B. Sc. (BOTANY)) SEMESTER-I, PAPER-II

Unit III (BRYOPHYTA)

Bryophyta:–Classification (Proskauer 1957), General characters (Hepaticopsida, Anthocerotopsida and Bryopsida), Economic importance, and alteration of generation

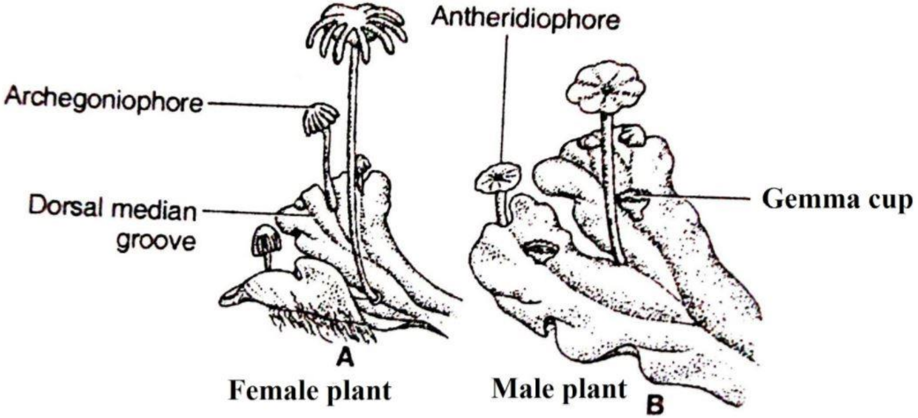
Life history of:-

Marchantia,

Anthoceros,

Funaria

MARCHANTIA



Antheridiophore
Archegoniophore
Dorsal median groove
Gemma cup
A
Female plant
Male plant
B

3
2
1
4

- Marchantia Characteristics
- The common habitat is moist and shady places.
- The plant body is thalloid. The thallus is dorsiventral, flat and dichotomously branched. The gametophyte is the dominant phase of plant life.
- The dorsal surface contains diamond-shaped markings, which has central pore in the middle for gaseous exchange. There are chambers present internally beneath the polygonal markings.
- The ventral surface contains scales and rhizoids. The rhizoids are unicellular and the root-like structure. The main function is to anchor the plant to the substratum and absorb water and minerals.

- The reproductive bodies are present on the dorsal surface.
- They bear a cup-shaped structure called gemmae for asexual reproduction.
- Sexual reproductive organs are born on the stalks called antheridiophore and archegoniophore. They contain male and female reproductive organs called antheridia and archegonia, respectively.
- The upper epidermis consists of air pores, which open in the air chamber present in the photosynthetic zone. The upper epidermis also contains few chloroplasts.
- Beneath the air chamber and photosynthetic zone lies the storage zone. It lacks chloroplasts and is made up of parenchymatous cells. They store protein, starch, oil and mucilage.
- The rhizoids and scales are extended from the lower epidermis.

Anatomy / Internal Structures:

i. **Epidermal Region:** Outermost region: upper and lower Numerous air pores analogous to the stomata in higher plants; Rhizoids and scales on lower epidermis.

ii. Photosynthetic Region: Just beneath the upper epidermis. Simple or branched photosynthetic filaments. Composed of Chlorophyll containing cells.

iii. Storage Region: . Just below the photosynthetic region. Compact zone of several layers of polygonal parenchymatous cells. Achlorophyllous without intercellular spaces. Mostly contain starch or protein granules, mucilage and oil.

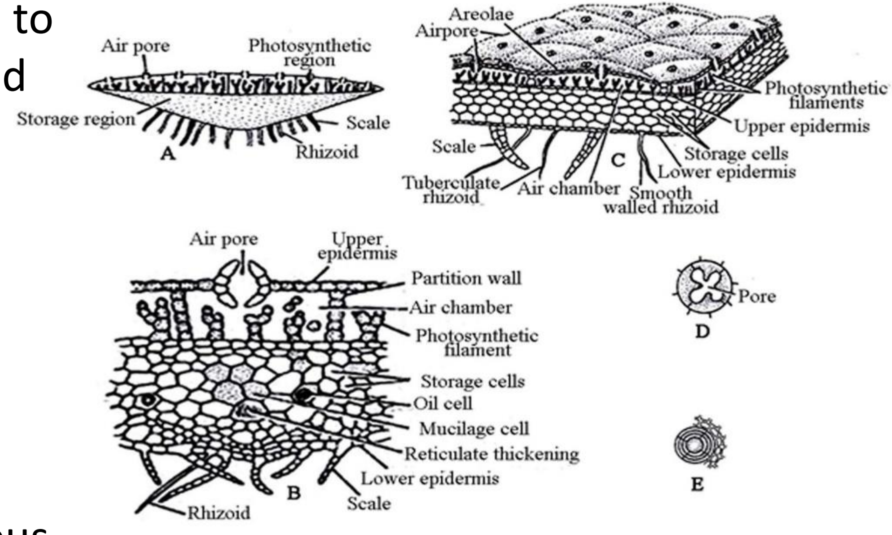


Fig: ***Marchantia.*** Internal structure of the thallus. **(A)** Vertical transverse section (diagramatic), **(B)** V.T.S of thallus (cellular), **(C)** V.T.S of thallus (3-dimensional view), **(D)** Air pore (ventral view), **(E)** Air pore (dorsal view).

Asexual Reproduction

Asexual reproduction in *Marchantia* is by fragmentation or by forming specialised structures known as gemmae.

Gemmae

They reproduce asexually by gemmae, which are asexual buds. They are formed in the receptacles known as gemma cups. Gemma cups are present on the dorsal surface, near the midrib of the gametophytic thalli. Gemmae are multicellular and green.
Gemmae detach from the parent plant and germinate to give rise to the new plant.

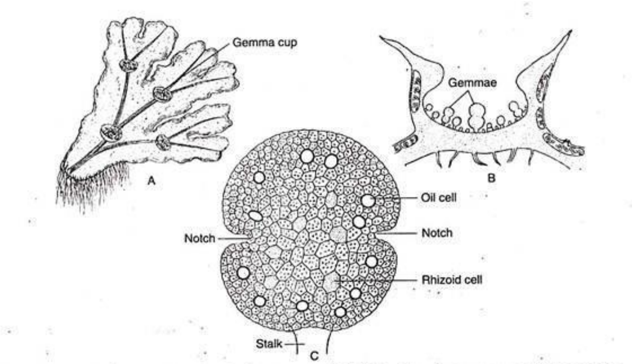


Fig. 6.11 : *Marchantia* : A. Thallus showing gemma cups. B. Vertical section of a gemma cup showing gemmae. C. A single gemma highly magnified

i. **Antheridiophore:** Arises at the apical notch. 1-3 cm long stalk 8-lobed peltate disc at its apex. Each lobe on the peltate disc have numerous minute cavities on the u.s. Antheridial chambers embedded in the photosynthetic region. Each antheridial chamber contains a single antheridium.

ii. **Archegoniophore:** Arises at the apical notch. 3-5 cm stalk and a terminal disc. Disc is star shaped with 8-9 radiating arms or 'Rays,' Each ray contains a row of 12-14 archegonia embedded in a fertile pocket along the ventral ridge.

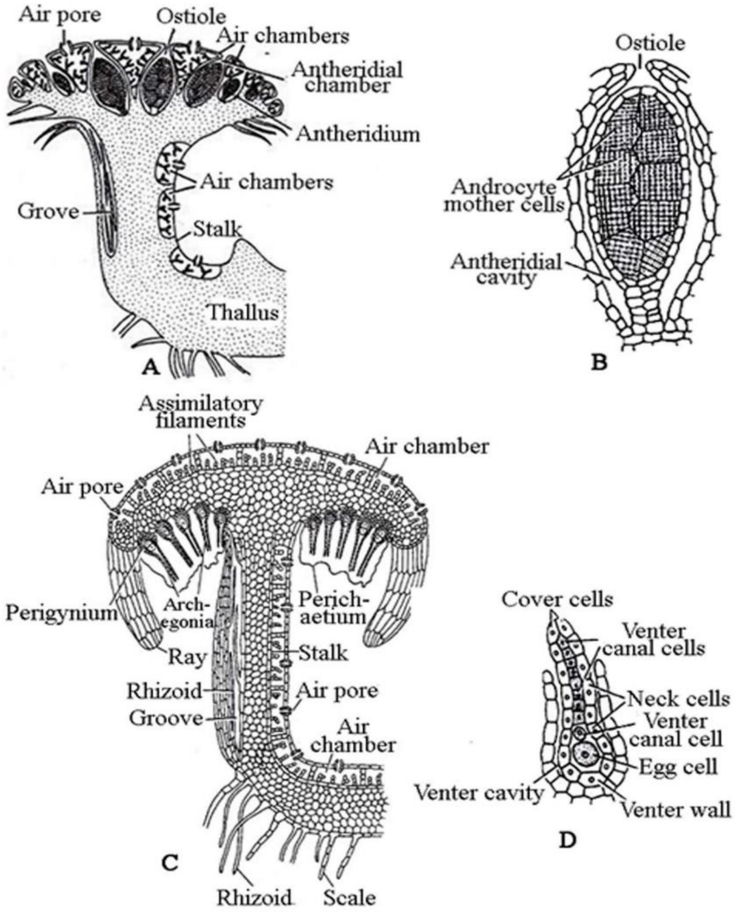


Fig: (A) Antheridiophore, (B) Antheridium), (C) Archegoniophore, (D) Archegonium.

Sporophyte

The diploid zygote does not undergo meiosis (reduction division) immediately. It rather divides mitotically and develops into a multicellular structure called the sporophyte. The sporophyte is differentiated into foot, seta and capsule. It is not the free-living stage, it is dependent on the gametophyte for nourishment.

Some of the cells of sporogenous tissue called spore mother cells (diploid) divide meiotically to produce haploid spores.

These haploid spores are released by the dehiscence of the capsule. Under favourable conditions, they germinate to form the new haploid plant or gametophyte.

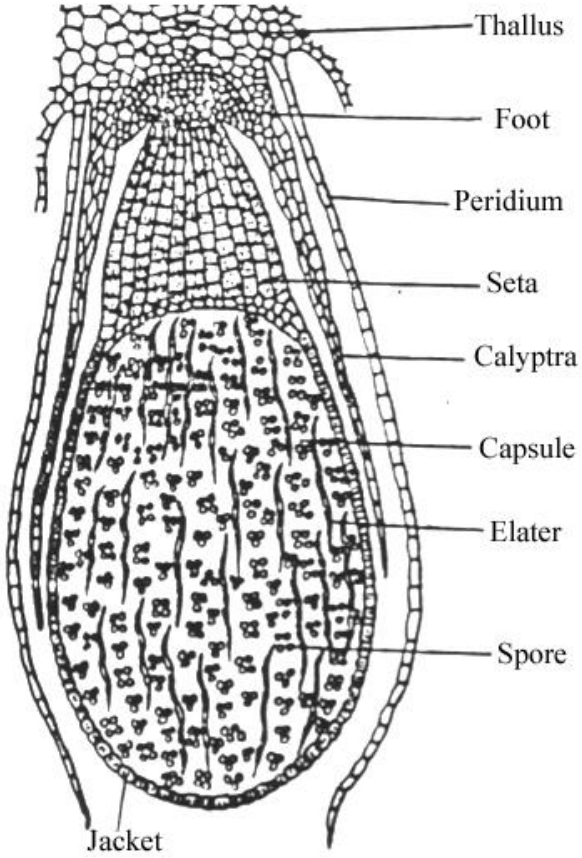


Fig: *Marchantia spp.* Structure of mature sporophyte.

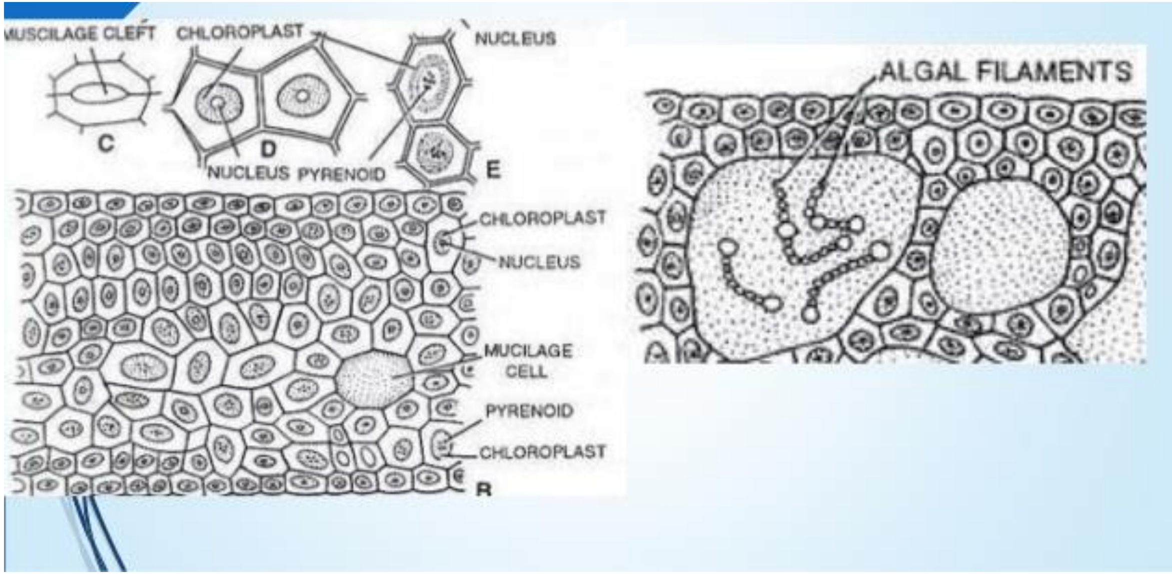
ANTHOCEROS

General structure

Anthoceros has 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 thallu' s. 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

1. Death of older pans: Vegetative reproduction takes place by the death of older parts. Younger parts form new thallus.

2. 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.

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

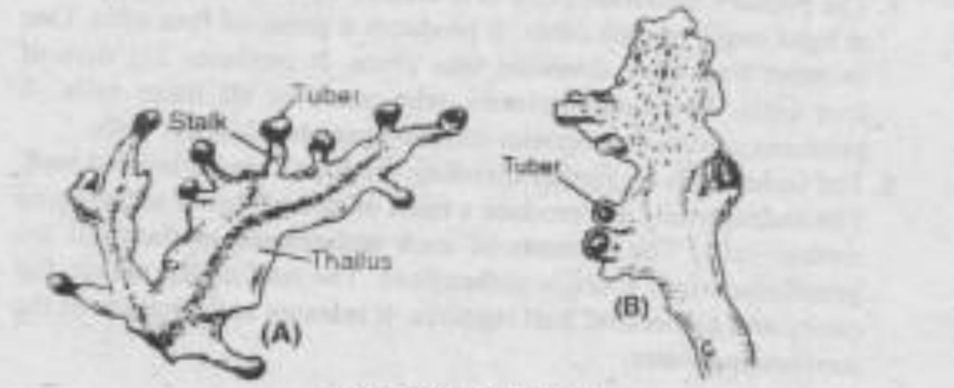


Fig: Tuber in Thallus

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 rnulticellular 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

Development of Antheridium

I. Antheridium develops from a single superficial cell of the thallus. This cell divides by a transverse division into an outer and an inner cell. The inner cell acts as antheridial initial. A space is produced between inner and outer cells. This space is filled by muci I ge.The inner cell is pushed towards the base of cavity. The outer cell divides to form roof of antheridial cavity.

2. The antheridial initial divides by one or two vertical divisions. It produces two or four cells. Each of which develops into an antheridium. Thus it gives rise to a group of antheridia in each cavity.

Archegonia: Archegonia are produced close to the growing point. Archegonia 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.

Development of Archegonium

1. 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.

2. The axial cell divides transversely. It cuts off a small cover cell at the top. It divides into a lower primary ventral cell and an upper primary canal cell.

3. 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.

4. The primary canal cell divides transversely to produce t. row of four **neck canal cells.** The cover cell divides vertically twice to produce four **cover cells. The** neck canal cells and vennal canal cells produces 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 dependent 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 colurrolla. This region contains spores and multicellular elaters**.** The Wall ofthe mature sporogonium is several cells in thickness. The outer most epidermal layer has cutinized walls. The epidermis has small stomata witlf guard cells. The cells of the capsule wall contain chloroplasts. They can perform photosynthesis. Therefore, the sporophyte is nct totally dependent on the gametophyte. The wall of the mature sporogonium ruptures at the apex into two valves. It exposes the columella and spores.

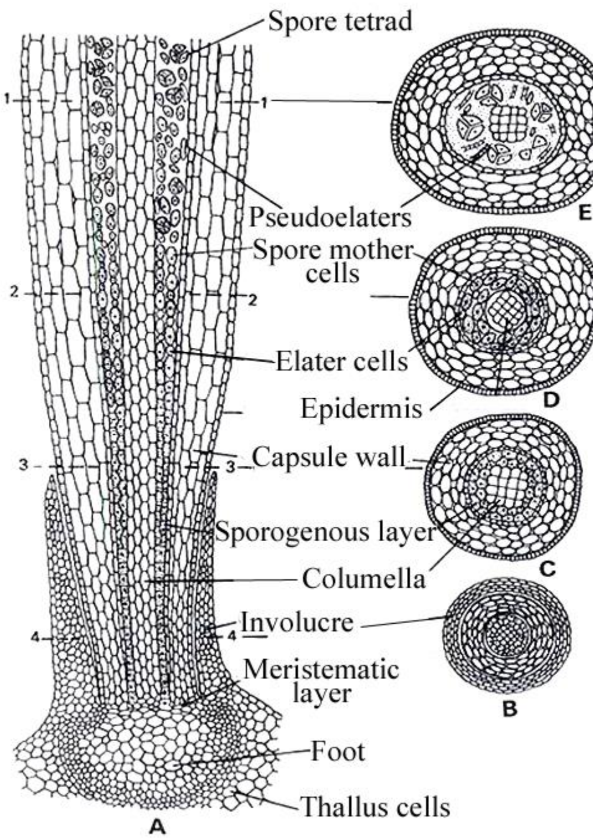


Fig: *Anthoceros*. (A) LS of sporangium; (B-E) Cross section of sporophyte

FUNARIA:

Funaria is commonly called 'cord moss'. It is distributed throughout the world. *Funaria hygrometrica* is the common species. It grows in close tufts on rocks, trunks of trees, damp walls and damp soils. They help in the process of soil formation (Pedogenesis).

The plant body is a gametophyte. It is small, 1 to 3 cm high and consists of slender erect radial stem covered with small, simple leaf like structures arranged in a spiral manner. The gametophyte is attached to the substratum by means of multicellular rhizoids. They are characterized by the presence of oblique septa. The leaves are simple, sessile ovate and have broad membranous base and pointed apex.

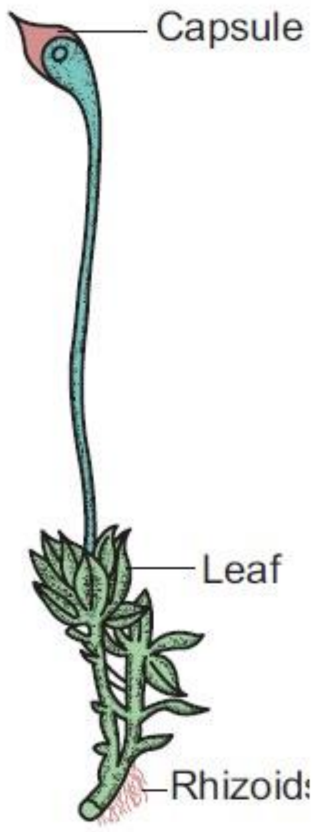


Figure 2.18:
Funaria Habit

Internal structure

T.S. of axis

The T.S. of axis shows the presence of epidermis, cortex and central cylinder. The epidermis is the outermost layer and contain chloroplast bearing cells. The cortex is made up of parenchymatous tissue. The cells of the young axis bear chloroplasts. In mature stems the outermost cells become reddish brown colour and become thick walled. Small leaf traces are also noticed. The central cylinder is made up of long, narrow, thin walled, colourless cells which lack protoplasts. They help in the conduction of water and minerals.

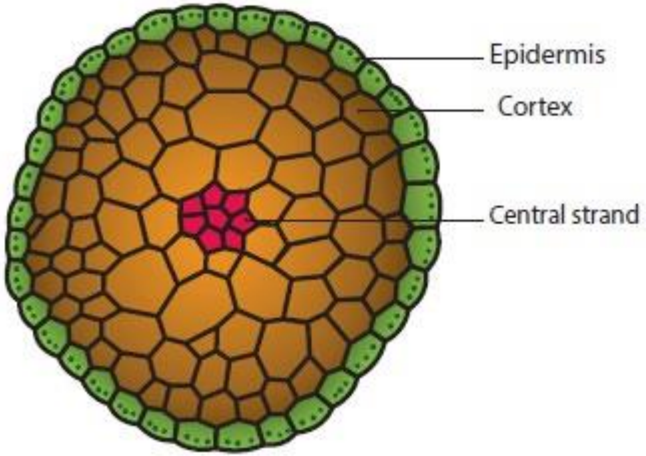
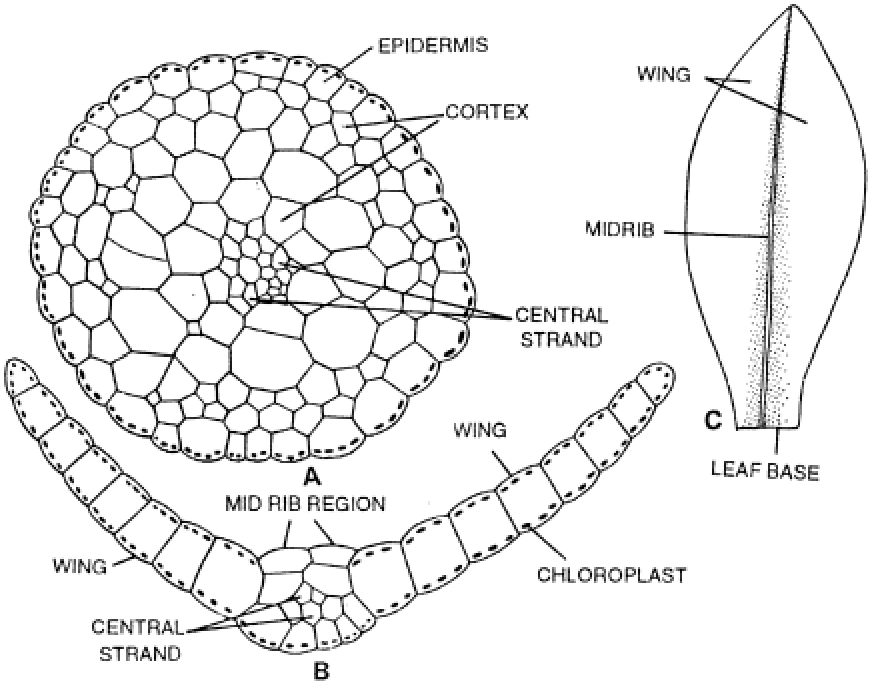


Figure 2.19: T.S. of axis

T.S. of leaf

A well defined midrib is present. It consists of several layers of cells but the lateral 'wing' or lamina is made up of single layer of thin walled cells which are rich in chloroplasts. Midrib contains small strands of slightly thickened narrow cells which help in conduction.



Funaria hygrometrica. Internal structure. A. Transverse section of stem. B. Transverse section of leaf; C. Entire leaf.

Reproduction

Funaria reproduces by vegetative and sexual methods.

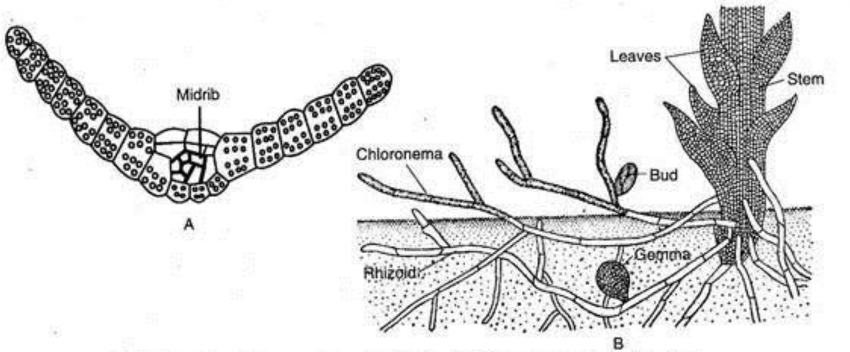


Fig. 6.48 : *Funaria hygrometrica* : A. T.S. of leaf, B. Gemma on gametophyte base.

Vegetative reproduction

(a) Fragmentation of Primary Protonema:

The primary protonema is developed through the germination of the spore. Under certain circumstances, it breaks into several fragments. Each detached fragment bearing buds may grow into a new plant.

(b) Secondary Protonema:

The protonema developing from any part of the plant other than spores are called secondary protonema. Generally, they are formed on injured rhizoids, stems, leaves or reproductive structures. They bear buds that are capable of growing into a new plant

(c) Bulbil:

The bulbils are multicellular, brown, bud-like structures that develop on the rhizoidal branches. The bulbils are useful for propagation during unfavourable environmental conditions by detaching them from the parent plants.

(d) Gemmae:

Gemmae (Fig. 6.48B) are multicellular green bodies formed from the terminal cells of the protonema. They remain dormant throughout the unfavourable condition. However, on return of favourable condition, a gemma detaches from the parent plant body and later germinates into a new plant.

(e) Apospory:

Apospory is the condition in which the haploid (n) gametophyte is developed from the diploid (2n) sporophyte without the formation of spores. In case of Funaria, gametophytic protonema may develop from any unspecialised cells of the sporophyte.

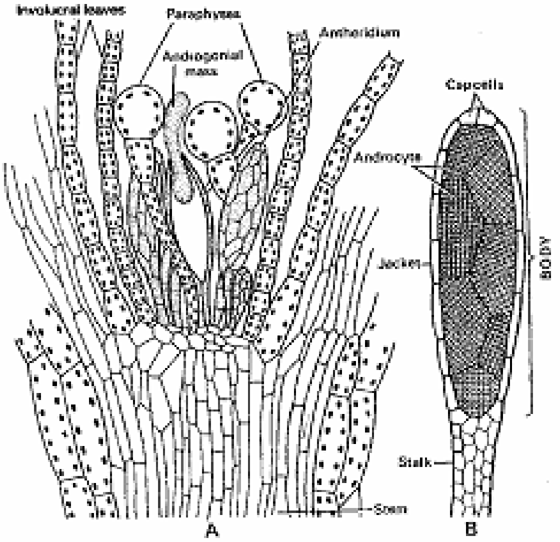
This protonema later, gives rise to gametophyte plant body. Though aposporously develop, gametophytes are normal in appearance, but are diploid (2n). Subsequently, the tetraploid sporophyte develops from the fusion of diploid gametes (2n) are sterile.

Sexual Reproduction in Funaria:

Funaria is autociously monoecious, because the male (antheridium) and female (archaegoni- um) reproductive structures develop on separate shoots of the same plant. Antheridia are borne on the main shoot of the plant. The female branch develops as a side shoot (Fig. 6.53), which grows more vigorously and becomes longer than the male branches.

Antheridium:

The antheridia are borne in clusters at the apex of the main axis. A number of long multicellular hairs, called paraphyses are intermingled with the antheridia (Fig. 6.53). Both antheridia and paraphyses are surrounded by a number of bract-like leaves forming a rosette called the perichaetium.



Moss: A. L.S of antheridial hend, B. L.S. of one antheridium

A mature antheridium has a multicellular long stalk and a red or orange coloured club- shaped body. The apical cell of the jacket forms a thick-walled, hyaline oper- culum or cap of the antheridium.

The dehiscence of the mature antheridium only takes place in presence of water. The opercular cell absorbs dew or rain water and swells up. The pressure thus created ruptures the inner wall and eventually a pore is formed at the distal end of the antheridium.

The androcytes spread out through the pore in the form of a viscous fluid due to the hygroscopic pressure developed within the antheridial cavity

Archegonium:

The archegonia are borne in clusters at the apex of the archegonial branch (Fig. 6.53).

Development of the Archegonium:

A cell at the tip of the female shoot differentiates into the archegonial initial. It divides transversely to form a upper cell and a lower cell (Fig. 6.49I, J). The upper cell becomes the archegonial mother cell which divides by two intersecting oblique walls forming an apical cell with two cutting faces (Fig. 6.49K).

The apical cell further divides by three intersecting oblique walls to form three peripheral cells surrounding a central axial cell (Fig. 6.49L). The peripheral cells divide anticlinally to form a single-layered jacket (Fig. 6.49M) which, by further divisions, becomes double-layered.

The axial cell divides by a transverse wall to form an outer primary cover cell and an inner central cell (Fig. 6.49N, O). The central cell, by further transverse division gives rise to an outer primary neck canal cell and an inner primary ventral cell.

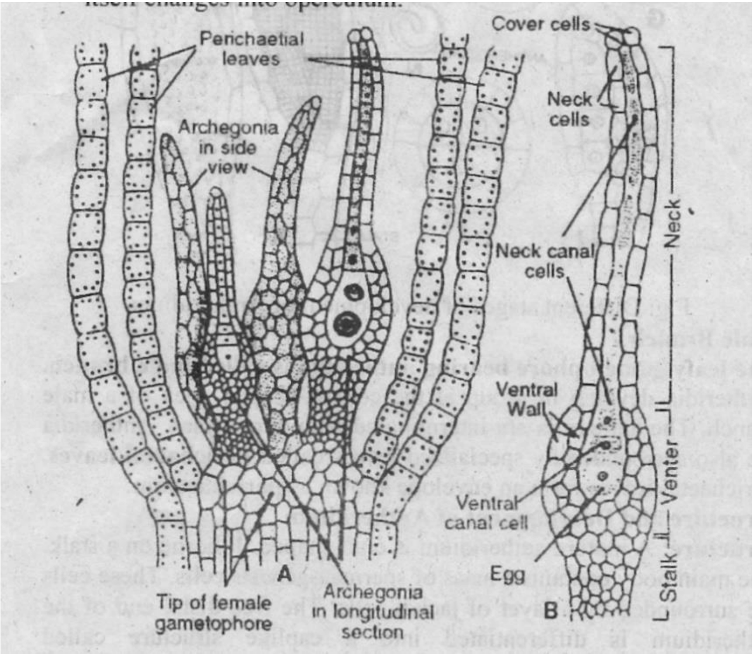
Primary neck canal cell, by further transverse divisions, forms a row of neck canal cells. The primary ventral cell, by further transverse divisions, forms a ventral canal cell and an egg (Fig. 6.49P, Q).

The primary cover cell cuts off successively three lateral segments and a basal segment. The' lateral segments form the jacket of the neck, while the fourth basal segment forms neck canal cells.

Thus, the single-layered long neck of the archegonium of Funaria have double origin, one from primary cover cell and the other from central cell.

Mature Archegonium:

The mature archegonium consists of a long stalk, a basal swollen venter and an elongated neck (Fig. 6.49Q & 6.53). The twisted and tubular neck encloses 4 to 10 or more neck canal cells. The archegonial jacket is single-layered thick in the neck region, but it is double-layered in the region of the venter. The venter contains a ventral canal cell and an egg.



Fertilisation of Archegonium:

During fertilisation, the ventral canal cell and the neck canal cells of the archegonium disintegrate forming a mucilaginous substance. This mucilaginous substance absorbs water accumulated as rain or dew water, then swells up and the resultant pressure breaks apart the terminal cover cell. Now sugar containing mucilaginous substances ooze out through the opening of the archegonial neck.

The liberated antherozoids are now attracted chemotactically towards the archegonia. A large numbers of antherozoids enter the neck, but only one of them fuses with the egg nucleus to form the diploid zygote.

The Sporophyte:

The fertilised egg or zygote is the first cell of the sporophytic generation. The zygote swells up, increases in size and forms a wall around it prior to further divisions.

Structure of the Mature Sporophyte:

The mature sporophyte of Funaria is differentiated into a foot, a long seta and a pear-shaped capsule at the tip.

1. Foot:

It is a poorly developed conical structure, embedded in the apex of archegonial branch.

2. Seta:

Seta is long, green in colour when young, but becomes reddish brown at maturity. T.S. of seta shows a single-layered epidermis, a central conducting strand of thin-walled cells surrounded by a cortex made up of comparatively thick-walled cells (Fig. 6.50A). Seta helps in conduction of nutrients and water from gametophyte to capsule.

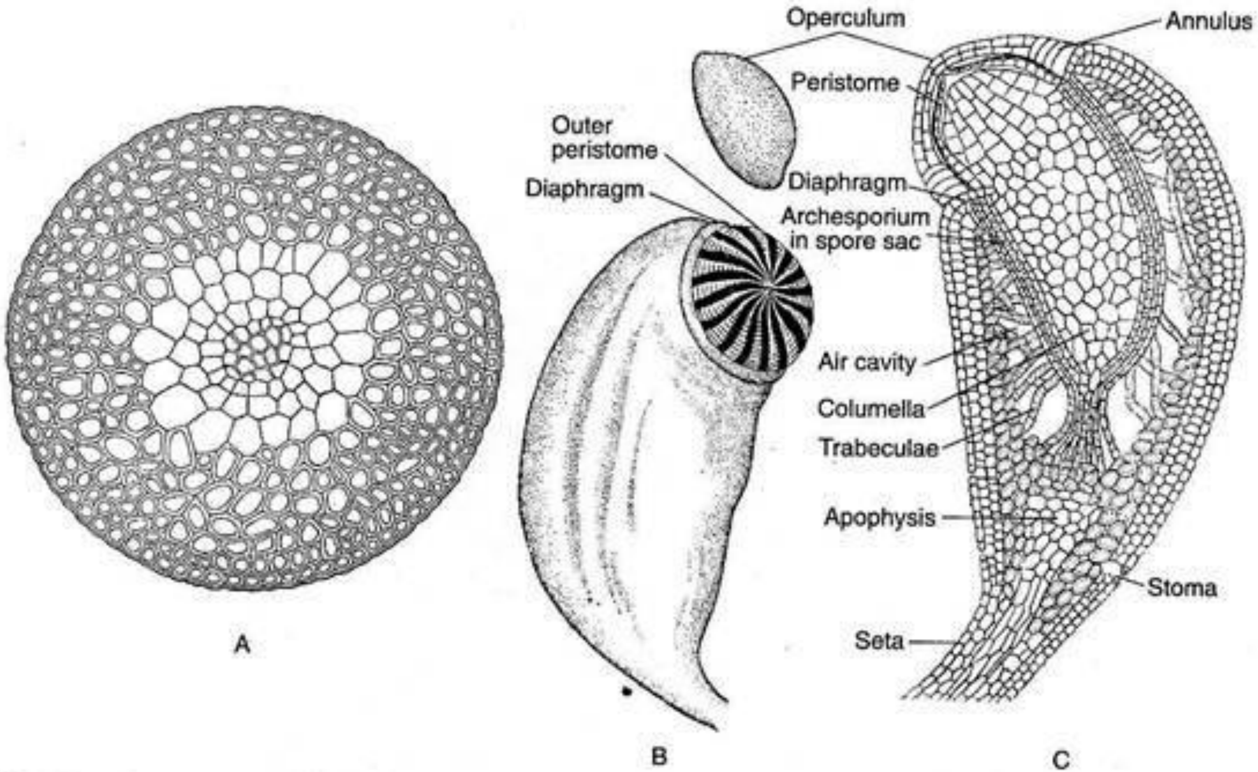


Fig. 6.50 : *Funaria hygrometrica* : A. T.S. of seta, B. Mature capsule with operculum removed (shown on side), C. L.S. of capsule

3. Capsule:

The mature capsule is pear shaped, asymmetrical (Fig. 6.50B, C). Internally, it is divided into three distinct parts viz., the sterile basal region, the apophysis, the central fertile region, the theca and the apical region.

Apophysis:

The lowermost part of the capsule is the apophysis or the neck that connects it with the seta below. The axis of the apophysis shows in the lower part a central strand of thin-walled elongated cells connected with the similar tissue of the seta.

Loosely arranged chlorophyllous cells are bounded by a rather thick-walled epidermis which is interrupted by the stomata (Fig. 6.50C).

The presence of chlorophyllous tissue in the apophysis makes the sporophyte carry out photosynthesis. Therefore, the sporophyte of Funaria is not fully dependent on the gametophyte for nutrition.

The Theca or Fertile Zone:

The central zone of the capsule situated in between the apophysis and the operculum is called the theca.

It is a slightly bent cylindrical structure, fertile in nature and has four distinct regions:

(a) Capsule wall,

(b) Spore-sacs

(c) Air chamber and

(d) Columella.

(a) Capsule Wall:

The capsule wall is many-layered. The single-layered outermost wall forms the epidermis which is followed by a 2-3 layered parenchymatous hypodermis (Fig. 6.50C). The inner 2-3 layers of parenchymatous cells are chlorophyllous, which constitute the photosynthetic tissue of the capsule.

(b) Spore Sacs:

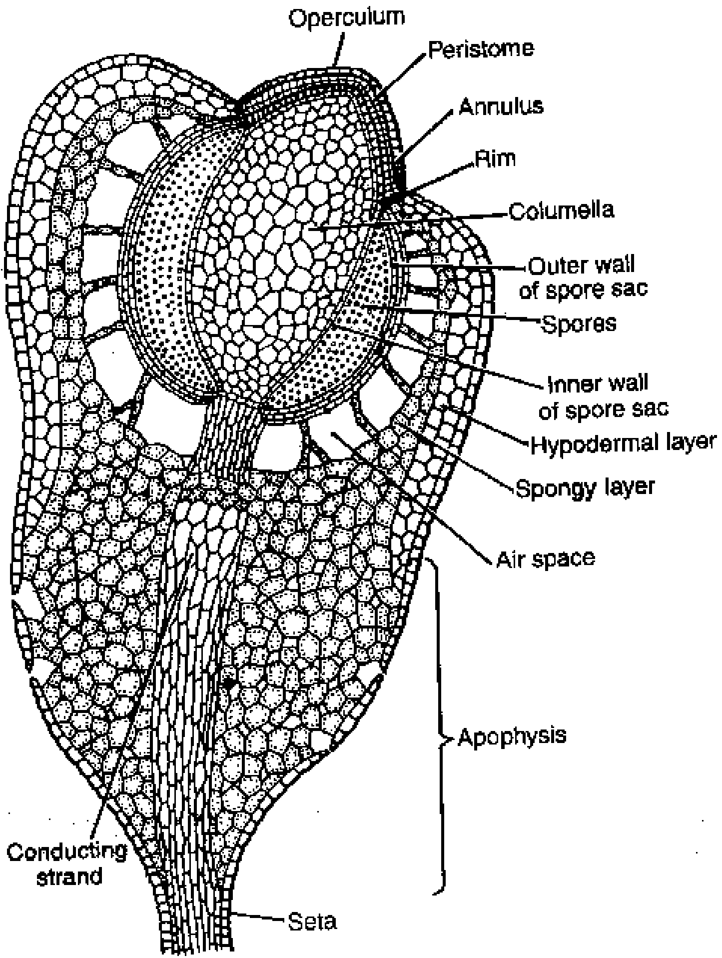
The columella is surrounded by two elongated spore-sacs (Fig. 6.50C). The spore-sac has a inner wall of one layer of small cells and an outer wall of 3 to 4 layers of such cells. The spore sacs are formed from the single layered archesporium. Archesporium first develops 6-8 layers of sporogenous cells. The sporogenous layer becomes a spore-sac by the production of spores from spore mother cells through meiotic divisions.

(c) Air Chamber:

The outer wall of the spore-sac is followed by a big cylindrical air chamber. It is traversed by strings of filaments of elongated green cells, known as trabeculae which bridges the air space between the outer wall of the spore-sac and the innermost layer of the capsule wall (Fig. 6.50C).

(d) Columella:

It is the central, axial part of the fertile zone, comprising of thin-walled, colourless, compact, parenchymatous cells, constricted at the base just above the apophysis (Fig. 6.50C). The distal part of the columella is cone-shaped which projects into the concavity of the operculum. The columella serves the purpose of conduction of water and nutrients to the growing sporophyte.


Operculum
Peristome
Annulus
Rim
Columella
Outer wall
of spore sac
Spores
Inner wall
of spore sac
Hypodermal layer
Spongy layer
Air space
Apophysis
Conducting
strand
Seta

The Apical Region:

The apical region of the capsule is a complicated structure. This joins the capsule proper through a notch (Fig. 6.50B, C). An annular rim (or diaphragm) of 2-3 layers of radially elongated small cells is present at this notch. The diaphragm demarcates the upper limit of the theca proper.

The operculum is an obliquely placed, dome-shaped lid that closes the mouth of the capsule (Fig. 6.50B). It is composed of 2 to 3 layers of thin-walled parenchymatous cells (Fig. 6.50C). The lower part of the operculum forms a ring of slightly large conspicuous cells, the annulus. The operculum keeps the peristome teeth covered, while the annulus helps in the dehiscence of the capsule.

The peristome teeth lies just below the operculum and are attached beneath the edge of the diaphragm. It consists of two rings of long triangular teeth, one within the other (Fig. 6.51 A, B). The teeth are not cellular in nature and are made up of cuticle.

Each ring of peristome possesses 16 teeth. The outer teeth (exostome) are larger, thicker, brown in colour and ornamented with transverse thickening bands. The inner peristome teeth (endostome) are small, delicate and of a pale colour.

The whole structure is called peristome which is epicranoid in nature, because the outer peristome teeth are superposed on the inner ring. The tapering distal ends of the outer peristome teeth are joined to a centrally placed disc of tissue (Fig. 6.50B & 6.51 A).

Dehiscence of the Capsule and the Dispersal of Spores:

At maturity, the operculum begins to dry up due to the non-availability of water supply to the capsule. Consequently, the thin-walled cells of the operculum, including the annulus which hold the operculum in place, shrink and shrivel. Ultimately, the annulus breaks and the loosened operculum is thrown away leaving the peristome teeth exposed (Fig. 6.50B).

The peristome teeth are twisted spirally appearing like an iris diaphragm (Fig. 6.50B).

THE END