Unit–1

Characters of Bryophytes and their Classification

(Lesson Structure)

1.0 Objective

1.1 Introduction

1.2 Characters of Bryophytes

1.3 Classification of Bryophytes

1.4 Questions for Exercise

1.5 Suggested readings

1.0 Objective :

Bryophytes occupy a position just intermediate between the green thallophytes (Algae) and the vascular cryptogams (Pteridophytes). The objective of this unit is to make the students familiar with the characters & classification of Bryophytes.

1.1 Introduction :

Bryophytes are plants of amphibious zone. During the dry period they become almost brittle in texture. With the onset of rainy season the apparently dried, brittle thalli turn green and become active to carry out the normal life functions.

The group Bryophyta (Greek word; Byon = moss, Phyton = plant) includes the simplest and most primitive land plants. About 960 genera & 24,000 species have been reported in Bryophyta. Most of the Bryophytes are land dwellers which inhabit damp, shaded and humid localities. They are essentially terrestrial but they fail to complete their life cycle without water. Thus due to

peculiar type of their habitats, they are neither treated as perfect land plants nor aquatic. They are therefore, most appropriately called as **amphibians** of the plant kingdom. However] a few grow under diverse habitat such as aquatic submerged in water (eg. *Riella, Riccia fluitans, Ricciocarpus),* in bogs (e.g. *Sphagnum),* as epiphytes on tree trunks and branches (e.g. *Dendroceros),* epiphyllous (e.g. *Radula protensa)* or even in desert (e.g. *Tortula desertorum*).

1.2 Characters of Bryophytes :

Habitat

(1) The plants usually grow in moist and shady places. They are terrestrial but require presence of water to complete their life cycle. The group Bryophyta, therefore, regarded as amphibians of the plant kingdom.

Gametophytic plant body

(2) The plant body is gametophyte which is haploid and bears gametes.

(3) The plants are small and inconspicuous ranging from a millimetres to 30-40 centimeters or more.

(4) The plant body may be thallus like i.e. , not differentiated into trueroots, stem and leaves (e.g. *Riccio, Marchantia, Pellia* etc.) or leafly shoots. The leafy shoots may be dorsiventral (e.g. *Porella*) or erect, differentiated into stem like central axis and leaf -like appendages (e.g. *Funaria, Polytrichum* etc.).

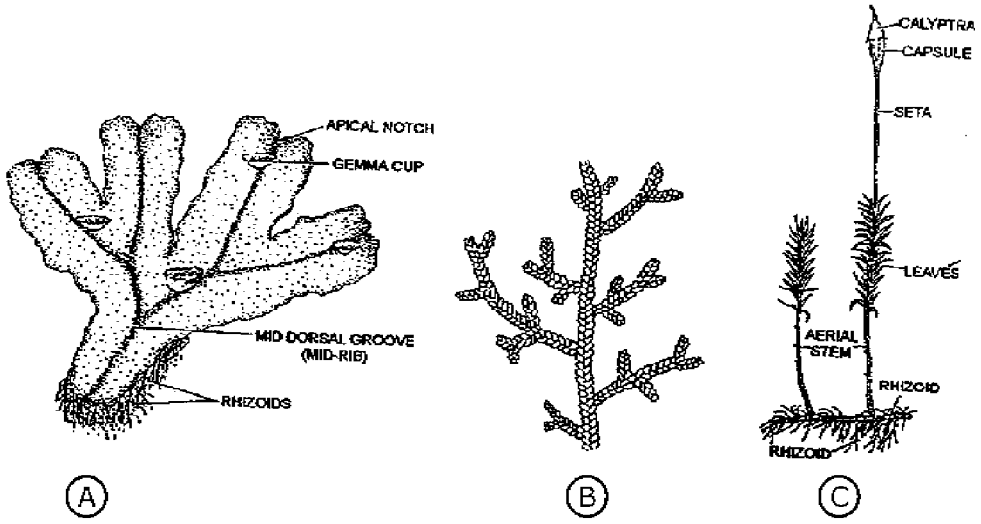


Fig-1.1 : Different types of Gametophyte
A. Marchantia; B. Frullania; C. Polytrichum

(5) The plant body is attached to the substratum by means of branched, multicelluar rhizoids apparently resembling the roots. True roots are completely absent.

(6) The plants are green and possess chloroplasts. They are autotrophic. However, a few species such as *Buxbaumia aphylla* (Mosses) and *Cryptothallus mirabilis* (liverwort) are saprophytes and lead a heterotrophic mode of nutrition.

(7) The vascular tissues (i.e., xylem & phloem) are completely absent. However, in few mosses the xylem like hydroids, which conduct water and phloem like leptoids, which conduct the assimilates have been reported e.g., *Polytrichum.*

(8) The gametophyte which bears gametes is concerned with sexual reproduction and constitutes the most conspicuous, nutritionally independent phase in the life cycle.

Reproduction

(9) Sexual reproduction is always oogamous type. (i.e., the male gametes are small, motile antherozoids and the female gametes are large, and non motile eggs).

(10) The gametes are produced in complex multicellular jacketed sex organs.

(11) Both kind of sex organs may be developed on the same individual or on different plants. The former are called monoeicous and the latter as dioecious.

(12) The male reproductive organs are antheridia and female reproductive organs are archegonia.

(13) The antheridium is ellipsoidal or club - shaped sometimes spherical in form. It is differentiated into a stalk and a body. The stalk attaches it self to the gametophyte tissue. The body of antheridium has wall of a single layer of sterile cells. It surrounds a mass of small squarish or cubical cells called the androcytes.

(14) The androcytes produce the biflagellate male gametes called as sperms. Several sperms are produced in each antheridium. Each sperm usually consists of a minute, slender, spirally-curved body with two long, terminal whiplash type flagella.

(15) The archegonia are flask.- shaped stalked organ. The slender and elongated upper portion is called neck and the lower sac - like, swollen portion, the venter. The neck encloses variable numbers of neck canal cells, whereas venter encloses venter canal cell, and a large egg.

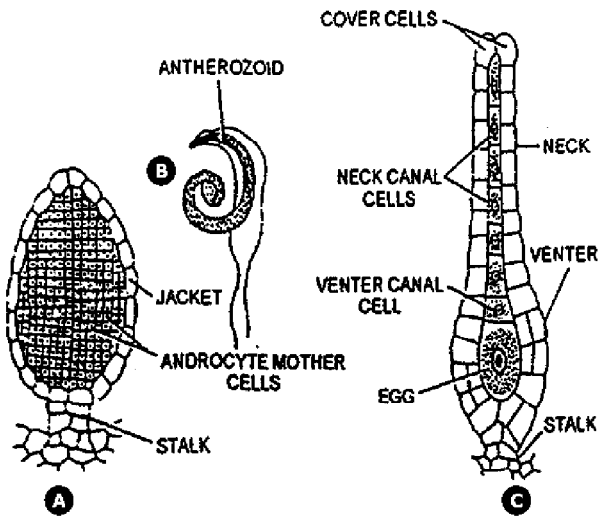


Fig-1.2 : Sex organs of Bryophytes
A. Antheridia; B. Antherozoid; C. Archegonia

Fertilization

(16) Water is essential for fertilization. The mature antheridium ruptures at its apex liberating the sperm. At the same time the axial row of neck canal cells including the ventral canal cell in the mature archegonium disorganize and the tip of the archegonia also opens. The liberated sperms swimming in thin film of water reach the archegonia and competable one reach there and fuses with egg. The fertilized egg (zygote) is retained within the venter and undergoes repeated division to form an embryo.

The gametes (sperms and eggs) are the last structures of the gametophytes generation.

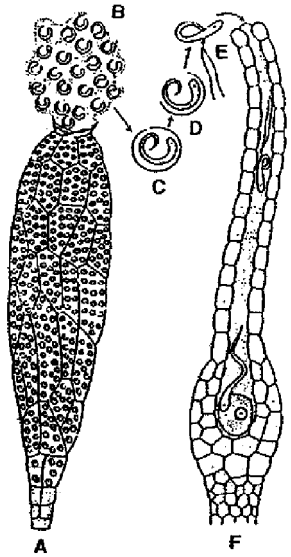


Fig-1.3 : Dehiscence of sex organs and fertilization in moss plant.

Sporophyte

(17) The dipliod zygote is the first cell of sporophyte generation. Within Venter of the archegonium, the zygote undergoes segmentation and develops without a resting period into a multicellular, undifferentiated embryo. It obtains its nourishment directly from the thallus.

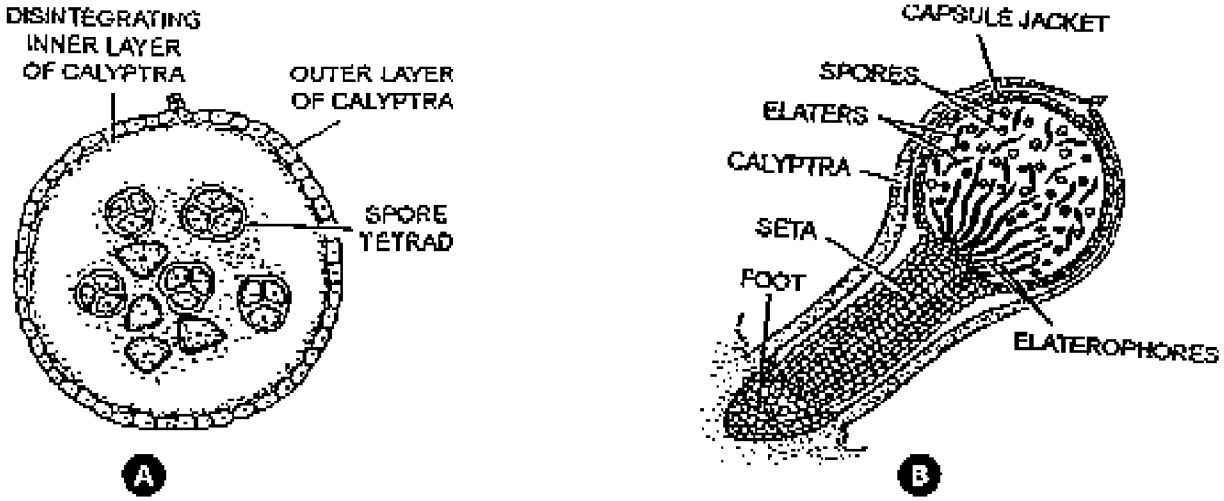
(18) The embryo by further segmentation and differentiation finally develop into a full-fledged sporophyte which is called as **sporogonium.**

(19) The sporogonium in most of the cases, gets differentiated into foot, seta and capsule. However, the foot and seta are absent in *Riccia* and the seta is absent in *Corsinia* and *Anthoceros.*

(20) The sporogonium is completely dependent on the gametophyte for water and mineral supply and in most of the cases, partly or wholly for organic nutrition. The sporophytes remains attached to the gametophytic plant body throughout its life.

(21) The foot is embedded in the tissue of the parent gametophyte. It absorbes nutrition for the sporogonium. The seta conducts the food absorbed by the foot to the capsule. The terminal capsule is mainly concerned in the production of spores which are non-motile and wind disseminated.

(22) The spores are morphologically similar in size and shape (i.e.; homosporous). However, in *Marchantia,* out of 4 spores produced from one spore mother cell, two produce male thalli and the other two female thalli.



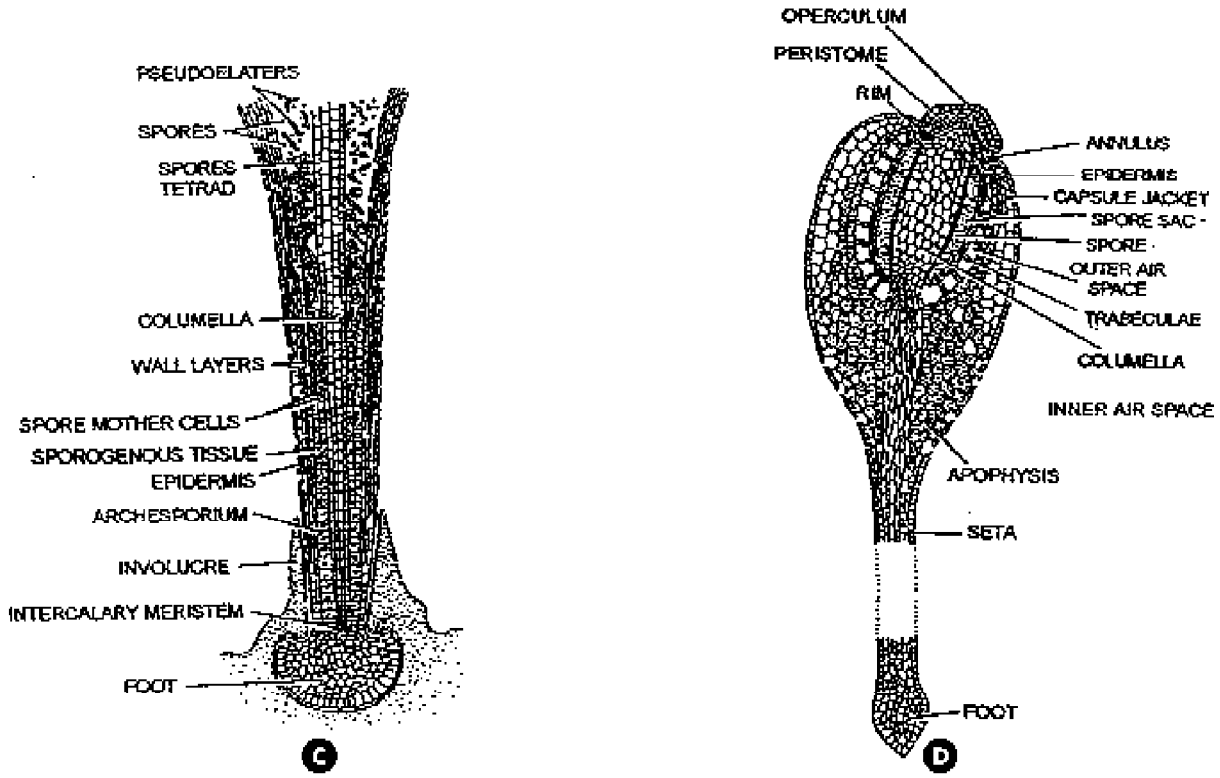


Fig-1.4 : Sporophytes of Bryophyte
A. Riccia; B. Pellia; C. Anthoceros; D. Funaria

The Young gametophyte

(23) The spores, produced from sporogonium,are haploid. They are the first cells of gametophytic generation.

(24) Each spore while falling on a suitable soil germinates to give rise the gametophyte plant either directly (e.g; *Riccia, Marchantia* etc.) or indirectly as a lateral bud from the protonema (e.g. *Funaria).*

(25) The occurrence of heterologous or heteromorphic type of alternation of generation is a constant feature of the life cycle of Bryophytes in which alternating individual are dissimilar. The distinct phases are -

(i) The gametophytic phases and

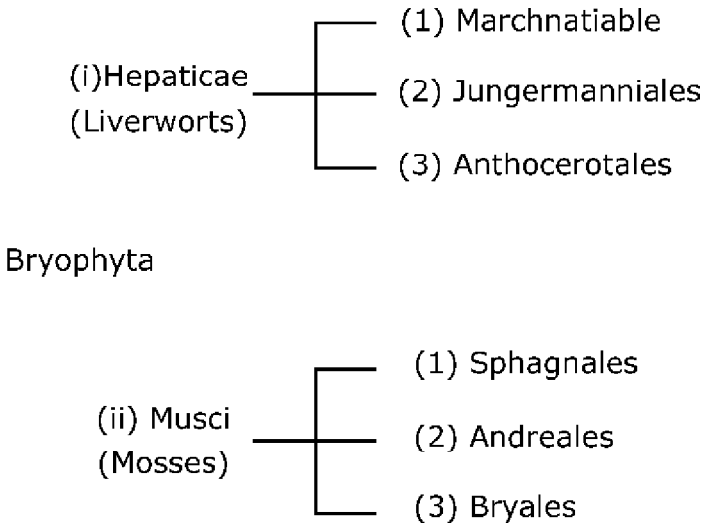
(ii) The sporophytic phase

The haploid spore, produced from the diploid sporophyte, on germination produce gametophytic plant body(n). The haploid gametophyte is mainly concerned with the production of haploid male & female gametes. These gametes after fertilization form diploid zygote which is the first cell of sporophytic

generation. It is retained within the archegonium and multiplies to produce the embryo, which later develops into sporophytic plant body, the sporogonium. The diploid spore mother cell of sporogonium after meiosis produces haploid spores which is the first cell of gametophytic generation.

1.3 Classification of Bryophytes :

Braun (1864) was the first person who introduce the term Bryophyta and called it acotyledonae. He included Algae, Fungi, Lichen and Mosses in it. Schimper (1879) gave Bryophyta as the rank of a division. Eichler (1883) divided Bryophyta into two groups Hepaticae and Musci. Engler (1892) divided the division Bryophyta into two classes Hepaticae and Musci, and further divided each of the two classes into 3 orders as follows -



A large number of botanists e.g; Bessey (1911), Fritsch (1929), Wettstein (1933-35), Buch, Evans and Verdoom (1938), Evans (1939), Engler, Melchior and Werdermann (1954) followed this traditional system of classification. Anthocerotales, usually listed as an order of Hepaticae was given an isolated position by Underwood (1894), Gayet (1897) gave Anthocerotales the rank of a class. Howe (1899), Campbell (1918, 1940), Smith (1938, 1955), Takhtajan (1953), Schuster (1953,1958) distinguished three classes in Bryophyta-Hepaticae, Anthocerotae and Musci.

Cavers (1911) omitted the words Hepaticae and Musci and divided Bryophyta into 10 order : Sphaerocarpales, Marchantiales, Jungermanniales, Anthocerotales, Sphagnales, Andreaeales, Tetraphidales, Polytrichales, Buxbaumiales, and Eubryales.

Finally, Rothmaler (1951) changed the nomenclature of the three classes of Bryophyta to Hepaticopsida (= Hepaticae), Anthoceropsida (= Anthocerotae) and Bryopsida (= Musci) which are in accordance with the latest recommendations of the International Code of Botanical Nomenclature, Utrecht, 1956. Proskauer(1957) has changed the name Anthoceropsida to Anthocerotopsida. The modern bryologists, thus classify Bryophyta into the following three classes-

Class 1. Hepaticapsida (Hepaticae)

Class 2. Anthocerotopsida (Anthocerotae)

Class 3. Bryopsida (Musci)

Class 1. Hepaticopsida :

The Latin word Hepatica means liver, thus the Hepaticopsida are popularly known as **liverworts**. The plants of Hepaticopside have following characteristic features. The vegetative plant-body of the gametophyte is usually dorsiventral and is either a thallus (thallose) or a leafy axis (foliose), when foliose the leaves are without mid-rib, arranged on axis in 2 - 3 rows.

Anatomically, the gametophyte is either simple or composed of many tissues. A photosynthetic tissues on the dorsal surface of gametophyte is always present and the cells forming it have numerous small chloroplast, without pyrenoids. These green cells have one to several simple or compound refractive oil bodies. The sex organs are formed from a single superficial cell. The sporogonium is small and generally without any chlorophyllous tissue or stomata. The sporogonium is determinate in development and usually differentiated into foot, seta and capsule. However, the foot and seta are absent in *Riccia* and the seta is absent in *Corsinia* and *Anthoceros.* The archesporium originates from the endothecium of an embryo. The sporogenous tissue of the capsule either become differentiated into spore mother cells and sterile cell called the elaters. The elaters are single-celled structures, with spirally-thickened walls. Columella is absent in capsule. The spores, on germination, usually directly or in some cases indirectly give rise to gametophyte plants.

The class Hepaticopsida consists of approximately 280 genera and about 9,500 species. This class is divided into five orders by incorporating the suggestions of Caveri's(1910), Campbell (1935) and Schuster (1963).

Order I Takakiales

Order II Calobryales

Order III Jungermanniales

Order IV Marchantiales

Order V Sphaerocarpales

Order I Takakiales :

The plant body is differentiated into an erect, radial leafy shoot or gametophore and branched subterranean, cylindrical rhizome devoid of rhizoids, entire plant body is covered with copious mucilage hairs.

Family - Takakiaceae

Genera - *Takakia,*

Order II Calobryales:

Gametophyte rhizomatous, erect leafy axis, leaves arranged in three vertical rows and all the leaves are similar, globose stalked antheridia, developing in a distinct manner, archegonia with a neck of four vertical rows of cells, elongate sporophyte differentiated into foot, seta and capsule, unistratose capsule wall which becomes multistratose at the apex.

Family: Calobryaceae :

Genera: *Calobryum* and *Haplomitrium*

Order III Jungermanniales:

Gametophyte simple thallus or leafy axis, with little internal differentiation, scales and tuberculate rhizoids absent, rhizoids only smooth-walled, antheridia spherical or sub - globose, archegonial neck consist of 5 vertical rows of cells, sporogonium which gets differentiated into foot, seta and capsule; capsule wall 2 or more cell-layered thick; elaters present; capsule dehisces by 4 valves.

The Qrder jungermanniales consists of **two sub-orders.**

(i) Sub - order : Metzgerineae (Jungermanniales Anacrogynae) :

Gametophyte thalloid, dorsiventral, prostrate, sex organs scattered on dorsal surface, the apical cells not used up in archegonia formation, capsule wall 2-5 cell layered thick.

The sub order includes about 9 families (Evans, 1939)

Family: **Pelliaceae** - Gametophyte thalloid, thallus lobed by irregular incisions, sex organs scattered on dorsal surface, capsule spherical or oval, elaterophore present at the base in capsule.

Genera - *Pellia, Noteroclada, Calycularia*

(ii) Sub- order : Jungermannineae jungermanniales Acrogynae)

Gametophyte bears leafy axis, with three rows of leaves- two lateral and one smaller ventral (amphigastria), branching never dichotomous, antheridia borne in axil of perigonial bracts; archegonia borne in groups at the apex of axis or branch, apical cell is used up in the formation of last archegonium, sporogonia terminal on stem or branches. This sub- order includes about 17 families (Evans, 1938).

Family - **Porellaceae (Madothecaceae)** : leaves usually incubous, rhizoid form tufts at the base of amphigastria, the amphigastria large, perianth large, bilabiate and inflated with mouth compressed; capsule valves split half way down.

Genus - *Porella (Madotheca)*

Order IV Marchantiales:

Gamatophyte usually a prostrate, green, dorsivemtral, dichotomously branched thallus with a more or less marked midrib: Internally, thallus is differentiated into dorsal air chambers, air pores and usually green photosynthetic tissues, and ventral storage zone; ventral surface bears scales and two types of rhizoids - **smooth-walled** and **tuberculate;** sex organs are sessile or sta1ked, scattered along with midrib or grouped in receptacles, the sprogonium simple with or without seta, capsule wall one cell layer thick, capsule dehisces by various ways but never by four regular valves.

Campbell (1940) divided the order into 5 families -

(i) Ricciaceae

(ii) Corsiniaceae

(iii) Marchantiaceae

(iv) Targioniaceae and

(v) Monocleaceae

Family - **Ricciaceae :** Thallus simple, differentiated into upper photosynthetic zone and lower storage zone; distinct air pores absent; sex organs borne single on the dorsal surface of thallus along the midrib; apex of archegonial neck projected; foot and seta absent in sporogonium, capsule sac-like, embedded in gametophytic thallus; Spore dispersal by disintegration of capsule wall; elaters absent.

Genera - *Riccia, Ricciocarpos, Ricciela and Oxymitra.*

Family: Marchantiaceae - Thallus shows rhomboidal area, each with central pore on dorsal surface, air pore well developed; thallus differentiated into upper photosynthetic zone and lower storage zone; sex organs borne in groups on receptacles; female receptacle called archegoniophore always sta1ked, sporogonium differentiated into foot, seta and capsule; sporogenous from forms spore mother cells and sterile elater.

Genera: About 23, common are *Marchantia, Plagiochasma* etc.

Order V Sphaerocarpales :

Gametophyte small, orbiculate to cuneate plate of green tissue which may be simple or dichotomously-branched thallus, without internal differentiation, all vegetative cells except the rhizoids contain chloroplasts, sex organs enclosed within involcres, borne singly; archegonial neck consists of 6 vertical rows of cells; capsule wall one cell layer thick. The order is divided into two families -

Family (1) Sphaerocarpaceae with bilaterally thallose gametophyte consisting of two genera *Sphaerocarps* and *Geothallus.*

(2) Riellaceae with-asymmentrical gametophytes consisting of the aquatic genus *Riella.*

Class 2. Anthocerotopsida :

Gametophyte simple, lobed, dorsiventral thallus devoid of any midrib, internally homogenous without any differentiation of tissues, air pores and air chambers absent but mucilage cavities may be present, rhizoids only smooth walled, tuberculate rhizoids and scales absent, each cell possesses single (sometimes more) large chloroplast with central pyrenoid, oil bodies absent, sex organs lie sunken in the thallus, antheridia borne singly or in group in antheridial chambers beneath the upper surface of the thallus, archegonia embedded on dorsal surface of thallus, sporogonium differentiated into foot, merisematic zone and capsule, seta absent, capsule has got central sterile columella (endothecial in origin) which is arched over by a dome shaped archesporium derived from amphithecium, archesporium differentiates into spores and pseudoelaters, capsule dehisces basipetally by two valves, showing hygroscopic twisting.

Order: The class Anthocerotopsida includes a single order, the Anthocerotales. This order includes two families -

(i) Anthocerotaceae and

(ii) Notothylaceae (Muller, 1940; Reimers 1954; Proskauer, 1951 and Udar, 1970).

Family: Anthocerotaceae : Capsule long,cylindrical and vertically placed on thallus, capsule - wall multilayered, cells contain chloroplast, stomata present in epidermis, columella endothecial in origin, pseudo - elaters simple or branched.

Genera: *Anthoceros, Megaceros, Dendroceros.*

Family: Notothylaceae : Capsule short, compact and horizontally-placed on margins of fertile lobes, capsule cylindrical and tapers at both ends, capsule wall 3- 4 layered, cells lack chlorophyll, stomata absent,columella may be present or absent, pseudoelaters simple with spiral or oblique thickening bands.

Genus - *Notothylas.*

Class 3. Bryopsida

Gametophyte differentiated into two stages -prostrate **protonema** and erect, radial, persistent leafy shoot, the **gametophore.** The rhizoids, both on the protonema and gametophore, are multicellular, branched and with diagonal cross walls. The gametophores have spirally arranged leaves on shem. Sex organs, elevated on long stalks on the gametophore, develop from superficial cells, sporogonium differentiated into foot, seta and capsule, wall of capsule several layers with stomata on epidermis, archesporium encloses central columella, forms only spore mother cells, elaters absent.

The class Bryopsida has been divided into 3 sub - classes :

(i) Sphagnidae

(ii) Andreaeidae and

(iii) Bryidae

(i) Sub - class: Sphagnidae - Most primitive sub - class of Bryopsida. The protonema is broadly thallose, one - celled thick and produces one gametophore. The rhizoids are multicelluar & obliquely septate. Leaves of gametophores unistratose, lack midrib, composed of narrow, living, green cells and large hyaline, dead cells, branches arise laterally in the axil of leaves, antheridia develop in the axils of leaves in antheridial branch while archegonia are terminal on archegonial branches, columella originates from endothecium, archesporium dome shaped, originates from amphithecium, seta short, operculum present but peristome absent, apex of archegonial branch elongates to form pseudopodium.

Order - Sphagnales : single order

Family - Sphagnaceae : Single family

Genus - *Sphagnum*

(ii) Sub - class Andreaeidae

Protonema thallose, adult gametophore small, dark brown or reddish and brittle, internally stem shown uniform cells, perichaetial leaves large, erect and convolute, archesporium and columella originate from endothecium, wall of capsule without spongy photosynthetic tissue, seta short, replaced functionally by pseusopodium.

Order: Andreales - single order

Family: Andreaceae - single family

Genera: *Andrea, Acroschisma and Neuroloma.*

(iii) Sub - class: Bryidae :

Protonema usually filamentous, adult gametophore leafy axis; leaves with distinct midrib; zygote divides by transverse division forming hypobasal and epibasal halves which form apical cells of their own, endothecium forms columella and archesporium, columella continues upto apex of capsule, spore sac separated from wall by air space traversed by trabeculae, seta long, pseudopodium not fomed, peristome usually present.

The sub - class Bryidae has been divided into 3 cohorts, 15 order and 79 families (Fleischer, 1920). Name ending modified by Utrechet (1956). Only two orders are as follow -

(i) Order -Funariales (5 families)

Gametophyte terrestrial, small, leaves, broad, ovate or spathulate, form terminal rosette, capsule wide operculum without beak, peristome arranged in two rows - outer peristome and inner peristome.

Family - Funariaceae - Leaves wide and soft, seta long and twisted, capsule pyriform somewhat drooping; calyptra has long beak.

Genus: - *Funaria* (+ 8 more)

Order: Polytrichales (includes single family)

Gametophore tall and perennial; leaves narrow with longidudianal lamellae on upper side of midrib; capsule erect or horizontal; peristome teeth arranged in

single ring, usually 32 or 64 in number pyramidal in shape, joined above to epiphragm which a covers mouth of capsule.

Family: Polytrichaceae

Genera : *Polytrichum, Pogonatum* (+ 13 more)

1.4 Questions for Exercise

Long answer questions:

1. *Describe the general characters of class Bryophyta.*
2. *Give an account of classification of Bryophytes upto order level and indicate special feature of each class.*

Short answer questions:

3. *Why Bryophytes are called the amphibians of plant kingdom?*
4. *The plant body of Bryophyte is a gametophyte or sporophyte. Explain.*
5. *Write five important characters of Bryophyte .*

1.5 Suggested readings

1. *Bryophyte by B.R. Vashishta, A.K. Sinha, Adarsh Kumar (S.Chand & Company ltd.)*
2. *Bryophtes: Morphology, Growth and differentailion by Dr. (Mrs.) Prempuri (ATMA RAM & SONS)*
3. *An Indroduction to Embryophyta: Bryophyta by N.S. Parihar (Central Book Depot).*

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