

# STUDY MATERIAL FOR B.Sc. SEM-II (BOTA), DT. 09/04/2020

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## ***Marchantia***

(Life History: Gametophyte Structure and Reproduction, Development and Structure of Sporophyte, Spore Dispersal)

### **SYSTEMATIC POSITION:** According to Proskauer (1957)

Division : Bryophyta

Class : **Hepaticopsida (Liverworts)**

Order : **Marchantiales**

Family : Marchantiaceae

Genus : ***Marchantia***

Species : ***M. polymorpha*, *M. palmata*** (available in Kolkata)

- ***Marchantia*** is the most common **liverwort** of the order **Marchantiales**.

### **DISTRIBUTION AND HABITAT:**

- *Marchantia* is a **cosmopolitan genus** with about **65** species.
- About **11** species are reported from **India** (Chopra, 1943), growing mainly in the **Himalayas**.
- All the species are **terrestrial** and commonly found in **moist, cool, shady places and burnt soil**.
- It grows on **damp soil, wet rocks** and the sides of **streams, springs** and **swamps**.

### **ADULT GAMETOPHYTE (PLANT BODY):**

#### **EXTERNAL FEATURES:**

- The gametophyte of *Marchantia* is a **prostrate, dorsiventral, thallus** branching **dichotomously**.
- Each branch ends in an **apical notch**, i.e., the growing point.
- The thallus has a **distinct midrib** usually **marked** on the **dorsal surface** by a **shallow groove** and on the **ventral side** by a **low ridge**.
- The **dorsal surface** is marked by **small rhomboidal or polygonal areas (areolae)** which indicate the outline of the underlying air chambers just beneath the upper epidermis, each with a distinct central **air pore**.
- **Along the midrib** there are certain **cuplike structures with frilled margins** called **gemma cups**.
- Certain branches of mature thallus bear **special upright reproductive structures** at the **growing apices**. These are of **2 kinds**- (i) **antheridiophore** bearing antheridia and (ii) **archegoniophore** bearing archegonia and borne on **different thalli**.
- On the **ventral surface** there are numerous **rhizoids and scales**. The **rhizoids** are **unicellular, unbranched and of 2 types** - (i) **smooth-walled** and (ii) **tuberculate**. They serve as **absorbing and anchoring organs**.
- The **scales** are **multicellular, one-celled thick** and arranged in **2-4 rows on both sides of the midrib**. They are of **2 types**-
  - (i) **appendiculate** (*larger and with an apical sub-rounded appendage*), situated **near the midrib** and
  - (ii) **ligulate** (*smaller and without any appendage*), situated **near the margin**. These scales **protect the growing apex** by retaining water.

## INTERNAL FEATURES (i.e. Anatomy):

Internally the thallus is differentiated into **3 distinct regions- epidermal, photosynthetic and storage region.**

### i. EPIDERMAL REGION:

- It consists of a **well-defined upper** (dorsal) and a **lower** (ventral) **epidermis**.
- The **upper epidermis** consists of a **single layer of thin walled quadrate cells** containing **few chloroplasts**.
- It is interrupted by **barrel-shaped air-pores** that **communicate** with the **air chambers below**. The **pore opening** is usually surrounded by **4-8 superimposed tiers of cells**. Each tier is an **oval ring** composed of **4-5 cells**.
- The **lowest tier** usually consists of **4 large cells** which **project into the passage** giving a **star-shaped** appearance to the pore (when viewed from the above).
- It has been reported that the surrounding cells by **imbibitional changes** in their cell walls bring about **opening and closing of the air pore**.
- The **lowermost ventral surface** of the thallus is covered by the **lower epidermis** that bears **two types of rhizoids and 4-8 rows of scales**.

### ii. PHOTOSYNTHETIC REGION:

- The **upper epidermis** contains **few chloroplasts**.
- Below the upper epidermis there are a number of **schizogenously formed air chambers** in a single horizontal layer, **separated** from one another by **single layer partitions of cells containing chloroplasts**.
- From the **floor** of each air chamber arise **simple or branched filaments of green cells**.
- **Each air chamber** opens to the exterior through an **epidermal air pore**.
- The **chlorophyll-bearing cells** constitute the **main photosynthetic tissue** of the gametophyte of *Marchantia*.

### iii. STORAGE REGION:

- The **ventral tissue** of the thallus, **lying below the air chambers** forms the storage region.
- It is composed of **compactly arranged, thin walled, polygonal parenchymatous cells** with a **few or no chloroplasts**.
- **Most** of the cells contain **starch grains** and **some** isolated cells may contain **large oil bodies or mucilage**.
- The **midrib** is formed of **elongated cells** with **reticulate thickenings**.

## REPRODUCTION:

*Marchantia* reproduces both **vegetatively** (asexually) and **sexually**.

### i. VEGETATIVE (ASEXUAL) REPRODUCTION : It takes place in *Marchantia* by the following methods:

#### a) FRAGMENTATION:

- It takes place by the **progressive growth of the apical region** followed by the **gradual death and decay of older basal part** of the thallus.
- When the **decay of the thallus reaches dichotomy**, the **young apical branches become separated** and each such branch grows independently into a new thallus.

#### b) ADVENTITIOUS BRANCHES :

- In **some species** (e.g. *M. palmata*), adventitious branches are formed either from the **ventral face** of the thallus or **rarely from the archegoniophores**.
- These branches become **detached** from the parent thallus and **grow** into new plants.

### c) GEMMAE FORMATION :

- A **prolific and specialized method** of vegetative reproduction in *Marchantia* is by **characteristic special asexual reproductive bodies** known as **gemmae**.
- The **gemmae** are produced in **large numbers** in **small cup-like receptacles** called **gemma cups** borne on the **dorsal surface** of the thallus **along the midrib**.
- The **gemma cups** have **colourless fringed margins** and are about **1/8th of an inch** in **diameter**.
- A **mature gemma** is a **multicellular, biconvex, discoid body**, which is **vertically inserted** in the gemma cup with **one-celled hyaline stalk**.
- Each gemma has **two shallow notches**, one on each **lateral margin**, possessing a **marginal row of apical cells** showing **two opposite growing points**.
- **Most** of the cells contain **chloroplasts** but **some** may be **colourless**, containing **oil bodies**.
- **Some colourless superficial cells** slightly **larger than the neighbouring cells** with **dense granular protoplasmic contents** are known as **rhizoidal cells**. These cells on the lower face of the gemma develop **rhizoids**.
- Some **club-shaped mucilage hairs** are present on the floor of the gemma cup. The hairs **secrete mucilage** that **swells up on absorbing water** and **causes the gemmae to get detached** from the gemma cup.
- The detached gemmae **germinate** after falling on a suitable substratum. By the **activity of the apical cells**, **two young thalli** are formed which grow **in opposite directions** simultaneously. These two new thalli are **separated** when the **central part of the gemma dies and decays**.
- Usually the **gemmae from a male thallus** produce **more male plants** and **those from a female thallus** develop into **more female plants**.

### ii. SEXUAL REPRODUCTION:

- The sex organs, **antheridia** and **archegonia**, are borne on **special upright stalked branches** of the thallus known as **antheridiophores** and **archegoniophores** respectively.
- These reproductive branches are produced only under **proper environmental conditions** like **day length, humidity, ratio between carbohydrate and nitrogen** of the medium etc.
- *Marchantia* is **dioecious** as the **antheridiophores** and **archegoniophores** are borne on **different thalli**.
- Each of these branches is composed of a **stalk** and a **terminal horizontal disc**.
- These sexual branches are **direct continuations of the prostrate thallus** which is evident from the dorsiventral nature of the erect shoots with air chambers and rhizoids.
- The **sex organs** are **exogenous in origin**.

### THE ANTHERIDIOPHORE:

- Each antheridiophore consists of a **1-3 cm long, prismatic stalk** bearing at its **apex usually a 8-lobed disc**.
- On the **upper surface of the disc** antheridia lie embedded in **flask-shaped antheridial chambers** which **open by a narrow channel**. The **antheridial chambers alternate** with **air chambers**. Air chambers contain branched filaments of green cells and open by air pores.
- The **antheridia** arise in the **acropetal order** (i.e. oldest towards the centre and youngest towards the periphery) and are arranged in **radiating rows**.

### ANTHERIDIUM:

- The **mature antheridium** consists of a **short stalk** and a **globular body**.
- The antheridial body is covered by a **single layered jacket** which encloses a **large number of androcytes** (antherozoid mother cells).
- Each androcyte gives rise to a **biflagellate antherozoid**.

## THE ARCHEGONIOPHORE:

- Each archegoniophore consists of a **long stalk** bearing at its apex a **stellate** (star-shaped) **disc with usually 9-rays**.
- **At young stage** the archegoniophore **forks** and becomes **swollen at its apex**. The **apex** becomes a **rosette like 8-lobed disc** after **3 successive dichotomizations** in quick succession.
- Soon **8 groups of archegonia** develop in **acropetal succession** on the **upper surface of the disc** corresponding to the 8 growing points of the disc.
- The **first-formed archegonia**, with their **necks directed upwards** become **mature** and **fertilization** is achieved at this stage.
- After fertilization the **stalk** of the archegoniophore **begins to elongate** and the **sterile central part of the disc starts to enlarge enormously**.
- As a result, the **marginal apical regions of the disc** along with the groups of archegonia are pushed down to the lower side of the disc.
- The **archegonia** become **inverted by the curvature of the disc**. The **youngest archegonium** comes **close to the stalk** and the **oldest** towards the **periphery of the disc**.
- **After the curvature** there is a development of **one-layered plate of tissue on either side of each group of archegonia**. Thus **each group**, containing about **12 to 15 archegonia**, is enclosed by a **two layered pendent, fringed involucre** known as **perichaetium** (involucre) which hangs down from the underside of the lobe of the disc.
- There is an **intercalary development** of **long, stout, green cylindrical processes or rays** from the periphery of the disc, between the groups of archegonia.
- In *M. polymorpha* the **rays are 9** in number. They radiate outwards from the central disc like bare umbrella ribs and give the archegonial disc a stellate form.

### ARCHEGONIUM:

The mature archegonium is a **short-stalked, flask-shaped structure**. It consists of a **swollen basal venter and a long slender neck**. The venter is surrounded by a single layered wall and encloses an egg and a ventral canal cell. The neck is composed of 6 vertical rows of jacket cells surrounding an axial column of 4 or more neck canal cells.

## SPOROPHYTE:

### DEVELOPMENT:

- **After fertilization the egg enlarges** in size until it fills the **cavity of the venter** and then **secretes a cellulose wall** around itself to become the **zygote**, the **first cell** of the sporophytic generation.
- The **stimulus of fertilization** is also transmitted to the surrounding gametophytic tissues of the zygote. The cells of the **venter wall** divide **periclinally to form a 2-3 layered calyptra** which envelops the developing sporogonium.
- **A ring of cells at the base of venter** divide and re-divide to form a **collar-like cylindrical outgrowth, one cell in thickness**, known as **perigynium** or **pseudoperianth**.
- Thus the **sporogonium** is surrounded by **3 concentric protective gametophytic coverings - calyptra, perigynium** (pseudoperianth) and **perichaetium** (involucre).
- At first the **zygote divides transversely** into an upper **epibasal** and a lower **hypobasal cell**. Further **development** of embryo shows **variations** in different species of *Marchantia*.
- In *M. polymorpha* and many other species, the **second division** of the zygote is **at right angle to the first division**, resulting in a **4-celled globular embryo** i.e. the **quadrant stage**. The **epibasal cells** form the **capsule** and the **hypobasal cells** the **seta and foot**.

- In *M. domingensis*, the **epibasal cells** develop into the **capsule** and the **upper portion of seta** and the **hypobasal cells** give rise to the **lower portion of seta** and the **foot**.
- In *M. chenopoda* the **two primary divisions** are **transverse** and thus a **3-celled filamentous embryo** is formed. On further development the **basal cell** develops into the **foot**, the **middle** into the **seta** and the **apical cell** into the **capsule**.
- In the **quadrant types**, the **4-celled embryo** divides **vertically** at right angles to the earlier divisions forming a **8-celled embryo** i.e. the **octant stage**. Now the embryo begins to elongate and the subsequent divisions in the two regions occur differently.
- The **cells in the capsular region** divide **periclinally** to form the **peripheral single-layered amphithecium** and the **central many-celled endothecium**.
- The **amphithecium** divides **anticlinally** to form the **single-layered jacket** of the capsule.
- The **endothecium** gives rise to the **archesporium**.
- The **archesporial cells** divide and re-divide to form a **massive sporogenous tissue**.
- Subsequently, about **half of the sporogenous tissue** develops a large number of **spore mother cells** (sporocytes). The **spore mother cells** form **spore-tetrads** by **meiosis**.
- The **remaining cells** of the sporogenous tissue remain sterile and function as **elater mother cells**.
- The **elater mother cells** are elongated to form **long, slender, *diploid*, spindle-shaped elaters, tapering at both ends**.
- The elaters lose their protoplasmic contents and develop **two *spiral bands*** on the inner surfaces of their cell walls.
- They are **hygroscopic** and perform **squirring movements** to help in dispersal of spores.

### MATURE SPOROPHYTE:

It is a somewhat **elongated structure** differentiated into **3 distinct regions: foot, seta and capsule**.

#### i. FOOT:

- It is a **basal bulbous part** which **anchors** the sporophyte to the disc of the archegoniophore.
- It also **absorbs nutrition** from the gametophyte.

#### ii. SETA:

- It is a **short, relatively thick stalk connecting** the foot and the capsule.
- After the spores mature the **seta elongates rapidly and pushes the mature capsule** out through the calyptra, perigynium and perichaetium.

#### iii. CAPSULE:

- It is a **spherical to oval, yellow structure** concerned both in the **production and distribution of spores**.
- It has a **single layered jacket** of sterile cells.
- Inside the wall there are **numerous spores and elaters**.
- The **spores** are **very minute, rounded** and provided with **outer thick exine** and **inner thin intine**.
- The **elaters** are **long narrow spindle shaped cells pointed at each end** and with **2 spiral thickenings** on their walls. These elaters are **hygroscopic** and help in **dispersal of spores**.

### DISPERSAL OF SPORES:

- After the spores are mature, the **capsule breaks through** the **calyptra, perigynium and perichaetium** by the **sudden elongation of the seta** and **hangs down, free and uncovered**, from the underside of the disc of archegoniophore.
- The **jacket** of the mature capsule **splits longitudinally from apex to about the middle**, into a **variable number of lobes** or valves which **roll back slightly**, exposing the mass of spores and elaters.
- **On exposure to dry atmosphere, drying of capsule** occurs and the **long bispiral, hygroscopic elaters** begin to **twist**. The **jerking motions of elaters loosen up** the spore mass and **throw** the spores into the air. The spores are then carried by air currents.