Bryophytes

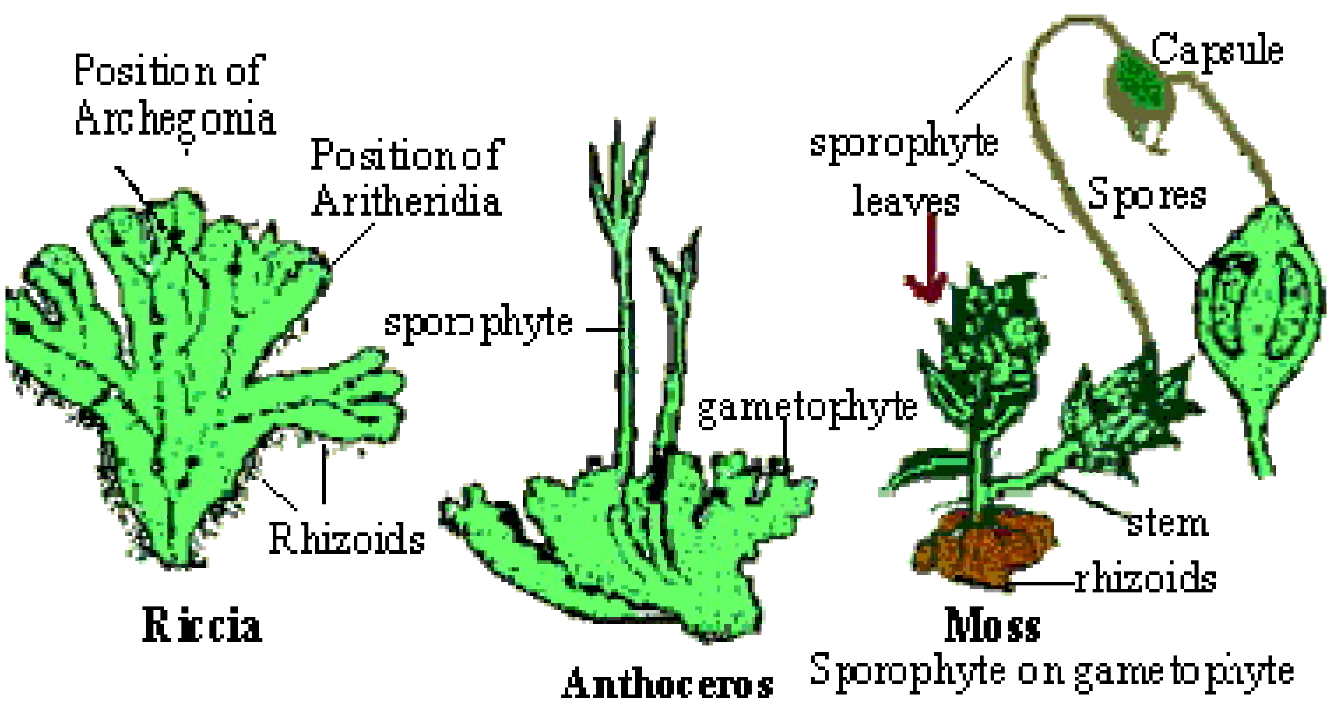
Characters of Bryophytes:
Bryophytes are nonvascular terrestrial plants of moist habitats in which z multicellular diploid sporophyte lives as a parasite on an independent multicellular haploid. Gametophyte that develops multicellular jacketed sex organs.

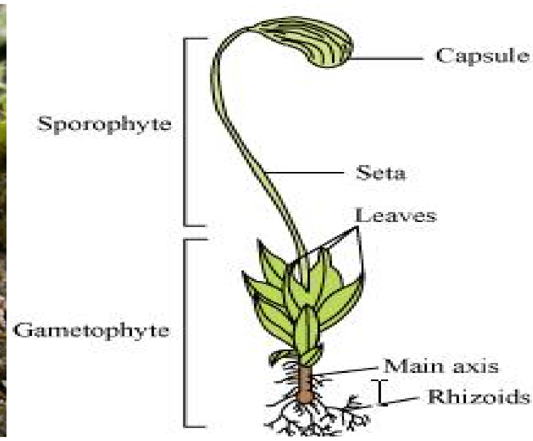
1. They have over 25,000 species.

2. Bryophytes live in damp and shady habitats. They are often found to grow during rainy season forming green carpets or mats on damp soil, rocks, walls, tree trunks, etc.

3. The plants are small. They seldom attain great length or height, the maximum being 60 cm for a moss species growing in New Zealand.

4. The dominant phase or plant body is a free living gametophyte.





5. Vascular tissues are absent.

6. Roots absent. Instead rhizoids occur. The latter may be unicellular or multicellular.

7. Accessory spores are not formed. Vegetative reproduction is quite common through fragmentation, tubers, gemmae, buds, adventitious branches, etc.

8. Sex organs are multicellular and jacketed.

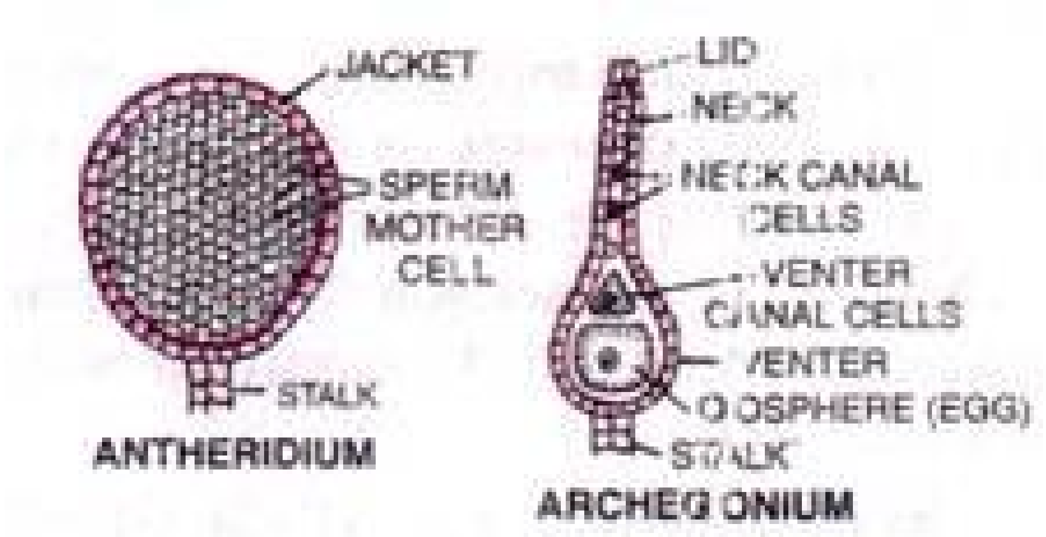


Fig. 3.10. Antheridium and archegonium.

They are of two types (Fig. 3.10), male antheridium and female archegonium. Antheridium produces a number of flagellate male gametes called sperms or anthropoids. Archegonium is flask-shaped with tubular neck and a swollen venter.

The single- layered wall of neck has 5-6 rows of cells. Internally it encloses a few sterile neck canal cells. The wall of venter is 1-2 layered. It encloses a venter cavity having a sterile venter canal cell and a fertile egg or oosphere.

9. The sterile internal cells of the archegonium (neck canal cells and the venter canal cell) degenerate and gelatinise. The gelatinous mass absorbs water and swells up into mucilage. The swelling mucilage opens the lid of the neck and creates a passage leading up to the oosphere. It possesses chemicals for attracting (chemo taxis) antherozoids.

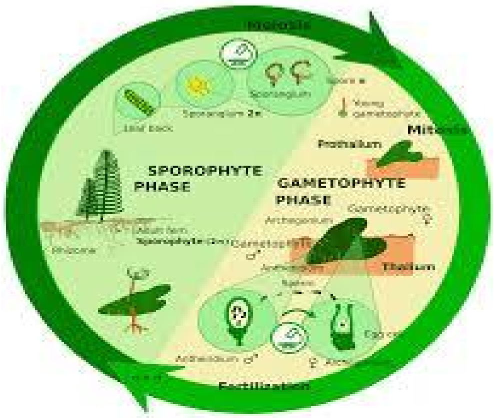
10. An external layer of water is essential for the swimming of male gametes to the archegonia.

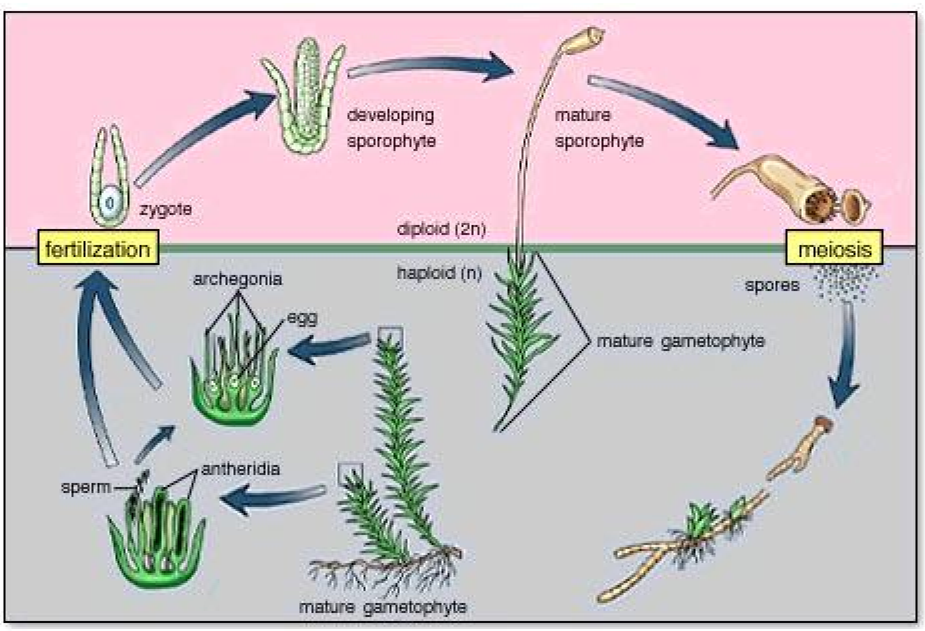
11. Fertilization produces an embryo inside the archegonium. The embryo grows into a sporophyte.

12. Sporophyte is parasite on gametophyte.

13. The sporophyte in bryophytes is also called sporogonium as it is attached and dependent on gametophyte. It produces haploid meiospores inside its capsule part.
14. On germination each spore produces a gametophyte either directly or through a juvenile filamentous stage called protonema.

15. Bryophytes show heteromorphic or heterologous alternation of generations.





Functions of Bryophytes:
Some of the important function of bryophytes are listed below:
1. Terrestrial Amphibians:
Bryophytes are called terrestrial amphibians as they require an external layer of water on the soil surface for their existence.

The external water is required for:
(a) Dehiscence of antheridia and archegonia

(b) Swimming of male gametes to archegonia

(c) Protection from transpiration and hence desiccation as the plant body is not covered by cuticle

(d) Supply of water to all parts through capillarity in the absence of vascular tissues.

2. Bryophytes do not Attain Great Heights:
Bryophytes seldom achieve great heights. They are small sized.

The possible reasons are:
(a) Absence of roots,

(b) Absence of vascular tissues. Materials are transported from cell to cell,

(c) Absence of cuticle on the plant body.

(d) Absence of mechanical tissue,

(e) Requirement of external sheet of water for capillary conduction to all parts and transport of male gametes.

Bryophytes are of three types—hepaticopsida (= hepaticae or liverworts), anthoceropsida (=anthocerotae or hornworts) and bryopsida (= musci or mosses).

Riccia

Gametophytic Phase of Riccia:

The plant body of Riccia is gametophytic and gametophytes are fleshy, prostrate and dichotomously branched. Repeated dichotomy results into a typically rosette like appearance (Figs. 1, 3).

In Riccia cruciata only two dichotomy result in a cruciate form (Fig. 4). Each branch of the thallus is linear, wedge-shaped or obcordate. Thallus is 5-7 mm long and 1.2 mm broad in all the terrestrial species. However, in R. fluitans it is 30-50 mm long and 1-2 mm broad.

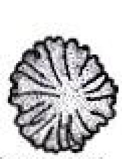


Fig. 1 *Riccia*. Rosette habit

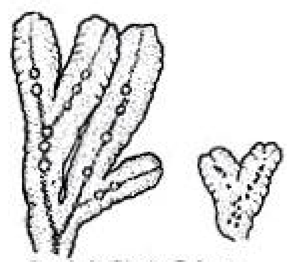


Fig. 2, 3. *Riccia*. Robust male thalli.

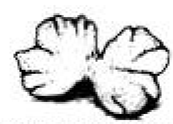


Fig. 4. *Riccia*. Cruciate thallus

Dorsal Surface:

The dorsal surface is light green or dark green body, each branch having a thick midrib. It is traversed by a conspicuous median longitudinal groove which ends in a depression at the apical region forming an apical notch.

Growing point is situated in the apical notch. The main function of the mid-dorsal groove is to retain water required for fertilization. Some hairy epidermal outgrowths are also seen in Riccia melanospora, though rarely (Fig. 5).

Vental Surface:

The ventral surface of thallus bears many scales and rhizoids. Scales are violet coloured, multicellular and one celled thick structures (Fig. 6). The colour of the scale is due to dissolution of the pigment in the cell sap. Scales are arranged all along the margin in a single row. In the apical region they project forward and

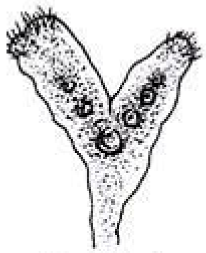


Fig. 5. *Riccia* Thallus of *R. melanospora.*

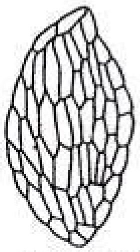


Fig. 6. *Riccia.* Scale

In hygrophilous species (species which need a large supply of moisture for their growth) the scales are ephemeral (i.e., short lived) but in xerophilous species the scales are leafy and persistent. In Riccia crystallina the scales are inconspicuous and absent. Rhizoids are unicellular and un-branched. They develop as prolongations of the lower epidermal cells.

They are of two types:

(i) Smooth-walled rhizoids

(ii) Tuberculate rhizoids.

In smooth-walled rhizoids both the inner and outer wall layers are fully stretched while in tuberculated rhizoids the inner wall layer modifies into peg-like or plate-like in growth which projects into the cell lumen (Fig. 7). The main function of rhizoids is to anchor the thallus on the substratum and to absorb water and mineral nutrients from the soil.

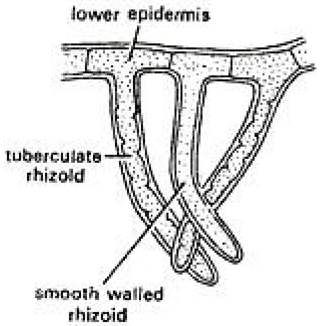


Fig. 7. *Riccia.* Smooth walled and tuberculated rhizoids

In Riccia fluitans, the only aquatic species, thallus is long, narrow, ribbon-like and dichotomously branched. Rhizoids and scales are absent (Fig. 8). This species can also grow on soil. In terrestrial species thallus bears many rhizoids and small, colourless or violet scales near the apex (Fig. 9).

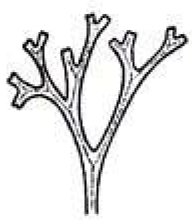


Fig. 8. *Riccia fluitans* (water form)

Fig. 9. *Ficcia fluitans* (land form)

Anatomy of the Gametophyte:

A vertical cross section of the thallus shows two distinct zones, viz., upper photosynthetic zone and lower storage zone (Fig. 10A, B).

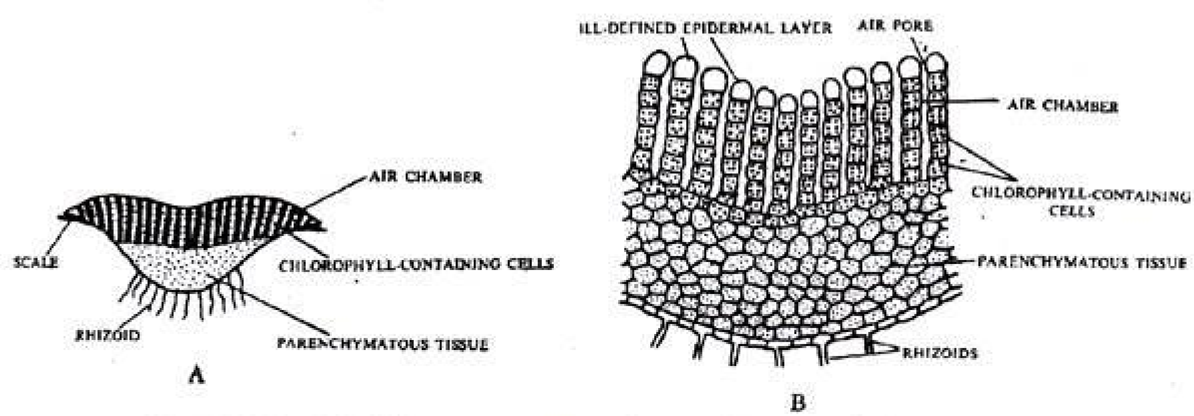


Fig. 10. (A, B) *Riccia.* (A) Tranverse section of thallus (diagrammatic); (B) A part cellular.

Upper Photosynthetic Zone:
It is green, dorsal on upper region of the thallus. It is made of somewhat vertical rows of un-branched photosynthetic filaments. All the cells of the photosynthetic filament except the uppermost one are isodiametric and possess many discoid chloroplasts. The terminal cells of photosynthetic filaments are large, hyaline and form loose, ill-defined and discontinuous one celled thick epidermis.

Photosynthetic filaments are separated from each other by narrow longitudinal vertical canals called air chambers. Each air chamber is bounded by four epidermal cells (e.g., Riccia glauca, (Fig. 11) or eight epidermal cells (e.g., R. vesiculosa). Each air chamber opens on the dorsal surface by an air pore. Air chambers spaces help in the gaseous exchange.

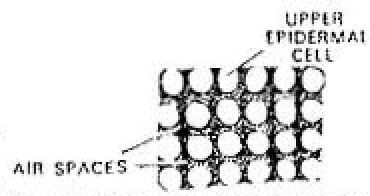


Fig. 11. *Riccia*. Air spaces bounded by epidermal cells (surface view)

In aquatic form of Riccia fluitans epidermis is continuous and air chambers are almost completely closed. However, in the terrestrial form of this species each air chamber opens on the upper surface by a small opening (Fig. 12).

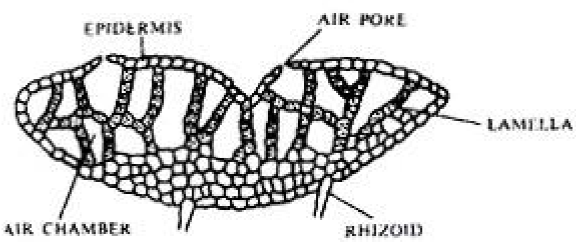


Fig. 12. *Riccia fluitans*. Transverse section of thallus of a land from.

In spongy thallus of Riccia crystallina the assimilatory or photosynthetic cells form a loosely- arranged network enclosing large air spaces.

Lower Storage Zone:
This zone represents the ventral tissue of the thallus and lies below the photosynthetic zone. It consists of compactly arranged parenchymatous cells. These cells are devoid of

chlorophyll and contain starch as reserve food material. The lowermost cell layer of this zone forms the lower epidermis. Some cells of the lower epidermis extend to form the scales and both types of rhizoids.

Reproduction in Riccia:

Riccia reproduces by vegetative and sexual methods.

(i) Vegetative Reproduction in Riccia:

Vegetative reproduction in Riccia is quite common and takes place by the following methods:

1. Death and decay of the older portion of the thallus:

The thallus in Riccia is dichotomously branched and the growing point is situated in its apical notch. The basal or the posterior part of the thallus starts rotting or disintegrating due to ageing or drought.

When this process of disintegration or decay reaches up to the place of dichotomy, the lobes of the thallus get separated. Thus detached lobes develop into independent plants by apical growth. It is the most common method of vegetative reproduction in Riccia.

2. By adventitious branches:

The adventitious branches develop from the ventral surface of the thallus in species like Riccia fluitans. On being detained, these branches develop into new thalli (Fig. 13).

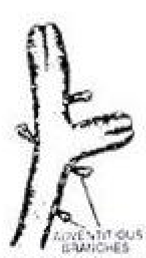


Fig. 13. ***Riccia Pluitans.*** **Thallus showing adventitious branches**

3. By persistent apices:

Due to prolonged dry summer or towards the end of growing season the whole thallus in some species (e.g., Riccia discolor) dries and gets destroyed except the growing point. Later, it grows deep into the soil and becomes thick. Under favourable conditions it develops into a new thallus. It is more a method of perennation rather than multiplication.

4. By tubers:
Towards the end of the growing season the apices of the thallus lobes get thickened and form the perennating tubers. These are capable to pass on the unfavorable conditions. On resumption of favourable conditions tubers produce new thalli. Tubers are common in Riccia discolor, R. billardieri, R. perenriis and R. vesicata (Fig. 14).

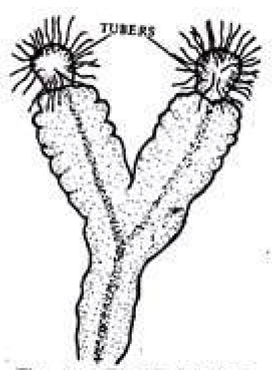


Fig. 14. *Riccia*. Thallus showing apical tubers.

5. By rhizoids:
The apical part of the young rhizoids divides and re-divides to form a gemma like mass of cells in some species (e.g., Riccia glauca). These cells contain chloroplast and are capable of developing into new thallus.

(ii) Sexual Reproduction in Riccia:

Sexual reproduction in Riccia is oogamous. Male reproductive bodies are known as antheridia and female as archegonia.

Some species of Riccia like R. crystallina, R. gangetica, R. billardieri and R. glaul are monoecious or homothallic (i.e., both anheridia and archegonia develop on the same thallus) while other species like R. curtisii, R. perssonii, R. bischoffii, R. frostii, R. discolor are dioecious or heterothallic (i.e., antheridia and archegonial develop on different thalli).

Antheridia and archegonia remain enclosed within the antheridial and archegonial chambers and develop on the dorsal surface of the thallus (Fig. 2, 3). Sex organs develop in acropetal succession (i.e., mature sex organs are present at the posterior end, the young ones towards the apex of the thallus).

In monoecious species alternate groups of antheridia and archegonia develop at a sufficient distance from the growing point. There is no particular time for the development of sex organs, and therefore one can see all the developmental stages in the different sections of the same thallus.

Antheridium:

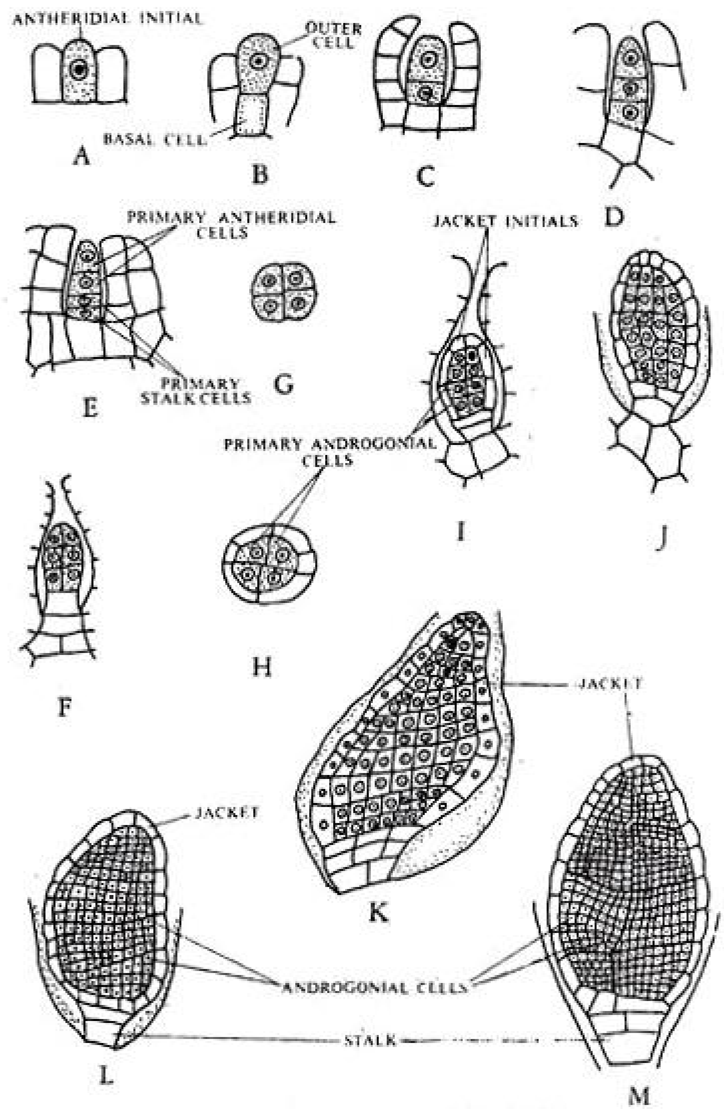


Fig. 15 (A–M) Riccia. Development of antheridium.

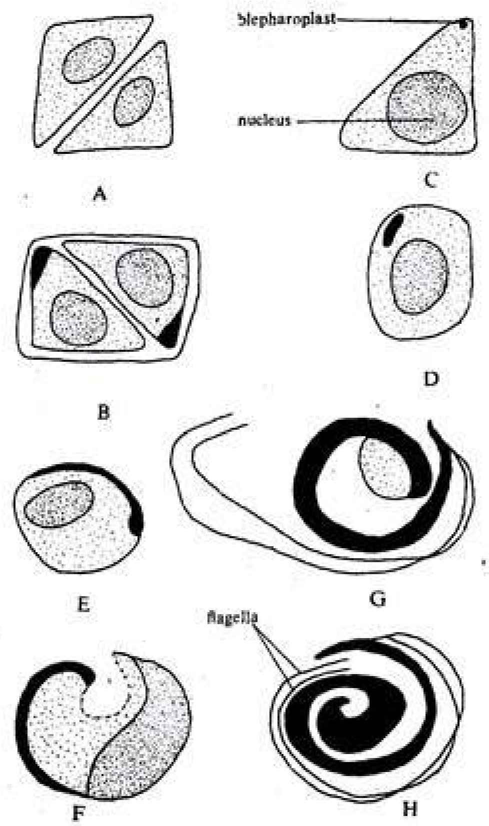


Fig. 16. *Riccia.* Metamophosis of androcyte into antherozoid.

Mature Antheridium:

A mature antheridium has a short stalk and oval shaped body with a flat base and conical apex (Fig. 15 M). Stalk attaches the antheridium to the base of the antheridial chamber. Antheridium is present singly in an antheridial chamber. A single-layered sterile jacket encloses the mass of androcytes which metamorphoses into antherozoids.

Mature Antherozoid:

A mature antherozoid is unicellular, uninucleate, biflagellate and coiled structure. Both flagella resemble morphologically but differ in function. One flagellum serves for propulsion and the other for rotation and for changes in direction (Fig. 15 H).

Dehiscence:

Water helps in the dehiscence of the anheridium. Antheridial chamber, in which an antheridium lies, communicates with the clorsal surface of the thallus by terminal opening. The cell walls form the semifluid content of the antheridium during the metamoiphosis. Mature antherozoids remain free in the semifluid substance in the antheridial cavity.

As water enters in their antheridial chamber, the sterile apical cells of the antheridial jacket enlarge by absorbing water, become softened and ultimately break open. The mature antherozoids along with semifluid mass, come out of the antheridium to the antheridial chamber and then to the dorsal surface of the thallus.

Archegonium:

Mature Archegonium:

A mature archegonium is a flask shaped structure. It remains attached to the thallus by a short stalk. It consists of upper elongated slender neck and basal globular portion called venter.

The neck consists of six vertical rows enclosing four neck canal cells. The venter consists of a single layered jacket. Twelve to twenty cells in perimeter enclose a small venter canal cell and large egg. Four cover cells are present at the top of the neck (Fig. 17 L).

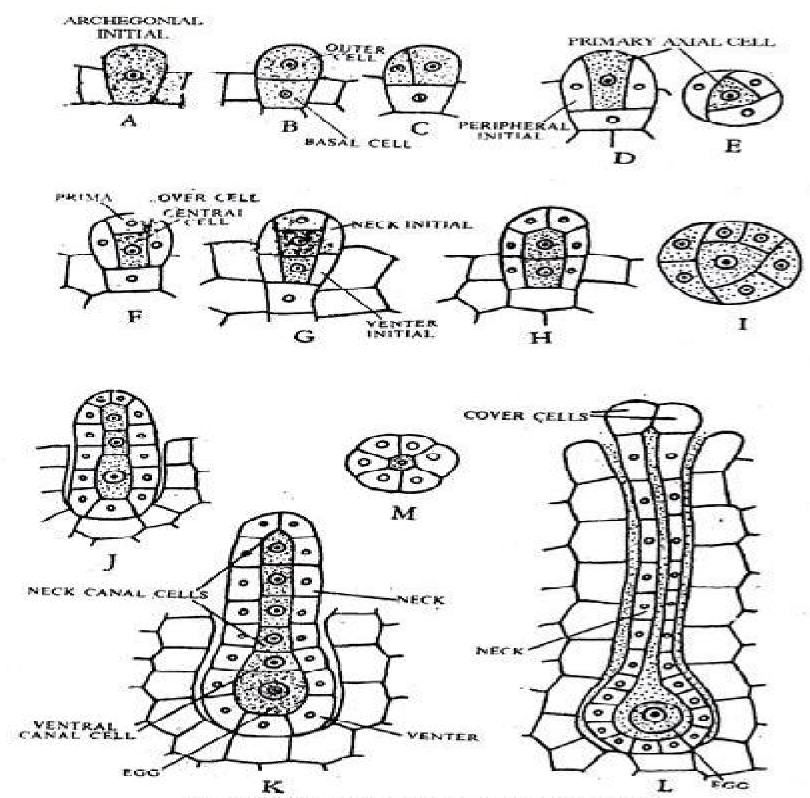


Fig. 17. *Riccia*. Development of archegonium.

Fertilization in Riccia:

Water is essential for fertilization. It enters the antheridial chamber. Apical cells of the antheridial wall get swollen by absorbing water. These cells become softened and finally breakdown to release mass of antherozoids. These antherozoids come up to dorsal surface of the thallus from the antheridial chamber where they swim in the thin film of water and reach the mouth of the neck of the archegonium.

In the mature archegonium the venter canal cell and neck canal cells disintegrate and 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 of chemical substances such as soluble proteins and certain inorganic salts of potassium.

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 (Fig. 18A-C). The fusion of the nuclei of male and female gamete results in the formation of diploid zygote or oospore. Fertilization ends the gametophytic phase.

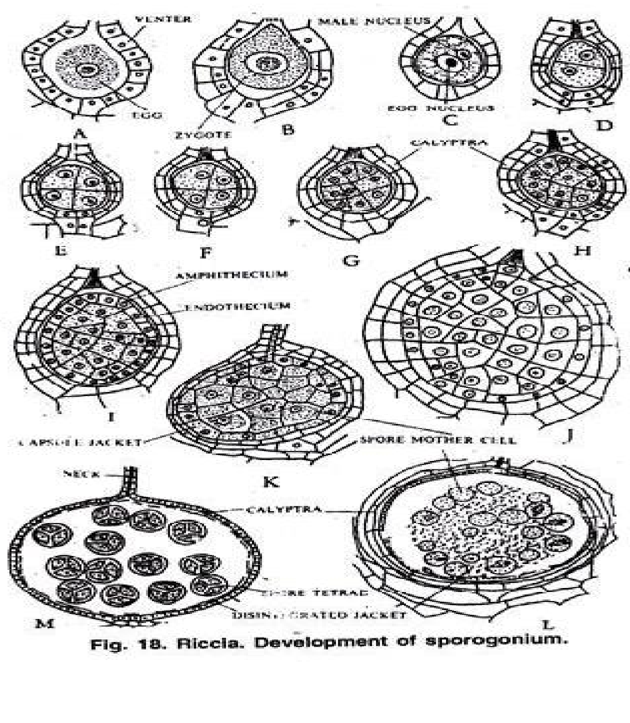


Fig. 18. Riccia. Development of sporogonium.

Sporophytic Phase:

After fertilization the diploid zygote or oospore enlarges until it completely fills the cavity of the venter of the archegonium. A wall is then secreted around the oospore. The act of fertilization also stimulates the division of the wall of the venter. It divides anticlinally and periclinally to form a two-layered calyptra along the developing sporophyte.

Mature Sporogonium:

A mature sporogonium is represented only by spherical spore sac or capsule. It lacks foot and seta (Fig. 19). It has a single-layered capsule wall which encloses spores. There are no elaters. A bilayered calyptra forms a protective covering around the capsule.

The capsule wall and inner layer of calyptra break down before the spore mother cells divide to form the spores. After meiosis the mass of spores lies free in the outer layer of calyptra and mature sporogonium has no diploid structure. The newly formed young gametophyte remains enclosed with in the old gametophyte (Fig. 18 M; 19).

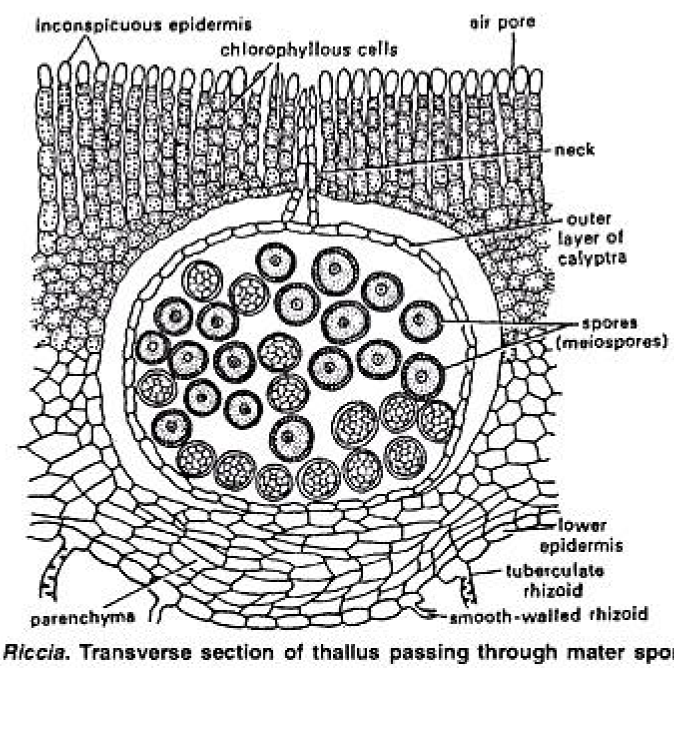


Fig. 19. *Riccia*. Transverse section of thallus passing through mater sporogonium.

Dispersal of Spores:
Spores are not immediately dispersed in Riccia. There is no special method of dispersal, Spores remain inside the thallus for one year or so and dispese after the death and decay of the calyptra and surrounding tissue.

The Spore:
Spores are very small (0.05-0.12 mm in diameter). They are haploid uninucleate and pyramidal in shape (Fig. 20 G). Each spore remains surrounded by three layers i.e., an outermost ornamented cutinised layer called exosporium, the middle layer called mesosporium (differentiated into 3 concentric zones) and the innermost layer called the endosporium. The endosporium is made up of cellulose and pectose (Beer, 1906).

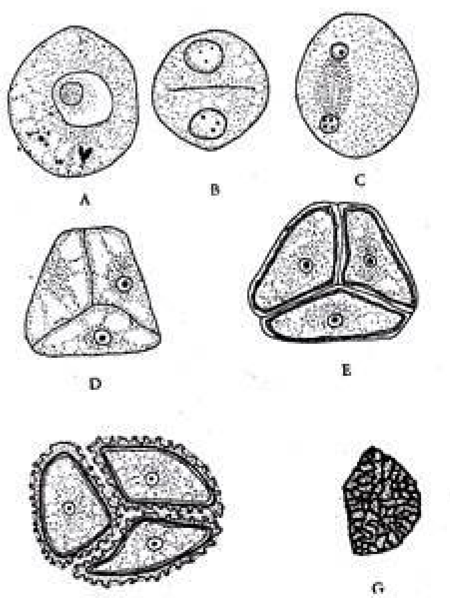


Fig. 20. *Riccia*. Sporogenesis

Germination of Spores and Formation of Young Gametophyte:
Light, low temperature and water is essential for spore germination. According to Campbell (1918) the exosporium and mesosporium rupture at the triradiate mark and the endosporium comes out in the form of a tubular outgrowth called the germinal (Fig. 21 A—C).

Germinal tube is filled with cytoplasm which contains albumin granules, chloroplasts and oil granules. The germ tube elongates rapidly to form a club-shaped structure because the content of the cytoplasm move to the distal end. At the end it divides by a transverse division to form a small cell (Fig. 21 D).

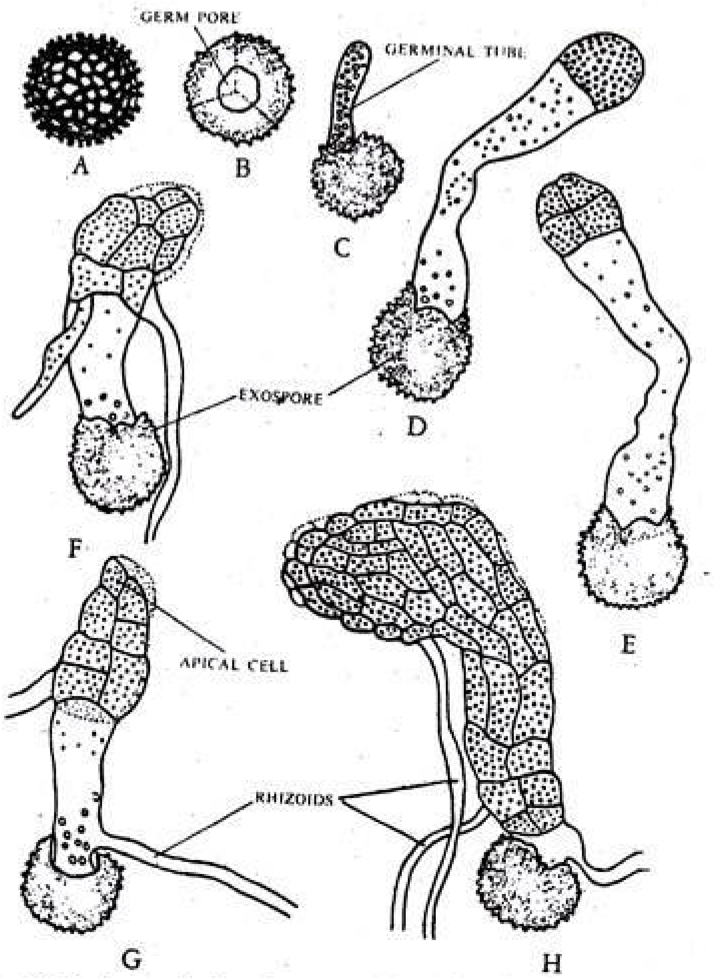


Fig. 21. *Riccia.* Germination of spore and formation of young gametophyte.

It again divides by a transverse division which is parallel to first division. Both these cells divide by two vertical divisions at right angle to one another and form two tiers of four cells each. This represents octant stage (Fig. 21 E). The distal tier of four cells of the octant stage functions as an apical cell with 2 cutting faces. It cuts a number of cells on its left and right side to form the multicellular thallus (Fig. 21 G, H).

Along with these divisions the first rhizoid develops at the base of the germ Lube. Many rhizoiu develop later on from the multicellular thallus and fix it on the soil (Fig. 22 A, H).

Formation of rhizoids is affected by light intensity. Rhizoids develop in the light medium intensity. In Riccia crustissi two spores of a tetrad develop into male thalli and two spores develop into female thalli.

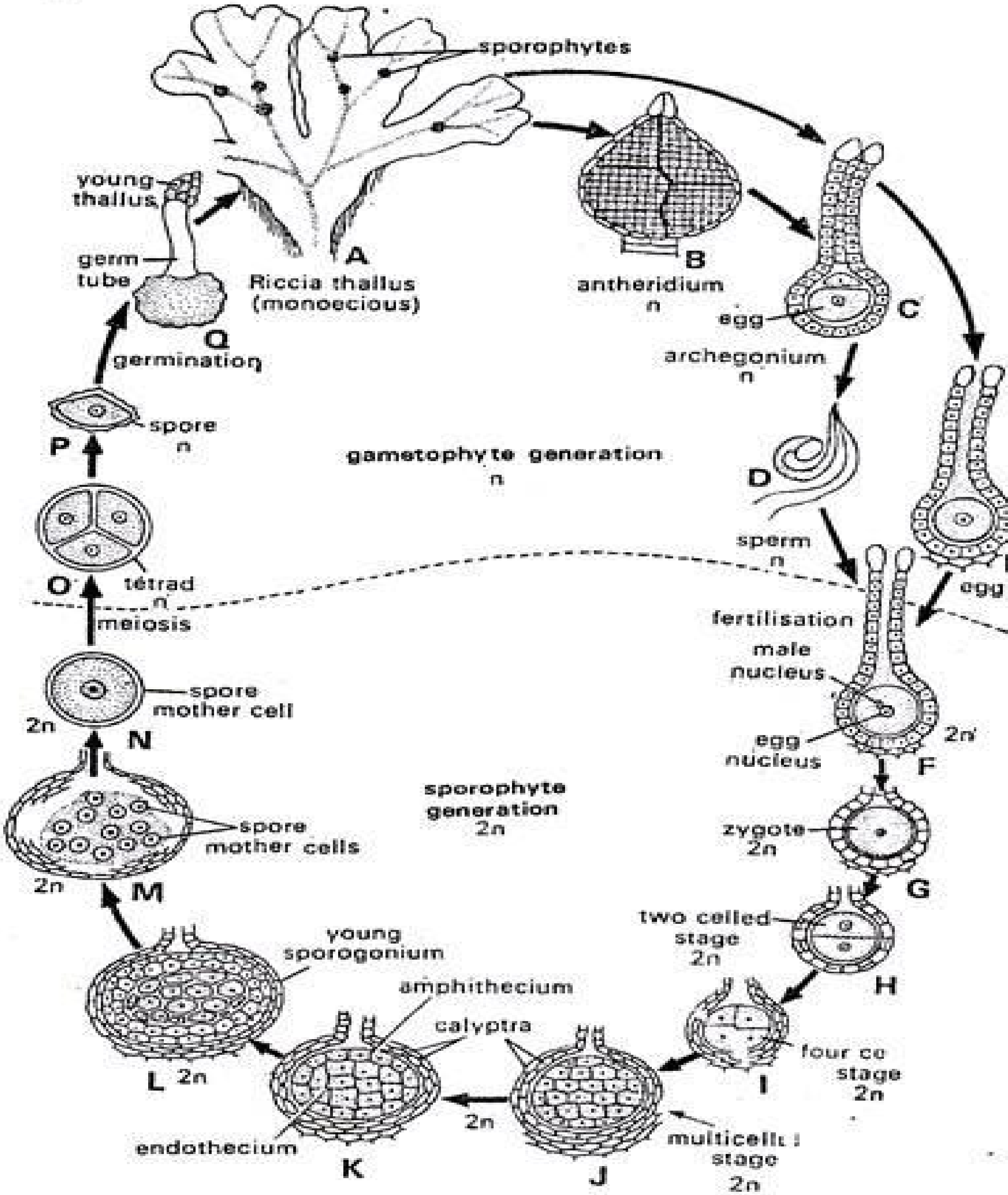


Fig. 22. *Riccia*. Diagrammatic life cycle.

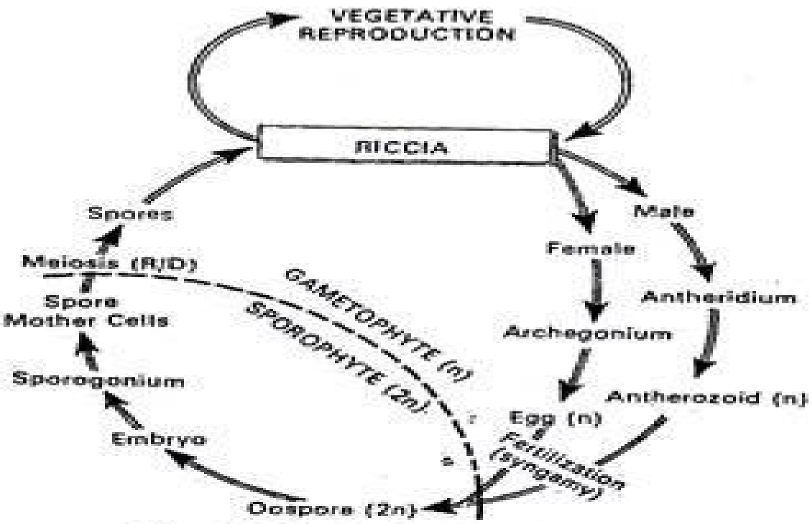


Fig. 23. *Riccia.* Graphic life cycle