Semester II Botany Major

Class Notes /hints on Lichens: Their Meaning, Characteristics, types ,Classfication etc.

Meaning of Lichens:

Lichens are a small group of plants of composite nature, consisting of two dissimilar organisms, an alga-phycobiont (phycos — alga; bios — life) and a fungus-mycobiont (mykes — fungus; bios — life); living in a symbiotic association.

Generally the fungal partner occupies the major portion of the thallus and produces its own reproductive structures. The algal partner manufactures the food through photosynthesis which probably diffuses out and is absorbed by the fungal partner.

Characteristics of Lichens:

1. Lichens are a group of plants of composite thalloid nature, formed by the association of algae and fungi.

2. The algal partner-produced carbohydrate through photosynthesis is utilised by both of them and the fungal partner serves the function of absorption and retention of water.

3. Based on the morphological structure of thalli, they are of three types crustose, foliose and fruticose.

4. Lichen reproduces by all the three means – vegetative, asexual, and sexual.

(a) Vegetative reproduction: It takes place by fragmentation, decaying of older parts, by soredia and isidia.

(b) Asexual reproduction: By the formation of oidia.

(c) Sexual reproduction: By the formation of ascospores or basidiospores. Only fungal component is involved in sexual reproduction.

5. Ascospores are produced in Ascolichen.

(a) The male sex organ is flask-shaped spermogonium, produces unicellular spermatia.

(b) The female sex organ is carpogonium (ascogonium), differentiates into basal coiled oogonium and elongated trichogyne.

(c) The fruit body may be apothecia! (discshaped) or perithecial (flask-shaped) type.

(d) Asci develop inside the fruit body containing 8 ascospores. After liberating from the fruit body, the ascospores germinate and, in contact with suitable algae, they form new lichen.

6. Basidiospores are produced in Basidiolichen, generally look like bracket fungi and basidiospores are produced towards the lower side of the fruit body.

7. The growth of lichen is very slow, they can survive in adverse conditions with high temperature and dry condition.

Habit and Habitat of Lichens:

There is about 400 genera and 15,000 species of lichens, widely found in different regions of the world. The plant body is thalloid; generally grows on bark of trees, leaves, dead logs, bare rocks etc., in different habitat. They grow luxuriantly in the forest areas with free or less pollution and with abundant moisture.

Some species like Cladonia rangiferina (reindeer moss) grows in the extremely cold condition of Arctic tundras and Antarctic regions. In India, they grow abundantly in Eastern Himalayan regions. They do not grow in the highly polluted regions like Industrial areas. The growth of lichen is very slow.

Depending on the growing region, the lichens are grouped as:

1. Corticoles:

Growing on bark of trees, mainly in the sub-tropical and tropical regions.

2. Saxicoles:

Growing on rocks, in cold climate.

3. Terricoles:

Growing on soil, in hot climate, with sufficient rain and dry summer.

Associated Members of Lichens:

The composite plant body of lichen consists of algal and fungal members.

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The algal members belong to Chlorophyceae (Trebouxia, Trentepohlia, Coccomyxa etc.), Xanthophyceae (Heterococcus) and also Cyanobacteria (Nostoc, Scytonema etc.) (Fig. 4.111).

The fungal members mainly belong to Ascomycotina and a few to Basidiomycotina. Among the members of Ascomycotina, Discomycetes are very common; producing huge apothecia, others belong to Pyrenomycetes or Loculoascomycetes.

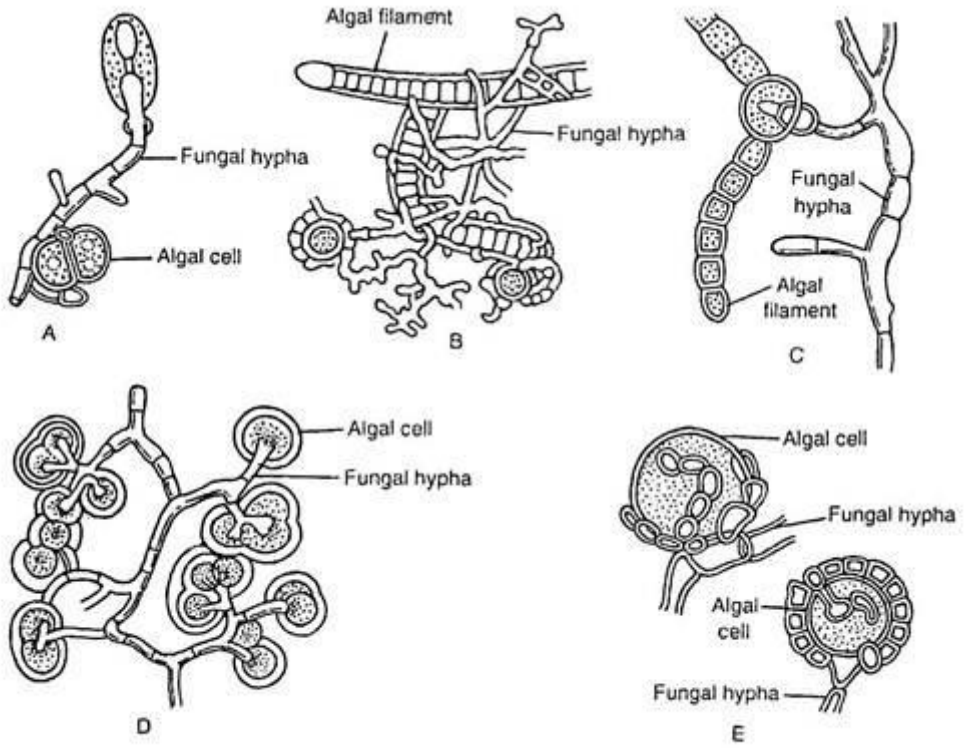

Fig. 4.111 :Lichen-forming Algae : A. *Pleurococcus viridis*, B. *Scytonema* sp., C. *Nostoc* sp., D. *Gloeocapsa* sp., E. *Pleurococcus* sp.

The members of Basidiomycotina belong to Thelephoraceae.

Nature of Association of Lichens:

There are three views regarding the nature of association of algal and fungal partners in lichen:

1. According to some workers, the fungus lives parasitically, either partially or wholly, with the algal components.

This view gets support for the following evidences:
(i) Presence of haustoria of fungus in algal cells of some lichen.

(ii) On separation, the alga of lichen is able to live independently, but the fungus cannot survive.

2. According to others, they live symbiotically, where both the partners are equally benefitted. The fungal member absorbs water and mineral from atmosphere and substratum, make available to the alga and also protects algal cells from adverse conditions like temperature etc. The algal member synthesises organic food sufficient for both of them.

3. According to another view, though the relationship is symbiotic, the fungus shows predominance over the algal partner, which simply lives as subordinate partner. It is like a master and slave relationship, termed helotism.

Classification of Lichens:

Natural system of classification is not available for lichens. They are classified on the nature and kinds of fruit bodies of the fungal partner.

Based on the structure of fruit bodies of fungal partners, Zahlbruckner (1926) classified lichens into two main groups:

1. Ascolichens:

The fungal member of this lichen belongs to Ascomycotina.

Based on the structure of the fruit body, they are divided into two series:

(i) Gynocarpeae:

The fruit body is discshaped i.e., apothecial type. It is also known as Discolichen (e.g., Parmelia).

(ii) Pyrenocarpeae:

The fruit body is flask-shaped i.e., perithecial type. It is also known as Pyrenolichen (e.g., Dermatocarport).

2. Basidiolichen:

The fungal member of this lichen belongs to Basidiomycotina e.g., Dictyonema, Corella.

Later, Alexopoulos and Mims (1979) classified lichens into three main groups:

i. Basidiolichen:

The fungal partner belongs to Basidiomycetes e.g., Dictyonema.

ii. Deuterolichen:

The fungal partner belongs to Deuteromycetes.

iii. Ascolichen:

The fungal partner belongs to Ascomycetes e.g., Parmelia, Cetraria.

Structure of Thallus in Lichens:

The plant body of lichen is thalloid with different shapes. They are usually grey or greyish green in colour, but some are red, yellow, orange or brown in colour.

A. External Structure of Thallus:

Based on the external morphology, general growth and nature of attachment, three main types or forms of lichens (crustose, foliose and fruticose) have been recognised. Later, based on detailed structures,

Hawksworth and Hill (1984) categorised the lichens into five main types or forms:

1. Leprose:

This is the simplest type, where the fungal mycelium envelops either single or small cluster of algal cells. The algal cell does not envelop all over by fungal hyphae. The lichen appears as powdery mass on the substratum, called leprose (Fig. 4.112A), e.g., Lepraria incana.

2. Crustose:

These are encrushing lichens where thallus is inconspicuous, flat and appears as a thin layer or crust on substratum like barks, stones, rocks etc. (Fig. 4.112B). They are either wholly or partially embedded in the substratum, e.g., Graphis, Lecanora, Ochrolechia, Strigula, Rhizocarpon, Verrucaria, Lecidia etc.

3. Foliose:

These are leaf-like lichens, where thallus is flat, horizontally spreading and with lobes. Some parts of the thallus are attached with the substratum by means of hyphal outgrowth, the

rhizines, developed from the lower surface (Fig. 4.112C), e.g., Parmelia, Physcia, Peltigera, Anaptychia, Hypogymnia, Xanthoria, Gyrophora, Collema, Chauduria etc.

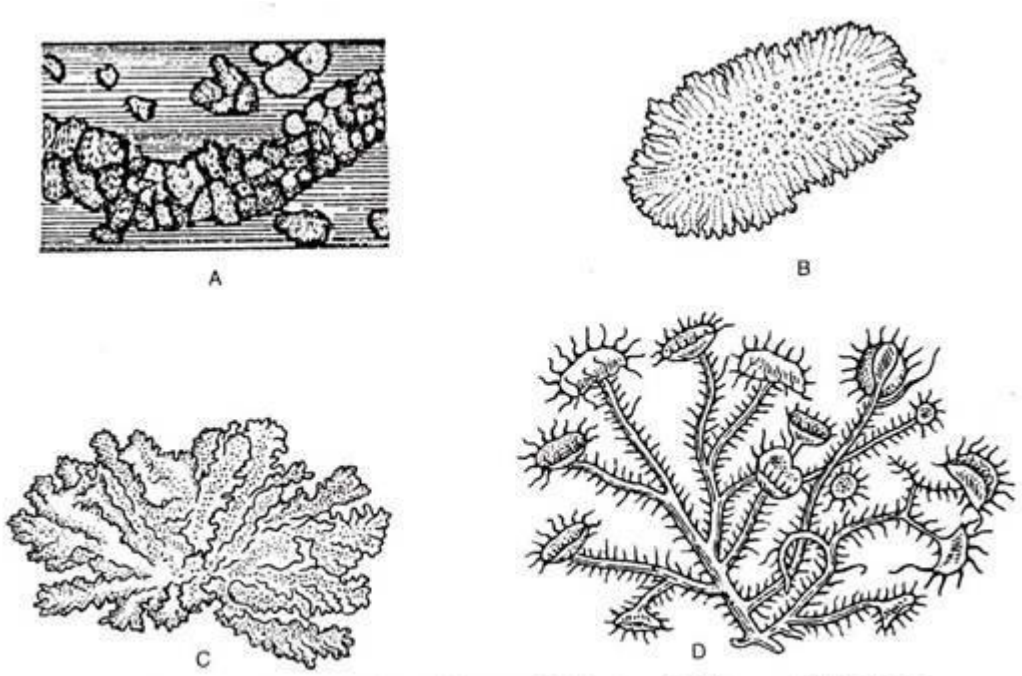

Fig. 4.112 : Different forms of lichen : A. Leprose, B. Crustose, C. Foliose and D. Fruiticose

4. Fruticose (Frutex, Shrub):

These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub-like (Fig. 4.112D), either grow erect (Cladonia) or hang from the substratum (Usnea). They are attached to the substratum by a basal disc e.g., Cladonla, Usnea, Letharia, Alectonia etc.

5. Filamentous:

In this type, algal members are filamentous and well-developed. The algal filaments remain ensheathed or covered by only a few fungal hyphae. Here algal member remains as dominant partner, called filamentous type, e.g., Racodium, Ephebe, Cystocoleus etc.).

B. Internal Structure of Thallus:

Based on the distribution of algal member inside the thallus, the lichens are divided into two types. Homoisomerous or Homomerous and Heteromerous.

1. Homoisomerous:

Here the fungal hyphae and the algal cells are more or less uniformly distributed throughout the thallus. The algal members belong to Cyanophyta. This type of orientation is found in

crustose lichens. Both the partners intermingle and form thin outer protective layer (Fig. 4.11 3A), e.g., Leptogium, Collema etc.

2. Heteromerous:

Here the thallus is differentiated into four distinct layers upper cortex, algal zone, medulla, and lower cortex. The algal members are restricted in the algal zone only. This type of orientation is found in foliose and fruticose lichens (Fig. 4.113B) e.g., Physcia, Parmelia etc.

The detailed internal structure of this type is:

(a) Upper Cortex:

It is a thick, outermost protective covering, made up of compactly arranged interwoven fungal hyphae located at right angle to the surface of the fruit body. Usually there is no intercellular space between the hyphae, but if present, these are filled with gelatinous substances.

(b) Algal Zone:

The algal zone occurs just below the upper cortex. The algal cells are entangled by the loosely interwoven fungal hyphae. The common algal members may belong to Cyanophyta like Gloeocapsa (unicellular); Nostoc, Rivularia (filamentous) etc. or to Chlorophyta like Chlorella, Cystococcus, Pleurococcus etc. This layer is either continuous or may break into patches and serve the function of photosynthesis.

(c) Medulla:

The medulla is situated just below the algal zone, comprised of loosely interwoven thick-walled fungal hyphae with large space between them.

(d) Lower Cortex:

It is the lowermost layer of the thallus. This layer is composed of compactly arranged hyphae, which may arrange perpendicular or parallel to the surface of the thallus. Some of the hyphae in the lower surface may extend downwards and penetrate the substratum which help in anchorage, known as rhizines.

The internal structure of Usnea, a fruticose lichen, shows different types of orientation. Being cylindrical in cross-section, the layers from outside are cortex, medulla (composed of algal cell and fungal mycelium) and central chondroid axis (composed of compactly arranged fungal mycelia).

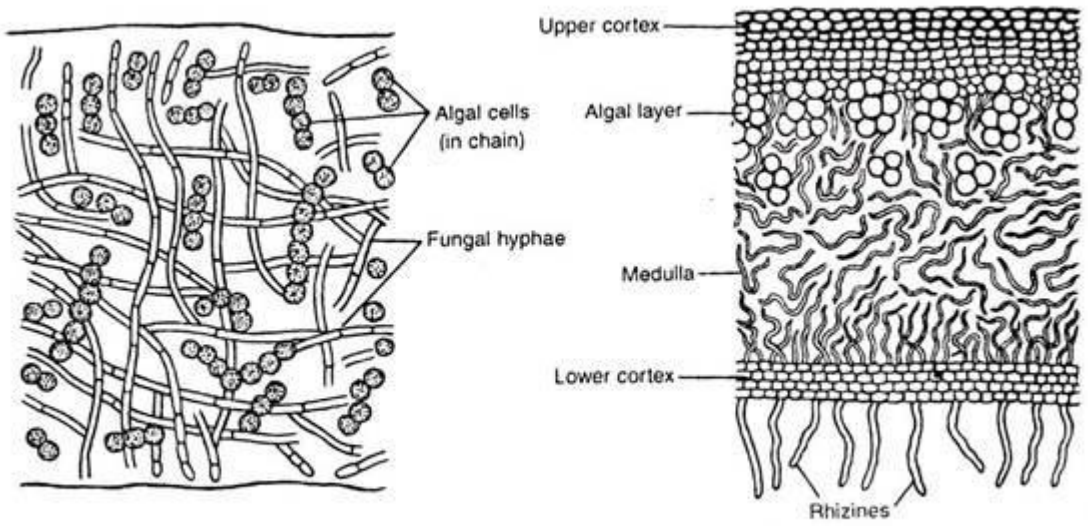

Fig. 4.113 : Internal structure of lichen thallus : A. Homoisomerous thallus, and B. Heteromerous thallus

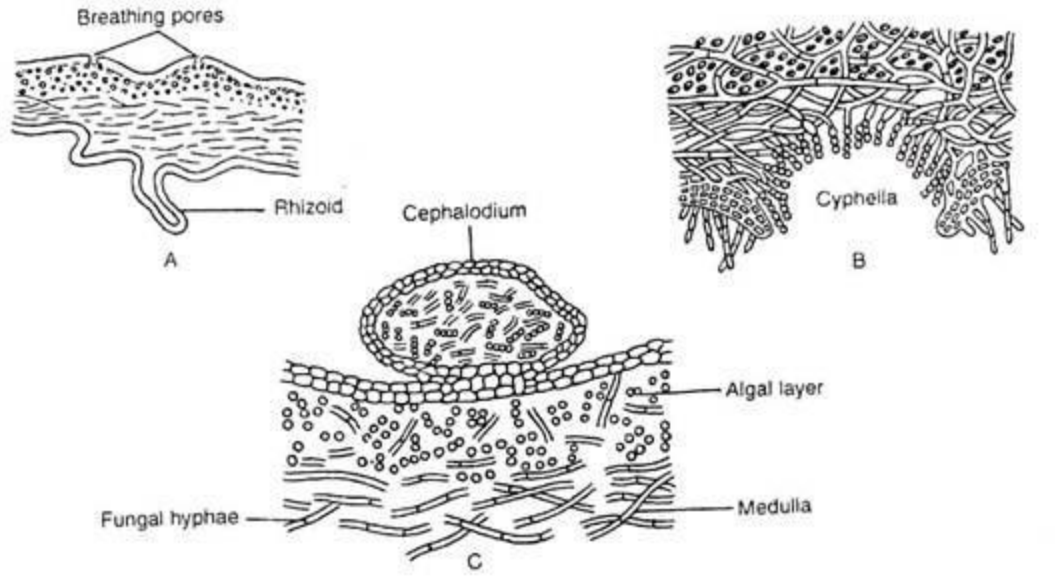

Fig. 4.114 : Specialised structures associated with lichen thallus : A. Breathing pores, B. Cyphella, C. Cephalodium

C. Specialised Structures of Thallus:

1. Breathing Pore:

In some foliose lichen (e.g., Parmelia), the upper cortex is interrupted by some opening, called breathing pores, which help in gaseous exchange (Fig. 4.114A).

2. Cyphellae:

On the lower cortex of some foliose lichen (e.g., Sticta) small depressions develop, which appears as cup-like white spots, known as Cyphellae (Fig. 4.114B). Sometimes the pits that

formed without any definite border are called Pseudocyphellae. Both the structures help in aeration.

3. Cephalodium:

These are small warty outgrowths on the upper surface of the thallus (Fig. 4.114C). They contain fungal hyphae of the same type as the mother thallus, but the algal elements are always different. They probably help in retaining the moisture. In Neproma, the Cephalodia are endotrophic.

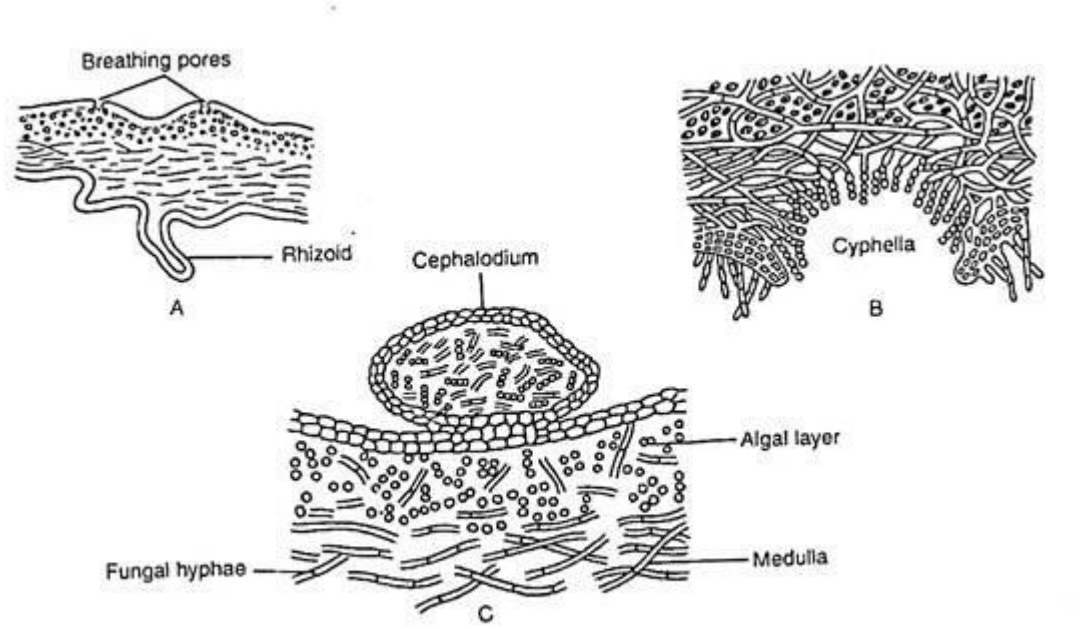

Fig. 4.114 : Specialised structures associated with lichen thallus : A. Breathing pores, B. Cyphella, C. Cephalodium

Reproduction in Lichens:

Lichen reproduces by all the three means, vegetative, asexual, and sexual.

I. Vegetative Reproduction:

(a) Fragmentation:

It takes place by accidental injury where the thallus may be broken into fragments and each part is capable of growing normally into a thallus.

(b) By Death of Older Parts:

The older region of the basal part of the thallus dies, causing separation of some lobes or branches and each one grows normally into new thallus.

II. Asexual Reproduction:

1. Soredium (pi. Soredia):

These are small grayish white, bud-like outgrowths developed on the upper cortex of the thallus (Fig. 4.115A, B). They are composed of one.or few algal cells loosely enveloped by fungal hyphae. They are detached from the thallus by rain or wind and on germination they develop new thalli.

When soredia develop in an organised manner in a special pustule-like region, they are called Soralia (Fig. 4.115D), e.g., Parmelia Physcia etc.

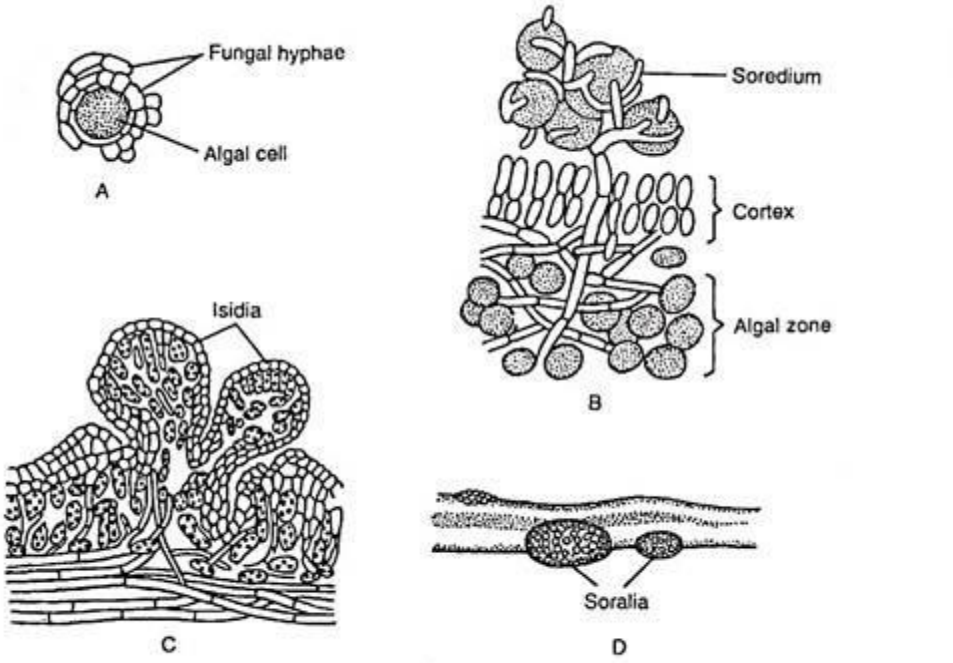

Fig. 4.115 : Asexual reproductive structures : A. Soredium of *Physcia pulverulenta* with single algal cell, B. Soredium of *Parmelia* with many algal cells, C. Isidia of *Peltigera* and D. Soralia on thallus

2. Isidium (pi. Isidia):

These are small stalked simple or branched, grayish- black, coral-like outgrowths, developed on the upper surface of the thallus (Fig. 4.115C). The isidium has an outer cortical layer continuous with the upper cortex of the mother thallus which encloses the same algal and fungal elements as the mother.

They are of various shapes and may be coral-like in Peltigera, rod-like in Parmelia, cigar-like in Usnea, scale-like in Collema etc. It is generally constricted at the base and detached very easily from the parent thallus. Under favourable condition the isidium germinates and gives rise to a new thallus.

In addition to asexual reproduction, the isidia also take part in increasing the photo-synthetic area of the thallus.

3. Pycniospore:

Some lichen develops pycniospore or spermatium inside the flask-shaped pycnidium (Fig. 4.116A).

They usually behave as gametes, but in certain condition they germinate and develop fungal hyphae. These fungal hyphae, when in contact with the appropriate algal partner, develop into a new lichen thallus.

III. Sexual Reproduction:

Only fungal partner of the lichen reproduces sexually and forms fruit bodies on the thallus. The nature of sexual reproduction in ascolichen is like that of the members of Ascomycotina, whereas in Basidiolichen is like that of Basidiomycotina members.

In Ascolichen, the female sex organ is the carpogonium and the male sex organ is called spermogonium (= pycnidium). The spermogonium (Fig. 4.116A) mostly develops close to carpogonium.

The carpogonium is multicellular and is differentiated into basal coiled ascogonium and upper elongated multicellular trichogyne (Fig. 4.116B). The ascogonium remains embedded in the algal zone, but the trichogyne projects out beyond the upper cortex.

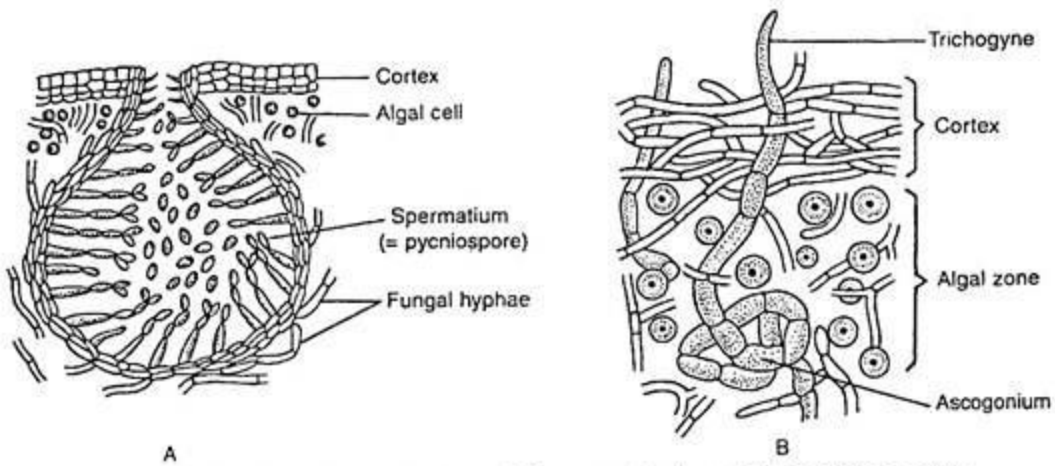

Fig. 4.116 : Sexual reproductive structures : A. Spermogonium (= pycnidium), B. Carpogonium

The spermogonium is flask-shaped and develop spermatia from the inner layer (Fig. 4.116A). The spermatia behave as male gametes. The spermatium, after liberating from the

spermogonium, gets attached with the trichogyne at the sticky projected part. On dissolution of the common wall, the nucleus of spermatium migrates into the carpogonium and fuses with the egg.

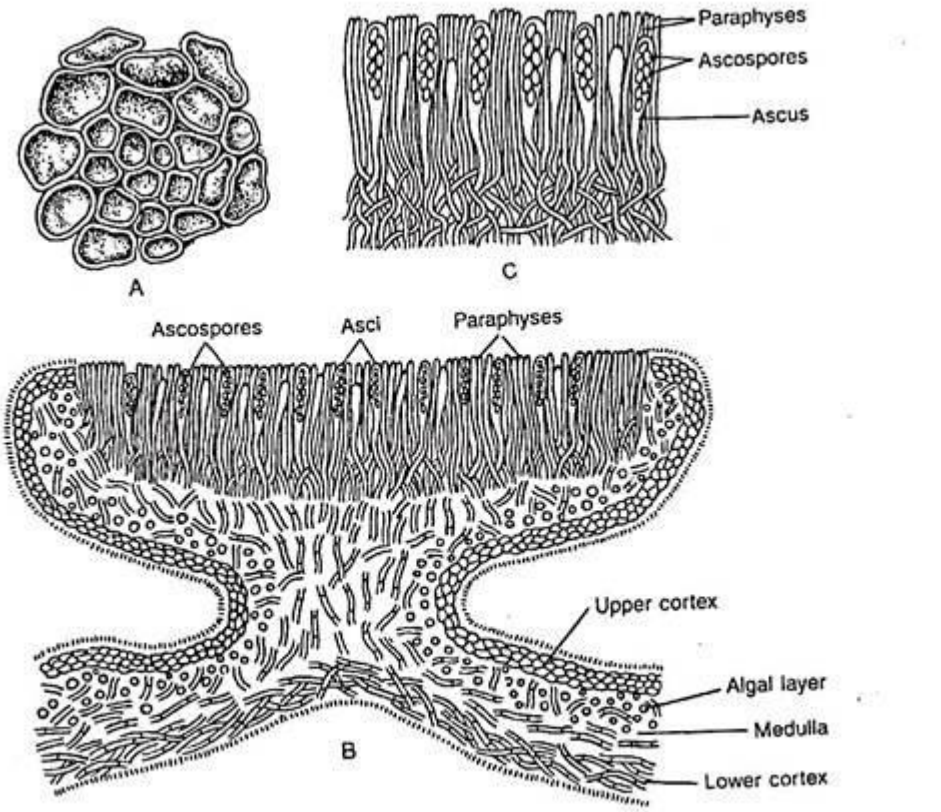

Fig. 4.117 : Structural features of ascolichen : A. Apothecia, B. V.S. of apothecium and C. Portion of hymenial region

Many ascogenous hyphae develop from the basal region of the fertilised ascogonium. The binucleate penultimate cell of the ascogenous hyphae develops into an ascus.

Both the nuclei of penultimate cell fuse and form diploid nucleus (2n), which undergoes first meiotic and then mitotic division — results in eight haploid daughter nuclei. Each haploid nucleus with some cytoplasm metamorphoses into an ascospore.

The asci remain intermingled with some sterile hyphae — the paraphyses. With further development, asci and paraphyses become surrounded by vegetative mycelium and form fruit body.

The fruit body may be ascohymenial type i.e., either apothecium (Fig. 4.117A) as in Parmelia and Anaptychia or perithecium as in Verrucaria and Darmatocarpon or ascolocular type (absence of true hymenium), which is also known as pseudothecia or ascostroma.

Internally, the cup-like (Fig. 4.117B, C) grooved region of a mature apothecium consists of three distinct parts; the middle thecium (= hymenium), comprising of asci and paraphyses, is the fertile zone covered by two sterile zones — the upper epitheca and lower hypotheca. The region below the cup is differentiated like the vegetative thallus into outer cortex, algal zone and central medulla (Fig. 4.117B).

Usually the asci contain eight ascospores (Fig. 4.117C), but the number may be one in Lopadium, two in Endocarpon and even more than eight in Acarospora.

The ascospores may be unicellular or multicellular, uninucleate or multinucleate, and are of various shapes and sizes. After liberating from the ascus, the ascospore germinates in suitable medium and produces new hypha. The new hypha, after coming in contact with proper algal partner, develops into a new thallus.

In Basidiolichen (Fig. 4.118), the result of sexual reproduction is the formation of basidiospores that developed on basidium as in typical basidiomycotina. The fungal member (belongs to Thelephoraceae) along with blue green alga, as algal partner forms the thalloid plant body.

The thallus grown over soil produces hypothallus without rhizines, but on tree trunk it grows like bracket fungi (Fig. 4.118A) and differentiates internally into upper cortex, algal layer, medulla and lower fertile region with basidium bearing basidiospores (Fig. 4.118B, C).

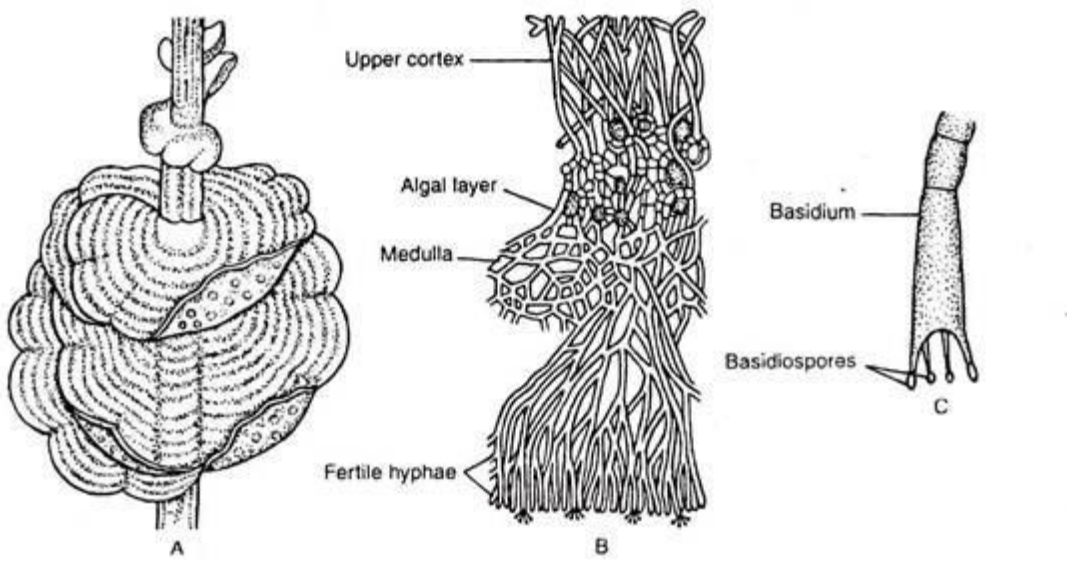

Fig. 4.118 : Structural features of basidiolichen (*Cora pavonia*) : A. Bracket-like thalli, B. Vertical section of thallus (portion), C. Basidium with basidiospores

Importance of Lichens:

A. Economic Importance of Lichens:

The lichens are useful as well as harmful to mankind. The useful activities are much more than harmful ones. They are useful to mankind in various ways: as food and fodder, as medicine and industrial uses of various kinds.

1. As Food and Fodder:

Lichens are used as food by human being in many parts of the world and also by different animals like snail, catterpiliars, slugs, termites etc. They contain polysaccharide, lichenin; cellulose, vitamin and certain enzymes.

Some uses of lichens are:

(i) As Food:

Some species of Parmelia are used as curry powder in India, Endocarpon miniatum is used as vegetable in Japan, Evernia prunastri for making bread in Egypt, and Cetraria islandica (Iceland moss) as food in Iceland. Others like species of Umbillicaria, Parmelia and Leanora are used as food in different parts of the world. In France, some of the lichens are used in the preparation of chocolates and pastries.

Lichens like Lecanora saxicola and Aspicilia calcarea etc. are used as food by snails, caterpillars, termites, slugs etc.

(ii) As Fodder:

Ramalina traxinea, R. fastigiata, Evernia prunastri, Lobaria pulmo- naria are used as fodder for animals, due to the presence of lichenin, a polysaccharide. Animals of Tundra region, especially reindeer and muskox use Cladonia rangifera (reindeer moss) as their common food. Dried lichens are fed to horses and other animals.

2. As Medicine:

Lichens are medicinally important due to the presence of lichenin and some bitter or astringent substances. The lichens are being used as medicine since pre-Christian time. They have been used in the treatment of jaundice, diarrhoea, fevers, epilepsy, hydrophobia and skin diseases.

Cetraria islandica and Lobaria pulmonaria are used for tuberculosis and other lung diseases; Parmelia sexatilisfor epilepsy; Parmelia perlata for dyspepsia. Cladonia pyxidata for whooping cough; Xanthoria parietina for jaundice and several species of Pertusaria, Cladonia and Cetraria islandica for the treatment of intermittent fever.

Usnic acid, a broad spectrum antibiotic obtained from species of Usnea and Cladonia, are used against various bacterial diseases. Usnea and Evernia furfuracea have been used as astringents in haemorrhages. Some lichens are used as important ingredients of many antiseptic creams, because of having spasmolytic and tumour-inhibiting properties.

3. Industrial Uses:

Lichens of various types are used in different kinds of industries.

(i) Tanning Industry:

Some lichens like Lobaria pulmonaria and Cetraria islandica are used in tanning leather.

(ii) Brewery and Distillation:

Lichens like Lobaria pulmonaria are used in brewing of beer. In Russia and Sweden, Usneaflorida, Cladonia rangiferina and Ramalina fraxinea are used in production of alcohol due to rich content of “lichenin”, a carbohydrate.

(iii) Preparation of Dye:

Dyes obtained from some lichens have been used since pre- Christian times for colouring fabrics etc.

Dyes may be of different colours like brown, red, purple, blue etc. The brown dye obtained from Parmelia omphalodes is used for dyeing of wool and silk fabrics. The red and purple dyes are available in Ochrolechia androgyna and O. tartaria.

The blue dye "Orchil", obtained from Cetraria islandica and others, is used for dyeing woollen goods. Orcein, the active principal content of orchil-dye, is used extensively in laboratory during histological studies and for dyeing coir.

Litmus, an acid-base indicator dye, is extracted from Roccella tinctoria, R. montagnei and also from Lasallia pustulata.

(iv) Cosmetics and Perfumery:
The aromatic compounds available in lichen thallus are extracted and used in the preparation of cosmetic articles and perfumes. Essential oils extracted from species of Ramalina and Evernia are used in the manufacture of cosmetic soap.

Ramalina calicaris is used to whiten hair of wigs. Species of Usnea have the capacity of retaining scent and are commercially utilised in perfumery. Evernia prunastri and Pseudevernia furfuracea are used widely in perfumes.

Harmful Activities of Lichens:
1. Some lichens like Amphiloma and Cladonia parasitise on mosses and cause total destruction of moss colonies.

2. Lichen like Usnea, with its holdfast hyphae, can penetrate deep into the cortex or deeper, and destroy the middle lamella and inner content of the cell causing total destruction.

3. Different lichens, mainly crustose type, cause serious damage to window glasses and marble stones of old buildings.

4. Lichens like Letharia vulpina (wolf moss) are highly poisonous. Vulpinic acid is the poisonous substance present in this lichen.

B. Ecological Importance of Lichens:
Lichens have some ecological importance.

Some of activities in this respects are:

1. Pioneer of Rock Vegetation:

Lichens are pioneer colonisers on dry rocks. Due to their ability to grow with minimum nutrients and water, the crustose lichens colonise with luxuriant growth. The lichens secrete some acids which disintegrate the rocks.

After the death of the lichen, it mixes with the rock particles and forms thin layer of soil. The soil provides the plants like mosses to grow on it as the first successor, but, later, vascular plants begin to grow in the soil. In plant succession, Lecanora saxicola, a lichen, grows first; then the moss Crtmmia pulvinata, after its death, forms a compact cushion on which Poa compressor grows later.

2. Accumulation of Radioactive Substance:

Lichens are efficient for absorption of different substances. The Cladonia rangiferina, the 'reindeer moss', and Cetraria islandica, the 'Iceland moss' are the commonly available lichens in Tundra region. The fallout of radioactive strontium ($_{90}Sr$) and caesium ($_{137}C_S$) from the atomic research centres are absorbed by lichen. Thus, lichen can purify the atmosphere from radioactive substances.

The lichens are eaten by caribou and reindeer and pass on into the food-chain, especially to the Lapps and Eskimos. Thus, the radioactive substances are accumulated by the human beings.

3. Sensitivity to Air Pollutants:

Lichens are very much sensitive to air pollutants like SO_2, CO, CO_2etc.; thereby the number of lichen thalli in the polluted area is gradually reduced and, ultimately, comes down to nil. The crustose lichens can tolerate much more in polluted area than the other two types. For the above facts, the lichens are markedly absent in cities and industrial areas. Thus, lichens are used as "pollution indicators".