LICHENOLOGY

- Lichens are a small group of curious plants of composite nature made up of two different organisms, an alga (***phycobiont***: in Latin phycos-alga; bios-life) and a fungus (***mycobiont***: in Greek mycos-fungus; bios-life).
- Algal and fungal components live in a truly intimate symbiotic relationship.
- This true nature of lichens was first identified by **Simon Schwendener**. He named the algal component as Phycobiont and the fungal component as Mycobiont.
- 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

- Lichens are a group of plants of composite thalloid nature, formed by the association of algae and fungi.
- 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.
- Owing to their symbiotic relationship, lichens can live in variety of habitats and climatic conditions including extreme environments.
- Based on the morphological structure of thalli, they are of three types- crustose, foliose and fruticose.

- Crustose lichens are called **microlichens** whereas foliose and fruticose lichens are called as **macrolichens.**
- Based on the substrate of growing, the lichens can be of following types
  - Corticolous (grows on tree barks),
  - Follicolous (grows on leaves surfaces),
  - Saxicolous (grows on rock surfaces),
  - Terricolous (grows on soil)
  - Musicolous (grows on mosses)
- Mycobiont (Ascomycete or Basidiomycete) establishes an intimate symbiotic relationship with phycobiont (green algae or blue green algae).
- After association, both phycobiont and mycobiont lose their uniqueness and they are known as lichens. Now the lichens act as a single organism, both morphologically and physiologically.
- 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.

- 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* (disc shaped) 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.
- Basidiospores are produced in Basidiolichen, generally look like bracket fungi and basidiospores are produced towards the lower side of the fruit body.

Habit and Habitat of Lichens

- 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.

CLASSIFICATION OF LICHENS

- 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.
  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.
- They are either wholly or partially embedded in the substratum, e.g., *Graphis, Lecanora, Ochrolechia, Strigula, Rhizocarpon, Verrucaria, Lecidia* etc.

3. Foliose:

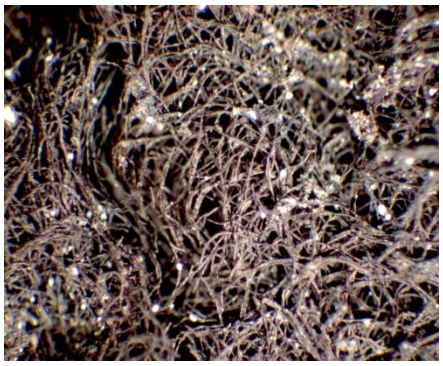
- These are leaf-like lichens, where thallus is flat, horizontally spreading and with lobes.
- Some parts of the thallus are attached with the substratum by means of hyphal outgrowth, the **rhizines**, developed from the lower surface.
- e.g., *Parmelia, Physcia, Peltigera, Anaptychia, Hypogymnia, Xanthoria, Gyrophora, Collema, Chauduria* etc.

4. Fruticose (Frutex, Shrub):

- These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub like, 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 uniformily 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
  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
  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 sub-stratum which help in anchorage, known as **rhizines.**

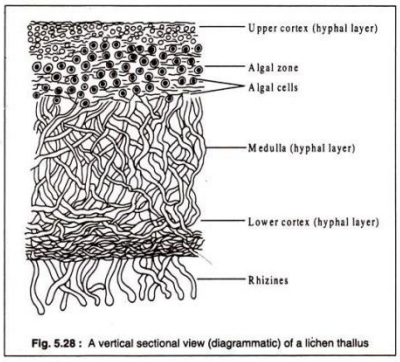


Fig. 5.28 : A vertical sectional view (diagrammatic) of a lichen thallus

- 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).

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**.

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**.
- Sometimes the pits that formed without any definite border are called Pseudocyphellae. Both the structures **help in aeration**.

3. Cephalodium:

- These are small warty out-growths on the upper surface of the thallus.
- 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.

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

- These are small grayish white, bud-like outgrowths developed on the upper cortex of the thallus.
- They are com-posed 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 . e.g., Parmelia Physcia etc.

2. Isidium

- These are small stalked simple or branched, grayish-black, coral-like outgrowths, developed on the upper surface of the thallus.
- The isidium has an outer corti-cal 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 con-dition 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.
- 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 Basidio-mycotina members.

- In Ascolichen, the female sex organ is the **carpogonium** and the male sex organ is called **spermogonium** (pycnidium).
- The spermogonium mostly develops close to carpogonium.
- The carpogonium is multicellular and is differentiated into basal coiled **ascogonium** and upper elongated multicellular **trichogyne**.
- The ascogonium remains embedded in the algal zone, but the trichogyne projects out beyond the upper cortex.

- The spermogonium is flask-shaped and develop spermatia from the inner layer.
- 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 com-mon wall, the nucleus of spermatium migrates into the carpogonium and fuses with the egg.
- 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** 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 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**.

- Usually the asci contain eight ascospores, 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 multi-nucleate, 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 con-tact with proper algal partner, develops into a new thallus.

- In **Basidiolichen**, 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 and differ-entiates internally into upper cortex, algal layer, medulla and lower fertile region with basidium bearing basidiospores.

ECONOMIC IMPORTANCE OF LICHENS:

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 choco-lates 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 pulmonaria* 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, *Usnea florida, 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 extrac-ted 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 prepara-tion 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 destruc-tion 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:

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 *Crtm Mia 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 avai-lable lichens in Tundra region.
- ✶ The fallout of radioactive strontium (90Sr) and caesium (137CS) from the atomic research centres are absorbed by lichen.
- ✶ Thus, lichen can purify the atmosphere from radioactive substances.

3. Sensitivity to Air Pollutants:

- ✶ Lichens are very much sensitive to air pollutants like SO2, CO, CO2 etc.; 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 mar-kedly absent in cities and industrial areas. Thus, "lichens are used as **"pollution indicators"**