# BOTONY SEP IMPORTANT QUESTION

**5–10 mark answer** for the question:

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## 1. General Characteristics of Bryophytes

Bryophytes are non-vascular, embryophyte plants that occupy a unique position between algae and pteridophytes in the plant kingdom. They are often referred to as **“amphibians of the plant kingdom”** because they require water for sexual reproduction.

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**Key Characteristics:**

**1. Habitat**

- Found in moist, shady places like rocks, tree trunks, soil, or riverbanks.
- Can tolerate desiccation and rehydrate when water becomes available.

**2. Plant Body**

- Dominated by **gametophyte** (haploid), which is green and photosynthetic.
- Body may be **thalloid** (flat, undifferentiated) or **leafy** (with stem-like and leaf-like structures).
- Lacks true roots, stems, and leaves.

**3. Rhizoids**

- Serve as anchoring organs.
- **Unicellular** in liverworts (*Marchantia*) and hornworts (*Anthoceros*),
- **Multicellular** and branched in mosses (*Funaria*).

**4. Vascular Tissue**

- Absent.
- Water and nutrients move by **diffusion and capillarity**.

**5. Sexual Reproduction**

- **Oogamous type** – male gametes (antherozoids) are motile, and female gametes (eggs) are stationary.
- Sex organs:

- **Antheridia** (male): produces biflagellate sperm.
- **Archegonia** (female): flask-shaped, produces egg.

- Fertilization requires water (sperm swims to egg).

**6. Sporophyte**

- Formed after fertilization.
- **Diploid** and **completely or partially dependent** on gametophyte for nutrition.
- Differentiated into:
  - **Foot**: attaches sporophyte to gametophyte
  - **Seta**: stalk
  - **Capsule**: produces spores

**7. Life Cycle**

- Shows **alternation of generations**:
  - **Gametophyte (n)** – dominant and independent
  - **Sporophyte (2n)** – dependent and short-lived

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**Examples**

- Liverwort: *Marchantia*, *Riccia*
- Hornwort: *Anthoceros*
- Moss: *Funaria*, *Polytrichum*

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**Diagram: Life Cycle of a Bryophyte**

Gametophyte (n) → Sex organs → Fertilization → Zygote (2n) → Sporophyte → Meiosis → Spores (n) → Gametophyte

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## 2) Classification of Bryophytes

Bryophytes are non-vascular cryptogams and are classified into **three main classes** based on the **structure of the gametophyte**, **nature of the sporophyte**, and **reproductive features**.

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1. **Class: Hepaticopsida (Liverworts)**

- **ORDER:-MARCHANTIALES**
- **FAMILY:-MARCHANTIACEAE**
- **GENUS:- *Marchantia***
- **Plant body**: Thalloid or leafy.
- **Rhizoids**: Unicellular and lack chloroplasts.
- **Sporophyte**: Simple, may lack seta (e.g., *Riccia*).
- **Reproduction**: By gemmae (in *Marchantia*), fragmentation, or sexual reproduction.
- **Examples**: *Riccia*, *Marchantia*, *Pellia*

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**2. Class: Anthocerotopsida (Hornworts)**

**ORDER:-Anthoceroles**

**FAMILY:Anthoceralaceae**

**GENUS:- *Anthoceros***

**Plant body**: Thalloid, dorsiventral.

- **Unique feature**: Cells contain **a single large chloroplast** with pyrenoid.
- **Sporophyte**: Long and horn-like with basal meristem, stomata, and pseudoelaters.
- **Examples**: *Anthoceros*, *Notothylas*

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**3. Class: Bryopsida (Mosses)**

**ORDER:-Funariales**

**FAMILY:-Funariaceae**

**GENUS:- *Funaria***

- **Plant body**: Differentiated into stem-like and leaf-like structures.
- **Rhizoids**: Multicellular and branched.
- **Sporophyte**: Highly developed with foot, seta, capsule, operculum, and peristome teeth.
- **Life cycle**: Two stages of gametophyte – protonema and leafy stage.

- **Examples**: *Funaria*, *Polytrichum*, *Sphagnum*

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| **Class** | **Example** | **Gametophyte Type** | **Special Features** |
|---|---|---|---|
| Hepaticopsida | *Marchantia* | Thalloid | Gemma cups for asexual reproduction |
| Anthocerotopsida | *Anthoceros* | Thalloid | Horn-like sporophyte with stomata |
| Bryopsida | *Funaria* | Leafy | Peristome teeth in capsule |

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## 3) Gametophytes in Bryophytes

In bryophytes, the **gametophyte (n)** is the **dominant, independent, and photosynthetic phase** of the life cycle. It bears the sex organs and is responsible for the nourishment and support of the dependent sporophyte.

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✅ **General Features:**

1. **Dominant Generation**:
   - The most conspicuous stage in the bryophyte life cycle.
   - Lives longer than the sporophyte.
2. **Structure**:
   - **Thalloid** in liverworts and hornworts.
   - **Leafy** in mosses, differentiated into stem-like and leaf-like parts.
3. **Rhizoids**:
   - Help in anchorage and water absorption.
   - **Unicellular** in *Marchantia* and *Anthoceros*
   - **Multicellular** in *Funaria*

✅ **Class-wise Gametophyte Details:**

| Class | Gametophyte Type | Features | Example |
|---|---|---|---|
| **Hepaticopsida** | Thalloid or leafy | Dorsiventral thallus with midrib, gemma cups | *Marchantia* |
| **Anthocerotopsida** | Thalloid | Rosette-like thallus with one chloroplast per cell | *Anthoceros* |
| **Bryopsida** | Leafy | Two stages: protonema (filamentous) and gametophore (leafy shoot) | *Funaria* |

✅ **Functions of Gametophyte:**

1. **Photosynthesis** – Main source of food.
2. **Sex Organ Formation** – Bears antheridia and archegonia.
3. **Supports Sporophyte** – Provides nutrition and anchorage to the developing sporophyte.
4. **Asexual Reproduction** – Occurs through fragmentation or gemmae in some species.

## 4) Evolution of Sporophytes in Bryophytes

This theory was advocated by Bower . 1908- 35) and supported by Cavers (1910) and Campbell (1940). According to this theory, the primitive sporophyte of bryophytes was simple and most of the sporogenous tissue was fertile (e.g., Riccia) and from such a sporophyte, the more complex sporophytes (e.g., mosses) have been evolved by the progressive sterilisation of potential sporogenous tissue. This theory is also known as "theory of sterilisation".

The **increasing sterilization of sporogenous tissue** in bryophyte sporophytes represents a key evolutionary trend—from a simple, spore-producing structure to a complex, partly sterile structure adapted for protection, support, and efficient spore dispersal. This process shows a gradual **conversion of potentially spore-producing cells into sterile supportive tissues**.

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🌱 **Stages of Increasing Sterilization from *Riccia* to *Funaria*:**

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**1. *Riccia* (Liverwort – Simplest Type)**

- **Sporophyte**: Capsule only, **no foot or seta**.
- **No sterilization**: Entire capsule is **sporogenous tissue**.
- **No elaters or sterile layers**.
- Completely embedded in the gametophyte.
  ➞ **All tissue forms spores** – 100% fertile.

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**2. *Marchantia* (Liverwort – Slightly Advanced)**

- **Sporophyte**: Foot, seta, and capsule.
- **Sterilization begins**:
  - Capsule wall (jacket layer) is sterile.
  - **Elaters** (sterile, hygroscopic cells) are present for spore dispersal.
- Sporogenous tissue is reduced compared to *Riccia*.
  ➞ **Partial sterilization** – Some tissue becomes sterile elaters and capsule wall.

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**3. *Anthoceros* (Hornwort – Intermediate Type)**

- **Sporophyte**: Foot and long, horn-like capsule.
- Capsule has **pseudoelaters** (sterile) and **columella** (central sterile axis).
- Outer part of capsule contains sporogenous tissue.
- Sporophyte has **stomata** and **photosynthetic ability**.
  ➞ **Increased sterilization** – More tissue used for support and dispersal mechanisms.

**4. *Funaria* (Moss – Most Advanced Type)**

- **Sporophyte**: Foot, long seta, and highly developed capsule.
- Capsule components:
    - **Capsule wall** (sterile)
    - **Operculum** (lid – sterile)
    - **Columella** (central sterile tissue)
    - **Peristome teeth** (sterile, regulate spore dispersal)
- **Less sporogenous tissue** compared to sterile parts.
  ➞ **Maximum sterilization** – Most internal tissue is sterile, aiding complex spore dispersal.

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## 🧠 Conclusion

The evolution of the sporophyte in bryophytes shows a **progressive increase in sterile tissue**, which:

- Improves **spore protection**
- Enhances **spore dispersal**
- Reflects adaptation to **terrestrial life**

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**Evolutionary Series (Based on Sterilization):**

Riccia (no sterilization) → Marchantia (elaters) → Anthoceros (columella + pseudoelaters) → Funaria (columella + peristome + operculum)

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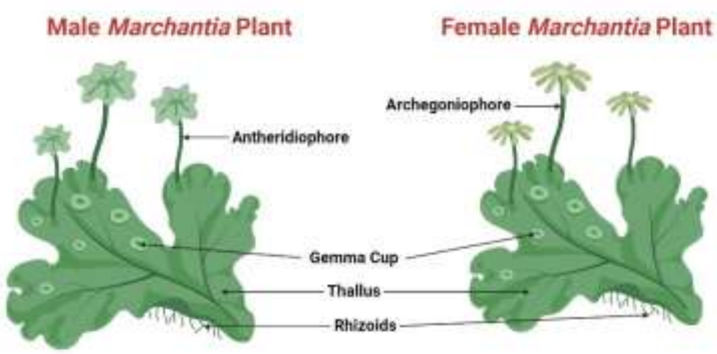
**5) Write the morphology, anatomy, reproduction, and life cycle of:**



a) **Marchantia (Liverwort)**

## 🔶 Morphology

- Thalloid, dorsiventral plant body with a prominent midrib.
- Dorsal surface has polygonal areas with air pores.
- Ventral surface bears **rhizoids** and **scales** for attachment and water absorption.
- **Dioecious**: Male and female plants bear antheridiophores and archegoniophores, respectively.

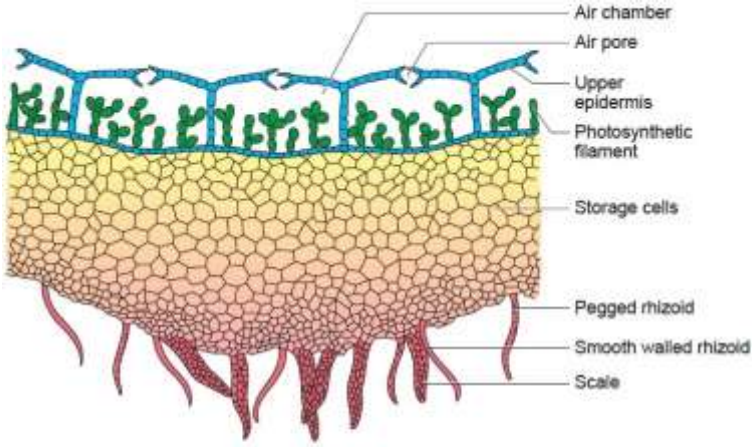



Figure 2.13: T.S. of Thallus

## 🔶 Anatomy

- Differentiated into:
    - **Upper photosynthetic region** with air chambers.
    - **Lower storage region** with colorless parenchyma.
- Air pores lead into chambers with chlorophyllous filaments.
- Rhizoids and scales arise from the ventral side.

## 🔶 Reproduction

- **Asexual**: By **gemmae** produced in gemma cups, and also by fragmentation.
- **Sexual**:
    - Antheridia (male organs) on the disc of antheridiophore.
    - Archegonia (female organs) hang from the underside of archegoniophore rays.
    - Water is required for fertilization.

## 🔶 Life Cycle

- Fertilization → Zygote → **Sporophyte** (foot, seta, capsule).
- Capsule undergoes meiosis to form spores and elaters.
- Spores germinate to produce new gametophyte.
  ✅ **Alternation of generations** is heteromorphic and distinct.

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**b) Anthoceros (Hornwort)**

🔶 **Morphology**

- Thalloid, dark green, rosette-like gametophyte.
- Dorsiventral and lobed, with **mucilage cavities**.

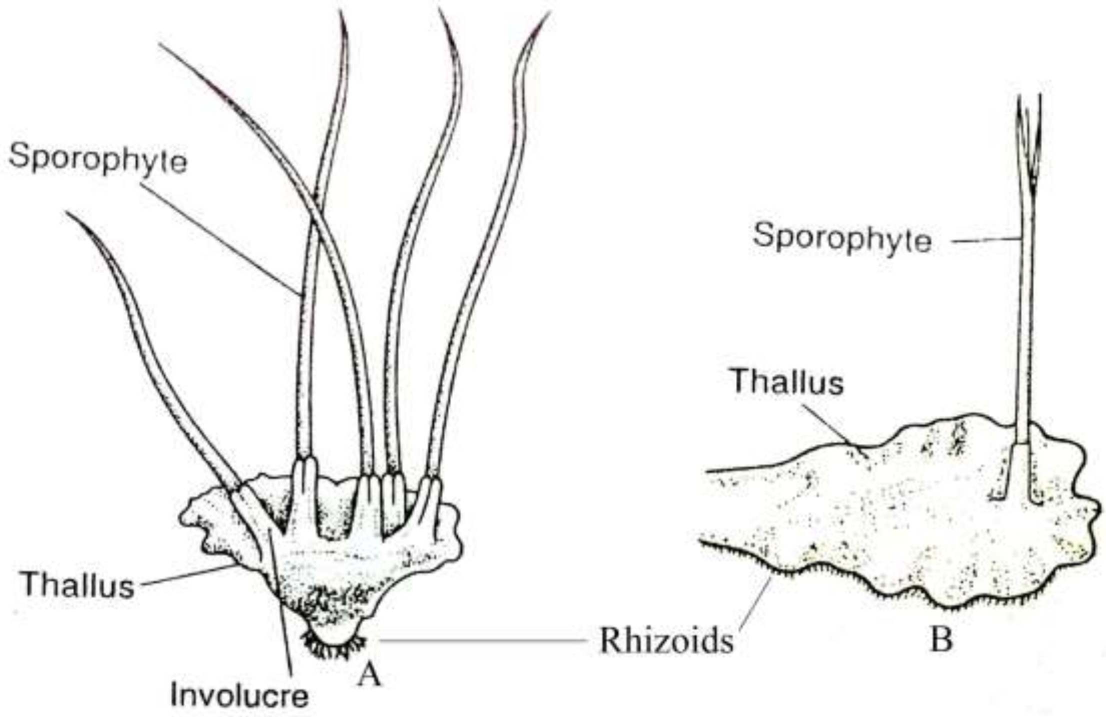
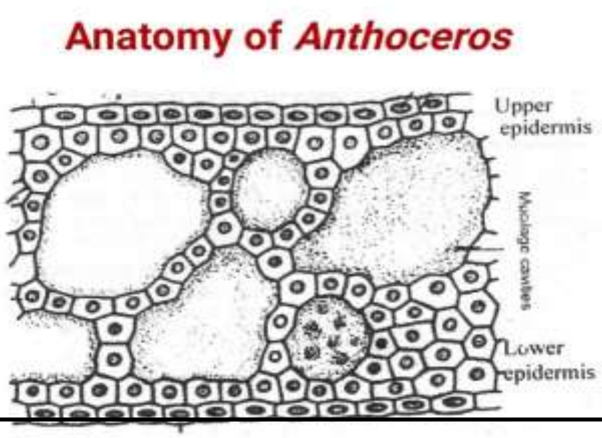
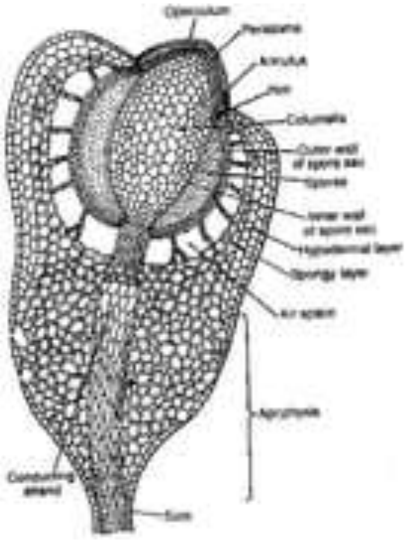
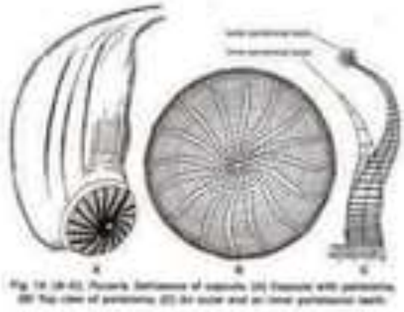



Fig: Anthoceros sp. External morphology.
(A) Thallus of A. *erectus*, bearing sporophyte;
(B) A. *laebis*, bearing dehiscent sporophyte

- Each cell contains **a single large chloroplast with a pyrenoid** (algal feature).







## Anatomy

- Parenchymatous thallus with simple structure.
- **Mucilage cavities** often contain symbiotic cyanobacteria (*Nostoc*).
- No air pores or chambers like liverworts.

## Reproduction

- **Asexual**: Fragmentation.
- **Sexual**:
    - **Antheridia** embedded within the thallus.
    - **Archegonia** are sunken in the upper surface.
    - Fertilization occurs in the presence of water.

## Life Cycle

- Zygote develops into a **horn-like sporophyte**.
- Sporophyte has **foot**, **capsule**, and **basal meristem** for continuous growth.
- Capsule contains **pseudoelaters** and **stomata**.

- Meiosis → Spores → New gametophyte.

✅ Life cycle shows alternation of generations with a more **independent sporophyte**.

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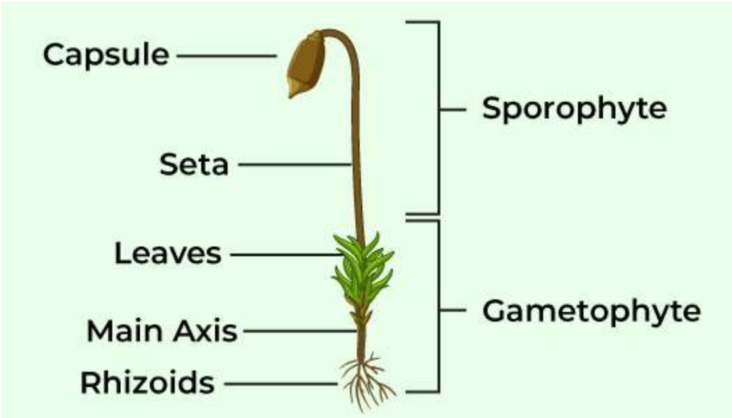
**c) Funaria (Moss)**




🔶 **Morphology**

- Grows from a **protonema** stage (filamentous) to **leafy gametophyte**.
- Leafy shoots with spiral leaves and **multicellular rhizoids**.
- Moist habitat preferred.

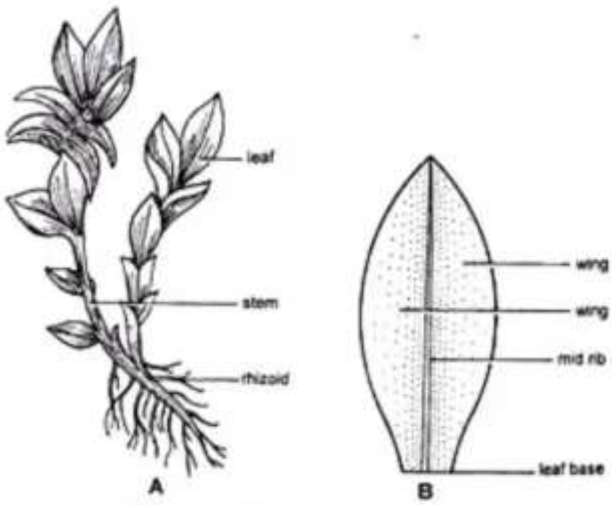



Fig. 1. (A, B). *Funaria*. (A) A plant, (B) Outline sketch of a leaf.

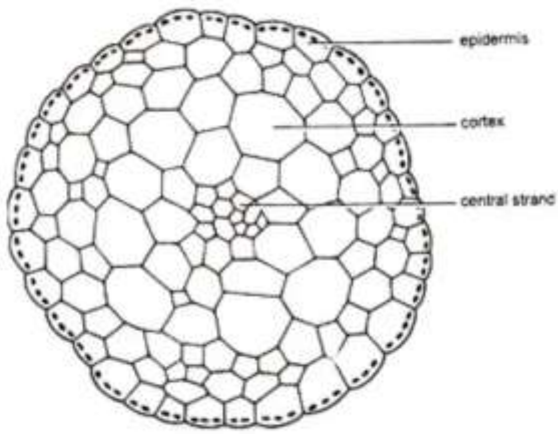



Fig. 2. *Funaria*. Transverse section (T.S.) of axis.

🔶 **Anatomy**

- Central stem with **hydroids (water conduction)** and **leptoids (food conduction)**.
- Leaves are usually one cell thick, rich in chloroplasts.
- No vascular bundles, but primitive conduction tissues.

🔶 **Reproduction**

- **Asexual**: By regeneration from protonema.
- **Sexual**:
  - **Antheridia and archegonia** develop at shoot tips.
  - Sperm swims to egg via water film → fertilization → zygote.

🔶 **Life Cycle**

- Zygote forms **sporophyte**: Foot, long seta, and **complex capsule**.
- Capsule has:
  - **Operculum** (lid)
  - **Columella** (sterile axis)
  - **Peristome teeth** (spore dispersal mechanism)
- Meiosis → Spores → Germinate into protonema → Gametophyte.
  ✅ Most complex bryophyte life cycle with efficient **spore dispersal**.

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## 6) Economic Importance of Bryophytes

Bryophytes, though small and non-vascular, play several ecological and economic roles:

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### 1. Soil Conservation

- Bryophytes like **mosses** form dense mats that **prevent soil erosion** by binding soil particles.
- They retain moisture and **reduce the impact of raindrops** on the soil surface.

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### 2. Ecological Indicators

- **Mosses** and **liverworts** are sensitive to environmental changes.
- Used as **bioindicators** of **air pollution**, heavy metals, and acidic conditions.

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**3. Formation of Peat**

- **Sphagnum** (peat moss) forms **peat deposits** in bogs.
- Peat is used as:
    - **Fuel**
    - **Soil conditioner** in horticulture (retains water and nutrients)
    - **Packing material** for transporting live plants.

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**4. Medicinal Uses**

- Some bryophytes possess **antibiotic** and **antiseptic** properties.
- Traditionally used for treating wounds and skin infections (e.g., *Sphagnum* used as surgical dressing in WWI).

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**5. Succession and Habitat Formation**

- Bryophytes colonize bare rocks and help in **primary succession**, forming **soil** by trapping dust and organic matter.
- They create microhabitats for microorganisms and small invertebrates.

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**6. Research and Education**

- Bryophytes are used in **botanical studies** to understand plant evolution, alternation of generations, and plant adaptation to land.

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🧠 **Example Plants**

- *Sphagnum* – Peat moss
- *Marchantia* – Model for plant morphology and life cycle studies

## 7) General Characteristics and Classification of Pteridophytes

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**General Characteristics of Pteridophytes:**

Pteridophytes are the first group of vascular plants that show a clear differentiation into roots, stems, and leaves. They are considered to be the **"first terrestrial plants with vascular tissues."**

Here are the key characteristics:

1. **Vascular Tissue Present:**
   - Have xylem and phloem for conduction of water, minerals, and food.
   - This differentiates them from bryophytes.
2. **Dominant Sporophyte Generation:**
   - The **sporophyte** is the dominant, independent, and conspicuous generation.
   - The **gametophyte** is small and usually lives in moist soil.
3. **Leaves:**
   - Range from small (microphylls) to large (macrophylls or fronds).
   - Many have **circinate vernation** (young leaves coiled).
4. **Reproduction:**
   - **Spore-producing plants**, not seeds.
   - Reproduce sexually through spores.
   - **Homospory** (one kind of spore) or **heterospory** (two kinds of spores: microspores and megaspores).
5. **Water Requirement:**
   - Need water for fertilization; motile sperm swim to egg cells.
6. **Habitat:**
   - Mostly terrestrial and thrive in moist, shady places.
   - Some are aquatic (e.g., *Marsilea*).
7. **Alternation of Generations:**

- Exhibit alternation between haploid gametophyte and diploid sporophyte generations.

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**Classification of Pteridophytes:**

Pteridophytes are traditionally divided into four main classes:

**1. Psilopsida (Whisk Ferns):**

- Example: *Psilotum*
- Features: Primitive; no true roots or leaves; dichotomous branching.
- Vascular tissue present.

**2. Lycopsida (Club Mosses):**

- Example: *Lycopodium*, *Selaginella*
- Features: Small leaves (microphylls), true roots and stems.
- *Selaginella* is **heterosporous**.

**3. Sphenopsida (Horsetails):**

- Example: *Equisetum*
- Features: Jointed stems with nodes and internodes.
- Leaves are small and arranged in whorls.
- Silica present in stem.

**4. Pteropsida (Ferns):**

- Example: *Dryopteris*, *Pteris*, *Adiantum*
- Features: Large leaves (fronds), well-developed roots, stems.
- Commonly homosporous, though some show heterospory.

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**Summary Table:**

| Class | Example | Features |
|---|---|---|
| Psilopsida | *Psilotum* | No true roots/leaves, primitive |
| Lycopsida | *Lycopodium*, *Selaginella* | Microphylls, roots present |

| Class | Example | Features |
|---|---|---|
| Sphenopsida | *Equisetum* | Jointed stems, whorled leaves |
| Pteropsida | *Pteris*, *Adiantum* | Large fronds, common ferns |

Here is a **comprehensive 10-mark answer** on the **morphology, anatomy, and reproduction** in the following pteridophytes:

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## 8) Morphology, Anatomy, and Reproduction

### a) Psilotum (Whisk Fern)

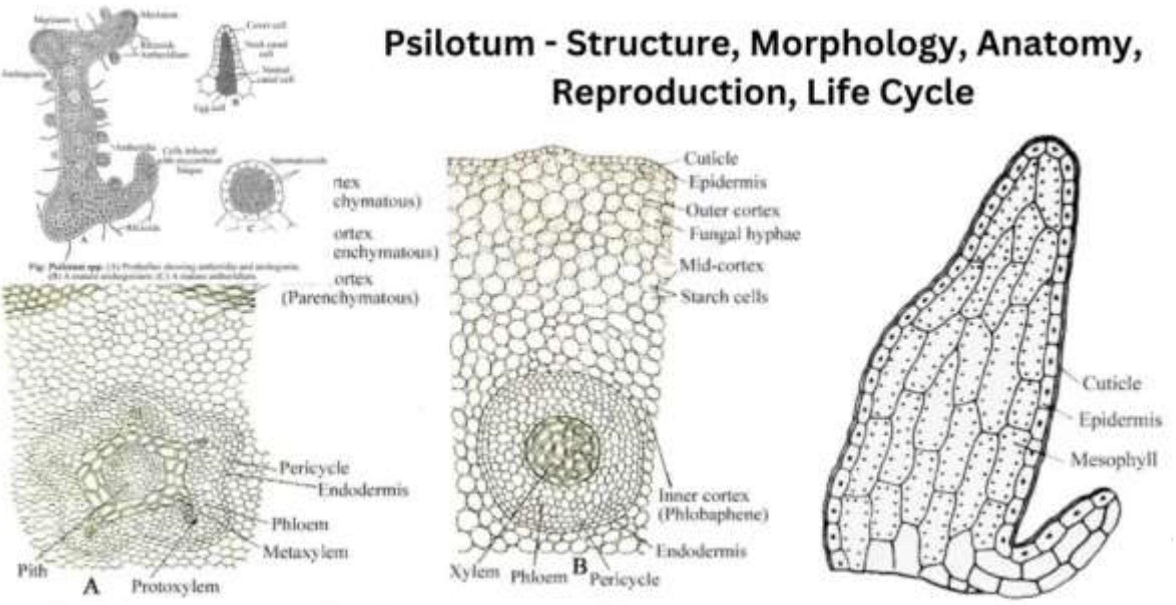


Fig: *Psilotum spp.* (A) A portion of T.S of aerial shoot; (B) A portion of T.S of rhizome

Fig : T.S of Leaf of Psilotum spp.

**Morphology:**

- **Root:** True roots are absent; instead, rhizoids are present.
- **Stem:** Dichotomously branched; green and photosynthetic.
- **Leaves:** Small, scale-like appendages; no true vascular supply (enations).

**Anatomy:**

- **Stem:**
  - Epidermis with cuticle.
  - Cortex divided into outer chlorenchyma and inner parenchyma.

- Central protostele (solid xylem core).

**Reproduction:**

- **Asexual:** By gemmae.
- **Sexual:** Homosporous; spores produced in trilocular sporangia.
- **Gametophyte:** Subterranean and saprophytic; bears antheridia and archegonia.
- **Fertilization:** Requires water; zygote forms sporophyte.

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**B) lycopodium (Club Moss)**

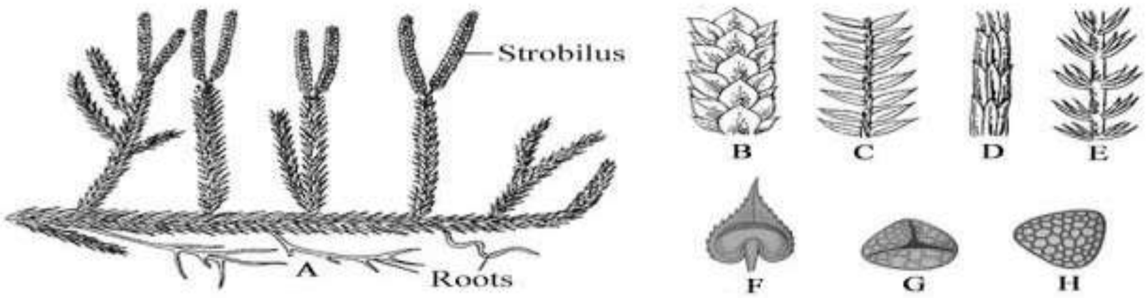


Fig: *Lycopodium spp.* (A) A portion of plant of *L. clavatum* showing strobili; Leaf form and arrangement in *Lycopodium* (B) *L. refescens*; (C) *L. volubile*; (D) *L. complanatum*; (E) *L. cernuum*; (F) A sterile leaf; (G) Sporophyll bearing sporangium; (H) Spore

**Morphology:**

- **Root:** Adventitious roots arise from stem base.
- **Stem:** Creeping or erect; dichotomously or monopodially branched.
- **Leaves:** Small, simple microphylls in spirals or whorls.

**Anatomy:**

- **Stem:**
  - Epidermis with cuticle and stomata.
  - Cortex has outer sclerenchyma and inner parenchyma.
  - Protostele (actinostele or plectostele types).

**Reproduction:**

- **Asexual:** By fragmentation or bulbils.
- **Sexual:** Homosporous; spores produced in sporangia on sporophylls.

- **Sporophylls** form a compact **strobilus (cone)**.
- **Gametophyte:** Small, bisexual or unisexual, subterranean.
- **Water required** for fertilization.

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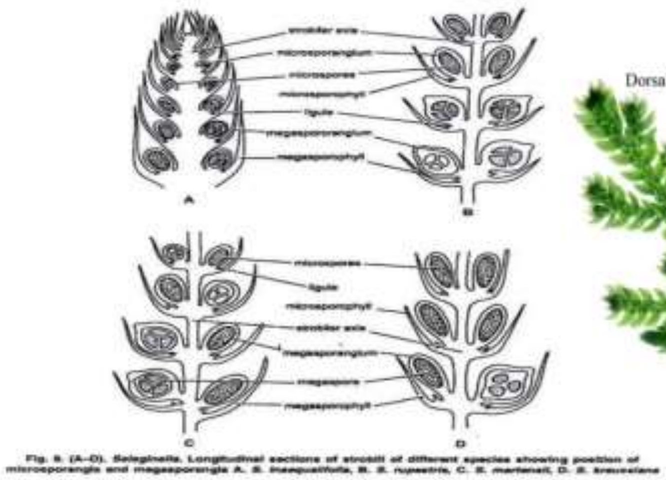
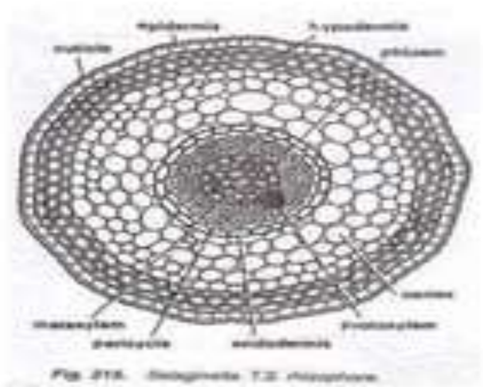
**c) Selaginella (Spike Moss)**




**Morphology:**

- **Root:** Adventitious roots; arise from rhizophore (root-like structure).
- **Stem:** Creeping or erect, with dichotomous branching.
- **Leaves:** Small microphylls, arranged in four rows (two large, two small).

**Anatomy:**



- **Stem**
  - 
  - Cortex with sclerenchyma and parenchyma.
  - Protostele (actinostele).
- **Ligules:** Present at leaf base.

**Reproduction:**

- **Asexual:** By fragmentation or tubers.
- **Sexual: Heterosporous** – produces **megaspores** and **microspores**.
- **Sporangia** borne in **strobilus**.
- Gametophyte develops **within the spore (endosporic)**.
- Water is required for fertilization.

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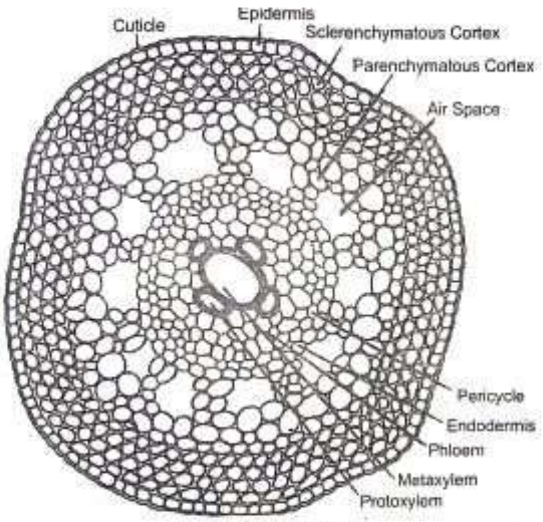
**d) Equisetum (Horsetail)**


**Morphology:**

- **Root:** Adventitious, arising from rhizome.
- **Stem:** Jointed with distinct nodes and internodes; hollow and ribbed.
- **Leaves:** Reduced, scale-like, arranged in whorls at nodes.

**Anatomy:**

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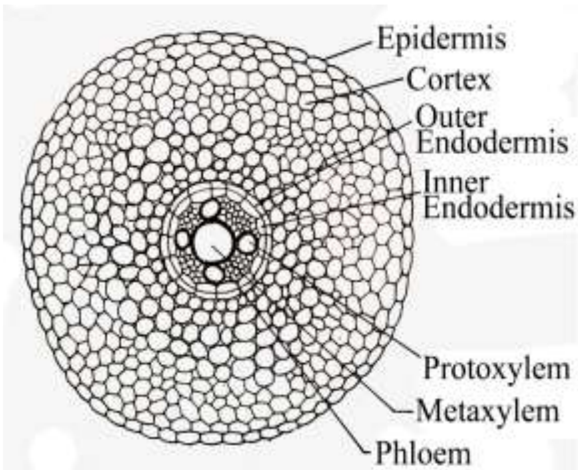


Fig: *Equisetum spp.* TS of root.

- **Stem:**
    - Epidermis has silica (rough texture).
    - Cortex with large air cavities (vallecular canals).
    - Vascular bundles around a central cavity (carinal canals).
    - Stele is eustele-like.

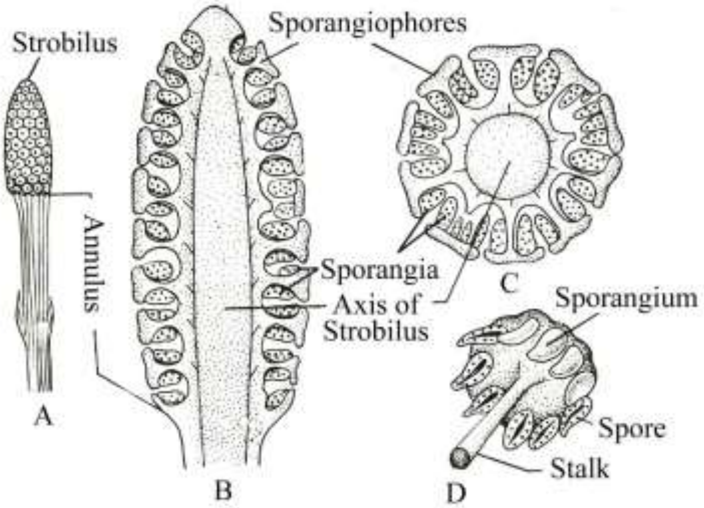


Fig: *Equisetum spp.* (A) A part of fertile shoot bearing strobilus; (B) LS of strobilus; (C) TS of strobilus; (D) Single sporangiophore.

**Reproduction:**

- **Asexual:** By fragmentation or tubers.
- **Sexual:** Homosporous; spores produced in sporangia on sporangiophores within **strobilus**.
- **Spores** have **elaters** for dispersal.
- Gametophyte is small, photosynthetic, and monoecious/dioecious.

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**e) Marsilea (Water Fern)**

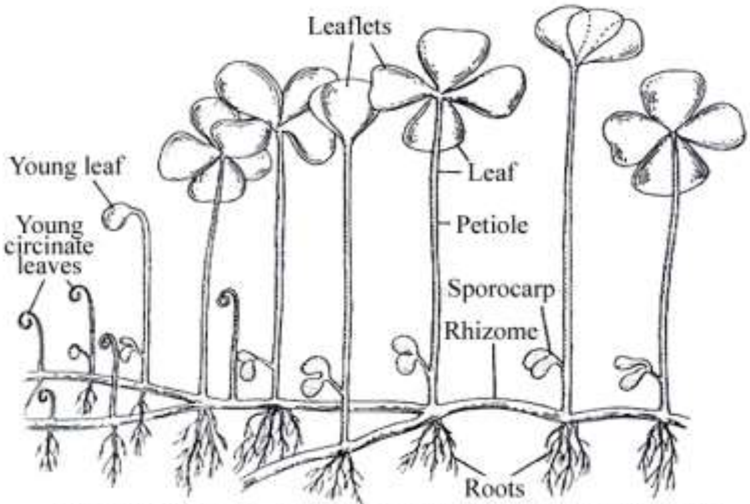




Fig: *Marsilea spp.* A sporophyte showing sporocarp, rhizome, leaves and roots.

**Morphology:**

- **Root:** Adventitious roots from rhizome.
- **Stem:** Creeping rhizome.
- **Leaves:** Compound with 4 leaflets (clover-like), sensitive to light and water.

**Anatomy:**

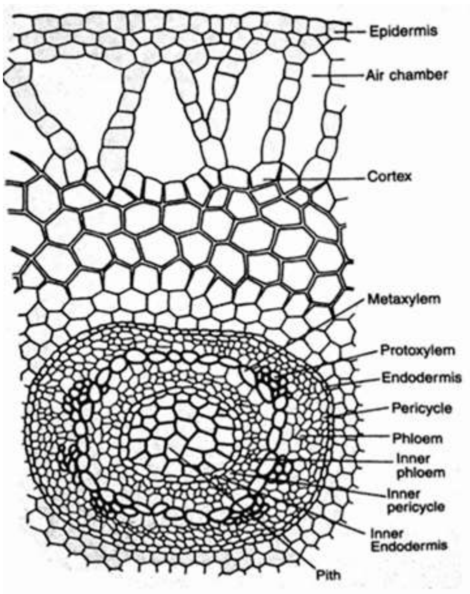


Fig: M2; Marsilea; T.S of stem

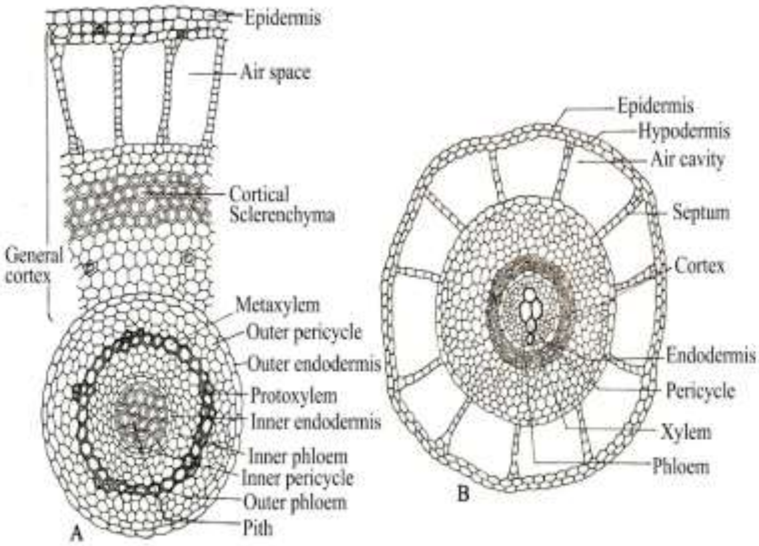


Fig: *Marsilea spp.* (A) TS of rhizome; (B) TS of root.

- **Rhizome:** Amphiphloic siphonostele (xylem surrounded by phloem).
- **Leaf:** Dorsiventral anatomy with vascular bundles.

**Reproduction:**

- **Asexual:** By fragmentation of rhizome.
- **Sexual: Heterosporous**.
- **Sporocarps** (hard, bean-shaped structures) contain both **micro- and megasporangia**.
- **Gametophytes** develop within spores (endosporic).
- Fertilization requires water.

---

## 9) Structure of Sporophytes in Pteridophytes

---

The **sporophyte** is the **dominant, independent, and diploid generation** in the life cycle of pteridophytes. It shows clear differentiation into **root, stem, and leaves**, and bears **sporangia** where spores are produced.

◆ **General Features of Pteridophyte Sporophyte:**

1. **Diploid (2n):**
    - Arises from the zygote after fertilization.
2. **Well-differentiated body:**
    - **Roots:** Usually adventitious; help in absorption and anchorage.
    - **Stem:** May be aerial or underground (rhizome); shows branching (dichotomous or monopodial).
    - **Leaves:**
        - **Microphylls** (small leaves without leaf gaps – e.g., *Lycopodium*)
        - **Macrophylls** or **fronds** (large, divided leaves – e.g., *Pteris*)
3. **Vascular tissues:**
    - Xylem and phloem are present.
    - Type of stele may vary: protostele, siphonostele, dictyostele, etc.
4. **Sporangia-bearing organs:**
    - **Sporangia** develop on leaves (sporophylls) or specialized structures (e.g., strobili or sporocarps).
    - Spores are formed by meiosis inside sporangia.
5. **Spore type:**
    - **Homosporous** (one type of spore) – e.g., *Lycopodium*, *Equisetum*
    - **Heterosporous** (two types of spores: microspores and megaspores) – e.g., *Selaginella*, *Marsilea*

---

◆ **Examples of Sporophyte Structure in Common Pteridophytes:**

| Pteridophyte | Sporophyte Features |
|---|---|
| **Psilotum** | Rootless, dichotomous stem, small scale-like leaves, trilocular sporangia |
| **Lycopodium** | Microphyllous leaves, protostelic stem, cone-like strobili with homosporous sporangia |
| **Selaginella** | Microphylls with ligules, heterosporous sporangia in strobilus |
| **Equisetum** | Jointed, ribbed stem with nodes/internodes, whorled leaves, strobilus with peltate sporangiophores |
| **Marsilea** | Rhizomatous stem, compound leaves, sporocarps with both micro and megasporangia (heterosporous) |

---

🔹 **Function of Sporophyte:**

- Main photosynthetic and reproductive phase.
- Produces spores via meiosis inside sporangia.
- Supports alternation of generations by giving rise to gametophytes after spore germination.

---

## 10) Economic Importance of Pteridophytes

Pteridophytes, though not as economically significant as flowering plants, have various uses in medicine, agriculture, industry, and environmental applications. Here's a detailed 10-mark answer:

---

🌿 **1. Medicinal Uses:**

- **Equisetum (Horsetail):**
  - Used as a **diuretic** and to treat kidney and bladder problems.
  - Contains silica – strengthens hair, nails, and bones.
- **Lycopodium spores:**

- Used in **homeopathy** and traditional medicine for urinary and digestive disorders.
- Acts as a **dusting powder** for pills and wounds (non-wettable and highly inflammable).

- **Adiantum (Maidenhair fern):**
  - Used for treating **coughs, colds**, and respiratory issues.

---

### 🌾 2. Soil Conservation:

- Many pteridophytes like **Selaginella** and **ferns** grow in shady, moist areas and help in **preventing soil erosion** by binding the soil with their roots or rhizomes.

---

### 🌸 3. Ornamental Use:

- **Ferns** (e.g., *Nephrolepis*, *Adiantum*, *Pteris*) are popular **ornamental plants**.
  - Grown indoors and in gardens for their attractive foliage.
  - Also used in flower arrangements.

---

### 🏭 4. Industrial Use:

- **Lycopodium spores:**
  - Used in **fireworks**, **flash photography**, and **coating pills** due to their inflammability.
- **Equisetum:**
  - Stems contain **silica** and were once used for **polishing metal and wood** ("scouring rush").

---

### 🌱 5. Ecological Role:

- **Pioneer species:** Some pteridophytes colonize bare, rocky soils and help in **soil formation**.
- **Habitat:** Provide shelter and microclimates for small insects and organisms in forests.

---

### 🧬 6. Research and Educational Importance:

- Pteridophytes are model plants for studying:
    - **Alternation of generations**
    - Evolution of **vascular tissues**
    - Transition from non-seed to seed plants

---

### 🧪 7. Bioindicators:

- Some ferns are sensitive to pollutants and are used as **bioindicators** of environmental pollution (especially heavy metals).

---

### ✅ Summary Table:

| **Use Type** | **Examples** |
|---|---|
| Medicinal | *Equisetum*, *Lycopodium*, *Adiantum* |
| Ornamental | *Adiantum*, *Nephrolepis* |
| Industrial | *Lycopodium spores*, *Equisetum* |
| Soil conservation | *Selaginella*, Ferns |
| Ecological/Research | Pioneer species, educational use |

---

### 11) General Characteristics of Gymnosperms

Gymnosperms are a group of seed-producing vascular plants that do **not produce flowers**. Their seeds are **"naked"** because they are **not enclosed within a fruit** but lie exposed on the surface of scales or cones.

---

### 🌲 General Characteristics of Gymnosperms:

---

### 🔹 1. Seed-Producing Plants (Spermatophytes):

- Produce **seeds**, but not fruits.
- Seeds are **naked** – not enclosed in an ovary.

---

### 2. Vascular Plants:

- Possess well-developed **xylem and phloem**.
- **Xylem** mostly lacks **vessels** (except in Gnetales).

---

### 3. Dominant Sporophyte:

- The **sporophyte** is large, long-lived, and independent.
- Differentiated into **roots, stems, and leaves**.

---

### 4. Leaves:

- May be **needle-like**, **scale-like**, or **broad**.
- Adapted to conserve water (xerophytic features).
  - Thick cuticle
  - Sunken stomata

---

### 5. Reproduction:

- **Heterosporous**: produce **microspores** and **megaspores**.
- **Male cones** produce microspores (pollen).
- **Female cones** bear ovules with megaspores.
- **No flowers or fruits**.

---

### 6. Pollination by Wind (Anemophily):

- Pollen grains are transferred by wind to ovules.

---

### 7. Fertilization:

- Occurs **without water** (advanced feature).
- **Pollen tube** carries sperm to the egg.

- **No double fertilization** (except partially in Gnetales).

---

🔹 **8. Seeds Exposed:**

- Seeds develop on the surface of cone scales.
- No true fruits are formed.

---

🔹 **9. Long Life Cycle:**

- Trees are usually **slow-growing** and **long-lived**.
- Some like *Sequoia* are among the **largest and oldest living trees**.

---

🌿 **Examples of Gymnosperms:**

- **Pinus** (Pine)
- **Cycas**
- **Ginkgo biloba**
- **Gnetum**
- **Thuja** (Cedar)
- **Cedrus** (Deodar)

---

✅ **Table:**

| Feature | Gymnosperms |
|---|---|
| Seed type | Naked seeds (no fruit) |
| Vascular tissue | Present; xylem lacks vessels |
| Dominant generation | Sporophyte |
| Leaves | Needle-like or scale-like |
| Reproduction | Heterosporous, no flowers |
| Pollination | By wind (anemophilous) |

| Feature | Gymnosperms |
|---|---|
| Fertilization | No water needed, via pollen tube |
| Examples | *Cycas*, *Pinus*, *Ginkgo*, *Gnetum* |

---

Here's a **10-mark answer** on the **study of gymnosperms** focusing on **Cycas**, **Pinus**, and **Gnetum** — covering their **morphology, anatomy, and reproduction**.

---

## 12) Study of Gymnosperms

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### 🔷 a) Cycas (Living fossil)

**Morphology:**

Fig. Cycas - Habit

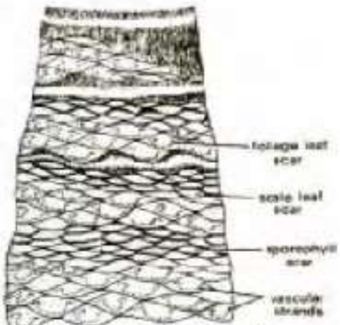


Fig. 1.58. A part of mature stem

Fig. Coralloid roots

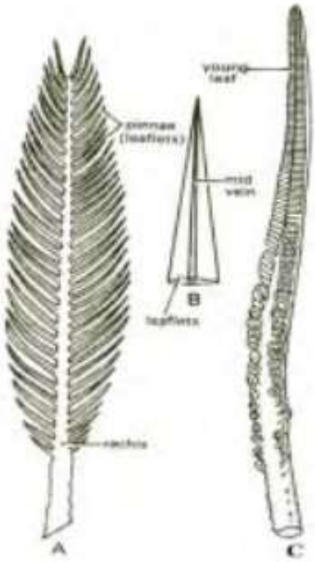


Fig. Cycas Leaf-let

- Unbranched, palm-like tree.
- **Leaves:**
  - Two types: *Scale leaves* and *green pinnate foliage leaves*.
- **Root:**
  - Normal tap roots and **coralloid roots** (contain nitrogen-fixing cyanobacteria like *Nostoc*).

**Anatomy:**

- **Stem:**
    - Girdle leaf scars.
    - Vascular bundles are **collateral and open**.
- **Leaf:**
    - Xerophytic: thick cuticle, sunken stomata.

**Reproduction:**

- **Dioecious** (male and female plants separate).
- **Male cone** present; female plant bears **megasporophylls** (no true cone).
- **Heterosporous**.
- **Fertilization:** Flagellated male gametes (motile).
- **Seeds are naked**, borne on megasporophylls.

---

### 🔷 b) Pinus (Conifer)

**Morphology:**

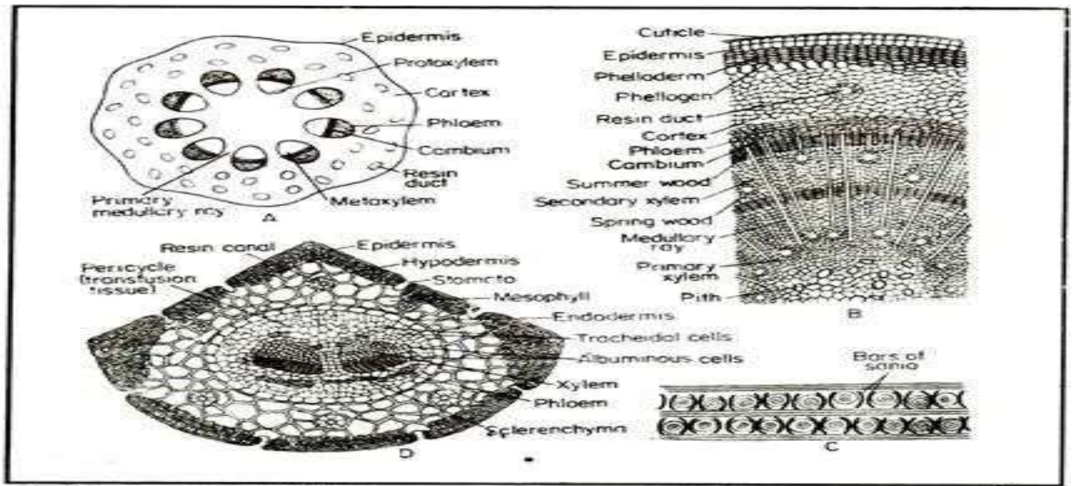


*Fig 7.6 Pinus Sp. : A – T.S. through stem (diagrammatic), B – T.S. through stem (magnified), C – Trachids showing bars of sanio, D – T.S. of leaf.*

- Tall, evergreen, branched tree.
- **Leaves:**
    - Two types: *Scale leaves* and *needle-like foliage leaves* in clusters (fascicles).

- **Root:**
  - Tap root system.

**Anatomy:**

- **Stem:**
  - Vascular bundles **conjoint, collateral, open**.
  - **Secondary growth** present (annual rings).
- **Leaf:**
  - Needles are xerophytic (thick cuticle, sunken stomata, resin ducts).

**Reproduction:**

- **Monoecious** (male and female cones on the same plant).
- **Male cone** produces microspores (pollen grains).
- **Female cone** bears ovules on megasporophylls.
- **Pollination:** Wind (anemophilous).
- Fertilization via **pollen tube** (non-motile sperms).
- **Winged seeds** formed on cone scales.

---

### 🔷 c) Gnetum (Advanced Gymnosperm)

**Morphology:**

- Woody climbers or shrubs (e.g., *Gnetum ula*, *Gnetum gnemon*).
- **Leaves:**
  - Broad, **dicot-like**, with reticulate venation.
- **Stem:**
  - Erect or twining with distinct nodes and internodes.

**Anatomy:**

- **Stem:**
  - Shows **vessels in xylem** (unique among gymnosperms).
  - Secondary growth is similar to dicots.
- **Leaf:**

- Dicot-like features (reticulate venation, mesophyll differentiation).

**Reproduction:**

- **Dioecious**.
- **Male and female cones** on separate plants.
- **Double fertilization** reported (but no endosperm like angiosperms).
- **Pollen tube** carries non-motile sperms.
- Seeds may appear like fruits due to fleshy outer covering.

---

✅ **Comparison Table (Summary):**

| Feature | Cycas | Pinus | Gnetum |
|---|---|---|---|
| Habit | Palm-like tree | Branched conifer | Climber/Shrub |
| Leaf type | Pinnate | Needle-like | Broad, dicot-like |
| Sex | Dioecious | Monoecious | Dioecious |
| Gamete type | Motile (flagellated) | Non-motile sperm | Non-motile sperm |
| Special feature | Coralloid roots | Winged seeds | Vessels in xylem, angiosperm-like features |

---

## 13. Evolutionary Significance of Gymnosperms

Gymnosperms represent a **transitional group** in the evolution of land plants from lower vascular cryptogams to flowering plants.

---

🔸 **Key Evolutionary Contributions:**

1. **First seed-producing plants:**
   - Provided better protection and survival of the embryo compared to spores.
2. **Independence from water for fertilization:**

- Except *Cycas*, gymnosperms use **pollen tubes** (an advanced trait shared with angiosperms).

3. **Development of secondary growth:**
   - Allows for large, woody structures and long lifespans.
4. **Foundation for angiosperm evolution:**
   - Features in **Gnetum** (vessels, dicot-like leaves, double fertilization) hint at the origin of flowering plants.
5. **Survivors of ancient flora:**
   - Gymnosperms dominated the **Mesozoic era** (Age of Gymnosperms), giving insight into early plant evolution.

---

## 14) Economic Importance of Gymnosperms

(For 5–10 marks)

Gymnosperms have significant economic value across various industries such as **timber, medicine, paper, food**, and **ornamentals**. Here's a structured answer:

---

### 🌲 1. Timber and Construction Wood

- **Pinus**, **Cedrus**, **Picea**, and **Abies** provide **softwood** used for:
  - Furniture
  - Construction
  - Matchsticks and packing boxes
  - Doors, windows, and plywood

---

### 🏭 2. Paper and Pulp Industry

- Wood of **Pinus** and **Spruce** is rich in cellulose and used to make **paper pulp**.
- Gymnosperm wood is favored because it has **long tracheids**, giving strong paper fibers.

---

### 🧴 3. Resin and Turpentine

- **Pinus** yields:
  - **Resin** (used in varnish, waterproofing)
  - **Turpentine oil** (used as a solvent and in paints, polishes, and medicine)

---

## 💊 4. Medicinal Uses

- **Ephedra** (a gymnosperm) contains **ephedrine**, used to treat:
  - Asthma
  - Cough and cold
  - Nasal congestion
- **Taxus baccata** (Yew tree):
  - Produces **taxol**, a **powerful anticancer drug** used in chemotherapy.
- **Ginkgo biloba:**
  - Used in herbal medicine to improve **memory and blood circulation**.

---

## 🛢️ 5. Oils and Aromatics

- Seeds of **Cycas** yield **starch** (Sago) and oil.
- Coniferous trees produce aromatic oils used in:
  - Perfumes
  - Soaps
  - Disinfectants

---

## 🌾 6. Food

- Seeds of **Pinus gerardiana** (*Chilgoza*) are **edible and nutritious**.
- **Cycas** stem and seeds are sources of **sago**, a starchy food.

---

## 🌳 7. Ornamental Plants

- **Cycas**, **Thuja**, and **Araucaria** are used in gardens and landscaping for their decorative appearance.

### 🌿 8. Soil Conservation and Ecology

- Gymnosperms, especially conifers, are planted for:
  - **Afforestation**
  - **Soil binding** on slopes (e.g., in hilly regions)

---

## 15) write a Note on Paleobotany

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### 🌿 Definition:

**Paleobotany** is the branch of botany that deals with the **study of fossil plants**, including their structure, evolution, and relationships to modern plants. It bridges **botany** and **geology**.

---

### 🦕 Key Points:

1. **Fossil Study:**
   - Paleobotanists examine **plant fossils** preserved in rocks from different geological periods.
2. **Time Scale:**
   - Studies cover ancient periods like the **Paleozoic, Mesozoic**, and **Cenozoic eras**.
   - Major plant groups like **algae, ferns, gymnosperms, and early angiosperms** are studied.
3. **Types of Fossils:**
   - **Impression fossils:** Outline of leaves or stems.
   - **Compression fossils:** Flattened plant parts in sediment.
   - **Petrified fossils:** Plant tissue replaced by minerals (e.g., silicified wood).
   - **Coal balls:** Fossilized remains of swamp plants.

---

🧬 **Importance of Paleobotany:**

- **1. Evolutionary Studies:**
    - Helps trace the **evolution of plants** from primitive forms to modern flowering plants.
- **2. Climate and Environment:**
    - Fossil plants provide clues about **past climates (paleoclimate)** and **ancient ecosystems**.
- **3. Age Dating:**
    - Helps in **dating rock layers** (stratigraphy) using **index fossils**.
- **4. Origin of Major Plant Groups:**
    - Fossil records reveal the rise and dominance of **gymnosperms** in the Mesozoic and **angiosperms** in the Cretaceous.
- **5. Economic Value:**
    - Fossil plants are the source of **coal, petroleum, and natural gas**.

---

🔬 **Famous Fossil Plants:**

- **Rhynia**.
- **Lepidodendron** – giant club moss.
- **Calamites**
- **– fossil cycadeoid**

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**16) Preservation of Plant Fossils**

---

🌿 **Definition:**

**Preservation of plant fossils** refers to the **processes by which plant parts** (like leaves, stems, roots, seeds, etc.) are **preserved in rocks or sediments** over geological time. These preserved remains provide vital information about ancient plant life and environments.

---

### ◆ Main Methods of Plant Fossil Preservation:

---

**1. Compression Fossils:**

- Soft plant parts (leaves, stems) are flattened and preserved as thin **carbon films** between layers of sedimentary rock.
- **Organic material** is often retained.
- Example: Fern leaves in shale.

---

**2. Impression Fossils:**

- Only the **outline or external shape** of the plant part is preserved.
- No organic material remains.
- Common in soft-bodied plant parts like leaves and flowers.

---

**3. Petrifaction (Permineralization):**

- **Minerals** (like silica, calcite) enter the plant tissues and **replace the organic material**, preserving **internal structures** (cells, tissues).
- Occurs under **high pressure and mineral-rich water**.
- Example: Petrified wood (e.g., *Araucarioxylon*).

---

**4. Casts and Molds:**

- A **mold** forms when plant material decays, leaving a cavity in sediment.
- A **cast** forms if the cavity is later filled with minerals or sediment.
- Often seen in fruits, seeds, and stems.

---

## 17) Radiocarbon Dating

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🧪 **Definition:**

**Radiocarbon dating** (also called **Carbon-14 dating**) is a scientific method used to **determine the age of organic materials** (such as wood, plant remains, or bones) by measuring the amount of **radioactive carbon-14 ($^{14}C$)** remaining in the sample.

---

🧬 **Principle:**

- **Carbon-14** is a radioactive isotope of carbon formed in the atmosphere.
- Living organisms constantly absorb **$^{14}C$** from the environment.
- When an organism dies, it stops taking in carbon, and the $^{14}C$ begins to **decay at a known rate** (its **half-life** is **5,730 years**).
- By measuring how much $^{14}C$ remains, scientists can calculate the **time since death**.

---

🔹 **Steps in Radiocarbon Dating:**

1. Collect the organic sample (wood, charcoal, bone, etc.).
2. Measure the **remaining $^{14}C$ content** using instruments like **Accelerator Mass Spectrometry (AMS)**.
3. Calculate the age based on the decay rate.

---

📏 **Time Range:**

- Effective for dating materials that are up to **50,000 years old**.
- Not useful for very ancient fossils (like dinosaurs or most gymnosperms), which are millions of years old.

---

🧱 **Uses of Radiocarbon Dating:**

- Dating **archaeological sites** (e.g., tools, pottery with charcoal).
- Studying **climate change** using plant and tree remains.

- Dating **fossilized wood**, peat, or ancient vegetation in **paleobotany**.
- Estimating the age of **historical artifacts**.

---

⚠️ **Limitations:**

- Only works on **organic materials**.
- Not accurate for samples older than **50,000 years**.
- Requires proper calibration due to fluctuations in atmospheric $^{14}C$ over time.

---

## 18) explain Types of Fossils

Fossils are the **preserved remains, impressions, or traces** of ancient organisms found in rocks. Fossils help us understand the **evolution**, **structure**, and **history** of life on Earth.

---

🦴 **Types of Plant Fossils:**

🔹 **1. Compression Fossils**

- Plant parts are **flattened** between layers of sediment.
- Retain some **organic material**.
- Show both **external shape** and partial internal structure.
- Example: Leaf fossils in shale or coal beds.

---

🔹 **2. Impression Fossils**

- Only the **surface imprint** or outline is preserved.
- No organic matter remains.
- Often found with compressions.
- Example: Leaf or fern impressions on rock.

---

🔹 **3. Petrified Fossils (Petrifactions / Permineralization)**

- Minerals (like silica or calcium carbonate) **replace plant tissues**.
- Excellent preservation of **internal anatomy** (cells and tissues).
- Example: **Petrified wood** (*Araucarioxylon*), stem of *Lyginopteris*.

---

### 🔹 4. Casts and Molds

- **Mold**: Impression left when plant part decays.
- **Cast**: Formed when the mold is filled with sediment/minerals.
- Preserves **3D structure**.
- Common in stems, seeds, fruits.

---

### 🔹 5. Coal Balls

- Fossilized plant material in **calcium carbonate or iron-rich nodules**.
- Found in coal seams.
- Preserve **tissue structure** in 3D.
- Example: Found in Carboniferous coal beds.

.

---

### 🧬 Other Fossil Types (Special Cases):

- **Chemical Fossils (Biomarkers):**
  - Trace chemicals or isotopes left behind by ancient life.
- **Microfossils:**
  - Microscopic remains like **pollen**, **spores**, or **algal cells**.

---

**19)explain the taxa Fossil Plants**

**a) Lepidodendron**
**b) Cycadeoidea**

---

### 🌿 a) Lepidodendron *(Giant Club Moss)*

🔹 **Classification:**

- Group: **Lycopsida** (Pteridophyta)
- Age: **Carboniferous Period** (approx. 300 million years ago)

🔹 **Key Features:**

- **Extinct, tree-like lycopod** (up to 30 meters tall).
- Possessed a **thick trunk** with **diamond-shaped leaf scars** arranged in a spiral (distinctive bark pattern).
- **Leaves:** Needle-like microphylls, arranged spirally.
- **Roots:** Called **Stigmaria**, spreading horizontally from the base.
- **Stem anatomy:** Contains a large central stele with secondary growth (unlike modern lycopods).

🔹 **Reproduction:**

- **Heterosporous** (produced both mega- and microspores).
- Cones or **strobili** at the branch tips bore sporangia.

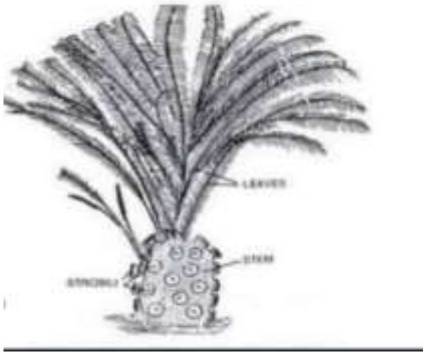
🔹 **Significance:**

- Contributed greatly to the formation of **coal deposits** (coal forests).

- Represents a **transition between herbaceous and woody vascular plants**.

---

### 🌴 b) Cycadeoidea *(Bennettitales)*



🔹 **Classification:**

- Group: **Gymnosperms (Order: Bennettitales)**
- Age: **Jurassic to Cretaceous Periods**

🔹 **Key Features:**

- **Extinct, palm-like or cycad-like gymnosperm**.
- Short, stout, unbranched stem covered with persistent leaf bases.
- **Leaves:** Pinnately compound, similar to modern *Cycas*.

🔹 **Reproductive Structures:**

- Produced **bisexual cones** (containing both male and female organs).
- **Flower-like structures** called **reproductive receptacles**, suggesting affinity with **angiosperms**.
- Fertilization likely via **pollen tubes**.

🔹 **Significance:**

- Thought to be **evolutionarily close to angiosperms** due to flower-like reproductive organs.
- Important in studying the **origin of flowering plants**.
- Represent advanced features among gymnosperms.

---

### ✅ Summary Table:

| **Feature** | **Lepidodendron** | **Cycadeoidea** |
|---|---|---|
| Group | Pteridophyte (Lycopsida) | Gymnosperm (Bennettitales) |
| Period | Carboniferous | Jurassic to Cretaceous |
| Habit | Tree-like, up to 30 m tall | Stout, palm-like shrub |
| Leaf type | Needle-like microphylls | Pinnate, cycad-like leaves |

| Feature | Lepidodendron | Cycadeoidea |
|---|---|---|
| Reproduction | Heterosporous, cones | Bisexual cones (flower-like) |
| Importance | Coal formation | Link to angiosperm evolution |

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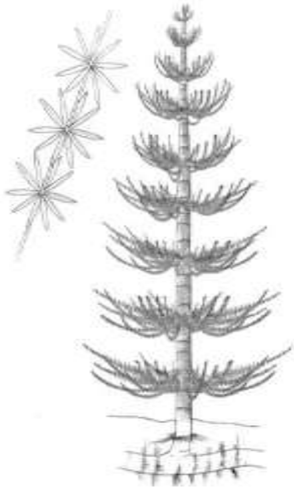
## 20) Explanation of Fossil Taxa: Calamites and Rhynia



### 🌿 a) Calamites

🔹 **Classification:**

- Group: **Sphenopsida (Horsetails)**
- Geological Age: **Carboniferous period** (~300 million years ago)
- Related to modern **Equisetum**

🔹 **Morphological Features:**

- **Tree-like sphenopsid**, grew up to 20 meters tall.
- **Jointed, ribbed stems** with **distinct nodes and internodes**.
- **Leaves:** Small, needle-like, arranged in **whorls** at the nodes.
- **Branches:** Also produced in whorls, like modern horsetails.
- **Roots:** Called **Astromyelon**, developed from rhizome.

🔹 **Anatomy:**

- Hollow central cavity like Equisetum.
- Vascular system shows **carinal canals** and **secondary growth** (unlike modern horsetails).

🔹 **Reproduction:**

- Reproduced by **cones (strobili)** bearing **homosporous** or **heterosporous** sporangia.

- Spores had **elaters** for wind dispersal.

🔹 **Significance:**

- Major component of **Carboniferous coal forests**.
- Shows evolutionary advancement in **secondary growth** among horsetails.

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🌱 **b) Rhynia**

🔹 **Classification:**

- Group: **Rhyniophyta (Primitive vascular plants)**
- Geological Age: **Silurian to Early Devonian period** (~400 million years ago)
- Among the **earliest known vascular plants**

🔹 **Morphological Features:**


- **Small, simple plant**, about 20–50 cm tall.
- **Dichotomously branched stem**; no true leaves or roots.
- Had **rhizoids** for anchorage and absorption.
- Grew in moist, swampy areas.

🔹 **Anatomy:**

- **Protostele** (solid central vascular tissue).
- Simple xylem (no vessels) and phloem.
- No secondary growth.

🔹 **Reproduction:**

- Produced **sporangia** at the tips of branches (terminal position).
- **Homosporous** (single type of spore).
- Spores released by sporangial dehiscence.

🔹 **Significance:**

- Considered one of the **first vascular land plants**.
- Represents the **transition from bryophytes to vascular plants**.
- Important in understanding **early terrestrial plant evolution**.

✅ **Summary Table:**

| **Feature** | **Calamites** | **Rhynia** |
|---|---|---|
| Group | Sphenopsida (Horsetail relative) | Rhyniophyta (Primitive vascular plant) |
| Period | Carboniferous (~300 MYA) | Devonian (~400 MYA) |
| Height | Up to 20 m | 20–50 cm |
| Stem | Jointed, ribbed, with nodes | Dichotomously branched |
| Roots | True roots (Astromyelon) | No true roots, rhizoids present |
| Leaves | Small, in whorls | No true leaves |
| Vascular tissue | Present, with secondary growth | Protostele (primitive vascular tissue) |
| Reproduction | Strobili with spores (homo/hetero) | Terminal sporangia, homosporous |
| Importance | Coal forest component | Earliest known vascular land plant |