A TEXTBOOK
OF
BOTANY

FOR DEGREE STUDENTS

Vol. I

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PHYLLUM. MARCHANTIOPHYTA

(LIVERWORTS)

CHARACTERISTIC FEATURES

1. Gametophytes are either flattened thalli or leafy shoots.
2. The flattened ribbon-like to leaf-like thallus of the thallose liverworts are either simple or structurally differentiated into a system of dorsal air chambers and ventral storage tissues.
3. The dorsal epidermis of the thallus is punctured with scattered pores that open into the air chambers.
4. In the leafy forms, the leaves are arranged on the stem in one ventral and two lateral rows or ranks.
5. The leaves are one cell layer thick throughout, never have a midvein and are usually divided into two or more parts called lobes.
6. The ventral leaves which actually lie against the substrate, are usually much smaller than the lateral leaves that are hidden by the stem.
7. Rhizoids are hyaline (colourless), unicellular and unbranched.
8. Liverworts synthesise a vast array of volatile oils, which they store in unique organelles called **oil bodies**. These compounds impart an often spicy aroma and seem to discourage animals from feeding on them.
9. Sporophytes develop completely, enclosed within gametophyte tissues until their capsules are ready to open.
10. The seta, which is initially, very short, consists of small thin-walled, hyaline cells, elongates its length up to 20 times its original dimensions just prior to spore release.
11. The rapid elongation of seta pushes the darkly pigmented capsule out of the gametophytic tissue.
12. With drying, the capsule opens by splitting into four segments or valves.
13. The spores are dispersed into the winds by the twisting motions of numerous intermixed sterile cells, called **elaters**.
14. The liverworts disperse the entire spore mass of a single capsule in just a few minutes.
15. Protonema is globose and forms a single bud (shoot).

RICCIA

Systematic position

Phyllum.	Marchantiophyta (Hepatophyta)
Class.	Marchantiopsida
Sub class.	Marchantiidae
Order.	Ricciales
Family.	Ricciaceae

Total number of species – About 200.

Number of species found in India – About 33.

Common Indian species – *Riccia discolor, R. gangetica, R. pathankotensis, R. frostii, R. melanospora, R. crystallina, R. fluitans.*

Species Endemic to India – *R. gangetica, R. pandei.*

Distribution and Habitat – The different species of *Riccia* prefer to grow on damp soil, moist and shady rocks and other similar terrestrial habitats, except *Riccia fluitans,* which is a free floating aquatic on stagnant or slowly running water.

Plant Body (Adult Gametophyte)

The gametophyte is the dominant phase in the life cycle of bryophytes. In case of *Riccia*, the main plant body is a thallus which represents a well-developed gametophytic phase in the life cycle.

External Structures

The gametophytic plant body of *Riccia* is a dichotomously branched dorsiventral prostrate thallus. In terrestrial habits, the plants usually occur in a rosette form due to the presence of a number of dichotomies that grow together from one place (Fig. 6.1A-C). These rosettes are up to 15 cm in diameter. Each dichotomy is a linear to wedge shaped structure where the median

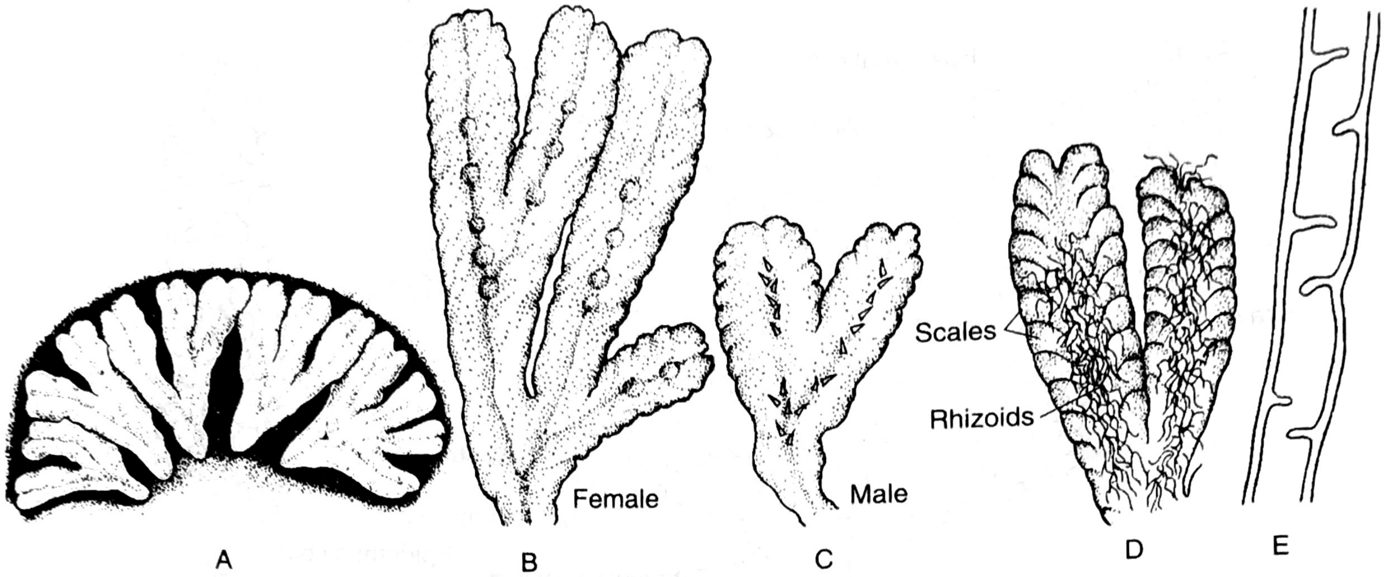

Fig. 6.1 : *Riccia discolor* : Gametophytic thalli (A), Female (B), and Male (C) plants, (D) Ventral surface of same showing scales and rhizoids, (E) Longitudinal sectional view of a tuberculate rhizoid

region is thickened with a conspicuous longitudinal groove on the dorsal (upper) side ending in a notch. The growing point is located at the tip of the notch. Transverse row of **scales** are present on the ventral (lower) surface. The scales are one cell in thickness that are more crowded near the apex and overlap the growing point, often pigmented violet. In the mature portion of the thallus, each scale is split into two to form two rows of scales along the two margins (Fig. 6.1D).

The thallus also bears numerous **rhizoids** in the ventral surface which are unicellular, elongated, tubular and hair-like structure. Rhizoids serve the purpose of anchorage to the substratum and absorption of water and nutrients from soil. There are two types of rhizoids : some with **smooth walls** and others **tuberculate** with internal peg-like or plate-like projections of the wall (Fig 6.1E & 6.2A). Rhizoids are devoid of protoplasm at maturity and are absent in aquatic forms.

Internal Features

The thallus of *Riccia* shows an internal differentiation of tissues (Fig. 6.2A). A vertical transverse section (V.T.S.) of the thallus shows two distinct regions (a) the **ventral storage region** and (b) the **dorsal assimilatory** (photosynthetic) **region**.

Storage region : The ventral region of the thallus is formed of a compact colourless parenchymatous tissue (Fig. 6.2A), often contains starch. This region serves as the storage region of the thallus. The scales and rhizoids develop from the basal part of this tissue.

Assimilatory region : This region is composed of vertical rows of green, chlorophyllous cells that are separated by vertical air canals (Fig. 6.2A). Usually each air canal is very narrow and surrounded by four vertical rows of cells (Fig. 6.2B). However, in a few species (e.g., *R. vesiculosa*) the canals may be wider and surrounded by 8 rows of cells. The canals are open on the dorsal surface so that the top of the thallus is porose, but does not show any organised air pores like *Marchantia*. The outermost cell in each vertical row is larger and colourless which forms an interrupted, one cell thick epidermis.

Apical growth : The growth in length of the thallus takes place by means of 3 to 5 **apical cells (initials)**. They are situated in the apical notch (growing point) and are more or less triangular in outline. Some of the median cells fails to divide or split vertically, as a result two separate growing points are formed, so that the thallus becomes dichotomous.

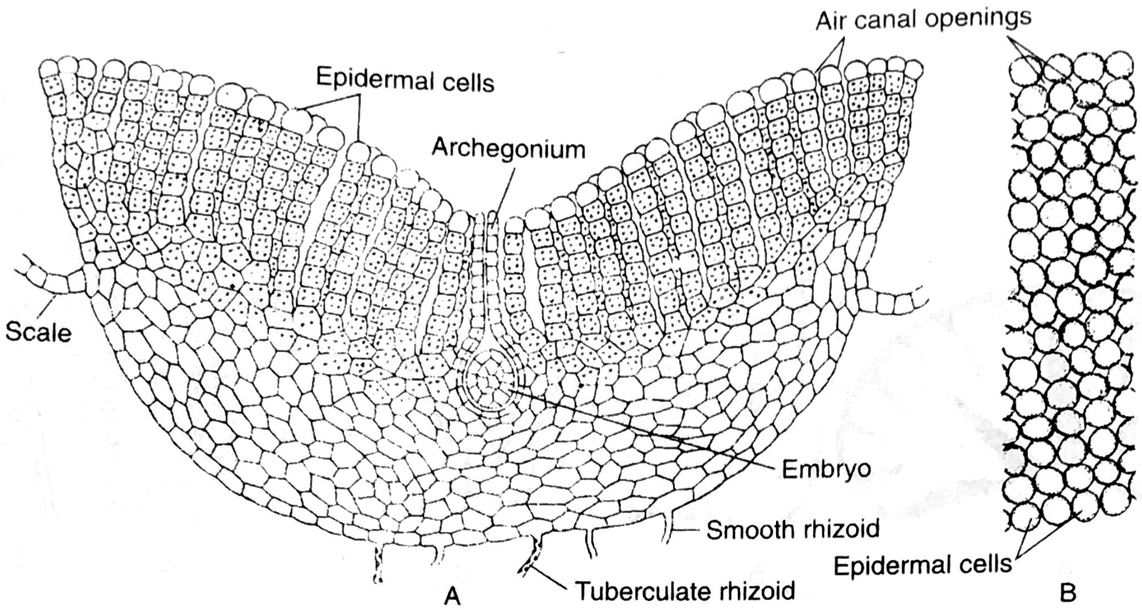

Fig. 6.2 : *Riccia* : A. V.T.S. through a gametophyte showing a sporophyte embryo within the venter of an archegonium. B. Top surface view of a portion of thallus showing the epidermis interspersed by air canal openings

Reproduction

Riccia propagates both by means of **vegetative reproduction** and **sexual** methods.

Vegetative reproduction : Vegetative reproduction of *Riccia* takes place by the following methods :

(a) **By progressive death and decay of the older parts of the thallus (fragmentation)** : Vegetative propagation is taking place usually by the continuous growth from the growing point.The older basal parts of dichotomies die and rot away, while the tip grows continuously to give separate plants. The growing tip survives the dry period one season, then grows next year.

(b) **By adventitious branches** : Vegetative growth of *Riccia* also takes place by the formation of adventitious branches from the lower surface of the thallus. The branch that separates from the parent thallus, grows into new plant (viz. *Riccia fluitans*).

(c) **By tubers** : In many species (viz. *R. bulbifera, R. discolor, R. perennis, R. vesicata*) tubers develop on the thallus. These perennating structures can easily survive a period of drought and germinate in favourable season.

(d) **By rhizoids** : It is found that new gametophytes develop from the tips of the rhizoids (eg. *R. glauca*). The tips of the rhizoids divide repeatedly to form a mass of chlorophyllous cells. These cells further grow to form new thallus.

Sexual Reproduction

Sexual reproduction takes place by means of well-developed sex organs : the male reproductive organ, **antheridium** and the female, **archegonium**. *Riccia* are mostly **monoecious** or **homothallic** (e.g. *R. melanospora, R. crystallina, R. cruciata, R. pathankotensis, R. glauca* and *R. robusta*), but some are also **dioecious** or **heterothallic** (*R. discolor, R. sanguinea, R. frostii, R. pearsonii*).

Sex organs develop singly. They are formed acropetally in a linear row on the upper median furrow (Fig. 6.1B-C). At first they are superficial, but at later stages of development they are enveloped by the outgrowth of tissues and are finally embedded in a cavity formed by the overarching tissues (Fig. 6.3D and 6.4D). These cavities are called **antheridial** and **archegonial chambers** that are open on the upper surface by narrow cylindrical canals.

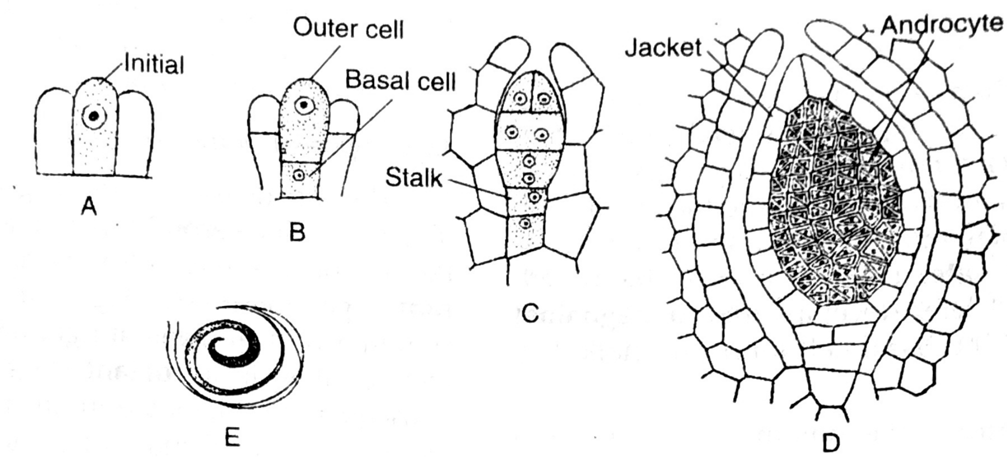

Fig. 6.3 : *Riccia* : A-C. Stages of development of antheridium, D. A mature antheridium, E. A spermatozoid

Antheridium

Development and structure

The antheridium develops from a single superficial dorsal cell, called the **antheridial initial** (Fig. 6.3A) which lies 2 or 3 cells behind the apical cell and placed in the median furrow. The antheridial initial divides transversely to form an upper **outer cell** and a lower **basal cell** (Fig. 6.3B). The outer cell later develops the antheridium with jacket and the basal cell forms the **stalk** (Fig. 6.3C). The tissue surrounding the antheridial initial tends to overgrow and ultimately envelops the antheridium leaving a pore at top.

The mature antheridium (Fig. 6.3D) is globular or pear-shaped with a single-layered jacket (wall) enclosing a number of androcyte mother cells. Each **androcyte mother cell** divides diagonally to form two triangular androcyte cells (Fig. 6.3D). Each **androcyte cell** forms a biflagellated **spermatozoid** or **antherozoid** (Fig. 6.3E). At maturity, all the cell walls inside the antheridium disintegrates. The antherozoids are now free inside the antheridial jacket in a gelatinous fluid.

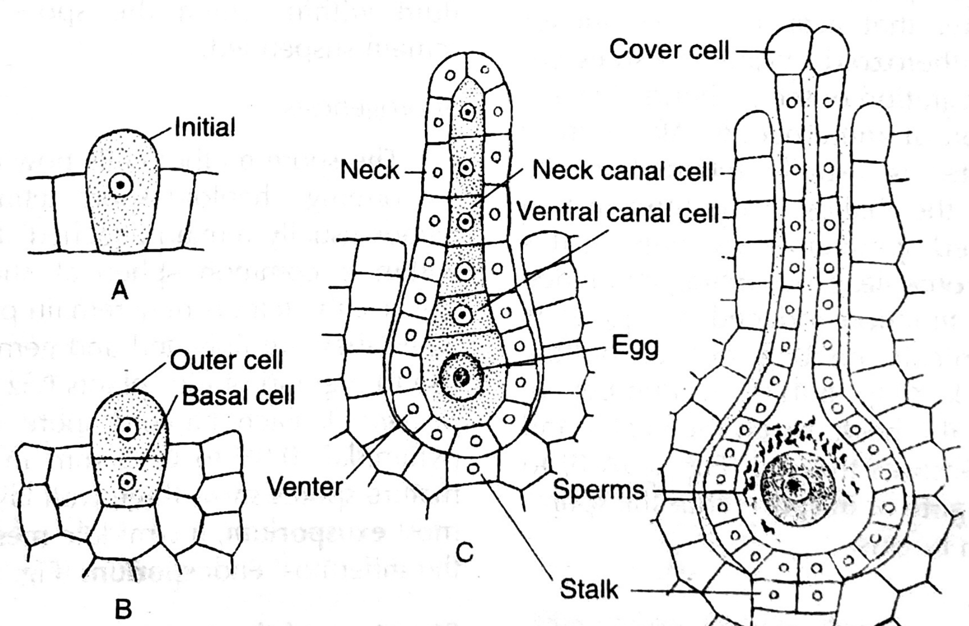

Fig. 6.4 : *Riccia* : A-C. Stages of development of archegonium, D. A mature archegonium

Archegonium

Development and structure

Like antheridium, the archegonium also develops from a single superficial dorsal cell, called the **archegonial initial** (Fig. 6.4A), placed in the median furrow and close to the apical cell. The archegonial initial divides transversely forming an upper **outer cell** and a lower **basal cell.** The outer cell later develops into **archegonium** proper, while the basal cell forms the **stalk** (Fig. 6.4B & C).

The mature archegonium (Fig. 6.4C) is a flask-shaped structure having a short **stalk**, a swollen basal **venter** containing a large **egg** or **ovum**, a **ventral canal cell** and an elongated **neck** containing a row of four **neck canal cells.** The tip of the neck is covered by four specialised **cover cells** that are larger than the remaining cells of the neck. The archegonium is not fully embedded in the archegonial chamber as in the case of the antheridium, so that the tip of the archegonial neck protrudes out.

Fertilisation

At maturity, the neck canal cells and the ventral canal cell of archegonia disintegrate to form a mucilaginous mass. The mucilage imbibes water, swells and comes out by forcing upon the cover cells, forming a narrow passage called the **neck canal.** In this condition, fertilisation takes place which requires the presence of water that acts as a medium for swimming the antherozoids. Water is also essential for the disintegration of the antheridial jacket vis-a-vis liberation of antherozoids. After rain or heavy dew, water is usually retained in the dorsal groove of the thallus in the form of thin film. The liberated spermatozoids swim in this water and they come near the archegonium due to chemotactic attraction induced by proteins and other chemicals coming out of hollow archegonial neck (Fig. 6.4D). A number of sperms pass into the neck, reach the venter and ultimately one fertilises the egg (Fig. 6.5A-B) to form a diploid **zygote** or **oospore**, thus the sporophytic generation begins.

The Sporophyte

The zygote invests itself with a thin cellulose wall immediately after fertilisation. It increases greatly in size and almost completely fills up the venter of the archegonium (Fig. 6.5B). Simultaneously, the walls of the venter divide periclinally and eventually form a two-layered **calyptra** around the young sporophyte.

Development of the sporophyte

The first division of the zygote is transverse (Fig. 6.5C). The second division, at right angles to the first one, results in the formation of a **quadrant** stage of four cells (Fig. 6.5D). Another division in a vertical plane at right angles to the former resulting in an **octant** stage of eight cells. Subsequent divisions are in all directions giving rise to a spherical mass of 20 to 30 cells. The superficial cells of this mass divides periclinally to form an outer **amphithecium** layer and a inner mass of **endothecium** (Fig. 6.5E). The amphithecium forms the **jacket** of the sporophyte, while the endothecium represents the **archesporium** (Fig. 6.5F). The archesporial cells divide further to form two types of cells, (a) the **spore mother cells** (**sporocytes**) and (b) the sterile **nurse cells** with a watery vacuolated cytoplasm (Fig. 6.5G). These nurse cells are probably the forerunners of elaters.

The spore mother cells or sporocytes are the last cells of the sporophytic generation after which it begins to disintegrate. The nurse cells and the amphithecial jacket layer also disintegrate further followed by disintegration of the inner cell layers of the venter wall (Fig. 6.5H). All the disintegrated products form a nutritive fluid within which the spore mother cells remain suspended.

Sporogenesis

The spore mother cells now undergo meiosis forming haploid spore tetrads. The spore tetrads usually remain attached for a long time within a common spherical sheath. In some species, the tetrads may remain permanent even when they are liberated and germinated to give rise to a group of four plants (viz. *R. crustisii, R. pearsonii*). Each haploid spore is uninucleate, pyramidal, 0.05 to 0.12 mm in diameter. The mature spores show three wall layers: the outermost **exosporium**, the middle **mesosporium** and the innermost **endosporium** (Fig. 6.5I).

Structure of the mature sporophyte

The sporophyte of *Riccia* is represented by only a single globular capsule which is found to

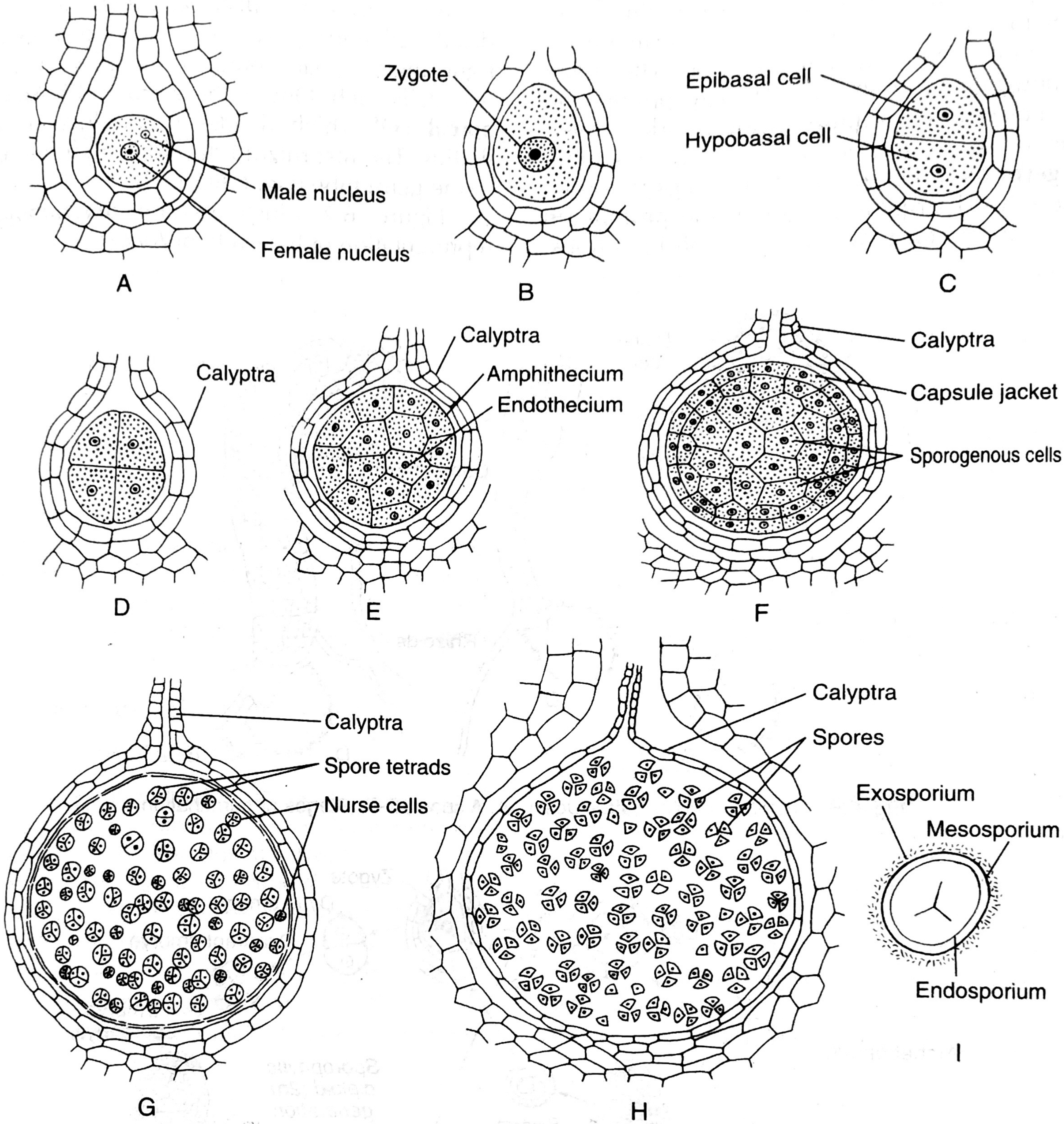

Fig. 6.5 : *Riccia* : A-G. Successive stages in the development of sporophyte, H. A mature sporophyte, I. A spore

be the simplest organisation among the bryophytes. Foot and seta are completely absent (Fig. 6.5H). The capsule lies embedded within the upper surface of the gametophytic thallus, where the spore mother cells are enveloped by a single layered jacket. The capsule has also a two-layered protective covering called calyptra which, in fact, is a part of the gametophyte. The capsule wall degenerates before the formation of spore tetrads and then the inner layer of the calyptra degenerates. Therefore, the mature sporophyte does not contain a single diploid sporophytic cell. Instead, the structure contain some haploid spores surrounded by the outermost layer of the calyptra which is a gametophytic tissue, but of the previous generation. Moreover, the capsule is represented a sporophyte because it has been derived from a diploid cell(zygote).

The young gametophyte

The spore is the first cell of the gametophytic generation (Fig. 6.6A). They are liberated only by the complete death and decay of the calyptra and the surrounding tissue of the gametophytic thallus. The spores germinate in favourable environmental condition, when there is enough water in the soil. The exosporium and the mesosporium rupture at the triradiate aperture and the endosporium comes out as a tubular **germ tube** (Fig. 6.6B). It elongates to form a club-shaped structure. Most of the protoplasm passes to the tip that is now cut off by a transverse wall to form a **distal cell** (Fig. 6.6B). This distal cell undergoes two vertical divisions at right angle to each other forming two tiers of four cells each. One of these four cells form an **apical cell** which divides to produce a new thallus. The first rhizoid develops from the base of the germ tube (Fig. 6.6C & D).

Figure 6.7 illustrates the diagrammatic representation of life cycle of *Riccia*.

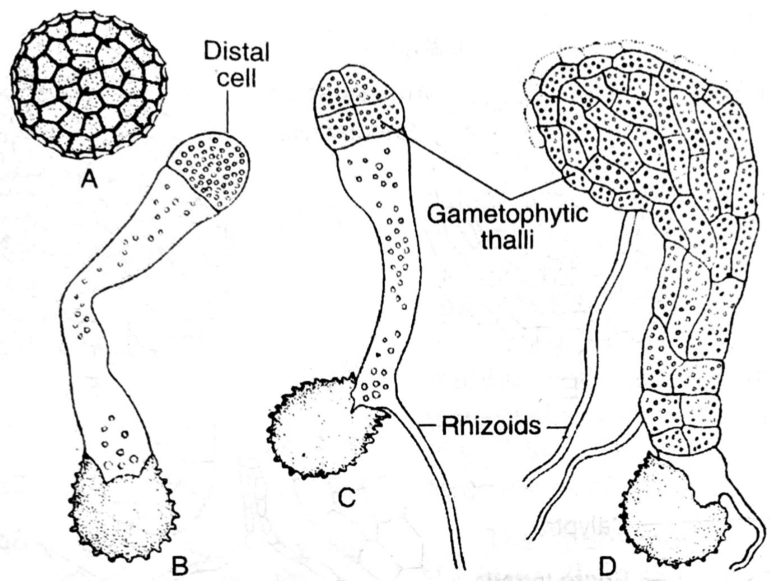

Fig. 6.6 : *Riccia billardieri* (after Udar) : A. A spore, B-D. Stages of germination

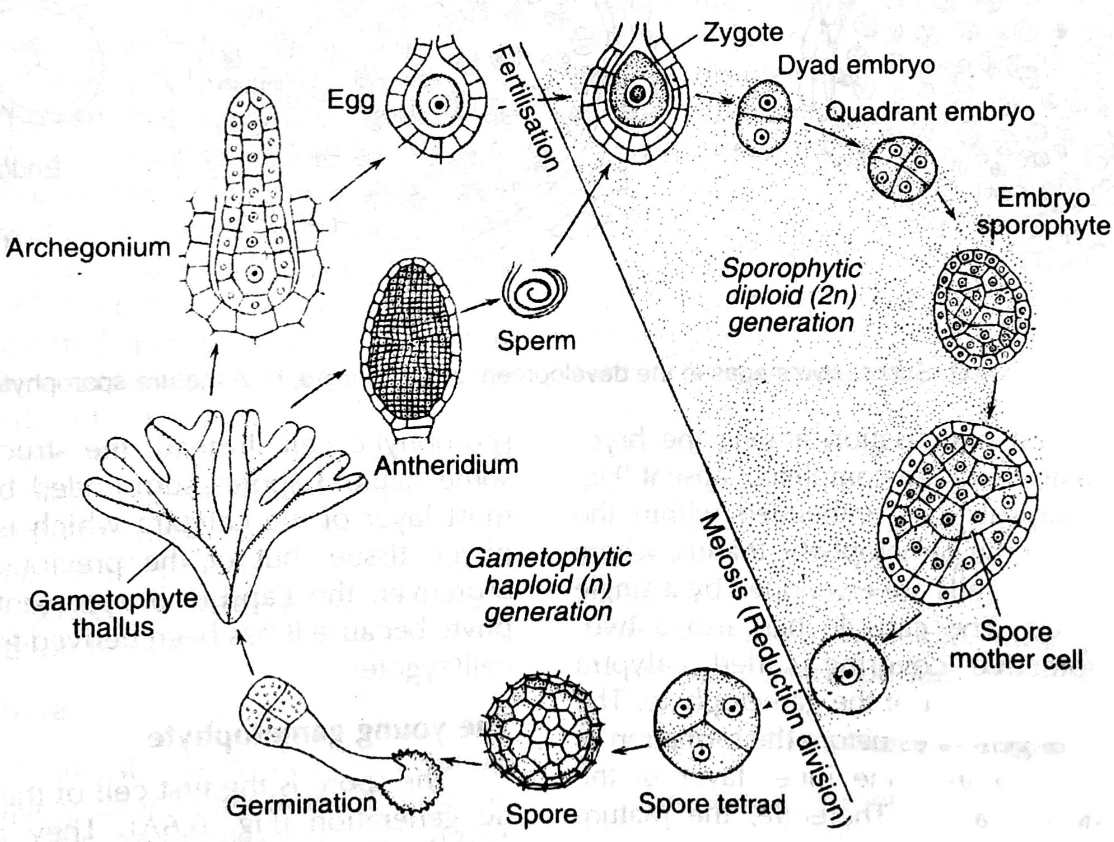

Fig. 6.7 : Life cycle of *Riccia* showing alternation of generations