Course: B.SC.Botany
Semester: II
Paper Code: BOT CC-204
Paper Name: Archegoniate
Topic: Funaria
Faculty Name: Dr.Anjana Verma
Department : Botany
Email Id: anjana.nath.verma@gmail.com

FUNARIA (MOSS)

Systematic position: KINGDOM PLANTAE
DIVISION BRYOPHYTA
CLASS BRYOPSIDA
SUBCLASS EUBRYA
ORDER FUNARIALES
FAMILY FUNARIACEAE
GENUS FUNARIA

Habit and Distribution

The genus is cosmopolitan in its distribution. It includes 117 species. F.*hygrometrica* is the most common moss which is found all over the world. The mosses grow luxuriantly in

humus soil and on the soil burnt by fire. They grow well on damp rocks and wall. The green protonema grows on the newly ploughed fields while some are epiphytic and grows well on tree trunks.

External structure of the gametophyte

The plant body is gametophytic and consists of two different stages :

1. **Juvenile stage** represented by primary protonema
2. **The leafy gametophyte** which is the adult form, differentiated into rhizoids, stem and leaves. Rhizoids arise from the base of the axis/ stem. They are slender, branched and multicellular and have oblique septa.

   Axis/ stem are 1-3 cm high, upright, slender and branched. Each branch is extra axillary i.e. arise below a leaf.

   Leaves are sessile, oblong-ovate with entire margin and pointed apex.

   Each leaf is traversed by a single mid rib. Leaves are borne in 1/3 phyllotaxy becomes 3/8 at maturity.

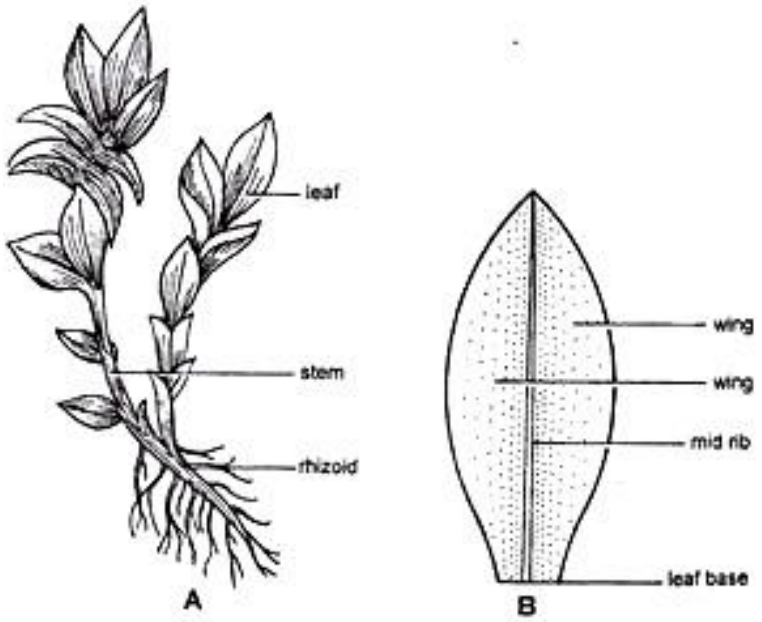

Fig. 1. (A, B). *Funaria*. (A) A plant, (B) Outline sketch of a leaf.

Internal structure of the gametophyte

Axis/ stem The transverse section of axis is differentiated into three distinct regions

1. **Epidermis** is the outer most single layered protective covering consisting of small tangentially elongated chlorophyll bearing cells. Cuticle and stomata are absent.
2. **Cortex** is present between the epidermis and conducting tissue. It is parenchymatous cells. Younger pary of the cortex contains chloroplasts but in older part they are lacking.
3. **Central** conducting strand is made up of long, narrow, thin walled dead cells which lack protoplasm. These cells are now called as hydroids. They are mechanical as well as conducting tissue which functions in the upward movement of water and solutes.

Leaf

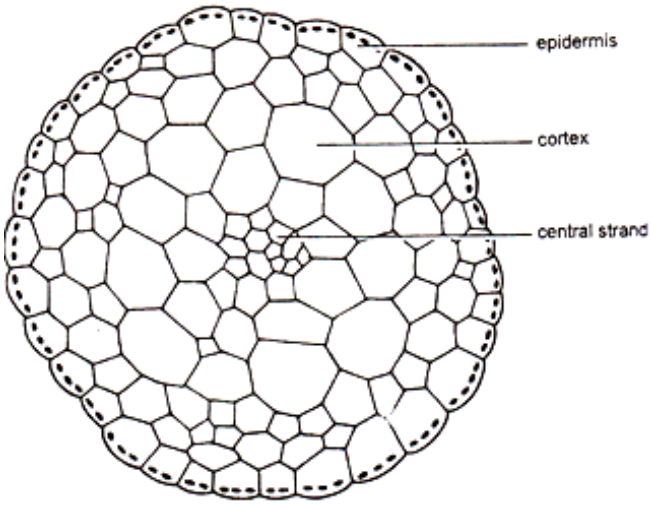

Fig. 2. *Funaria*. Transverse section (T.S.) of axis.

Transverse section of leaf shows a well–defined midrib with lateral wings. Except the midrib region, the leaf is composed of single layer of parenchymatous polygonal cells. The cells contain many large and prominent chloroplasts. The central part of the midrib has narrow conducting strand of thick walled cells which help in conduction.

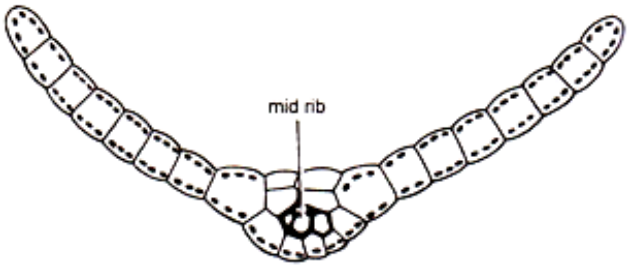

Fig. 3. *Funaria*. Transverse section (T.S.) of 'leaf'

REPRODUCTION

Vegitative reproduction In moss the vegetative reproduction takes place by means of various methods :

1. By multiplication of primary protonema

In Funaria spores on germination form a branched, filamentous, multicellular structure. It is pr. protonema which certain colorless separations are formed by intercalary divisions. These cells die out and break up the protonema into many fragments. These fragments grows into new protonema cotaining buds which develops into leafy gametophytes.

2. By secondary protonema

When protonema is developed by other than the germination of the spore the it is called as sec. protonema. It may develop from any detached living part of the gametophyte.

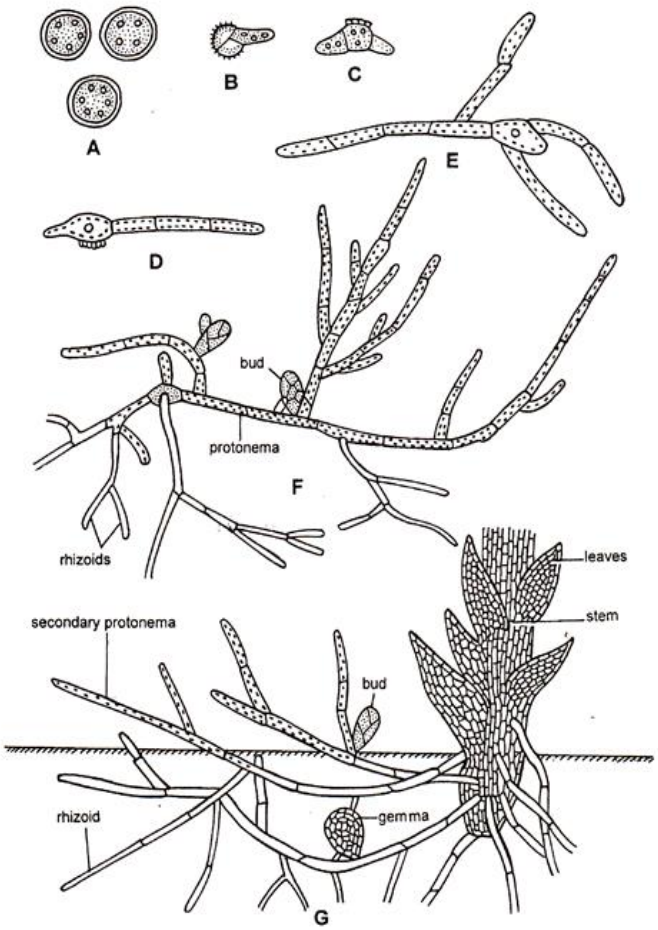

Fig. 16. (A–G). *Funaria*. (A–G). (A) spores, (B–F) Stages in the germination of spores and formation of primary protonema, (G) Secondary protonema.

3. By Gemmae

Durimg unfavorable condition the terminal cells of the protonemal branches divide by trnsverse, longitudinal divisions and form green multicellular bodies of 10-30 cells. These are called gemmae. At maturity gemmae become slightly reddish brown in color. On the return of favourable conditions gemmae germinate and form new plant.

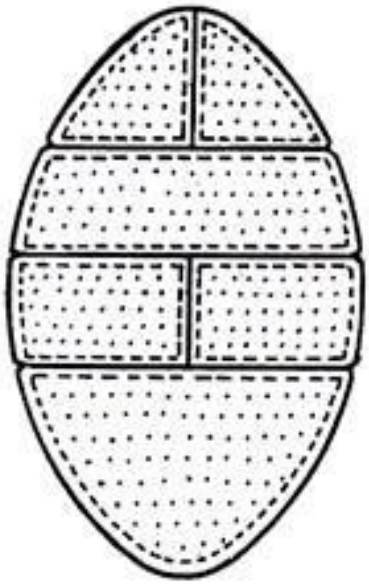

Fig. 4. *Funaria*. Gemma

4. By Bulbils

When such gemmae like structures are produced on rhizoids inside the sustratum these are called bulbils. They are devoid of chloroplasts but capable of developing them into leafy individuals under favourable conditions.

5. Apospory

Development of gametophyte from sporophyte without formation of spores is known as apospory. Any vegetative cell of the sporophyte may form green protonemal filaments which bears lateral buds later develop into leafy gametophyt. The gametophyte thus formed are diploid. Sexual reproduction in such gametophyte results in the formation of tetraploi (4n) zygote capable of bearing spores.

Sexual reproduction

Sexual reproduction is **oogamous**. Male reproductive structure is known as antheridium and female as archegonium. Funaria is **monoecious** (having male and female sex organs on the same thallus) and **autoicous** (antheridia and archegonia develop on separate branches of the same thallus). Sex organs are borne on leafy gametophores in terminal clusters. The main shoot of the leafy gametophore bears antheridia and act as male branch. Female branch develops as a lateral outgrowth from the base of the male branch and bears archegonia. It grows higher than the male branch. Funaria ia **protandrous** (antheridia mature before the archegonia). It ensures the **cross fertilization**.

Male branch or Antheridiophore

Longitudinal section of male branch shows that its apex is expanded and convex shaped. It bears large number of reddish brown or orange antheridia in different stages of development. Projected antheridia are surrounded by rosette of spreading leaves called **perigonial leaves**.

The antheridial cluster with surrounding perigonial leaves is called **perigonium**. The antheridia are intermingled with large number of sterile hair like club shaped structure called **paraphyses** which store water, protect developing antheridia, help in photosynthesis and dehiscence of antheridia.

Structure of an Antheridium

The antheridium is club shaped. It is differetiated into a short **multicellular stalk** and **antheridium body** which has a single layered **jacke**t of polyhedral flattened cells. When young jacket contain chloroplast but turs orange or reddish brown at maturity. Jacket encloses a large number of **androcytes** (antherozoid mother cells).

At maturity the distal end of the antheridium bears one or two thick walled colorless cells called **operculum**. The opercular cells become mucilaginous, absorb water and swell, break connection with the neighbouring cells and form a narrow pore. Androcytes ooze out in the form of viscous fluid through this pore.

Each androcyte mother cell divides further and form two androcytes, each produces a single biflagellate sperm or **antherozoids** or spermatozoid. Each antherozoid is elongated, spirally coiled, biflagellated structure.

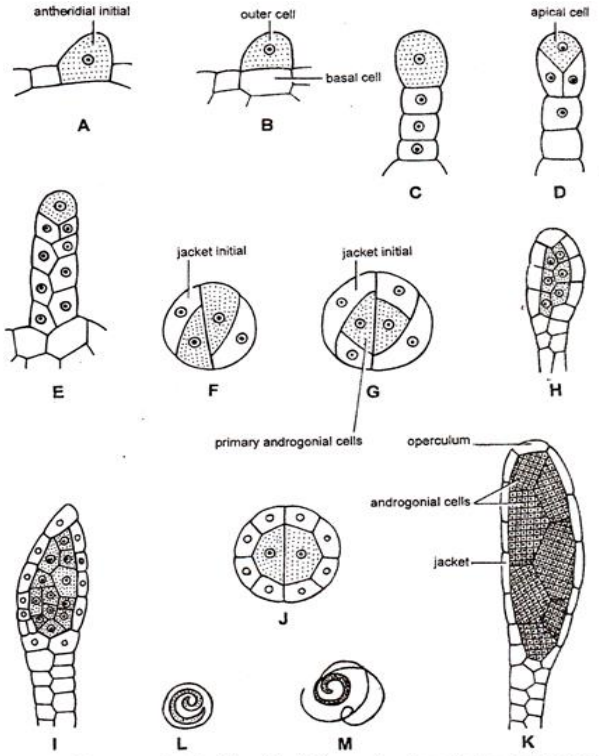

Fig. 6. (A–K). *Funaria.* Development of antheridium. (A–J). Successive stages in the development of antheridium, (K) A mature antheridium, (L) Antherozoid inside the wall of anodrocyte, (M) Free antherozoid.

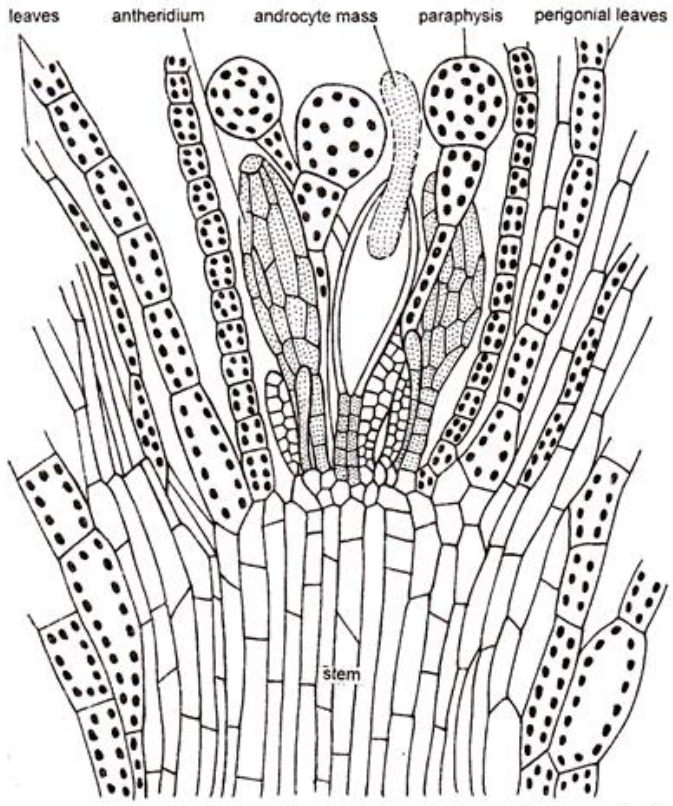

Fig. 5. *Funaria.* Longitudinal Section (L.S.) of male brach showing antheridia.

Female Branch or Archegoniophore

The female branch arises from the base of the male branch. Longitudinal section shows that many archegonia intermingled with **paraphyses** occurs at the apex. The terminal cell of paraphyses is not swollen. The cluster of archegonia is enclosed by a group of green foliage leaves called **perichaetial** leaves. The archegonial cluster with the surrounding perichaetial leaves is called **perichaetium**.

Structure of an Archegonium

A mature **archegonium** is flask shaped structure. It remains attached to the female branch by a massive **stalk**. It consists upper elongated slender **neck** and basal globular portion called **venter**

The neck is slightly tubular, twisted, single layered and consists of six vertical rows of **neck cells** which enclose an axial row of ten or more vertical **neck canal cells**. The venter wall is two layered and encloses **venter canal cell** and **egg cell**. Venter canal cell is situated just below the neck canal cells.

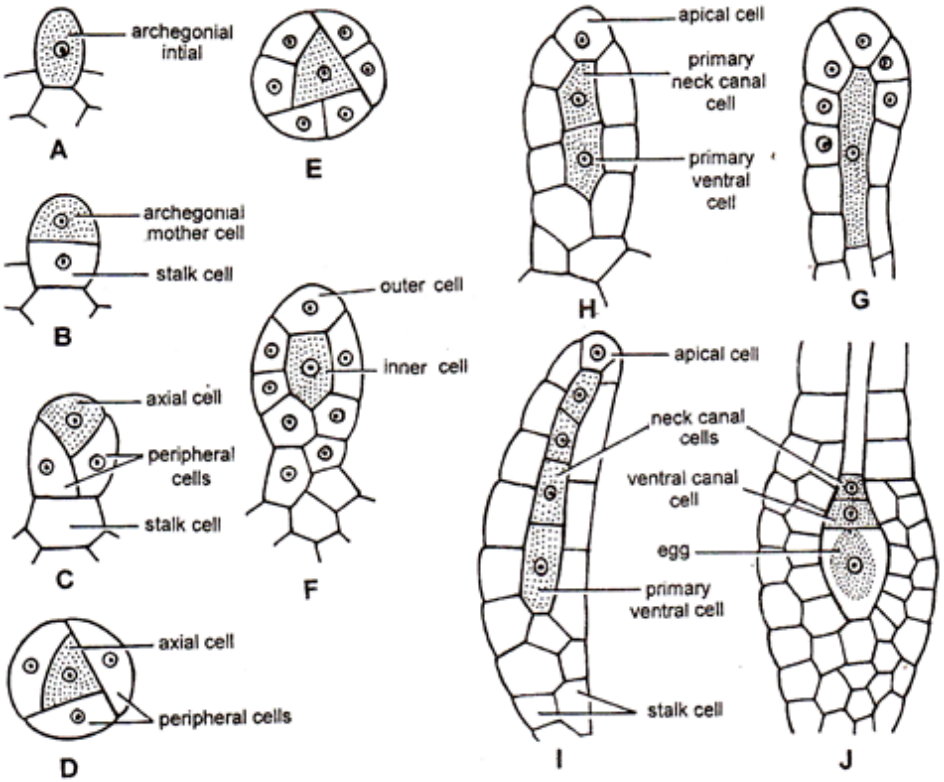

Fig. 8. (A–J) *Funaria.* Successive stages in the development of archegonium.

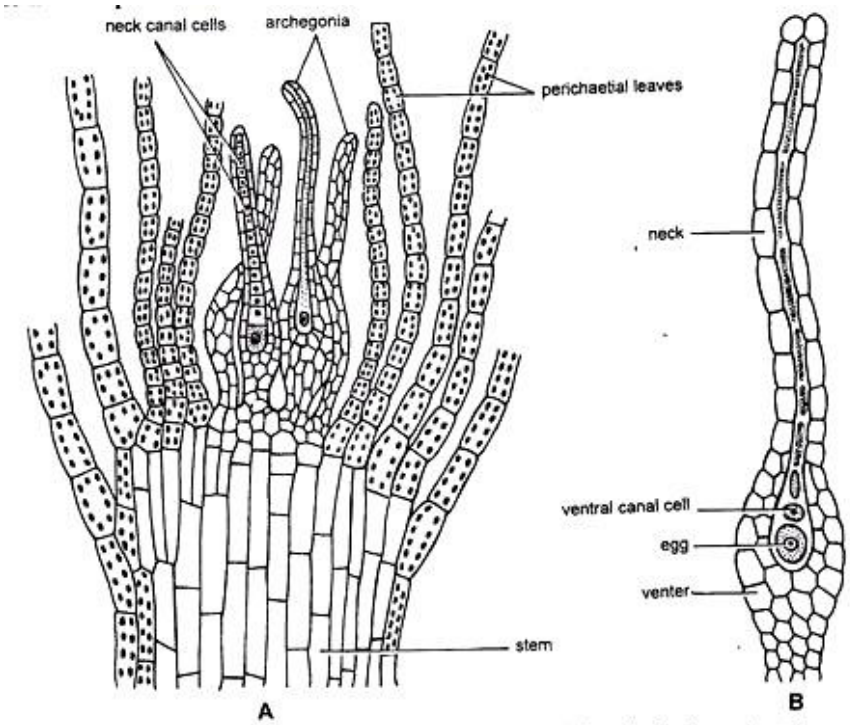

Fig. 7. (A, B). *Funaria*. (A) Longitudinal section (L.S.) of female branch showing archagonia, (B) a mature archegonium.

Fertilization

In Funaria water is essential for fertilization. The operculum cells of the antheridium rupture and releases mass of antherozoids. When archegonium reaches at maturity the neck canal cells and venter canal cell disintegrate to form a mucilaginous mass. It absorbs water, swells up and comes out of the archegonial mouth by pushing the cover cells apart. This mucilaginous mass consists chemical substance mainly sugars.

The cover cells of the neck separate widely from each other and form a passage leading to the egg. Many antherozoids enter the archegoniial neck because of chemical response but only one of them fuses with the egg to form zygote.

Sporophytic phase

Zygote is the first cell of the sporophytic phase. Development of the sporophyte takes place within the venter of the archegonium.

Structure of Sporophyte

The sporophyte is semi-parasitic in nature.

A mature sporophyte can be differentiated into three distinct parts:

1. **FOOT**

It is the basal portion of the sporogonium. It functions as an choring and absorbing organ.

2. **SETA**

It is long, slender, stalk like hygroscopic structure. It bears the capsule at its tip and raises it above the apex of leafy gametophores. Its internal structure is similar to axis. It is mechanical in function and also conducts water and nutrients to the developing capsule.

3. **CAPSULE**

It is the terminal part of sporophyte and is green in color when young but on maturity becomes bright orange coloured. It is covered by a cap like structure called calyptras.

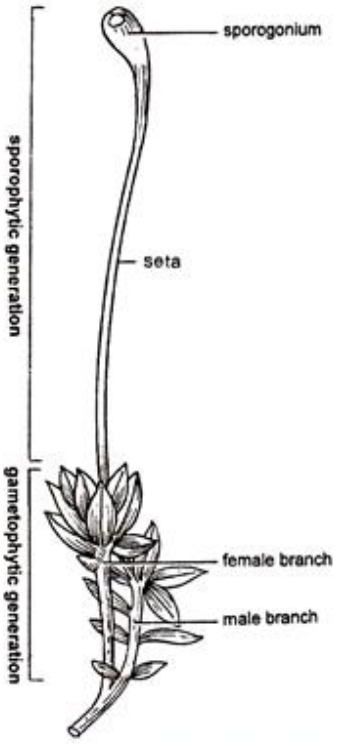

Fig. 9. *Funaria*. A gametophytic plant with sporophyte.

Internal structure of the capsule

Longitudinal section of the capsule shows that it can be differentiated into three distinct regions

1. **APOPHYSIS**

It is the sterile part of the capsule. It is bounded by the single layered epidermis which is interrupted by stomata. The stomata have single ring like guard cells. Below the epidermis is spogy parenchyma. The central part of the apophysis is

made up of elongated thin walled cells forming a conducting strand. It is called neck of the capsule. It is the photosynthetic region and connects seta and capsule.

2. **THECA**

It is the middle, slightly bent spore bearing region of the capsule which lies in between the apophysis and operculum. L.S. passing through theca shows following regions: epidermis, hypodermis, spogy parenchyma, air spaces, spore sacs and collumela. When young the cavity of spore sac is filled with many spore mother cells. At maturity the SMC divide meiotically and form haploid spores. The spongy parenchyma consists of two to three layers of loosely arranged chlorophyllous cells. Collumela is the central part made up of compactly arranged colorless parenchymatous cells which helps in conduction of water and mineral.

3. **OPERCULUM**

It is the upper region of the capsule. It is dome shaped and consists of four to five layers of cells. The outermost layer is thick walled and called epidermis. Operculum is differentiated from theca by a well marked constriction below which is a diaphragm or rim. Above the rim is annulus which consists of 5-6 superimposed layers of cells. Below the operculum lies the peristome. It consists of two rings of radially arranged peristomal teeth. In each ring there are sixteen teeth. Teeth are not cellular but stripes of the cuticle.

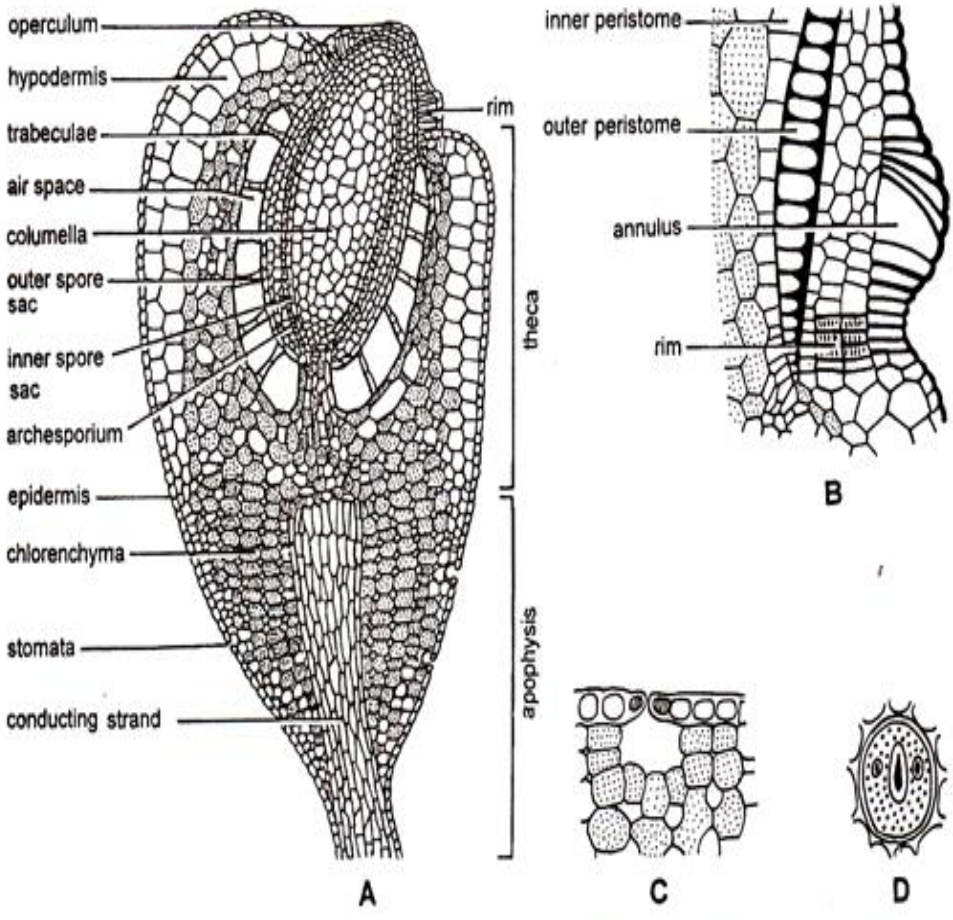

Fig. 11. (A–D). *Funaria*. Internal structure of the capsule. (A) Longitudinal Section (L.S.) of entire capsule, (B) L.S. through annulus region, (C) Structure of stomata in L.S., (D) Stomata in surface view.

Development of sporophyte

Soon after fertilization the zygote secretes a wall around it and enlarges in size. It divides by transverse wall forming an upper epibasal cell and lower hypobasal cell. The entire development of sporophyte is bi-apicalas it develops from both the cells..

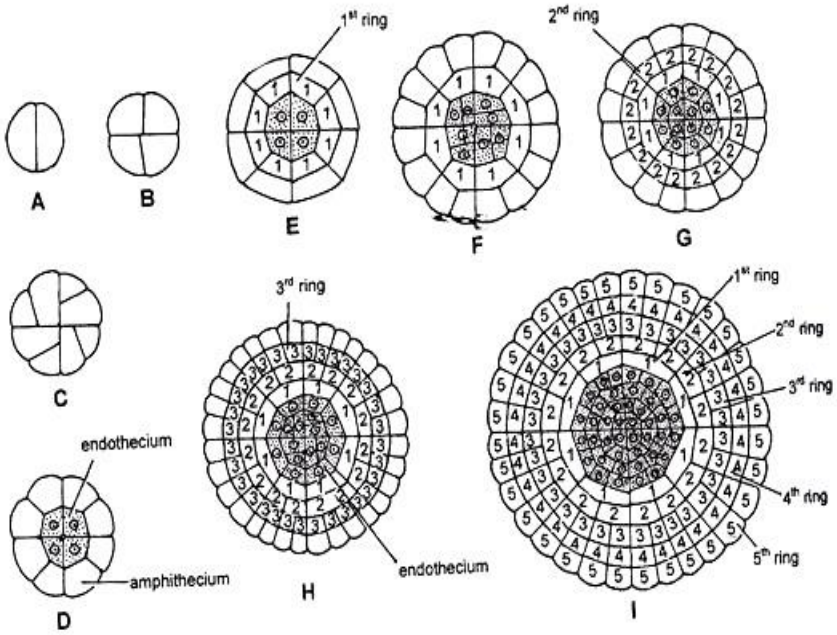

Fig. 13. (A–I). *Funaria.* Various stages in the development of capsule.

Dehisence of the capsule

Funaria is a stegocarpous moss (dehisce along pre determined line. It occurs by breaking off of annulus. The thin walled cells of annulus break away, the operculum is thrown off and the peristome teeth are exposed. The lengthening and shortening of the outer peristome teeth help in the dispersal of spores.

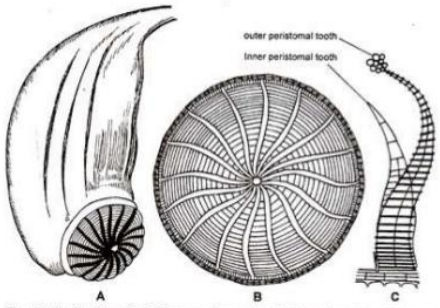

Fig. 14. (A–C). *Funaria.* Dehisence of capsule. (A) Capsule with peristome, (B) Top view of peristome, (C) An outer and an inner peristomial teeth.

Structure and Germination of spores

Each spore is spherical and surrounded by two wall layers. The outer wall is thick, smooth, brown and known as exosporium. While the inner wall is thin, hyaline called as endosporium. Spore wall encloses single nucleus, chloroplast and many oil globules. Under favourable conditions spores germinates, exosporium ruptures and endosporium

forms one or two germ tubes. Each germtube is multicellular, green whch grows into protonema.

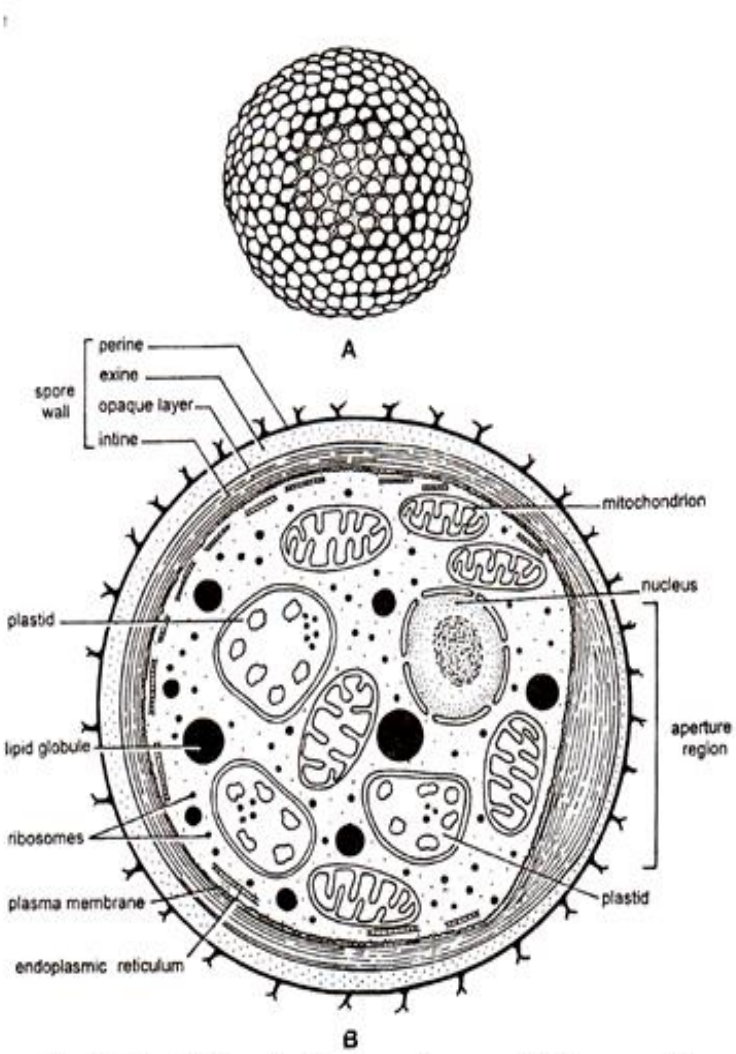

Fig. 15. (A, B). *Funaria*. Structure of spore. (A) Diagrammatic representation, (B) Structure as seen under SEM.

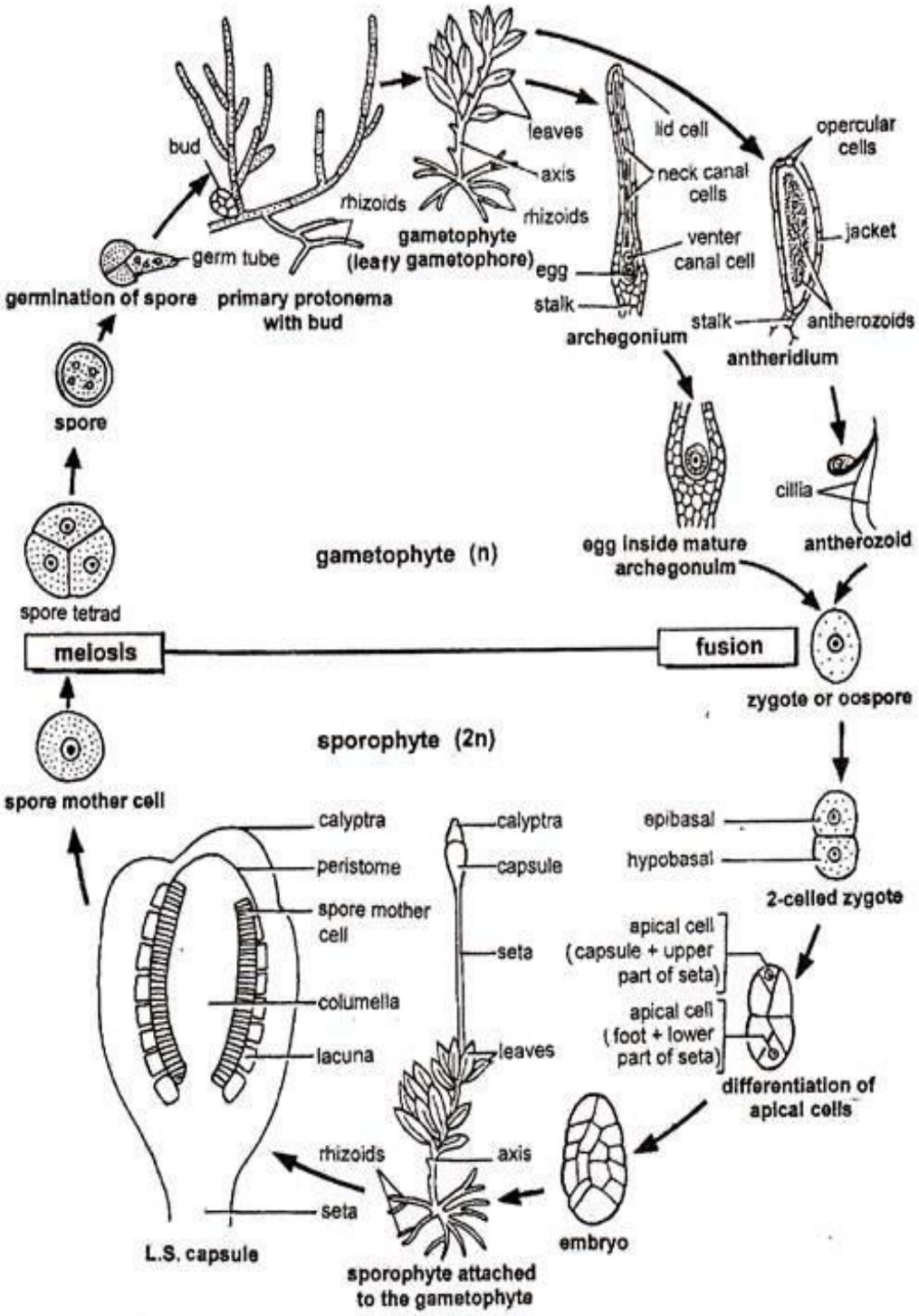

Fig. 17. *Funaria.* Diagrammatic life cycle.

----------X----------