PTERIDOPHYTES

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INTRODUCTION

- Pteridophytes are plants that do not have any flowers or seeds.
- Hence another name for it is Cryptogams.
- They include ferns and horsetails. In fact, they can be considered as the first terrestrial vascular plants, showing the presence of the vascular tissue, xylem, and phloem.
- Mostly, we find these plants in damp and shady places. Also, most ferns are grown as ornamental plants.

- The plant body can be divided into true root, stem, and leaves.
- A saprophyte is the main plant body here. Some of the species belonging to this division have small leaves called the microphylls.
- For example, *Selaginella*. *Megaphylls* are the large leaves that some pteridophytes have. For example, fern plants.
- The main plant bears the sporangia. These bear some leaf-like appendages called the sporophylls.
- In a few species such as *Selaginella* and *Equisetum*, the sporophylls form compact structures called cones or strobili.

8 Minute Simplified Summary

PTERIDOPHYTA

BIOLOGYEXAMS4U
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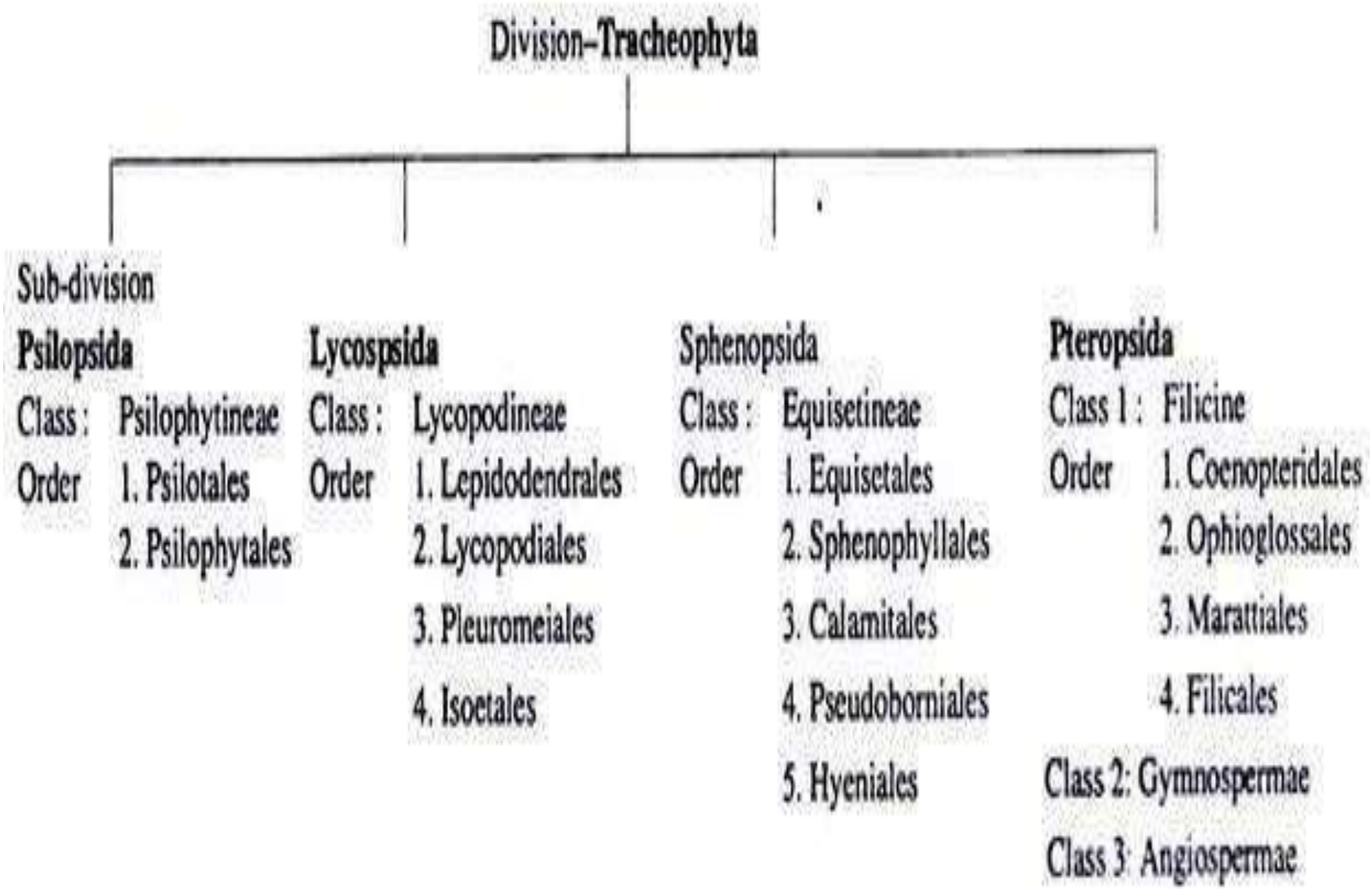
Divisions

- **Psilophyta**
- **Lycophyta**
  Lycopods
- **Sphenophyta**
  Horse tails
- **Pterophyta**
  Ferns

Primitive

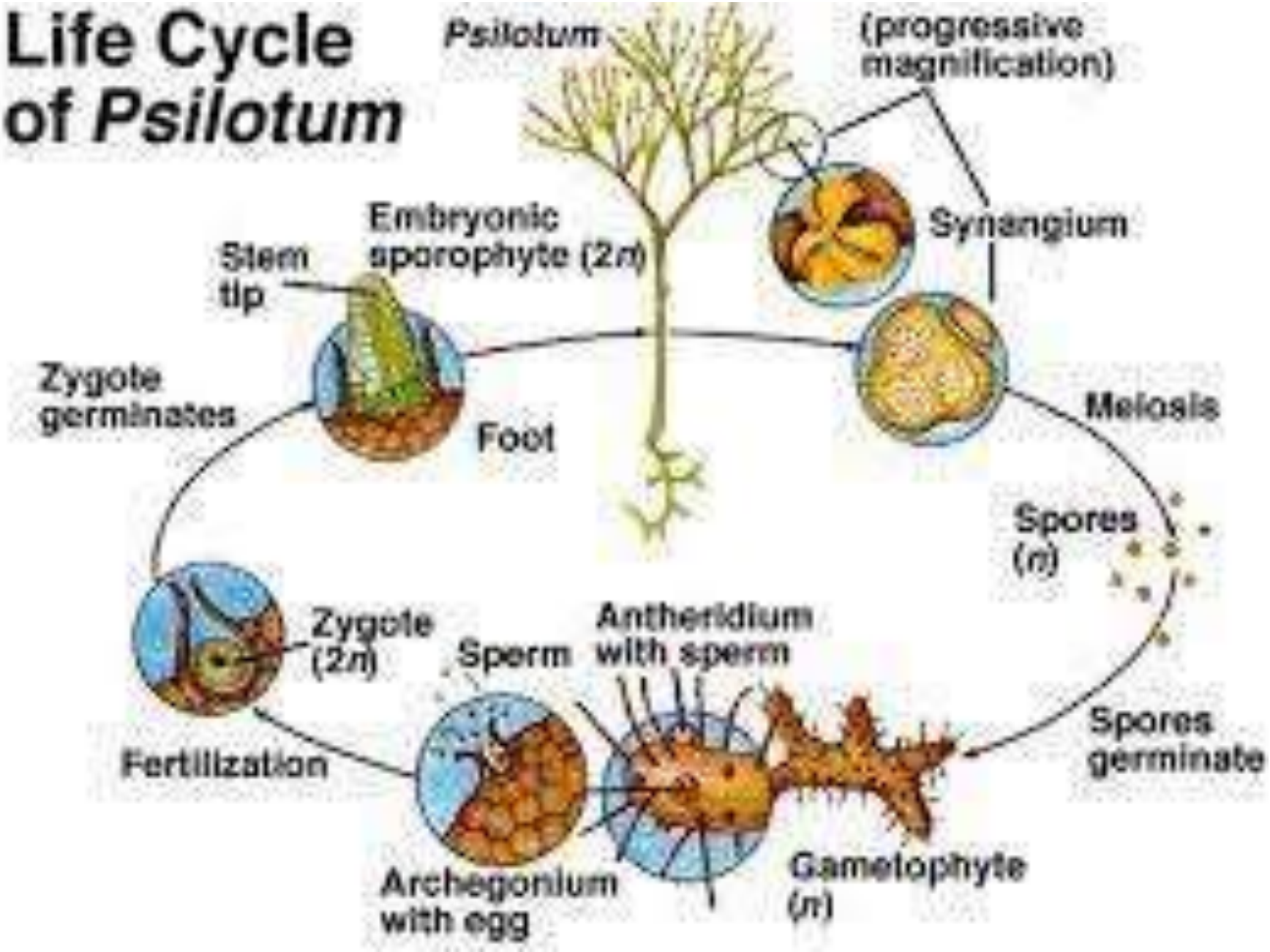
Advanced


Division–Tracheophyta
Sub-division
Psilopsida
Class : Psilophytineae
Order 1. Psilotales
2. Psilophytales
Lycospsida
Class : Lycopodineae
Order 1. Lepidodendrales
2. Lycopodiales
3. Pleuromeiales
4. Isoetales
Sphenopsida
Class : Equisetineae
Order 1. Equisetales
2. Sphenophyllales
3. Calamitales
4. Pseudoborniales
5. Hyeniales
Pteropsida
Class 1 : Filicine
Order 1. Coenopteridales
2. Ophioglossales
3. Marattiales
4. Filicales
Class 2: Gymnospermae
Class 3: Angiospermae

- Tracheophyta :-
- Group I. Psilopsida (Psilophytales and Psilotales)
- Group II. Lycopsida (Lycopodiales, Selaginellales, Lepidodendrales, Pleuromeiales and Isoetales)
- Group III. Sphenopsida (Hyeniales, Sphenophyllales and Equisetales)
- Group IV. Pteropsida (Filicineae, Gymnospermae and Angiospermae)

- I. Psilophyta (*Psilotum)*

Life Cycle of *Psilotum*



I. Psilophyta (Psilopsida)

1. The plant body is a rootless sporophyte that differentiates into a subterranean rhizome and an aerial erect shoot.

2. Branching is dichotomous in both subterranean rhizome and aerial shoot.

3. Rhizoids borne on the rhizome absorb water and nutrients from the soil.

4. Leaves often absent or if present, they are spirally arranged scale like (e.g. *Psilotum*) or leaf-like appendages (e.g. *Tmesipteris*) are bone

5. The vascular tissue is of primitive type i.e., simple, cylindrical protostele with annular or spiral tracheids.

6. Secondary growth is absent.

7. Sporangia are borne at the apex of the aerial shoots. They are either solitary (e.g., *Rhynia*) or in groups and terminal in position. There was nothing like that of sporophyll.

8. Sporangia always bearing the same type of spores i.e., they are homosporous

9. The gametophyte is known only in *Psilotum* and *Tmesipteris* (living genera) while unknown in Psilophytales.

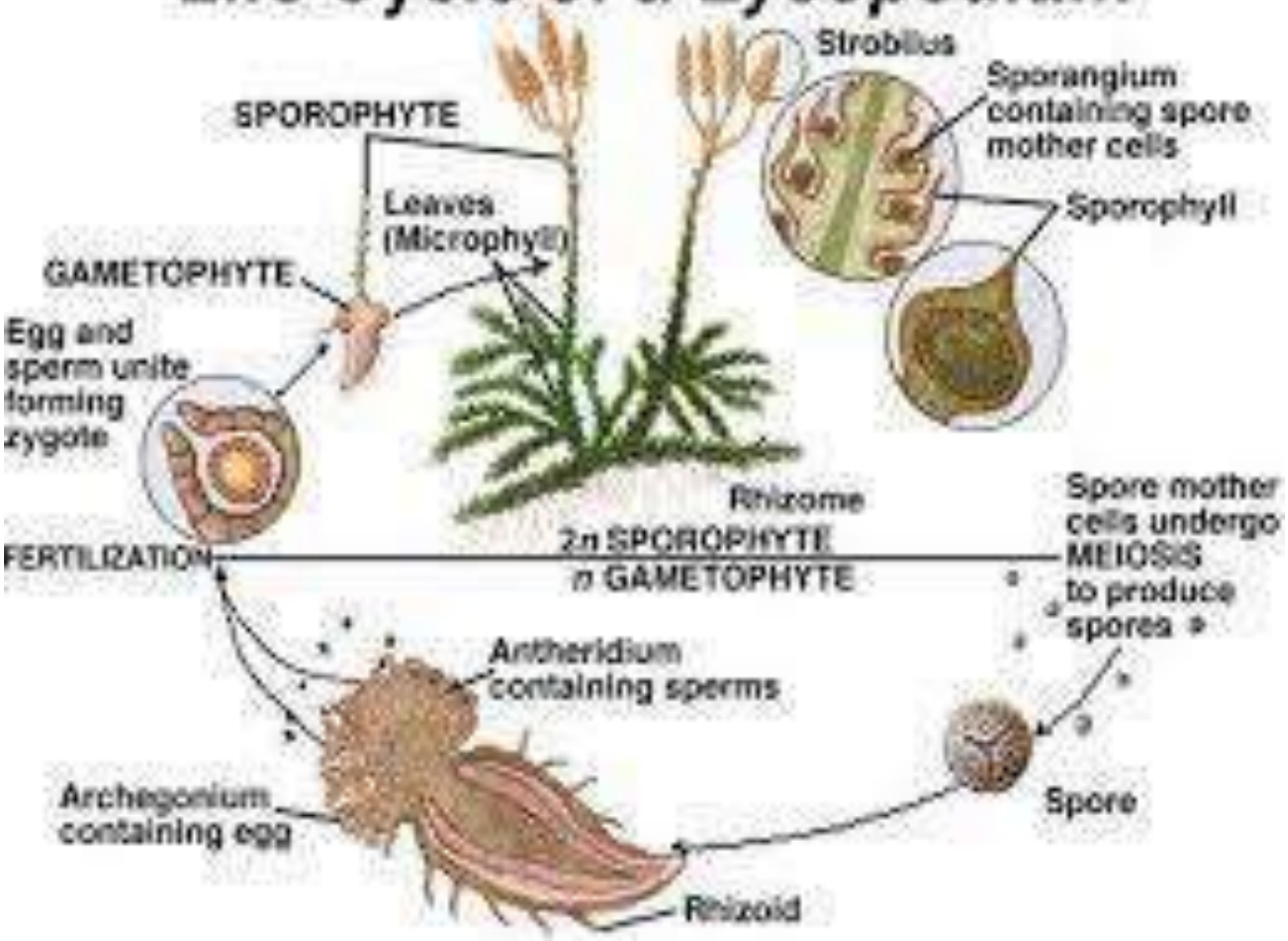
10.The gametophyte is cylindrical or branched, subterranean and colourless.

11. Sex organs are partially embedded in the prothallus.

12. Antherozoids are spirally coiled and multi-flagellated.

II. Lycophyta

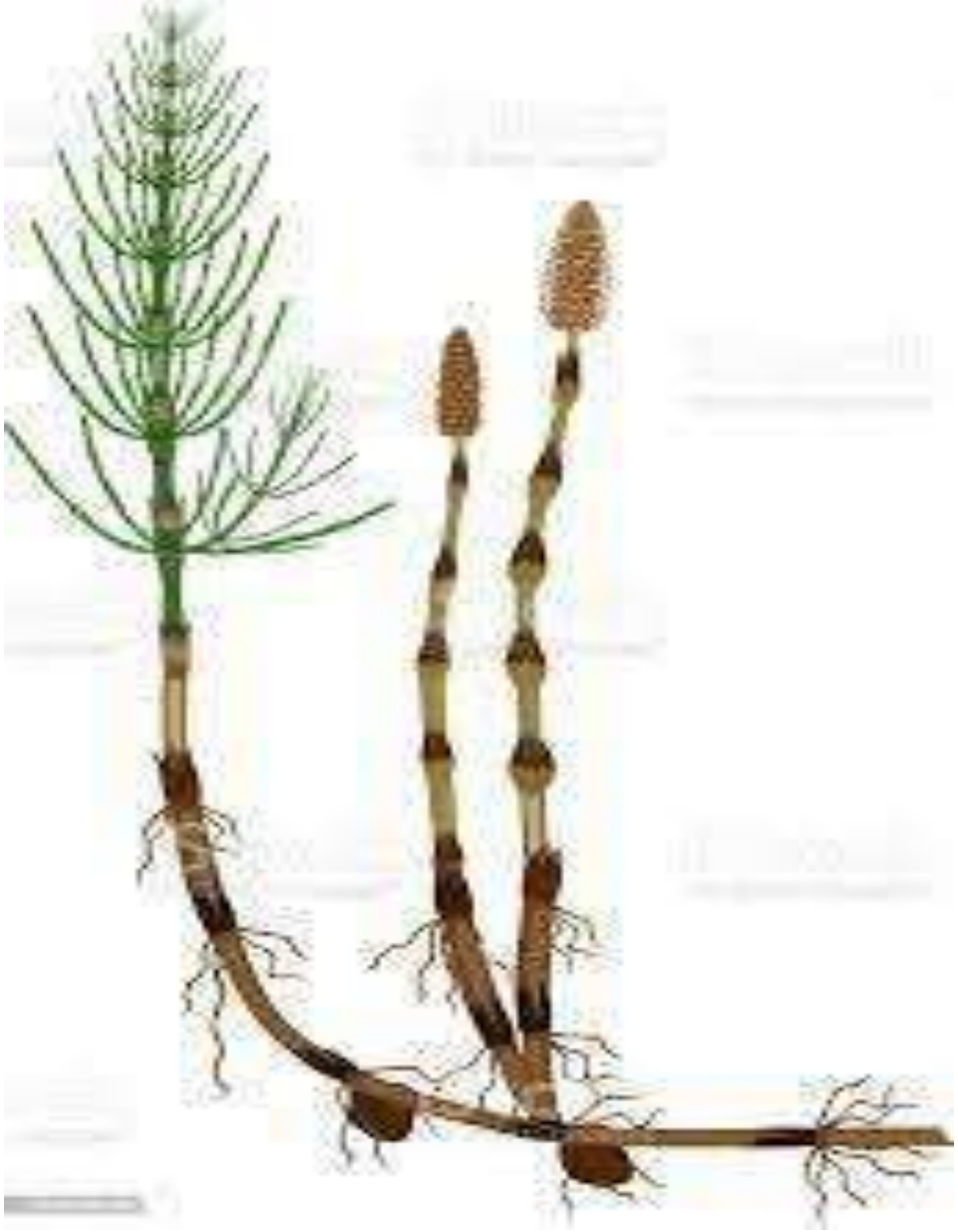
Life Cycle of a *Lycopodium*



II. Lycophyta (Lycopsida, Lepidophyta, Lycopodophyta,)

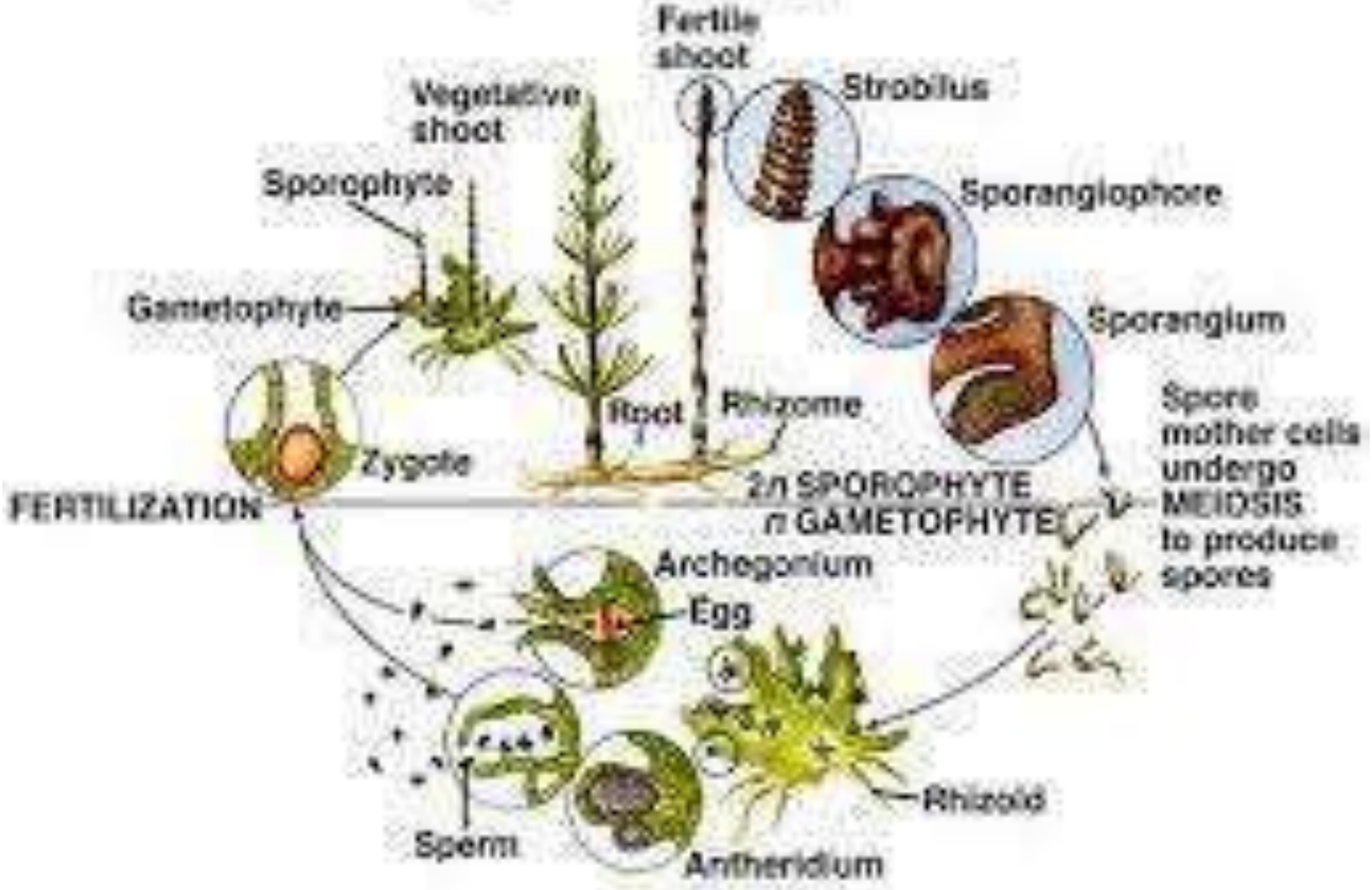
- 1.The plant body is sporophytic and can be differentiated into root, stem and leaves.
- 2. The leaves are small (microphyllous), simple with a single mid vein. They are usually spirally arranged, sometimes in opposite fashion and or even in whorls.
- 3. In some cases the leaves are ligulate (e.g., *Selaginella*, *Isoetes*). The ligule is present at the base of each leaf.
- 4. The vascular tissue may be either in the form of plectostele, siphonostele or sometimes even polystele. Leaf gaps are absent.
- 5. Sporophylls are loosely arranged or aggregated to form strobilus or cones.

- 6. Some members are homosporous (e.g. *Lycopodium*) while others are heterosporous (e.g. *Selaginella*).
- 7. Heterosporous forms have endoscopic gametophytes while in homosporous forms the gametophyte is exosporic.
- 8. Antherozoids are biflagellate or multi-flagellate.
- 9. Secondary growth does not take place except in *Isoetes*



III. Sphenophyta

Life Cycle of *Equisetum*



III. Sphenophyta (Sphenopsida, Calamophyta, Arthrophyta)

1. The plant body is sporophytic and can be differentiated into root, stem and leaves.
2. The stem in majority of the forms is long, jointed or articulated and is ribbed i.e., having ridges and grooves. Stem is divisible into nodes and internodes and is developed as upright aerial branches from the underground creeping rhizome.
3. Leaves are thin, small, scaly brown and are arranged in transverse whorls at the nodes of the aerial branches.
4. Branches also develop in whorls from the axil of the scaly leaves.
5. As the foliage leaves are reduced to scales, the process of photosynthesis is taken up by the stem and hence it becomes green.
6. The stem has a solid protostele (e.g., Sphenophyllum) or medullated protostele (e.g., *Equisetum*).

7. The sporangia are borne on specialized appendages called sporangiophores (the whole structure resembling but not homologous with a strobilus)

8. Sporangia are developed at the apex of the fertile branches in whorls forming compact cone.

9. Most of the members are homosporous but some fossil forms are heterosporous (e.g., *Catamites*).

10. Gametophytes (prothalli) may be monoecious or dioecious. Gametophytes are exosporic and green.

11. Antherozoids are large and multi-flagellate.

12. The embryo is without suspensor and is exoscopic in nature.

IV. Pterophyta

Ferns: Sporophyte is large and long lived but, when young, depends on gametophyte for nutrition.

IV. Pterophyta (Pteropsida, Filicophyta,)

- It includes the plants which are commonly known as ‘ferns’. It is represented by about 300 genera and more than 10000 species.

1. They occur in all types of habitats. Majority of the ferns are terrestrial and prefer to grow in moist and shady places. Some are aquatic (e.g., *Azolla, Salvinia, Marsilea*), xerophytic (e.g., *Adiantum emarginatum*), epiphytic (e.g., *Asplenium nidus*), halophytic (e.g., *Acrostichu*
2. Majority of the members (except some tree ferns (e.g., *Angiopteris*) have short and stout rhizome. The rhizome may be creeping, upright or growing above the soil.*m aureum*) or climbing (e.g., Stenochlaena).

3. Leaves are large, may be simple (e.g., *Ophioglossum*) or pinnately compound (majority of the ferns for example, *Pteridium*, *Marsilea, Adiantum* etc.) and described as fro

4. Leaves are ex-stipulate (e.g., *Filicales*) while stipulate in some other groups.

5. The vascular cylinder varies from a protostele to a complicated type of siphonostele. Solenostele, dictyostele and polystele are also found.nds. Young fronds are circinately coiled.

6. Vegetative reproduction takes place by fragmentation (e.g., *Adiantum, Pteridium*), stem tubers e.g., *Marsilea*), adventitious buds (e.g., *Asplenium bulbiferum*) or by apogamy (e.g., *Marsilea*).

7. Sporangia arise from placenta (a swollen cushion of cells) in groups (sori).

8. Sori develop on the margins or abaxial surface of the leaves (sporophylls) or leaflets.

9. Sori are protected by true (e.g.*Marsilea*) or false indusium (e.g. *Adiantum*, *Pteris*)

10.The sporangial development may be leptosporangiate (e.g., *Osmunda*) or eusporangiate type (e.g., *Ophioglossum*).

11. The sporangia in most cases have a distinct annulus and stomium.

12. Members may be homosporous (e.g., *Pteris*, *Adiantum* etc.) or heterosporous (e.g., *Marsilea*, *Azolla*, *Salvinia* etc.).

13. The gametophyte may be exosporic or endosporic.

14. Antheridia and archegonia are partially or completely embedded in the gametophyte. Antherozoids are multi-flagellated.

15. Embryogeny largely endoscopic. Embryo may or may not have suspensor.

PTERIDOPHYTA

Divisions

Psilophyta

Primitive, Rootless with rhizoids, Dichotomously branched photosynthetic stem, Leaves often absent, Protostele.

Homosporous synangium Eg: Fossil genera: Rhynia and Horneophyton Living genera **Psilotum** and Tmesipteris

Lycophyta
Lycopods

Differentiated plant body, Microphyllous leaves, Protostele sometimes siphonostele,Sporophylls aggregate to form strobili or cones,Homosporous (lycopodium) or hreterosporous (Selaginella)

Gametophyte depends on fungus for food

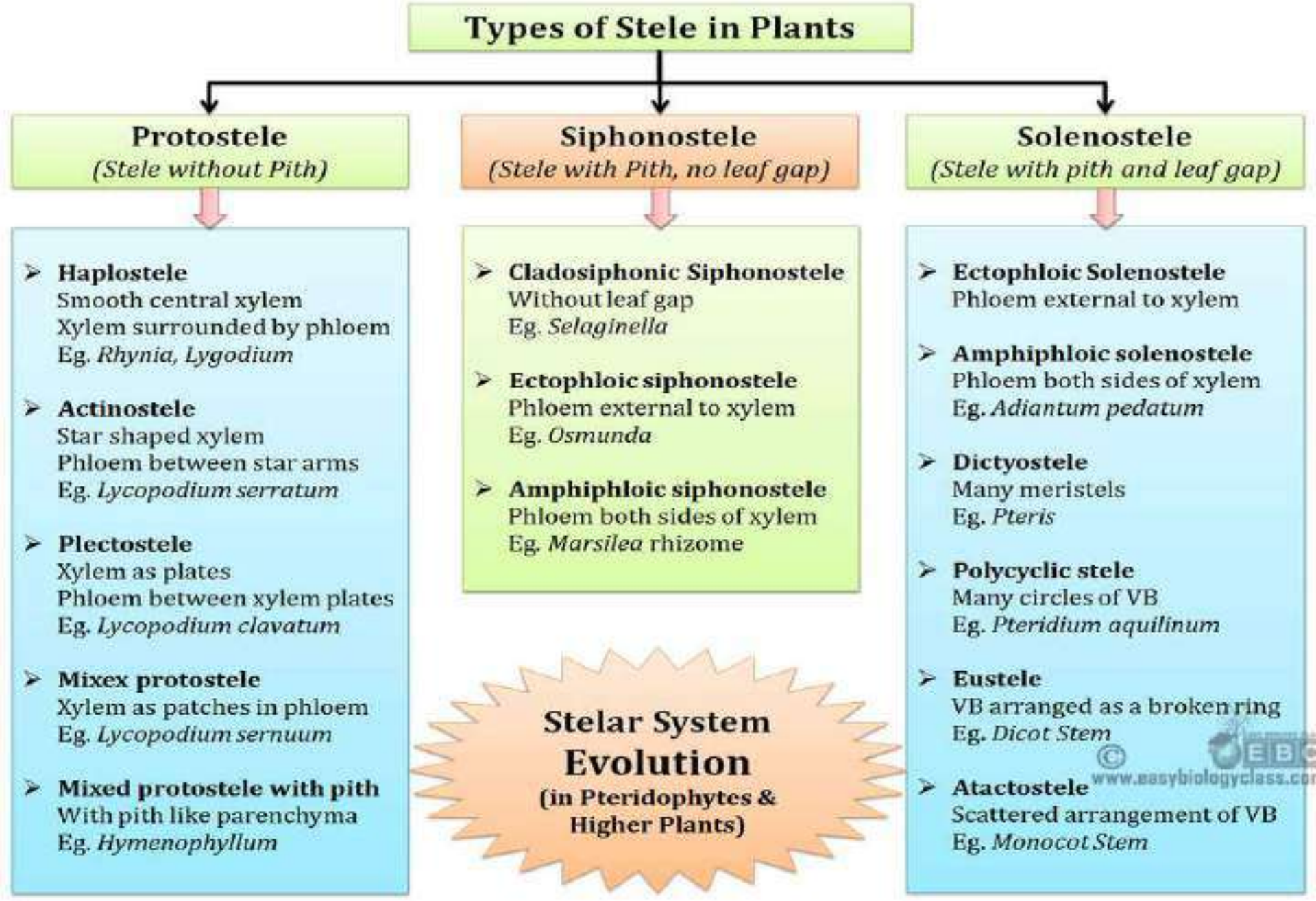
Sphenophyta
Horse tails

All are fossils except Equisetum, Differentiated plant body, Stem joined with nodes and internodes,Scaly leaves seen as whorl around the node, Sporangia forming strobili or cones,homosporous,

Pterophyta
Ferns

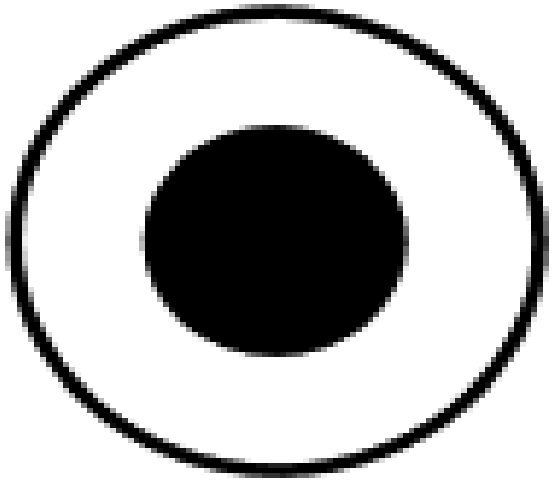
Most distributed, Differentiated plant body, stem mostly rhizomatous, Leaves macrophyllous called fronds,Young leaves show circinate vernation (spirally coiled), Stele: protostele, siphonostele or dictyostele, Sporangia form sori on abaxial side, Sporocarp in Marselia, Homosporous (*Pteris*) or heterosporous(Marselia), Antherozoids multiflagellated

Stelar evolution



PROTOSTELE

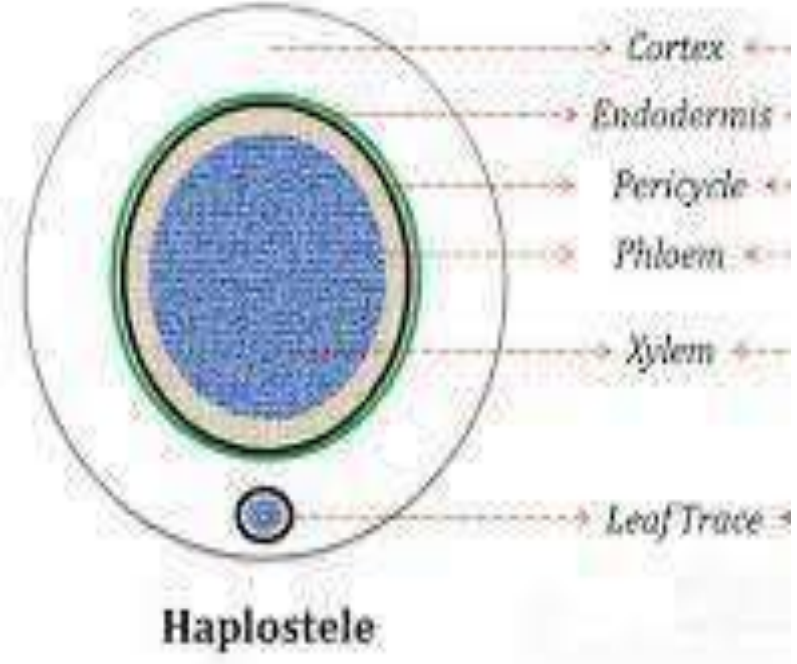
- The primitive type of stele is protostele.
- In protostele, the vascular tissue is a solid mass and the central core of the xylem is completely surrounded by the strand of phloem.
- This is the most primitive and simplest type of stele.

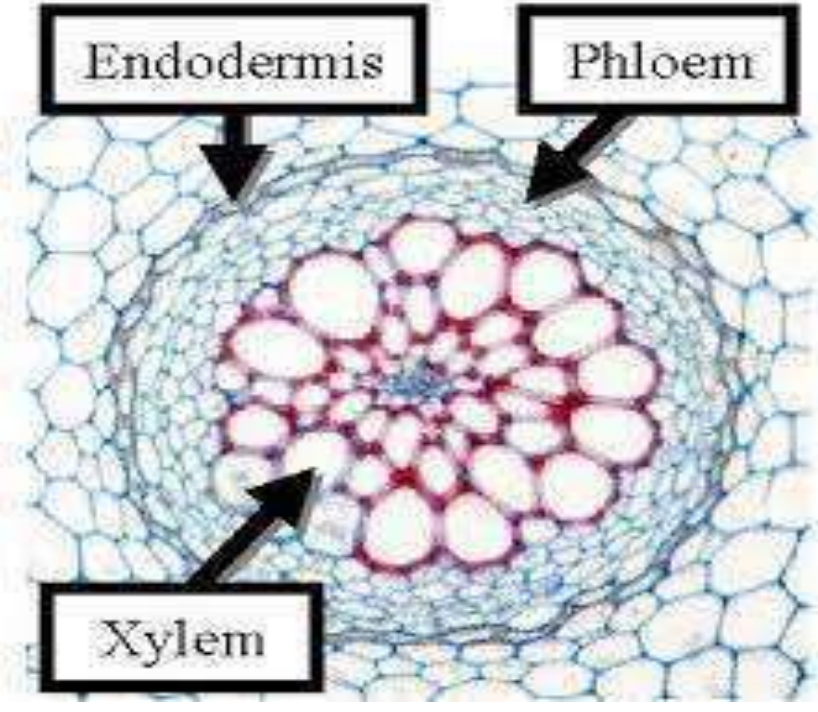


Protostele

(a) Haplostele

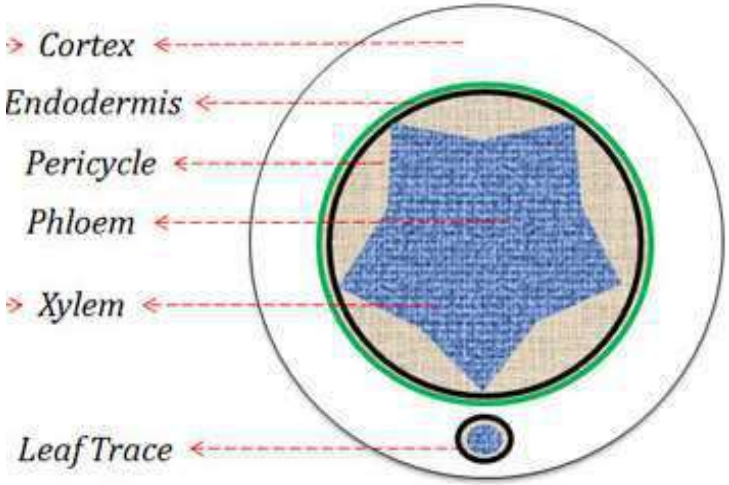
- This is the most primitive type of protostele.
- Here the central solid smooth core of xylem remains surrounded by phloem.
- (e.g., *Selaginella* spp.).



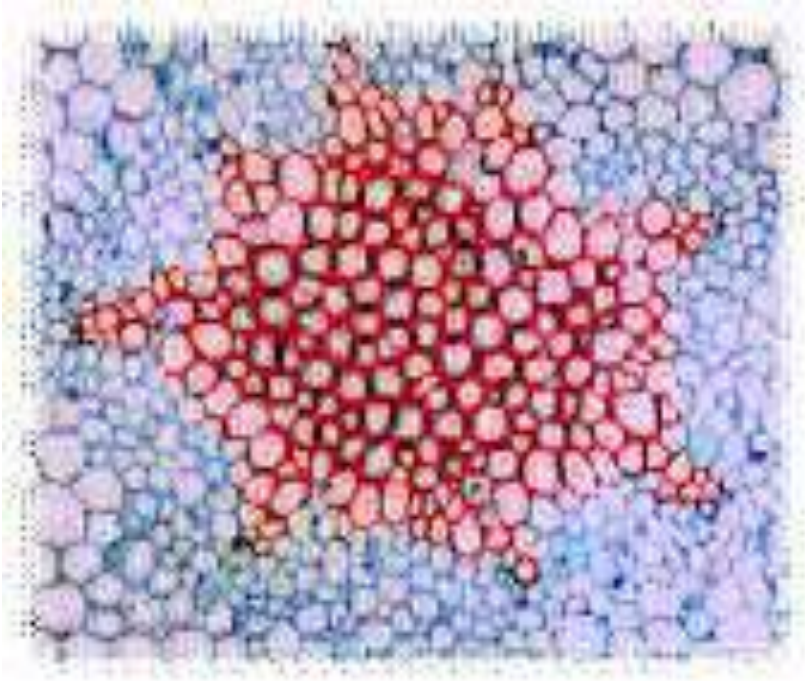


(b) Actinostele

- This is the modification of the haplostele and somewhat more advanced in having the central xylem core with radiating ribs
- e.g., *Psilotum* sp.

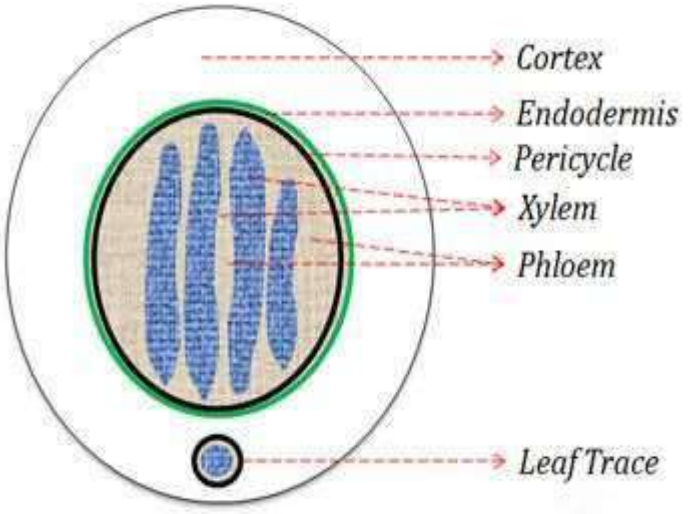


Actinostele

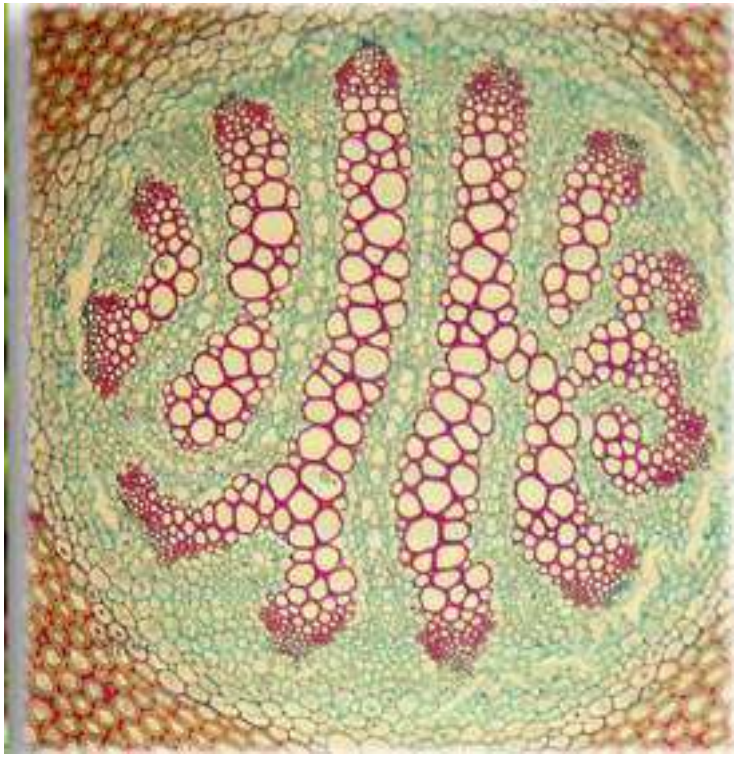


(c) Plectostele

- This is the most advanced type of protostele. Here the central core of xylem is divided into number of plates arranged parallel to each other.
- The phloem alternates the xylem
- e.g., *Lycopodium*.

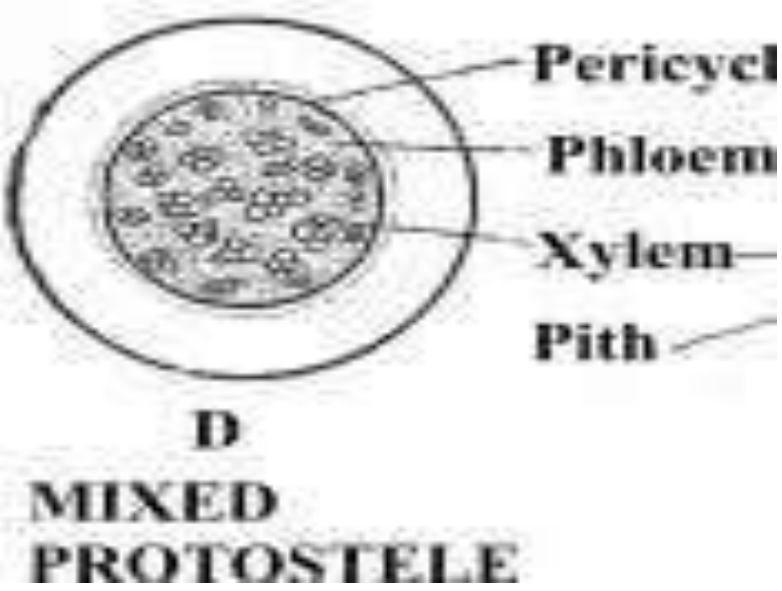


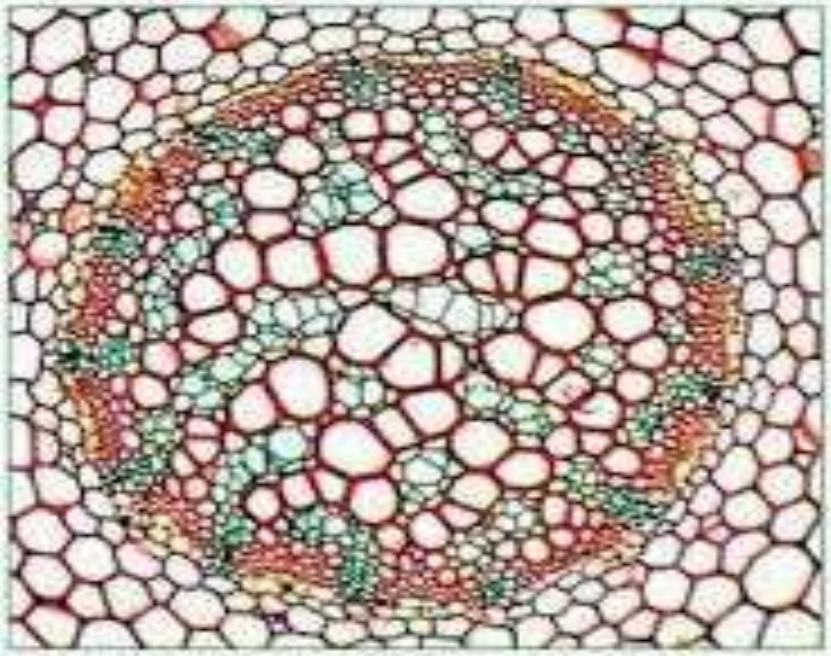
Plectostele



(d) Mixed-proto stele

- Here the xylem elements (i.e., tracheids) are mixed with the parenchymatous cells of the pith.
- This type is found in primitive fossils and living ferns.
- They are treated to be the transitional types in between true protosteles on the one hand and siphonosteles on the other
- e.g., *Lycopodium cernum* sp.





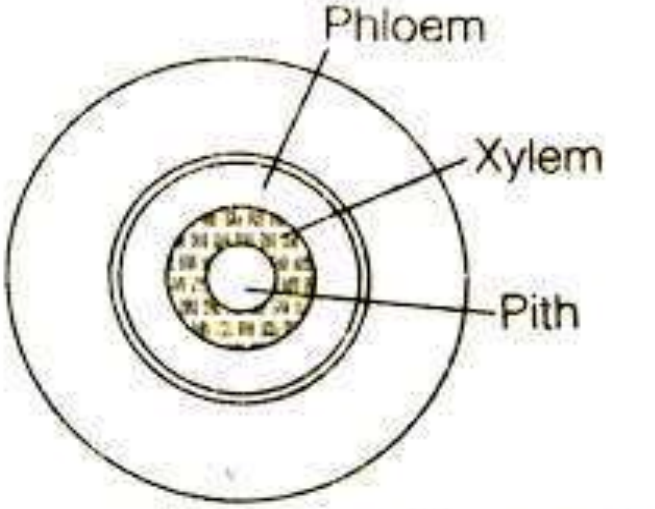
Mixed Protostele
(*Lycopodium cernuum*)

2. Siphonostele

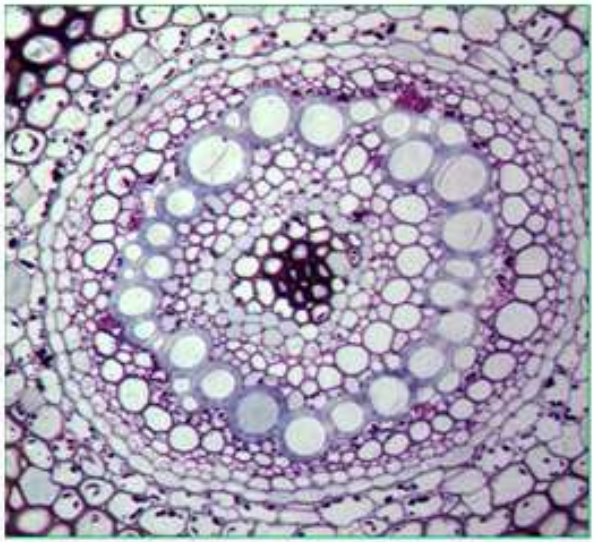
- This is the modification of protostele. A stele in which the protostele is medullated is known as siphonostele.

Ectophloic Siphonostele

This type of stele has centre pith which is surrounded by concentric rings of xylem followed by phloem. Eg: *Osmunda*

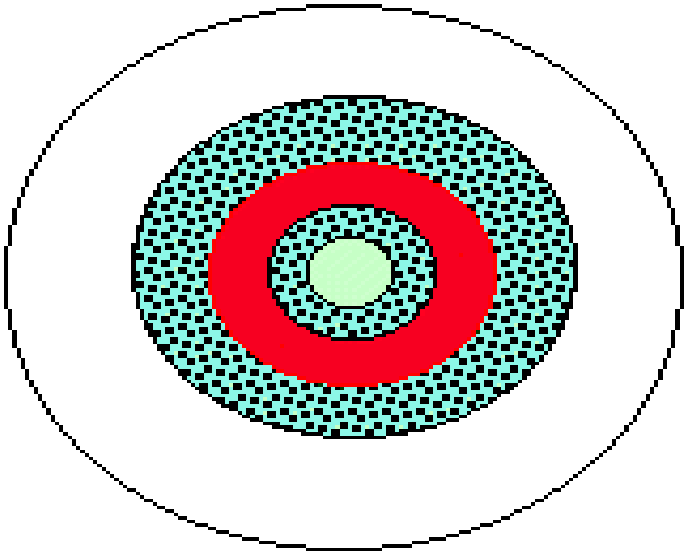


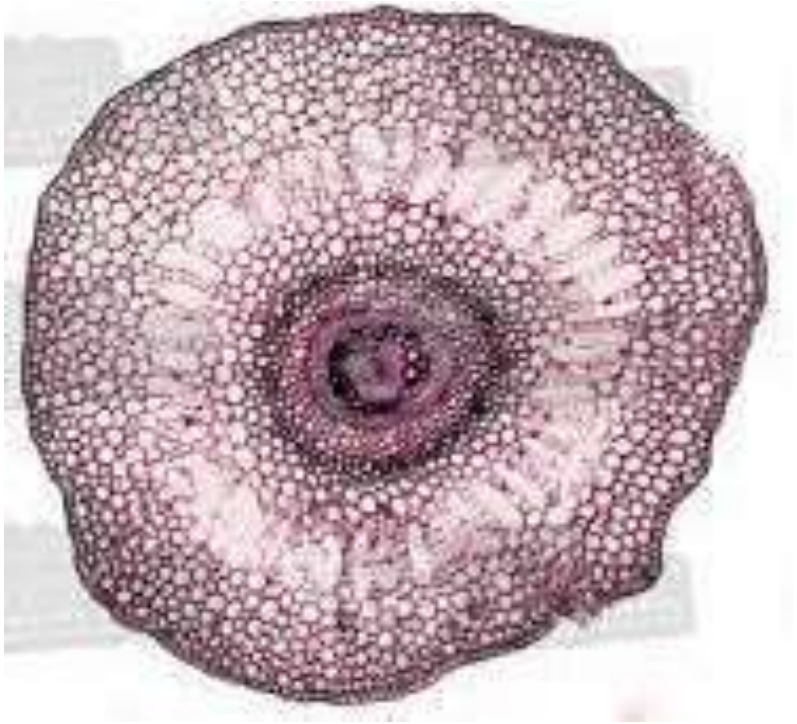
Ectophloic siphonostele


Ectophloic Siphonostele

b) Amphiphloic Siphonostele

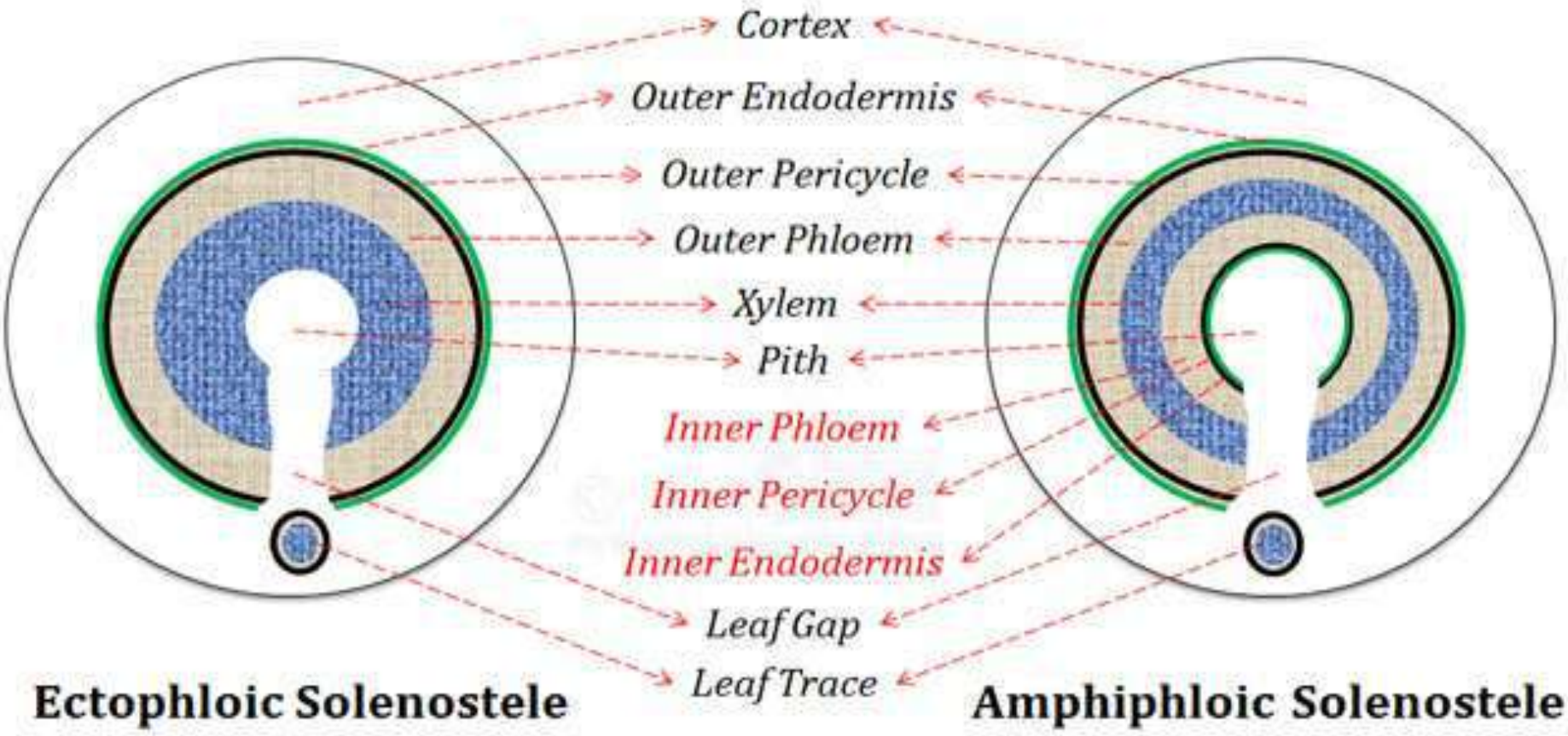
- In this type of siphonostele the pith is surrounded by the vascular tissue.
- The concentric inner phloem cylinaer surrounds the central pith.
- Next to the inner phloem is the concentric xylem cylinder which is immediately surrounded by outer phloem cylinder
- e.g., *Marsilea* rhizome





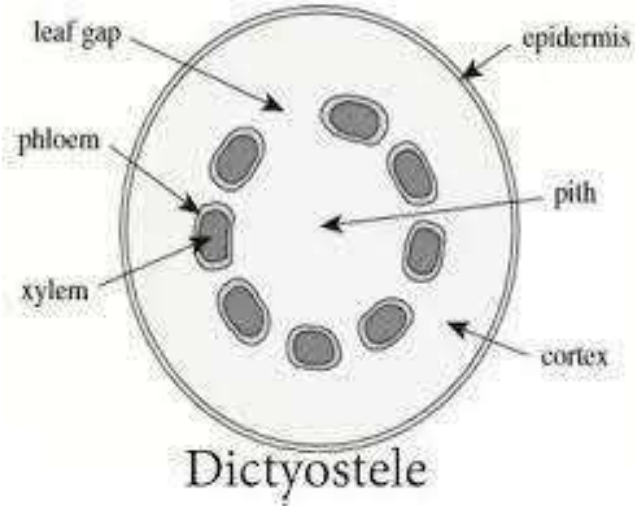
3. Solenostele

- The vascular plants have been divided into two groups on the basis of the presence or absence of the leaf gaps.



Amphiphloic Solenostele
(*Adiantum pedatum*)

Dictyostele



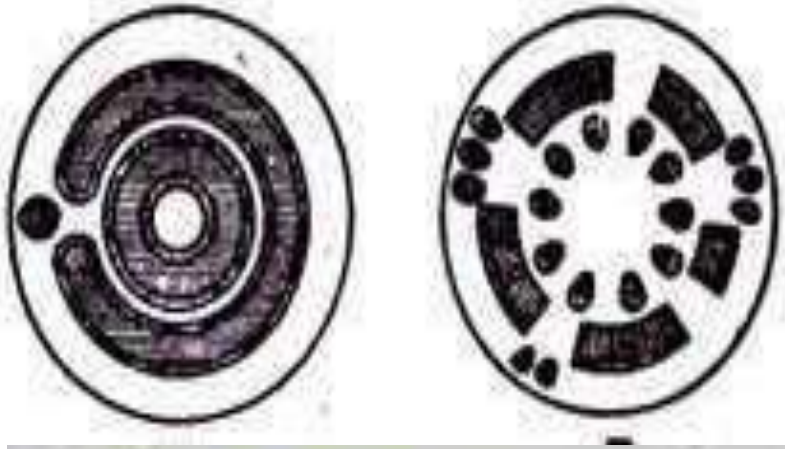
Dictyostele

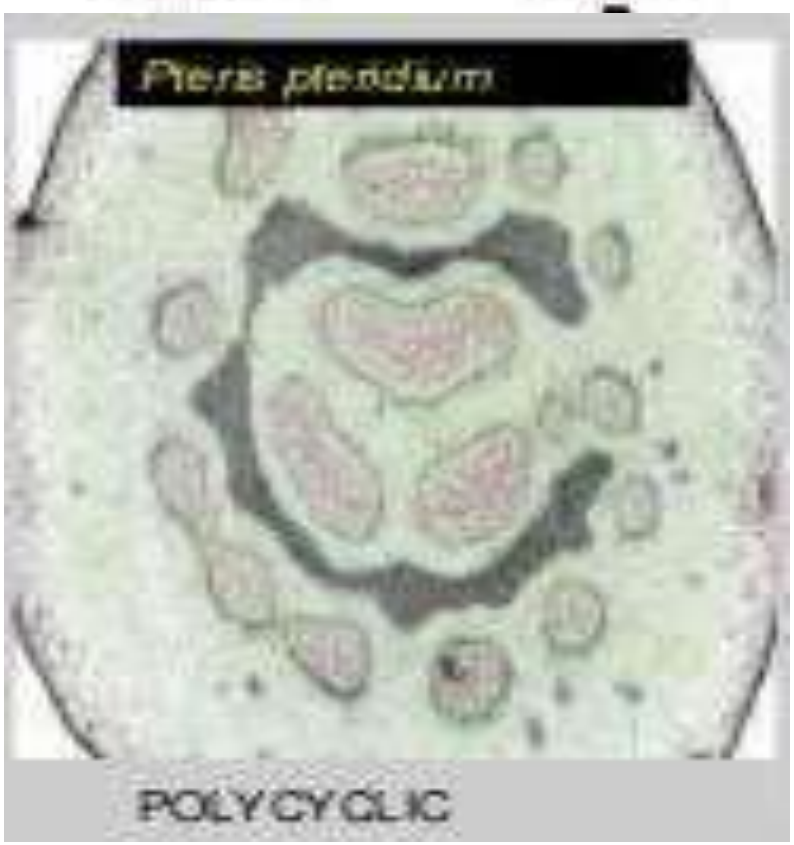
- Solenostele that is broken into a network of separate vascular strands.
- Breaking up of stelar core is due presence of large number of leaf gaps.
- Each such separate vascular strands is called meristele. Each meristele is of protostelic type.

Eg: *Pteris, Polypodium*

5. Polycylic Stele:

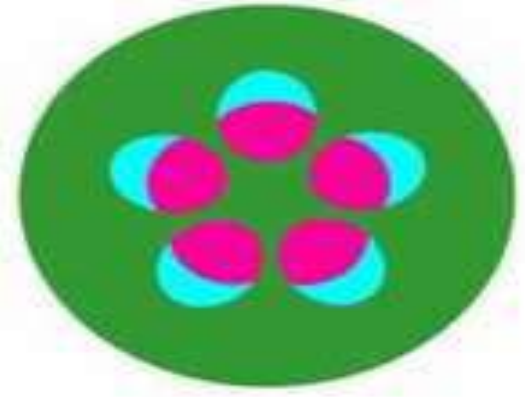
- Most complex amongst all vascular cryptogams
- Such type of steles are always siphonostelic in structure
- Possesses two or more concentric rings of vascular tissue
- This may be a solenostele or a dictyostele
- 2 concentric ring – e.g. *Pteridium*

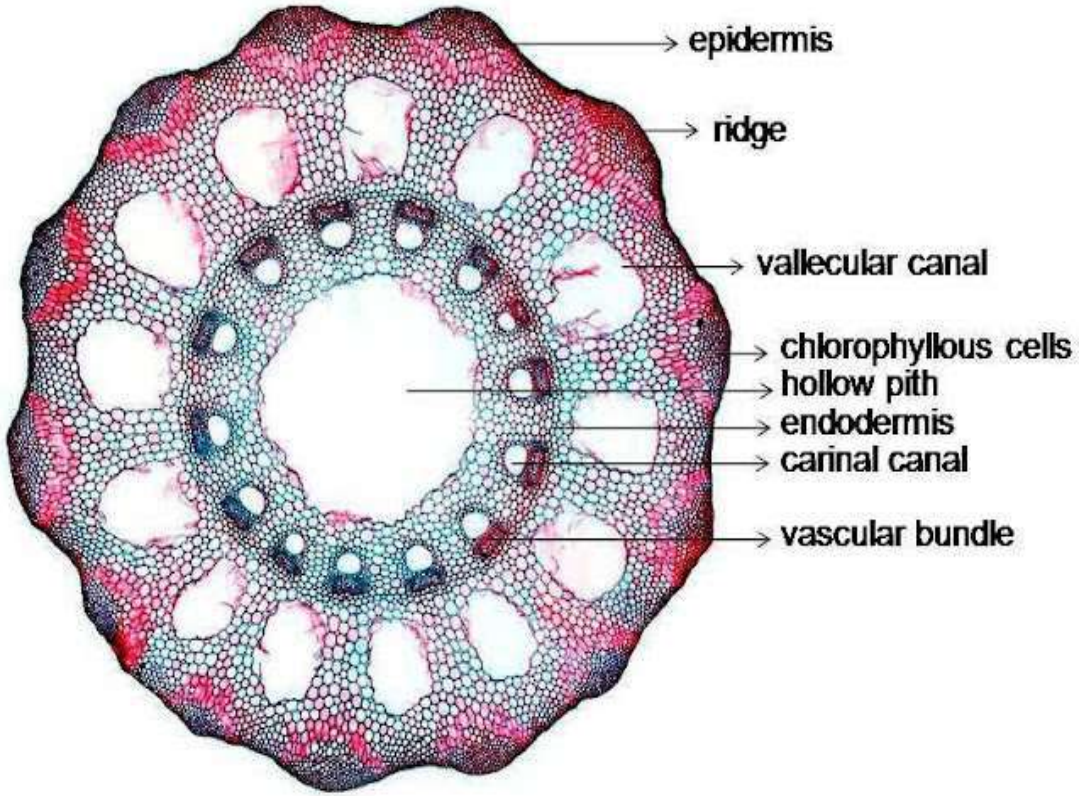




6. Eustele

- Modification of the siphonostele
- Vascular system consists of a ring of collateral or bicollateral vascular bundles situated on the periphery of the pith.
- E.g. *Equisetum*





Psilotum

- Division : Psilophyta
- Class : Psilotopsida
- Order : Psilotales
- Family : Psilotaceae
- Genus : *Psilotum*

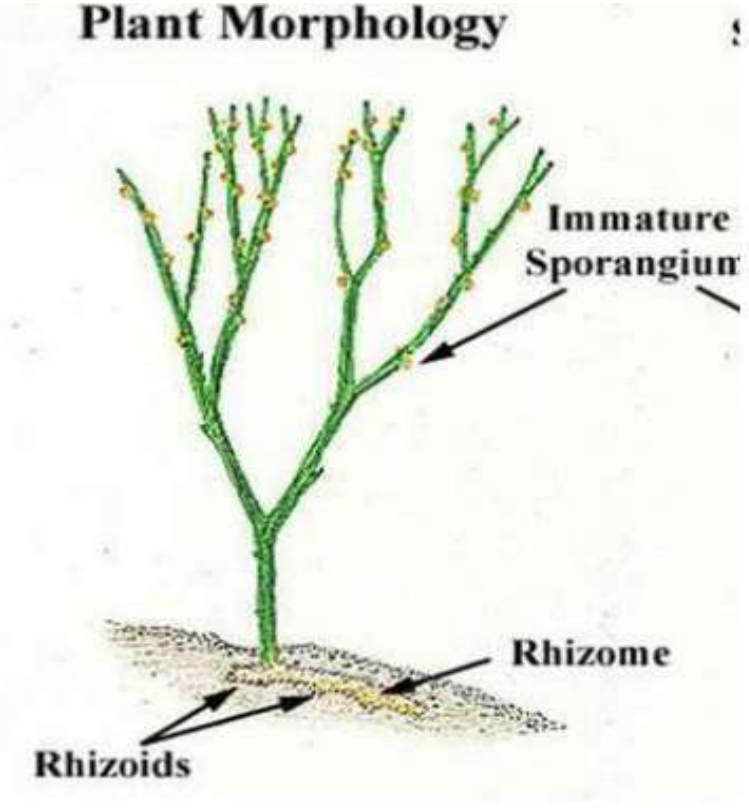
Occurrence

- It is commonly called as whisk fern (because it is a fern without leaves and so the stem performs all function).
- Found in humus rich soil , in tropical and sub tropical regions.
- Some species grows as epiphytes (tree trunk)

Vegetative morphology

- Plant Body: It is sporophyte and contains following parts

1. Rhizome
2. Aerial branch
3. Sporangia

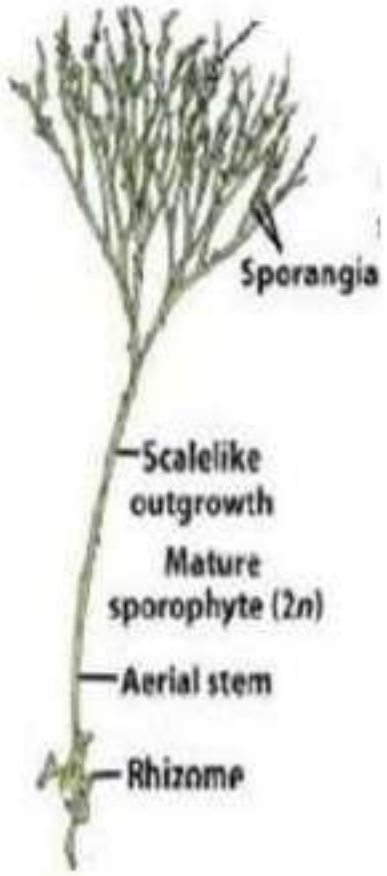


Rhizome

- The horizontal portion is rhizome, buried in soil or humus.
- Dichotomously branched
- 2 celled rhizoids are present near the apices of the younger branches
- These rhizoids absorb water and nutrients from soil for aerial branches.

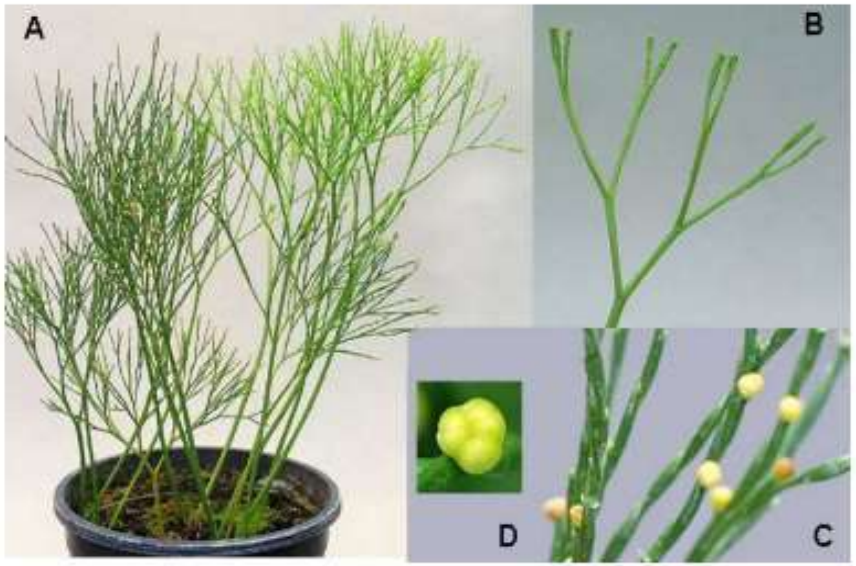
Aerial branch

- The branches are green, cylindrical and dichotomously branched
- The leaves are small, scale like and are scattered over these branches.



Sporangia

- The sporangia are borne in triads.
- They have very short stalks.
- They are borne in the axils of small bifid leaves on the aerial branches.
- This triad of sporangia is called a synangium.
- The two lobes of the leaf are closely united with the synangium.



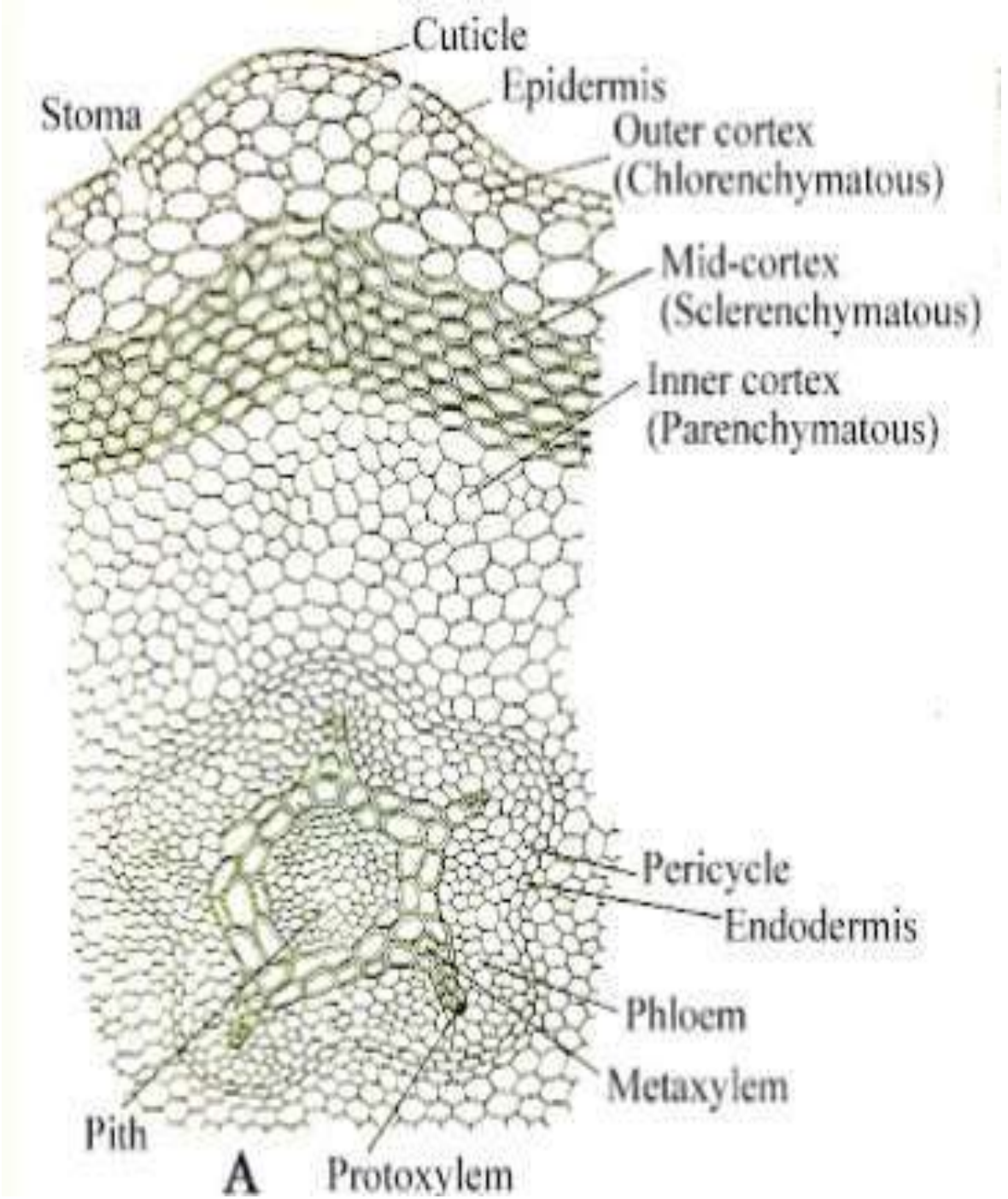
Stem Anatomy

It has following parts.

1.Epidermis

2.Cortex

3.Steler system

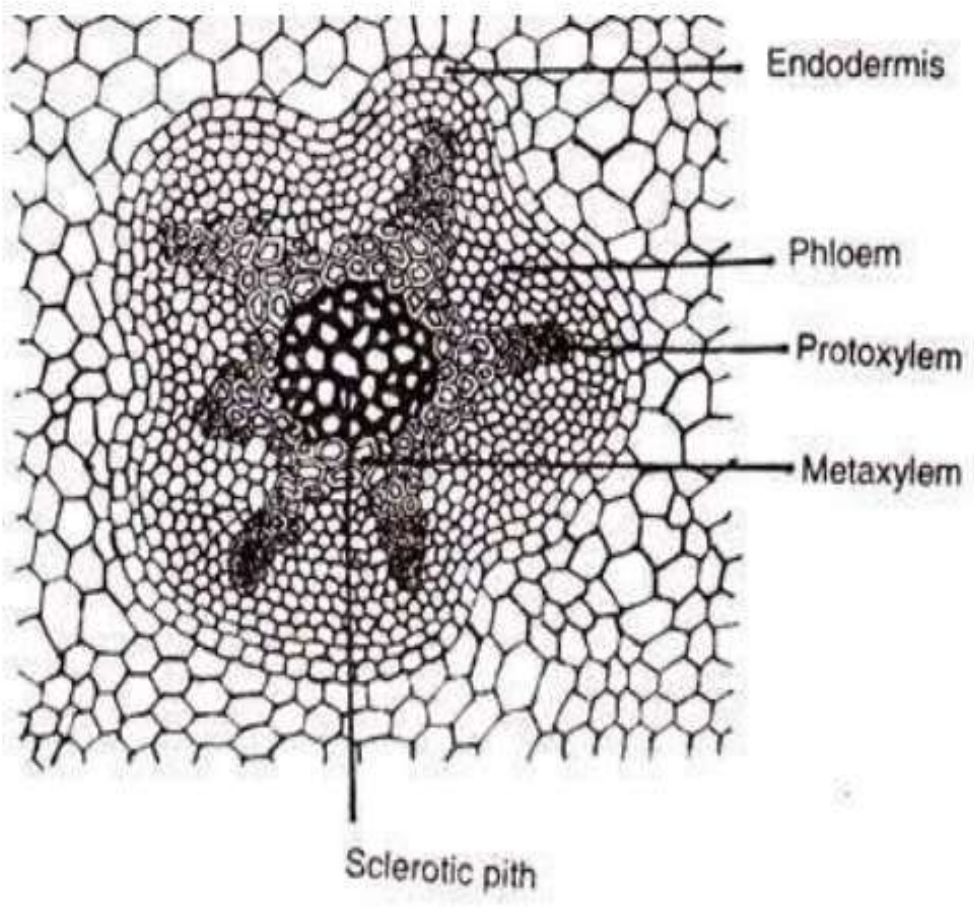


- Epidermis: There is a single layer of epidermis present outside. It is heavily cutinized, Stomata are also present on epidermis , situated at the grooves.
- Cortex: Cortex of *Psilotum* is divided into following parts. a) Chlorenchymatous cortex: It is the outermost part of cortex and has 2 to 5 layers of cells. The cells are thin walled and are parenchymatous . They are photosynthetic as they contained chloroplast.
- Seclerenchymatous cortex: Below the parenchymatous cells there are 2- 4 layers of sclerenchymatous cells . The cells are thick walled and provide support.
- Parenchymatous They form the major portion of the stem. The cells are thin walled and no inter cellular spaces in them

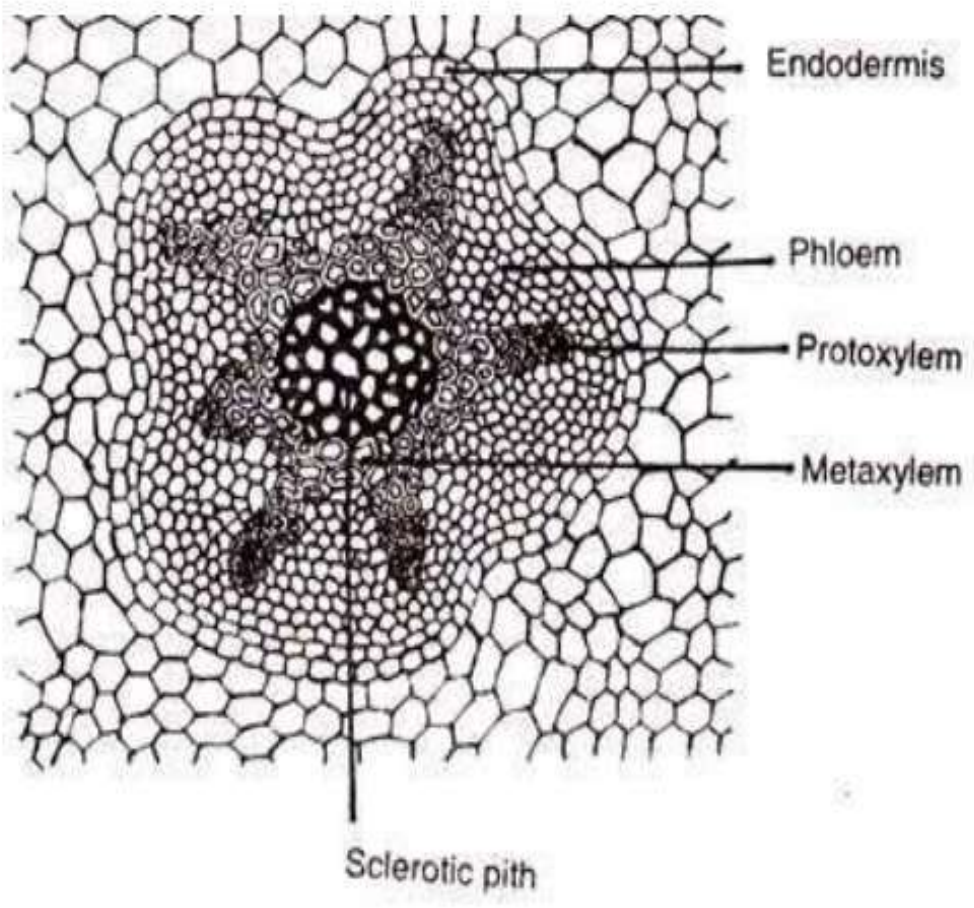
Steler system

1: Endodermis There is well developed endodermis between the stele and the cortex. These cells has casparian bands on their radial walls

2: Xylem : The xylem is actinostelic and radial in outside in 6 rays, the protoxylem is located at the tip of the rays. In the center the metaxylem xore is present The cells of xylem are thick walled and their main function is transport of nutrients

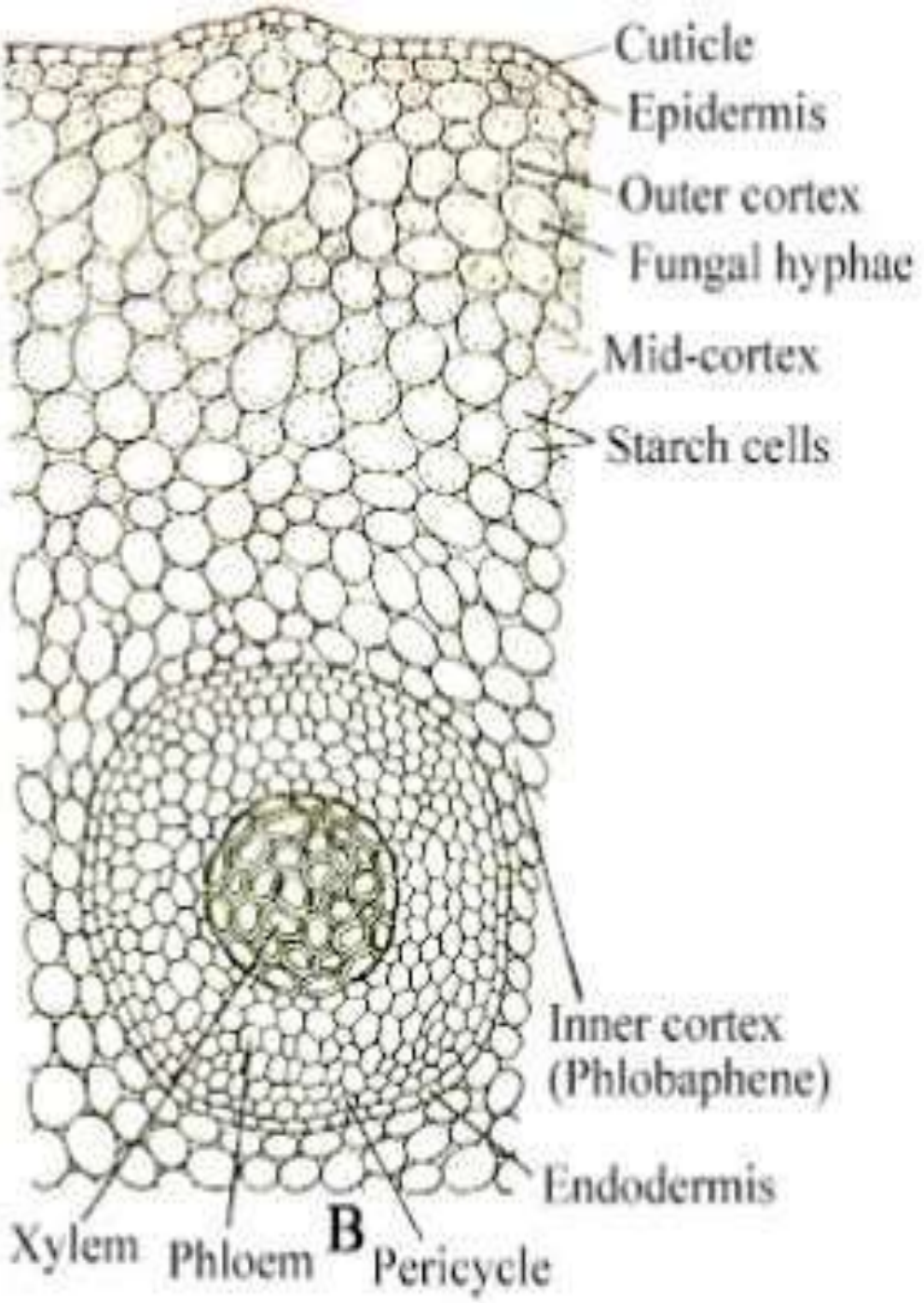


Phloem Between the endodermis and the xylem there is phloem. It is of thin walled cells It consist of sieve cells and sieve areas in their oblique end walls. Nuclei disintegrate at maturity



Anatomy of rhizome

- In rhizome the epidermis is inconspicuous and all the cells of outermost layer of cortex extend into rhizoids.
- The cortex is thin walled and cells contain fungus The endodermis is conspicuous The stele in rhizome is protostele (xylem is surrounded by phloem)
- The pith is absent And xylem occupies center of the axis and surrounded by the phloem



Reproduction

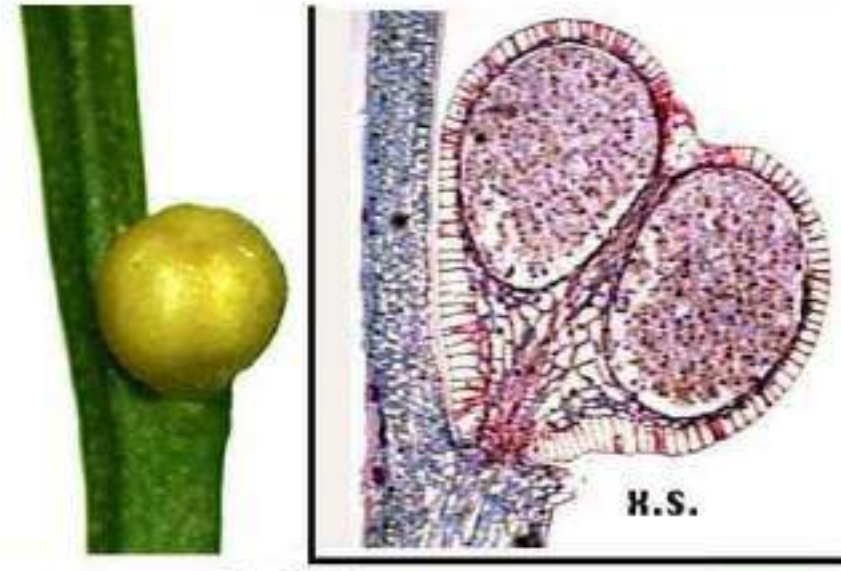
- It is characterized by alternation of generation
- Both spore producing and gamete producing regeneration are independent
- Sporophyte reproduces by asexual reproduction
- Gametophyte reproduces by sexual reproduction

Structure of synangium

- Each synangium is trilobed , stalked structure borne at the apex of short lateral branch .
- A bilobed appendage is present at the base of each synangium that curve and surround the stalk of synangium

Nature of synangium

1. The trilobed synangium is formed by fusion of two or more sporangia
2. One sporangium with 3 chambers (trilocular sporangium)
3. Synanium is cauline (developed at the apex of stem) in nature and it is actually modified trilocular sporangium present on lateral branches

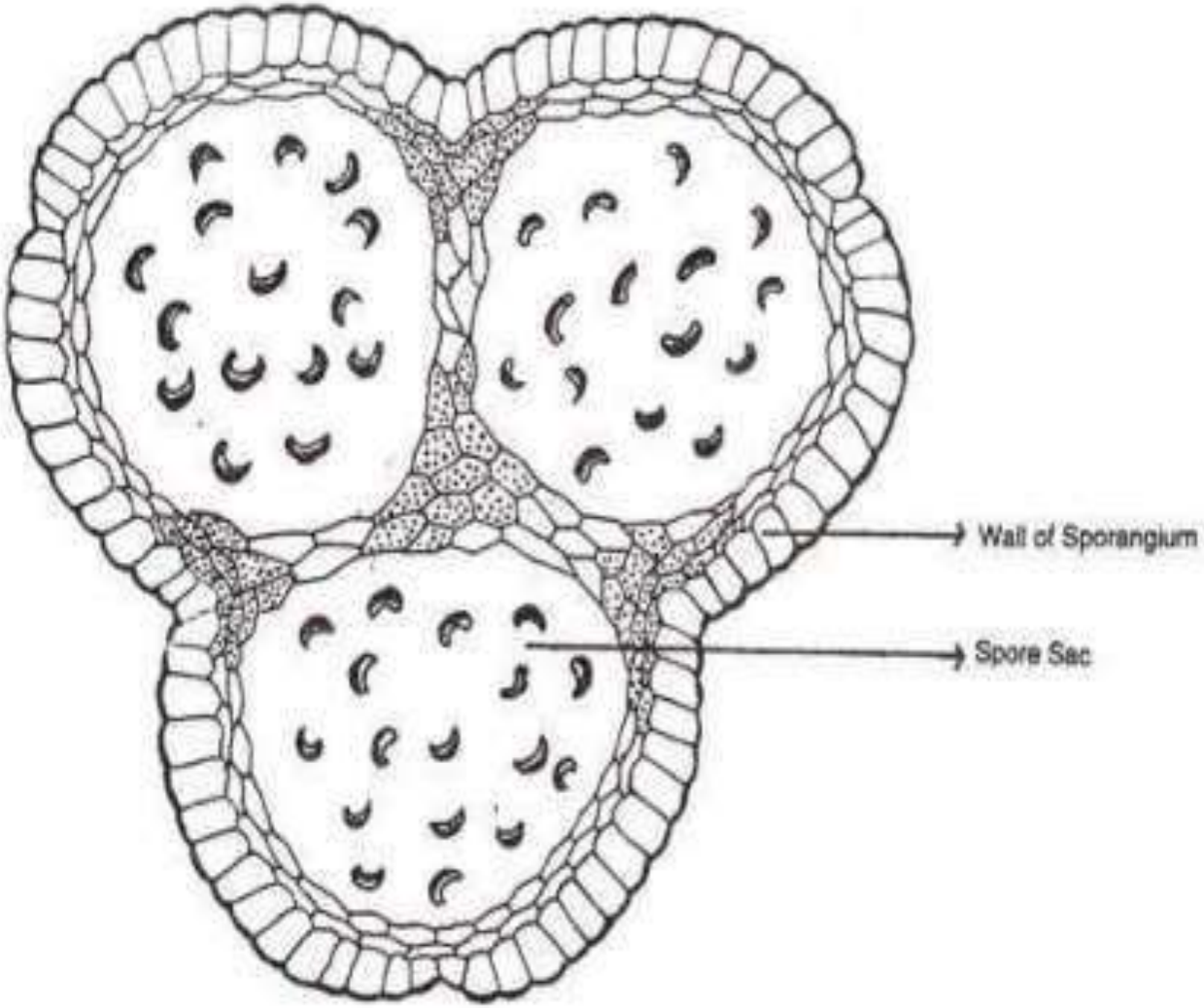


Psilotum
Sporangium

Internal Structure of synangium

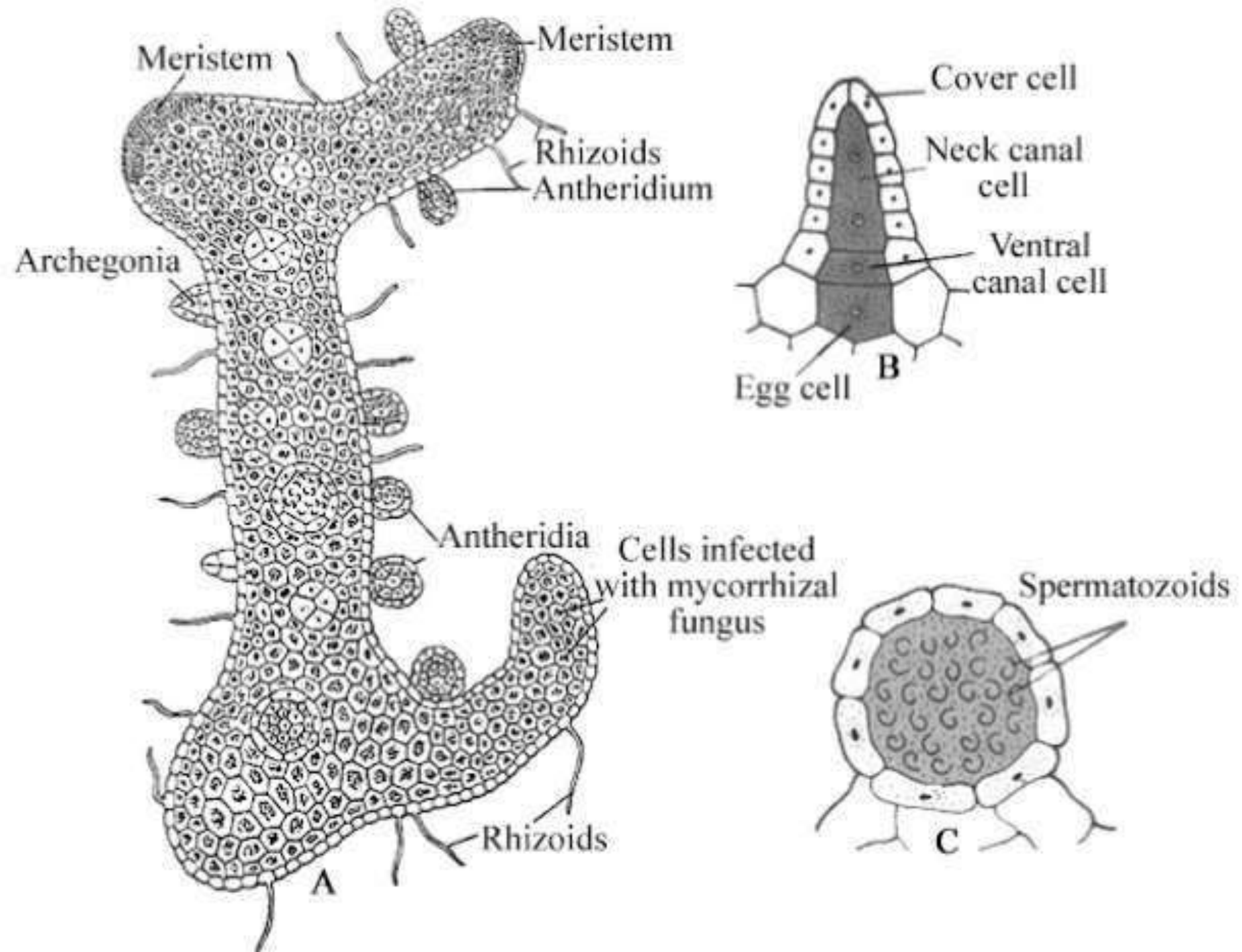
It consist if three chambers or locules

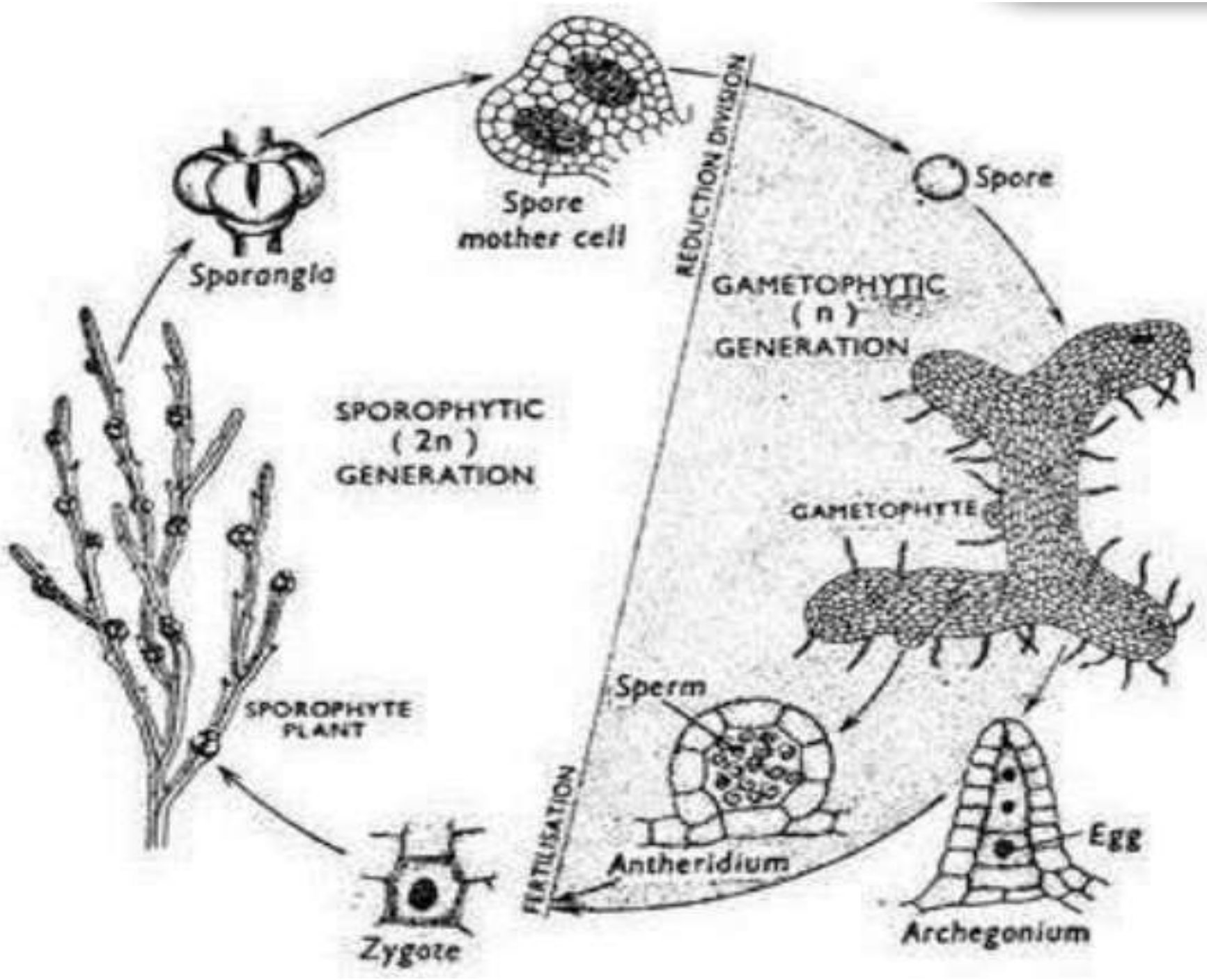
1. Wall of synangium is 3 – 4 layers
2. Thick outer wall forms the epidermis
3. Inner wall separates the three locules
4. Each locule is filled up with large number of spore. And these are homosporous in nature
5. Synangium splits up from 3 lines along the epidermis and dehiscence occurs.


Wall of Sporangium
Spore Sac

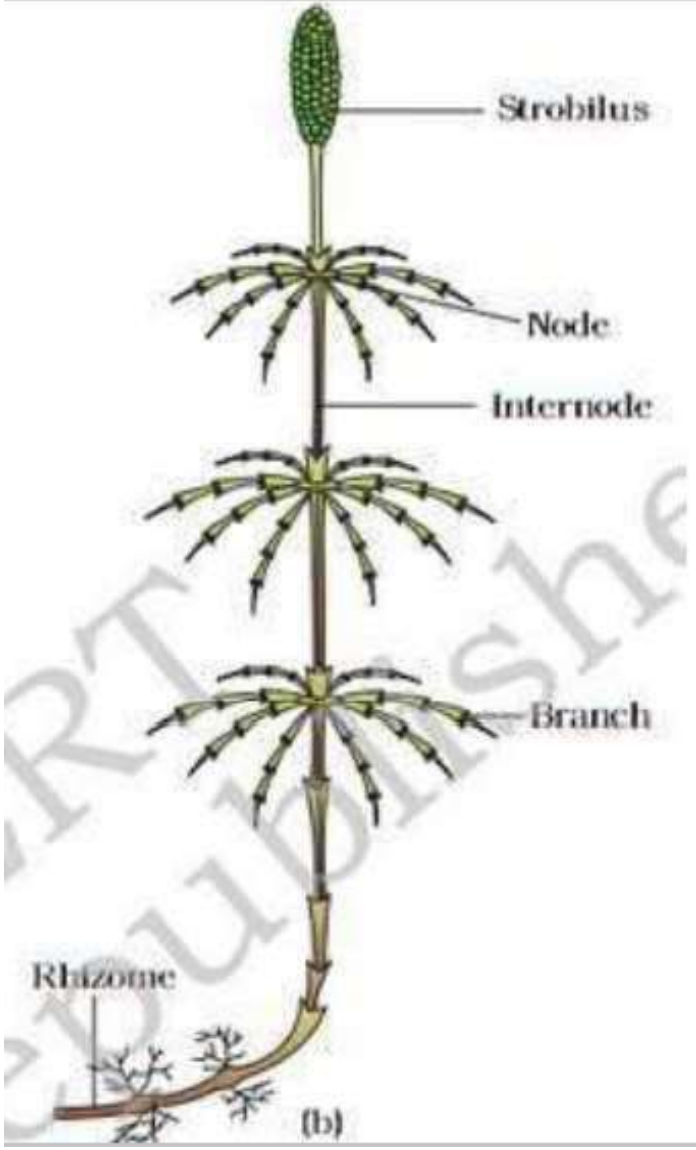
Sexual reproduction

- The gametophyte lives underground as a saprophyte, sometimes in a mycorrhizal association.
- When the gametophyte is mature, it produces both egg and sperm cells. ... The gametophyte of *Psilotum* is unusual in that it branches dichotomously, lives underground and possesses vascular tissue.
- The gametophyte of *Psilotum* is called as Prothallus . It contains parenchyma cells and there is strand of tracheid extending back from the apex.


Meristem
Meristem
Rhizoids
Antheridium
Archegonia
Antheridia
Cells infected with mycorrhizal fungus
Rhizoids
A
Cover cell
Neck canal cell
Ventral canal cell
Egg cell
B
Spermatozoids
C


Sporangia
Spore mother cell
REDUCTION DIVISION
Spore
GAMETOPHYTIC (n) GENERATION
SPOROPHYTIC (2n) GENERATION
GAMETOPHYTE
SPOROPHYTE PLANT
Sperm
Antheridium
FERTILISATION
Egg
Archegonium
Zygote

EQUISETUM



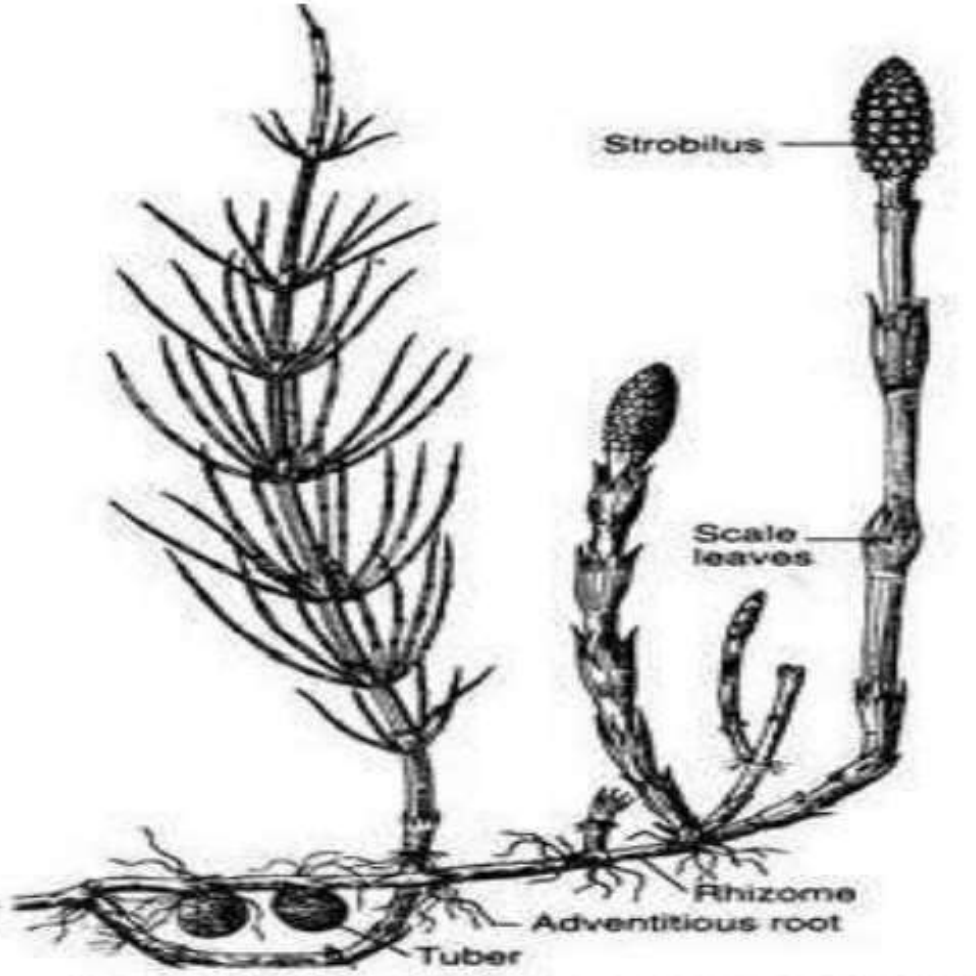


Fig. 7.83 : *Equisetum arvense* sporophyte

Habit and habitat of Equisetum

- The plant body of *Equisetum* has an aerial part and an underground rhizome part. The rhizome is perennial, horizontal, branched and creeping in nature. The aerial part is herbaceous and usually annual. Majority of the species are small with a size range in between 15 and 60 cm in height and 2.0 cm in diameter.
- *Equisetum* generally grow in wet or damp habitats and are particularly common along the banks of streams or irrigation canals (*E. debile, E. palustre*). However, some species are adapted to xeric condition (e.g., *Equisetum arvense).*

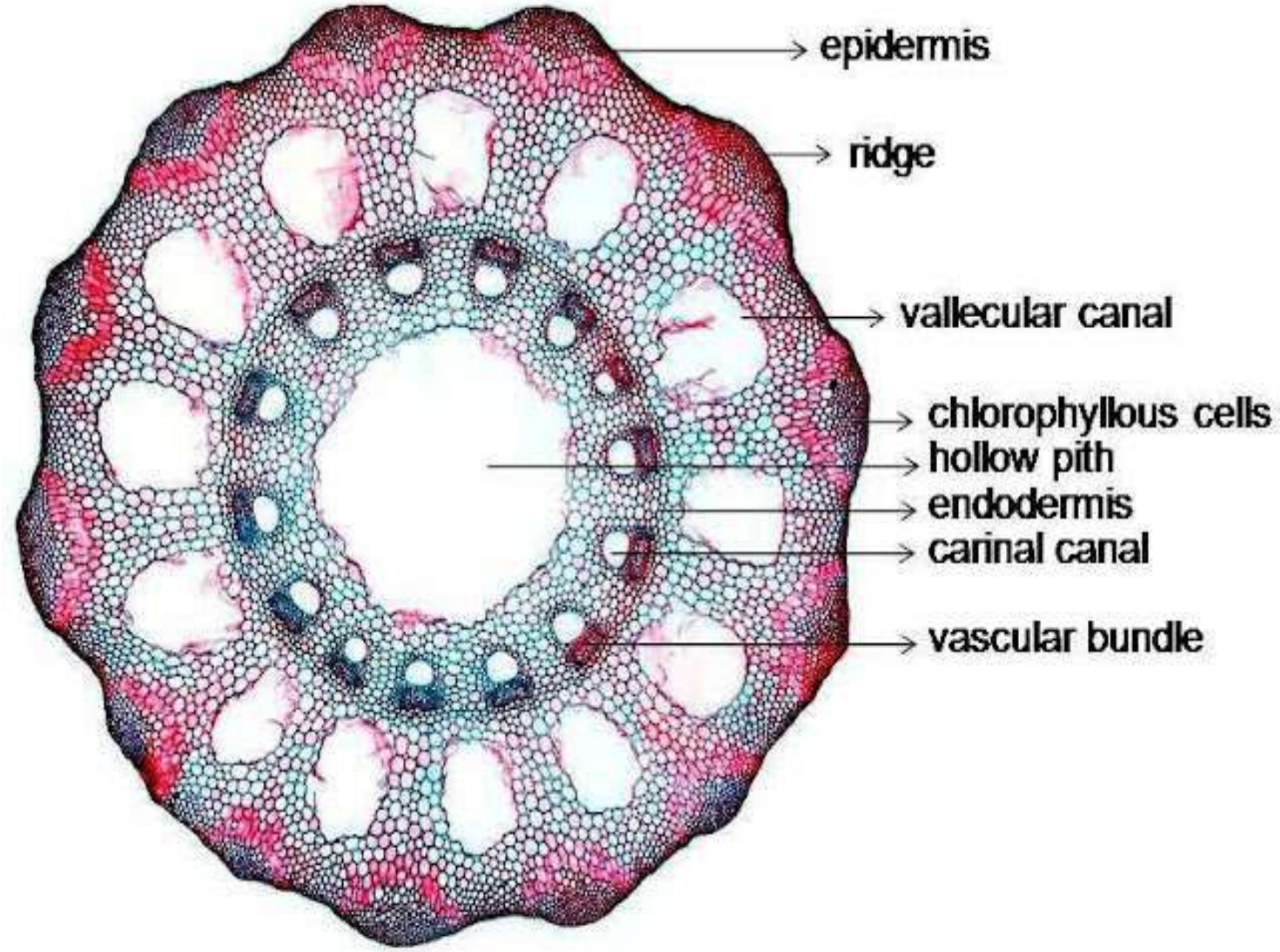
THE SPOROPHYTE MORPHOLOGY

- The sporophytic plant body of Equisetum is differentiated into stem, roots and leaves.
- Stem: The stem of *Equisetum* has two parts: perennial, underground, much-branched rhizome and an erect, usually annual aerial shoot.
- The branching is monopodial, shoots are differentiated into nodes and internodes. Sometimes shoot shows dimorphism (two types of shoots i.e., vegetative and fertile) e.g., *E. arvense*.
- Some shoots are profusely branched, green (chlorophyllous) and purely vegetative. The others are fertile, unbranched, brownish in colour (achlorophyllous) and have terminal strobili.
- The underground rhizome and the aerial axis appear to be articulated or jointed due to the presence of distinct nodes and internodes. Externally, the internodes have longitudinal ridges and furrows and, internally, they are hollow, tube-like structures. The ridges of the successive internodes alternate with each other and the leaves are normally of the same number as the ridges on the stem.

Internal Features of Stem

- The stem of Equisetum appears wavy in outline with ridges and furrows. The epidermal cell walls are thick, cuticularised and have a deposition of siliceous material.
- Stomata are distributed only in the furrows between the ridges. A hypodermal sclerenchymatous zone is present below each ridge which may extend up to stele in *E. giganteum*.
- The cortex is differentiated into outer and inner regions. The outer cortex is chlorenchymatous, while the inner cortex is made up of thin-walled parenchymatous cells.
- There is a large air cavity in the inner cortex corresponding to each furrow and alternating with the ridges, known as vallecular canal.
- New leaves and branches of *Equisetum* are produced by the apical meristem, however, most of the length of the stem are due to the activity of intercalary meristem located just above each node.

- The stele is ectophloic siphonestele which is surrounded by an outer endodermal layer.
- An inner endodermis is also present in some species of *Equisetum* (e.g., *E. sylvaticum*).
- The endodermis is followed by a single-layered pericycle. The vascular bundles are arranged in a ring which lies opposite to the ridges in position and alternate with the vallecular canals of the cortex. Vascular bundles are conjoint, collateral and closed.
- In the mature vascular bundle, protoxylem is disorganised to form a carinal cavity which lies opposite to the ridges.
- The metaxylem tracheids (scalariform or reticulate) are present on both sides of the phloem. In some species vessels with reticulate perforations are reported. The central part of the internode of aerial shoot is occupied by a large pith cavity which is formed due to rapid elongation of the internodal region.


epidermis
ridge
vallecular canal
chlorophyllous cells
hollow pith
endodermis
carinal canal
vascular bundle

INTERNAL STRUCTURE OF THE NODE REGION

- In the nodal region, the xylem is extensively developed as a conspicuous circular ring.
- There are no vallecular or carinal canals at this level. In addition, a plate of pith tissue occurs at the node which separates one internode from another.
- The xerophytic features are:
- (i) Ridges and furrows in the stem,
- (ii) Deposition of silica in the epidermal cells,
- (iii) Sunken stomata,
- (iv) sclerenchymatous hypodermis,
- (v) Reduced and scaly leaves, and
- (vi) photosynthetic tissue in the stem.
- The hydrophytic characteristics on the other hand are (i) we 11-developed aerating system like carinal canal, vallecular canal and central pith cavity, and (ii) reduced vascular elements. I

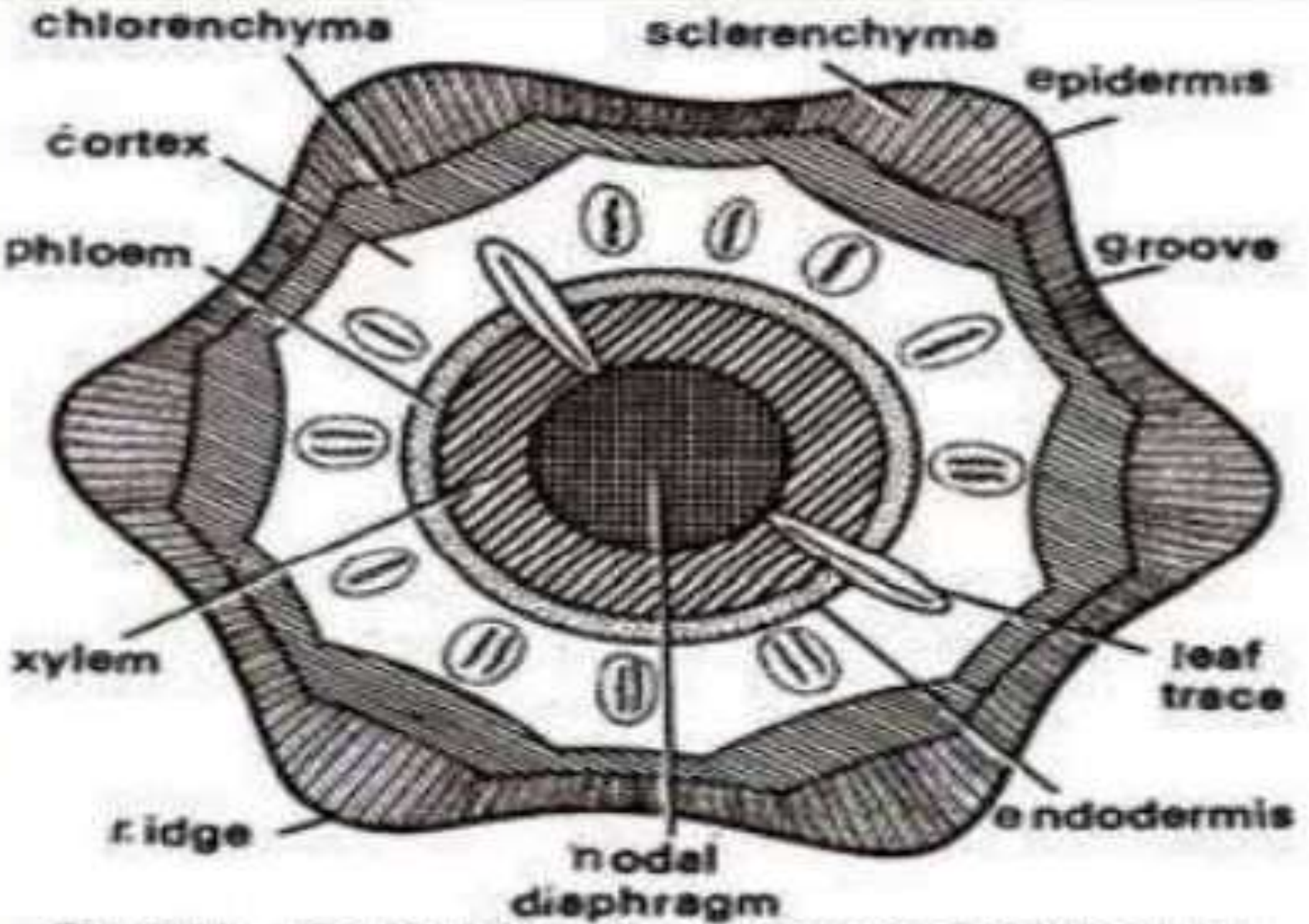


Fig. 241. Equisetum. T.S. node of aerial sterile shoot (diagrammatic).

ROOT

- Primary root is ephemeral. The slender adventitious roots arise endogenously at the nodes of the stems. In T.S., the root shows epidermis, cortex and stele from periphery to the centre.
- The epidermis consists of elongated cells, with or without root hairs. The cortex is extensive; cells of the outer cortex often have thick walls (sclerenchymatous) and those of the inner cortex are thinner parenchymatous.
- A large metaxylem element is present in the centre of the stele and the protoxylem strands lie around it. The space between the protoxylem groups is filled with phloem. There is no pith.

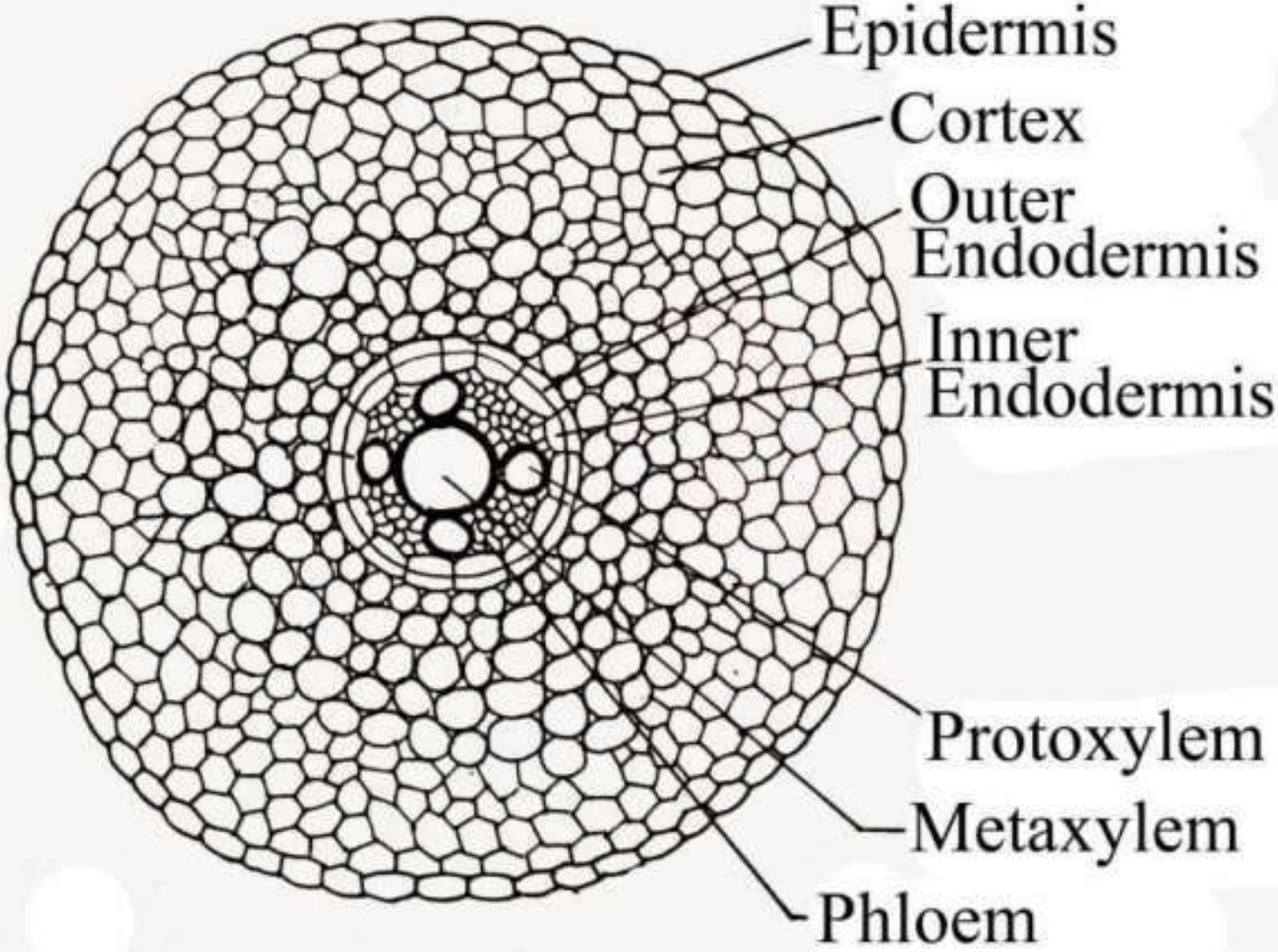
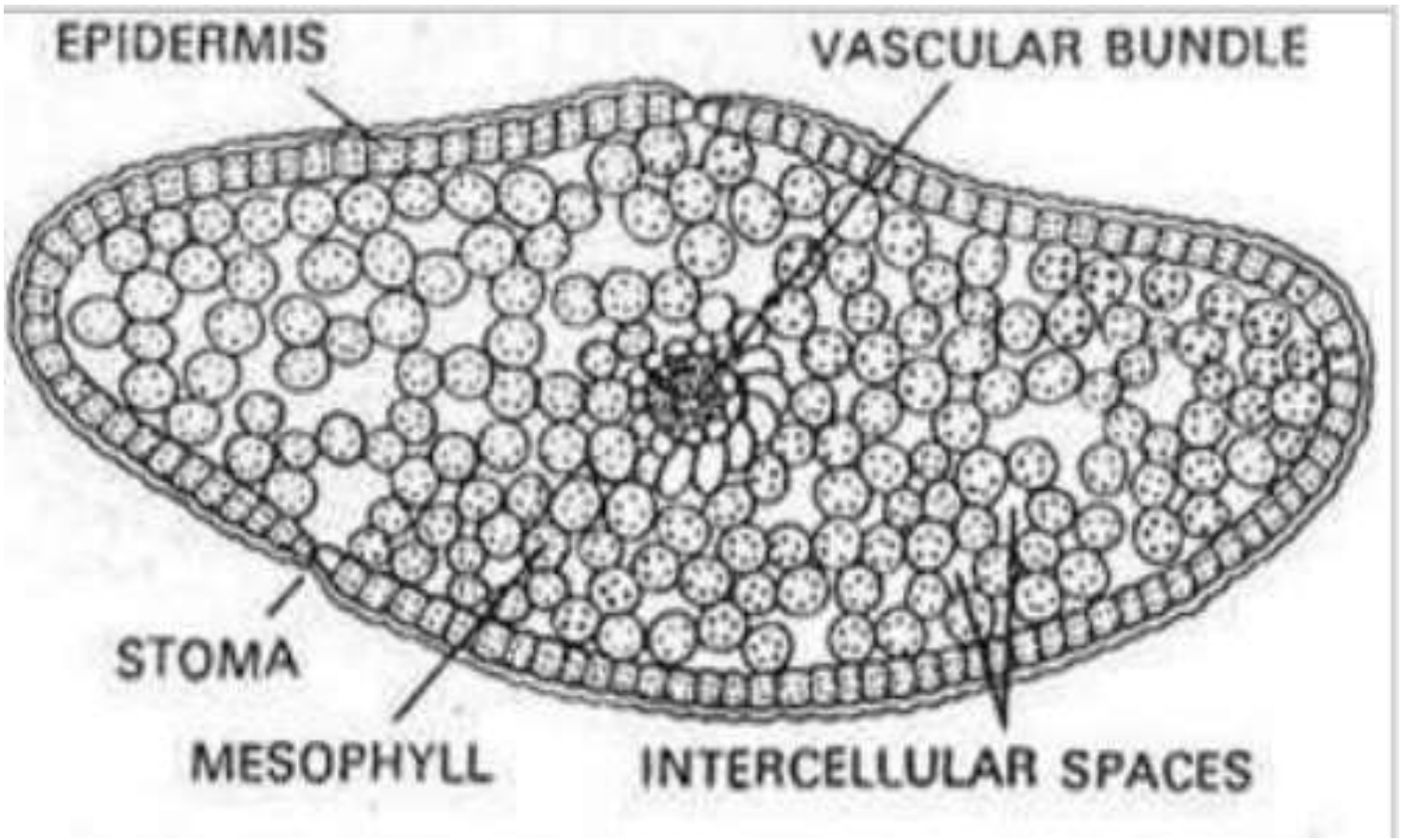


Fig: ***Equisetum spp.*** TS of root.

LEAVES

- The leaves of *Equisetum* are small, simple, scale-like and isophyllous; they are attached at each node, united at least for a part of the length and thus form a sheath around the stem.
- The sheath has free and pointed teeth-like tips. The number of leaves per node varies according to the species.
- The species with narrow stems have few leaves (e.g., 2-3 leaves in *E. scirpoides*) and those with thick stem have many leaves (e.g., up to 40 leaves in *E. schaffneri*).
- The number of leaves at a node corresponds to the number of ridges on the internode below.
- The leaves do not perform any photosynthetic function and their main function is to provide protection to young buds at the node.


EPIDERMIS
VASCULAR BUNDLE
STOMA
MESOPHYLL
INTERCELLULAR SPACES

Reproduction

- Equisetum reproduces vegetatively and by means of spores.

i. Vegetative Reproduction: The subterranean rhizomes of some species (e.g., *E. telmateia, E. arvense*) form tubers which, on separation from the parent plant, germinate to produce new sporophytic plants.

ii. The tubers develop due to irregular growth of some buds at the nodes of the rhizomes.

iii. Reproduction by Spores: Spores are produced within the sporangia. The sporangia are borne on the sporangiophores which are aggregated into a compact structure termed strobilus or cone or sporangiferous spike

Strobilus:

- The strobilus are terminal in position and generally are borne terminally on the chlorophyllous vegetative shoot. However, they may be borne terminally on a strictly non- chlorophyllous axis (e.g., *E. arvense*). The strobilus is composed of an axis with whorls of sporangiophores.
- Each sporangiophore is a stalked structure bearing a hexagonal peltate disc at its distal end.
- On the under surface of the sporangiophore disc 5-10 elongate, cylindrical hanging sporangia are borne near the periphery in a ring. The flattened tips of the sporangiophores fit closely together which provide protection to the developing sporangia.
- The axis bears a ring-like outgrowth, the so-called annulus immediately below the whorls of sporangiophores which provide additional protection during early development.
- The annulus has been interpreted as a rudimentary leaf sheath by some botanists, whereas others consider it to be sporangiophoric in nature as occasionally it bears small sporangia.

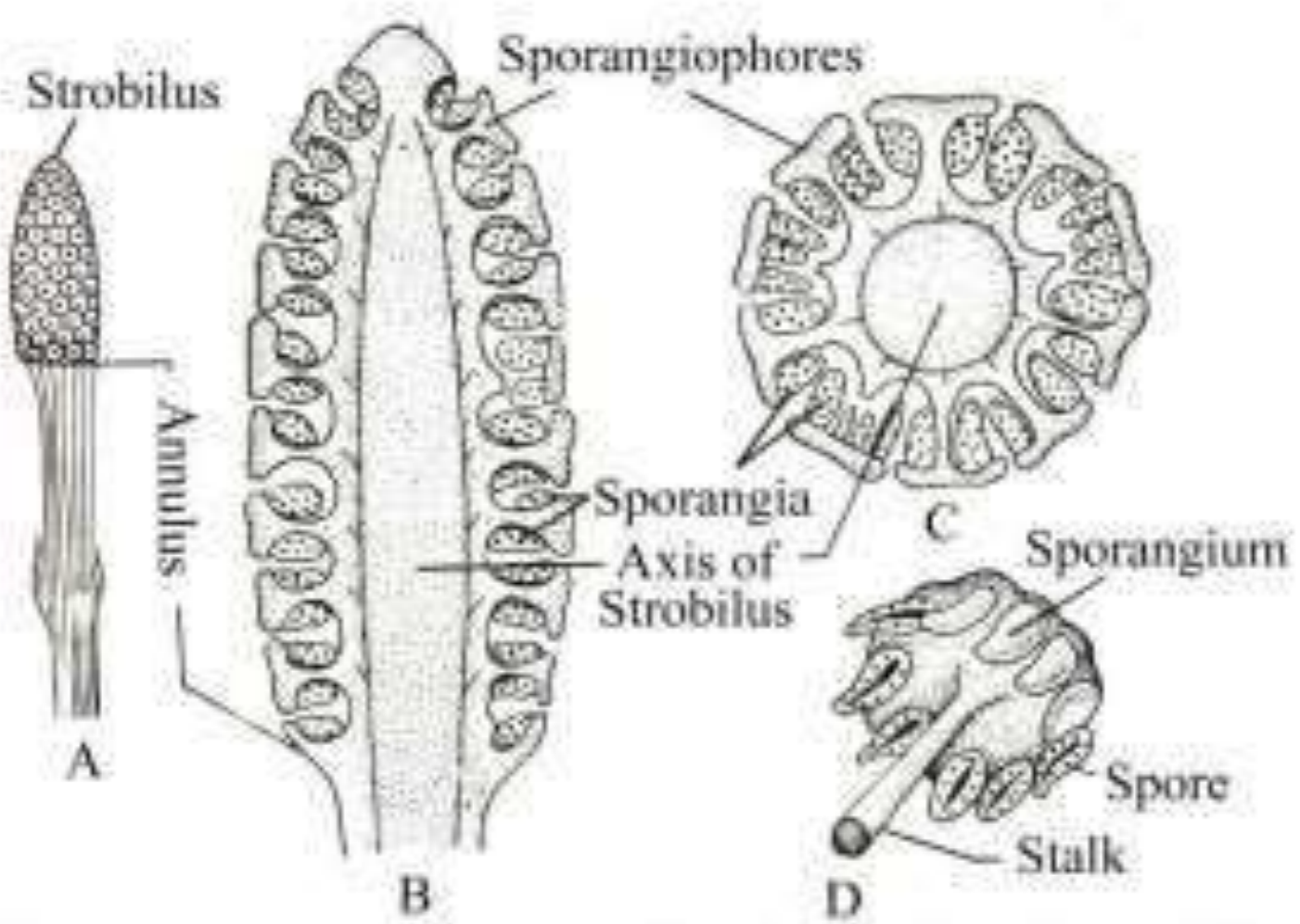
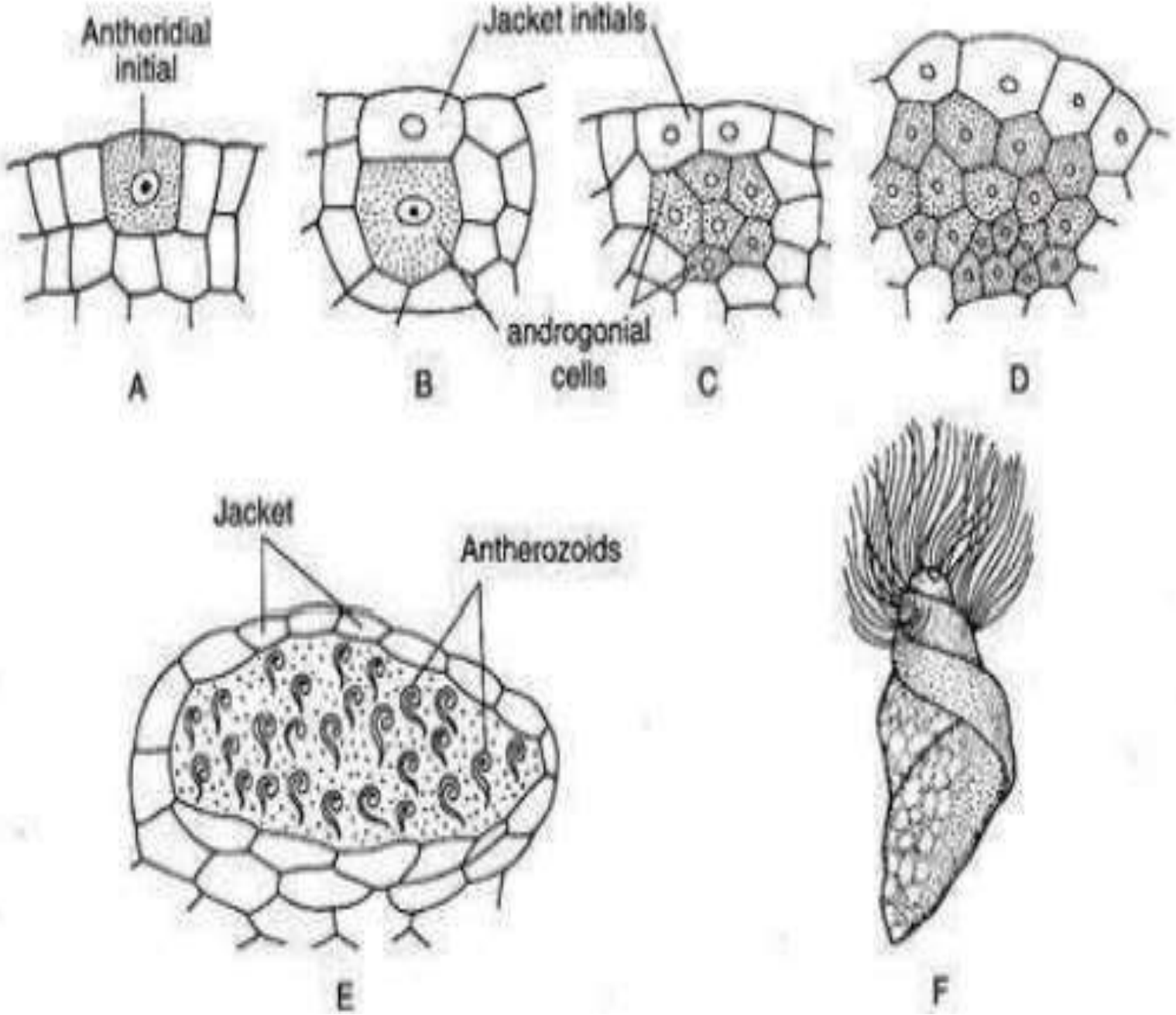


Fig: ***Equisetum spp.*** (A) A part of fertile shoot bearing strobilus; (B) LS of strobilus; (C) TS of strobilus; (D) Single sporangiophore.

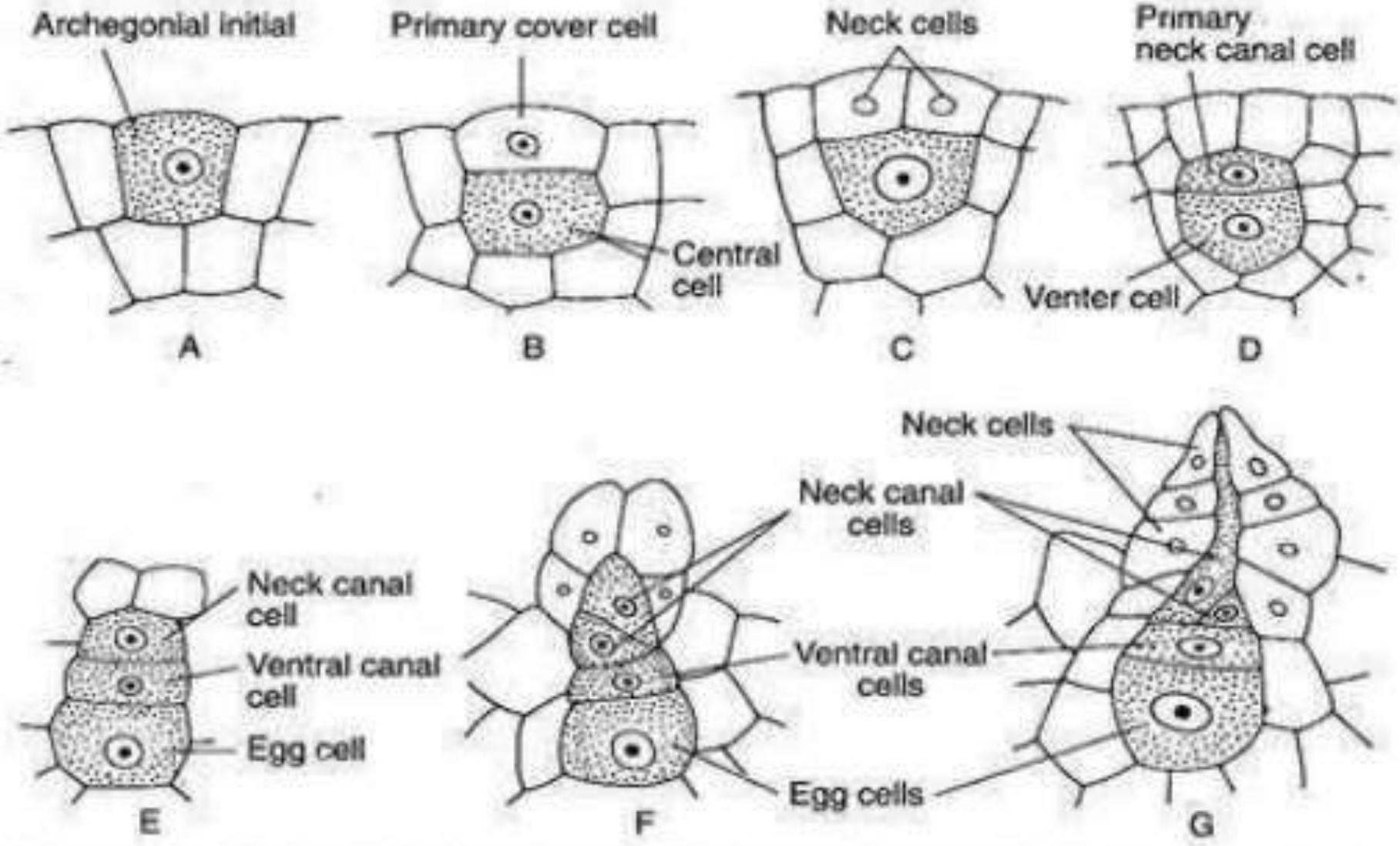
Antheridium:

- In monoecious species, antheridia develop later than archegonia.
- They are of two types — projecting type and embedded type. Antheridia first appear on the lobes of the gametophyte. The periclinal division of the superficial antheridial initial gives rise to jacket initial and an androgonial cell.
- The jacket initial divides anticlinally to form a single-layered jacket. The repeated divisions of androgonial cells form numerous cells which, on metamorphosis, produce spermatids/antherozoids.
- The antherozoids escape through a pore created by the separation of the apical jacket cell. The apical part of the antherozoid is spirally coiled, whereas the lower part is, to some extent, expanded


Antheridial initial
Jacket initials
androgonial cells
A
B
C
D
Jacket
Antherozoids
E
F

Archegonium

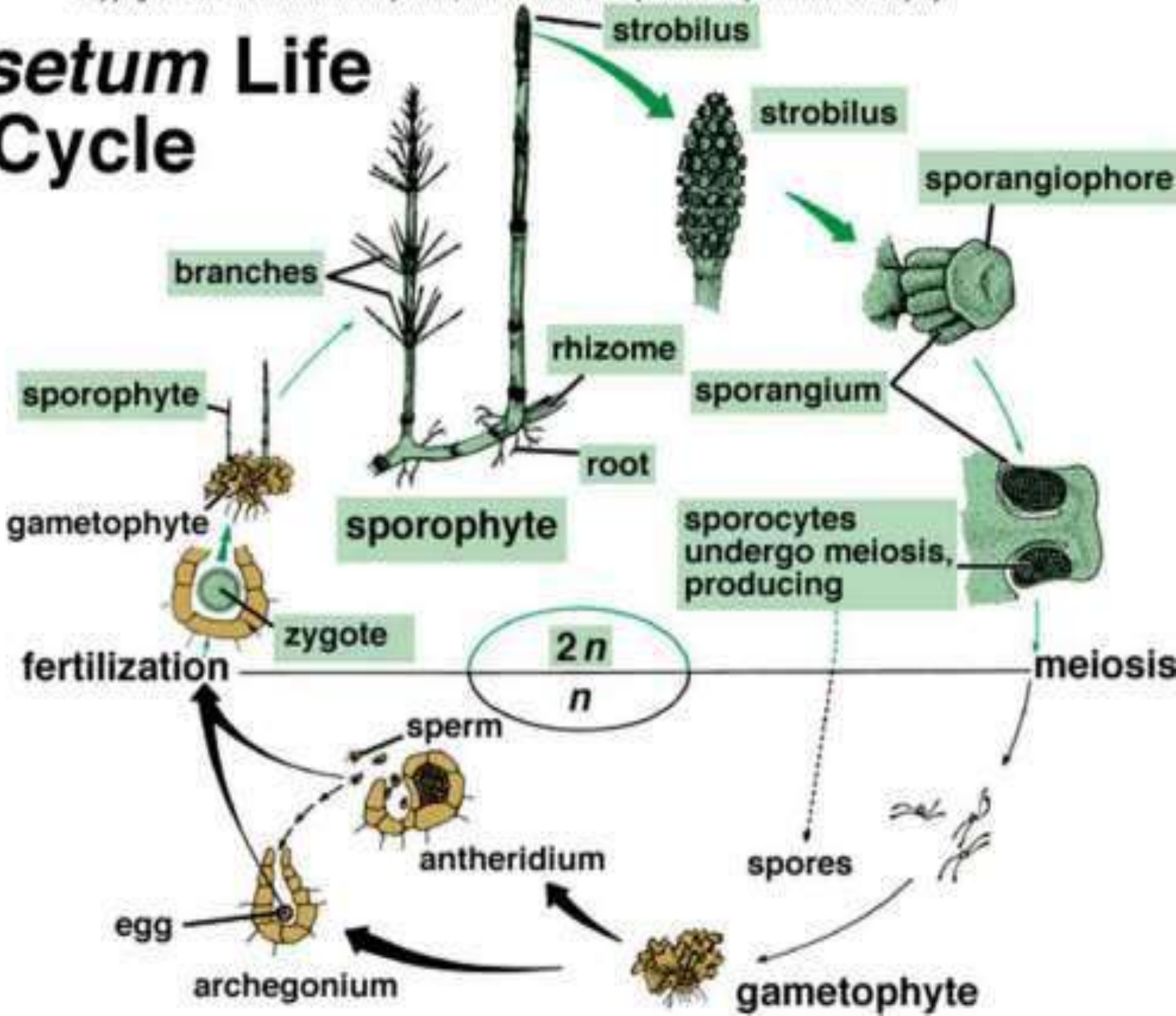
- Any superficial cell in the marginal meristem acts as an archegonial initial which undergoes periclinal division to form a primary cover cell and an inner central cell.
- The cover cell, by two vertical divisions at right angle to each other, forms a neck.
- The central cell divides transversely to form a primary neck canal cell and a venter cell. Two neck canal cells are produced from the primary neck canal cell.
- While, the venter cell, by a transverse division, forms the ventral canal cell and an egg. At maturity, an archegonium has a projecting neck comprising of three to four tiers of neck cells arranged in four rows, two neck canal cells of unequal size, a ventral canal cell, and an egg at the base of the embedded venter


Archegonial initial
Primary cover cell
Neck cells
Primary neck canal cell
Central cell
Venter cell
A
B
C
D
Neck canal cell
Ventral canal cell
Egg cell
Neck canal cells
Ventral canal cells
Egg cells
Neck cells
E
F
G

Fertilization

- Water is essential for fertilization.
- The gametophyte must be covered with a thin layer of water in which the motile antherozoides swim to the archegonia.
- The neck canal cells and ventral canal cell of the archegonia disintegrate to form a passage for the entry of antherozoids.
- Many antherozoids pass through the canal of the archegonium but only one of them fuses with the egg. Thus diploid zygote is formed.
- Generally more than one archegonia are fertilized in a prothallus. Embryo (The New Sporophyte): The embryo is the mother cell of the next sporophytic generation.
- Unlike most pteridophytes, several sporophytes develop on the same prothallus. The first division of the zygote is transverse.
- This results in an upper epibasal cell and lower hypobasal cell. The embryo is therefore exoscopic (where the apical cell is duacted outward. No suspensor is formed in Equisetum

Equisetum Life Cycle



- Division : Lycophyta
- Class : Eligulopsida
- Order : Lycopodiales
- Family : Lycopodiaceae
- Genus : *Lycopodium*

There are about 180 species in this genus

- The modern representatives are small and herbaceous sporophytes The leaves are small and simple.
- Each leaf possesses an unbranched midrib. The leaves have no ligules.
- There are no leaf gaps in the stele of the stem. The sporophylls may or may not be restricted to the terminal.
- The sporophylls and simple vegetative leaves may be similar or dissimilar.
- They possess homosporous sporangia, i.e., all the spores of one kind only. The gametophytes are wholly or partly subterranean.
- The antheridia remain embedded in the tissue of the prothallus. The antherozoids are biflagellate.

Distribution and Habitat

- The species of Lycopodium are world-wide in distribution.
- They are mainly found in tropical and sub-tropical forests.
- In India they are found in the hills of Eastern Himalayas.

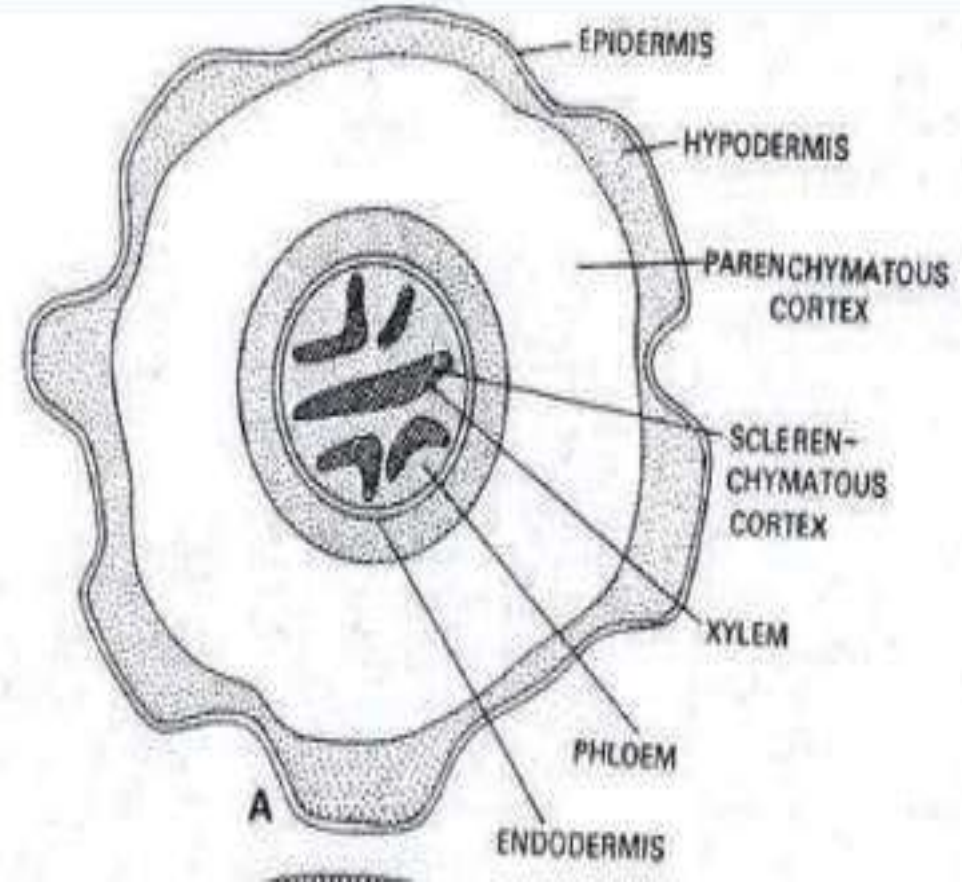
- The plants are commonly known as ‘ground pines’, ‘club mosses’ and ‘trailing evergreens’ many species occur in the tropics as hanging epiphytes
- (e.g., *Lycopodium*. These species are: *Lycopodium clavatum*,
- *L. cernuum*
- *L. heamiltonii,*
- *L. setaceum*
- *L. phlegmaria,*
- *L. wightianum*
- *L. serratum,*
- *L. phyllanthum*
- The most common species is *L . clavatum*

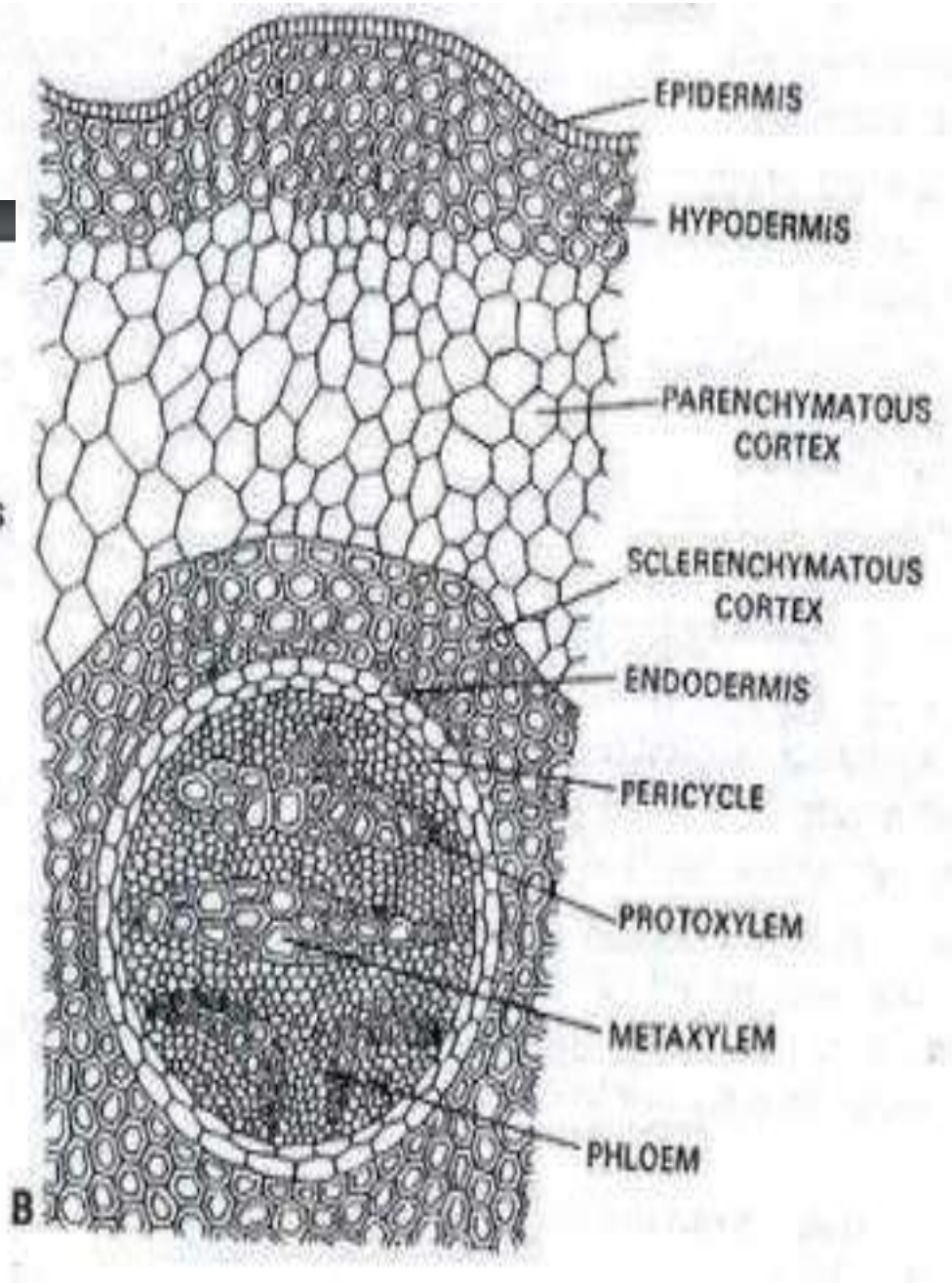
Sporophyte - Habit

- All species possess small, herbaceous or shrubby sporophytes.
- The stem in almost all the species is delicate and weak.
- Some species are epiphytic and with erect or pendant sporophytes while other species are terrestrial and have a trailing habit.
- The stem and its branches are densely covered with small leaves.

Stem

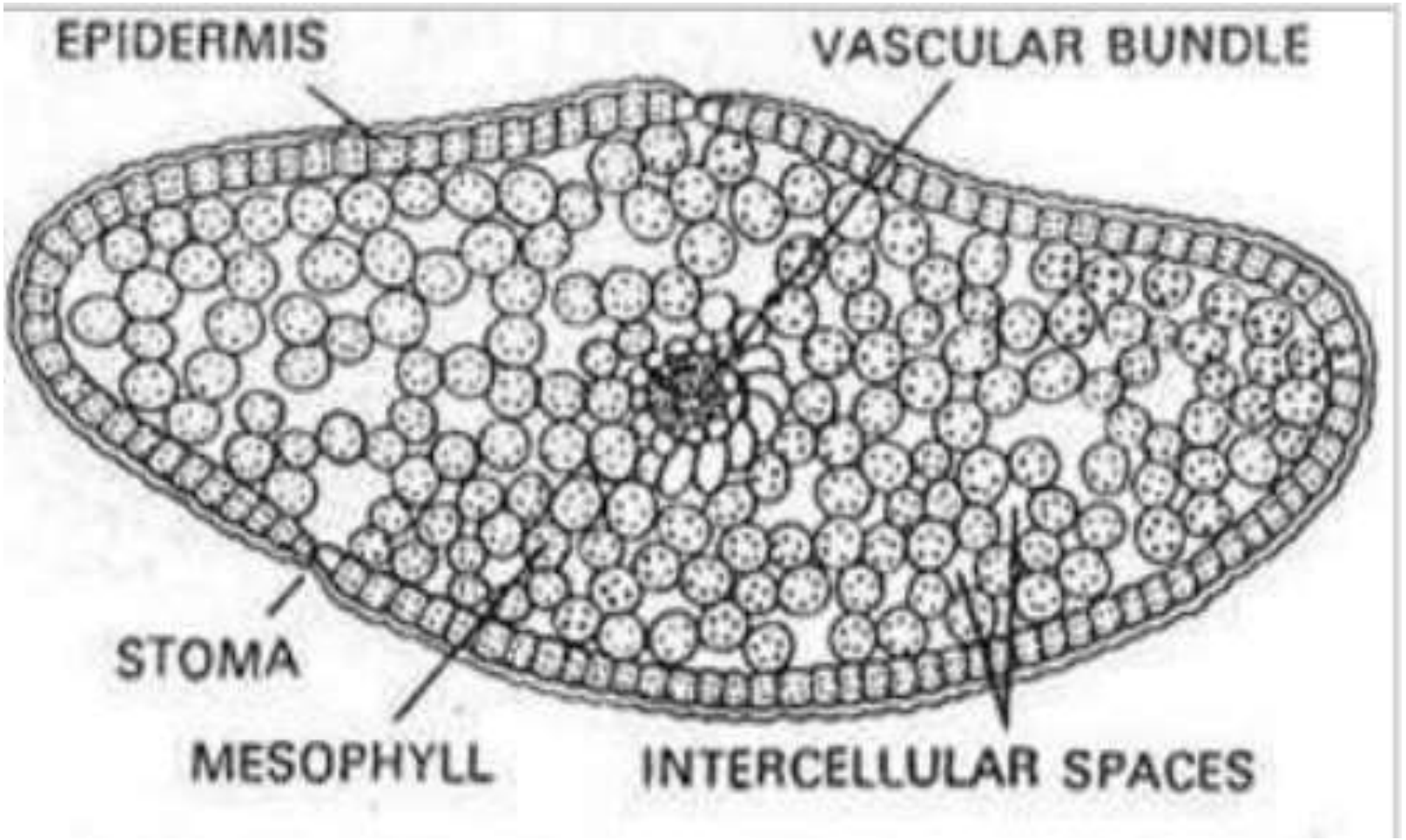
- Species referred to the sub-genus Urostachya possess branched or unbranched stems that are erect or pendant but never creeping.
- This subgenus includes the species, eg., *L. selago*, *L. lucidulum*, *L. phlegmaria* and others.
- If the stem is branched, the branching is always dichotomous.
- Usually the successive dichotomies are found at right angles to one another


EPIDERMIS
HYPODERMIS
PARENCHYMATOUS CORTEX
SCLEREN-CHYMATOUS CORTEX
XYLEM
PHLOEM
ENDODERMIS
A


EPIDERMIS
HYPODERMIS
PARENCHYMATOUS CORTEX
SCLERENCHYMATOUS CORTEX
ENDODERMIS
PERICYCLE
PROTOXYLEM
METAXYLEM
PHLOEM
B

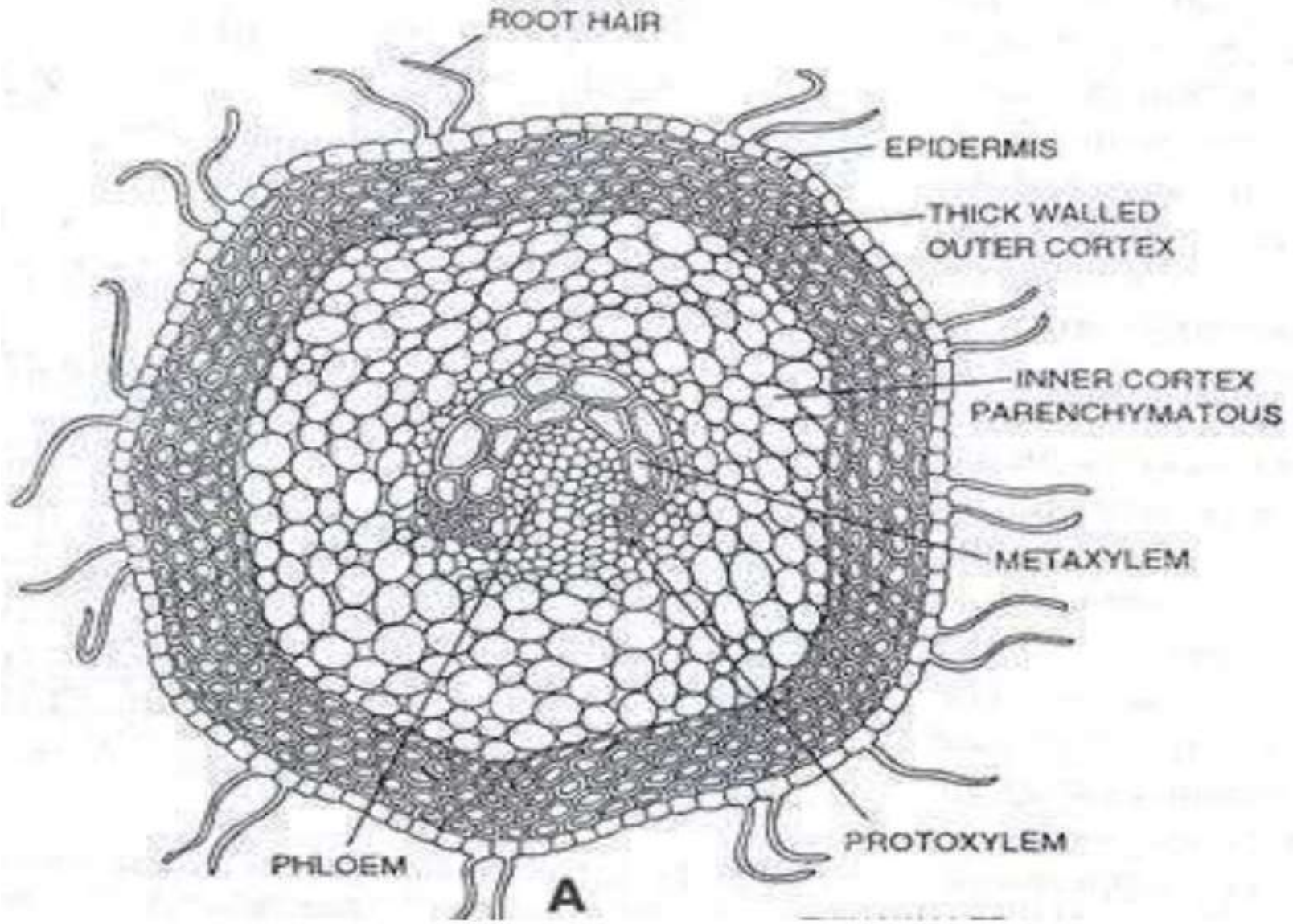
Leaves

- The leaves are small, simple, sessile, numerous and cover the axis closely.
- Typically the leaves are 2 to 10 mm long. Usually the leaves are arranged in closed spirals (e.g., in *L. clavatum* and *L. annotinum*)
- while in other cases they are arranged in whorls (e.g., in *L. verticillatum* and *L. cernuum*).
- In some species the leaves are found to be arranged in opposite pairs (e.g., *L. alpimum*); in others they are irregularly arranged.
- Usually the leaves are lanceolate (pointed)


EPIDERMIS
VASCULAR BUNDLE
STOMA
MESOPHYLL
INTERCELLULAR SPACES

ROOTS:

- The roots that arise on the outside of the stele do not penetrate the cortical region of the stem at once.
- These roots turn downward and penetrate the soft middle cortex making canals through it, and ultimately they emerge only at the stem. Such roots are known as ‘cortical roots’


ROOT HAIR
EPIDERMIS
THICK WALLED
OUTER CORTEX
INNER CORTEX
PARENCHYMATOUS
METAXYLEM
PROTOXYLEM
PHLOEM
A

Development of sporangium

- The sporangia begin to develop at a time when the sporophyll is composed of embryonic cells.
- The development is of eusporangiate type. These superficial cells are called sporangial initials These cells divide by periclinal divisions forming an outer and inner layer of cells.
- The outer cells divide periclinally and anticlinally forming three celled thick wall of the sporangium The inner daughter cells formed by this periclinal division give rise to the stalk and the basal portion of a sporangium.
- The outer daughter cells contribute to the formation to the bulk of the sporangium.
- The outer cells again divide periclinally forming an outer layer, the jacket initials; and an inner layer, the archesporial cells.

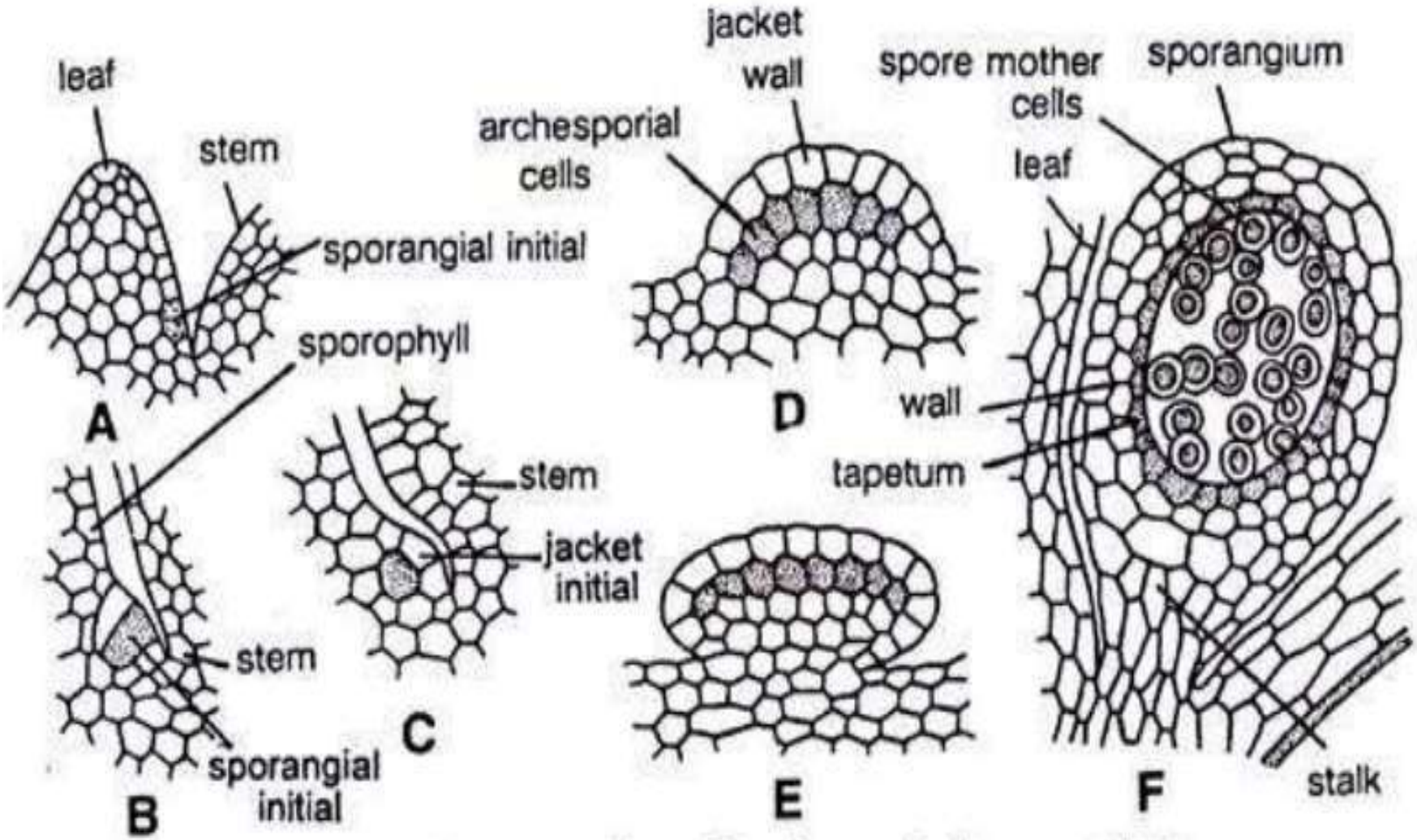


Fig. 9 (A–F). *Lycopodium* : Development of sporangium

- The archesporial cells divide periclinally and anticlinally forming a massive sporogenous tissue.
- The cells of the last generation of the sporogenous tissue act as spore mother cells.
- They become rounded and are being separated from one another.
- Now these spore mother cells float about in a viscous liquid and divide meiotically into tetrads of spores

- The jacket initials, which are found external to the sporogenous tissue divide repeatedly forming a jacket layer of three or more cells, in thickness.
- Shortly before the development of the spore mother cells a nutritive tapetal layer is formed around the This layer is partly formed from the inner-most layer of jacket cells and partly from sporangial cells found just beneath the sporogenous tissue.
- As found in most other pteridophytes, in Lycopodium there is no disintegration of the Tapetum during spore formation.

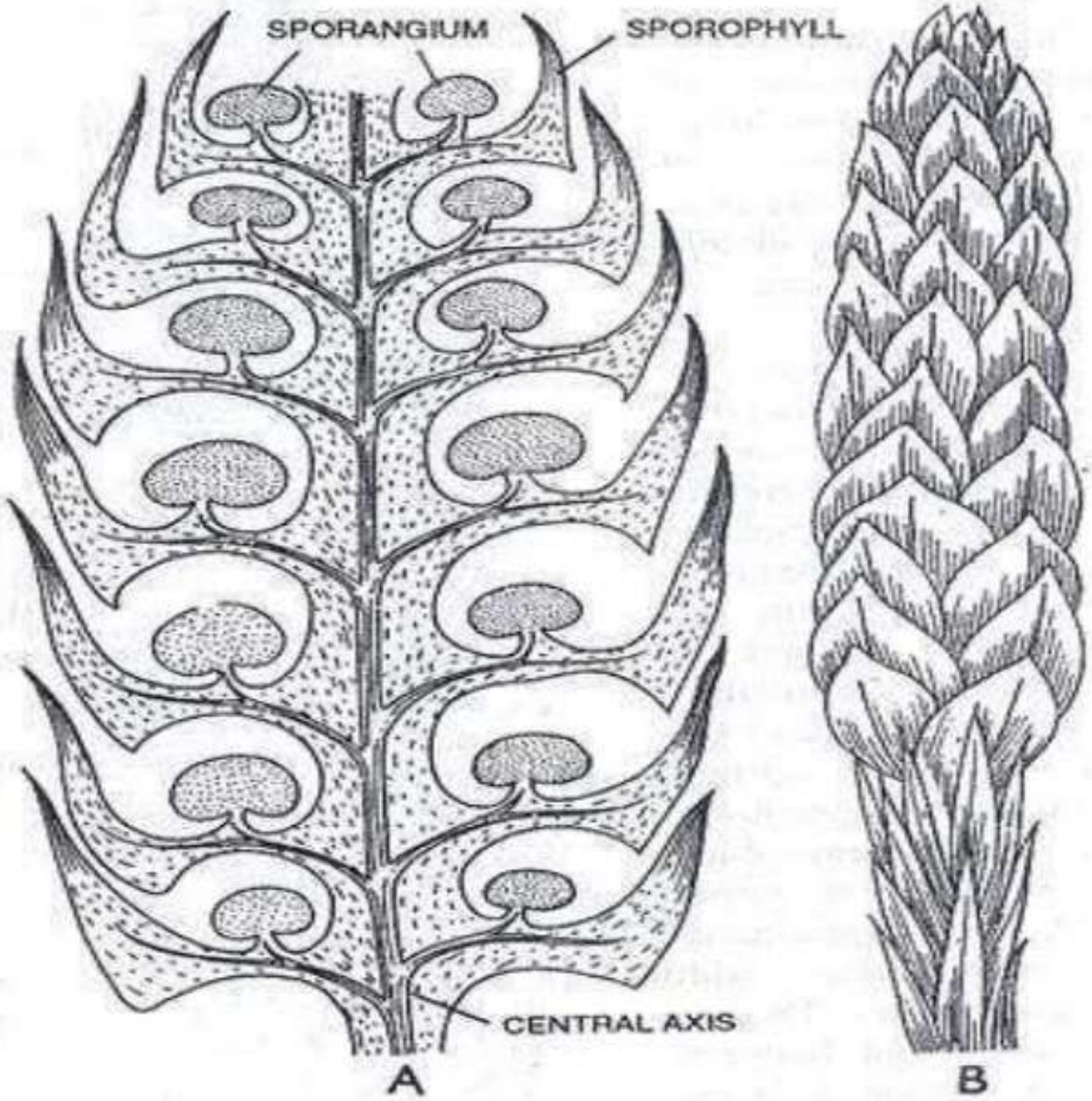
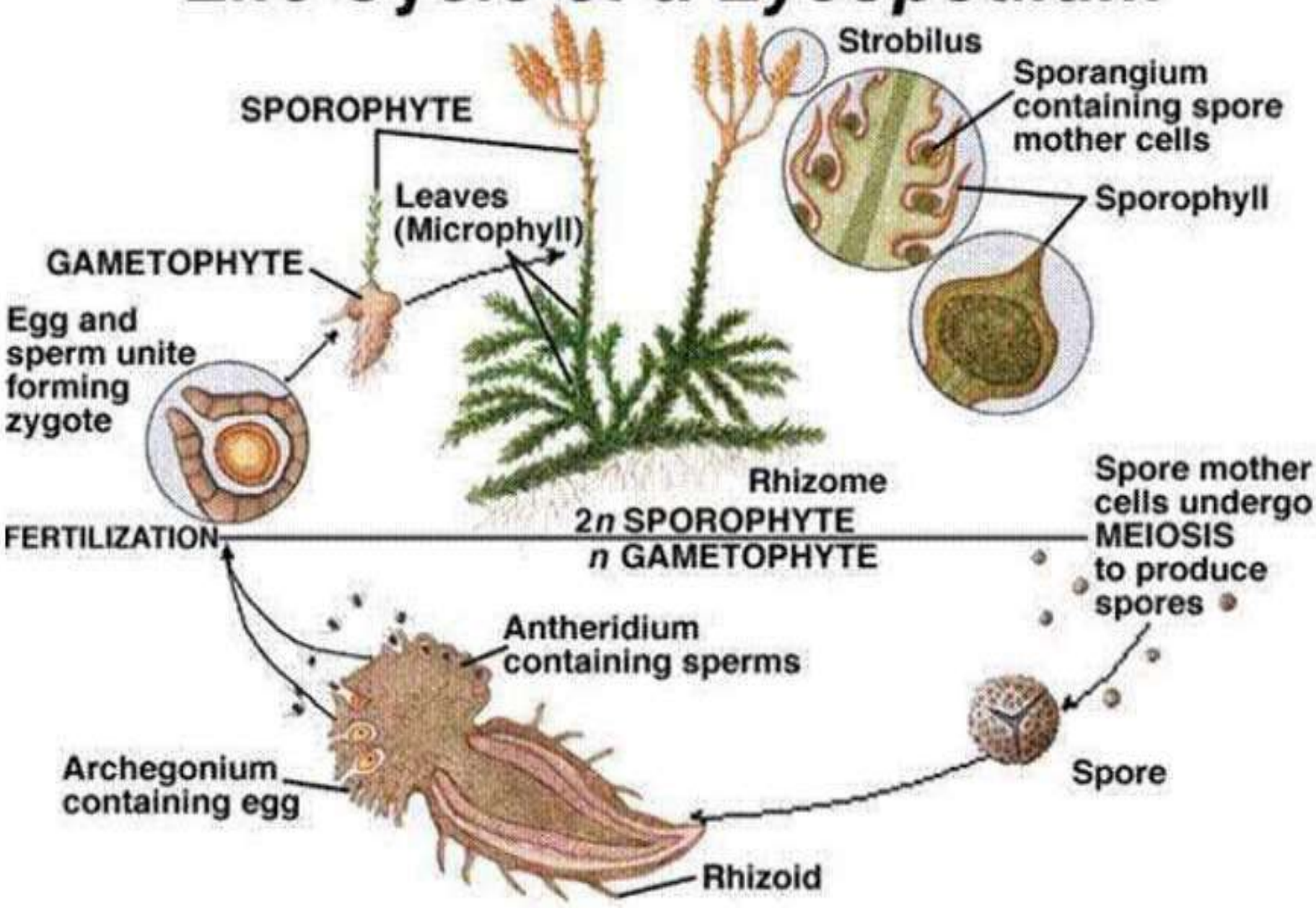


Fig. 27.12. *Lycopodium clavatum.* A, L.S. of strobilus bearing sporophylls and sporangia; B, a strobilus.

Life Cycle of a *Lycopodium*



Selaginella

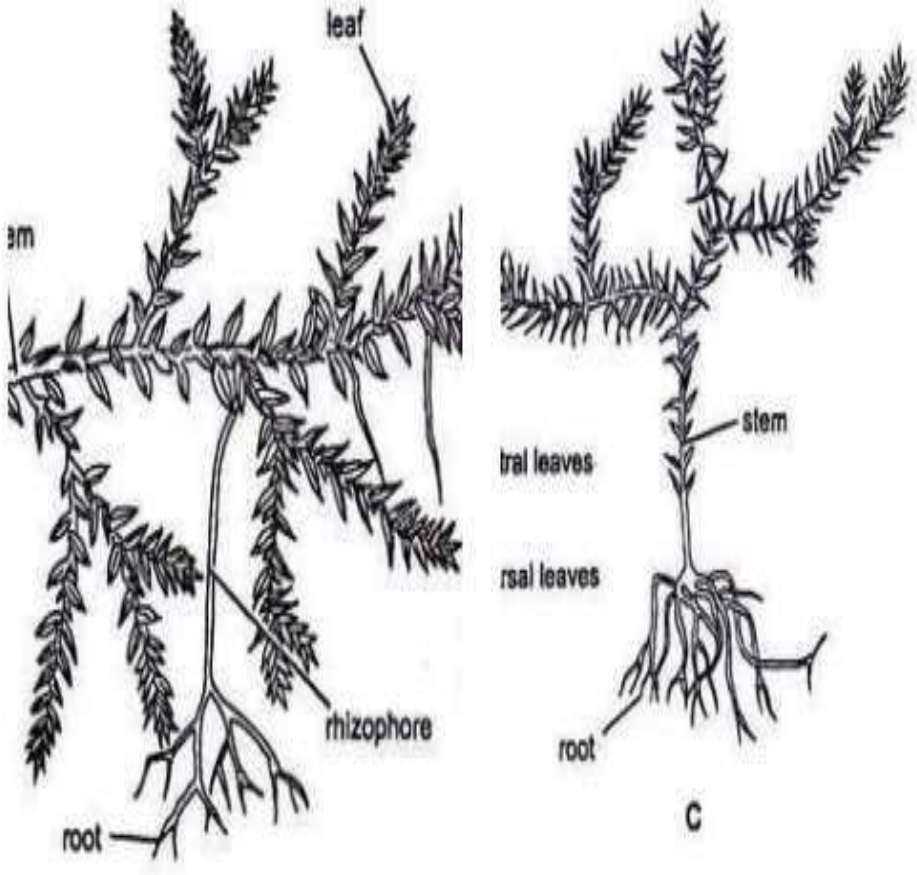
- Division : Lycophyta
- Class: Ligulopsida
- Order: Selaginellales
- Family: Selaginellaceae
- Genus: *Selaginella*

Distribution and habitat

- It is commonly called as club moss and spike moss.
- It has world wide distribution Abundant in tropics and grows in ground and shady places
- Most common species is *Selaginella kraussiana*

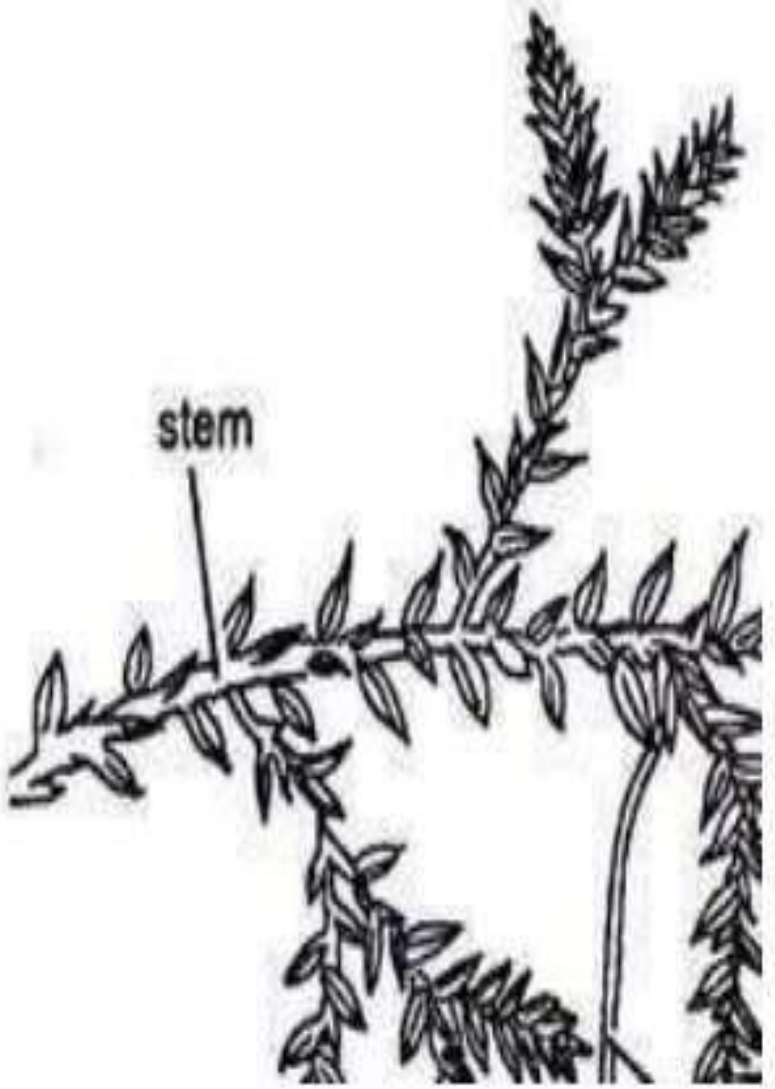
Root

- The root of young sporophyte is of primary root while others are adventitious The adventitious roots are at the tips of rhizophores Aerial roots have developed caps, and cutinized epidermal cells And enter soil.



STEM

- Stem is green, dorsiventral and prostrate with short erect branches
- The branches are arranged dichotomously
- They are also pseudomonopodia (false ,growth from one point)
- The shoot apex consists of a single apical cell in most cases



LEAVES

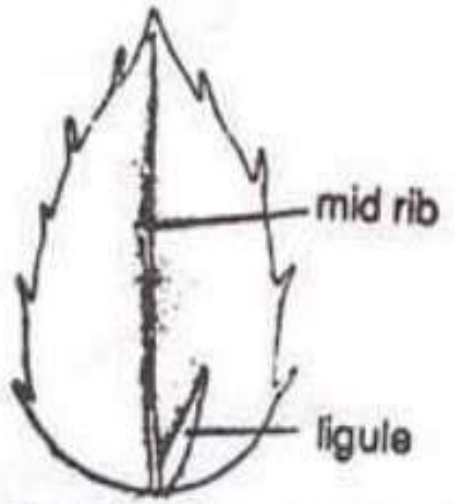
- Microphylls are present. (leaves are small and single veined.
- They are of 2 types

1. Isophyllous
2. Anisophyllous.

- The anisophyllous leaves are in pairs.
- They may be Small: these are inserted on the dorsal side of stem
- Larger: these leaves are inserted on the ventral side of stem

Ligule:

- there is small outgrowth on adaxial side (upper side) of the leaf near base. It is vestigial organ and provide water .



Selaginella. Adaxial surface of a leaf showing ligule.

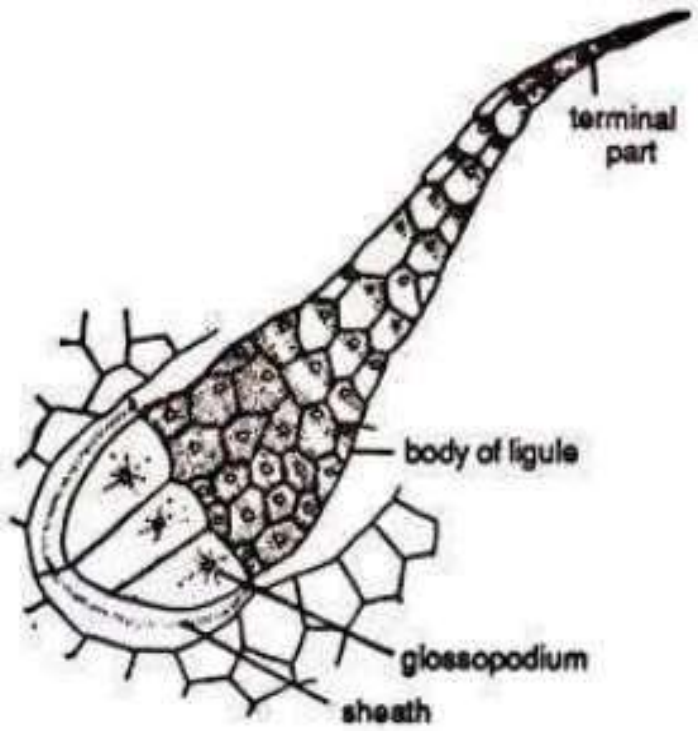


Fig. 212. Selaginella. A single ligule.

Stem anatomy

- Epidermis : thick epidermis , thin walled, rectangular cells, covered with cuticle
- cortex : many layered , outer 2-4 are thick walled called as hypodermis

Below is thin walled parenchyma having chloroplast, have small intercellular spaces.

Central portion is separated from cortex by a cavity having air spaces

- endodermis :the cortex and central tissue is connected by radially elongated cells called trabeculae

They contain casparian strips, trabuculae are modified endodermal cells.

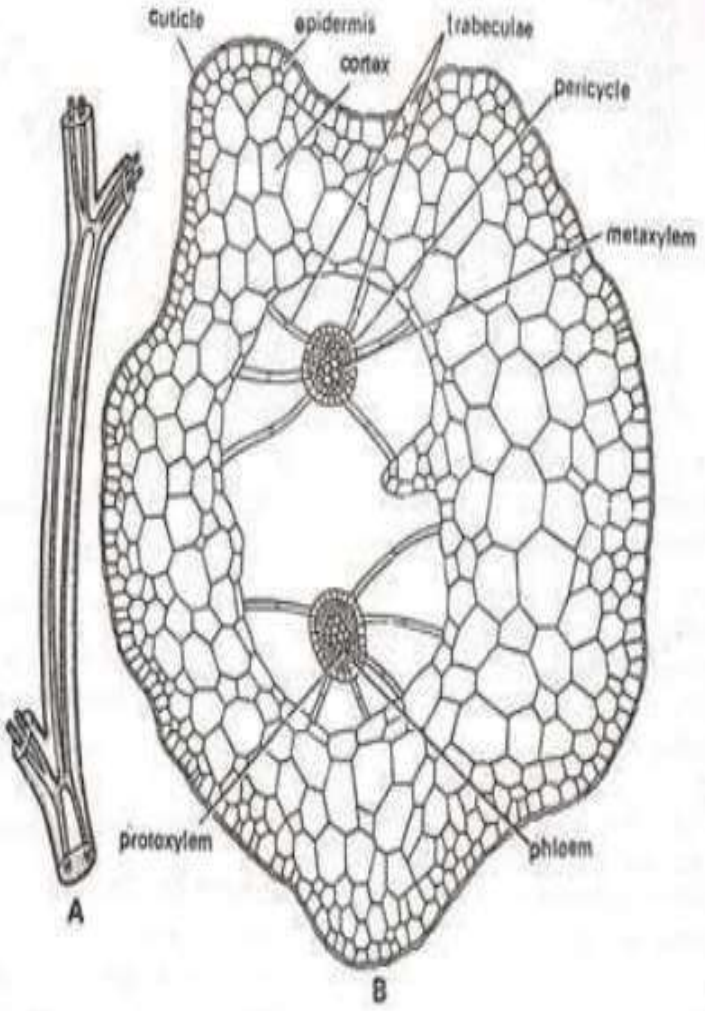


Fig. 213. Selaginella kraussiana. A, A part of cleared distolic stem showing vascular cylinder; B, T.S. of a distolic stem.

- Pericycle : there is single layer of pericycle formed of thin walled cells, enclosing vascular tissue (xylem and phloem)
- Phloem : there are phloem composed of sieve cells and phloem parenchyma, companion cells are absent , phloem surrounds the xylem completely
- Xylem : present in center ,
- it consists of 1. Protoxylem : occupies two ends of meta xylem 2. Metaxylem: occupies the major portion of stele These are composed of tracheid and parenchyma cells Fibers are absent

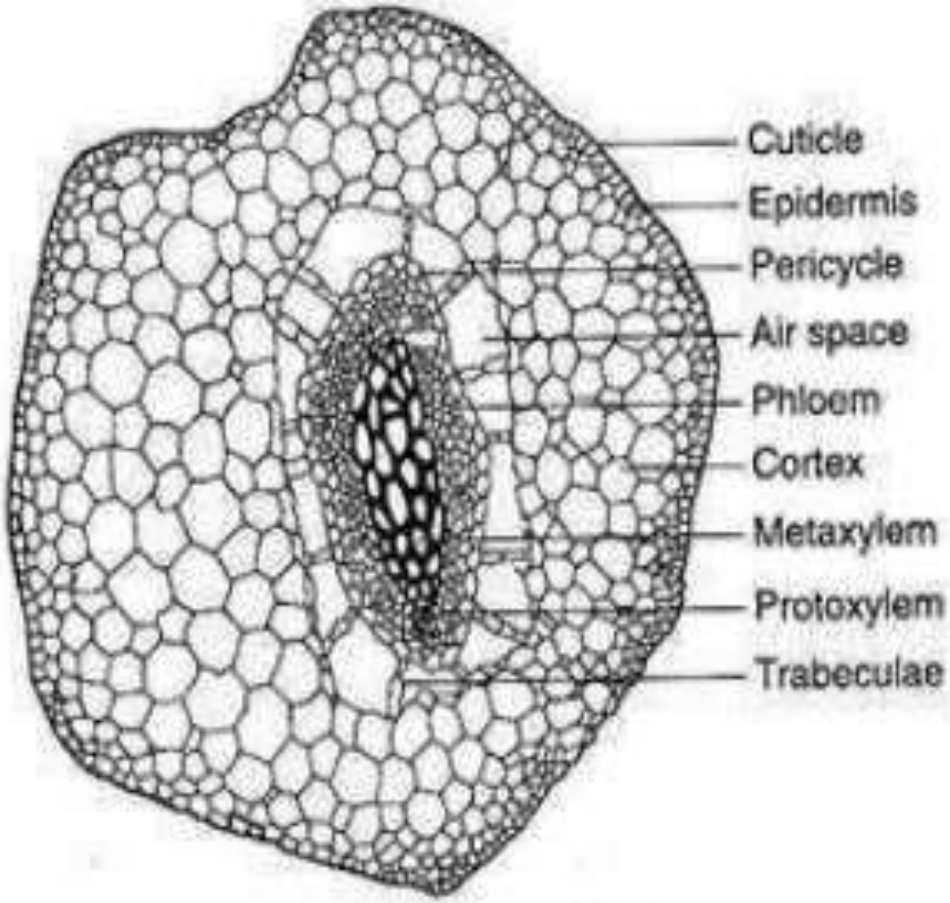


Fig. 7.47 : T.S. of *Selaginella* stem

Rhizophore

- Outermost layer is epidermis It is of thick walled and single layer cells Beneath the epidermis there is cortex
- Hypodermis (thick walled)
- Thin walled parenchymatous region
- Inner most layer is endodermis Thin walled pericycle is present around the vascular tissue Stele is protostele (xylem is in center and phloem surrounds the xylem).

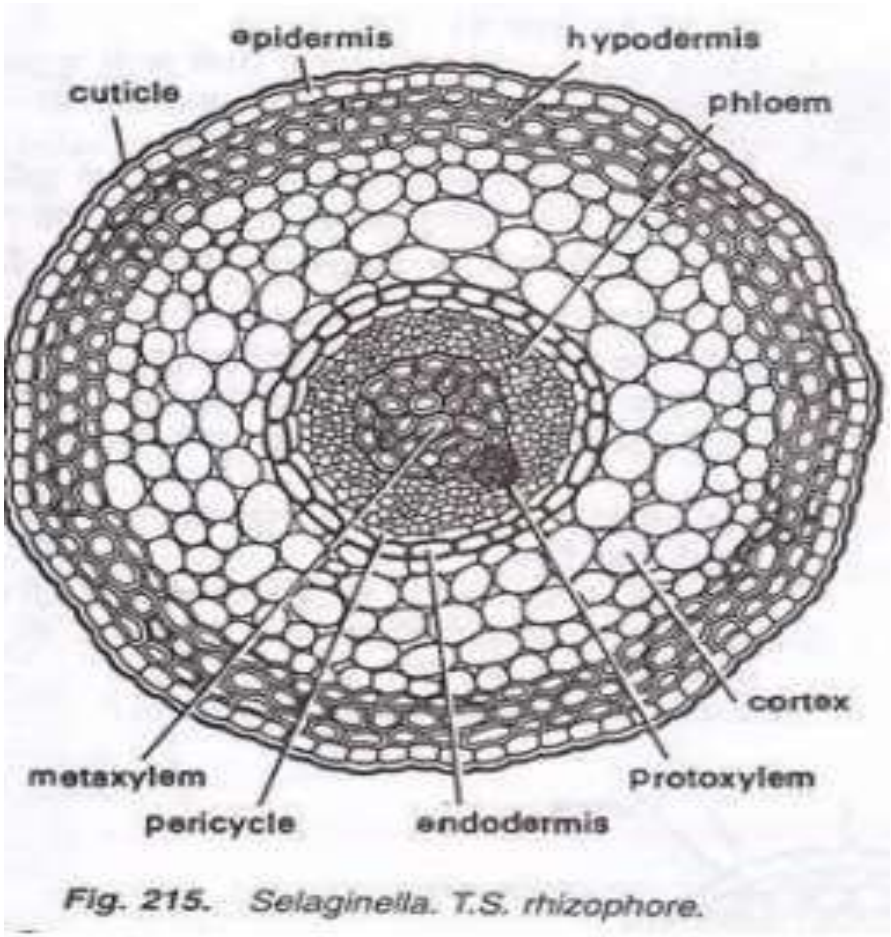


Fig. 215. Selaginella. T.S. rhizophore.

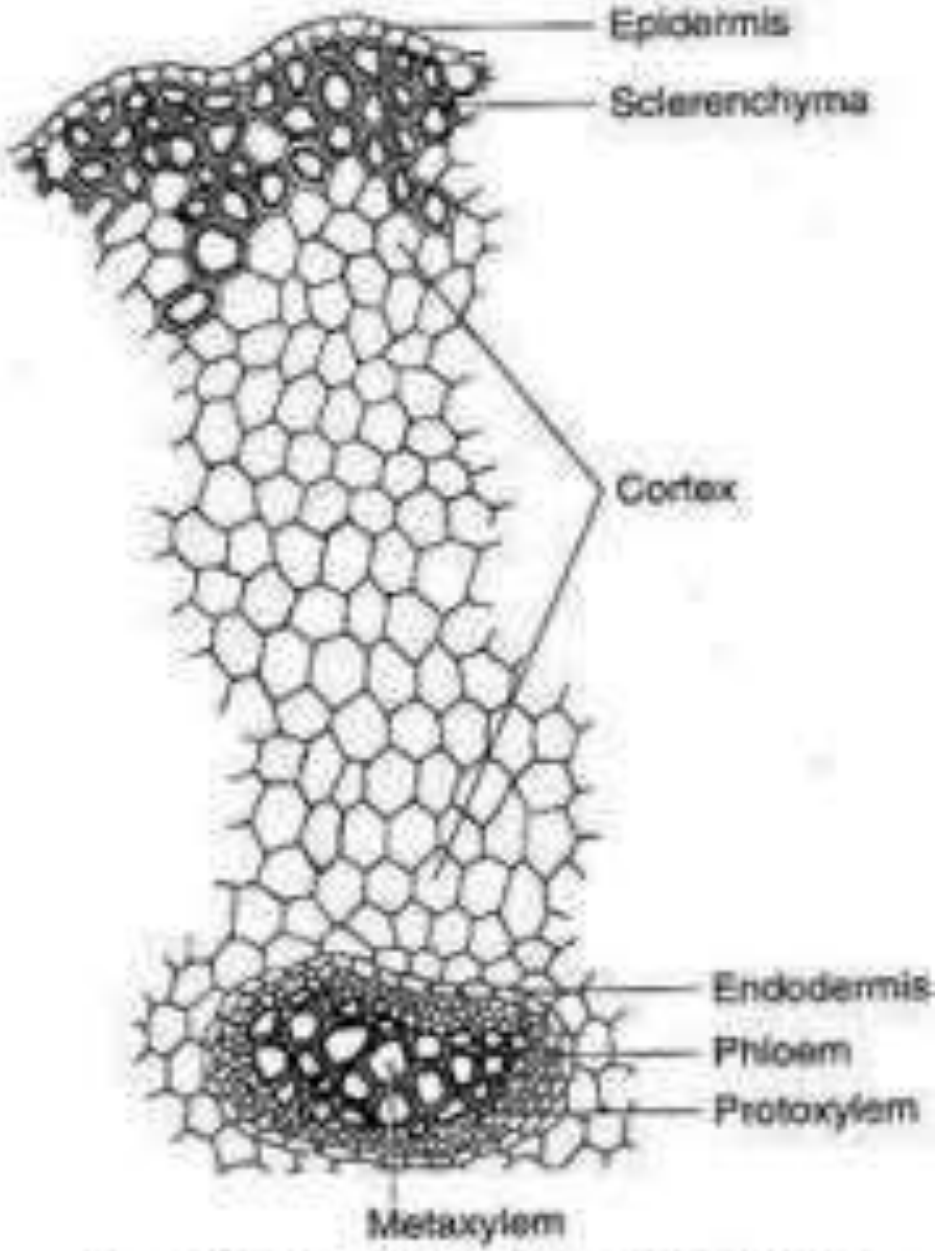


Fig. 7.48 : T.S. of rhizophore of *Selaginella*

Leaf anatomy

- The upper and lower epidermis are present They are one celled thick and contain chloroplast Stomata are present on upper and lower epidermis (but majority have in lower side)
- Below the epidermis there is mesophyll tissue having thin walled parenchyma cells, these contain chloroplast and have small and large air spaces Vascular tissue is present in center Phloem has few sieve cells and many parenchyma Vascular bundle is surrounded by single layer forming bundle sheath

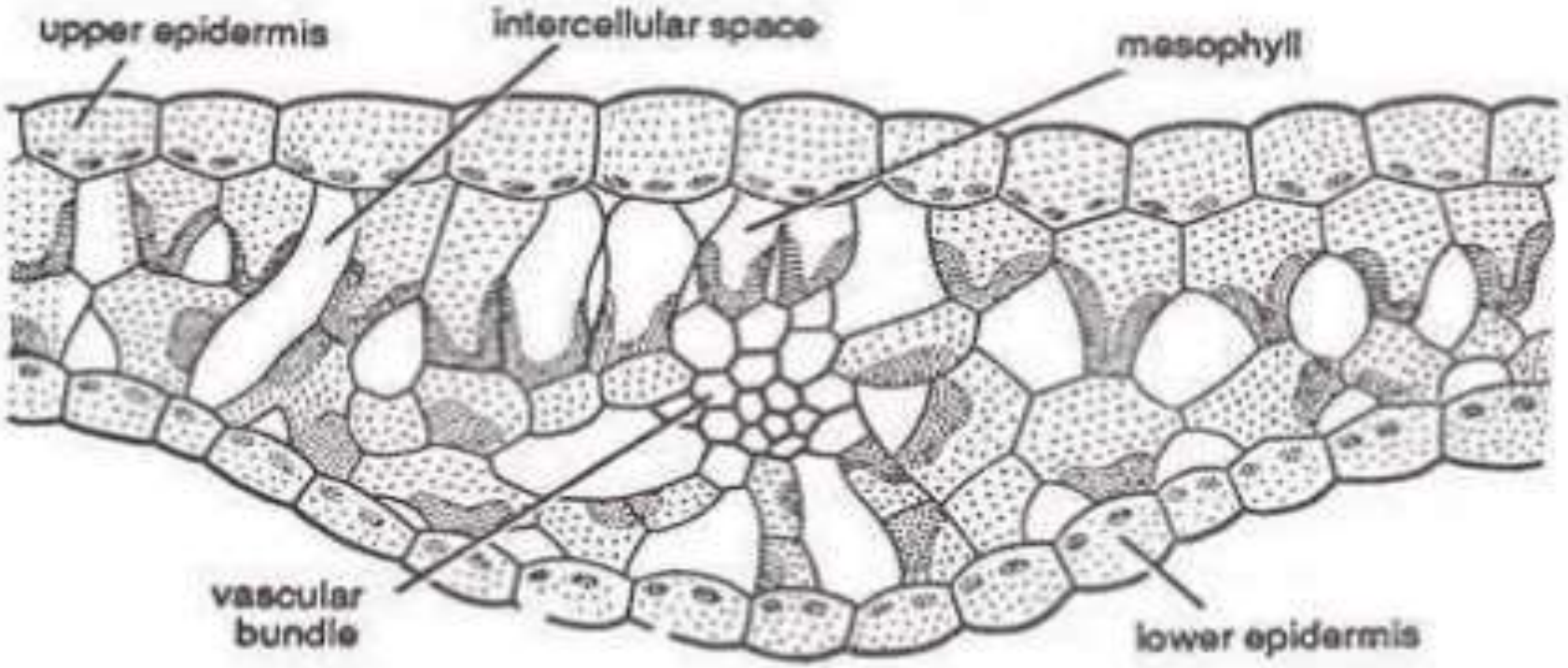


Fig. 216. Selaginella. T. S. leaf.

Root anatomy

- Outermost layer is epidermis (single layer), covered
- by thin cuticle Root hairs are present and arise from epidermis Beneath the epidermis, wide zone of cortex is present
- Outer hypodermis (have sclerenchyma cells)
- Endodermis (inconspicuous) Single layered pericycle is present Protostele is next Xylem is surrounded by phloem

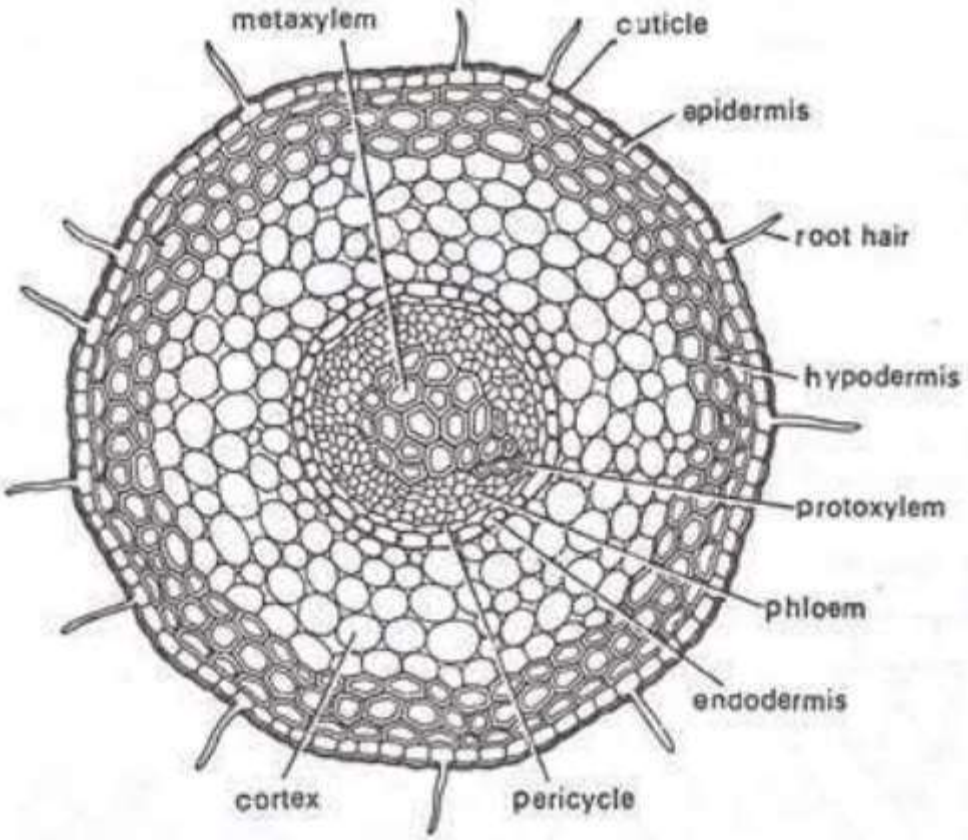


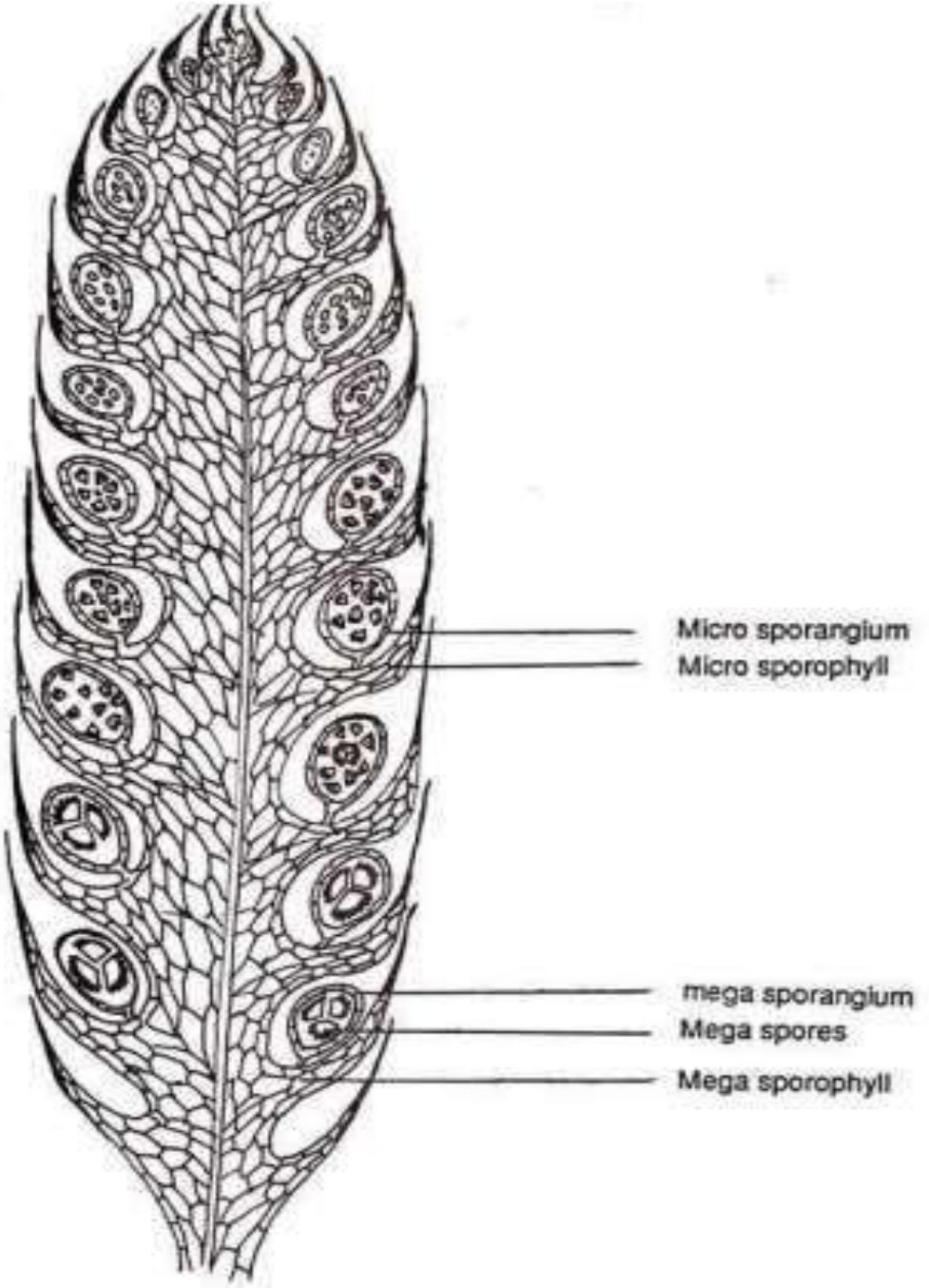
Fig. 214. Selaginella. T.S. root.

REPRODUCTION

- There are following methods for vegetative reproduction
- Adventitious branches
- Tuber production during unfavorable conditions By production of resting buds at the ends of aerial branches.
- These are surrounded by leaves and can survive in adverse conditions, upon reaching suitable conditions they develop into new plants.

Strobilus

- Sporangia are produced on the axils of ligulated leaves called sporophylls These sporophylls are organized to form strobili at the ends of shoots The sporophylls in strobilus is arranged just like bracts in angiosperm plants. That's why it is also called as sporangioferous spike



Structure of sporangia

- Microsporangia : they are small, stalked, oval and varying in shapes,
- Mega sporangia : they are stalked and 4 lobes, larger in size and present at base of strobilus , spores are of larger size.
- 1. Both consist of 2 layered sporangial wall surrounding the tapetum and sporogenous tissue.
- 2. Tapetum is developed from innermost layer of sporangial wall.
- 3. Both differ in their size, location, and number of spores
- 4. To release spore, both sporangia form vertical cleft in wall .

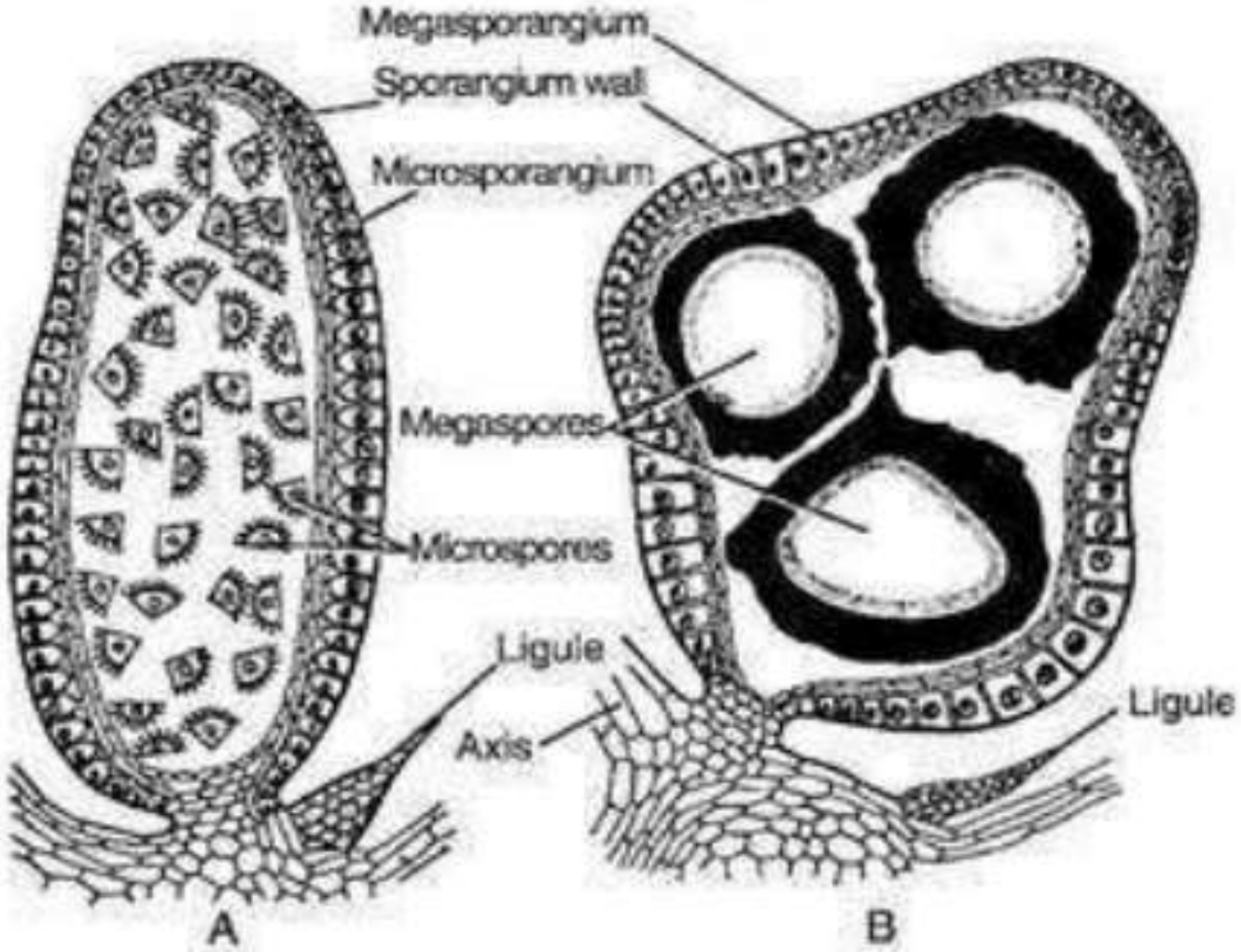


Fig. 7.52 : *Selaginella* : A. A mature microsporangium, B. A mature megasporangium

LIFE CYCLE OF SELAGINELLA

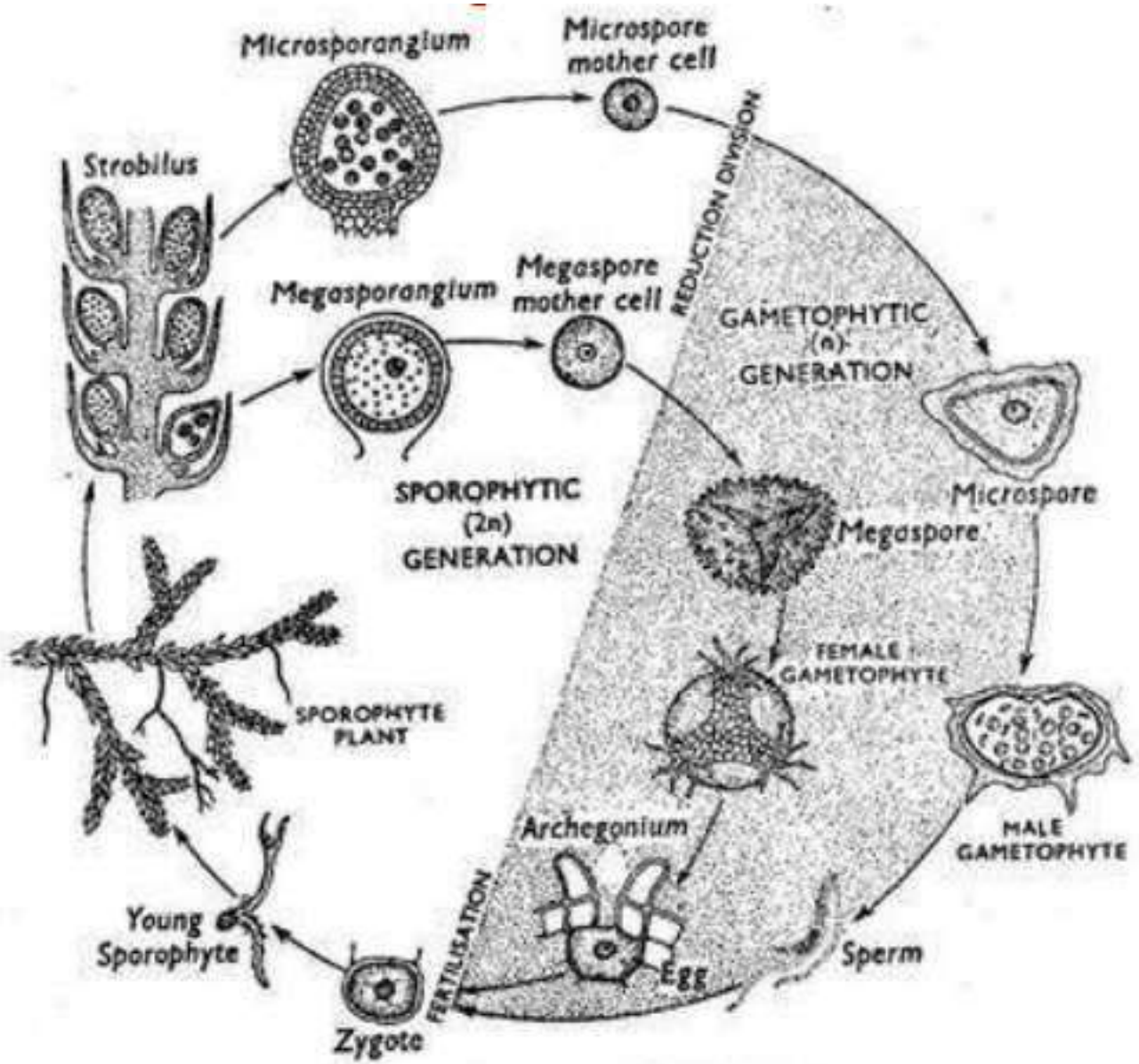


Fig. 7.58 : Life cycle of *Selaginella*

	Homosporous pteridophytes	Heterosporous pteridophytes
1.	In these pteridophytes only one kind of spore is produced.	In these pteridophytes two kinds of spore are produced.
2.	The spores are equal in size.	The smaller spores are called microspores and the larger spores are called megaspores.
3.	The spores are produced from the same sporangia.	The microspores are produced from the microsporangia and the megaspores are produced from the megasporangia.
4.	The spores develop one kind of gametophyte.	The microspore develops into male gametophyte whereas the megaspore develops into female gametophyte.
5.	Spores germinate in soil and produce independent gametophyte.	Spores germinate within sporangia and produce dependent gametophyte.
6.	e.g. Lycopodium	e.g. Selaginella, Salvinia.

EVOLUTION OF SORUS

- Sorus is a group of sporangia produced on the abaxial surface of the sporophylls in ferns.
- In some plants, sori may be circular, linear, or reniform.
- The location of sori may be slightly away from the margin on the frond lamina.
- Fern taxa can be distinguished in some cases on the basis of the presence or absence of indusium. They originate in different ways;
  a) Marginal sorus
  b) Intra-marginal
  c) Superficial / abaxial sorus

- During its development stage, sorus in some plants is covered and protected by a thin flap or a scale of tissue called an indusium, which protects the sporangial cluster from drying, exposure, drying, and other dangers.
- Sometimes, in the absence of an indusium, sori are covered by protective structures like the edge of a leaf.
- These structures partially surround the sporangia, which are considered as ‘naked’ in such cases.
- When the sporangia are matured, the indusium shrinks to allow for the unhindered release of the spores.
- These spores are then released when the sporangia bursts. After release, those spores produce and grow into the gametophytic generation.

- There are broadly three stages in the progressive evolution of sorus:
- Simple Sporangia Clusters: They are more or less separate (Gleicheniaceae) or are coalesced (family Marattiaceae). They all mature at the same time.
- Graduate Sporangia Clusters: The outermost clusters mature first and the innermost mature at the last.
- Mixed Sporangia Clusters: There is a presence of all ages with the younger ones arising from the same meristematic zones just like the older ones.
- This sequence or change has an adaptive significance and is most likely related to the spore production duration. The more advanced sorus has a mixed character and it extends the time period beyond that for simple simultaneously maturing sorus.

- https://www.vedantu.com/question-answer/describe-the-evolution-of-sorus-in-pteridophytes-class-11-biology-cbse-615337a11d254265a64e10c2