BRYOLOGY:

Unit-III

General characters and classification (Smith, 1965) of Bryophytes. Morphology, structure and reproduction of the following: *Marchantia* and *Porella*,General characteristics of bryophytes

Bryophytes are a group of plant species that reproduce via spores rather than flowers or seeds. Most bryophytes are found in damp environments and consist of three types of non-vascular land plants: the mosses, hornworts, and liverworts.

Bryophyte Characteristics

Bryophytes are non-vascular land plants. Although they do exhibit specialized structures for water transportation, they are devoid of vascular tissue.

Bryophytes grow primarily in damp environments but can be found growing in diverse habitats ranging from deserts, the artic, and high elevations. Since bryophytes do not depend on root structures for nutrient uptake like vascular plants, they are able to survive in environments that vascular plants cannot (e.g., on the surface of rocks).

All bryophytes have a dominant gametophyte stage in their life cycle. During this stage, the plant is haploid and the sex organs that produce the gametes are developed. Bryophytes are unique compared to many other plant species in that they remain in this stage for long periods.

The sporophytes (the diploid form of the plant) of bryophytes are unbranched, producing a single spore-producing capsule (sporangium). Moreover, the sporophytes are dependent on the gametophyte for nutrition and develops within the female sex organ (archegonia).

Bryophyte Life Cycle

The bryophyte lifecycle consists of alternating generations between the haploid gametophyte and the diploid sporophyte. During the gametophyte stage, haploid gametes (male and female) are formed in the specialized sex organs: the antheridia (male) and archegonia (female). The gametes consist of flagellated sperm, which swim via water or are transported by insect species. The two haploid gametes (sperm and egg) fuse, a diploid zygote is formed. As described above, the zygote of bryophytes grows inside the archegonia and will eventually become a diploid sporophyte. Mature sporophytes remain attached to the gametophyte and generate haploid spores via meiosis inside the sporangium. These spores are dispersed, and under favorable environmental conditions become new gametophytes.

Liverworts

Liverworts are extremely small plants characterized by flattened stems and undifferentiated leaves, as well as single-celled rhizoids. Liverworts can be distinguished from other bryophyte species by the presence of membrane-bound oil bodies within their cells, compared to other species which do not contain enclosed lipid bodies.

Mosses

Mosses are green, clumpy plants often found in moist environments out of direct sunlight. Mosses are characterized by leaves that are only one cell wide attached to a stem that is used for water and nutrient transportation. Mosses are able to absorb a substantial amount of water and have historically been used for insulation, water absorption, and a source of peat

Hornworts

Hornworts are named after the characteristic long horn-like sporophyte that develops. In contrast, the gametophyte form is a flat, green-bodied plant. Most hornworts are found in damp environments (e.g., tropical climates), garden soils, or tree bark.

The fossil record indicates that bryophytes evolved on earth about 395 – 430 million years ago (i.e. during Silurian period of Paleozoic era). The study of bryophytes is called bryology. Hedwig is called 'Father of Bryology'. Shiv Ram Kashyap is the 'Father of Indian Bryology'.

Salient features of Bryophytes:

1. Bryophytes grow in damp and shady places.
2. They follow heterologous haplodiplobiontic type of life cycle.
3. The dominant plant body is gametophyte on which sporophyte is semiparasitic for its nutrition.
4. The thalloid gametophyte differentiated in to rhizoids, axis (stem) and leaves.
5. Vascular tissues (xylem and phloem) absent.
6. The gametophyte bears multi-cellular and jacketed sex organs (antheridia and archegonia).
7. Sexual reproduction is oogamous type.
8. Multi-cellular embryo develops inside archegonium.
9. Sporophyte differentiated into foot, seta and capsule.
10. Capsule produces haploid meiospores of similar types (homosporous).
11. Spore germinates into juvenile gametophyte called protonema.
12. Progressive sterilization of sporogenous tissue noticed from lower to higher bryophytes.
13. Bryophytes are classified under three classes: Hepaticae (Liverworts), Anthocerotae (Hornworts) and Musci (Mosses).

Classification of Bryophytes:

According to the latest recommendations of ICBN (International Code of Botanical Nomenclature), bryophytes have been divided into three classes.

1. Hepaticae (Hepaticopsida = Liverworts)
2. Anthocerotae (Anthocertopsida= Hornworts)
3. Musci (Bryopsida= Mosses)

Class 1. Hepaticae or Hepaticopsida:

1. Gametophytic plant body is either thalloid or foliose. If foliose, the lateral appendages (leaves) are without mid-rib. Always dorsiventral.
2. Rhizoids without septa.
3. Each cell in the thallus contains many chloroplasts; the chloroplasts are without pyrenoi.
4. Sex organs are embedded in the dorsal surface.
5. Sporophyte may be simple (e.g., Riccia) having only a capsule, or differentiated into root, seta and capsule (e.g., Marchantia, Pallia and Porella etc.)
6. Capsule lacks columella.
7. It has 4 orders:

(i) Calobryales

(ii) Jungermanniales

(iii) Spherocarpales

(iv) Marchantiales.

Class 2. Anthocerotae or Anthocerotopsida

1. Gametophytic plant body is simple, thalloid; thallus dorsiventra without air cambers, shows no internal differentiation of tissues.
2. Scales are absent in the thallus.
3. Each cell of the thallus possesses a single large chloroplast with a pyrenoid.
4. Sporophyte is cylindrical only partly dependent upon gametophyte for its nourishment. It is differentiated into bulbous foot and cylindrical capsule. Seta is meristematic.
5. Endothecium forms the sterile central column (i.e., columella) in the capsule (i.e. columella is present). 6. It has only one order-Anthocerotales.

Class 3. Musci or Bryopsida:

1. Gametophyte is differentiated into prostrate protonema and an erect gametophores

2. Gametophore is foliose, differentiated into an axis (=stem) and lateral appendages like leaves but without midrib.

3. Rhizoids multi-cellular with oblique septa.

4. Elaters are absent in the capsule of sporangium.

5. The sex organs are produced in separate branches immersed in a group of leaves.

6. It has only three orders:

(i) Bryales,

(ii) Andriales and

(iii) Sphagnales.

Marchantia is a genus of bryophytes. They are liverworts and found in moist and shady places. They lack true roots, stem and leaves. The plant body is thalloid. Bryophytes are known as the amphibians of the plant kingdom as they require water to reproduce sexually and complete their life cycle.

Marchantia reproduce asexually as well as sexually. The life cycle is haplodiplontic and the haploid gametophyte is the dominant phase. The diploid sporophyte is short-lived and dependent on the gametophyte.

Classification of Marchantia

Marchantia is classified under division Hepaticophyta, which includes all the liverworts.

The genus Marchantia contains around 65 species. They are present in moist and shady places all over the world. Some of the examples are: Marchantia polymorpha, Marchantia berteroana, Marchantia palmata, Marchantia nepalensis, etc.

Marchantia Characteristics

The common habitat is moist and shady places. The plant body is thalloid. The thallus is dorsiventral, flat and dichotomously branched. The gametophyte is the dominant phase of plant life. The dorsal surface contains diamond-shaped markings, which has central pore in the middle for gaseous exchange. There are chambers present internally beneath the polygonal markings. The ventral surface contains scales and rhizoids. The rhizoids are unicellular and the root-like structure. The main function is to anchor the plant to the substratum and absorb water and minerals.

The reproductive bodies are present on the dorsal surface. They bear a cup-shaped structure called gemmae for asexual reproduction. Sexual reproductive organs are born on the stalks called antheridiophore and archegoniophore. They contain male and female reproductive organs called antheridia and archegonia, respectively. The upper epidermis consists of air pores, which open in the air chamber present in the photosynthetic zone. The upper epidermis also contains few chloroplasts.

Beneath the air chamber and photosynthetic zone lies the storage zone. It lacks chloroplasts and is made up of parenchymatous cells. They store protein, starch, oil and mucilage. The rhizoids and scales are extended from the lower epidermis.

Marchantia Reproduction

Marchantia reproduces asexually as well as

sexually. Asexual Reproduction

Asexual reproduction in Marchantia is by fragmentation or by forming specialised structures known as gemmae.

Gemmae

They reproduce asexually by gemmae, which are asexual buds. They are formed in the receptacles known as gemma cups. Gemma cups are present on the dorsal surface, near the midrib of the gametophytic thalli. Gemmae are multicellular and green.

Gemmae detach from the parent plant and germinate to give rise to the new

plant. Sexual Reproduction

Marchantia is dioecious. Male and female sex organs develop on different thalli. Male reproductive organ is antheridia and the female reproductive organ is archegonia. They are born on the mature gametophyte and are erect and modified stalks known as antheridiophore and archegoniophore, respectively.

Antherozoids are produced in the antheridium. They are biflagellated and produced from the androcytes.

The archegonium is a flask-shaped structure. It consists of several neck canal cells, a ventral canal cell and an egg.

Fertilization

They need water for fertilization like other bryophytes. The neck canal cells and the ventral canal cell disintegrate and form a mucilaginous mass, which oozes out as the archegonia swells after absorbing water. It consists of chemical substances, which triggers the chemotactic response. The antherozoids get attracted and swim towards archegonia. One of the antherozoids fuses with egg and fertilization takes place. The male and female nuclei fuse together to form a diploid cell called the zygote.

Sporophyte

The diploid zygote does not undergo meiosis (reduction division) immediately. It rather divides mitotically and develops into a multicellular structure called the sporophyte. The sporophyte is differentiated into foot, seta and capsule. It is not the free-living stage, it is dependent on the gametophyte for nourishment. Some of the cells of sporogenous tissue called spore mother cells (diploid) divide meiotically to produce haploid spores. These haploid spores are released by the dehiscence of the capsule. Under favourable conditions, they germinate to form the new haploid plant or gametophyte.

Marchantia Life Cycle

Marchantia show alternation of generation, i.e. the haploid sexual and diploid asexual phase alternates. The life cycle of Marchantia is haplodiplontic. Both the haploid and diploid phases are represented by multicellular structures. The main free-living plant body is the gametophyte (haploid). The short-lived sporophyte (diploid) stage is dependent on the gametophyte for anchorage and nourishment. The male and female gametophyte gives rise to antherozoids and an egg respectively, which fuse to form the diploid zygote. The zygote divides by mitotic division to form multicellular sporophyte. The spore mother cells divide by meiosis to form the haploid spore, which germinates to form the haploid gametophyte.

PORELLA

Porella, often termed as ‘leafy liverwort’, grows on rocks and barks of trees forming light-green or brownish green patches. The genus consists of about 180 species, found both in the tropical as well as in the temperate regions. In India there are about 34 species, mainly found in the Himalayas, of which the important ones are P. decurrents, P. obtusifolia and P. platiphylla.

The Gametophyte of Porella

The gametophyte is a prostrate structure which is differentiated into the stem and leaves. The stem is pinnately branched with leaves arranged in three rows, two dorsal and one ventral. The dorsal rows form the lateral leaves, while the ventral row forms the amphigastria or under leaves. Each lateral leaf is un•equally bilobed. In some epiphytic species, the under leaf is modified into a water sac. The arrangement of the lateral leaves is incubous, since they are obliquely in•serted on the stem in such a way, so that the lower leaf over•laps the margin of the succeeding upper one on the dorsal sur•face. The lateral leaves are chlorophyllous and form the photosynthetic organs.

Smooth-walled rhizoids are developed from the ventral surface of the stem and branches and fix the plant to the substratum. It is to be noted that where branching takes place, the branches replace the lower lobes of the lateral leaves. There is but little internal differentiation of the tissues of the thallus. All the cells of the gametophyte are parenchymatous. Air chambers and mucilaginous cavities are entirely absent.

Reproduction in Porella

Porella, reproduces both by vegetative and sexual methods.

Vegetative reproduction takes place by three different ways

(a) By the progressive growth of the thallus and subsequent death and decay of the older parts,

(b) By the formation of adventitious branches, and

(c) By the produc•tion of one or two-celled gemmae from the leaf-margins.

The plants are either mono•ecious or dioecious, and the sex organs are borne on short lateral branches together with the bracts. Each antheridium is borne in the axil of a leaf of an antheridial branch. A mature antheridium is more or less globose with a long stalk. The jacket of the antheridium is one cell in thick•ness except at the apical region. Antherozoids are typically biflagellate and crescent-shaped. The archegonial branches are shorter than those of the antheridial ones and bear archegonia at their apices in groups. They are surrounded by a rosette of modified enlarged leaves. An archegonium develops from the apical cell, thereby checking further growth of the branch.

A mature archegonium has a broad venter containing a ventral canal cell and an egg. The wall of the venter is more than one cell in thickness. The neck is long and contains 6-8 neck canal cells. Each group of mature archegonia is surrounded by a thin sheath developed from the archegonial branch. This sheath is termed as marsupium. The gametic union requires the presence of sufficient water.
The antherozoids are carried by the current of water near the archegonium, one of which ultimately unites with the egg, thereby, effecting fertilization. With fertilization and formation of oospore, sporophytic or diploid generation begins.

The Sporophyte of Porella

The oospore, produced as a result of fertilization, divides transversely into a hypobasal cell and an epibasal cell. The hypobasal cell produces a haustorium of two or more cells. The rest of the sporophyte develops entirely from the epibasal cell. A mature sporo•phyte has a foot, a seta and a capsule. The foot is bulbous, the seta is short and the capsule is large and globose. The jacket of the capsule is more than one cell in thickness. The cells of the outer•most layer are thick- walled, except along the four vertical lines which form the future lines of dehis•cence of the capsule. The jacket develops from the amphithecium. The endothecium forms the sporogenous tissue. Cer•tain portion of the sporogenous tissue is fertile and by reduction division forms the spore tetrads, while the rest are sterile and develop into elaters.

The spores may be brown or golden brown in colour and in many cases, they may be winged. With reduction division and formation of spores, the gameto•phytic or haploid generation begins. The ela•ters may be branched or unbranched. A mature sporophyte is protected by the marsupium, perianth (formed by the bracts of the archegonium) and the multi-layered calyptra (formed from the venter). The mature capsule, prior to dehiscence, is carried up beyond the calyptra, perianth and marsupium by the sudden elongation of the seta. The capsule then splits from apex downwards along the four vertical lines of dehiscence. The dehiscence is mainly due to the hygroscopic movements of the elaters.

The New Gametophyte of Porella

The spores, falling upon suitable substratum, germinate to pro•duce new gametophytes.

CLASSIFICATION OF BRYOPHYTES BY SMITH

Division Bryophyta

Class 1. Hepaticae (liverworts) Order 1. Sphaerocarpales

Family 1. Sphaerocarpaceae

Family 2. Riellaceae

Order 2. Marchantiales

Family 1. Ricciaceae

Family 2. Corsiniaceae

Family 3. Targioniaceae

Family 4. Monocleaceae

Family 5. Marchantiaceae

Order 3. Jungermanniales

Suborder 1. Metzgerineae

Suborder 2. Jungermannineae

Order 4. Calobryales

Class 2. Anthocerotae (hornworts) Order 1. Anthocerotales

Class 3. Musci (mosses)

Subclass 1. Sphagnobrya

Subclass 2. Andreaeobrya

Subclass 3. Eubrya

Classification of Bryophyts (As per G. M. Smith):

Division: Bryophyta