Unit – IV

Morphology, structure and reproduction of the following: *Anthoceros* and *Polytrichum*. Evolution of sporophyte and gametophyte; ecological aspects. Fossil bryophytes. Economic importance of Bryophytes.

Economic importance of Bryophytes

1. Protection from soil erosion:

Bryophytes, especially mosses, form dense mats over the soil and prevent soil erosion by running water.

2. Soil formation:

Mosses are an important link in plant succession on rocky areas. They take part in binding soil in rock crevices formed by lichens. Growth of Sphagnum ultimately fills ponds and lakes with soil.

3. Water retention:

Sphagnum can retain 18-26 times more water than its weight. Hence, used by gardeners to protect desiccation of the seedling during transportation and used as nursery beds.

4. Peat:

It is a dark spongy fossilized matter of Sphagnum. Peat is dried and cut as cakes for use as fuel. Peat used as good manure. It overcomes soil alkalinity and increases its water retention as well as aeration. On distillation and fermentation yield many chemicals.

5. As food:

Mosses are good source of animal food in rocky and snow-clad areas.

6. Medicinal uses:

Decoction of Polytrichum commune is used to remove kidney and gall bladder stones. Decoction prepared by boiling Sphagnum in water for treatment of eye diseases. Marchantia polymorpha has been used to cure pulmonary tuberculosis.

7. Other uses:

Bryophytes arc used as packing material for fragile goods, glass wares etc. Some bryophytes act as indicator plants. For example, Tortell tortusa grow well on soil rich in lime.

Ecological aspects and Economic importance of Bryophytes

1. Ecological Importance

Bryophytes are of great ecological importance due to following reasons:

(a) Pioneer of the land plants. Bryophytes are pioneer of the land plants because they are the first plants to grow and colonize the barren rocks and lands.

(b) Soil erosion. Bryophytes prevent soil erosion. They usually grow densely and hence act as soil binders. Mosses grow in dense strands forming mat or carpet like structure.

They prevent soil erosion by:

(i) Bearing the impact of falling rain drops

(ii) Holding much of the falling water and reducing the amount of run-off water.

(c) Formation of soil. Mosses and lichens are slow but efficient soil formers. The acid secreted by the lichens and progressive death and decay of mosses help in the formation of soil.

(d) Bog succession. Peat mosses change the banks of lakes or shallow bodies of water into solid soil which supports vegetation e.g., Sphagnum.

(e) Rock builders. Some mosses in association with some green algae (e.g., Chara) grow in water of streams and lakes which contain large amount of calcium bicarbonate. These mosses bring about decomposition of bi-carbonic ions by abstracting free carbon dioxide. The insoluble calcium carbonate precipitates and on exposure hardens, forming calcareous (lime) rock like deposits.

2. Formation of Peat:

Peat is a brown or dark colour substance formed by the gradual compression and carbonization of the partially decomposed pieces of dead vegetative matter in the bogs. Sphagnum is an aquatic moss. While growing in water it secretes certain acids in the water body.

This acid makes conditions unfavorable for the growth of decomposing organisms like bacteria and fungi. Absence of oxygen and decomposing microorganisms slows down the decaying process of dead material and a large amount of dead material is added year by year. It is called peat (that is why Sphagnum is called peat moss).

Uses of Peat are:

(a) Used as fuel in Ireland, Scotland and Northern Europe.

(b) In production of various products like ethyl alcohol, ammonium sulphate, peat, tar, ammonia, paraffin, dye, tannin materials etc.

(c) In horticulture to improve the soil texture.

(d) In surgical dressings.

3. As Packing Material:

Dried mosses and Bryophytes have great ability to hold water. Due to this ability the Bryophytes are used as packing material for shipment of cut flowers, vegetables, perishable fruits, bulbs, tubers etc.

4. As Bedding Stock:

Because of great ability of holding and absorbing water, in nurseries beds are covered with thalli of Bryophytes.

5. In Medicines:

Some Bryophytes are used medicinally in various diseases for e.g.,

(a) Pulmonary tuberculosis and affliction of liver—Marchantia spp.

(c) Acute hemorrhage and diseases of eye—Decoction of Sphagnum.

(d) Stone of kidney and gall bladder—Polytrichum commune.

(e) Antiseptic properties and healing of wounds—Sphagnum leaves and extracts of some Bryophytes for e.g., Conocephalum conicum, Dumortiera, Sphagnum protoricense, S. strictum show antiseptic properties.

6. In Experimental Botany

The liverworts and mosses play an important role as research tools in various fields of Botany such as genetics. For the first time in a liverwort, Sphaerocarpos, the mechanism of sex determination in plants was discovered.

7. As Food

Some Bryophytes e.g., mosses are used as food by chicks, birds and Alaskan reindeer etc.

ANTHOCEROS

Most species of Anthoceros, commonly known as 'horned liver-worts', occur frequently along hillside roads and on very moist clay banks. They differ so greatly from the Liverworts that the present day workers separate them as a distinct Class co-ordinate with the Classes Hepaticae and Musci. Anthoceros is a cosmopolitan genus with about 200 species and is found both in the hills as well as in the plains, in tro•pical and temperate regions. There are about 25 species occurring in India, of which the commonly growing ones are A. himalayansis, A. erectus, A. crispulus, etc.

The Gametophyte of Anthoceros

The vegetative body of each plant is a small, dorsiventral and very simple, greasy dark- green gametophytic thallus, which is inconspicuously branched or somewhat lobed, and without any internal differen•tiation of tissues.

There are numerous smooth-walled rhizo•ids on the under surface of the thallus, the scales being entirely absent. On the ventral side of the thallus there are nu•merous large intercellular spaces, each of which opens externally by a narrow slit. These cavities are usually filled up with mucilage and often contain colonies of an endophytic blue-green alga (e.g. Nostoc). Each cell of the thallus usually contains a single large chloroplast with a conspicuous pyrenoid, which is made up of numerous disc- or spindle-shaped bodies destined to be metamorphozed into small starch grains. Thus, it is evident that sim•plicity is the most prominent feature of the thallus in comparison, with those of Riccia and Marchantia.

Reproduction in Anthoceros

Anthoceros reproduces both by vegetative and sexual methods. The vegetative reproduction is usually effected by progressive growth and death of the thallus. Under certain conditions of prolonged desiccation the gametophyte often produces tubers, formed due to marginal thickenings. Each tuber is externally protected by a cork layer and under favourable conditions gives rise to a new thallus. Anthoceros is chiefly monoecious, though in some species the antheridia may attain maturity early (protandrous). It is a note•worthy feature that the sex organs are entirely embedded in the dorsal side of the thallus and not borne on special receptacles, as in Marchantia.

Antheridia develop in clusters within closed ca•vities (antheridial cham•bers) just beneath the upper surface of the tha•llus. From the floor of each antheridial chamber two to four antheridia develop. The sterile layer, over-roofing each anthe•ridial chamber, may be one or more (usually two) cells in thickness. Each antheridium develops a stalk of several cells in height. Numerous biflagellate antherozoids are produced from each antheridium. When the antheridia attain maturity the sterile cell layers, over-roofing each antheridial chamber, disintegrate and the antherozoids are liberated.

Archegonia develop singly and are closely embedded in the thallus. The vegetative cells of the thallus are confluent with a part of the neck and venter of each archegonium, the extreme end of the neck being only protruding. When fully developed, there is a single axial row of cells in each archegonium, consisting of four to six neck canal cells, a ventral canal cell and an egg cell.

At matu•rity, the neck canal cells and the ventral canal cell disorganize and fertilization of the egg is brought about by one of the antherozoids passing down the neck into the venter. After fertilization the fertilized egg secretes a wall around it and forms an oospore. With fertilization and formation of oospore, the sporophytic or diploid generation begins.

The Sporophyte of Anthoceros

The oospore, without any period of rest, divides and re-divides and forms a sporophyte. The sporophyte is gradually differentiated into a basal foot, and an upper slender cylindrical structure of more or less uniform thickness, the capsule. The zygote usually first divides longitudi•nally and then trans•versely. This is follo•wed by another longitu•dinal division of the four daughter cells forming an eight-celled embryo, made up of two tiers of four cells each. The foot develops by division and re-division of the cells of the lower tier. When fully formed, it becomes a massive in•verted cap-like struc•ture, by means of which the sporophyte does not only remain anchored to the gametophyte but also absorbs nourish•ment therefrom. The cells of the upper tier also by repeated divi•sions form the capsule, which when very young, becomes differ•entiated into amphithecium and endothecium. When fully deve•loped, the capsule stands erect on the thallus and attains a height of 2.5 cm. or more in some cases.

The structure of a mature sporophyte is very complex. At the centre there are some elongated cells forming a sterile tissue called columella. It appears 16-celled in rectangular arrangement in cross-section. The entire columella is derived from the endothecium. Surrounding and over-arching the top of the columella there is a cylindrical sheet of sporogenous tissue, the archesporium.

The sporogenous tissue either remains one cell in thickness through•out its development or becomes two- to four-celled in thickness in some cases. Alternate groups of sporogenous cells develop into spores and elaters. Those sporogenous cells which behave as spore mother cells undergo reduction division and from each a spore tetrad is formed. With reduction division and formation of spores, the gametophytic or haploid generation begins. The cells developing into elaters are joined with one another forming filaments of 3-4 cells each. Their walls are either smooth or thickened. The sporo•genous tissue is again externally surrounded by a cylinder of sterile tissue possessing an epidermis.

This jacket (of sterile tissue) and the entire archesporium are derived, in most cases, from the amphithecium. The outer cells of the jacket contain chloroplasts and the epidermis is provided with numerous stomata, each with a typical pair of guard cells. Thus, the sporophyte is able to carry on pho•tosynthesis from the raw food materials absorbed from the soil by the gametophyte and subsequently supplied to it as well as with carbon dioxide absorbed from the air. This ability to synthesize carbohydrates is more highly developed than other liverworts.

The lower portion of the capsule is provided with a meristematic tissue, which continually adds new cells to the upper portion and, as a result, the capsule grows and produces spores over an extended period. The spore-production begins at the upper end of the capsule, and as the capsule grows, the spores are produced succes•sively from lower layers. On maturity, the capsule dehisces at the apex into two valves and the split is continued downwards with gradual formation, maturation and liberation of spores. During the early stages of development of the sporophyte, the gametophytic tissue surrounding the archegonium also grows upwards, finally stops and forms a sheath surrounding the base of the developing capsule.

The New Gametophyte of Anthoceros

Each spore, under suitable conditions, germinates and forms a new gametophytic thallus.

Evolved Characters

1. The sporophytes contain a few chloroplasts by which it can manufacture a portion of its food hence it is partially dependent on the gametophyte for nutrition. It depends on the gametophyte for supply of water only for manufacturing food.

2. In the Californian sp. of Anthoceros (A. fusiformis), the gametophyte sometimes disintegrates so the sporophyte becomes independent.

3. Like higher plants stomata are present in the epidermis of the capsule.

4. The columella acts as a conducting tissue and it seems that in higher plants the columella is replaced by conducting cylinders.

5. The amphithecium forms the sporogenous tissue and the jacket layer, while the endothecium forms only the columella—a higher character.

6. Presence of sterile filaments known as Pseudoelaters.

7. Owing to the presence of the meristematic tissue at the base of the capsule (sporophyte) is indeterminate in its growth.

8. Presence of single chloroplasts in the cell of the thallus suggests evolved characters, as in Selaginella, Isoetses, etc.

Type Polytrichum – Occurrence , Structure & reproduction life cycle

Occurrence

Polytrichum have worldwide distribution. They are very common in cool temperature and tropical regions. Plants live in cool and shady places.

General structure

The main plant body is gametophyte. The adult plant consists of two parts: rhizome and upright leafy shoot.

1. Rhizome: It is horizontal portion and grows underground. It bears three rows of small brown or colourless leaves. It also bears rhizoids. The cells are rich in protoplasm and oil globules.

2. Upright leafy shoot: The leafy shoots are much longer. It is the most conspicuous part of the plant. It arises from rhizome. These branches consist of central axis. These branches bear large leaves arranged spirally.

3. Leaves: Leaves have broad bases. Leaves in the upper portion are green. But the lower ones are brown. Each leaf has a broad. colourless sheathing leaf base and narrow distal limb. The mid-rib forms the major part of the leaf. These leaves possess extra photosynthetic tissue in the form of closely set vertical plates of green cells. These are known as lamellae. Green lamellae act as additional photosynthetic tissue.

Leaf: Polytrichum have complex internal structure. The mid-rib region is thick. But the margins are only one cell thick. The lower surface is bounded by epidermis. One or two layers of sclerenchymatous tissues are present above the epidermis. The central tissue of leaf is composed of thin-walled parenchymatous tissues. Above this are again sclerenchymatous cells. The upper surface is formed of a layer of large cells from which arise numerous lamellae. This upper portion is the main photosynthetic region of the leaf.

Stem: The T.S. of stem shows three regions: medulla, cortex and epidermis. The medulla is again differentiated into two zones: central zone and peripheral zone. The cortex consists of thick-walled cells. The innermost layer of cortex around the conducting strands is known as a mantle. Its cells contain starch grain. Epidermis is present over the cortex.

Life cycle

Vegetative reproduction

I. Protonema: The spores germinate to form protonema. Several buds grow on the protonema. Each bud by of its apical cell develops into gametophyte.

2. These are also called vegetative buds. They are formed on the rhizoids.

3. Fragmentation: The rhizome gives rise to erect lea& shoots at intervals. Death or breaking of shoots separates the erect branches. These branches behave as independent plants.

Sexual reproduction

Polytrichum is dioecious. Antheridia archegonia occur on different plants.

Antheridial head

The antheridia are borne in the axillary clusters at the tips of leafy stems. They are surrounded by a rosette of leaves called perigonial leaves. These leaves are different from the ordinary vegetative leaves. The perigonial leaves are spirally arranged. The antheridia are produced in groups in the axils of these leaves. Thus the antheridial head have different antheridial groups. Paraphyses also occur among the antheridia.

Mature antheridium is club-shaped. It is composed of a short stalk and a club-shaped body. Jacket is present around the capsule. Inside the jacket are present androcyte mother cells. They give rise to biflr.gel late sperms.

Development of antheridium

1. The antheridia arise from the embryonic cells at the tip of male shoot. The embryonic superficial cell forming antheridium is called antheridial initial. It increases in size. It undergoes transverse division to form lower primary stalk cell and the upper antheridial mother cell.

2. The primary stalk cell forms a few stalk cells. The antheridial mother cell divides to form an apical cell with two cutting faces. The apical cell cut off 3-4 segments. Now this apical cell functions as the operculum cell.

3. The last segment divides by two vertical divisions. It forms peripheral jacket initials and central primary androgonial cells.

4. Die jacket initials further divide to form a single-layered jacket. The primary androgonial cells divide to form androgonial cells.

5. The last generation of primary androgonial cells is called the androcyte mother cells. Each androcyte mother cell gives rise to two coiled biflagellate sperms.

6. The antheridia always dehisce in the presence or wren The operculum cell is thrown out and pore is formed at the apex. Sperm mass contained in mucilage comes out.

Archegonial head

The flask-shaped archegonia are borne at the apices of leafy stems. Archegonitim is surrounded by perichaerial leaves. These leaves overlap to form a closed bud-like structure. The archegonia occur in cluster of 3 to 6.

Mature archegonium is flask-shaped. It has a thick multicellular stalk. The neck is long and twisted. It contains neck canal cells. The neck consists of 6-vertical rows of cells. Neck gradually merges into venter. Venter contains upper small venter canal cell and lower large egg cell. Paraphyses are absent.

Development of archegonium

1. Any apical cell in the apical region acts an archegonial initial. The archegonial initial enlarge. It divides by a transverse division to form lower primary stalk cells and upper archegonial mother cell.

2. The primary stalk cell forms a massive stalk. The archegonial mother cell forms the main body of archegonium. It undergoes three vertical division s to form three peripheral cells surrounding an axial cell.

3. Three peripheral cells divide to form 2-3-layered jacket around the venter. The axial cell divides transversely to form inner central cell and outer apical cell.

4. Czntral cell forms upper small venter canal cell and lover large egg cell. Apical cell divides to form long neck which consists of 6 vertical rows of cells. The cells cut off from the base foem neck canal cells.

Fertilization

The sex organs dehisce in the presence of water. The venter canal cell and the neck canal cells dissolve to form mucilage. This mucilage exerts pressure and the neck opens out. The mucilage comes out of the neck. The sperms reached the archegonial heads by rain water. They are attracted towards the archegonia. One of the sperm swims down the open neck and reaches the base. It fuses with the egg to form oospore. Oospore is the first stage of sporophytic generation.

Sporophyte

Development of Sporogonium

2. The hypobasal region forms foot and lower part of seta. The foot region consists of thin-walled cells. It is embedded ir the stalk of the archegonium. The cells of the seta are larger and poor in cytoplasmic contents. 3. The epibasal region forms upper portion of seta and the capsule. Epibasal cell divides to form young embryo. Young embryo is cylindrical and completely surrounded by calyptra. Cells of the embryo divide to form amphithecium and the endothecium regions. 8-amphithecium cells are surrounded by a group of 4- endothecium cells.

4. Endothecium forms central conducting strands of apophysis. It forms columella and spore sac of theca. It also forms membranous tissues of the operculum. The outermost layer of endothecium forms archesporium or spore mother cells. These cells divide meiotically to form haploid spores.

5. The amphithecium divides to form seven rings of cells. These cells give rise to spongy tissues and epidermis of apophvsis. They also form outer wall of theca.

Structure of Mature Sporogonium (Sporophyte)

The mature sporogonium is differentiated into foot, seta and capsule. Foot.: The foot is buried deep in the tissue of gametophyte. It is absorptive in function. It consists of thin-walled narrow cells containing dense cytoplasm.

Seta: The seta is several inches long. It carries the capsule high into the air. It also conducts water and food. It consists of epidermis, cortex and central conducting strands.

Capsule: The upper part is capsule. It is differentiated into three regions: apophysis, theca and operculum.

1. Apophysis: It is the lower part of capsule. It is continuous with the seta. It is in the form of a swollen ring-like protuberance. Its cells are thin-walled, green and loosely arranged. The apophysis is the main photosynthetic region of the capsule.

2. Theca: It is the middle part of the capsule. It is four-lobed. Its wall is several layered. The outermost layer is epidermis. Trabecular air spaces are present inside the wall layers. These spaces have filaments of thin-walled elongated cells containing chloroplasts. Outer spore sac wall is present internal to outer trabecular spaces. This is followed by spore-sac proper. Then 2-layered inner spore-sac wall is present. Then inner trabecular air space is present. The centre is occupied by solid columella. All the sporogenous cells are fertile and form spores after reduction division.

3. Operculum: This is the uppermost part of the capsule. It is conical. The operculum is covered by calyptra. The calyptra forms a hairy structure. So Polytrichum is also known as hair moss. A constriction is present between operculum and theta. A rim or diaphragm is present at the base of this constriction. The celumella of the theca is continuous into the operculum. It expands into a fan-shaped epiphragm. Peristome is present in the form of a thick rim. It bears a number of rigid teeth. The epiphragm fills the space inside the ring of peristome teeth and is attached to their tips. Peristome teeth arise from the rim or diaphragm.

Dispersal of spores

Cells of the epiphragm dry up during dry conditions. It separates the operculum. The calyptra falls. Epiphragm also dries up between the peristome pores. The central tissue of theca region except the spores degenerates. Thus the spores lie free in the centre of the capsule at maturity. Spores come out through pores. They are dispersed by wind.

Structure and germination of spores

The spores are yellow. Each spore is uninucleate and has two wall laye:s. The outer layer is exosporium (exine). The inner layer is endosporium. The spore germinates under favourable conditions.

Exosporium ruptures and endosporium comes out. It forms prntonema. Protonema develops many buds. These buds produce new moss plants.

Altrnation of generation

Polytrichum shows heteromorphic alternation of generation. 3. Gametophyte: The plant body is gametophytes. Gametophyte is haploid. It develops antheridia and archegonia. Antheridia produce antherozoids and archegonium produces egg. Antherozoids fuse with egg to produce diploid oospore. 4. Sporophyte: The oospore is the first stage of sporophyte generation. It is diploid generation. Sporophyte has three parts: foot, seta and capsule. Haploid spores are produced in the capsule by meiosis. Spore is the first stage of gametophyte. Spores germinate to produce protonema stage. It gives rise to mature gametophyte completing the life cycle

EVOLUTION OF SPOROPHYTES IN BRYOPHYTE

According to the complexity of structure, the sporophye of bryophytes may be arranged in a series between the simple and the most elaborate. The series start with the simple sporophyte of riccia, runs through that of sphaerocarpos , anthoceros, marchantia and finally ends in a highly complex sporophye of funaria and pogonatum.

a) Theory of sterilization

b) Reduction Theory

1.Theory of Sterilization

This theory was put forward by BOWER and supported by Cavers, Campbell and Smith. This theory illustrates that a natural advance in the progressive elaboration and complexity of the sporophyte. The fundamental of principle upon which he formulated his argument is " the progressive sterilization of the potentially fertile cells (sporogenous tissue)" .

Instead of forming spores and serving a propogating function they remain sterile. These sterile cells are put to the other uses such as nutrition , support , dehiscence , dispersal etc. This hypothesis of Bower is called "Theory of Sterilization".

The detail process of Sterilization of some of the important genera discussed as follow-

(a) Riccia Sporophyte- In riccia, zygote divide and redivides to farm a spherical mass of 20-30 undifferentiated cell. Periclinal segmentation forms an inner mass of cell called endothecium and outer single layer amohithecium. The amohithecium forms the single layered capsule wall. The endothecium forms the central mass of sporogenous tissue. Practically , all the sporogenous cells are fertile and develop into spores. However, few of them undergo degeneration to form the nurse cells.

The sporophye of riccia is simplest among all of the bryophytes and has least amount of sterile cells. The entire embryo froms the spore producing capsule. There is not foot and Seta. It is just a spore producing organ without any distributing function.

(b) Marchantia Sporophyte- Sterilization of fertile cells is more advanced in the genus. Half of the embryo divided from the hypobasal regions remians sterile. It forms the foot and Seta. The upper epibasal half is fertile and forms the spore producing capsule. The sterile cell elongate, develop spirally thickened walls and become the elators. A few of the cells of sporogenous cells at the top may be differentiated into sterile, apical cell. The capsule of Marchantia has both spore producing and spore distributing body. It illustrates a step further in the progressive sterilization of the sporogenous tissue.

(c) Anthoceros Sporophyte- It illustrates a step further than riccia and Marchantia in the progressive sterilization ot the potentially of fertile tissue. The endothecium cells become completely sterile and forms a group of cells known as columella. The sporogenous cells arise from the innermost layer of the amohithecium.

It surrounds the columella. The sporogenous cells become differentiated into spore mother cell and pseudo-elaters. The archegonium of anthoceros is extremely reduced. The outer amohithecium develops into several cells layer thick capsule wall. The capsule wall develops a well ventilated photosynthetic tissue protected by the Epidermis.

(d) Funaria Sporophyte- In funaria major portion of the Sporophyte remain sterile to form the foot and Seta. The capsule is differentiated into central column of andothecium surrounded by many layered amphithecium. The inner layer of the endothecium forms the sterile columella and the superficial cell form the sporogenous tissue. Thus the archesporium arise from the outermost layer of cells of the endothecium.

It is thus extremely reduced and consists of single layer of fertile tissues. The amohithecium become differentiated into the Epidermis , photosynthetic tissue of the capsule wall and the outer spore sac.

The Bower theory of sterilization gives a clear explanation of the evolution of sporophye into upward direction. This theory is more conveincing and reliable.

2. REDUCTION THEORY

This theory was put forward by kashyap, church, Goebal and Evans. They hold that the evolution of sporophye has been in downward direction. They hold the fact that evolution of Sporophyte is retrogressive evolution. They mainly based their theory on the reduction of different organs which result in the simplification of Structure of Sporophyte.

On the basis of this view the simplest type of Sporophyte of riccia is considered as the most advance one.

Simplification of dehiscence appratus.

Reduction of the green photosynthetic tissue in the capsule wall.

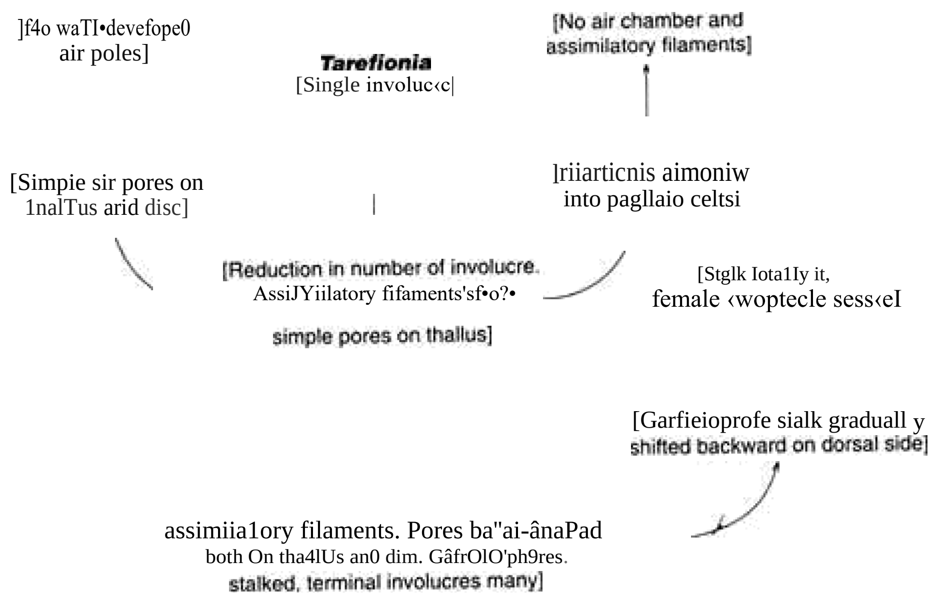
Disappearence of stomata and intercellular spaces.

Increase in the thickness of capsule wall.

The gradual elimination of foot and Seta.

All these changes accompanied by the progressive increase in the fertility of sporogenous cells. The changes eliminates the presence of sterile cells and elater in the capsule.

Evidence from comparative morphology and experimental genetics support the view that the simple Sporophyte of riccia is an advanced but a reduced structure.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Fossil Brophytes

List of four important fossil bryophytes:- 1. Fossil Hepatophyta 2. Fossil Anthocerotophyta 3. Fossil Bryophyta 4. Problematic Fossil Bryophytes.

1. Fossil Hepatophyta (Marchantiophyta)

The earliest record of vegetative fossil bryophyte remains is the liverwort from the Upper Devonian of New York which has been assigned to the form-genus Pallavicinites, (= Hepaticites) devonicus

The reproductive structures are not found with any of the species of Pallavicinites. The vegetative features suggested that the species of Pallavicinites may be more closely related to the anacrogynous Jungermanniales. Various species of Pallavicinites have been described from the Carboniferous to the Pleistocene deposits (Fig. 6.60B) and can easily be compared with living bryophyte genera like Pallavicinia, Metzgeria, Treuba and Fossombronia.

Diettertia, an interesting hepatic, has been identified from Cretaceous era which may be more closely compared with the Jungermanniales. The best known bryophyte fossil is Naiadita lanceolata that has been described by Harris (1938) from the Rhaetic (Upper Triassic) of England (Fig. 6.61 A-D). The spores of Naiadita show the closest resemblance to the member of the Marchantiales and Sphaerocarpales.

The type of spores, unicellular rhizoids, the nature of archegonia and capsules suggested that Naiadita represents a liverwort similar to the living genus Riella of Sphaerocarpales. However, Schuster (1966) argued that the vege•tative features of Naiadita showing closer proxi•mity to the Calobryales.

A fossil bryophyte, Marchantiolites, has been described from the Lower Cretaceous rock of central Montana. M. porosus has been identified from the Jurassic deposit of Sweden. Marchan•tiolites has been placed in the Marchantiales due to the similarity in the airpores.

A thalloid bryophyte identified from the Upper Triassic of South America has been placed in the genus Marchantites. Ricciopsis, a rosette- shaped bryophytic thallus has been identified from the Jurassic of Sweden. The similar rosette-shaped thallus has been identified from Deccan Intertrappean beds of India and has been placed in the modern genus Riccia.

Fossil Hepatophyta -Naiadita Lanceolata

2. Fossil Anthocerotophyta (Hornworts)

There are no reports of fossil Anthocero•tophyta thalli, although some reliable reports of hornwort spores are available from the Cretaceous (Maastrichtian) rocks of North America. The spores are trilete, circu•lar and possess a distinct cingulum with variable ornamentations which are comparable with the modern hornwort genus Phaeoceros.

3. Fossil Bryophyta (Mosses)

The fossil record of the mosses is much less complete as compared to the fossil hepatics, though they are recorded as early as the Permian. An impression of a leafy shoot of Muscites plumatus has been described from the rocks of Lower Carboniferous age.

This plant shows an axis, covered with helically arranged leaves. Sex organs, sporophyte capsules or rhizoids were not associated with the gameto•phytic plant. Several species of Muscites have been reported from the Upper Carboniferous of France and the Triassic of Africa. An extensive moss flora has been identified by Neuberg (1960) from the Permian rocks of Siberia, of which six identified genera (Intia, Salairia, Uskatia, Polyssaiuria, Bajdaieira and Buchtia) were placed under the Bryales and three (Protosphagnum, Vorentannularia and Jungajia) to a new order, the Protosphagnales.

The genus Protosphagnum has leaves comparable to the modern genus Sphagnum, except for the pres•ence of a midrib. Ignatov (1990) described a diverse flora of well-preserved gametophytes of mosses from the Upper Permian of the Russian platform which are comparable to the modern forms like Dicranales, Pottiales, Funariales, Leucodontales and Hypnales.

The permineralised well-preserved moss, Mercerea augustica, has been described by Smoot and Taylor (1986) from the Permian of Antarctica. The plant has a delicate axis to which are attached helically arranged leaves containing a midrib and rhizoids. Reproductive organs or sporophytes are not found associated with the plants. The external morphology and anatomy of the axes suggest its affinity with the Bryidae.

Several compression fossils of true mosses have been described from the Mesozoic, of which Tricostium and Yorekiella from the Jurassic of the Bureja Basin, Russia and Aulacomnium heterostichoides from deep water varved clays (Eocene) of a fresh water lake in British Columbia.

The well-preserved Aulacomnium heterosti•choides has been extensively studied which is very closely related to the present day living species, Aulacomnium heterostichum found in eastern North America and eastern Asia.

4. Problematic Fossil Bryophytes

The Lower Devonian compression fossil Sporogonites is one of the oldest plants that resembles a bryophyte. The plant consists of many parallel-oriented sporangial stalks that ter•minate in elongate capsules, developed from a common thallus. The sporangium is multilayered and possibly contains a central columella. Numerous trilete spores are present in the spo•rangium. Sporogonites has been considered to be an early hornwort or gametophyte-bearing sporophyte of a moss.

A Precambrian bryophytic fossil, Longfengshania, has been described from China which shows striking similarity with Sporogonites. This unusual fossil of Precambrian age makes it doubtful about the validity of its systematic position. Tortilicaulis is an early Devonian fossil described from South Wales that shares a few morphological features common with the modern liver-worth Pellia.