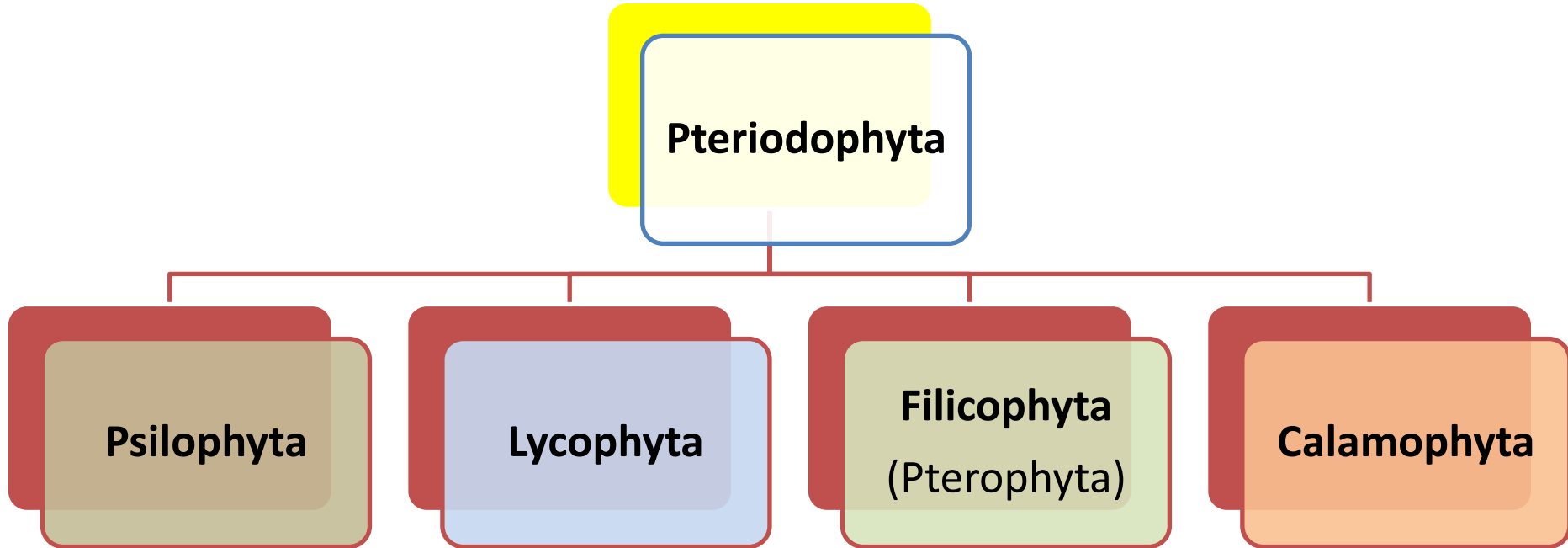


Pteridophyta



Class(2): Lycophyta

Subclass(1): Homospora (Eligulatae)

Order: Lycopodiales

Family: Lycopodiaceae

e.g. **Lycopodium**



Subclass(2): Heterospora (Ligulatae)

Order: Selaginellales

Family: Selaginellaceae

e.g. **Selaginella**



Phylum: Lepidophyta

- It is characterized by:
 1. The plant is differentiated into stem, leaves and roots.
 2. Leaves are microphyllous (small, one vein and with no leaf gap).
 3. The stele is protostele, siphonostele or polystele.
 4. Protoxylem is exarch (ranging from a complete external cylinder to a polyarch stele in which there are many protoxylem ribs).
 5. Sporangia are solitary, carried on special leaves (sporophylls). Sporophylls are usually collected in strobili.

- Among this phylum there are two independent evolutionary lines

Heterospora (Ligulatae)

- Characterized by presence of ligule (small outgrowth on the upper surface of the leaf).
- Heterosporous character (2 types of spores: microspores-- small, give rise to male gametophyte. & megaspores– larger, give rise to female gametophyte.)

Homospora (Eligulatae)

- Eligulate (ligule lacking).
- Homosporous (one type of spores).

- The phylum includes one class: Lycopodinae.
- The class is classified into 4 orders:

Lycopodiales

Selaginellales

Lepidodendrales

Isoetales

- Plants belong to the first order are homosporae (eligulatae), while the remaining three are heterosporae (ligulatae).

Class(2): Lycophyta

Subclass(1): Homospora
(Eligulatae)

Order: Lycopodiales

Family: Lycopodiaceae

e.g. **Lycopodium**



Subclass(2): Heterospora
(Ligulatae)

Order: Selaginellales

Family: Selaginellaceae

e.g. **Selaginella**



Lycopodiales

This order is characterized by:

1. Homosporous and eligulatae.
2. Herbaceous **without** secondary growth.
3. Sporophylls may or may not be arranged in strobilli.
4. Antherozoids are biflagellate.

□ The order includes two families:

- a) Protolpidodendrales:** with extinct members (fossils).
- b) Lycopodiaceae:** 2 living genera and 1 extinct genus.

Lycopodiaceae

Characteristics of Lycopodiaceae:

1. Sporophytes are herbaceous.
2. Stem densely covered with microphyllous eligulate leaves.
3. Foliage leaves may be similar or dissimilar to sporophyllous leaves.
4. Homosporous.
5. Gametophyte reduced. Wholly or partially underground. Nutrition through micorrhizal association.

The family includes to genera: *Lycopodium* and *Phylloglossum*.

Lycopodium (clubmosses)

Habitat and External Morphology:

- the genus comprises 180 species, of wide distribution.
- Stem is branched or unbranched, prostrate or erect.
- Sometimes, stem behaves as a rhizome from which arise erect aerial branches.
- Stem densely covered with small leaves.
- Leaves may behave as sporophyll (carrying sporangia), or as foliage leaves.
- Roots are all adventitious, and usually dichotomously branched.



Lycopodium selago

- Creeping stem from which branches arise.
- Stem densely covered with leaves.
- On the aerial branches, there are fertile zones (with sporangia) alternating with sterile ones. (No strobilus)
- Sporangia axillary.
- Primitive form.

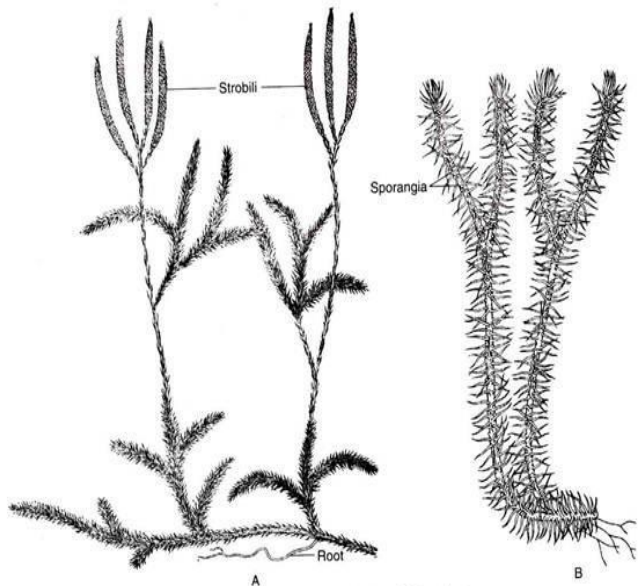


Fig. 7.23 : A. *Lycopodium clavatum*. B. *L. selago*

Lycopodium clavatum

- Sporophylls are dissimilar to foliage leaves.
- Sporophylls are assembled together into strobili which occupy the terminals of the stem branches.
- Naked zone between strobili and vegetative parts.
- Sporangia are carried directly on the upper surface of sporophylls.



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Lycopodium selago



Lycopodium clavatum

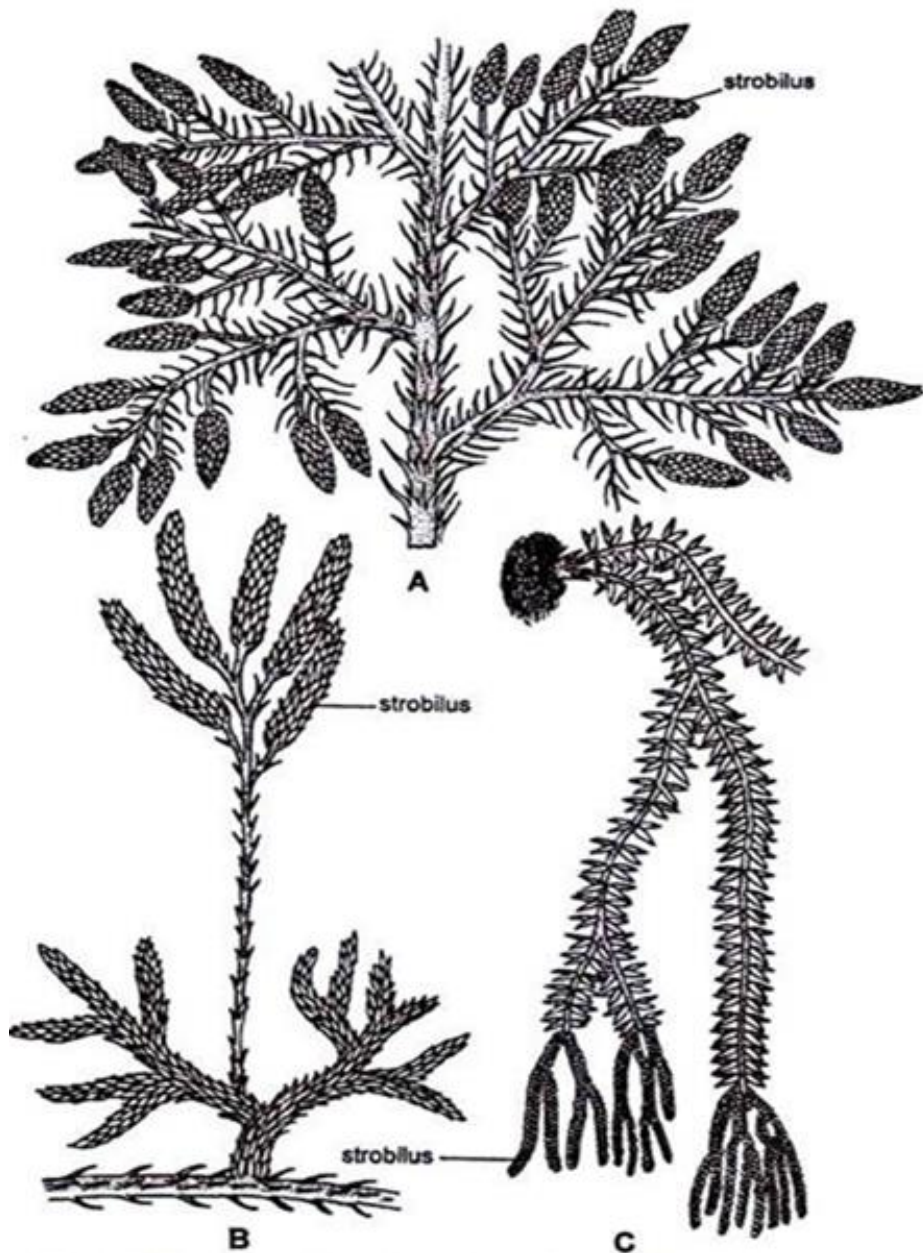


Fig. 1 (A-C). *Lycopodium*. Sporophyte with strobili : A. *L. cernuum* (terrestrial), B. *L. clavatum* (terrestrial), C. *L. phlegmaria* (epiphytic)

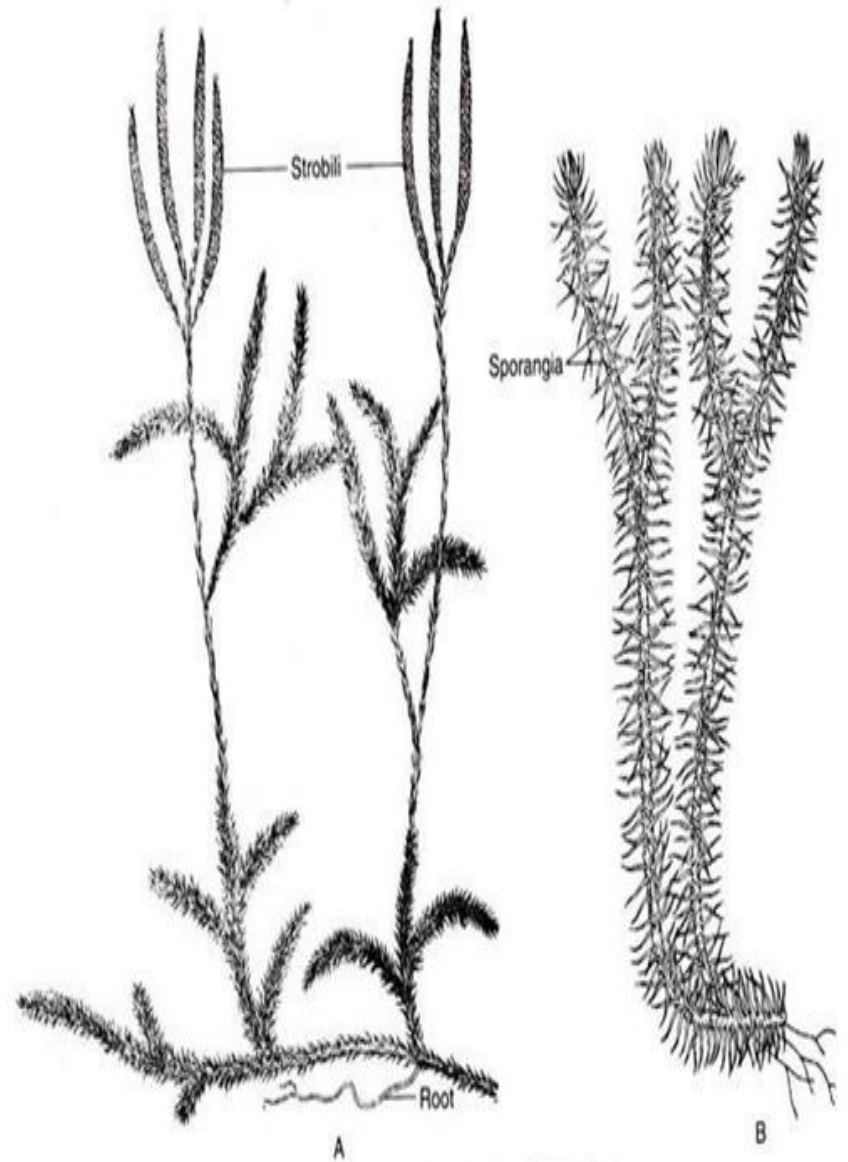


Fig. 7.23 : A. *Lycopodium clavatum*, B. *L. selago*



A Pendant Epiphytic *Lycopodium* from Puerto Rico. note the Dichotomous Branching. This plant is over 1 m in length.



Vertical *Lycopodium* with Isotomous Branching. This plant is about 15-20 cm tall.



Lycopodium lucidulum: Note the Vertical Stem. The **Roots** are adventitious and originate in the stem. They branch **Dichotomously**.

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Anatomy of *Lycopodium* stem:

- **Epidermis**: one cell in thickness, provided with stomata.
- **Cortex**: wide, equal to or several times thicker than the stele. Differs according to species. It can be:
 - I. All parenchymatous with intercellular spaces.
 - II. All sclerenchymatous, with **no** intercellular spaces.
 - III. Can be distinguished into outer and inner sclerenchyma and middle parenchyma.
 - IV. Can be distinguished into outer and inner parenchyma and middle sclerenchyma.
 - V. Outer parenchyma and inner sclerified.
- **Endodermis**: with casparian strips on the radial walls, which may be extended to other walls.

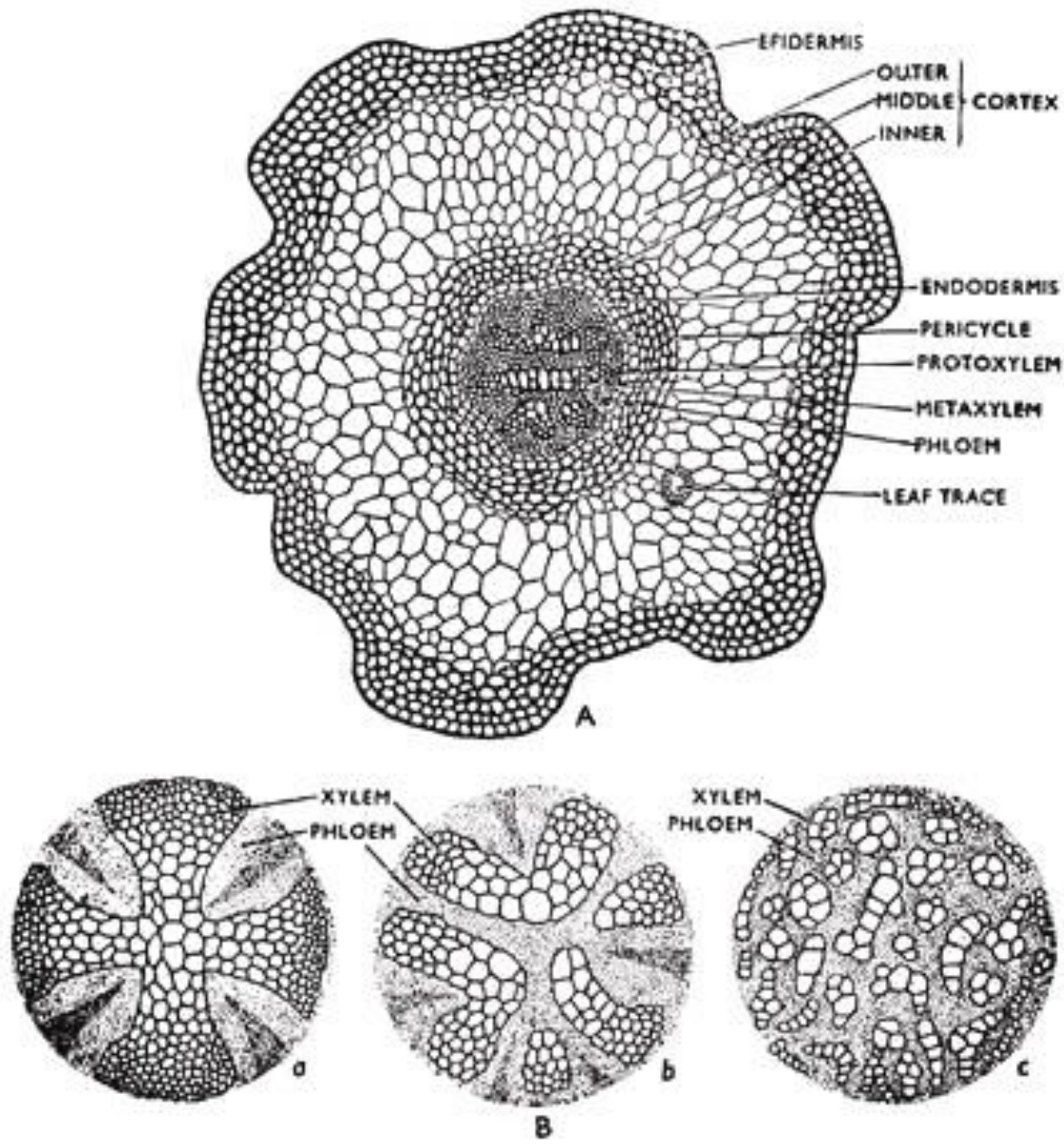
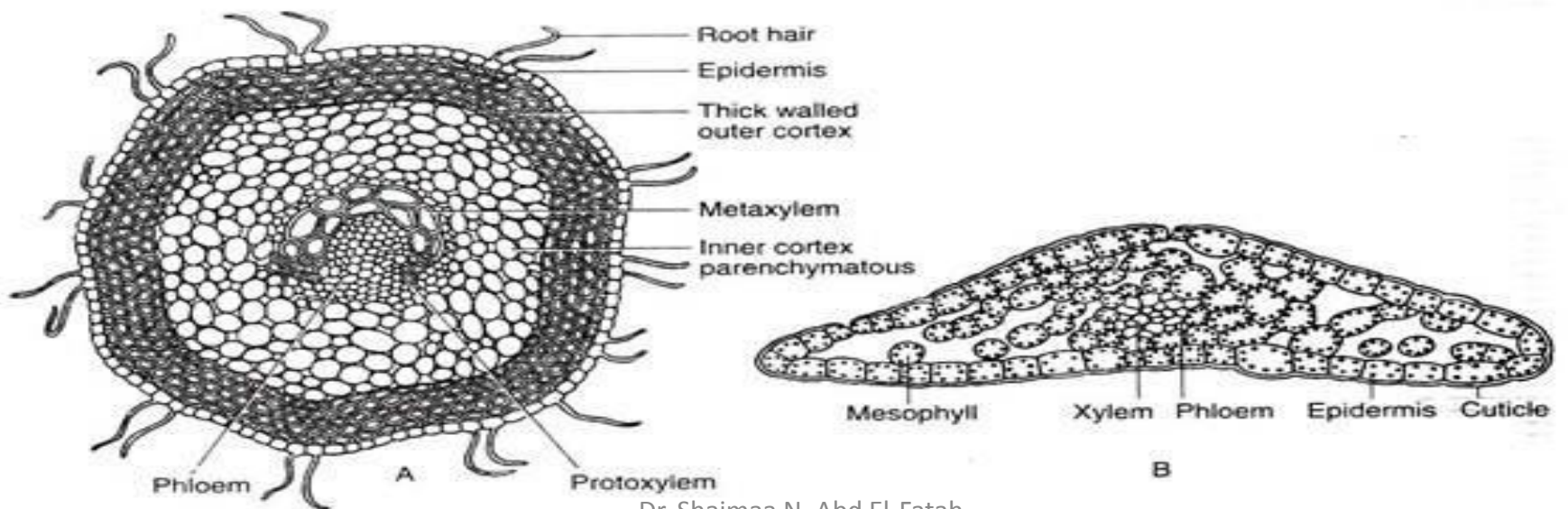
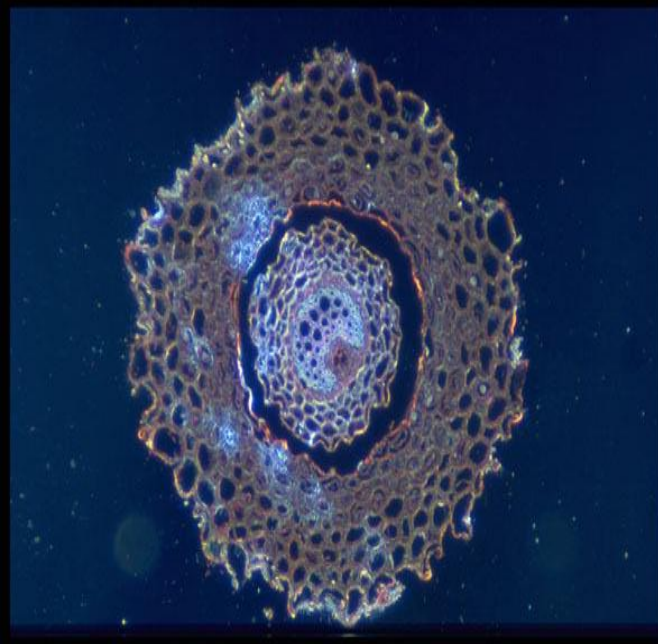


Fig. 599. A. T.s. of *Lycopodium clavatum* stem. B. T.s. of stelar regions of stems of (a) *L. serratum*, (b) *L. annotinum* and (c) *L. cernuum*.

- Pericycle: parenchyma, 3-6 cells in thickness.
- The Stelar structure: varies according to the species, the age and position of the section.
 - In the younger parts of the stem, the stele is exarch actinostele.
 - In the older parts, the actinostele either persists (*L. selago*) or changes into plectostele (*L. clavatum*). (more advanced)
- Each leaf (and each sporangium of *L. selago*) receives a single vascular bundle which forms an unbranched midrib.

Anatomy of *Lycopodium* root:

- Most species have diarch root, with a crescent shaped xylem.
- In some species, the stele of the root is very similar to that of the stem e.g. the plectostele in *L. clavatum*.



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 Fig. 7.24 : *Lycopodium*. A. T.S. of root, B. V.S. of leaf

Lycopodium strobilus:

- **Primitive species:** no strobili, alternate fertile and sterile portions.
- advanced species: apical portion of the branches only bear sporangia (sporophylls) and form cones.
- Homosporous.

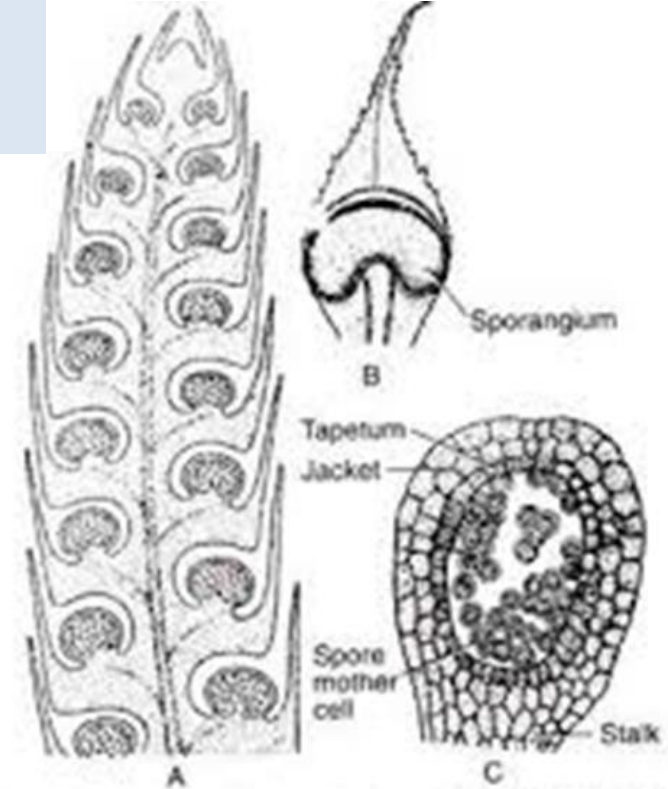


Fig. 7.27 : *Lycopodium clavatum* : A. L.S. of strobilus. B. A sporophyll (adaxial view). C. L.S. of a mature sporangium

- The sporophylls may be of the same size or of different size from the foliage leaves according to species.
- The arrangement of sporophylls is same on the central axis as that of the vegetative leaves on the stem (spiral, whorled or decussate etc.)

- The position of the sporangium is also different in different species. The sporangia may be axillary and protected with the help of sporophylls (e.g., *L. inundatum*) or foliar and protected (e.g., *L. cernuum*) or subfoliar and exposed (e.g., *L. squarrosum*) or axillary and exposed (e.g., *L. lucidulum*).
- Spores germinate to give hermaphrodite gametophyte

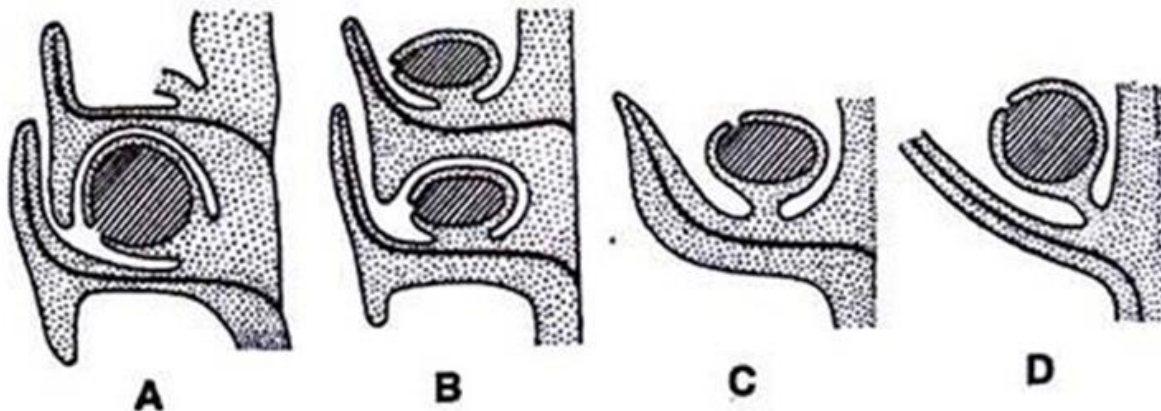


Fig. 7 (A–D) *Lycopodium* : A strobilus showing position of sporangia in various species;
 A. *L. inundatum*, B. *L. cernuum*, C. *L. squarrosum*, D. *L. lucidulum*

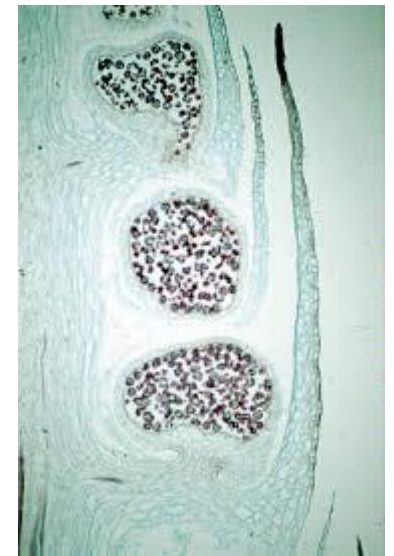
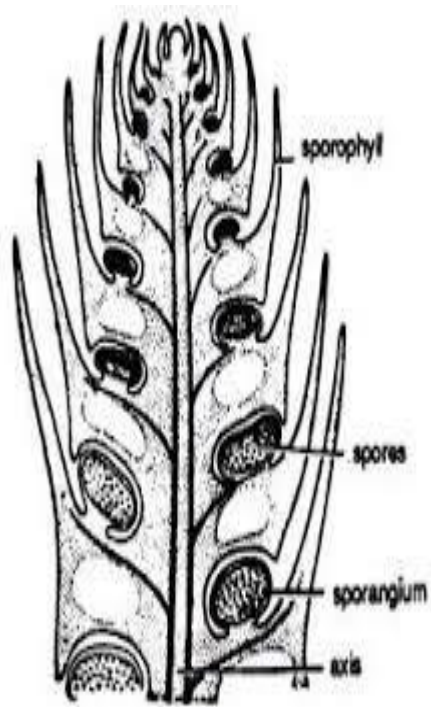
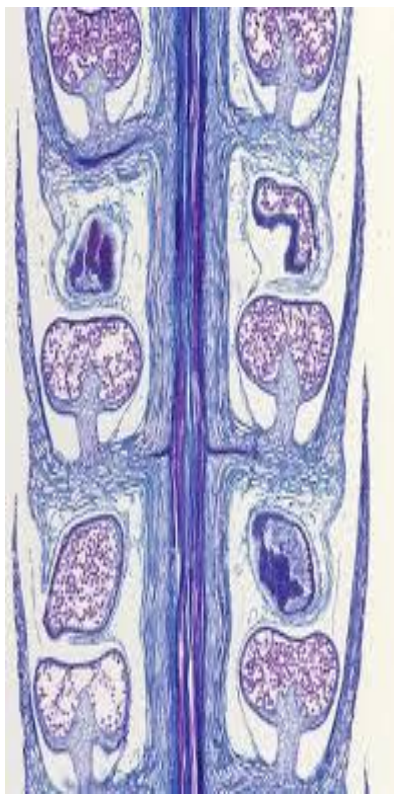
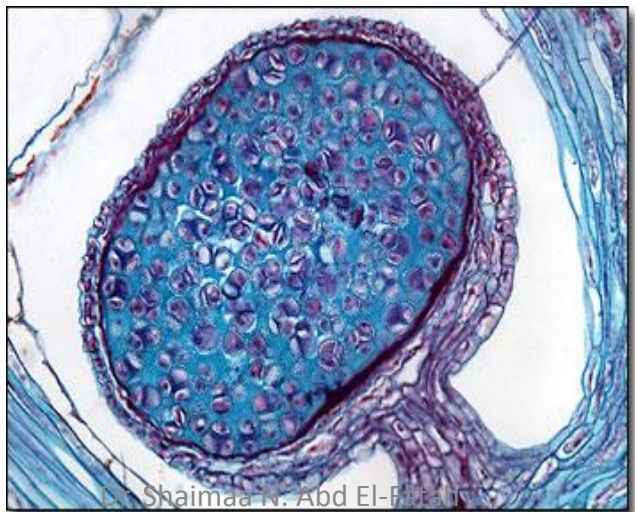
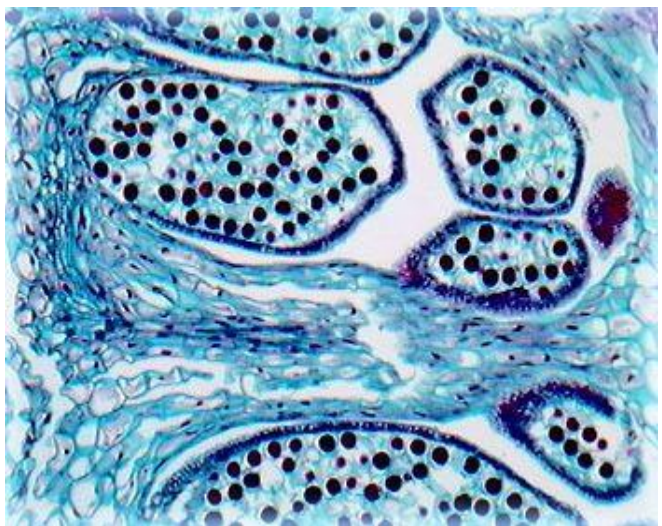
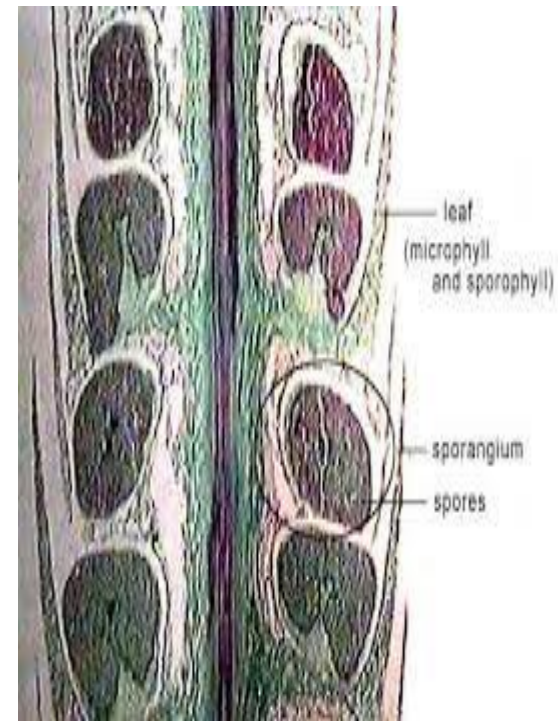


Fig. 233. *Lycopodium*. V.S. of the apical portion.



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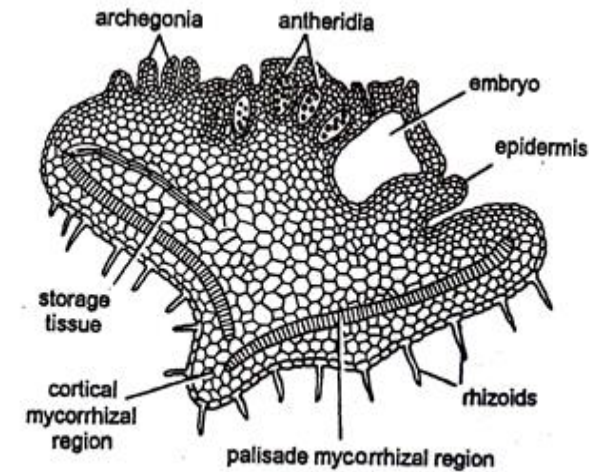


Lycopodium gametophyte:

- In general they have been grouped under three categories:

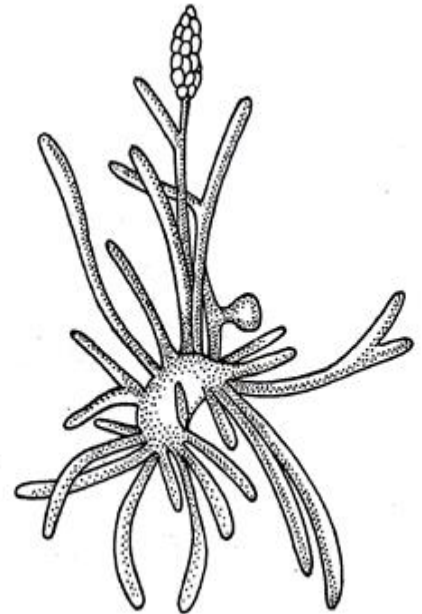
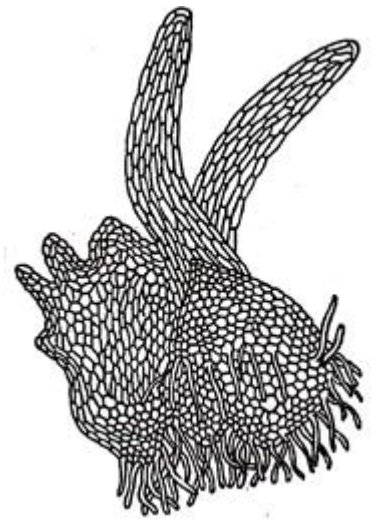
1. Type I or Cernuum type:

- Gametophyte is partially aerial and partly
- The prothalli are usually 2 to 3 mm in height and diameter.
- consist of a colourless **basal portion buried in soil** and a **conspicuous upright, fleshy, green aerial portion having lobes**.
- The sex organs develop between the green expanding lobes.
- The prothallus itself is a nourishing body.
- The underground part contains endophytic fungus (e.g., *L. cernuum*, *L. inundatum* etc.)

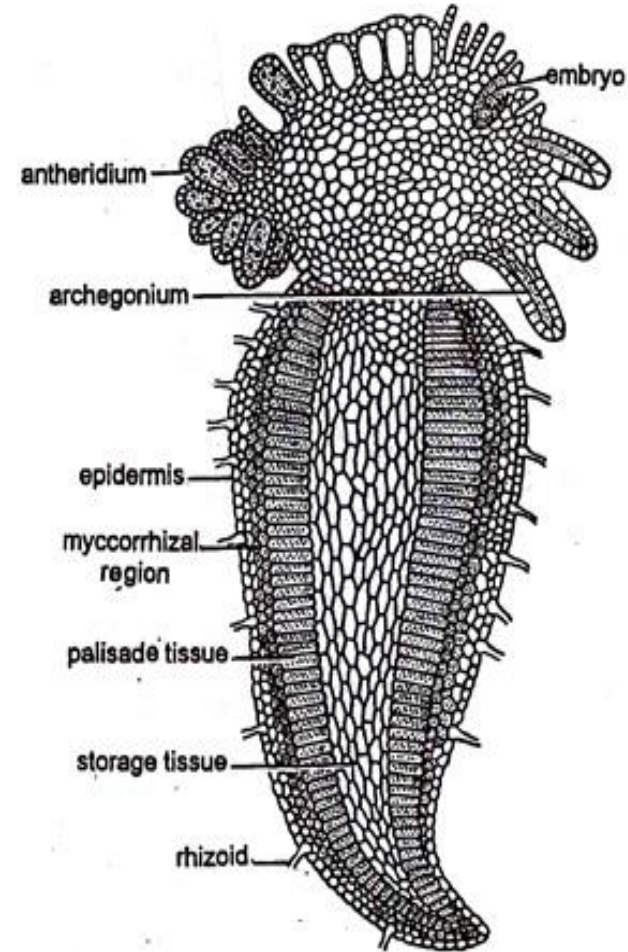


2. Type II or Clavatum Type:

- The gametophyte is wholly subterranean.
- totally saprophytic (non- green structure).
- tuberous and without lobes.
- It may be one to two cm long or wide.
- conical or discoid.
- with two growing points.
- Archegonia and antheridia are on the upper surface.
- The outer layer is the mycorrhizal layer.
- *L. annotinum*, *L. complanatum*, *L. clavatum* etc.
- The plant can produce either type I or II upon the position of spore at germination time (near soil surface: first, deep: second).



- **Type III or Phlegmaria type:**
- The gametophyte is subterranean.
- saprophytic and colourless.
- In *L. phlegmaria* and other epiphytic species.
- about 2 mm in diameter.
- Sex organs are borne on upper surface of large branches and are interspersed with slender filaments known as paraphyses.



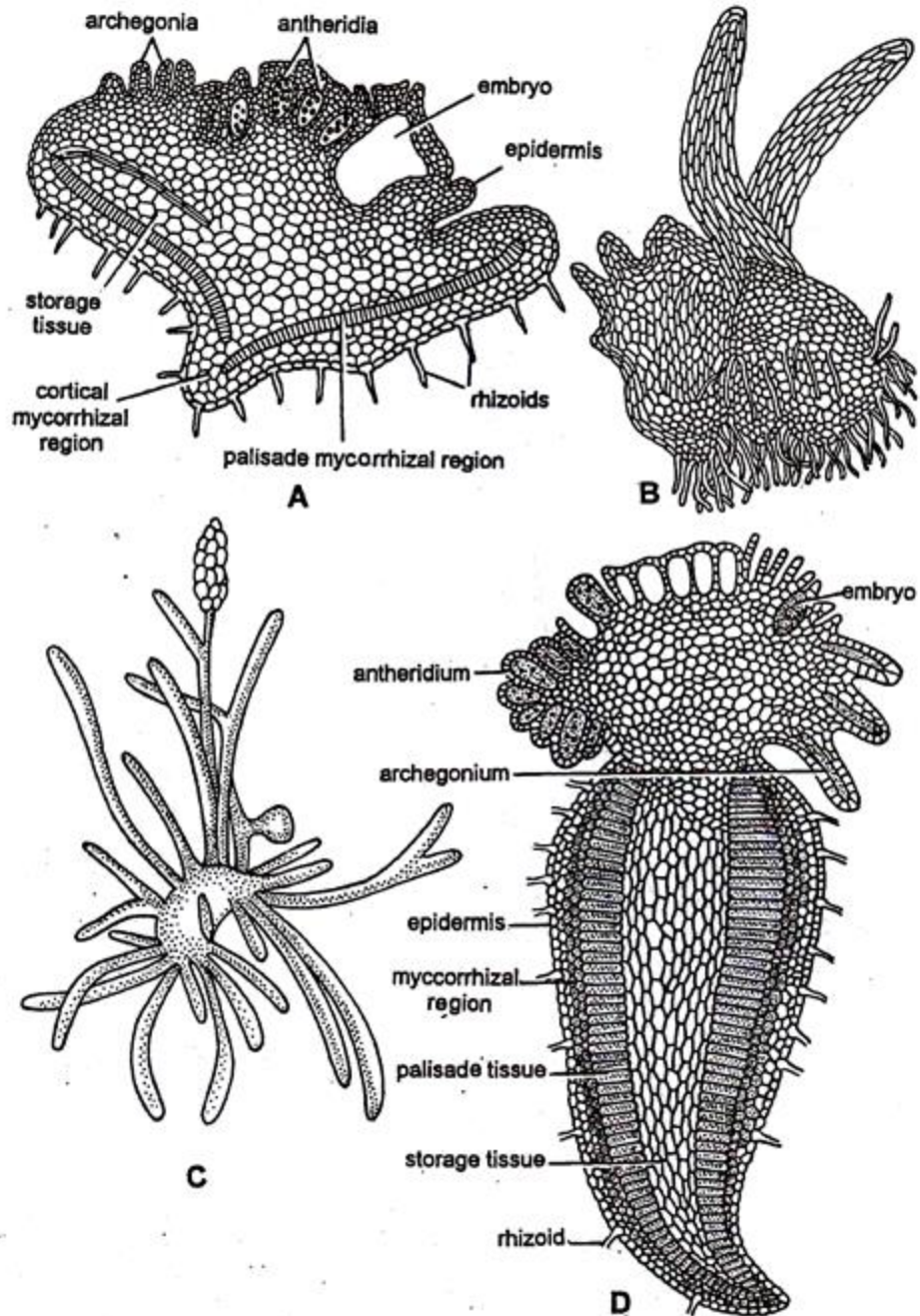


Fig. 11 (A–D). *Lycopodium* : A. *L. cornutum*, B. *L. clavatum*, C. *L. complanatum*, D. *L. phlegmaria*

- Antherozoids biflagellate, resembles those of Bryophyta.
- One of the archegonia is fertilized.
- The zygote divides into 2 cells: the upper (the suspensor) & the lower divides 3 divisions to give an octant (8 cells)((2 form the stem, 2 forms a leaf, 4 forms the foot i.e. haustorium deriving food from prothallus.
- The stem germinates upwards from the thallus. The primary stem is of short duration and replaced by horizontal outgrowths that form the permanent shoot from which arise the permanent adventitious roots.

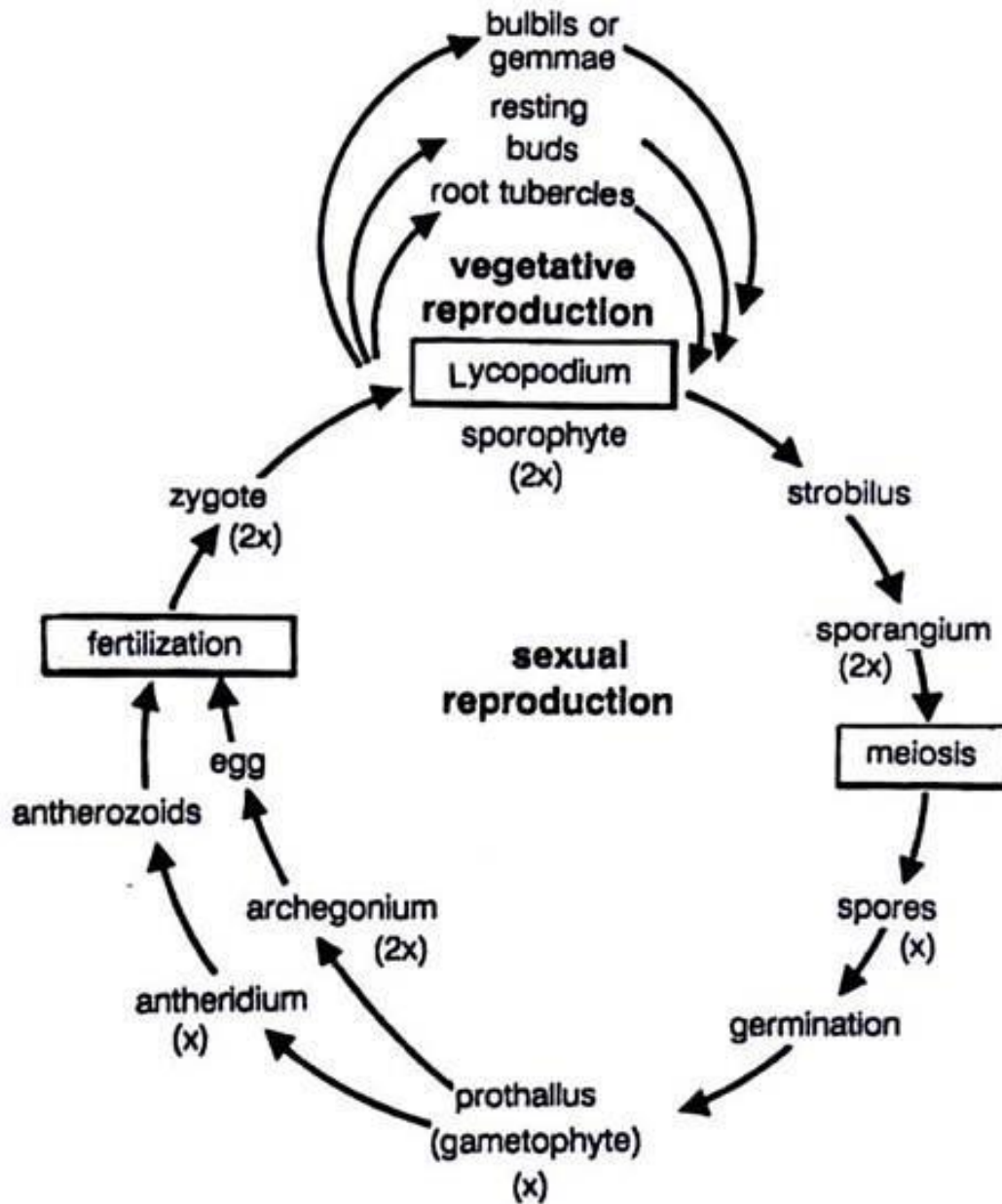


Fig. 15. *Lycopodium* : Schematic representation of life cycle

Dr. Shaimaa N. Abd El-Fatah

Selaginellales

1. Herbaceous stem, without secondary thickening.
2. Roots borne at the end of leafless branches called rhizophores.
3. Sporophytes heterosporous.
4. Sporophylls arranged in strobili.
5. Male and female gametophytes.
6. Biflagellate antherozoids.

□ includes one family Selaginellaceae. The family includes two genera: *Selaginella* (living) and *Selaginellites* (extinct).

Selaginella (spikemosses)

- Comprises about 600 species.
- Wide distribution: species are (tropical, temperate, damp shady habitats, severe xerophytic conditions.)

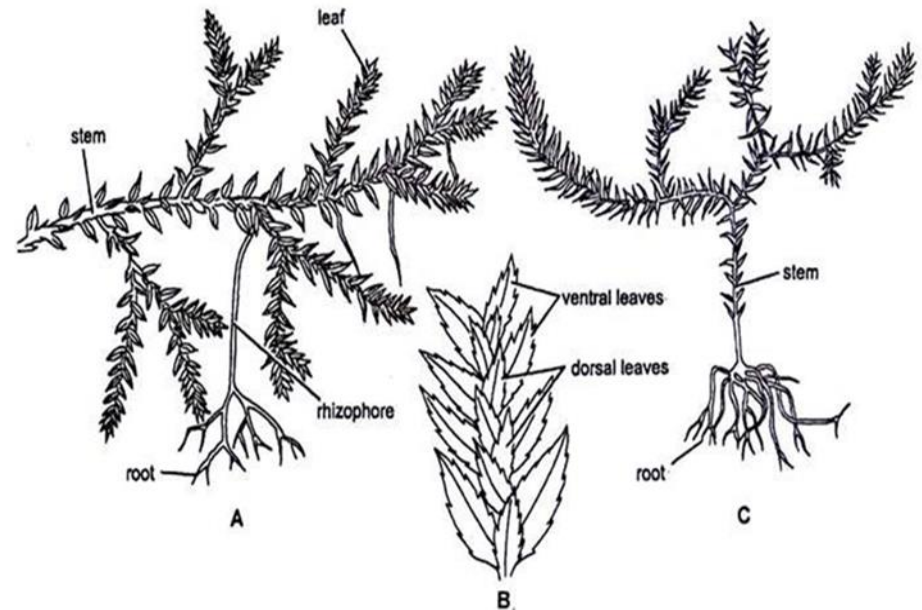


Fig. 1 (A-C). *Selaginella*. External features : A. *S. kraussiana*, B. Leaf arrangement in a branch of *S. kraussiana*, C. *S. spinulosa*

Selaginella kraussiana

Dr. Shaimaa N. Abd El-Fatah

External Morphology:

- Creeping rhizome, gives lateral prostrate branches.
- Rhizome and its branches are covered with microphyllous leaves.
- Leaves arranged in 4 rows: 2 dorsal of small leaves and 2 ventral of large leaves.
- A root-like organ (rhizophore) arise of the base of each lateral branch.
- Rhizophore is leafless (like root), with no root cap (unlike root).
- Some lateral branches grow erectly and carry sporangia (strobili).
- Strobilli carry sporophylls, which are all of the same size, and similar to vegetative leaves.

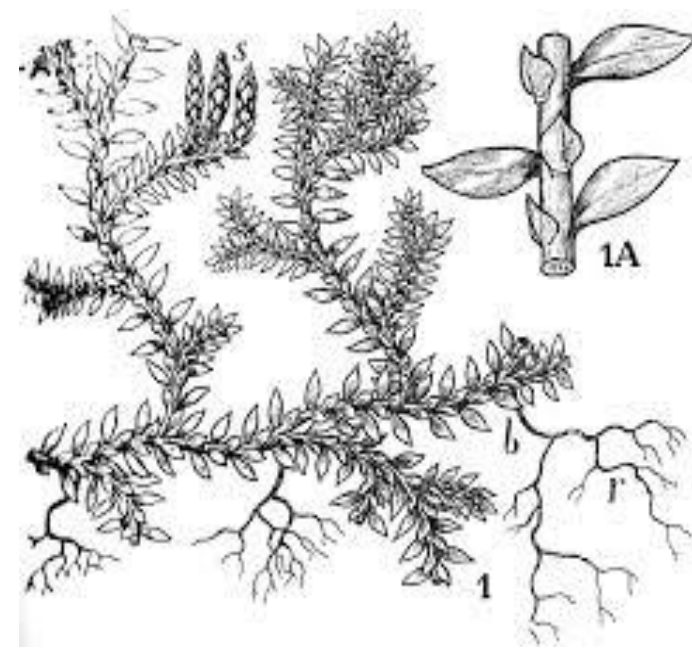
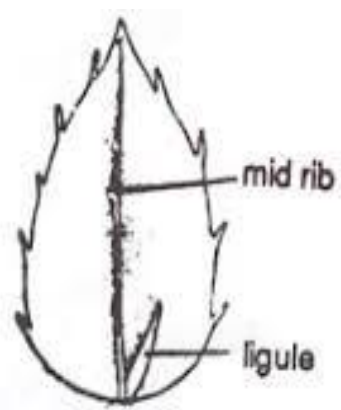
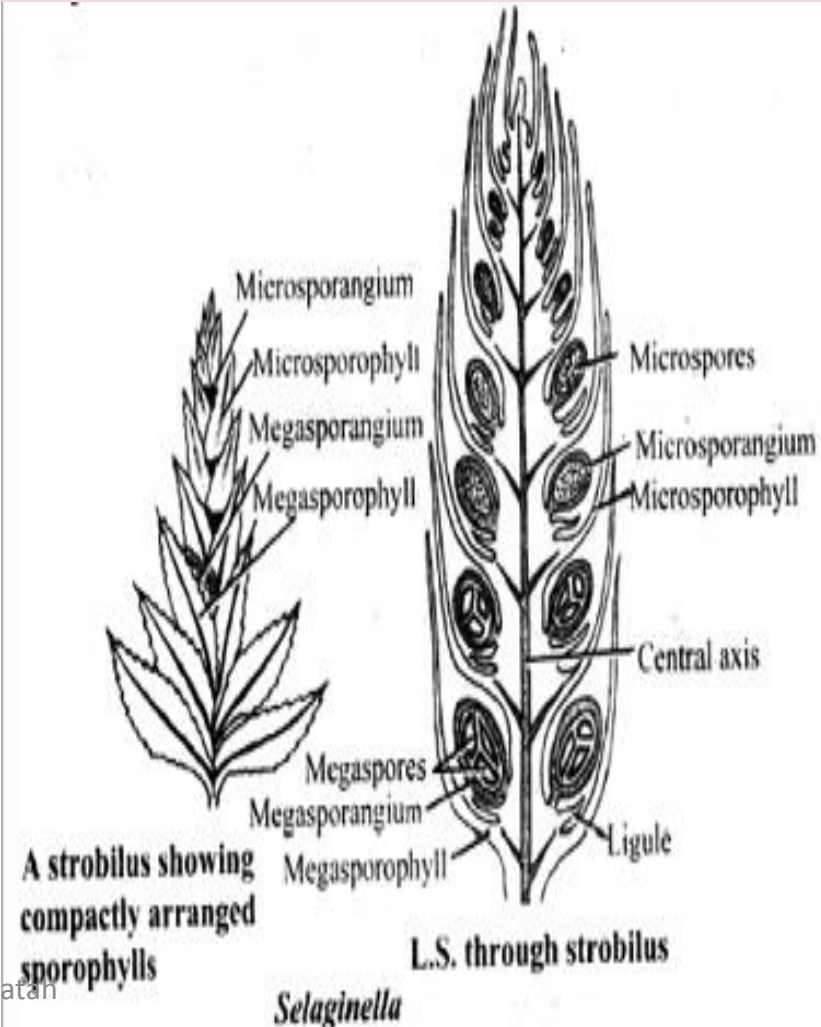


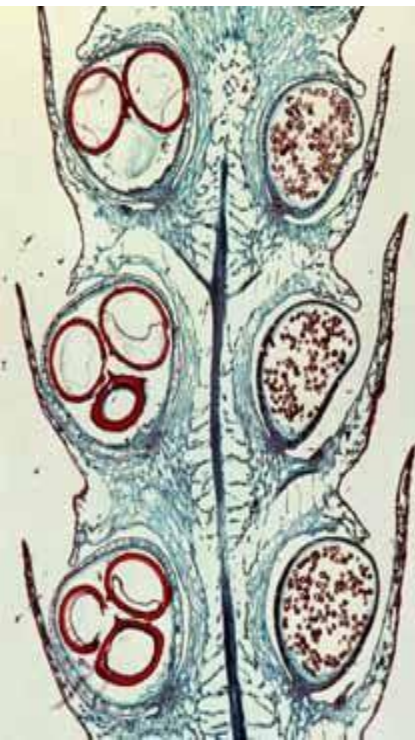
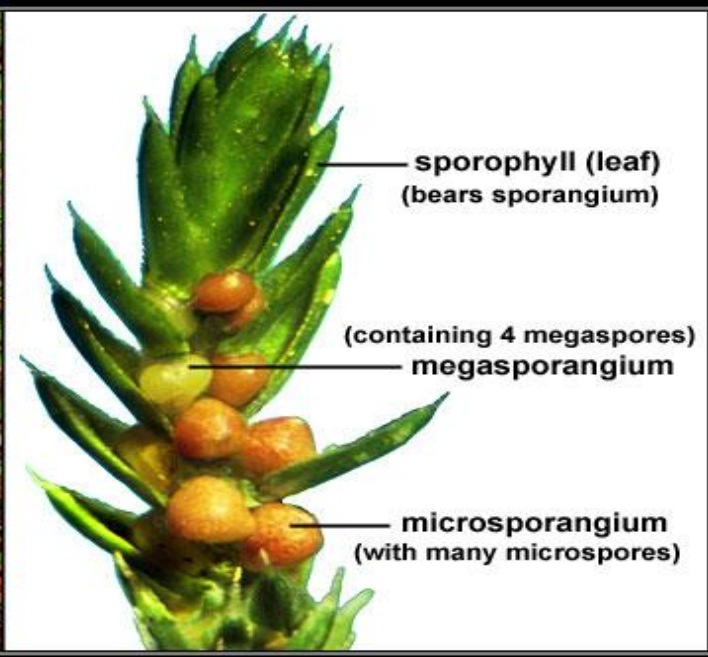
Fig. 210. *Selaginella*. Adaxial surface of a leaf showing ligule.



- Sporangia are carried in the axils of the sporophylls.
- Sporophylls of 2 kinds: megasporophyll (carrying mporangia) and microsporophylls (carrying microsporangia).

- In *Selaginella kraussiana*, the microsporangia are found towards the apex of the strobilus, while the megasporangia towards the base.





Selaginella

Longitudinal Section of Strobilus

Megasporangia

Dissected Strobilus



Microsporangia

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Anatomy of the stem

- epidermis, cortex and centrally located stele.
- Outermost one-celled thick epidermis consists of cutinized cells with no stomata.
- In most of the species, the cortex is differentiated into outer layers of sclerenchymatous and inner layers of parenchymatous.,
- in very delicate species it is fully composed of thin-walled parenchymatous cells.
- Cortex is completely sclerenchymatous in xerophytic species.
- Centrally located stele (or steles) is connected with the cortex with the help of many long, radially elongated cells called trabeculae.

- In between these trabeculae there are present many air cavities or big intercellular spaces.
- That these trabeculae are the endodermal structures is shown by the presence of many band like casparian strips in (them during their development elongate radially).
- Trabeculae are absent in species like *S.adunca*, *S. rupestris*, etc.
- 10. The number of stele is variable from 1 to 16 as under:
 - (i) *S. spinulosa*- one stele (monostelic).
 - (ii) *S. kraussiana* – two steles (distelic).
 - (iii) *S. laevigata*-up to sixteen steles (polystelic).
- Structurally, a stele varies from a simple protostele to a polycyclic siphonostele in different species. But typically it is protostelic.

- Structurally, a stele varies from a simple protostele to a polycyclic siphonostele in different species. But typically it is protostelic.
- *S. kraussiana*: distelic (internodal zone), exarch, in the nodal zone, they fuse in one flattened protostele with 2 groups of exarch protoxylem.
- Each stele consists of pericycle, phloem and xylem.
- Pericycle consists of many thin-walled parenchymatous cells.

Anatomy of the rhizophore

- Single concentric mesarch protostele.
- A thick-walled epidermis (covered with cuticle) is the outermost layer.
- Endodermis not well developed.
- Differ from root in absence of Root hairs.

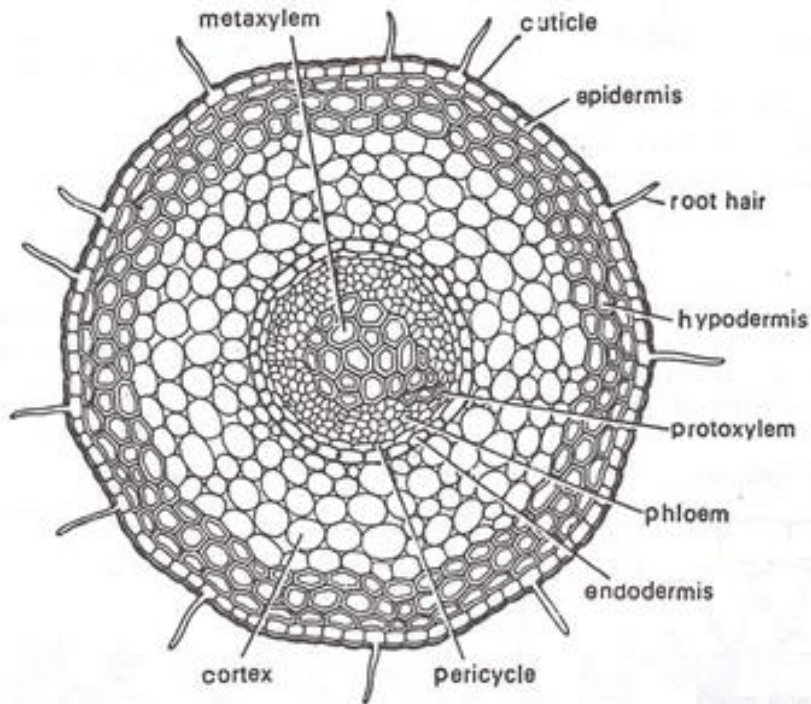
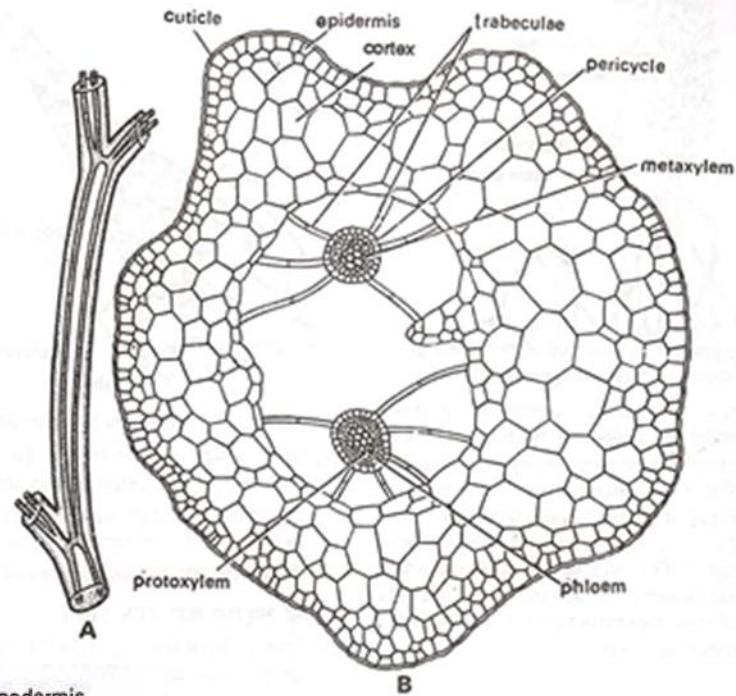
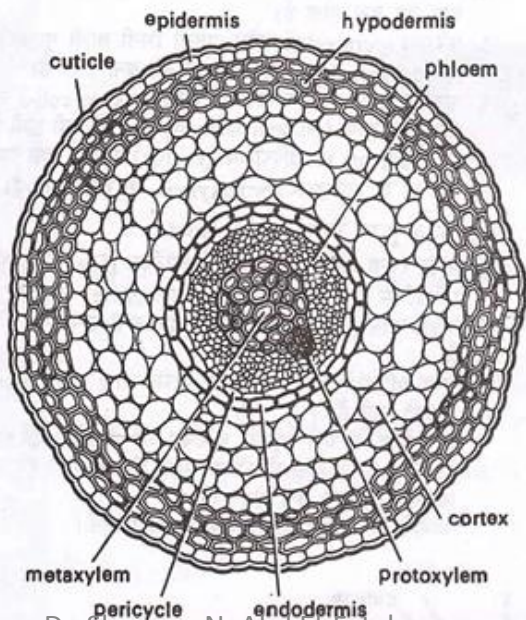


Fig. 214. *Selaginella*. T.S. root.



ina. A, A part of cleared distelic stem showing vascular cylinder; B, T. S. of distelic stem.



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Fig. 215. *Selaginella*. T.S. rhizophore.

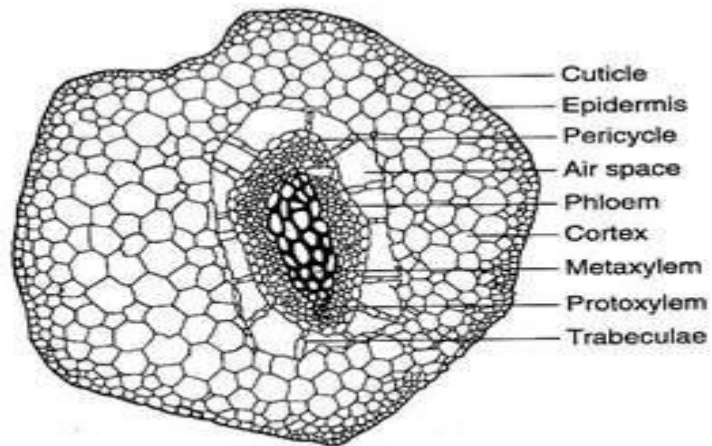
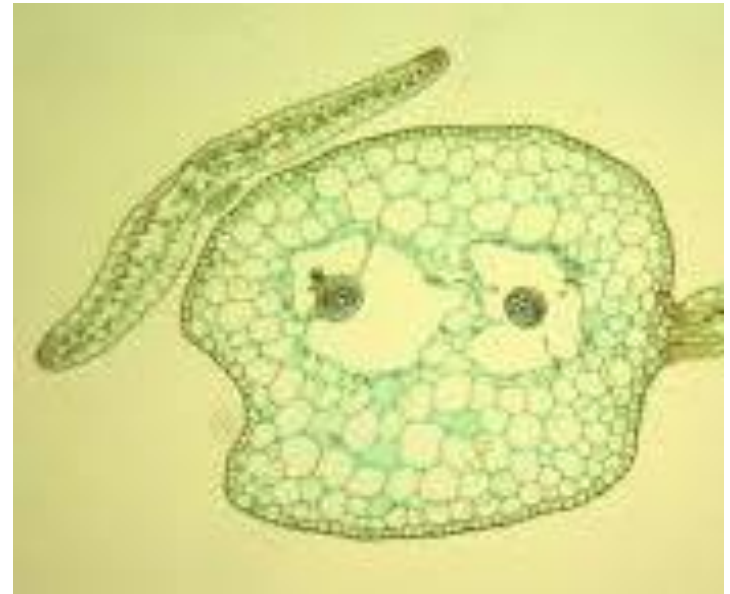
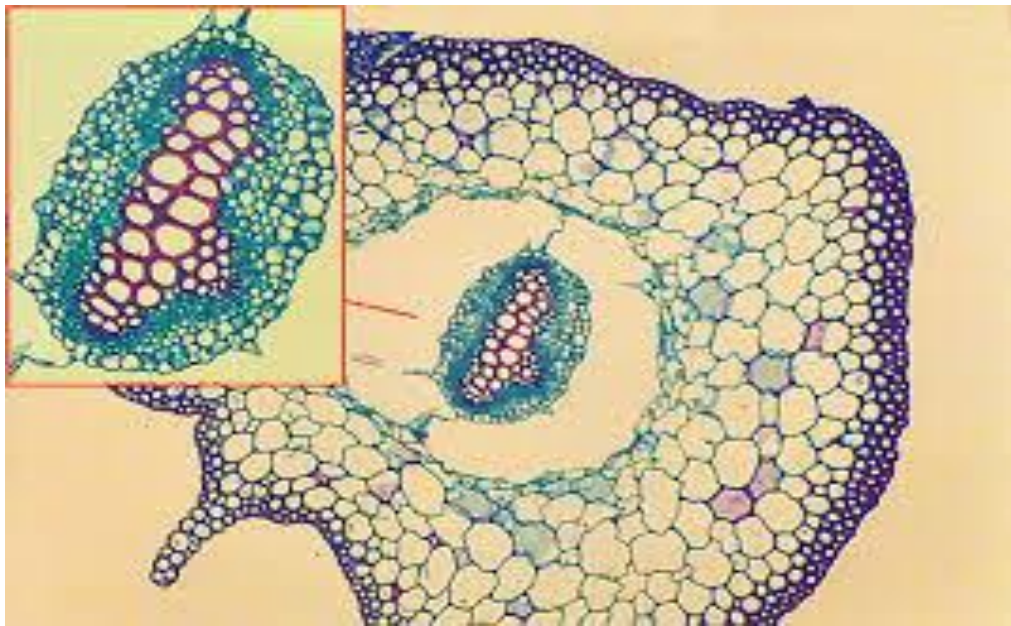


Fig. 7.47 : T.S. of *Selaginella* stem

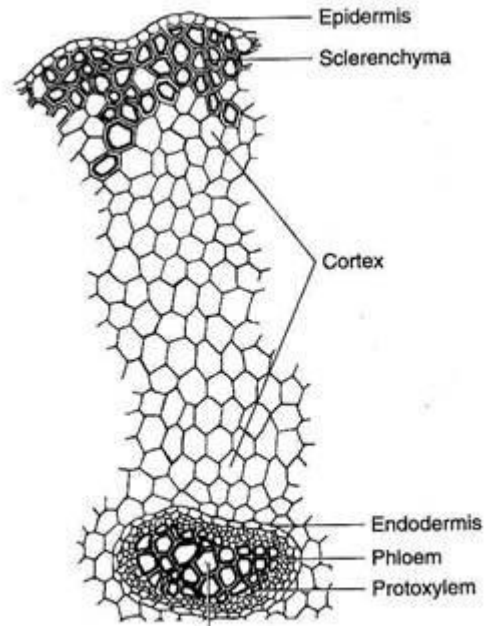
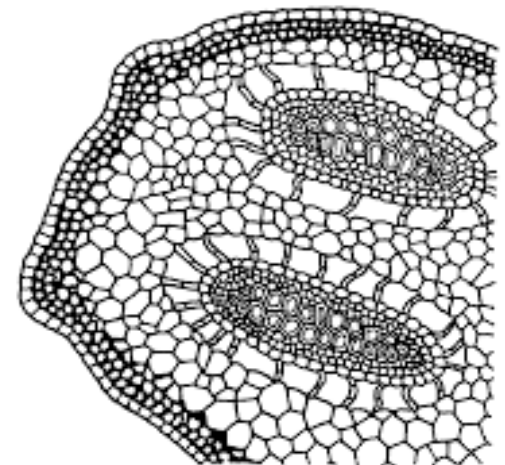


Fig. 7.48 : T.S. of rhizophore of *Selaginella*

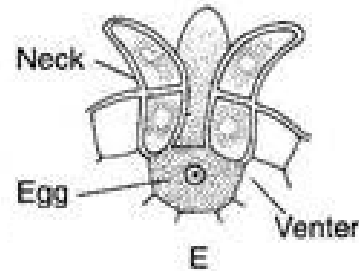


Dr. Shaimaa N. Mohamed Fatah

- The haploid spores germinate to form the **endosporic** gametophytes. The development of microspores and megaspores generally starts while they are still inside their respective sporangia. Therefore, the spores are shed at multicellular stage.

Such gametophytes are better able to withstand dry conditions and this pattern of development may be seen as a step in the evolution of the seed

- The microspore germinates to form the male gametophyte.
- The megaspore germinates to form the female gametophyte.
- Female gametophyte is made of storage tissue, at its top simple archegonia develop (eight neck cells arranged in two rows of four cells each, 1 neck canal cell, 1 ventral canal cell and 1 egg cell).
- Biflagellate sperms (haploid) are liberated, then they swim to the archegonia through a thin film of water and fertilize the egg (haploid) to form diploid zygote.



. A mature archegonium

How far *Selaginella* approaches seed habit?

Selaginella exhibits a **significant approach** towards seed habit because of the following notable features:

- (i) It is a heterosporous pteridophyte.
- (ii) In some species of *Selaginella*, (*S. rupestris* and *S. monospora*) the megaspore number is reduced to one.
- (iii) In *S. rupestris*, the megaspore is retained within the megasporangium and the development of female gametophyte and subsequent fertilisation takes place in situ and even the young sporophyte can be seen developing on the parent plant.

approach to the true seed is not complete due to the following reasons:

- (a) The megasporangium wall is dehiscent and is not covered with the protective integuments,
- (b) The retention of the megaspore permanently within the megasporangium has not become established,
- (c) The absence of complete histological fusion between the megasporangium wall and the megaspore,
- (d) The direct access of sperms to the egg,
- (e) There is lack of resting period after the development of embryo.

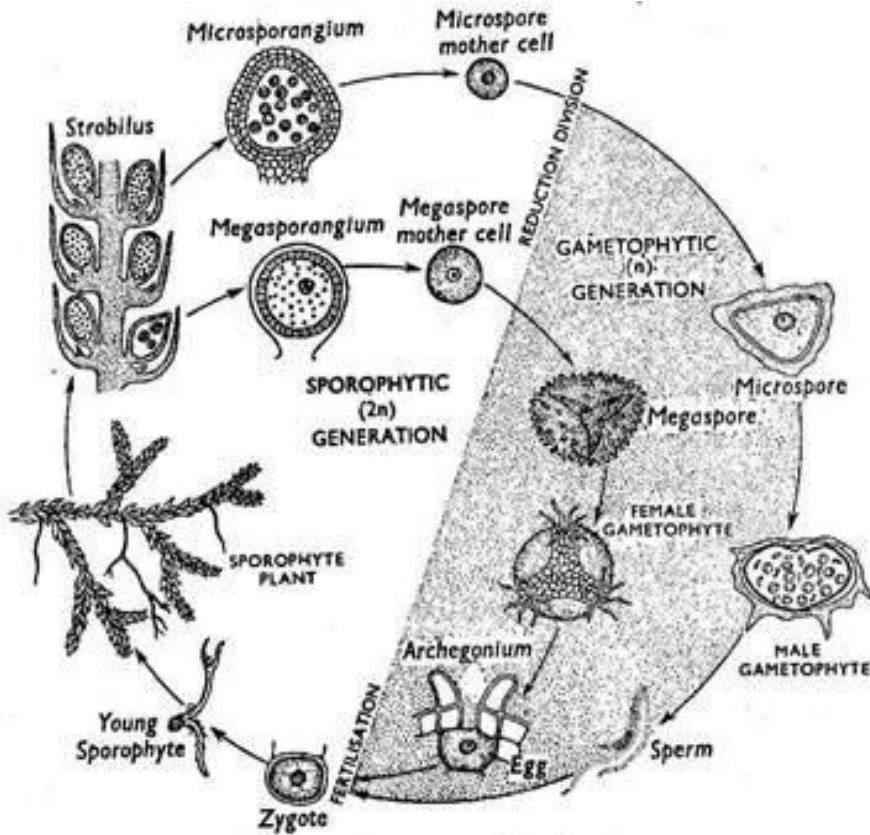


Fig. 7.58 : Life cycle of *Selaginella*

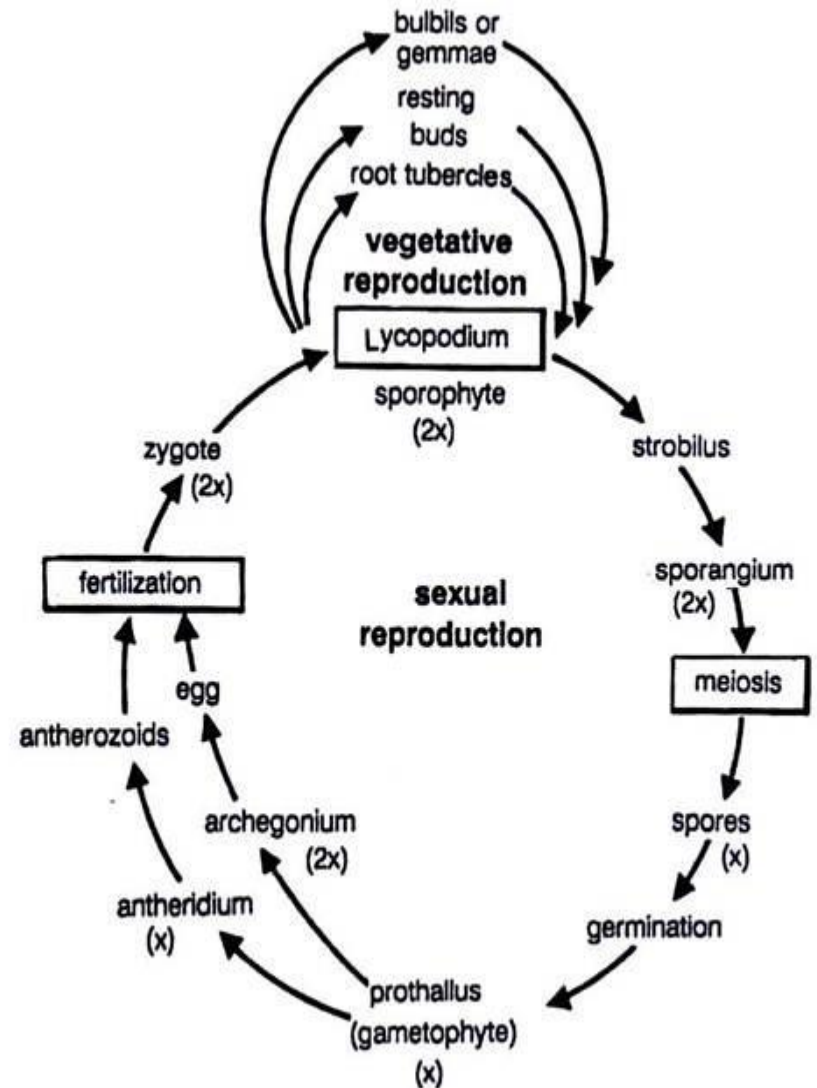


Fig. 15. *Lycopodium* : Schematic representation of life cycle