Lycopodium

By
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Classification

DIV. Lycopodiophyta
Class : Lycopsida
Order: Lycopodiales
Family: Lycopodiaceae
Genus: Lycopodium

Two subgenera:

Urostachya : erect (e.g., *L. selago*) or pendent (e.g., *L. phlegmaria*) plants which are never creeping. They may be un-branched or dichotomously branched. The adventitious roots come out only through the base of the stem and are not to be found along the surface of the stem. The sporophylls are green and usually of the same size as the vegetative leaves. In L. selago or smaller forming strobili at the tips

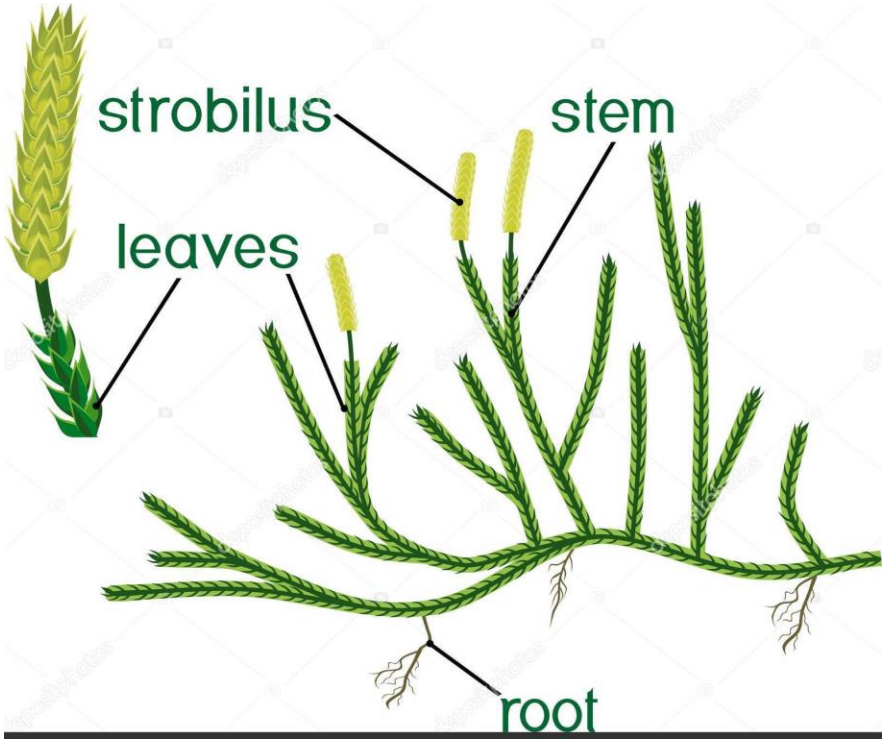
Rhopalostachya: the stem is prostrate with adventitious roots developing on the under surface of the prostrate stem. In some species (e.g., L. phlegmaria), however, the sporophylls, though green, are shorter and localised at the tips forming distinct dichotomously branched strobili. e.g. : *L. clavatum* , *L. cernuum*, L. *complanatum* etc.

Habit and Habitat

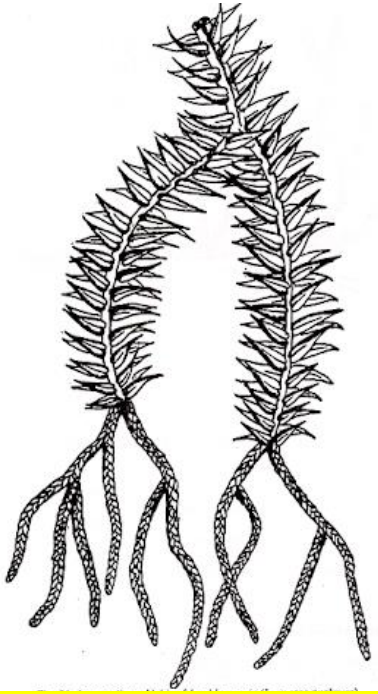
Lycopodium is a large genus with about 180 species having world-wide distribution in tropical to temperate regions. They are herbaceous, terrestrial plants or erect to pendent epiphytes. The stems are densely covered with microphylls and are protostelic. The genus is homosporous with the sporangia on the adaxial faces of the sporophylls.

Terrestrial species: *L. clavatum, L. cernuum, L. complanatum. L. selago*
Epiphytic species: *L. phlegmaria*

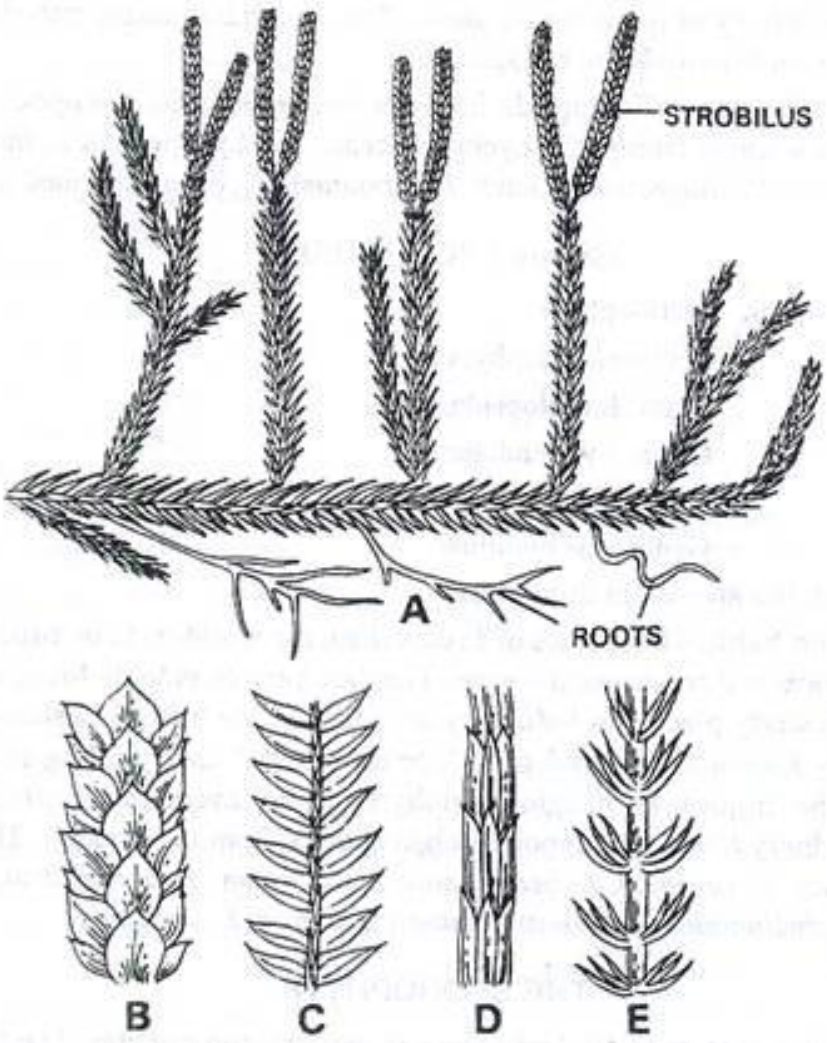
External Morphology



Lycopodium clavatum



Lycopodium phlegmaria



Lycopodium. A, part of a plant of *L. clavatum* showing strobili; B-E, leaf form and arrangement in *Lycopodium*; B, *L. refescens*; C, *L. volubile*; D, *L. complanatum*; E, *L. cernuum*.

The plant body is distinctly differentiated into following three regions

(i) Stem,

(ii) Roots, and

(iii) Leaves.

(i) Stem:

In the sub-genus Urostachya stem is erect (terrestrial) or pendent (epiphytic) and may be branched (dichotomously) or unbranched. In the sub-genus Rhopalostachya the stem is prostrate with erect branches. First the branching is dichotomous and later on becomes monopodial.

(ii) Root:

Usually small, adventitious roots are present. In the sub-genus Urostachya roots originate only from the base of the stem (not arising from the whole length of the stem). In some species e.g., L. selago etc. the roots arise endogenously from pericycle of the stem, do not penetrate the cortex of the stem but turn downward through the cortex and finally emerge only at the base of the stem.

Due to this reason a T. S. of stem usually shows roots within the cortex and are known as cortical roots (inner roots). In sub-genus Rhopalostachya also roots are adventitious and arise all along the underside of the prostrate portion of the stem.

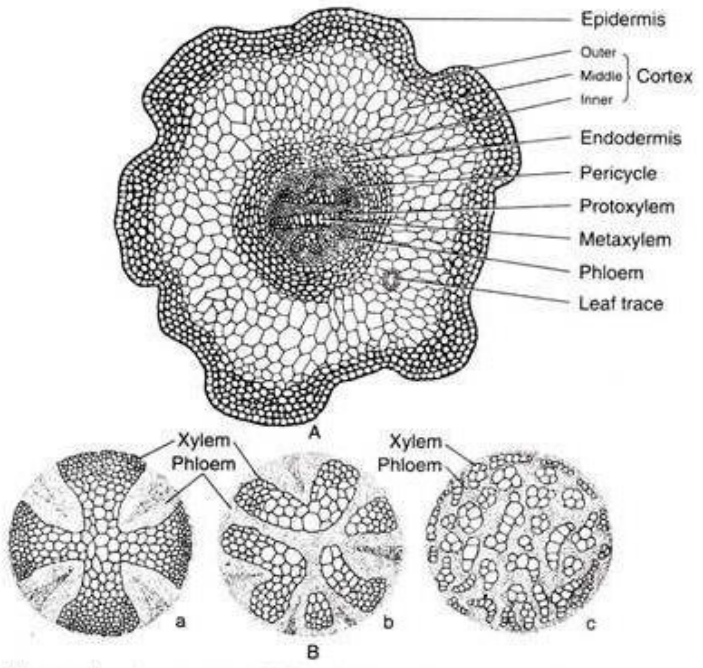
(iii) Leaves:

Leaves are simple, sessile, small in size, eligulate and possess a single unbranched midrib and are known as microphylls. Usually the leaves are spirally arranged (e.g., *L. clavatum*) but may be arranged in whorls (e.g., *L. cernuum*) or pairs (e.g., *L. alpinum*).

In all the cases they condensely cover the surface of the stem. Leaves are usually homophyllous (isophyllous) i.e., of same size and shape but in some cases e.g., in L. complanatum the leaves are heterophyllous (anisophyllous) i.e., of different size.

Usually the leaves near the apical portion of the branches bear sporangia and are called sporophylls. Depending upon the species the sporophylls may or may not be differentiated from the ordinary leaves. These sporophylls usually form a condense structure at the apex of the branches which are known as strobili. The numbers of strobili at the tip of branches differ in different species.

Anatomy of stem



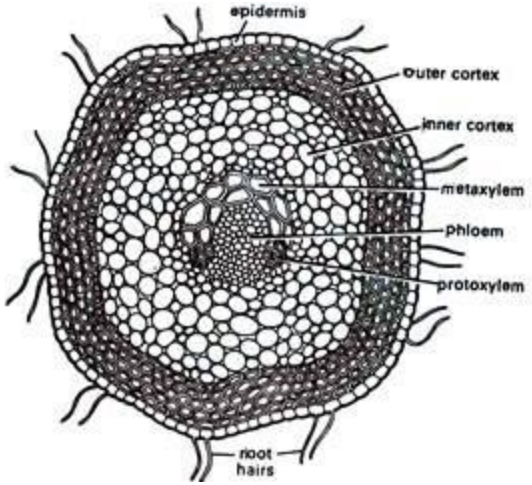
: A. T.S. of *Lycopodium clavatum* stem. B. T.S. of stelar regions of stems of (a) *L. serratum*, (b) *L. annotinum* and (c) *L. cernuum*

Outline in T.S. wavy due to leaves attached to the stem. Outermost layer epidermis covered with cuticle; cortex differentiated in to outer (slerenchyma), middle (parenchyma) and inner (sclerenchyma) regions.

Centre occupied by stele where protostele has xylem surrounded by phloem, pericycle and endodermis successively towards outer Shape of exarch xylem varies in T.S. in different species: band shaped (plectostele in L. clavatum); star shaped with wide ray ends (actinostele in L. serratum) and narrow ray ends (stellate stele in L. annotinum) in form of scattered patches (mixed protostele in L. cernuum).

Anatomy of root

The epidermis of roots has paired root hairs, cortex is undifferentiated while stele is similar to that of stem of corresponding species. In case of L. pythioides shape of xylem is semilunar



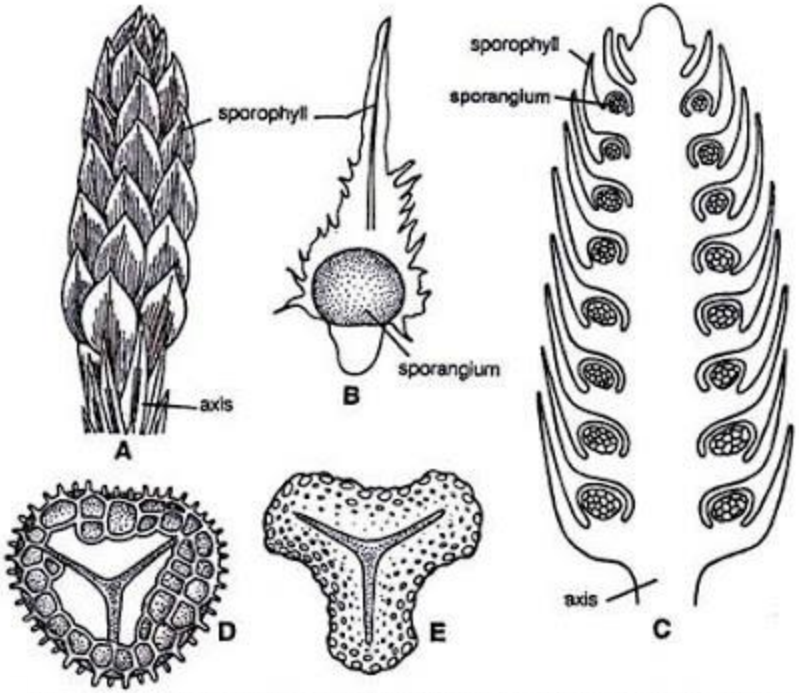
T.S. root L. pythioides

Peculiar feature : Being a primitive genus *Lycopodium* shows exarch xylem both in root and stem. Root remains unchanged through out evolution while stem became modified with endarch in majority of plants.

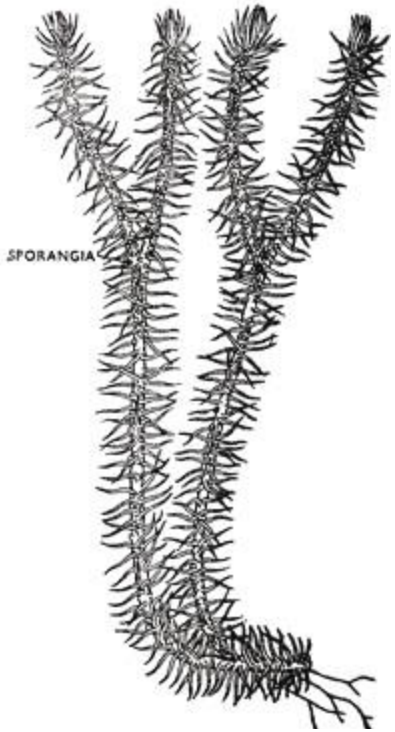
Strobilus

Homosporous, spores of same size range, trilete, sporophylls eligulate,
Strobili terminal on stem mostly erect, in *L. phlegmaria* pendand
Sporophylls either similar to vegetative leavesin size and shape or different e.g., in *L. phlegmaria* smaller

Selago condition: strobili not organized, sporophylls like vegetative leaves, sterile and fertile zones alternately present on stem



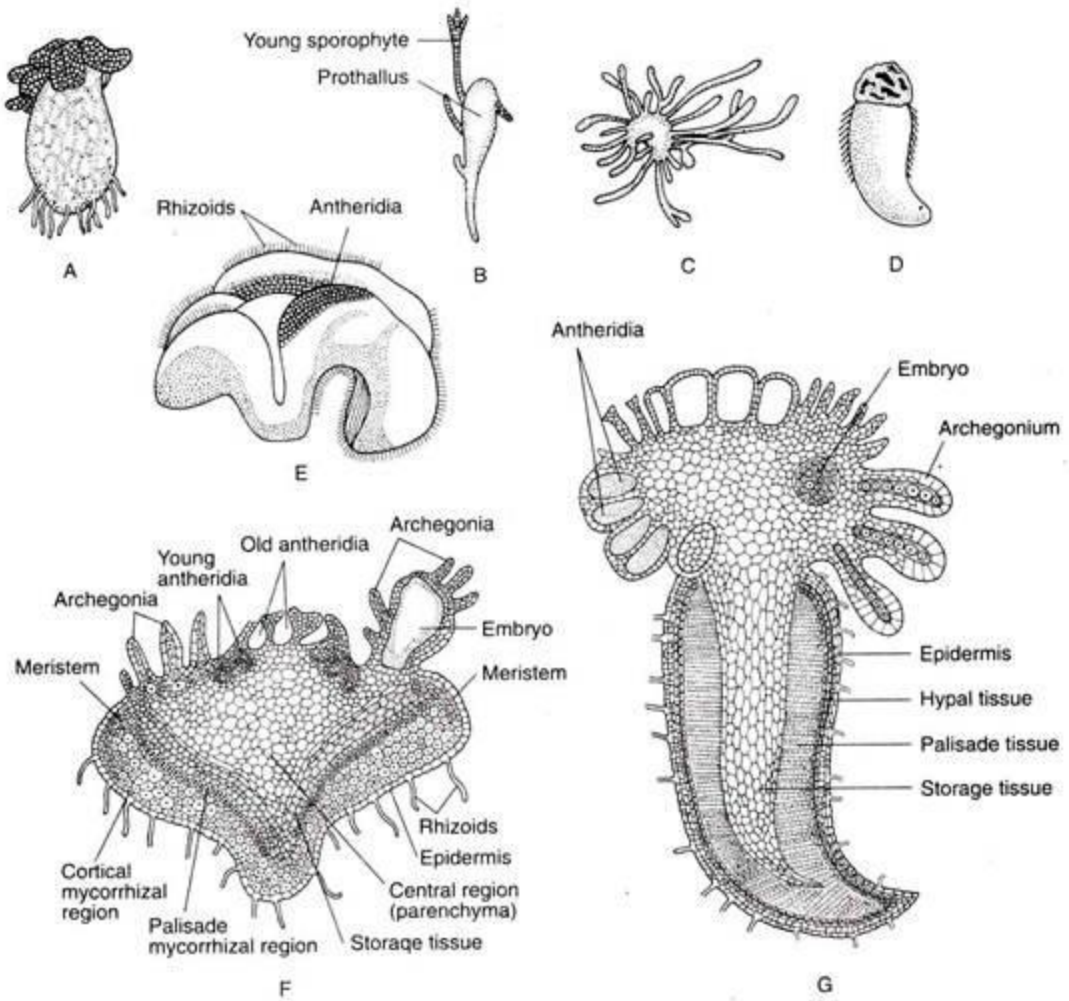
Lycopodium : Structure of strobilus; (A) A strobilus, (B) Longitudinal section of strobilus, (C) A sporophyll showing sporangia on the adaxial surface, (D, E). Spores.



Lycopodium selago

Gametophytes of Lycopodium

Three types of gametophytes produced as a result of series of mitotic divisions in spores after dispersal



Gametophytes of *Lycopodium* sp. : A. *L. cernuum*, B. *L. selago*, C. *L. phlegmaria*, D. *L. annotinum*, E. *L. clavatum*, F. V.S. of mature prothallus of *L. clavatum*, G. V.S. of mature prothallus of *L. complanatum*

1. **Cernuum Type (***L. cernuum, L. innundatum*): The prothalli small, green half buried in the soil, rhizoids on the colourless subterranean region which contains an endophytic fungus. The entire body about 3 mm long, annual in nature. The upper green part exposed with a number of irregular leaf-like lobes (photosynthetic) forming a crown. Prothallus both autotrophic and saprophytic. The sex organs (antheridia and archegonia) at the bases of the aerial lobes.

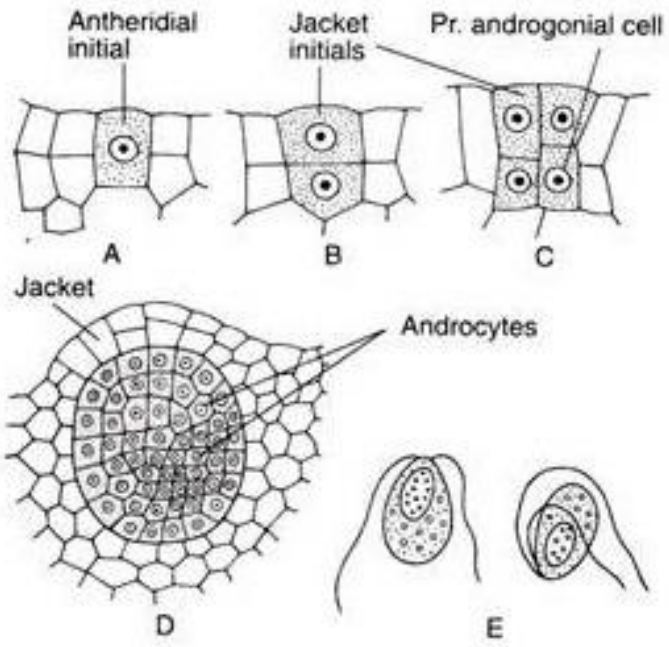
2. Clavatum Type (*L. clavatum,* *L. complanatum and L. annotinum*): Spore germination idelayed (one to many years), prothallus with longer lifespan; prothalli fleshy, non-green, totally saprophytic and completely subterranean and perennial in nature within a layer of humus; prothalli large up to 2 cm in length, top-shaped with a convolute margin (L. clavatum) or carrot-shaped (L. complanatum and L. annotinum); top lobed with the sex organs and the growing embryos located on these lobes; tissue differentiation in the lower portion; central region with storage tissue made up of vertically elongated cells. The radially elongated, closely packed chlorenchymatous cells constituting the palisade mycorrhizal layer. External to the palisade tissue the cortical mycorrhizal region bound by epidermis with some cells producing rhizoids.

3. Phlegmaria Type (Fig. 7.30C): e.g., *L. phlegmaria*
Prothalli aerial, saprophytic tree trunks below a coating of humus; spore germination immediate. The prothallus made up of short, tuberous central part producing a number of colourless, slender and cylindrical branches developing in an irregular fashion; branches bearing sex organs usually surrounded by glandular hairs called paraphysis.

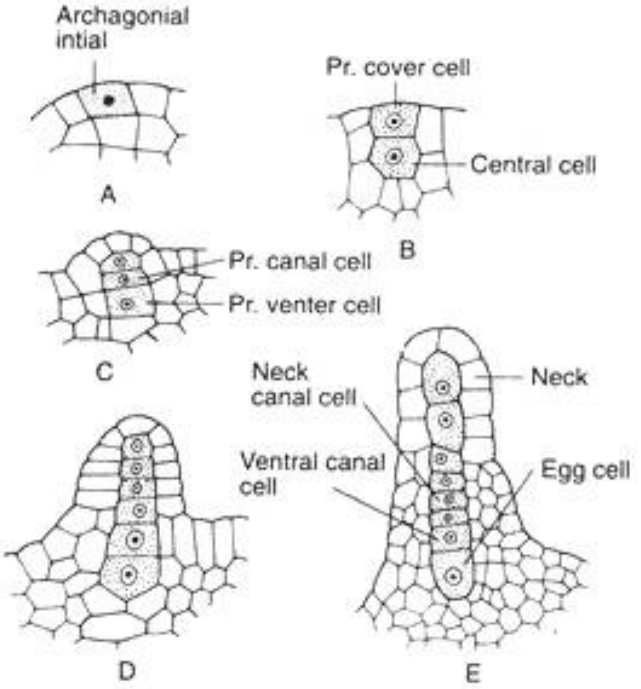
There are also some intermediate types in between these forms. For example, the gametophyte of *L. selago* is in-between the Cernuum and Clavatum types. Here spore germination and gametophyte development take place immediately like Cernuum type. However, the spores germinate after a long resting period if the spores are deeply buried in the soil. As a result a subterranean saprophytic Clavatum type of gametophyte is formed. Hence more than one type of prothalli may occur in the same species.

Sex organs:
Antheridial development as shown in figure. Antherozoids pear shaped biflagellate.

Archegonial deveopment as shown in figure. Ventre embedded in gametophytic tissue.
Fertilization : By zoidogamy and chemotaxix



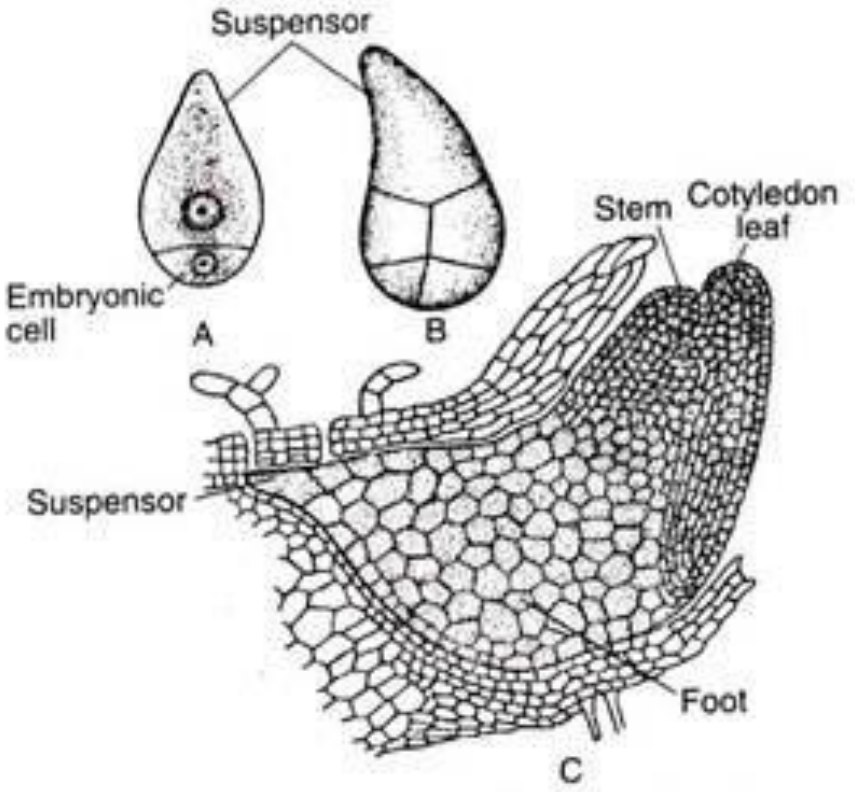
Lycopodium : A–D. Stages in the development of antheridium, E. Antherozoids



Lycopodium : A–D. Stages in the development of archegonium, E. A mature archegonium

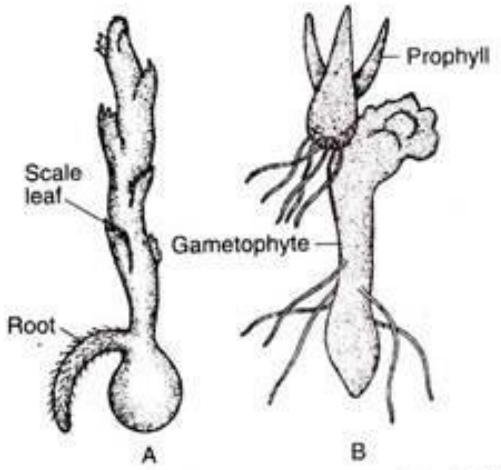
Embryogeny

By series of mitotic divisions in diploid zygote. Embryo development endoscopic with suspensor. Suspensor cell undivided. Embryonic cell produces 8-celled proembryo.



Lycopodium : A–C. Stages in the development of embryo

In species with green surface-living gametophytes.
The early developmental stages, until the differentiation into specialised parts, are similar to that of the subterranean species. In this case, foot is formed as usual, but, instead of shoot apex, a spherical parenchymatous body termed protocorm (extraprothalial undifferentiated tuberous body) is developed.
No root is produced but rhizoids occur on the lower surface and leaf-like outgrowths, called Proto- phylls or prophylls, arise on the upper surface of the protocorm. The protocorm remains in this stage for some time and a shoot apical meristem becomes organised and a "normal" type of shoot is produced, e.g., L. cernuum; L. corolinianum; L. inundatum; L. laterale etc.



A. A new *Lycopodium* sporophyte, B. Protocorm of *L. cernuum*

Morphological Nature of the Protocorm:

Treub (1890) considered protocorm to be an undifferentiated sporophytic structure of great antiquity and the phylogenetic precursor of the sporophyte. In the course of evolution the protocorm gave rise to sporophytic plant body that is differentiated.

According to Bower (1908, 1935) the proto- corm is an adaptive structure of the plant to escape the unfavourable condition for differentiation of sporophyte.
Goebel (1918) and Holloway (1939) considered the protocorm as merely a structural modification to meet certain physiological conditions like perreneation during unfavourable seasons.
According to Browne (1913) the protocorm is a reduced stem.
On the basis of experimental evidences, Wardlaw (1955) suggested that the development of protocorm is dependent- on certain genetic factors and metabolic patterns. The higher C/N (Carbon/Nitrogen) ratio induces protocorm formation and eventually delay in differentiation of sporophyte. As soon as the excess reserve food is exhausted or comes to the normal state, the differentiation of sporophyte starts.