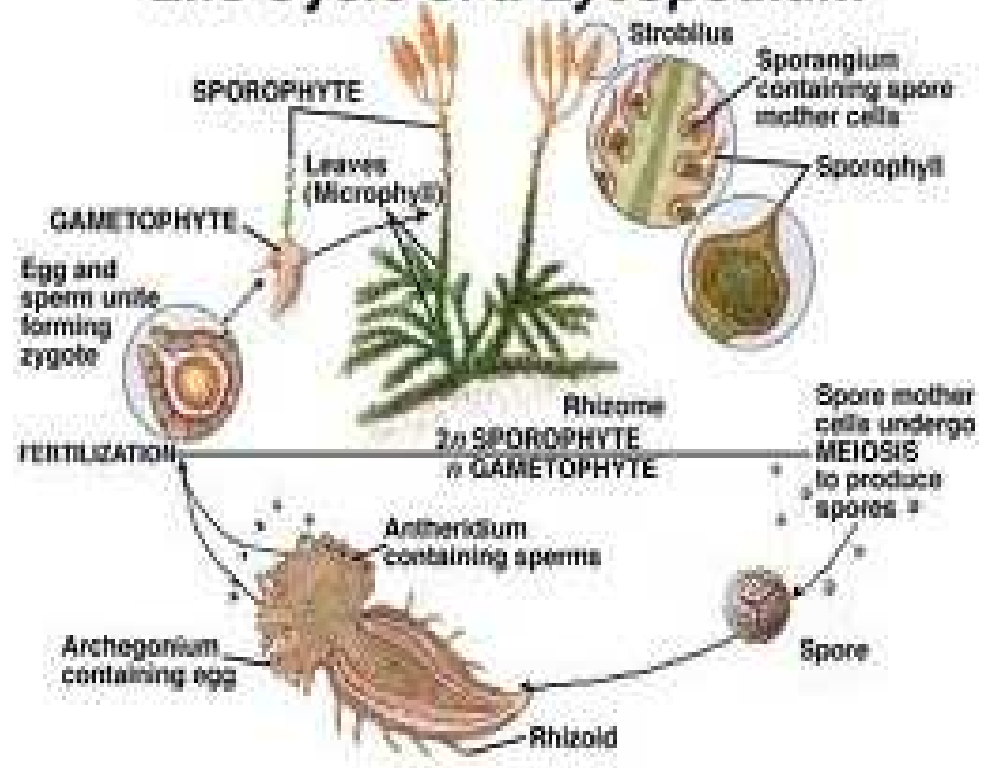


# FERTILIZATION

- When archegonium matures, tip of neck cells split, neck canal cells and venter canal cell disintegrate and form a mucilaginous substance
- Antherozoids enter the archegonium and one fuses with the egg to form the oospore
- The diploid oospore germinates and produces the sporophytic generation

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# Life Cycle of a *Lycopodium*



## CICLO DE *LYCOPodium CLAVATUM* (Lycopodiales, Lycopodiophyta) DIGENETICO-HETEROMORFICO CON ESPOROÏTO DOMINANTE, DIPLOHAPLOÏASICO ORGANISMO DIPLOÏDENTICO e ISOSPOROÏ

