1. (a) Match the following (Attempt any five):
    - (i) Horsetail & Equisetum
    - (ii) Pseudoelaters & Anthoceros
    - (iii) Winged pollen grains & Pinus
    - (iv) Coenosorus & Pteris
    - (v) Gemma cup & Marchantia
    - (vi) Sago Palm & Cycas

(b) Give botanical name of the plants showing the following structural features (Attempt any five):

- (i) Archegoniophore: *Marchantia*
- (ii) Vallecular canals: *Equisetum*
- (iii) Ovuliferous scale: *Pinus*
- (iv) Trabeculae: *Selaginella*
- (v) Coralloid roots: *Cycas*
- (vi) Peristome teeth: *Funaria*

2. (c) Define the following citing examples (Attempt any five):
    - (i) Appendiculate scale
        - Definition: An appendiculate scale is a type of ovuliferous scale in certain conifers that possesses a sterile, usually upwardly projecting, free tip beyond the ovule-bearing part.
        - Example: *Pinus*
    - (ii) Perigynium

  - Definition: A perigynium is a protective, flask-shaped bract that completely encloses the archegonium (and later the developing sporophyte) in some bryophytes, particularly in certain mosses and Jungermanniales.
  - Example: *Marchantia*
- (iii) Spur
  - Definition: A spur is a short shoot with limited growth that bears leaves and reproductive structures (e.g., cones) in certain woody plants, typically gymnosperms.
  - Example: *Pinus*
- (iv) Bulbil
  - Definition: A bulbil is a small, detachable bud or miniature plantlet, often fleshy, that develops in the axil of leaves or in inflorescences, serving as a means of vegetative propagation.
  - Example: *Agave*, *Dioscorea*
- (v) Rhizophore
  - Definition: A rhizophore is a leafless, colourless, dichotomously branched organ found in some pteridophytes (e.g., *Selaginella*) that grows downwards from branching points on the stem and produces roots at its apex. Its morphological nature (stem or root) is debated.
  - Example: *Selaginella*
- (vi) Stomium
  - Definition: The stomium is a specialized region of thin-walled cells in the wall of a sporangium (in ferns and some other plants) or an anther (in flowering plants)

where dehiscence (splitting open to release spores or pollen) occurs.

- Example: *Pteris* (sporangium), *Funaria* (capsule)

3. Differentiate between the following (Attempt any three):

   - (a) Ovule of Cycas and Gnetum
     - Ovule of *Cycas*:
       - Orthotropous, large, and sessile.
       - Single integument.
       - Micropyle is wide.
       - Presence of a distinct nucellar beak.
       - Pollen chamber is well-developed.
       - Fertilization is siphonogamous, but involves motile sperms.
     - Ovule of *Gnetum*:
       - Anatropous.
       - Two or three integuments (often called envelopes).
       - Micropyle forms a long tubular prolongation (micropylar tube).
       - No nucellar beak.
       - Pollen chamber is absent or poorly developed.
       - Fertilization is siphonogamous, with non-motile sperms.
   - (b) Liverwort and mosses
     - Liverworts (e.g., *Marchantia*):

        - Thalloid or leafy, if leafy, leaves are usually dorsiventral, without a distinct midrib.
        - Rhizoids are usually unicellular and unbranched.
        - Sporophyte is small, simple, and short-lived, typically consisting of foot, seta (short or absent), and capsule, often completely dependent on the gametophyte.
        - Capsule dehisces irregularly or by valves, often with elaters.
        - Gemma cups are common for asexual reproduction.
    - Mosses (e.g., *Funaria*):
        - Always leafy, with spirally arranged leaves around a central stem-like axis, usually with a distinct midrib.
        - Rhizoids are multicellular and branched.
        - Sporophyte is more complex and persistent, consisting of foot, elongated seta, and capsule (spore sac) with a complex peristome. Partially photosynthetic when young.
        - Capsule dehisces regularly, usually by an operculum, and lacks elaters.
        - Asexual reproduction by fragmentation, gemmae rare.
- (c) Apogamy and Apospory
    - Apogamy:
        - Definition: Development of a sporophyte directly from the gametophyte without the fusion of gametes

(i.e., without fertilization). The sporophyte is typically haploid.

- Ploidy: The resulting sporophyte is haploid (n).
- Origin: From any vegetative cell of the gametophyte (e.g., prothallus cell).
- Example: Common in some ferns like *Dryopteris* and *Adiantum*.

▪ Apospory:

- Definition: Development of a gametophyte directly from the sporophyte without the formation of spores (i.e., skipping meiosis). The gametophyte is typically diploid.
- Ploidy: The resulting gametophyte is diploid (2n).
- Origin: From any vegetative cell of the sporophyte (e.g., sporangial wall cells, leaf cells).
- Example: Observed in some ferns like *Osmunda* and *Adiantum*.

○ (d) Strobilus of Selaginella and Equisetum

▪ Strobilus of *Selaginella*:

- Consists of an axis bearing sporophylls.
- Sporophylls are arranged spirally and bear sporangia in their axils.
- Heterosporous: Bears two types of sporangia, microsporangia (producing microspores) and megasporangia (producing megaspores), often intermixed or in distinct zones.

        - Sporophylls are usually uniform in appearance, sometimes slightly larger megasporophylls.
        - No sporangiophore.
    - Strobilus of *Equisetum*:
        - Consists of an axis bearing peltate (shield-shaped) sporangiophores.
        - Sporangiophores are hexagonal, stalked structures, each bearing 5-10 sporangia on its inner surface.
        - Homosporous: Produces only one type of spore (though physiologically differentiated).
        - Sporophylls are absent; sporangia are borne on specialized sporangiophores.
        - Presence of annulus below the sporangiophores.

- (e) Sporophyte of Funaria and Marchantia
    - Sporophyte of *Funaria* (Moss):
        - More differentiated and complex.
        - Consists of a foot, a long, well-developed seta, and a capsule (theca).
        - Capsule is specialized for spore dispersal, possessing a complex peristome (teeth-like structures) and an operculum.
        - Partially photosynthetic when young due to the presence of chloroplasts, thus partially independent of the gametophyte for nutrition.
        - Remains attached to the gametophyte for an extended period.

- Sporophyte of *Marchantia* (Liverwort):
  - Less differentiated and simpler.
  - Consists of a foot, a very short or absent seta, and a capsule.
  - Capsule is simpler, dehisces irregularly or by valves, and contains elaters mixed with spores.
  - Non-photosynthetic and completely dependent on the gametophyte for nutrition.
  - Short-lived and quickly degenerates after spore dispersal.

4. Draw well labelled diagram of the following (Attempt any three):
   - (a) V.S. antheridiophore of Marchantia
   - (b) T.S. needle of Pinus
   - (c) T.S. stem of Selaginella
   - (d) T. S. Coralloid root
   - (e) V.S. sporophyll of Pteris
5. Write short notes on (Attempt any three):
   - (a) Heterospory and seed habit
     - Heterospory:
       - Definition: The production of two different sizes of spores (heterospory) by the sporophyte: microspores (small, male spores) and megaspores (large, female spores). Microspores develop into male gametophytes, and megaspores develop into female gametophytes.

        - Significance: It led to the differentiation of male and female gametophytes, a crucial step towards the evolution of the seed. It also promoted cross-fertilization.

    - Seed Habit:

        - Definition: The characteristic reproductive strategy of gymnosperms and angiosperms, involving the retention of the megaspore within the megasporangium (nucellus), its development into a female gametophyte *in situ*, fertilization of the egg within the archegonium (or ovule in angiosperms), and the subsequent development of the embryo within the protective layers of the ovule, which matures into a seed.

        - Link to Heterospory: Heterospory is a prerequisite for seed habit. The large, persistent megaspore provides nourishment for the developing female gametophyte and embryo. The retention of the megasporangium (which becomes the ovule) on the parent sporophyte provides protection and nutrition.

        - Advantages: Seeds offer several advantages: protection of the embryo, dispersal mechanism, dormancy, and stored food reserves, which greatly enhanced plant survival and colonization of diverse terrestrial environments.

- (b) Progressive sterilization of sporogenous tissue in bryophytes

    - Progressive sterilization of sporogenous tissue refers to the evolutionary trend observed in bryophytes where an increasing proportion of the initial sporogenous (spore-producing) cells within the sporophyte develop into sterile tissues (like foot, seta, and capsule wall with elaters or columella) instead of producing spores.

- **In Liverworts (e.g., *Marchantia*):**
  - The sporophyte is simple, with a relatively large proportion of sporogenous tissue developing into spores.
  - A significant part of the sporogenous tissue, however, differentiates into sterile elaters (hygroscopic structures aiding spore dispersal).
- **In Hornworts (e.g., *Anthoceros*):**
  - Shows a more advanced sterilization. The sporophyte has a distinct foot, an intercalary meristem (leading to indeterminate growth), and a central sterile columella.
  - The sporogenous tissue surrounds the columella, and some cells also form pseudoelaters. The existence of a meristem and a photosynthetic capsule wall further reduces dependence on sporogenous tissue for structure.
- **In Mosses (e.g., *Funaria*):**
  - Represents the highest degree of sterilization among bryophytes.
  - The sporophyte is highly differentiated with a well-developed foot, a long seta, and a complex capsule (spore sac).
  - A significant portion of the capsule wall, operculum, peristome teeth, and columella are sterile tissues. The sporogenous tissue is confined to specific regions within the capsule.

- **Significance:** This progressive sterilization is interpreted as an evolutionary advancement. It represents a shift from focusing solely on spore production to developing more elaborate structures for protection, efficient spore dispersal (e.g., seta, peristome), and prolonged survival of the sporophyte, thus increasing the overall reproductive success of the plant. It also highlights an increasing complexity and independence of the sporophyte from the gametophyte in the evolutionary lineage of bryophytes.

- (c) Economic importance of gymnosperms
  - Gymnosperms, though less diverse than angiosperms, hold significant economic importance, particularly conifers:
    - **Timber and Pulpwood:** Conifers like pines, spruces, firs, and cedars are primary sources of softwood timber for construction, furniture, and plywood. Their wood is also extensively used for producing paper, pulp, and rayon.
    - **Resins, Turpentine, and Varnishes:** Many conifers produce resins, which are tapped and processed to yield turpentine (used as a solvent, in paints and varnishes) and rosin (used in soaps, paper sizing, and varnishes).
    - **Food Products:**
      - **Edible Seeds:** Pine nuts (from *Pinus edulis*, *P. gerardiana*, etc.) are a popular edible seed.
      - **Sago:** Sago starch is extracted from the pith of *Cycas revoluta* (Sago Palm).
      - **Medicinal Uses:** *Ephedra* species are a source of ephedrine, used as a decongestant

and bronchodilator. *Taxus baccata* (Yew) is a source of taxol, an anti-cancer drug. Ginkgo biloba extracts are used in traditional medicine for cognitive enhancement.

- **Ornamental Plants:** Many gymnosperms are valued for their aesthetic appeal and are widely planted in gardens, parks, and landscapes (e.g., various species of *Pinus*, *Picea*, *Abies*, *Juniperus*, *Cycas*, *Ginkgo biloba*).
- **Essential Oils:** Some gymnosperms yield essential oils used in perfumes, aromatherapy, and as insect repellents.
- **Fuel:** Wood from gymnosperms is also used as fuelwood.

- (d) Ecological importance of bryophytes with reference to Sphagnum
  - Bryophytes, particularly mosses like *Sphagnum*, play crucial ecological roles, especially in moist and cold environments.
  - **Pioneer Species:** Bryophytes are often pioneer colonizers of barren lands (e.g., rocks, burnt areas, lava flows). They initiate soil formation by breaking down rocks through acid secretion and accumulating organic matter, preparing the ground for succession by larger plants.
  - **Soil Erosion Control:** Their dense mats act as natural sponges, absorbing rainwater and reducing runoff, thereby preventing soil erosion, especially in hilly and forested areas.
  - **Water Retention:** Bryophyte mats have excellent water-holding capacity, which helps maintain soil moisture,

benefiting other plants and contributing to stable microclimates.

- **Habitat for Microbes and Small Invertebrates:** They provide shelter and a moist environment for various microorganisms, small invertebrates, and insects, contributing to biodiversity.
- **Sphagnum (Peat Moss) - Specific Importance:**
    - **Peat Formation:** *Sphagnum* is the primary component of peat bogs. Its unique structure allows it to hold vast amounts of water (up to 20 times its dry weight). When it dies, it decomposes slowly in anaerobic, acidic bog conditions, forming peat.
    - **Carbon Sequestration:** Peat bogs are significant carbon sinks, storing large amounts of atmospheric carbon, which is crucial in mitigating climate change.
    - **Water Filtration and Regulation:** Peat bogs regulate water flow, acting as natural filters and reservoirs, releasing water slowly into streams and rivers.
    - **Fuel:** Peat is harvested and used as a fuel source in some regions.
    - **Horticulture:** Dried *Sphagnum* is widely used as a potting medium, soil conditioner, and for packaging due to its high water-holding capacity and antiseptic properties.
    - **Ecological Niche:** Peat bogs, dominated by *Sphagnum*, create unique acidic, nutrient-poor habitats that support specialized flora (e.g., carnivorous plants) and fauna.

- (e) Significance of Ceratopteris or Ephedra as a model system
  - **Significance of *Ceratopteris* (Water Fern) as a model system:**
    - **Rapid Life Cycle:** *Ceratopteris* has an extremely short and simple life cycle (approximately 3-4 weeks from spore to spore), making it ideal for genetic studies, particularly for observing multiple generations quickly.
    - **Ease of Culture:** It can be easily grown *in vitro* on defined media under sterile conditions, simplifying experimental manipulation.
    - **Homosporous Life Cycle:** Being homosporous, it produces a single type of spore that develops into a bisexual gametophyte (prothallus) with both antheridia and archegonia. This allows for self-fertilization, which is useful for genetic analysis.
    - **Genetic Amenability:** Its haploid gametophyte stage allows for direct observation of mutations, making it suitable for mutagenesis screens and understanding gene function.
    - **Response to Hormones:** It shows distinct responses to plant hormones (e.g., gibberellins influencing sexual differentiation of gametophytes), making it valuable for studying hormonal regulation in plants.
    - **Environmental Studies:** It is used to study responses to various environmental stresses, heavy metal toxicity, and nutrient deficiencies.
  - **Significance of *Ephedra* as a model system:**

- **Unique Gymnosperm:** *Ephedra* is a gymnosperm that exhibits certain angiosperm-like features (e.g., vessels in xylem, double fertilization, though the second fertilization does not form endosperm), making it a crucial model for understanding the evolution of angiosperms from gymnosperm ancestors.
- **Gnetophytes:** It belongs to the Gnetophytes, a small and enigmatic group of gymnosperms (along with *Gnetum* and *Welwitschia*) that are phylogenetically close to angiosperms.
- **Molecular and Evolutionary Studies:** Its phylogenetic position makes it valuable for comparative genomics and evolutionary studies, particularly concerning the origin of angiosperm traits.
- **Medicinal Importance:** It is a source of ephedrine, a widely used alkaloid, making it relevant for studies in plant secondary metabolism and pharmaceutical research.
- **Drought Adaptation:** As a desert plant, *Ephedra* is a model for studying adaptations to arid environments, including water-use efficiency and specialized photosynthetic pathways.

6. (a) Discuss the hydrophytic and xerophytic characters of Equisetum with the help of suitable diagrams. (8)
    - *Equisetum* (horsetail) is a fascinating genus that exhibits a unique combination of characters, reflecting adaptations to both aquatic (hydrophytic) and dry (xerophytic) environments, largely due to its evolutionary history and widespread distribution.
    - **Hydrophytic Characters:**

- **Presence of well-developed aerenchyma (Vallecular Canals):** The stem of *Equisetum* contains large air cavities, the vallecular canals, located beneath the furrows in the cortex. These continuous air channels facilitate aeration and buoyancy, which are typical adaptations for plants growing in waterlogged soils or aquatic environments where oxygen availability is limited.
- **Carinal Canals:** These are central canals located beneath the ridges, formed by the disintegration of protoxylem. While primarily for water conduction, their large size can also be seen as an adaptation for efficient water transport in conditions where water is abundant.
- **Reduced Vascular Tissue:** Compared to terrestrial plants, *Equisetum* often has a relatively reduced vascular cylinder, which is common in hydrophytes as water absorption is less of a challenge.
- **Rhizomatous Growth:** Extensive underground rhizomes with adventitious roots can spread in waterlogged or marshy soils, facilitating vegetative propagation and providing anchorage in soft substrates.

o **Xerophytic Characters:**

- **Highly Reduced Leaves (Microphylls):** The leaves are reduced to small, scale-like structures arranged in whorls at the nodes. This significantly reduces the surface area for transpiration, minimizing water loss.
- **Stems as Primary Photosynthetic Organs:** The green, jointed stems are the main photosynthetic organs, taking over the function from the reduced leaves. This also reduces the number of stomata exposed on leaves.
- **Silica Impregnation of Epidermis:** The epidermal cells of the stem are heavily impregnated with silica. This

makes the stem rough and abrasive ("scouring rush"), providing mechanical strength and acting as a physical barrier against herbivory. Crucially, the thick silicified wall also reduces water loss by strengthening the cuticle and making it less permeable.

- **Sunken Stomata:** The stomata are typically located in the furrows of the stem epidermis and are often sunken or protected by epidermal outgrowths. This creates a humid microenvironment around the stomata, reducing the transpiration rate.
- **Thick Cuticle:** The stem epidermis is covered by a thick cuticle, a waxy layer that is highly impermeable to water, further minimizing evaporative water loss.
- **Endodermal Sheath:** A distinct endodermis surrounds the vascular tissue, potentially regulating water movement into and out of the stele.
- **Deep-seated Photosynthetic Tissue:** The chlorenchymatous (photosynthetic) tissue is often located deeper within the cortex, away from the surface, further protected by the thick, silicified epidermis.

- **Conclusion:** *Equisetum*'s morphology and anatomy reflect a dual adaptation strategy. The internal air canals and rhizomatous growth facilitate survival in moist or waterlogged conditions, while the highly reduced leaves, silicified and cuticularized stems, and sunken stomata are clear adaptations to conserve water, allowing it to withstand periods of dryness or to thrive in exposed, well-drained habitats. This unique combination makes *Equisetum* a highly resilient and widespread genus.

(b) Give an account of adaptation of land habit in bryophytes. (7)

- Bryophytes (mosses, liverworts, and hornworts) are considered the "amphibians of the plant kingdom" because, while they represent the earliest group of land plants, they are not fully adapted to a completely terrestrial existence and still largely depend on water for reproduction. However, they exhibit several crucial adaptations that enabled their transition from aquatic to land habitats:
- **1. Development of Cuticle and Epidermis:**
  - **Cuticle:** A thin, waxy, water-impermeable layer on the exposed surfaces of the plant body (especially the stem and leaves in mosses, or the thallus in liverworts). This minimizes water loss through evaporation, a major challenge on land.
  - **Epidermis:** A protective outer layer of cells that helps prevent desiccation.
- **2. Presence of Stomata (in some bryophytes):**
  - Stomata (or simple pores in some liverworts) on the sporophyte (and sometimes gametophyte in hornworts) allow for controlled gas exchange while regulating water loss. This is a critical adaptation for photosynthesis in a terrestrial environment.
- **3. Rhizoids for Anchorage:**
  - Bryophytes develop rhizoids (unicellular or multicellular hair-like structures) that anchor the plant body to the substratum. Unlike true roots, they primarily provide anchorage and limited water/nutrient absorption.
- **4. Protection of Gametes and Embryo:**
  - **Archegonium:** The female sex organ (archegonium) is flask-shaped and protects the egg cell within its venter, preventing desiccation.

- **Antheridium:** The male sex organ (antheridium) protects the motile sperm.
- **Embryo Protection:** The zygote and the developing embryo (young sporophyte) are retained and protected within the archegonium on the parent gametophyte, which also provides nourishment. This is a key step towards seed habit.

- **5. Spore Dispersal and Dormancy:**
  - **Walled Spores:** Spores have thick, resistant walls (sporopollenin) that protect them from desiccation and UV radiation, allowing them to be dispersed by wind on land.
  - **Elaters/Peristome Teeth:** Specialized structures like elaters (in liverworts) or peristome teeth (in mosses) aid in the dispersal of spores more effectively in the air.

- **6. Photosynthetic Gametophyte (Dominant Phase):**
  - The dominant and independent phase of the life cycle is the gametophyte, which is photosynthetic and can absorb water directly from the environment. This reduces reliance on a sophisticated vascular system.
- **7. Development of Parenchymatous Body:**
  - Bryophytes have a multicellular, parenchymatous plant body, which is more robust and resistant to desiccation than a simple filamentous body.
- **8. Limited Internal Conduction (Hydroids and Leptoids):**
  - While lacking true vascular tissues (xylem and phloem), some advanced mosses possess simple conducting tissues (hydroids for water, leptoids for food) in their stems, representing a primitive attempt at internal

transport, though most water absorption is through the general body surface.

- **Persistent Dependence on Water for Fertilization:** Despite these adaptations, bryophytes are still tied to water for sexual reproduction because their male gametes (antherozoids) are flagellated and require a film of water to swim to the archegonium for fertilization. This limits their distribution to moist habitats.

7. (a) Discuss in detail the stelar evolution in pteridophytes with the help of suitable diagrams. (8)

   - The stele is the central cylinder of the stem and root in vascular plants, consisting of vascular tissue (xylem and phloem) along with associated pericycle and pith (if present). Pteridophytes exhibit a remarkable diversity of stelar types, illustrating a clear evolutionary progression from simpler to more complex arrangements.
   - **1. Protostele:**
     - **Definition:** The most primitive type of stele, characterized by a solid core of vascular tissue, with xylem forming the center and phloem surrounding it, and no pith.
     - **Types:**
       - **Haplostele:** Simplest type, with a central cylindrical core of xylem surrounded by a ring of phloem.
         - Example: *Rhynia*, young stem of *Selaginella*.
       - **Actinostele:** Star-shaped or stellate xylem core, with phloem situated in the indentations between the xylem arms.
         - Example: *Psilotum*, mature stem of *Selaginella*, *Lycopodium*.

        - **Plectostele:** Xylem occurs in parallel plates or bands, alternating with phloem plates.
            - Example: Some species of *Lycopodium*.
    - **Evolutionary Significance:** Represents the ancestral condition, efficient for small plants but limits the formation of leaf gaps.
- **2. Siphonostele:**
    - **Definition:** Evolution from protostele by the development of a central pith, resulting in a hollow cylinder of vascular tissue. The pith is a parenchymatous core in the center.
    - **Types:**
        - **Ectophloic Siphonostele:** Phloem is present only on the outside of the xylem cylinder.
            - Example: Some species of *Equisetum*, *Osmunda*.
        - **Amphiphloic Siphonostele:** Phloem is present on both the outside and inside of the xylem cylinder, encircling the pith.
            - Example: *Marsilea*, *Adiantum* (some species).
    - **Evolutionary Significance:** The presence of pith allows for larger stem diameters and may offer increased storage capacity. The formation of leaf traces from the stele creates a gap in the vascular cylinder, leading to the next stage.
- **3. Solenostele:**
    - **Definition:** A type of siphonostele with one or more non-overlapping leaf gaps (or branch gaps) in the vascular cylinder. A leaf gap is a region of parenchyma in the stele

just above the point where a leaf trace (vascular supply to a leaf) diverges.

- **Characteristic:** Appears as a continuous cylinder in transverse section, but longitudinal section reveals the leaf gaps.
- **Example:** *Osmunda*, *Adiantum* (some species), *Dryopteris* (some species).
- **Evolutionary Significance:** The emergence of leaf gaps is associated with the evolution of megaphyllous leaves (large, complex leaves with branching veins).

- **4. Dictyostele:**
  - **Definition:** A siphonostele where multiple overlapping leaf gaps are present, causing the vascular cylinder to appear as a network of interconnected vascular strands (meristeles) in transverse section. Each meristele is essentially a protostele-like unit.
  - **Characteristic:** Due to overlapping gaps, the stele does not form a complete cylinder at any single level.
  - **Example:** Most advanced ferns (e.g., *Pteris*, *Dryopteris*).
  - **Evolutionary Significance:** Represents the most complex stelar arrangement in pteridophytes, highly efficient for large megaphyllous leaves, allowing for continuous supply of water to numerous large leaves without compromising the main stem's vascular integrity.

- **Summary of Evolution:** The evolutionary trend in steles in pteridophytes moves from simple, solid protosteles (found in early fossil forms and some extant primitive groups) to more complex siphonosteles, solenosteles, and dictyosteles, often correlated with the evolution of larger, more complex leaves (megaphylls). This diversification reflects adaptations for efficient water and nutrient transport in increasingly larger and more complex plant bodies.

(As per the saved instructions, I cannot make any kind of schematic diagram or code block.)

(b) Discuss the evolutionary significance of the sporophyte of Anthoceros.

- The sporophyte of *Anthoceros* (a hornwort) holds significant evolutionary importance because it exhibits features that are considered more advanced and indicative of a greater degree of independence from the gametophyte compared to other bryophytes (liverworts and mosses), bridging the gap towards vascular plants.
- **Key Evolutionary Significant Features:**
  - **Persistent and Indeterminate Growth:** Unlike the sporophytes of liverworts (which are determinate and short-lived) and even mosses (which have a defined growth period), the *Anthoceros* sporophyte possesses a basal intercalary meristem. This meristem continuously adds new cells at the base of the capsule, allowing for prolonged spore production over several weeks or months. This indeterminate growth is a significant step towards the more independent and long-lived sporophytes of vascular plants.
  - **Presence of a Central Sterile Columella:** The central part of the capsule contains a sterile columella. While also present in mosses, in *Anthoceros*, it is more prominent and aids in nutrient transport to the developing spores and provides structural support. This represents a further sterilization of sporogenous tissue for structural and physiological efficiency.
  - **Presence of Photosynthetic Tissue and Stomata:** The sporophyte wall (capsule wall) of *Anthoceros* contains

chloroplasts and true stomata. This allows the sporophyte to be photosynthetic and synthesize its own food, reducing its complete dependence on the gametophyte for nutrition. This is a marked departure from liverwort sporophytes (non-photosynthetic) and an advancement over moss sporophytes (partially photosynthetic but lacking true stomata on the capsule wall). The ability to perform photosynthesis is a hallmark of sporophytic independence seen in vascular plants.

- **Pseudoelaters:** While true elaters (found in liverworts) are hygroscopic and unicellular, *Anthoceros* has multicellular, branched structures called pseudoelaters. These assist in spore dispersal, and their multicellular nature might be seen as an intermediate step towards more complex dispersal mechanisms.
- **Cuticle on Sporophyte Epidermis:** The sporophyte is covered by a cuticle, which helps prevent desiccation, an essential adaptation for terrestrial life.
- **Embedded Foot:** The foot of the sporophyte is deeply embedded in the gametophyte, facilitating efficient nutrient transfer.

- **Transitional Status:**
  - The combination of these features (indeterminate growth, photosynthetic capability with stomata, and central columella) makes the *Anthoceros* sporophyte morphologically and physiologically more complex and self-sufficient than that of other bryophytes.
  - It highlights an evolutionary trend towards the dominance and independence of the sporophyte generation, a defining characteristic of pteridophytes and higher vascular plants. While still attached to the gametophyte

and dependent for initial establishment and water/mineral supply, its photosynthetic capacity and prolonged growth signify a crucial evolutionary bridge between the gametophyte-dominant bryophytes and the sporophyte-dominant vascular plants.