Topic: Lycopodium; Reproduction
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Vegetative Reproduction

Vegetative means of propagation is quite common in the sporophyte of *Lycopodium* which take place by the following methods:

By the Formation of Gemmae or Bulbils:

- These are modified lateral branches which develop on the stem apex in the axils of leaves. Each bulbil consists of a short axis where several thick and fleshy leaves are arranged spirally and compactly.
- These leaves store food material. These bulbils fall on the ground and grow into new sporophytic plants, e.g., many Urostachya members like *L. selago; L. phlegmaria* and *L. lucidulum*.

By Fragmentation and Decay:

- In this method, the progressive death and decay of older parts reach the region of branching; as a result the two branches separate and each branch develops into a new plant e.g., *L. incondatum* and other creeping species.

By the Formation of Adventitious Buds:

- The adventitious buds are formed near the base of the main stem and on separation from the main axis they are capable of forming new plants e.g., *L. phlegmaria, L. reflexum*.

By the Formation of Root Tubercles:

- Bud-like tubercles are formed in the apical region of the adventitious root by the proliferation of the parenchymatous cells. These tubercles on germination produce new sporophyte e.g., *L. ramulosum, L. cernuum*.

Reproduction by Spores

The plant body is a sporophyte i.e., it bears spores. The spores are developed in the sporangia.

Sporangia - the Spore-Producing Organ:

- Position of the sporangium and organization of the strobilus. Sporangia always occur singly on the adaxial surface of the specialized leaves called sporophylls or fertile

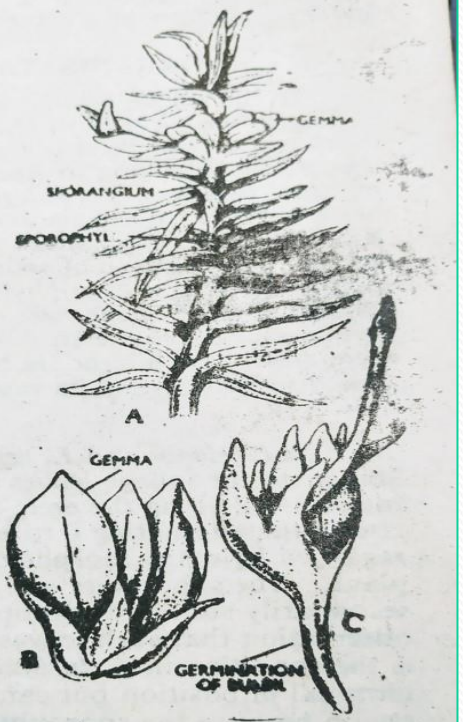

Fig. 4.9. *Lycopodium.* Vegetative reproduction.
A. Portion of stem of *L. lucidulum* bearing gemmae.
B. A gemma.
C. Germinating gemma of *L. selago,*

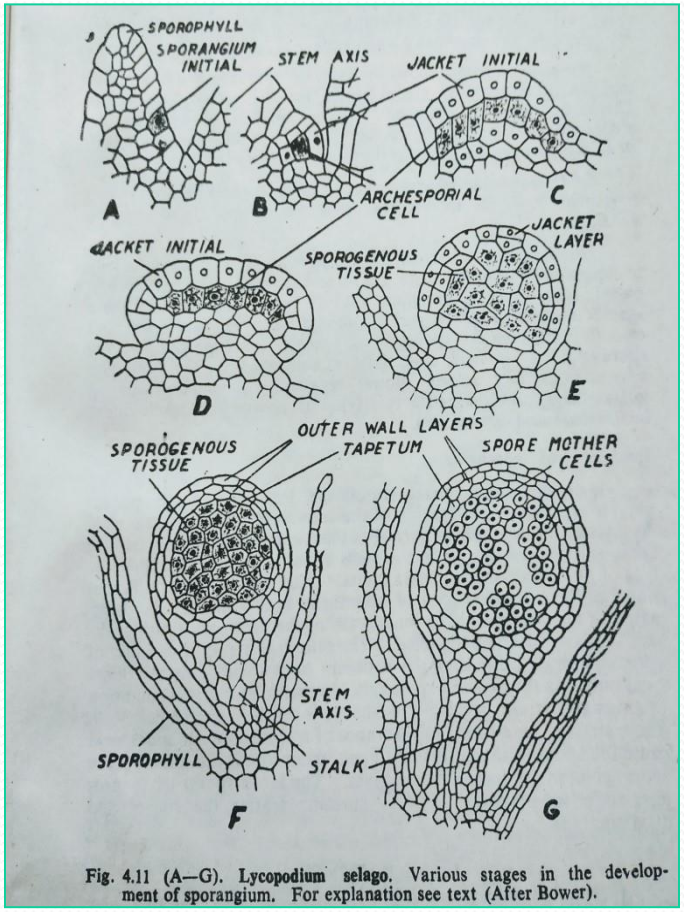

Fig. 4.11 (A—G). **Lycopodium selago.** Various stages in the development of sporangium. For explanation see text (After Bower).

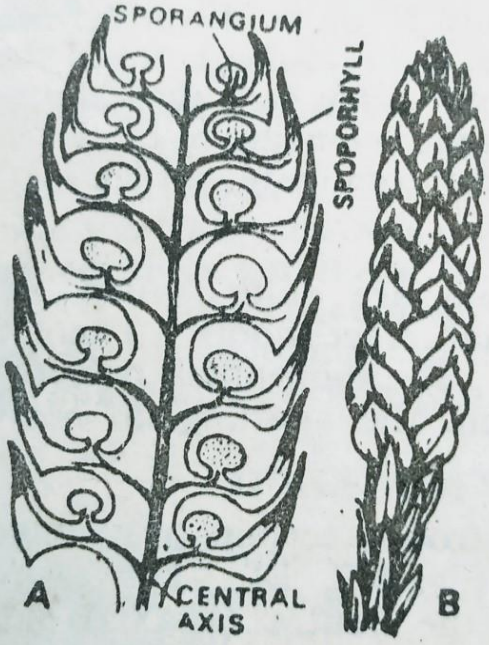

Fig. 4.10. Lycopodium A. V. S. portion of strobilus of *L. clavatum.* B. A compact strobilus of *L. stichense.*

leaves.

- The sporophyll forms a protective covering around the sporangium. The sporophylls may be aggregated into a definite strobilus (aggregation of sporophylls is called strobilus).
- The sporophylls of such strobili are different from vegetative leaves in size, shape, and colour. These types of strobili may occur on leafy stems or may be erected on lateral branches having very small, scale-like leaves (e.g., *L. clavatum; L. digitatum; L. obscurum*).

Structure of the Sporangium:

- Mature sporangia of most species are unilocular, sub-spherical or reniform (kidney-shaped) in shape.
- The size of the sporangium varies from 1.0 to 2.5 mm in diameter and colour ranges from yellow to orange. The sporangium has a short and massive stalk.

- The outer cells form the multilayered wall and the sporogenous tissue/cells derived from the inner cells of such divisions.
- The innermost layer of the sporangial wall functions as tapetal layer (i.e., nourishing tissue).
- The sporogenous tissue undergoes repeated mitotic divisions and ultimately gives rise to spore mother cells.
- As the sporangium matures, spore mother cells separate from each other and undergo meiotic division (reductional division) to form numerous spore tetrads (i.e., group of four cells produced by a meiotic division of a spore mother cell).
- Spores are triangular in shape with triradiate ridge, present on the inner (proximal) face
- Lycopodium is a homosporous pteridophyte i.e., it produces spores of equal size and shapes. The mature spores are yellow in colour. The spore wall is divisible into two layers viz., the inner wall, called the intine, and an outer layer, the exine. The exine

- displays ornamentation that varies with the species

Dehiscence of Sporangium:

- The mature sporangium splits along a vertical line of weakness (stomium) chiefly because of the stress and strain caused by drying of the sporangial cells. The spore mass projects out of the open slit and eventually disseminate by air currents.

Gametophyte

The germination of spore leads to the formation of prothallus which is the gametophyte.

- *Lycopodium* is homosporous, therefore, spore germinates exosporically to produce gametophytic prothallus, which bears both male and female sex organs (i.e., monoecious and homothalic). The germination of the spores may be immediate in some species (e.g., *Lycopodium cernuum, L. inundatum*) or after a delay of several years (*L. clavatum, L. complanatum*).

The spores absorb water before germination. The first division of the spore is asymmetric to produce one small biconvex rhizoidal cell and a large cell. Soon after this division, the exine ruptures along the triradiate ridge. The rhizoidal cell disintegrates, while the large cell again divides by a vertical wall to form two cells.

Of these two cells, the one nearer to rhizoidal cell is called basal cell which does not divide further. The other cell, by further divisions, forms apical cell with two cutting faces. The further development of gametophyte does not proceed if there is no infection into the basal cell by the mycorrhizal fungus.

Variation in the form and structure of Prothallus

The prothalli (gametophytes) of Lycopodium shows great variation in form and structure in different species and however three main types may be distinguished which are as follows-

i. L. ceranum: The massive prothallus stands upright in the soil with its upper part exposed. The prothallus sends out irregular leafy outgrowths. The prothallus is a self nourishing body.

ii. *L. annotinum:* The prothallus is a conical and massive structure without any leaf like lobes. Endophytic fungi are well developed, the sex organs are found on the upper side.

iii. *L. phlegmaria:* The prothallus is an attenuated branched structure. The colourless branched arise irregularly at point away from the apex of the main branch and extend through dead bark. The sex organs are borne on the upper surface of prothallus.

Development of sex organs on the gametophyte

The gametophytic prothallus of *Lycopodium* is monoecious (homothallic) i.e., male (antheridia) and female (archegonia) sex organs are developed on the same prothallus.

The antheridia and archegonia are generally intermingled near the bases of the upright lobes in those species where gametophytes are of the green annual type. In subterranean perennial forms, the sex organs are segregated into definite groups.

In both types, antheridia generally appear first near the middle of the crown of the gametophyte.

Development of Antheridium:

The antheridium develops from a single superficial cell called antheridial initial of the prothallus. The initial cell divides transversely forming an upper jacket initial and a lower primary androgonial cell.

The jacket initial divides anticlinally to form one-layered jacket. The lower androgonial cell forms a mass of androcytes through many irregular divisions. Each androcyte matures into a biflagellate sperm resembling the sperms of certain bryophytes or algae.

A sperm is a blunt-ended, fusiform cell, 8-10 µm long and 4-5 µm wide. There are two flagella, each one is about 38 µm long. The antheridia are almost wholly embedded in the gametophytic tissue. The sperms are released by breaking down the operculum at top.

Development of Archegonium:

The archegonium develops from a superficial archegonial initial cell. The first periclinal division of archegonial intial gives rise to an upper primary cover cell and a

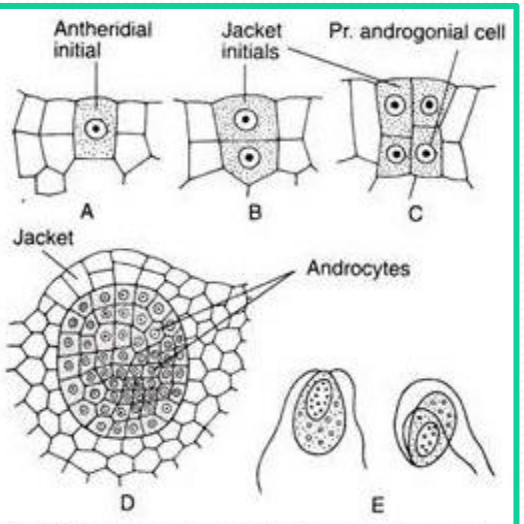

Fig. 7.31 : *Lycopodium* : A–D. Stages in the development of antheridium, E. Antherozoids

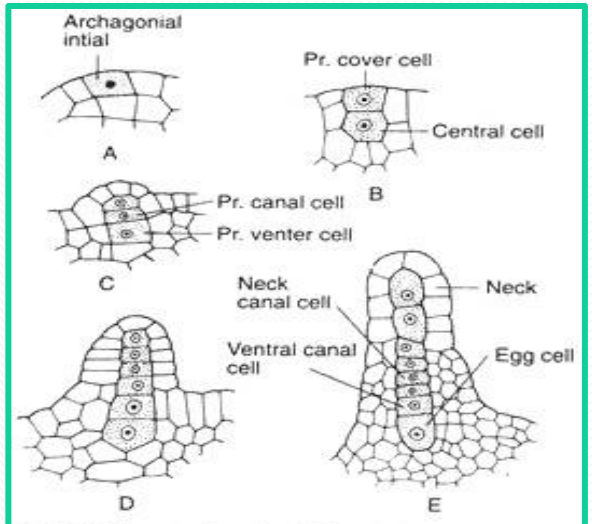

Fig. 7.32 : *Lycopodium* : A–D. Stages in the development of archegonium, E. A mature archegonium

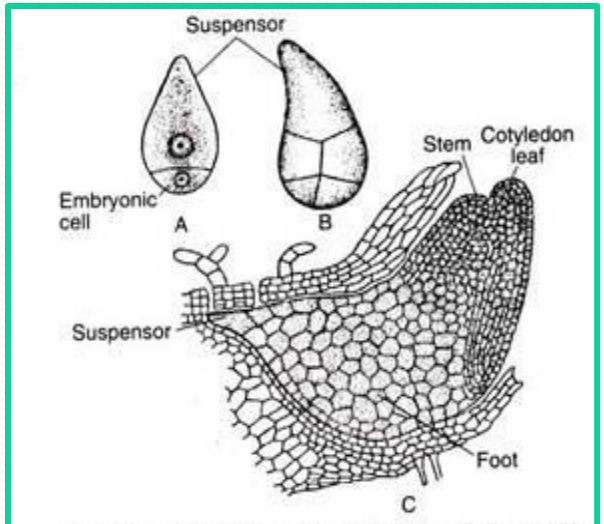

Fig. 7.33 : *Lycopodium* : A–C. Stages in the development of embryo

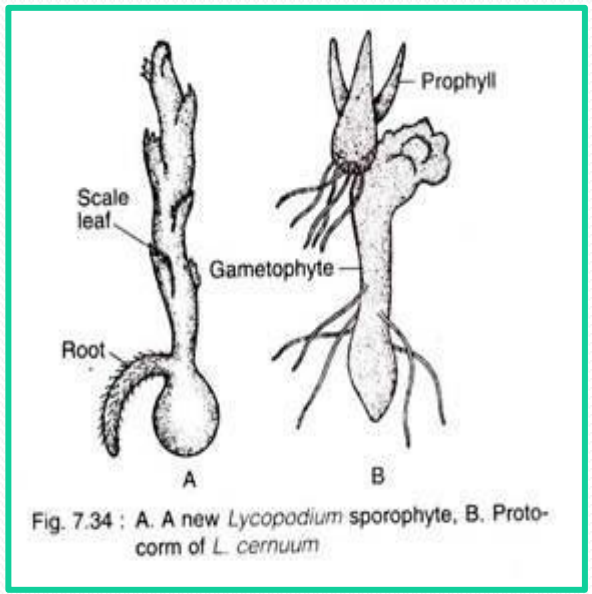

Fig. 7.34 : A. A new *Lycopodium* sporophyte, B. Protocorm of *L. cernuum*

lower central cell. The central cell divides by a transverse wall to form a lower primary venter cell and an upper primary canal cell.

The primary canal cell, by repeated divisions, forms 4-8 neck canal cells (exception, one neck canal cell in *L. cernuum*, 14 in *L. complanatum*).

The venter cell forms the egg often after cutting off a ventral canal cell. The upper primary cover cells divide and redivide to form neck of archegonium. The Venter is embedded in the gametophyte tissue and the neck of the archegonium protrudes out.

Fertilization

Fertilization takes place in the usual way. The neck canal cells and the ventral canal cell disintegrate to form a passage for the entrance of the motile biflagellate sperms.

The sperm reaches the archegonium by swimming through a film of water on the surface of the gametophyte.

Free citric acid or salts of citric acid, available in the canal as a by-product of disintegration of canal cells, may play a role in the attraction of sperms to the archegonia.

Only one sperm eventually fertilizes the egg that develops into the zygote.

New Sporophyte (Embryo):

The early stages in the development of zygote reveals a common basic plan in all the species, but later stages differ according to the species.

In species with subterranean gametophyte. The first division of the zygote is transverse to right angle to the long axis of the archegonium which produces an outer suspensor cell and an inner embryonic cell . The outer cell may or may not enlarge but it does not undergo further divisions and becomes a suspensor.

The subsequent divisions of lower cell produces a multicellular embryo. The embryo in Lycopodium is endoscopic in nature. Further development of the embryo produces shoot apex and foot. The shoot apex grows laterally and upward Suspensor and the foot develops along the lower side of the embryo. The roots generally come out from the areas between the first leaf and foot. The foot enlarges, and with the help of the foot the embryo remains embedded in the gametophyte.

The foot acts as a haustorial structure until the sporophyte becomes physiologically independent e.g., *L. clavatum, L. phlegmaria*

In species with green surface-living gametophytes. The early developmental stages, until the differentiation into specialized 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 .

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*