

Bryophytes
Riccia
Anthoceros

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General Characters

Bryophyta (Gr. bryon=moss) includes over 25000 species of non-vascular embryophytes such as mosses, liverworts and hornworts. Hedwig is called ‘Father of Bryology’. The study of bryophytes is called **bryology**. Bryophytes are small plants that grow in damp, shady and moist shady places. They don’t attain great heights because of absence of roots, vascular tissues, mechanical tissues and cuticle. They are terrestrial but require water to complete their life cycle. Therefore also known as “**Amphibians of plant kingdom**”.

- The dominant plant body is gametophyte on which sporophyte is semiparasitic for its nutrition.
- The thalloid gametophyte differentiated in to rhizoids, axis (stem) and leaves. Vascular tissues (xylem and phloem) absent.
- The gametophyte bears multi-cellular and jacketed sex organs (antheridia and archegonia).
- Sexual reproduction is oogamous type.
- Multi-cellular embryo develops inside archegonium.
- Sporophyte differentiated into foot, seta and capsule.
- Capsule produces haploid meiospores of similar types (homosporous).
- Spore germinates into juvenile gametophyte called protonema.
- The fossil record indicates that bryophytes evolved on earth about 395 – 430 million years ago (i.e. during Silurian period of Paleozoic era).
- They exhibit heterologous haplodiplobiontic type of life cycle.

Classification of Bryophytes:

Bryophytes are classified under three classes:

- **Hepaticopsida** (Liverworts),
- **Anthoceropsida** (Hornworts)
- **Bryopsida** (Mosses).

Hepaticopsida:

- Gametophytic plant body is either thalloid or foliose. If foliose, the lateral appendages (leaves) are without mid-rib. Always dorsiventral.
- Rhizoids without septa.
- Each cell in the thallus contains many chloroplasts; the chloroplasts are without pyrenoi.
- Sex organs are embedded in the dorsal surface.
- Sporophyte may be simple (e.g., *Riccia*) having only a capsule, or differentiated into root, seta and capsule (e.g., *Marchantia*, *Pallia* and *Porella* etc.)
- Capsule lacks columella.

- **Anthocerotopsida:**
- Gametophytic plant body is simple, thalloid; thallus dorsiventral without air canbers, shows no internal differentiation of tissues.
- Scales are absent in the thallus.
- Each cell of the thallus possesses a single large chloroplast with a pyrenoid.
- Sporophyte is cylindrical only partly dependent upon gametophyte for its nourishment. It is differentiated into bulbous foot and cylindrical capsule. Seta is meristematic.
- Endothecium forms the sterile central column (i.e., columella) in the capsule (i.e. columella is present). 6. It has only one order-Anthocerotales.
- **Bryopsida:**
- Gametophyte is differentiated into prostrate protonema and an erect gametophores
- Gametophore is foliose, differentiated into an axis (=stem) and lateral appendages like leaves but without midrib.
- Rhizoids multi-cellular with oblique septa.
- Elaters are absent in the capsule of sporangium.
- The sex organs are produced in separate branches immersed in a group of leaves.

Riccia (Liverwort)

Kingdom: Plantae
Div: Bryophyta
Class: Hepaticopsida
Order: Marchantiales
Family: Ricciaceae
Genus: *Riccia*

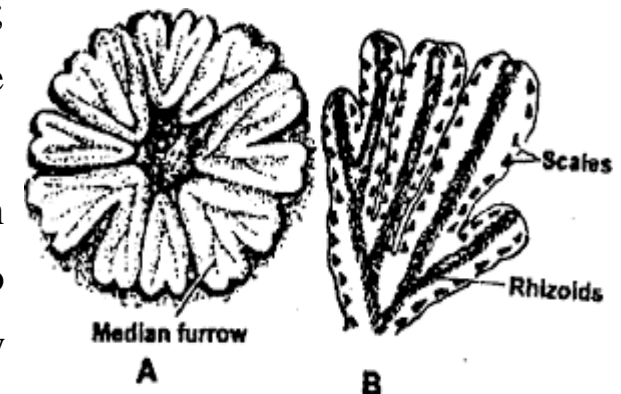
One of the more than 100 species in this genus is the "slender riccia" (*Riccia fluitans*), which grows on damp soil or, less commonly, floating in ponds.

These plants are small and **thalloid** which is dorsiventrally differentiated. that is not differentiated into root, stem and leaf. Depending on species, the thallus may be strap-shaped and about 0.5 to 4 mm wide with dichotomous branches or may form rosettes or hemi rosettes up to 3 cm in diameter, that may be gregarious and form intricate mats .

Its dorsal surface is green and chlorophyll-bearing, with a mid-dorsal longitudinal furrow or groove. Air pores occasionally break through the dorsal surface, giving the thallus a dimpled appearance. The ventral surface has a mid-ventral ridge bearing multicellular scales that originate as a single row but normally separate into two rows as the thallus widens. The scales are multicellular and hyaline (glassy) in appearance, or violet due to the anthocyanin.

Rhizoids are nearly lacking in aquatic forms, but there are usually numerous unicellular rhizoids of two types on the ventral surface. One type is called smooth and the other type is the pegged or tuberculated rhizoids; these help in anchorage and absorption. The inner surface of the smooth rhizoids is smooth while that of the tuberculate rhizoid will have internal cell wall projections.

Plants are usually monoicous, and sexual reproduction is by antheridia and archegonia. Asexual reproduction occurs by spores, by fragmentation of the rosettes, and by formation of apical tubers. Spores are large (45 to 200 μ) and formed in tetrads. The **sporophyte** of *Riccia* is the simplest amongst bryophytes. It consist of only a capsule, missing both foot and seta, and does not perform photosynthesis.



Photosynthetic region is situated on the upper or dorsal surface of the thallus and consists of loose green tissue. It is also known as assimilatory region. It consists of a layer of epidermis, many air pores, air spaces or air chambers and many one-celled thick vertical rows of chlorophyll-containing cells. In the cells of vertical rows are present many discoid chloroplasts. In between these vertical rows are present air spaces or air chambers. Uppermost cells of these vertical rows remain devoid of chloroplast and thus form a hyaline discontinuous layer of upper epidermis. Continuity of the upper epidermis is broken by many air pores.

Storage Region: is situated on the lower or ventral surface of the thallus and consists of colorless cells. Cells are closely packed and parenchymatous and contain starch and are without intercellular spaces.

The lowermost cells of this region form a regular lower epidermis, from which arise scales and rhizoids.

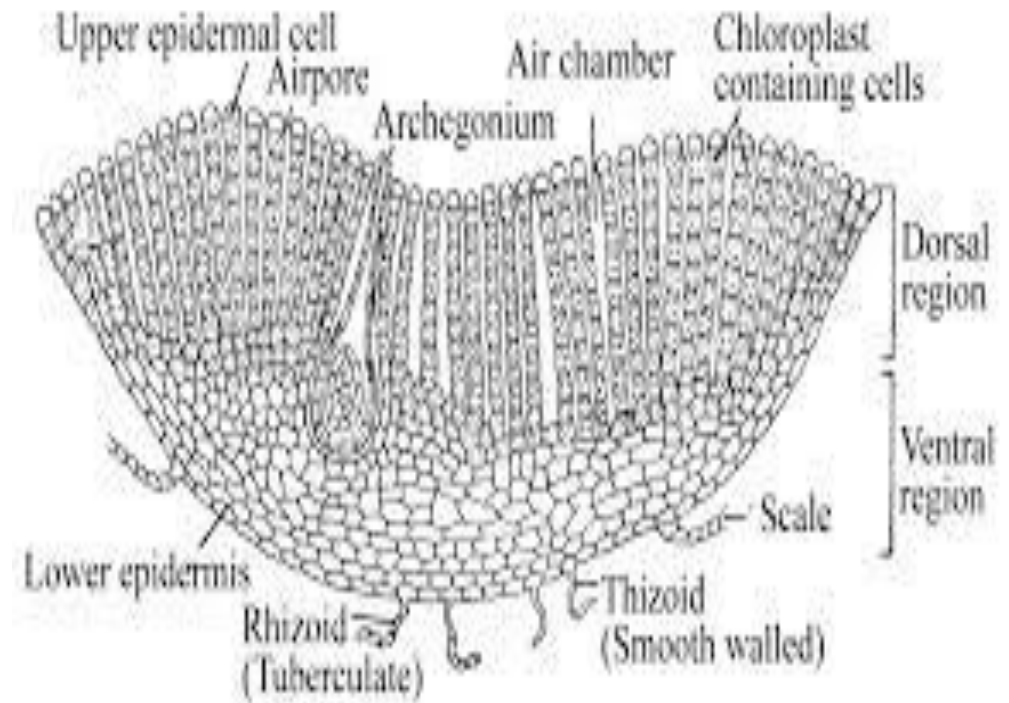


Fig. *Riccia* spp. Vertical cross section of thallus showing different regions.

Reproduction:

Vegetative reproduction Death and decay of the older portion of the thallus. 2. By adventitious branches 3. By persistent apices 4. By tubers 5. By rhizoids

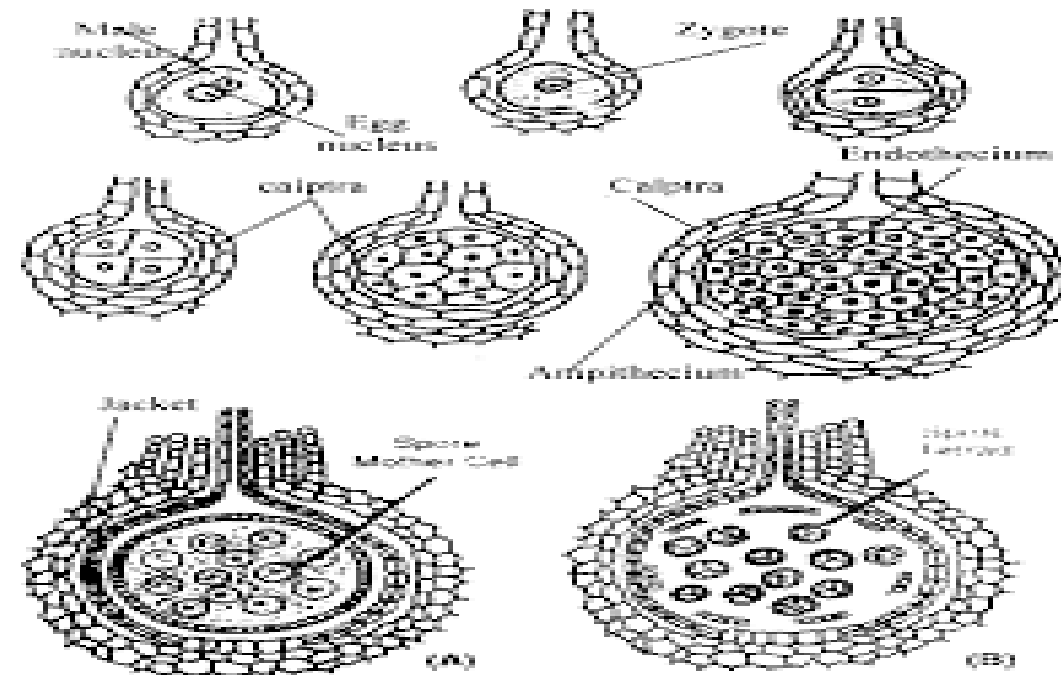
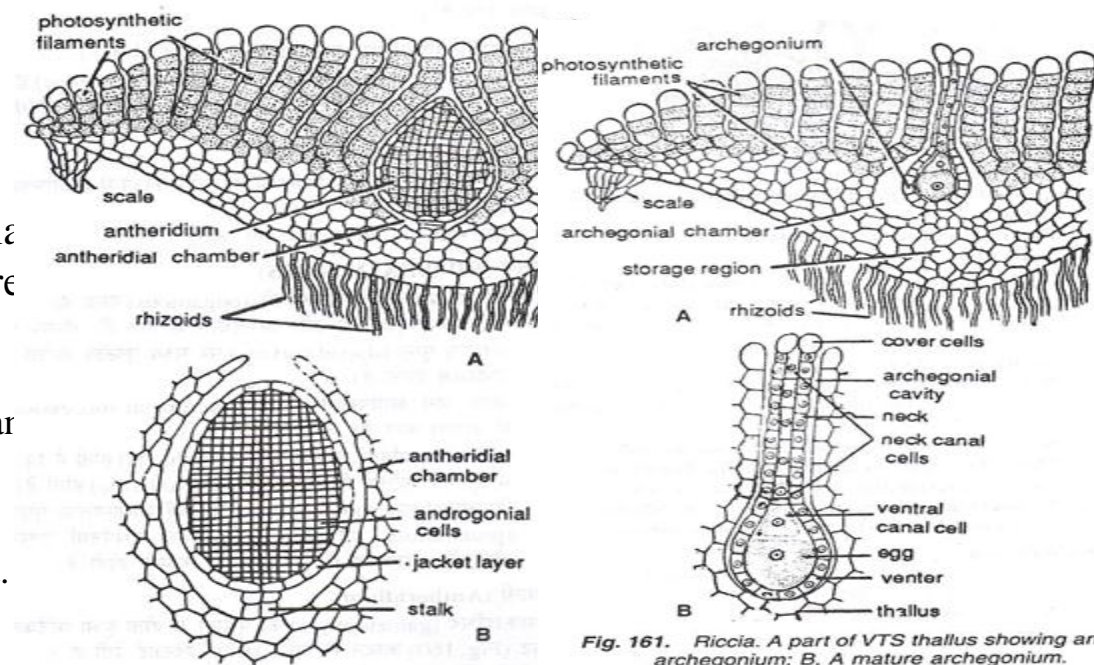
Sexual Reproduction: oogamous. Male reproductive bodies are known as antheridia and female as archegonia. Some spp. are monoecious or homothallic while some are dioecious or heterothallic.

Antheridia: produced in a cavity on the dorsal surface called antheridial chamber with an opening on apical side.

- A mature antheridium is a stalked, club-shaped or pear-shaped body. Antheridial stalk is multicellular. It remains surrounded by an outermost layer of one-celled thick sterile jacket.
- Inside the jacket layer are present many small, cubical androcyte mother cells. Each androcyte mother cell contains dense cytoplasm and large nucleus. Each androcyte metamorphoses into a single structure, variously called antherozoid, spermatozoid or sperm. Each antherozoid is a minute, uninucleate body containing two long flagella at its anterior end. Lower flagellum is slightly larger than upper one. **Dehiscence** of antheridium takes place in the presence of water.

Archegonium: remains embedded in the archegonial cavity on the dorsal surface of the gametophyte.

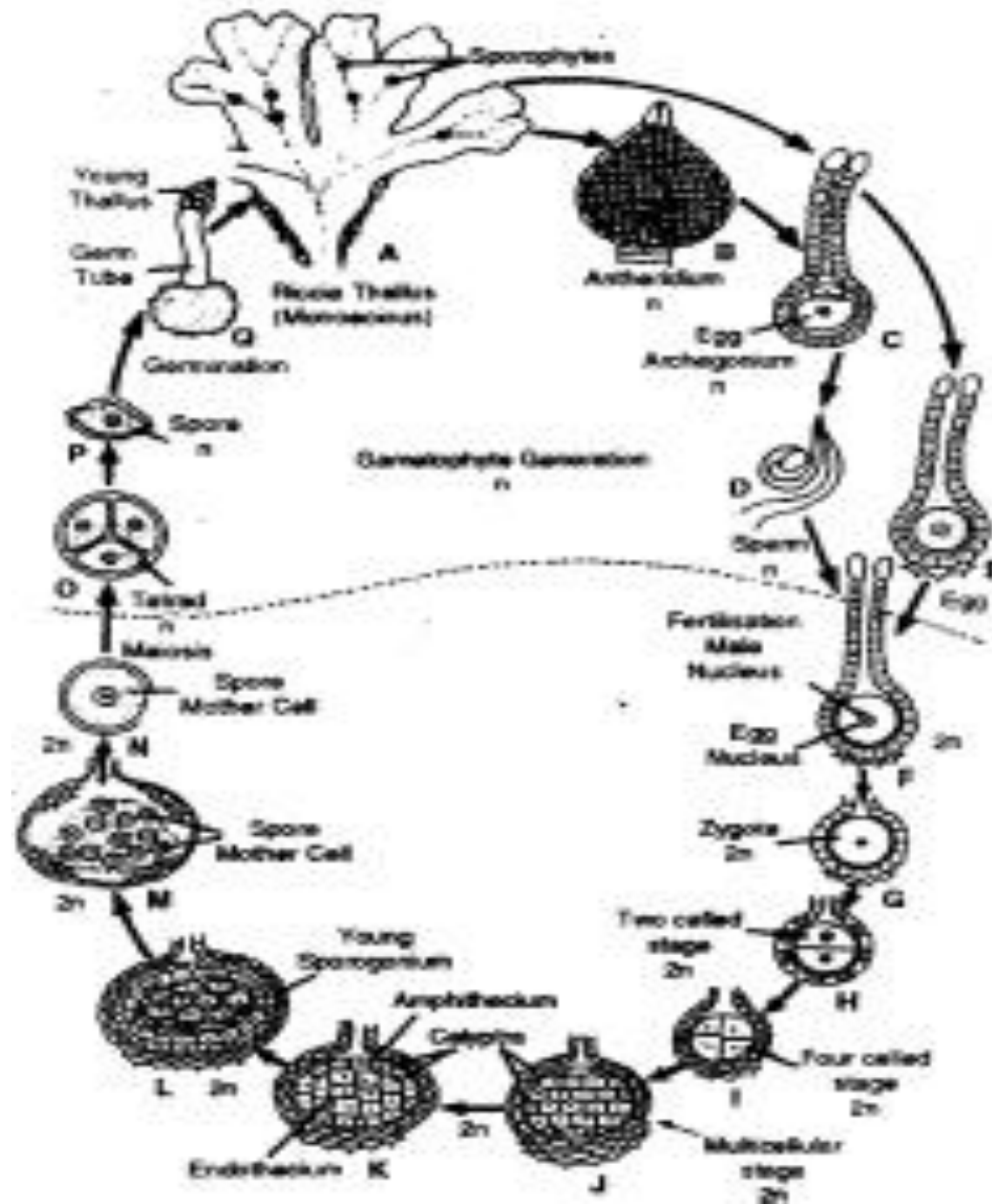
- Upper part of the neck of archegonium generally protrudes out of the cavity.
- An archegonium is a flask-shaped structure made up of a long, elongated neck and a globular venter which is sessile and surrounded by a one-celled thick layer, made up of 12 to 20 cells. Neck consists of 4 to 6 neck canal cells, and remains surrounded by six vertical rows of cells.
- At the tip of the neck are present four cover cells or lid cells. Venter contains an upper, small ventral canal cell and a lower, large egg cell.
- **Fertilization** all the cells, except the egg, disintegrate and form a mucilaginous liquid, which gives entry to the spermatozoids. The ultimate product of the fertilization is zygote.



- **Fertilization:** Many antherozoids enter the archegonial neck because of the chemotactic response and reach up to egg. One of the antherozoids penetrates the egg and fertilization is effected. The fusion of the nuclei of male and female gamete results in the formation of diploid zygote or oospore. Fertilization ends the gametophytic phase.

Sporogonium:

- It is simple and made up of only capsule or spore-sac. **Foot and seta are absent.** It remains embedded in the gametophyte, and it is a non-green structure, thus depending entirely on the gametophyte for food.
- Inside sporogonium are present many spore mother cells which remain surrounded by a capsule wall and two-layered calyptra. Spore mother cells divide reductionally and each of them thus forms four haploid spores, arranged tetrahedrally. **Elaters are absent.** Neck of the long archegonium may remain outside for some time but it ultimately withers.
- **Spore:** is the first cell of the gametophytic generation. Shape of the spore is rounded or pyramidal with a thick, black or sculptured wall. Wall of the spore consists of three layers: outermost exine or exosporium, which is thick and sculptured; middle thin mesosporium and: innermost, thin intine or endosporium
- They germinate into gametophyte.



Anthoceros

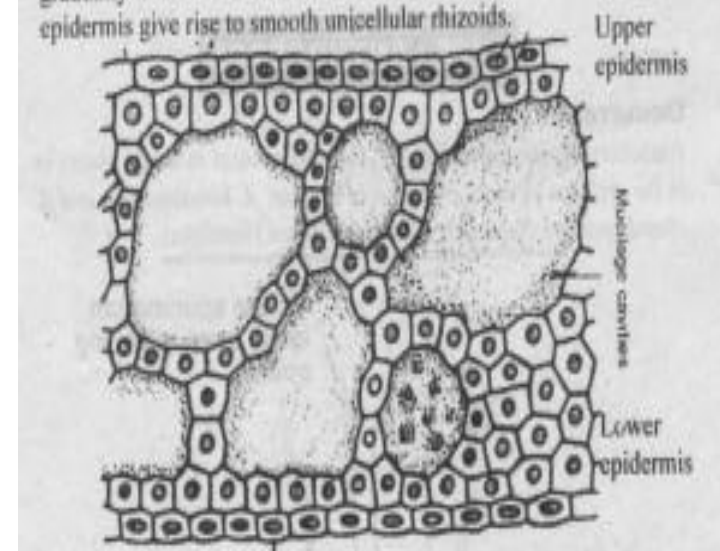
Division	:	Bryophyta
Class	:	Anthocerotopsida
Order	:	Anthocerotales
Family	:	Anthocerotaceae
Genus	:	<i>Anthoceros</i>

thallus body. It is lobed and it has irregular or dichotomous branches. The lobes have a wavy margin. Anthoceros form small rosette like plant. Unicellular rhizoids are attached to the underside of the thallus. Small mucilaginous cavities are present on the ventral side. These cavities contain colonies of a blue green alga like Nostoc. Stomata like small slits are present on the dorsal side of the thallus. Mucilage oozes out through these slits.



Internal Structure of the thallus

The thallus has uniform tissue of parenchymatous cells. Epidermis is present on both sides. The cells in the upper region contain the chloroplasts. Generally each cell contains a single chloroplast. Each chloroplast has a pyrenoid. The thallus is thickest in the middle. It gradually becomes thinner towards the margins. Cells of the lower epidermis give rise to smooth unicellular rhizoids.



Reproduction

Vegetative Reproduction

Death of older parts: takes place by the death of older parts. Younger parts form new thallus.

Tuber: Some thallus forms tubers. These tubers are rich in stored fats and proteins. These tubers germinate to on the margin of the lobes. They can survive long periods of drought. Tuber detach and from new plants.

Gemmae: Gemmae are also produced on short stalks on the upper surface of the thallus. These are also act as vegetative reproductive bodies.

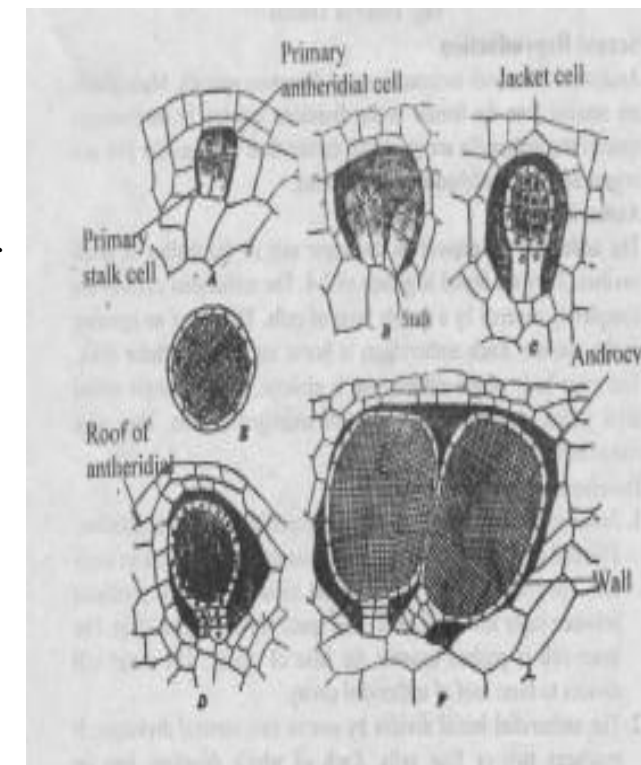
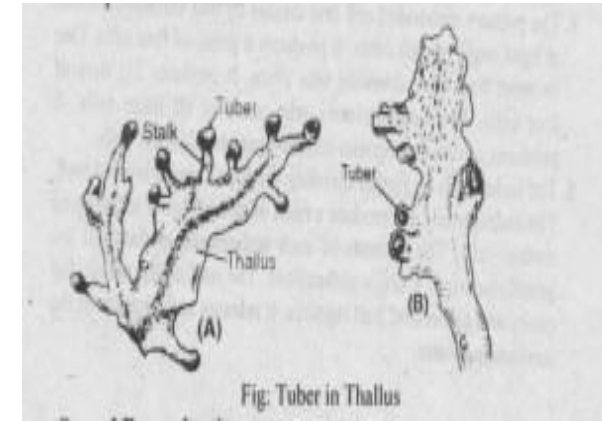
Sexual Reproduction

Anthoceros has both monoecious and dioecious species. Male plants are smaller than the female in the dioecious species. In monoecious species the antheridia are produced earlier than archegonia. The sex organs are deeply embedded in the thallus.

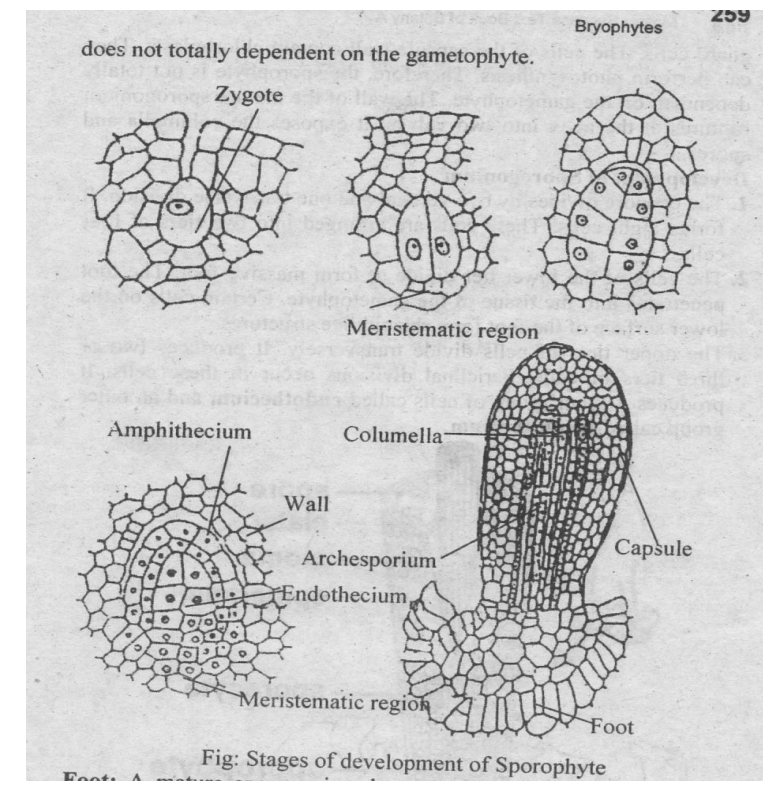
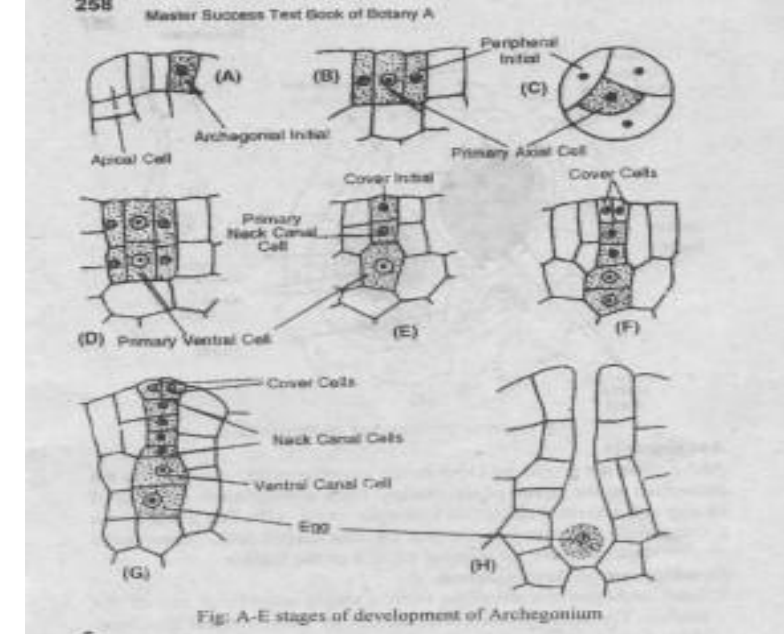
Antheridia

The antheridia are present on the upper side of the thallus in small cavities. They are found in groups of 2-4. The antheridial cavities are completely covered by a double layer of cells. They have no opening to the outside. Each antheridium is borne on a multicellular stalk. The main body of the antheridium is globose. It has a single celled thick jacket. Antheridia have mass of androgonial cells. They give rise to biflagellate antherozoids.

Archegonia: Archegonia are produced close to the growing point and are embedded in the tissue of the thallus. Each archegonium consists of an egg and a ventral canal cell four neck canal cells. The canal of the archegonium is closed at the top by four cover cells. These cells project slightly above the general surface of the thallus. Each archegonium develops from a single superficial cell of the thallus. The archegonial initial divides by three vertical divisions. It produces a large axial cell and three peripheral jacket initials.



- The axial cell divides transversely into a lower primary ventral cell and an upper primary canal cell. The primary ventral cell divides transversely. It produces a larger egg or oosphere at the base and a small **ventral canal cell** at the top.
- The primary canal cell divides transversely to produce four **neck canal cells**. The cover cell divides vertically twice to produce four **cover cells**. The neck canal cells and ventral canal cells produce a mass of mucilage at maturity. It forms an opening for the release of antherozoids.
- **Fertilization:** The plant becomes wet with dew or rain during fertilization. The antherozoids are attracted towards the archegonium chemotactically. Antherozoids enter the archegonium through the neck canal. One of them fuses with the egg to complete the fertilization. The zygote increases in size and completely fills the venter. It secretes a wall to become the oospore.
- **Sporophyte or Sporogonium:** The sporophyte of Anthoceros has certain unique features. Sporogonium is borne on the gametophyte. But mature sporogonium does not totally depend on the gametophyte.
- **Foot:** A mature sporogonium has a well developed cup-like foot. This foot has few rhizoids at the base.
- **Capsule:** Capsule forms the upper part of the sporogonium. It is long, narrow and cylindrical. It has no distinct seta. The cells in the basal part of the capsule are meristematic. Therefore, capsule continues to grow. A columella is present in the centre of the capsule. A narrow region encircles the columella. This region contains spores and multicellular elaters. The wall of the mature sporogonium is several cells in thickness. The outer most epidermal layer has cutinized walls. The epidermis has small stomata with guard cells. The cells of the capsule wall contain chloroplasts. They can perform photosynthesis. Therefore, the sporophyte is not totally dependent on the gametophyte. The wall of the mature sporogonium ruptures at the apex into two valves. It exposes the columella and spores.



Spore Germination

Each spore has an outer thick wall exosporium and an inner thin wall **endosporium**. The spores undergo a period of rest of few weeks or months. The outer wall ruptures during germination. The inner wall protrudes out to form protonema. The cells of the protonema become green. The apical cell of protonema form thallus. Since rhizoids come out from certain cells of the lower surface. They fix the thallus to the soil. Some mucilaginous cavities also develop at the lower side. Nostoc filaments enter through these tubes.

Apospory

Certain cells of the sporophyte can develop into gametophytes directly under certain conditions. This phenomenon is called apospory. It produces diploid gametophyte.

Alternation of Generation

Anthoceros shows heteromorphic alternation of generation. Thallus is a gametophyte. It develops sex organs which produce the gametes. The gametes fuse to form oospore. Oospore gives rise to the sporophyte. The sporophytes are semi-independent. The tissue of the sporophyte is diploid. The spore mother cells undergo meiosis and give rise to spores. Spores germinate to form haploid gametophyte.

