B. Sc.–I, Semester- I

Paper-II: Biology of Archegoniate

PTERIDOPHYTES

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PTERIDOPHYTES

- Term "**Pteridophytes**"= Pteron- Featherlike, Phyton- plants

  i.e. Plants bearing featherlike leaves
- Term First introduced by Haeckel.
- First plant to represent **Sporophytic** phase.
- These are Cryptogams having well developed vascular system.
- Represented by more than 400 living and fossil genera; 10,500 species.
- Pteridophytes originated in **Silurian Period** of **Palaeozoic Era.**
- They were **1st** successful group of land plants, majority of them have completely changed their habitat and become terrestrial.
- **1st colonizers** on land plants.p0

GENERAL CHARACTERS OF PTERIDOPHYTES:

- Mostly herbacious plants, grow in moist shady places,
- some are Aquatic
  (eg. ***Azolla, Salvinia, Marsilea***),
- Epiphytic- (e. g. ***Lycopodium***),
- Some are small annual herbs, perennial and trees eg. ***Alsophila, Cyathia***.
- **Tallest fern**: ***Alsophila***
- **Smallest fern**: ***Azolla***
- Sporophytic plants- differentiated into roots, stem and leaves. Nutritionally independent of gametophyte.
- Roots- **a. Primary roots-** short lived
  b. Adventitious roots- having permanent growing apex.
- Stem is underground rhizome, few posses aerial stem.
- Leaves: **a.** Scaly- simple and sessile
  b. Foliage- i. **Microphylls-** small single nerved, do not form leaf gap.
  ii. **Megaphylls-** large, pinnate leaves, form prominent leaf gap in stele of stem.
- Sporophytic stem is branched, it may be **monopodial** or **dichotomous**.
- Sporophytic leaf and stem posses **Filiform trichomes**.
- Stomata present on both surface of leaves.
- Well developed Vascular systems in root and stem.
- Vascular tissue- 1. Xylem : composed of **Tracheids**
- 2. Phloem : composed of **Sieve tubes**
- Cambium is absent.

- Pteridophytes show wide range of stele or stelar evolution:
  1. **Protostele:** eg. ***Lycopodium***
  2. **Siphonostele**: eg. ***Equisetum***
  3. **Dictyostele**: eg. ***Pteris***
  4. **Polystele:** eg. ***Angiopteris***
- Megaphyllous foliage leaves are composed of **Spongy** and **Palisade** cells.

Smallest Fern: **Azolla**

Tallest fern: **Alsophila**

REPRODUCTION :

- Sporophytes produce **Haploid** spores, produced in sporangia.
- **Sporangia** are formed towards ventral surface of leaf; in some cases towards axil of the leaf.
- The leaf producing sporangium is called **'Sporophyll'.**
- In some genera, Photosynthetic leaf becomes sporophyll during later stages of life-cycle.
- Whereas, in some genus, sporophylls are distinct special type of leaves during later part of life cycle.
- Plants may be **Homosporous** (eg. ***Lycopodium, Equisetum***) or **Heterosporous** i. e. produce 2 kinds of spores- Microspores and Megaspores (eg. ***Marsilea, Selaginella***)
- Classification of Pteridophytes based on development of sporangia: **1. Eusporangiate-** eg. ***Lycopodium, Equisetum***

Sporangia develop from a group of superficial cells

2.Leptosporangiate- eg. ***Marsilea, Dryopteris.***

Sporangia develop from a single superficial cells

- Sporophyll may be distributed either uniformly or aggregated to form compact cone called **"strobilus".**
- In some aquatic forms the sporophylls gets modified into specialized structure called **"Sporocarp".**
- The spore germinates to produce gametophyte.
- In Homosporous pteridophytes, gametophyte is **monoecious** and **exosporic**, called as **'Prothallus'.**
- In Heterosporous pteridophytes, gametophyte is **dioecious** and endosporic.
- **Microspore** forms male gametophyte and
  Megaspore forms female gametophyte**.**
- Sometimes gametophyte shows presence of endophytic fungal hyphae which are symbiotic.
- Male sex organ – **Antheridium** produces **Multiflagellate Antherozoids.**
- Female sex organ- **Archegonium** produce **Egg**.
- The sex organs are embedded in the prothallus.
- Fertilization occurs is in presence of **water.**
- After fertilization diploid oosore is formed, which develop into embryo.
- Classification of embryo: 1. Exosporic 2. Endosporic
- **Oospore** represent first cell of Sporophytic phase.
- Pteridophytes shows typical **Heteromorphic alternation** of generation.

CLASSIFICATION: As per G. M. Smith (1955)

plantscience4u

Classification by Smith (1955), Bold(1957) and Zimmerman (1959)

Psilophyta

- Most 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

Psilotum

Lycophyta (Club moss or spike moss)

- Differentiated plant body
- Microphyllous leaves
- Protostele sometimes siphonostele
- Sporophylls aggregate to form strobili or cones
- Homosporous *(Selaginella) Lycopodium)* or hreterosporous
- Gametophyte depends on fungus for food

Selaginella

Sphenophyta (Horse tail)

- 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,

Equisetum

Pterophya (Ferns or Filicophyta)

- Most widely distributed vascular cryptogams
- Differentiated plant body stem mostly rhizomatous
- Leaves macrophyllous called as fronds
- Young leaves show circinate vernation (spirally coiled)
- Stele: protostele, siphonostele or dictyostele
- Sporangis form sori on abaxial side of the leaf
- Sporocarp in Marselia
- Indusium may be true or false
- True indusium and false indusium
- Homosporous *(Pteris)* or heterosporous(*Marselia)*
- Antherozoids multiflagellated

Pteris

PSILOPHYTA: MAIN CHARACTERS

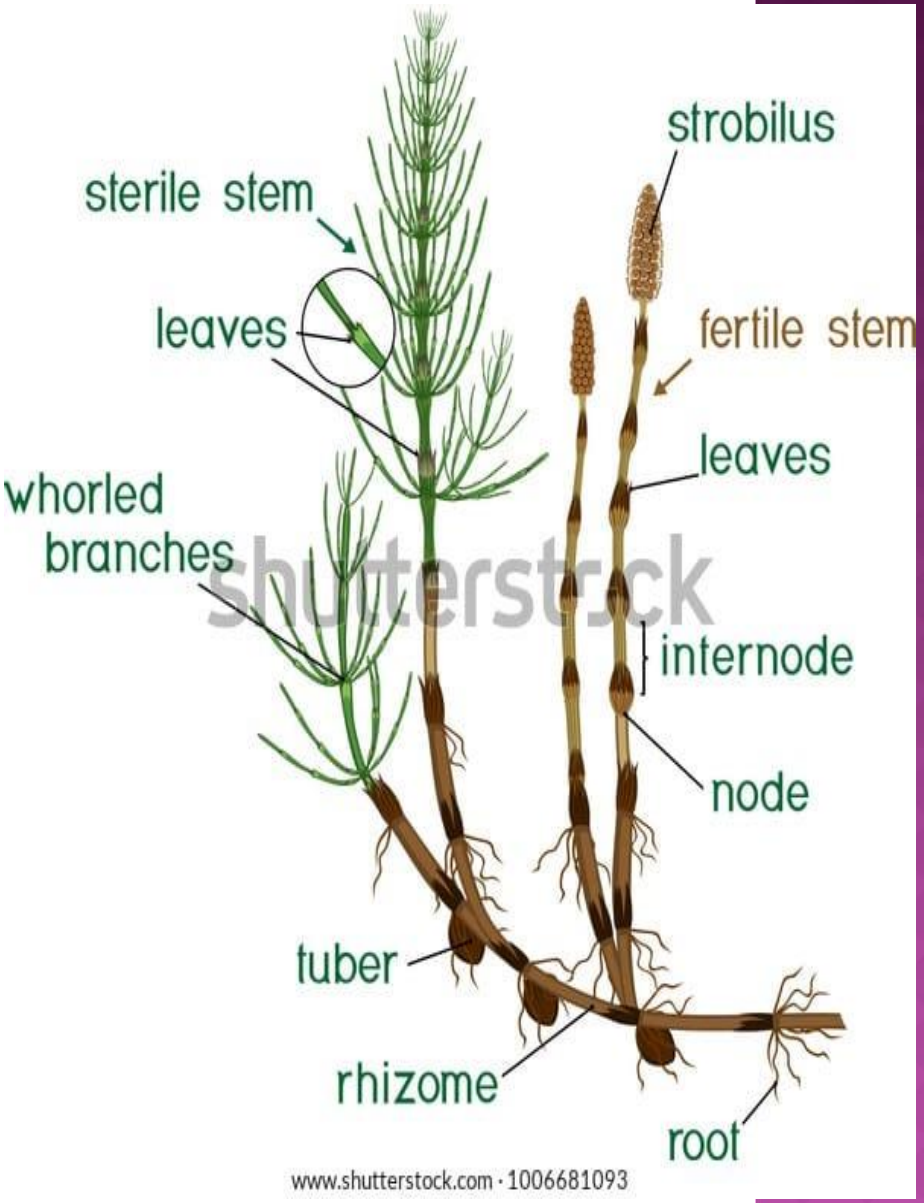
- Sporophytes are without roots and leaves.
- Vascular system is present only in **stem**.
- Rhizoids develop for absorption of water.
- Sporangia present on stem or branch apices.
- **Homosporous** plants.
- Some genera are of fossil forms, few are of living forms.
- Example: ***Psilotum***

LEPIDOPHYTA: MAIN CHARACTERS

- **Lycopods**
- Sporophytes differentiated into stem, leaves and roots.
- Leaves **Microphyllous** with single vein.
- Stele: **Protostelic, Siphonostelic** or **Polycyclic**.
- Sporophylls produce single sporangium and are borne in strobili.
- **Homosporous** or **Heterosporous** plants.
- Leaf gaps and Leaf branches are absent in stele.
- Example: ***Selaginella***

CALAMOPHYTA : MAIN CHARACTERS

- Horsetails
- Sporophytes differentiated into stem, leaves and roots.
- Leaves- Foliage leaves are single veined in whorls produced at the nodes on stem.
- Vascular cylinder- Protostelic or Siphonostelic.
- Stem hollow, jointed with vertical ridges and furrows.
- Sporangia borne on Sporangiophore.
- **Homosporous** plants.
- Leaf gaps and Leaf branches are absent in stele.
- Example: ***Equisetum***



PTEROPHYTA: MAIN CHARACTERS

- Sporophytes differentiated into stem, leaves and roots.
- Vascular cylinder of stem – **Siphonostele**, shows presence of leaf gaps.
- Leaves- **megaphyllous** with branched veins.
- **Homosporous** or **Heterosporous**
- Leaf gaps and Leaf branches are present.
- Example: ***Pteris***

CLASSIFICATION AS PER G. M. SMITH (1955)

- Linnaeus divided the plant kingdom into 25 classes; one of which is Cryptogamia.
- Class: Cryptogamia incldes all plants with hidden reproductive organs.
- It is further divided into 4 orders, among them order **Fillicales** includes all known Pteridophytes.
- In natural system of classification plants are grouped according to their natural affinities.
- After the theory of evolution by Darwin, at the end of the 19th Century, the natural system of classification appeared.
- In these systems, fundamental basis for classification was **phylogeny,** Plants were arranged in ascending series from the simple i. e, Primitive to most complex i. e. Advanced.
- In natural system of classification, Cryptogams are divided into 3 divisions: 1. Thallophyta
  2. Bryophyta
  3. Pteridophyta

- This system of classification with more or less modifications widely adopted and still followed.
- According to G. M. Smith's (1955) Classification system, Pteridophytes shows 2 distinct groups of plants:

1. Plants with **Macrophyllous** leaves and with leaf gaps in the Siphonostele.
2. Plants with **Microphyllous** leaves and without leaf gaps in Stele.

- This classification system is a natural system of Classification. Its fundamental basis is **Phylogeny** i. e. considering interrelationships of plants belonging to different divisions.
- Plants are arranged in an ascending series. i.e., from the most simple (Primitive) to most complex (Advanced) forms.

Classification:

- Vascular cryptogams/ Pteridophytes are divided into **4** divisions, **one** division is for fossil Pteridophytes.
- According to this system of Classification, Vascular cryptogams are considered as **most complex** in non-flowering plants.

In the course of evolution, the pteridophytes might have produced the **ancestors** of seed bearing plants.

- Life cycle of Pteridophytes is divided into **2** phases:
  1. Sporophytic Phase
  2. Gametophytic Phase
- Up to Bryophytes, main plant body is **gametophytic** and sporophytic phase is for shorter duration.
- But in Pteridophytes, main plant body is **sporophytic** and Gametophytic phase is of Short duration.
- Pteridophytes are **Vascular cryptogams** i.e., Sporophytes of Pteridophytes have well developed a system of conducting tissues.
- It includes the **Fibro-vascular cylinder**, consisting of Xylem, Phloem and other mechanical elements for conduction of Water and Food material.
- Due to presence of Vascular system, the sporophytes of pteridophytes exhibit peculiar **anatomical characters** as well as **Stelar evolution**.
- Sporophytes in Pteridophytes produce Haploid sporesin special structure i. e., **Sporangia.**
- **Spore** is the 1st Cell of gametophytic generation. The gametophytic phase is important, because during this phase of lifecycle, Antheridium and Archegonium are produced and sexual reproduction occurs.
- **Stele**: Central conducting column in the main plant body.

MORPHOLOGY, ANATOMY AND LIFE CYCLE:

a. Lycopsida: *Selaginella*

Systematic Position:

Kingdom: Plantae
Sub-kingdom: Cryptogams
Order: Selaginellales
Family: Selaginellaceae
Genus: ***Selaginella***

Distribution:

- Comprises more than **700** species,
- Commonly called as "**Spike Moss**" or "**Club Moss**".
- Mostly grow in damp and shaded forests of the Tropics,
- Some are **Xerophytic** growing on expose rock surface.
- Some species are cultivated in gardens as Ornamentals.
- In India, 70 species of *Selaginella* have been recorded.
- Common Species: ***S. kraussiana*, *S. megaphylla***

Morphology:

- Plant body is **sporophytic.**
- Sporophyte is differentiated into roots, rhizophore, stem and leaves.
- The plant is **flat, creeping-** eg. ***S. kraussiana***,
- **Sub-erect** with **upright** moss like branches eg. ***S. trachyphylla***
- **Climbers**- eg. ***S. alligans***
- Posses special discoid Pads on their rhizosphores for climbing.
- Species ranges from annuals to perennials; with few cm to more than several feet in length.
- Divided into 2 genera:

1. **Homoeo-phullum**- have erect and dichotoumously branched stem, Leaves isophyllous and spirally arranged. It consists of more than 50 species.

2. **Heterophyllum**- Members have prostrate and dorsiventral stem with erect branches which are always irregular.

Leaves show 2 dorsal rows of small leaves and 2 ventral rows of large leaves.

- **Roots:**

1. Adventitious, bit primary roots are ephemeral. Roots are endogenously produced on dichotoumous branches; at the right angles to each others.
2. In creeping species roots arises at or close to the point of dichotomy eg. ***S. rupetris***.
3. In ***S. selaginoides*** roots arise from knot like swellings at basal stem region.

- **Rhizophore:**

1. Peculiar leafless, prop-like structure arises from the lower side of the stems at the point of dichotomy, called as "**Rhizophores**".
2. Grow downwards into the soil. And produce tuft of adventitious roots at their free ends.

- **Stem:**

1. Homeophyllous- stem is erect, dichotomously branched.
2. Heterophylllous- stem is prostrate, or sub-erect with lateral branches.

Leaves:

1. 2 types of leaves- Vegetative and Reproductive.
2. Vegetative leaves- green, arranged on the stem surface in rows.
3. Reproductive leaves- called as ‘Sporophylls’, produced at the apices of the branches in form of cones/ strobilus.
4. Reproductive leaves types- 1. Microsporophylls
   2. Megasporophylls

- Leaves are simple, small, sessile and lanceolate to ovate in shape and have single mid-vein.
- Leaf has small flap-like appendage called as Ligule on upper surface close to its base.
- Basal part of the ligule has a distinct hemispherical foot like structure called- ‘Glossopodium’; it is made up of large thin walled vacuolated tubular cells.
- Glossopodium remail embedded at the base of the leaf in a pit like structure called “Ligular pit” or “glossopodial sheath”.
- Function of Ligule: Associated with absorption of water and secretion.

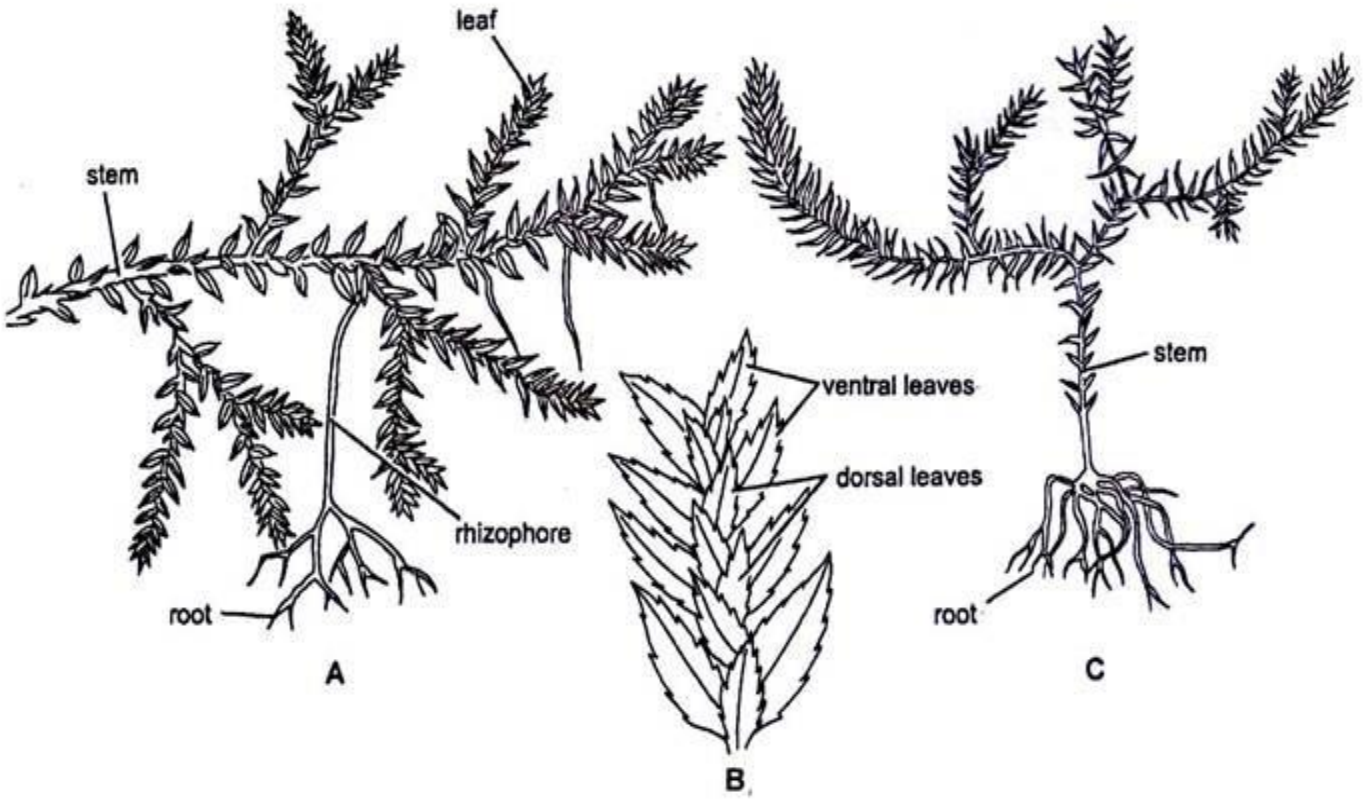


Fig. 1 (A–C). *Selaginella*. External features : A. *S. kraussiana*, B. Leaf arrangement in a branch of *S. kraussiana*, C. *S. spinulosa*

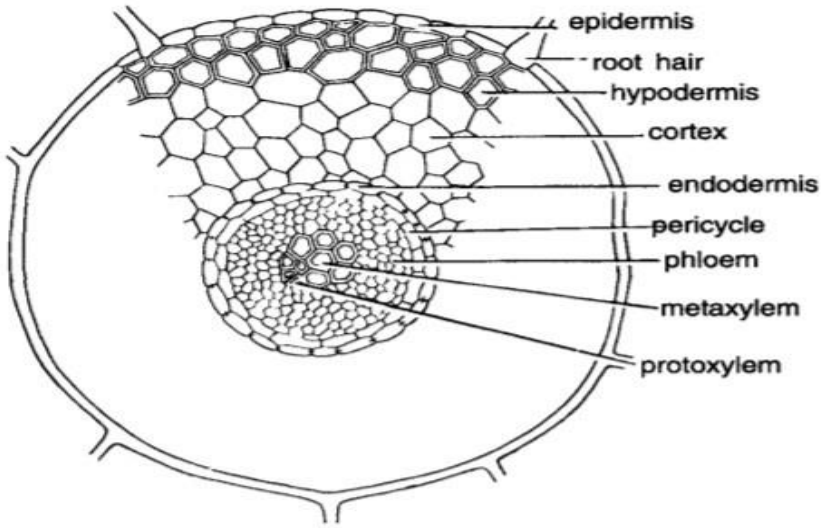
Selaginella

ANATOMY:

1. **T. S. of Root:**

- Epidermis forms outermost layer.
- Cells are compact, elongated and occasionally produce root hairs.
- Cortex- parenchymatous,.
- Endodermis- it separates cortical region, followed by pericycle.
- Vascular region: core of stele is Monarch with exarch Xylem.

Phloem occurs in the form of ring around xylem. Therefore, stele is **Protostele.**



Selaginella. T.s. root (a part cellular).

2. Rhizophore:

- Anatomy is similar to root, except hypodermis.
- Epidermis- outermost layer with thick cuticle.
- Cortex- divided into-

outer- **Sclerenchymatous hypodermis**,

inner- wide **parenchymatous zone**

- Stele- **Protostele**, surrounded by Pericycle. May be Monarch and exarch.

3. T. S. of Stem:

- Epidermis- forms outermost layer. Some cells are tangentially elongated and some are papillate and highly cutinized.
- Stomata and hairs are absent.
- Cortex: differentiated into-

1. **Outer** thick walled lignified cells forming **Sclerenchymatous** hypodermis.
2. **Inner** cortex is made up of **Parenchymatous** cells without intercellular spaces. Green in colour.
3. Stele- 1. *S. spirulosa*- **monostelic**
   2. *S. habellata*- **distellic**
   3. *S. kraussiana*- **polystellic**

- Stele is surrounded by single layered Pericycle.
- Some species have **Protostele**; some have **Siphonostele**
- Xylem is Monarch or Diarch, consists of only tracheids.

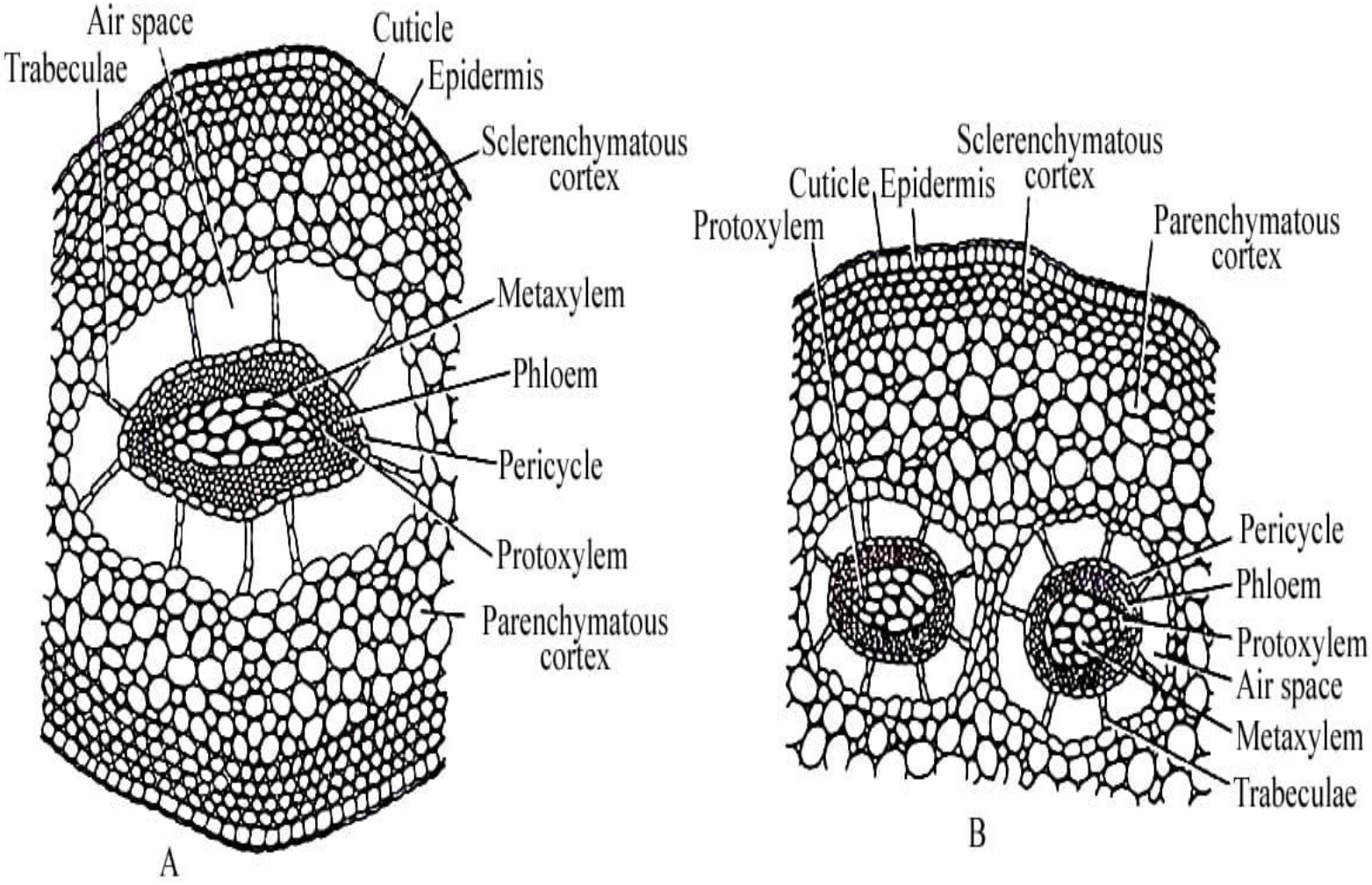
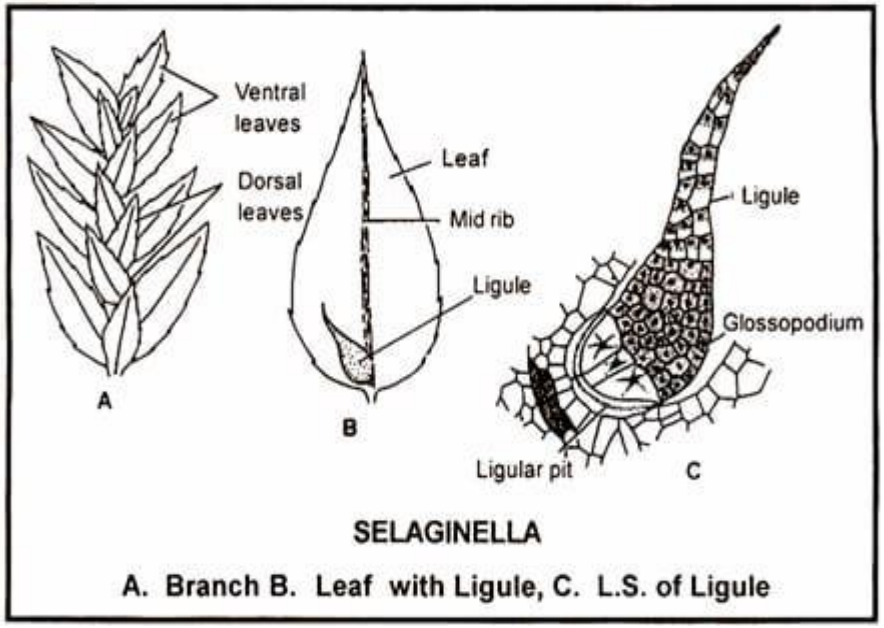


Fig: *Selaginella spp.* T.S of Stem. (A) T.S of monostelic stem; (B) T.S of distelic stem.

4.Leaf:

- Epidermis: Upper and lower epidermis present.
- **Chloroplast** is present in epidermis.
- Leaves- **Amphistomatic** but sometimes **Hyphostomatic**.
- Stomata found mostly on midrib region.
- In **mesophyll tissue** large intercellular spaces are present.
- Vascular bundle- single, present in the center; surrounded by a bundle sheath.



MORPHOLOGY OF RHIZOPHORE:

- Some consider it as a stem, other consider as root.

1. According to Van Tieghem (1902): Harvey, Gibson and Uphof (1920)- Rhizophore is root due to-

1. They are positively geotropic.
2. They have no leaves.
3. They exhibit root like internal structure. (Monostelic condition)

2. According to Burchmann (1905), Worsdell (1910) and Cusick (1954), it is shoot because-

1. It arises exogenously.
2. Root cap, root hairs absent.
3. It grows by means of an angle meristem.
4. Under controlled experimental conditions, it can be induced into a shoot.

REPRODUCTION:

A. Vegetative reproduction:

- Takes place by means of Tubers, Bulbils, Dormant buds and Fragmentation.
- Tubers are formed at the end of the vegetative branches of ***S. chrysorhizos.***
- Under favourable conditions, tubers develops into new plant.

B. Reproduction by spore formation: Sexual Reproduction

- It is a heterosporous sporophyte.
- Produces 2 types of spores- Microspores and Megaspores.
- Each sporangium is produced in the axil of a leaf called **Sporophyll.**
- Sporophylls are of 2 types- Microsporophylls and Megasporophylls
- No. of Microspores- Many in Microsporangium
- No. of Megaspores- 1-4 in Megasporangium.
- Megaspores are larger than Microspores.

Strobilus or Cone:

- Sporophylls are crowded and aggregated at the apex of the main stem.
- Where It forms a compact structure called as Strobilus.
- Size- 5 mm to 6-8 mm.
- It is heterosporous plant, therefore sporangia are of 2 types- **Microsporangia** and **Megasporangia**
- In ***S. kraussiana***- Microsporophylls and Megasporophylls born on the same axis forming strobilus.
- In ***S. inaequafolia*** one side of the strobilus bears only Megasporophylls while other bears only Microsporophylls.

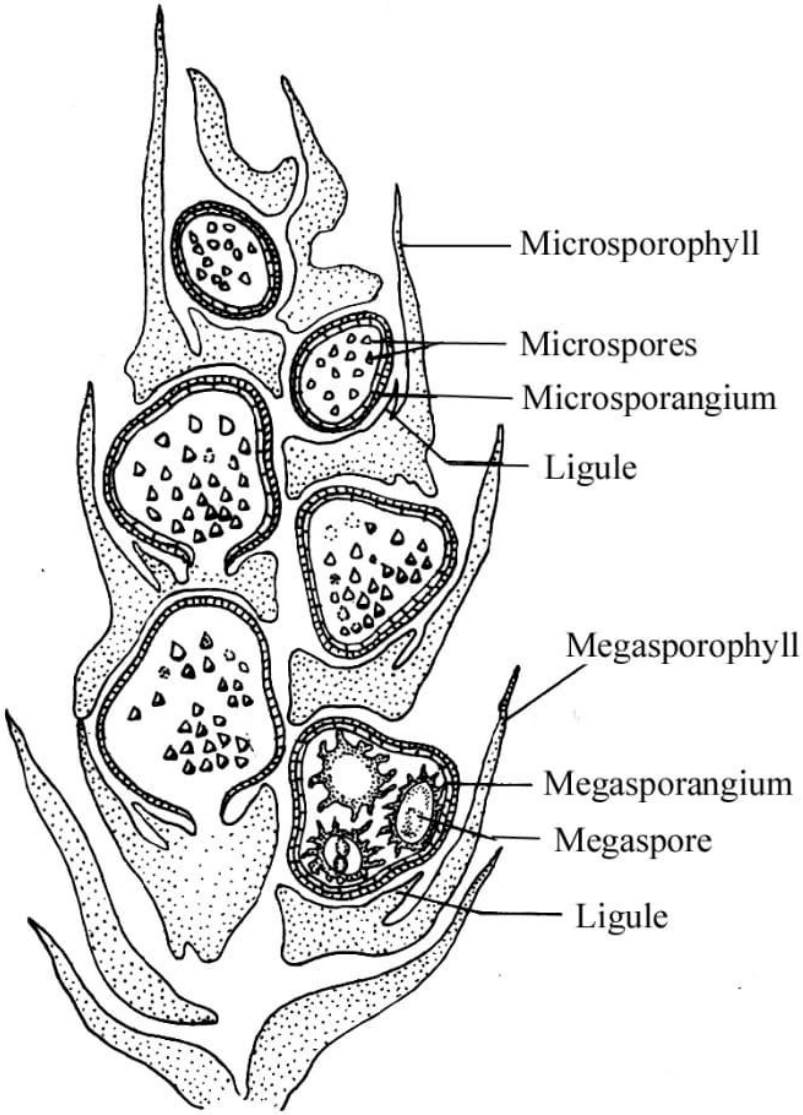
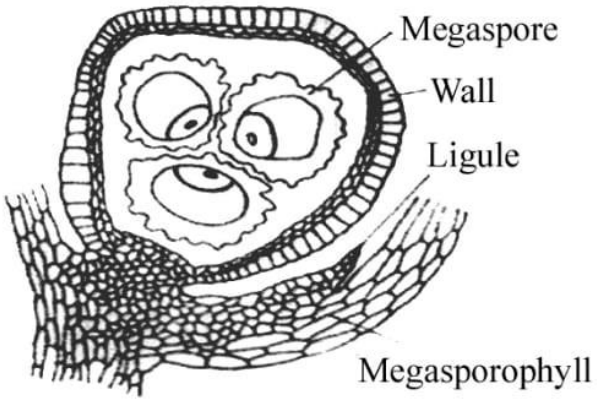
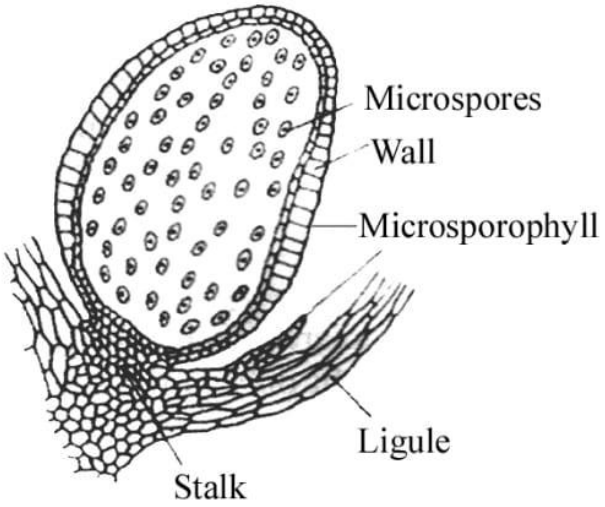


Fig: *Selaginella spp.* L.S of strobilus.



Mature megasporangium



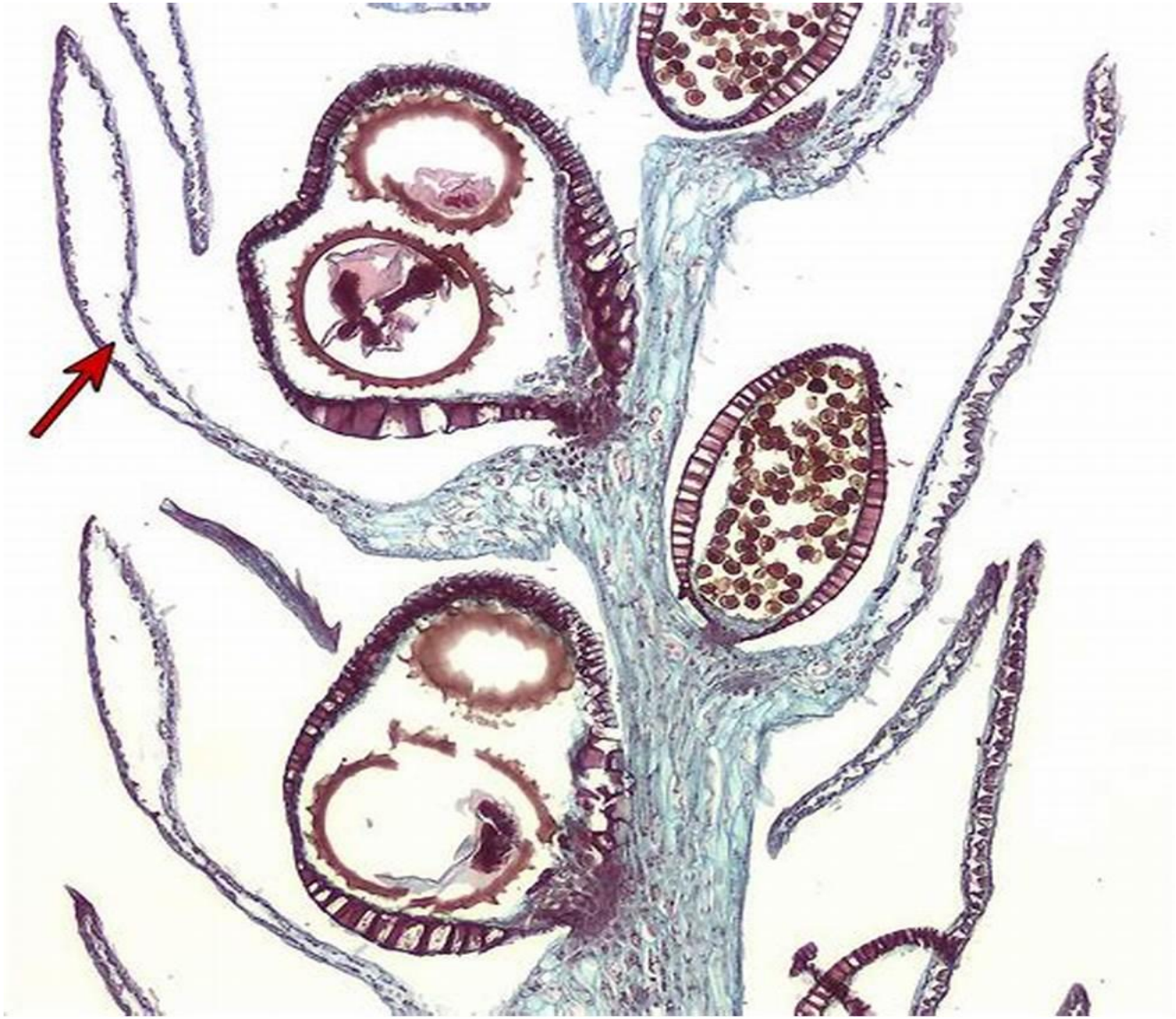
Mature microsporangium

Mature Microsporangium:

- It is a stalked structure with 2 layered sporangial jacket.
- Outer cell of jacket contain Chloroplasts.
- Microsporangia are elongated, yellow to red orange in colour, Subtended by flap like Ligule.
- Microsporangium contains microspores., they germinate inside the microsporangium forming **male gametophyte.**

Mature Megasporangium:

- It is short stalked, large and lobed structure due to presence of **Globular** megaspores.
- Liberation of spores takes place along the **line of dehiscence** present at its distal end.



Mature Microsporangium and Megasporangium

Gametophyte:

- **Spore** is the **first** cell for gametophytic generation.
- *Selaginella* produces Microspores and Megaspores.
- Microspores germinates to produce **Male gametophyte** and Megaspore germinates to produce **Female gametophyte**.
- Both microspore and Megaspore begin to germinate inside respective sporangium.

Microspore and Male Gametophyte:

- Very Small, Spherical structure ranging from **0.015-0.15 mm** in diameter.
- Microspore consists of 2 layers:

1. Outer thick ornamented- **Exine**: Variously sculptured.
2. Inner thin – **Intine**

- Microspore has single **haploid** nucleus, granular cytoplasm with reserved food material in the form of **oil globules** and **Nitrogenous material**.

Development of male gametophyte:

- Male gametophyte germinates within microsporangium, before sporangium dehisces.
- It is upto **13** celled stage.
- Its 1st division is asymmetrical, results in a:

  small: **Prothalial** and

  large: **Antheridial initial**
- Prothalial cell doesn't divide further and entire sporangium develops from **Antheridial intial**.
- Antheridial cell divides vertically to form 2 primary cells of antheridium.
- At this stage there are 3 cells in male gametophyte.
- Primary antheridial cell divides transversely to form 4 cells. At this stage male gametophyte is 5 celled.
- By furthers divisions it attains **9** cells. Out of these 9 cells, **1** cell forms prothallial cell, **4** jacket cells and **4** antheridial cells.
- 4 antheridial cells undergo periclinal division to form central group of 4 cells surrounded by peripheral cells.
- Now, gametophyte consists of 13 cells:

(1- **Prothalial cell**; 4- **Primary Androgonial**; 8- **Jacket cells**)

- Peripheral cells form jacket layer whereas, Central cells forms Primary Androgonial Cells.
- Primary Androgonial Cells divide repeatedly to form mass of 128-256 Antherozoid Mother Cells/**Androcytes.**
- Each androcyte metamorphoses into **Biflagellate spindle shaped Antherozoid**.
- **Antherozoid of *Selaginella*** are **the smallest** amongst Vascular plants.

Development of Female gametophyte:

- It starts while the **megaspores** are still inside the Megasporangium.
- A conspicuous vacuole develops within the cytoplasm of the Megaspore.
- Megaspore nucleus undergoes repeated nuclear divisions without cell wall formation i. e. **Free Nuclear Division**.
- It results in a thin layer of multinucleate cytoplasm, developed around the large vacuole.
- In ***S. kraussiana***, the apical patch of cells is separated from the rest of gametophyte by conspicuous arching wall.
- The stage at which Megaspore shed from the megasporangium varies from species to species.
- Size of female gametophyte increases, pressure exerts on the wall which results in splitting of wall.
- Tufts of rhizoids may develop from the exposed area of gametophytic tissue, which play an important role in absorption of water and nutrients.
- In ***S. rupestris***, megaspore are not shed and development of female gametophyte and fertilization takes place inside the sporangium.

Fertilization:

- At the time of fertilization, the **Center canal cell** and the **Neck canal cells** degenerate.
- Only egg remains.
- **Atherozoids** swim in the current moisture and one of them moves towards the egg to fertilize it.
- This results in diploid Zygote.

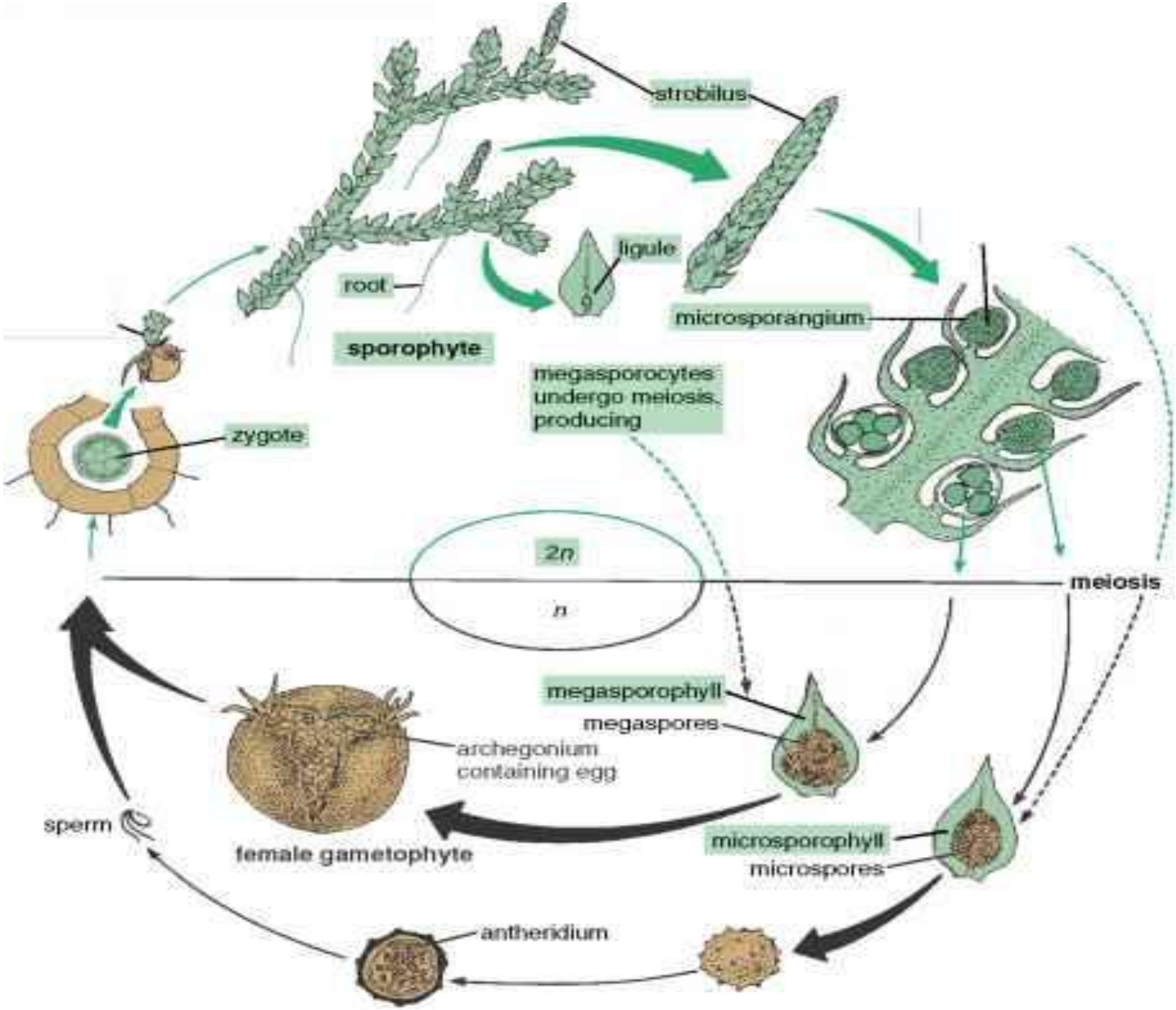
Embryo development:

- Zygote divides transverly to form an **upper Epibasal** cell and a **lower Hypobasal** cell.
- Entire hypobasal cell develops into a Suspensor.
- Hypobasal cell contributes to all parts of the embryo.
- Hypobasal cell gives rise to the **stem apex, cotyledon, foot and root.**

Alternation of generation:

- 2 types of generations alternate with each other-
  1. Sporophytic – Dominant generation.
  2. Gametophytic
- Cones/Strobilus are produced at the apices of Sporophytic plant.
- In this strobilus micro and megasporophylls are present, which bears Micro and Megasporangia respectively.
- microspore mother cells (2n) forms many microspores by meiotic division.
- From Megaspore mother cells (2n), 1-4 megaspores formed.
- Therefore, Microspores and Megaspores are formed and sporophytic generation end and gametophytic generation begins.

Lifecycle: *Selaginella*



b. Pteropsida: *Pteris:*

Systematic position:

Division: Pterophyta

Class: Fillicinae

Order: Filicales

Family: Polypodaceae

Genus: *Pteris*

Morphology:

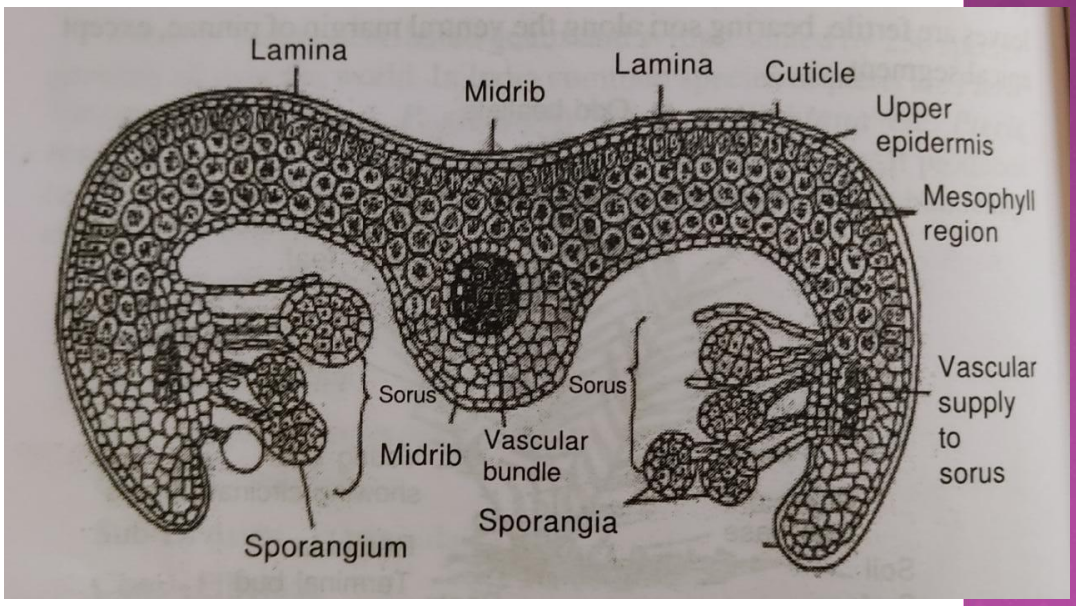
- Main plant body: Dominant **sporophyte**
- Shoot system- in form of underground **creeping rhizome**, covered with brownish scales.
- Aerial stem absent
- Roots arises from lower surface of the rhizome.
- Leaves: large, **Pinnately compound** with distinct petiole.
- Each pinna shows **single midrib** and lateral veins.
- Roots: produced from lower surface of rhizome

Anatomy:

1.T. S. of Leaflet:

- Upper and Lower epidermis is present.
- Mesophyll may or may not be differentiated into palisade tissue and spongy parenchyma.
- Midrib region- single concentric vascular bundle is present, with distinct Endodermis.
- Stomata- present at lower epidermis.
- Xylem is ‘U’ or ‘V’ shaped, surrounded by Phloem.
- Bundle sheath layer present with thick walled cells.

Marginal sori of Pteris vittata



2.T. S. of Rhizome:

- It is irregular, circular in outline.
- Epidermis- single layered with compactly arranged cells.
- Epidermis is followed by ground tissue, it consists of **Hypodermal sclerenchyma** and Central region of **Parenchymatous** cells.
- Central region shows- meristeles, root traces, leaf traces.
- Stelar organization in Pteris rhizome varies with species, it is either **Soenostelic** or **Dictyostelic** in nature.
- Medullary strands absent.

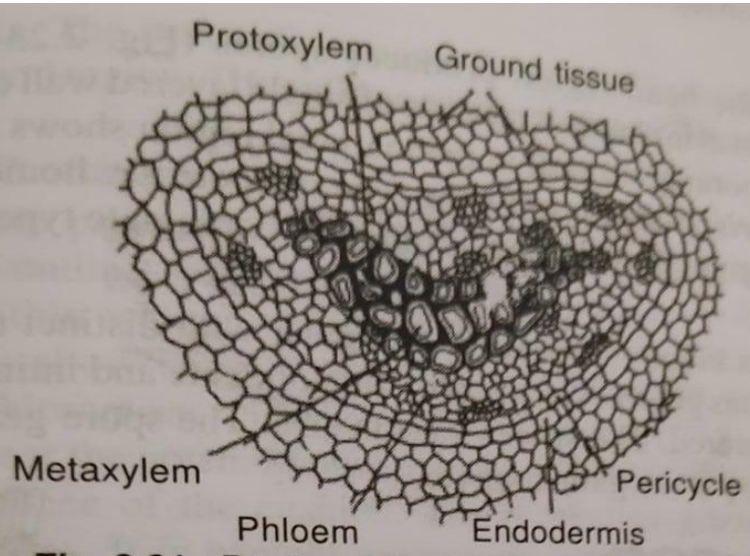
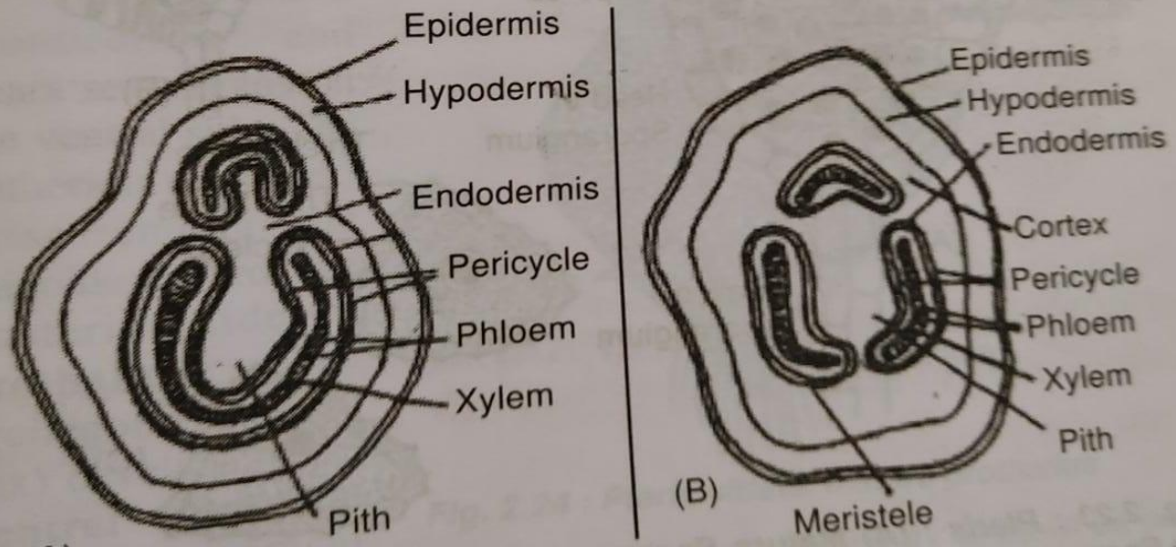


Fig. 2.21 : Pteris : T. S. of rhizome with single meristele (Showing detailed structure)

Anatomy : T. S. stem (Rhizome) (fig A.B.)



Reproduction:

- It reproduces by **Spores.**
- Each leaf is a potential sporophyll, because no special sporophylls are produced.
- Sporangia develops on intramarginal receptacle, forming continuous linear sorus called **"Coenocones".**
- Sorus is protected by upper indusial flap i. e., **False Indusium**.
- Each sporangium consists of-Elongated stalk and Capsular head.
- Stalk is attached to Placenta, Head produces spores.
- Capsular Head is oval in shape.it consists of single layered wall enclosing **48** spores.
- Sporangial wall in the marginal region shows **Stomium** and **Annulus**.
- *Pteris* is **Homosporous**.
- Sporangial development is **Leptosporangiate** type.

Spore: roughly triangular with distinct triradiate mark.

It has thick wall consisting of Exine and Intine. Exine is variously sculptured. Spore germinates and forms exosporous gametophyte.

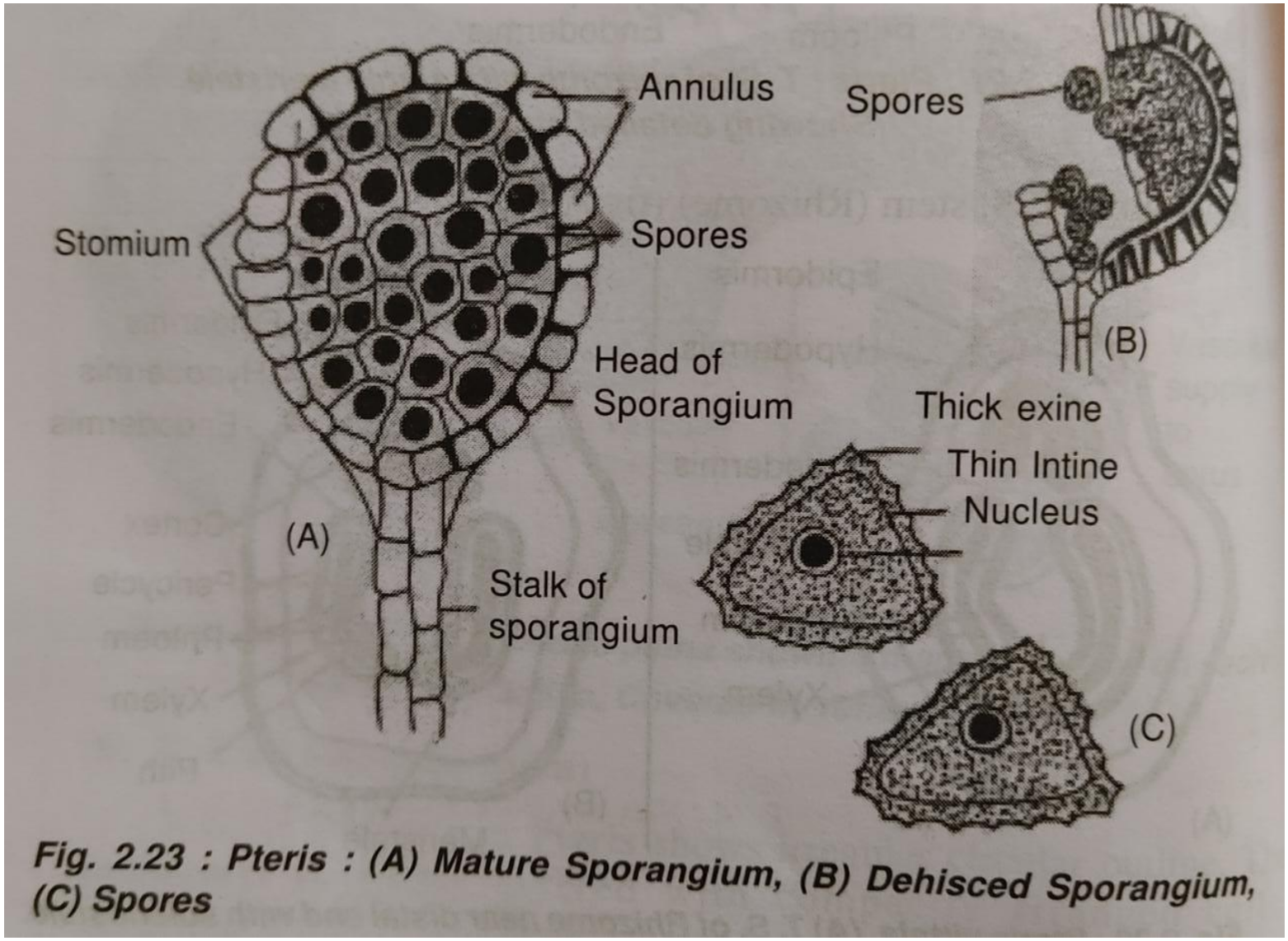


Fig. 2.23 : Pteris : (A) Mature Sporangium, (B) Dehisced Sporangium, (C) Spores

Gametophyte:

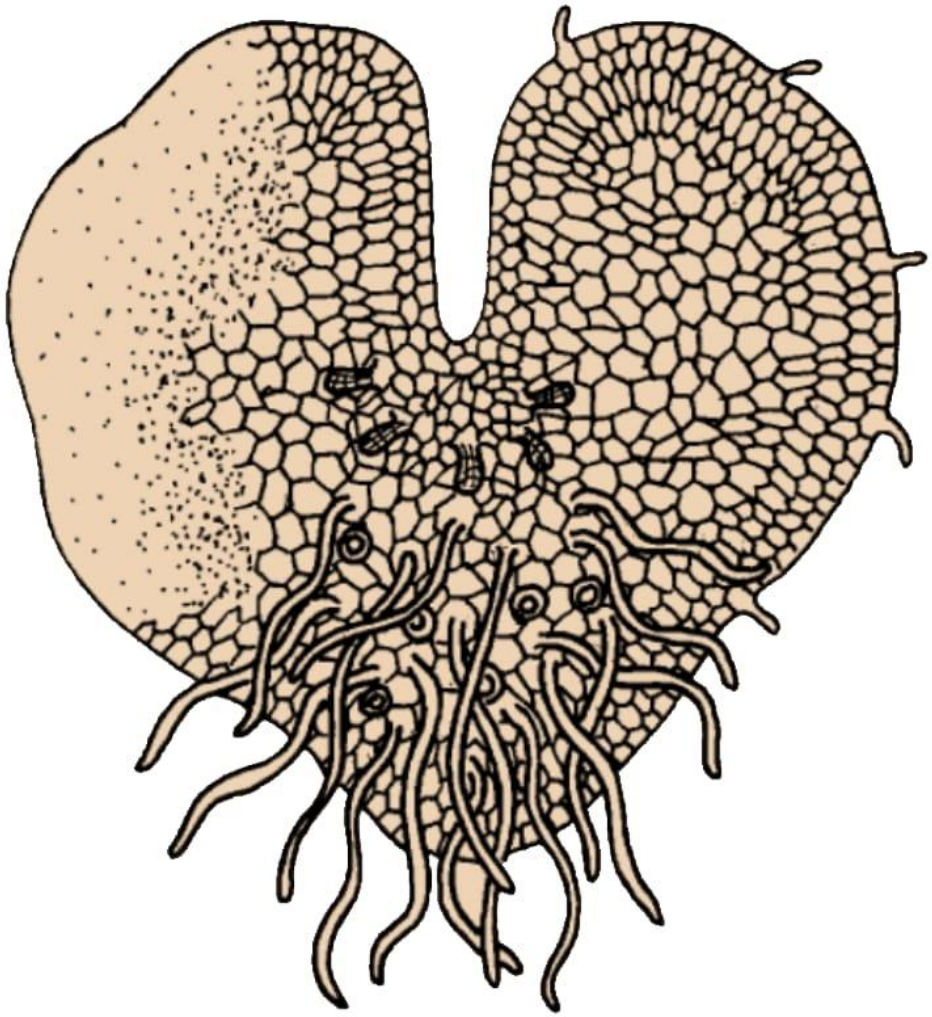
- Spore germinates on suitable substratum.
- Exine ruptures and inner contents forms a germ tube and produce **1st rhizoid** and **1st prothalial cell.**
- Prothalial cell divides to form **apical cell**, which again divides to produce **Spathulate 1st Prothallus.**
- Later, Fully mature prothallus is formed, which is Heart shaped, dorso-ventrally flattened, aerial, green coloured, photosynthetic.
- Prothallus is **parenchyamatous**, it has rhizoids on the ventral surface.
- **Monoeciuos** prothallus, Produce Antheridia and Archegonia.
- Antheridia- appears first.

Mature Prothallus:

- Small, green, flat Heart shaped.
- Size- **5 to 13 mm** in diameter.
- Prothalial cells are **thin walled, elongated, polygonal or hexagonal.**
- Cells shows Central vacuole, single nucleus and many small **discoid chloroplasts.**
- Prothallus is Autotrophic.
- Brownish, unbranched rhizoids arise from lower surface.
- It grows only in moist shady places.

Sex Organs:

- Prothallus- Monoecious, Antheridium- Arise among the rhizoids towards the **posterior** side of prothallus.
- Archegonium: develops in the **central** cushion behind the apical notch.
- Both sex organs are exposed directly to moist air and water.



Mature Prothallus

Antheridium:

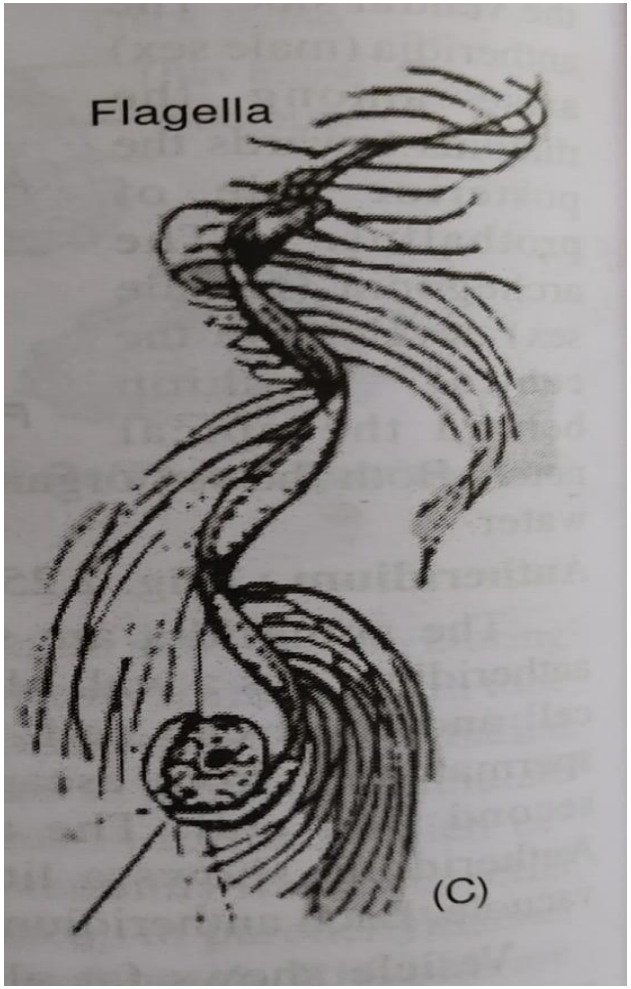
- Small, sessile, globular structure.
- It has a wall of 3 cells, namely 1st ring cell, 2nd ring cell and 3rd cap cell.
- Antheridium shows a little cytoplasm, nucleus, cell organelles, vacuole.
- Each antheridium produces 32 sperms.
- Vacuoles shows fat globules.
- Spermatozoids liberated in presence of water, enclosed within a thin membrane.

Development of Antheridia:

- Develops from single superficial cell of the prothallus.
- Active superficial cells divides to form basal cell and Antheridial initial, which again divides transversely into **Upper central cell** and **Lower 1st ring cell**.
- Central cell divided to produce- **outer jacket cell & central primary androgonial cell.**
- Jacket cell divide into- **upper cover cell** and **2nd ring cell**.
- Central **Primary androgonial cells** divides to produce 16 sperm mother cell, which again divide to produce 32 spermatids.
- Later, mature **multiflagellate spermatozoids** are produced, which acts as male gamete.

Structure of Antherozoids:

- Large, multiflagellate, coiled, structure.
- Shows motor apparatus, composed of- Basal granules and Mitochondrial part.
- Shows 2-3 spiral vesicles, fat globules and plastids.



Antherozoid

Archegonium:

- Present close to the Prothallus notch.
- It is **Flask** shaped structure.
- It consists of – 1. a swollen base,
  2. venter,
  3. projecting, short slender neck.
- Venter is embedded in the prothallus.
- Venter shows **necked egg** with small **ventral canal cell**.
- Neck region shows **4** vertical rows of sterile Neck Canal Cells.
- Each row is 3-7 cells in height.
- Archegonial neck exudes **mucilage** containing **malic acid**.

Development of Archegonium:

- Archegonium develops from single superficial cell.
- This cell divides transversely into-

1.Upper Primary Cover cell

2. Lower Basal cell- again divides to form 3 cells:-

i. Primary Cover Cell

ii. Middle Central Cell

iii. Lower Primary Ventral canal cell.

- Primary neck canal cell divides to form 3-7 cell in height.
- Primary Ventral canal cell produce- Upper ventral canal cell

  Lower larger Egg cell

Fertilization:

- Occurs in presence of Water fluid between lower surface of prothallus and soil.
- Antheridium absorbs water and swells, results in increase in pressure on the antheridium wall.
- **Antherozoids** are released in thin film of water on prothallus surface.
- Ventral canal cell, neck canal cell and neck region of archegonium disintegrates to form passage.
- Male and female nuclei fuses to form **zygote** (2n).

Embryo:

- **Zygote** is 1st cell of new sporophyte
- 1st division is vertical followed by transverse division to form a **Quadrant**.
- Later **32** celled embryo is formed.
- Embryo differentiation started at **32** celled stage.
- **Hypobasal** cells form **stem apex** and **foot**.
- **Epibasal** cell produces **cotyledon** and **root.**
- Venter of archegonium forms a protective layer **Calyptra** around embryo.

Heterospory and Seed Habit:

- **Heterospory**: Production of **2** kinds of spores, differing in structure and function,
- smaller is male gametophyte, larger is female gametophyte. This is termed as **Heterospory.**
- Heterospory is directly connected to Evolutionary process leading to **seed formation.**
- **Examples**: ***Selaginella, Isoetes, Stylites, Marsilea, Pilularis, Regnellidium, Salvinia, Azolla, Platyzoma.***
- Heterospory is considered as pre-requisite character for the formation seed.

Life Cycle of a Fern