MARCHANTIA

Systematic Position

Phyllum. Marchantiophyta(Hepatophyta)
Class. Marchatiopsida
Subclass. Marchantiidae
Order. Marchantiales
Sub-order. Marchantiineae
Family. Marchantiacece

Total number of species – About 65

Number of Indian species – About 11

Common Indian species – *Marchantia polymorpha, M. palmata, M. simlans, M. nepalensis,* etc.

Distribution and Habitat – *Marchantia* is cosmopolitan in distribution. It prefers to grow on moist, cool and shady environment. Usually it is found on surface of damp soil, in the sides of streams, springs and swamps.

The Plant Body (The Adult Gametrophyte)

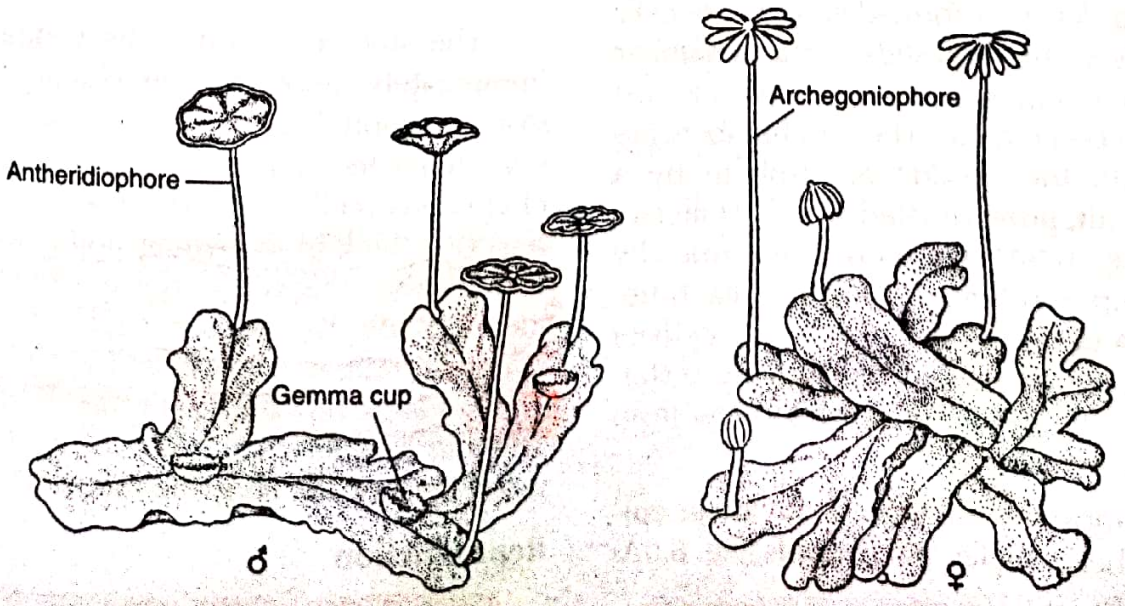
(a) External structure

The gametophyte of *Marchantia* is a dichotomously branched, prostrate, dorsiventral thallus (Fig. 6.8). The dorsal surface of the thallus shows many regular rhomboidal or polygonal areas (Fig. 6.9A). Each area has a pore at the center. A distinct median groove (midrib) is present on the upper (dorsal) surface in each branch of the thallus with a corresponding ridge on the ventral surface. The branches grow indefinitely by means of a growing point situated in the terminal groove (**apical notch**).

The ventral surface of the thallus bears three to four rows of **scales** and rhizoids on both sides of the midrib (Fig. 6.9B). The scales are membranous, one-layered thick, usually violet in colour due to the presence of **anthocyanin** pigments. Morphologically, the scales are of two types — **appendiculate** and **ligulate** (Fig. 6.10D & E). The appendiculate scales situated near the midrib are larger and more elaborate by the presence of an apical sub-rounded appendage (Fig. 6.10D). The ligulate scales, on the other hand, are relatively small, situated towards the margin, which do not have any appendage (Fig. 6.10E). These scales protect the growing point of the thallus from desiccation.

Besides the scales, the ventral surface of the thallus bears **rhizoids** between the scales. They are usually unicellular, colourless and are of two types viz., **smooth walled** and **tuberculate** as in *Riccia* (Fig. 6.10A-C). The rhizoids perform the functions of anchorage to the substratum as well as absorption of water and nutrients from soil.

The sexually mature thalli bear specialised erect branches called **gametophores** or **gametangiophores** which bear sex organs. These branches are umbrella shaped and arises from the apical notch. They are of two types viz., **antheridiophore** and **archaegoniophore** (Fig. 6.8). The antheridiophore bears antheridia and the archegoniophore, the archegonia. *Marchantia* is **dioecious** or **heterothallic**, therefore, a thallus bears either antheridiophores or archegoniophores.



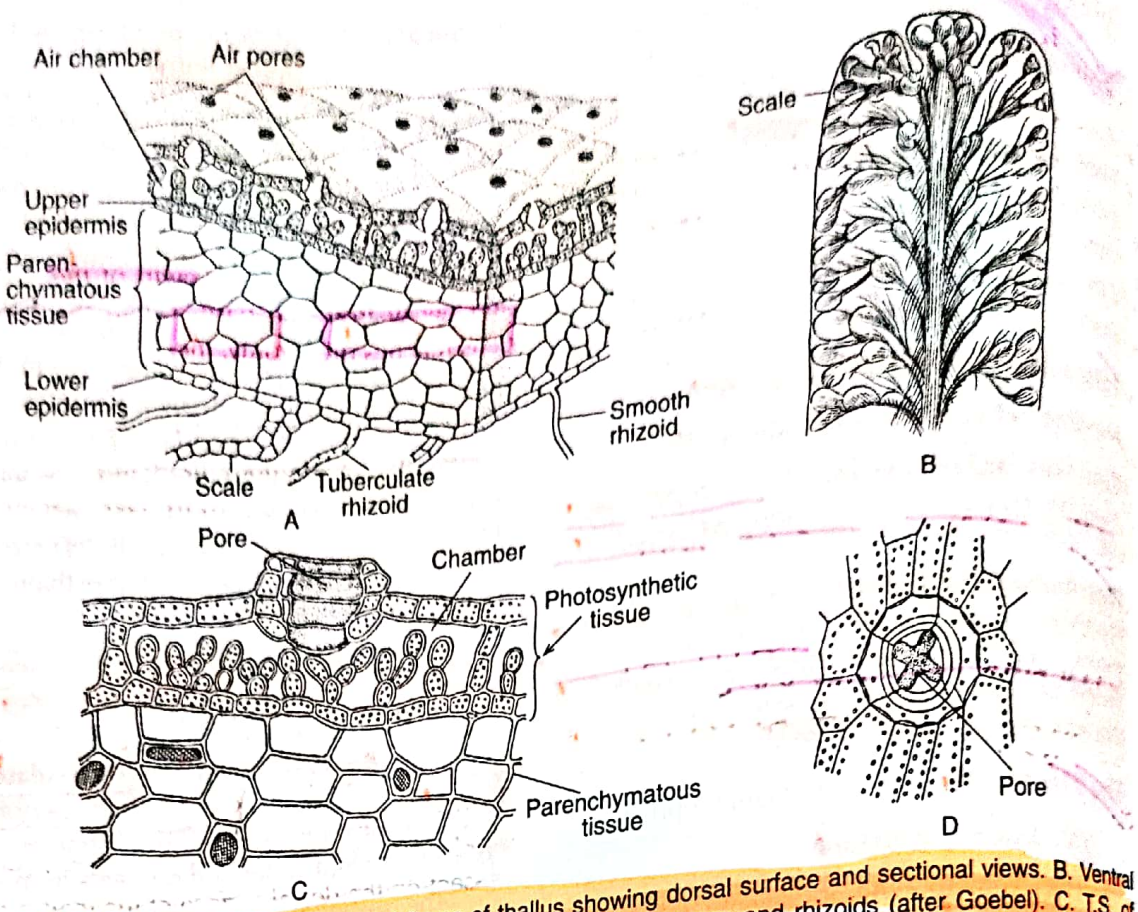


Fig. 6.9 : *Marchantia* : A. Three-dimensional figure of thallus showing dorsal surface and sectional views. B. Ventral surface of thallus showing median ridge, scales with appendages and rhizoids (after Goebel). C. T.S. of thallus showing photosynthetic tissue with an air pore and lower parenchyme tissue. D. Surface view of an air pore (after Strasburger)

(b) Internal features

A section (V.T.S.) of the thallus shows three distinct regions viz., the **epidermal region**, the **photosynthetic region**, and the **storage region**.

The epidermal region : It consists of a well-defined upper (*dorsal*) and lower (*ventral*) epidermis. The epidermis is formed of quadrate cells containing a few chloroplastids. An **air chamber** of schizogenous origin (Fig. 6.9A) is present just below the polygonal area . The air chambers are connected with the outside atmosphere by a barrel-shaped **air pore** situated at the center of the polygon (Fig. 6.9A). The air pore is formed by 4 to 8 superimposed tiers of cells, and each tier composed of 4 or 5 cells (Fig. 6.9C). The cells of the lowermost tier project inwards giving a star-shaped appearance to the pore when view from the above (Fig. 6.9D).

The lowermost ventral layer is the lower epidermis, which bears scales and rhizoids (Fig. 6.9A)

The photosynthetic region : The upper dorsal epidermis contains a few chloroplastids. The air chamber is demarcated from others by single layered partitions of cells containing chloroplastids. Simple or branched filaments formed of cells in horizontal row full of chloroplastids arise from the floor of the air chamber. These horizontal row of cells form the main photosynthetic tissue of the *Marchantia* (Fig. 6.9A, C).

The storage region : The ventral tissue lies immediately below the air chambers forms the storage region. It is a compact zone comprised of several layers of thin-walled, polygonal parenchymatous cells devoid of chloroplasts. This region is thick in the center and gradually tapers towards the margin (Fig. 6.9A). However, most of the cells of the storage region contain starch grains or protein granules and some isolated cells contain large oily bodies or mucilage (Fig. 6.9C). The midrib of the thallus is made up of cells elongated tangentially showing reticulate thickening.

Reproduction

Marchantia reproduces both by vegetative and sexual methods.

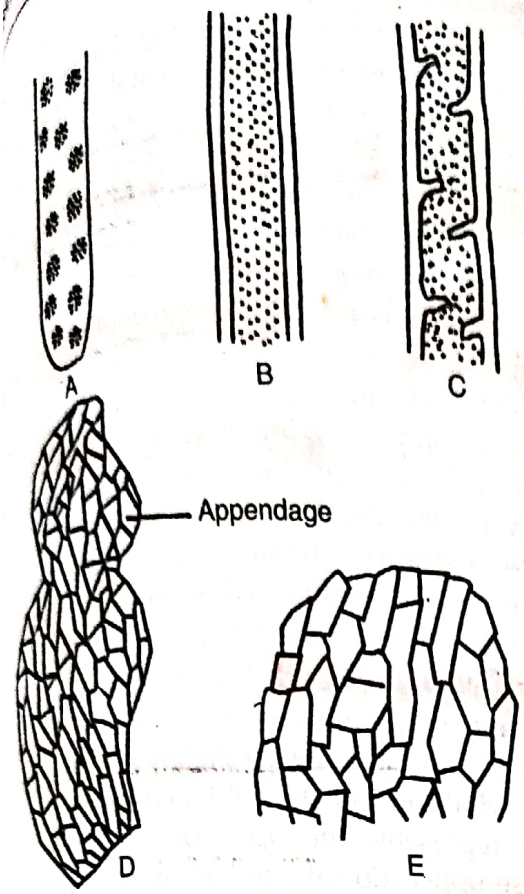


Fig. 6.10 : *Marchantia* : A. Tuberculate rhizoid (surface view), B. Smooth-walled rhizoid, C. Tuberculate rhizoid (internal view), D. Appendiculate scale, E. Ligulate scale

Vegetative reproduction

Vegetative propagation of *Marchantia* takes place by the following methods :

(a) **By progressive death and decay of the thallus** : Like *Riccia*, the vegetative propagation of *Marchantia* is quite common which takes place by the unlimited growth of the branches and decay from the base. When the decay of cells reaches dichotomy, the two lobes becomes separated from each other and the each separated lobe forms independent plants.

(b) **By adventitious branches** : Vegetative propagation is also known to take place by the development of adventitious branches from the ventral side of the thallus or even from the reproductive buds (e.g. *M. palmata*). These branches, on separation from parent thallus, grow into new plants.

(c) **By gemmae** (singular = gemma) : The most common method of vegetative propagation is by specialised asexual multicellular bodies, known as **gemmae**. They are borne in large numbers in small receptacles called gemma cups present on the dorsal surface of the thallus in the midrib region (Fig. 6.11A). A **gemma cup** is about 2 mm in diameter and 3 mm in height, the mar-

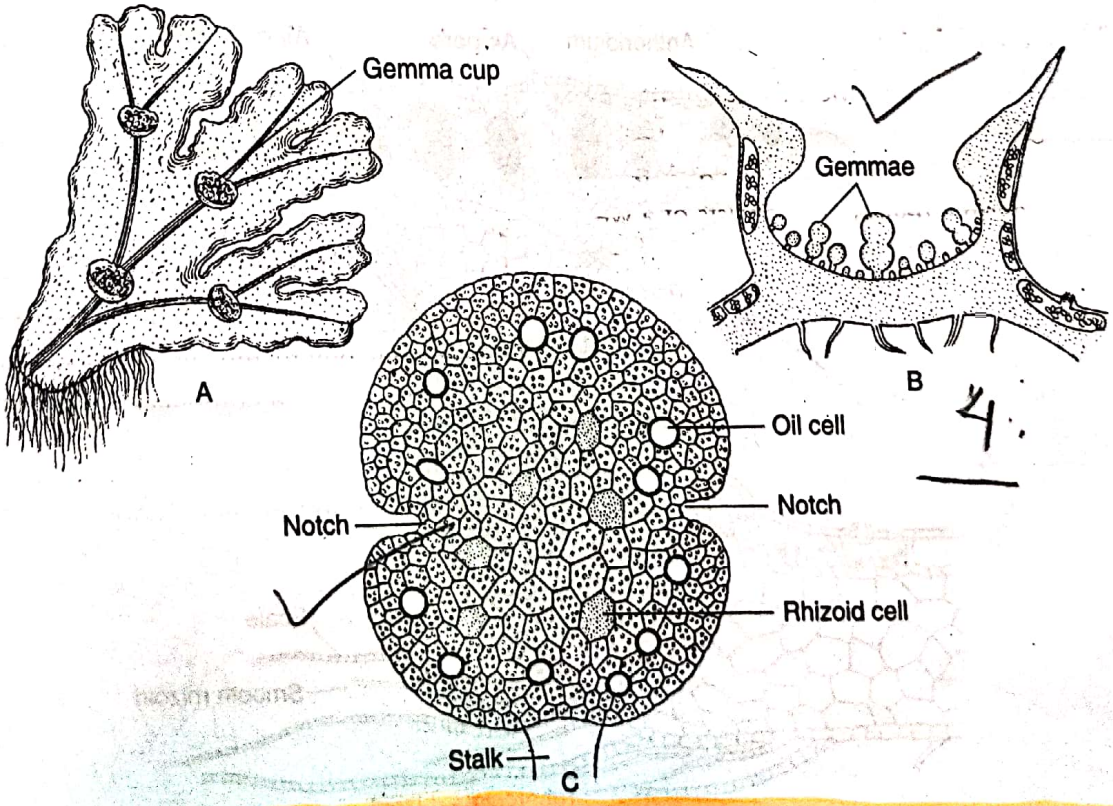


Fig. 6.11 : *Marchantia* : A. Thallus showing gemma cups. B. Vertical section of a gemma cup showing gemm C. A single gemma highly magnified

gins of which are hyaline, lobed, spinuous or entire.

Many small stalked gemmae develop on the floor of the gemma cup (Fig. 6.11B). Each gemma is vertically attached to the base of the gemma cup by a one-celled stalk (Fig. 6.11B, C). The gemmae are multicellular, biconvex, discoid bodies constricted at the middle. The two notches in the constriction possess a row of apical cells showing two growing points. Most of the cells of gemma contain chloroplastids but some superficial cells in either sides may be colourless, containing oil bodies (Fig. 6.11C). Some club-shaped mucilage hairs are present on the floor of the cupule. The mucilage secreted by these hairs imbibes water and the pressure thus generated causes the gemmae to disseminate from the stalks. The detached gemma germinates after falling on a suitable substratum. Some colourless superficial cells larger than the neighbouring cells having dense and granular cytoplasm are called **rhizoidal cells**. These cells on the lower face of the gemma develop rhizoids. Subsequently, the apical cells present in the two notches grow to develop two thalli of new independent plants in opposite direction. Usually, the gemmae present on the male thallus produce male plants and those on the female thallus form female plants.

Sexual reproduction

In *Marchantia*, the production of sex organs is dependent on environmental conditions like day length, humidity, excess of nitrogenous substance, etc. The sex organs are borne on special stalked receptacles called **gametophores**. The receptacles bearing male (**antheridium**) and female (**archegonium**) sex organs are called **antheridiophore** and **archegoniophore** or **carpocephallum**, respectively (Fig. 6.8). These are developed on separate plants, so that the *Marchantia* is **dioecious** or **heterothallic**. Although, the gametophores are erect branches, they are actually the direct extension of the prostrate vegetative thallus. This is clearly evident from the dorsiventral nature of the erect shoots with air chambers, airpores and rhizoids.

Antheridiophore : The antheridiophore (Figs 6.8 and 6.12) shows a 1-3 cm long prismatic stalk bearing at its apex a slightly convex (peltate) disc which is usually a 8-lobed structure. Each lobe represents the apex of a branch along whose upper (dorsal) median line the antheridia are borne in a row. The antheridia develop in a acropetal manner i.e., the oldest are being at the center and the youngest ones towards the periphery. The antheridia are within the flask-shaped antheridial chamber. Each antheridial

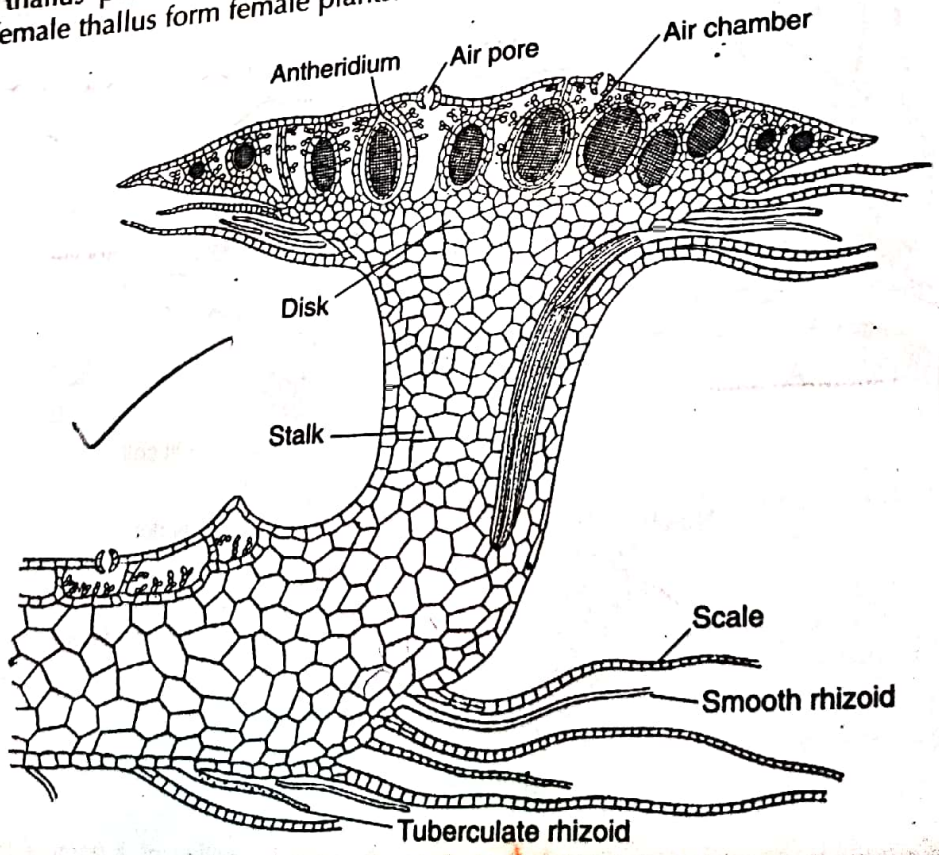


Fig. 6.12 : *Marchantia polymorpha* : A vertical section through antheridiophore

chamber contains a single antheridium. Each antheridial chamber is separated from one another by air chambers with air pores.

Antheridium

Development and Structure

The development of antheridium in *Marchantia* is similar to that of *Riccia*. The antheridium develops from the antheridial initial, situated on the dorsal surface of the disc of the antheridiophore. The antheridial initial increases in size and a transverse division differentiates it to an **outer cell** and a **basal cell** (Fig. 6.13A, B). The basal cell follows no further development. The outer cell later undergoes transverse division forming a basal **primary stalk cell** and a terminal **primary antheridial cell** (Fig. 6.13C). Eventually the antheridium is formed from the primary antheridial cell. The basal primary stalk cell however, forms the stalk of the antheridium (Fig. 6.13D-G).

A mature antheridium has a short stalk and a globular body encircled by a sterile jacket which encloses a number of sperm mother cells. A single sperm mother cell forms two trianguiar androcytes, each of which develops a biciliated **sperm** or **antherozoid** (Fig. 6.13H). The dehiscence of antheridium in *Marchantia* is similar to that of *Riccia*.

Archegoniophore or Carpocephalum

The archegoniophore or the carpocephalum is comprised of a **stalk** and a **disc** that bears 9 rays (Fig. 6.14D) instead of lobes. In the early stage, the archegonia develop on the upper (dorsal) side of the disc (Fig. 6.14A, A'). About 12-14

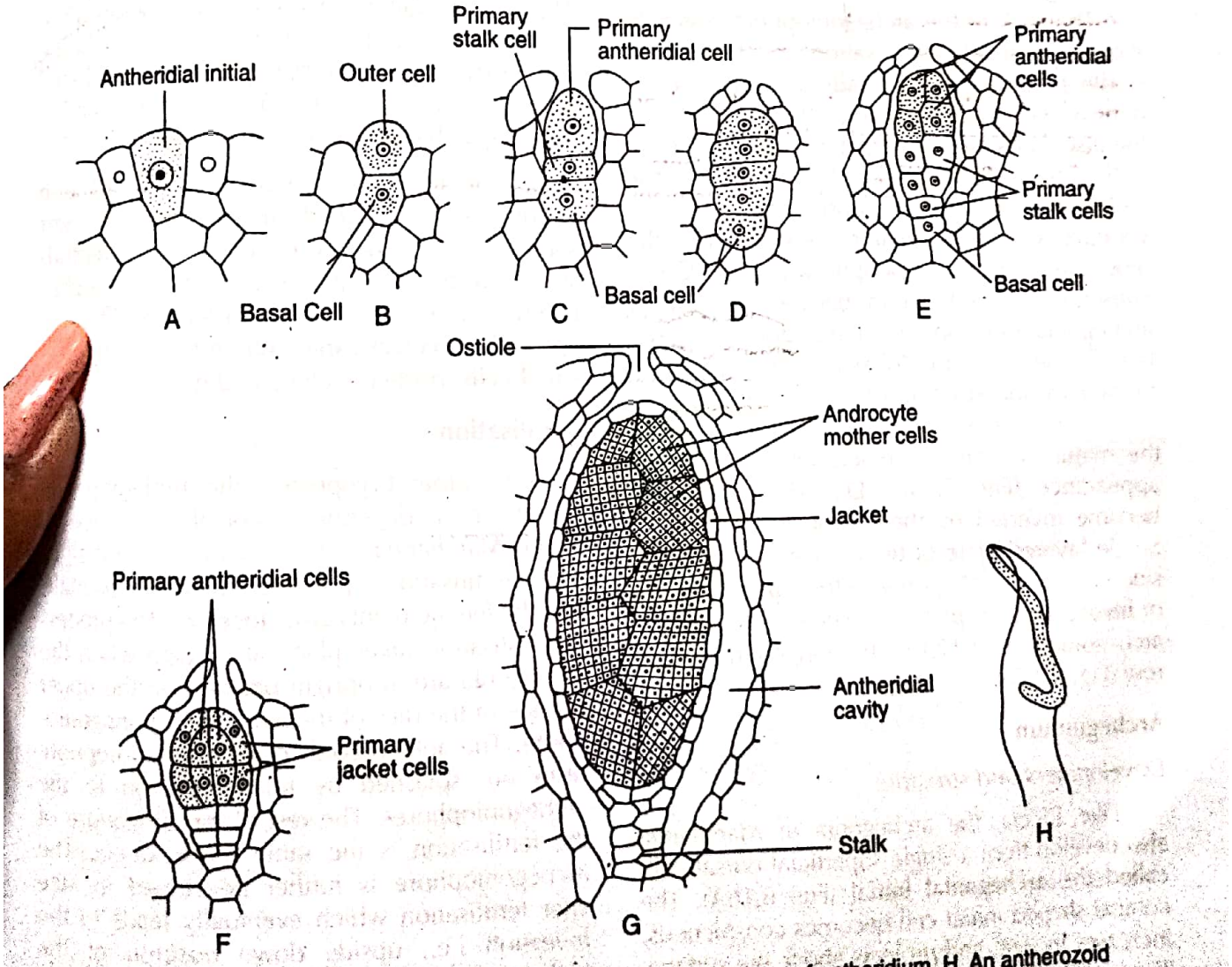


Fig. 6.13 : *Marchantia* : A-G. Successive stages in the development of antheridium, H. An antherozoid

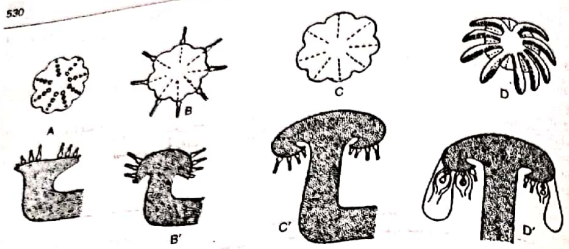


Fig. 6.14 : *Marchantia polymorpha*. Stages of development of the archegoniophores : Upper row — top views. Lower row — V.L.S. (Modified from Smith, 1955)

archegonia are arranged in a single row on each ray of the disc.

The stalk of the archegoniophore begins to elongate just after fertilisation and the central sterile part of the disc starts to enlarge enormously. As a result, the marginal apical region of the disc containing archegonia are pushed down to the lowerside of the disc (Fig. 6.14B, B'). The archegonia are hanging upside down — the youngest one being nearer the stalk while the older ones towards the periphery (Fig. 6.14C, C'). Subsequently, the tissue in between the rows of archegonia develop and hang down as rays. Initially the number of lobes is 8, later 9 rays are formed by the splitting of one. Rays are long, stout and green finger-like projections that give the mature female receptacle an umbrella-like appearance (Fig. 6.14D, D'). The archegonia become inverted by the curvature of the disc. Single layered plate of tissue overlaps on either side of row of archegonia to form **perichaetium** or **involucre**. This plate of tissue encloses all the archegonia (about 12 to 14) arranged in a single row (Fig. 6.15A).

Archegonium

Development and structure

Like *Riccia*, the archegonia of *Marchantia* also develop from a single superficial dorsal cell, called the **archegonial initial** (Fig. 6.16A). The conical shaped initial cell becomes conspicuous, increases in size, and projects above the surface. The initial cell divides by a transverse wall to form an upper (or outer) **primary archegonial cell** and a lower (or inner) **primary stalk cell** (Fig. 6.16B). The primary stalk cell by a few irregular divisions forms a short but distinct multicellular stalk of the archegonium. The primary archegonial initial undergoes several phases of regular divisions to form the archegonium (Figs. 6.16B-H).

A mature archegonium (Figs. 6.15B) is a pendulous flask-shaped structure with a short stalk, which attaches to the lower (ventral) surface of the archegonial disc. A single archegonium has a basal swollen **venter** containing an **egg cell**, a **ventral canal cell** and a row of **neck canal cells** inside the elongated neck.

Fertilisation

Like other bryophytes, the fertilisation of *Marchantia* is dependent upon the presence of water. *Marchantia* is dioecious or heterothallic, so the fertilisation is possible only when the male and the female plants grow together. The process of fertilisation takes place at a stage when the archegonia are in upright position on the upper surface of the disc of the very short archegoniophore. The antherozoids of the antheridiophore discs are splashed by rain water on to the archegoniophores. The rest of the procedure of the fertilisation is the same as in *Riccia*. The archegoniophore is further developed in size after fertilisation which eventually leads to the inversion i.e., upside down position of the archegonia. In this phase the development of rays and perichaetium take place.

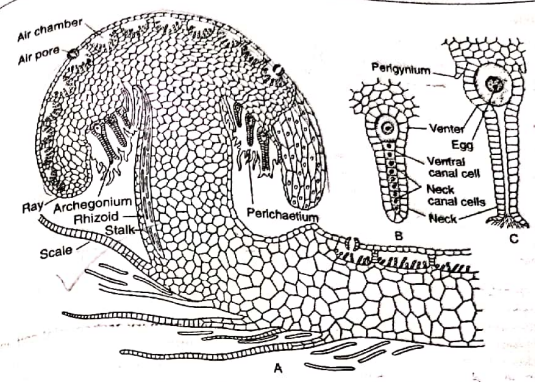


Fig. 6.15 : *Marchantia polymorpha* : A. Vertical section through archegoniophore showing two radial rows of archegonia, B. A mature archegonium, C. An archegonium after disintegration of neck and ventral canal cells showing rudiments of the perigynium. (Modified from Smith)

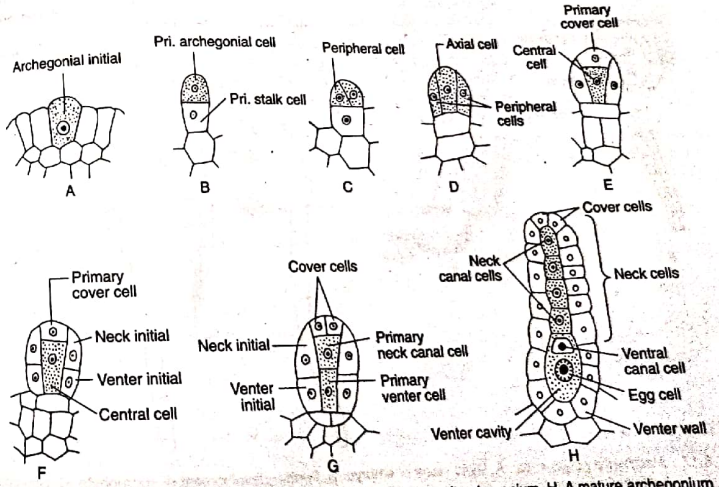


Fig. 6.16 : *Marchantia* : A-G. Successive stages of development of archegonium, H. A mature archegonium

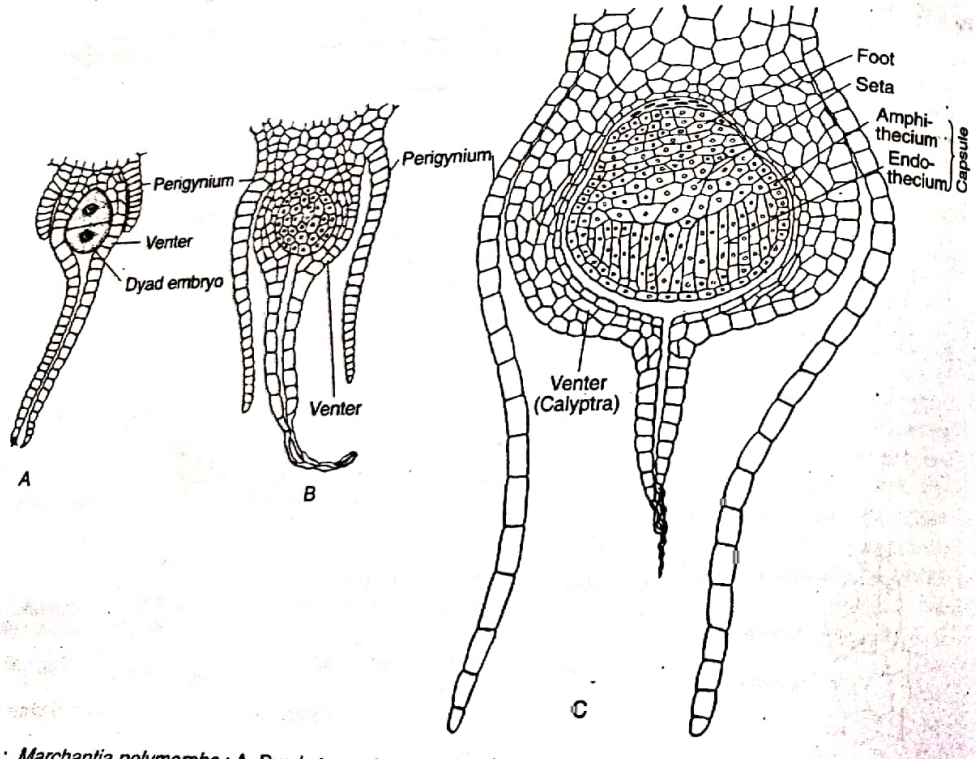
Sporophyte

Development of the sporophyte

The fertilised egg enlarges in size and fills up the cavity of the venter. It invests itself immediately with a thin cellulose wall and becomes the **oospore** or **zygote** which is the mother cell of the sporophytic generation.

The zygote cell inside the venter divides first by a transverse wall forming an outer **epibasal cell** and an inner **hypobasal cell** (Fig. 6.17A) This is followed by a second division at right angle to the first division forming **a quadrant** of cells. The two upper **epibasal cells** of the quadrant divide and redivide to form the **capsule** and the **upper part of the seta**. The two **hypobasal cells** after several divisions form the **lower part of the seta** and the **foot**. The cells within the capsule are early differentiated into the peripheral single layered **amphithecium** and the central many-celled **endothecium** (Fig. 6.17C). A single-layered outer **jacket** is formed from the anticlinal divisions of amphithecial cells. All the cells of endothecium on the other hand functions as archesporium and forms a massive **sporogenous tissue**. Subsequently, about half of the sporogenous tissues by repeated divisions, form a large number of **spore mother cells**. Each spore mother cell following a meiotic division gives rise to a **spore tetrad**. The remaining cells of the sporogenous tissue function as **elater mother cells** and, subsequently, become elongated, endowed with two spiral thickenings and become the sterile **elaters** (Fig. 6.18A, D). Unlike spores, the elaters are diploid cells and are hygroscopic, help in spore dispersal.

The early development of zygote is associated with several significant changes in the gametophytic tissue surrounding the embryo. The stimulus of fertilisation leads to the periclinal division of the venter wall which eventually gives rise to a 2-3 layered **calyptra** enveloping the growing sporangium. A ring of basal cells of archesporium forms a second one cell thick



17 : *Marchantia polymorpha* : A. Dyad stage of embryo, B. Further development of sporophyte, C. Sporophyte sufficiently formed to show differentiation. (Redrawn after Smith)

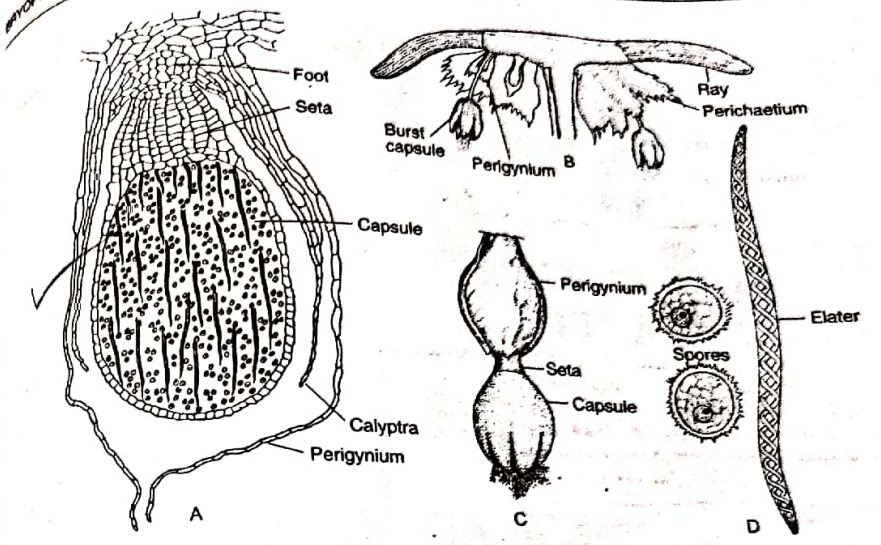


Fig. 6.18 : *Marchantia polymorpha* : A. L.S. of sporophyte, B. Vertical section through archegonial head at the time of bursting of capsules, C. One burst sporophyte, D. Spores and an elater

protective covering round the growing sporangium. It is called the **perigynium** or the **pseudoperianth**. Therefore, the sporangium of *Marchantia* develops within three gametophytic coverings viz., calyptra, perigynium and perichaetium (Fig. 6.18A-C).

Structure of the mature sporophyte

The mature sporophyte of *Marchantia* (Fig. 6.18A) is differentiated into three parts — **foot**, **seta** and **capsule**.

(a) Foot — It is an expanded bulbous mass of cells at the base of the sporogonium, serves as an absorbing and anchoring organ. It absorbs nutrients from the gametophyte.

(b) Seta — It is a slightly elongated stalk that connects the foot to the capsule. The cells are parenchymatous and elongated lengthwise. Thus, seta increases in length and pushes the mature capsule out of the calyptra.

(c) Capsule — It is a yellow-coloured spherical structure, contains numerous **spores** and **elaters**. The capsule is protected by three coverings viz. **calyptra, perigynium** and **perichaetium**.

Dehiscence of the Capsule

The jacket of the hanging mature sporogonium (capsule) gets dried and splits longitudinally into a variable number of longitudinal lobes (Fig. 6.18B). These lobes extend from the apex to the middle of the capsule. The discharge and dispersal of spores to the air are assisted by the coiling and uncoiling of the elaters due to their hygroscopic nature. The spores are almost rounded and are very minute in size (12 to 30 μm in diameter)

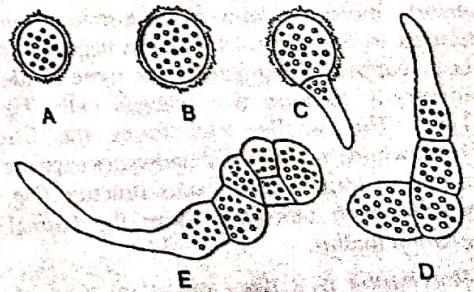


Fig. 6.19 : A-E. Stages of germination of Marchantia spore up to the beginning of differentiation of the new gametophytic thallus

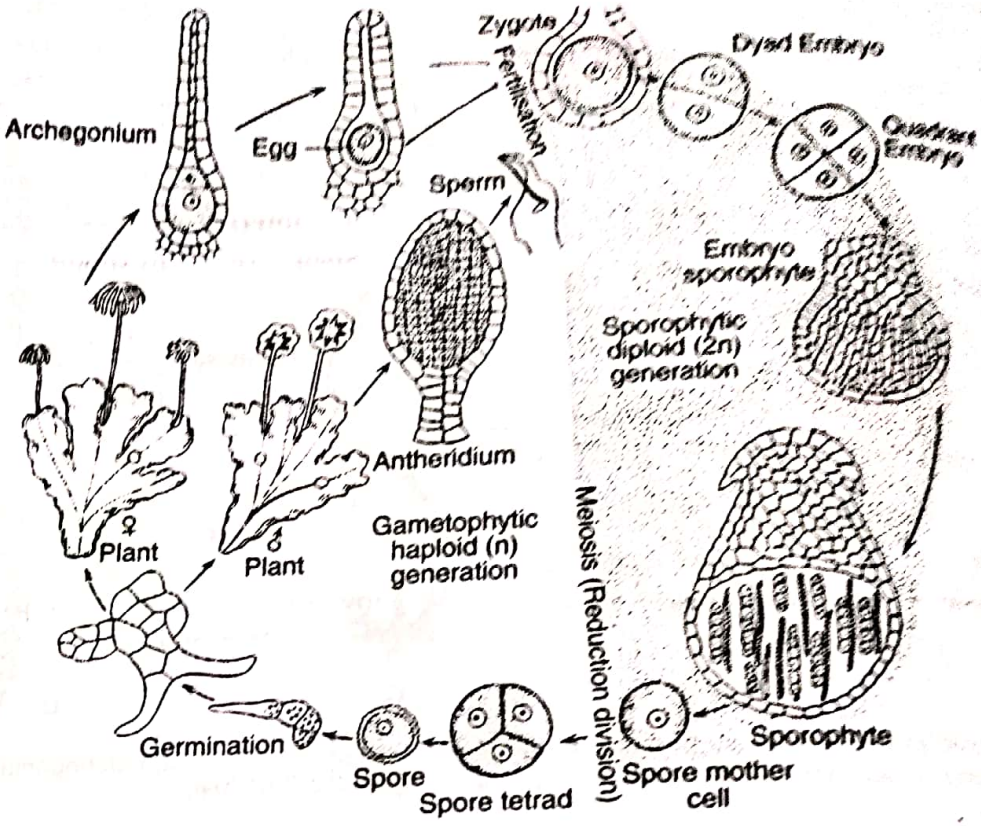


Fig. 6.20 : Life cycle of *Marchantia* showing alternation of generations

with a thin inner **intine** and a slightly thicker outer **exine** (Fig. 6.18D). In some species an additional layer called **perispore** is also found outside the exine.

The new Gametophyte

Spore is the first cell of the gametophyte which germinates to form a new gametophytic plant (Fig. 6.19A). Spores remain viable for about a year. Under favourable conditions they absorb moisture from the substratum and increase in size (Fig. 6.19B). At this stage chloroplasts reappear. Subsequently, the spore divides transversely to form two unequal cells (Fig. 6.19C). The smaller cell forms the first rhizoid, while the larger cell undergoes irregular divisions to form a filamentous structure (Fig. 6.19D-E) which ultimately forms the normal *Marchantia* thallus.

Marchantia is a dioecious plant. Out of each spore tetrad, two spores grow into two male plants and the other two into two female plants.

Fig. 6.20 represents the life cycle of *Marchantia*.

PORELLA

Systematic Position

Phyllum.	Marchantiophyta
Class.	Jungermanniopsida
Subclass.	Jungermanniidae
Order.	Porellales
Sub-order.	Porellineae
Family.	Porellaceae

Total number of species – About 180

Number of species found in Indian – Abou

Common Indian species – *Porella plan*
P. plumosa, P. acutiphylla, P. dent
P. microloba, P. gollani, P. variabilis, P.
rens, P. obtusifolia.

Distribution and Habitat – *Porella* is cos
tan in distribution, occurs almost in all