Lichenology:

Unit – V

Lichens: Introduction, types, Occurrence, distribution, classification, external and internal structural organization, types of reproduction. Biological significances of Lichens. Economic importance of Lichens.

Lichen

INTRODUCTION , TYPES, AND OCCURANCE

A lichen is a composite organism that arises from algae or cyanobacteria living among filaments of multiple fungi species in a mutualistic relationship. Lichens have properties different from those of
their component organisms. Lichens come in many colors, sizes, and forms and are sometimes plant- like, but lichens are not plants. Lichens may have tiny, leafless branches (fruticose), flat leaf-like structures (foliose), flakes that lie on the surface like peeling paint (crustose), a powder-like appearance (leprose), or other growth forms.

A macrolichen is a lichen that is either bush-like or leafy; all other lichens are termed microlichens. Here, "macro" and "micro" do not refer to size, but to the growth form. Common names for lichens may contain the word moss (e.g., "reindeer moss", "Iceland moss"), and lichens may superficially look like and grow with mosses, but lichens are not related to mosses or any plant. Lichens do not have roots that absorb water and nutrients as plants do, but like plants, they produce their own nutrition by photosynthesis. When they grow on plants, they do not live as parasites, but instead use the plant's surface as a substrate.

Lichens occur from sea level to high alpine elevations, in many environmental conditions, and can grow on almost any surface. Lichens are abundant growing on bark, leaves, mosses, on other lichens, and hanging from branches "living on thin air" (epiphytes) in rain forests and in temperate woodland. They grow on rock, walls, gravestones, roofs, exposed soil surfaces, rubber, bones, and in the soil as part of biological soil crusts. Different kinds of lichens have adapted to survive in some of the most extreme environments on Earth: arctic tundra, hot dry deserts, rocky coasts, and toxic slag heaps. They can even live inside solid rock, growing between the grains.

It is estimated that 6–8% of Earth's land surface is covered by lichens.There are about 20,000 known species of lichens. Some lichens have lost the ability to reproduce sexually, yet continue to speciate. Lichens can be seen as being relatively self-contained miniature ecosystems, where the fungi, algae, or cyanobacteria have the potential to engage with other microorganisms in a functioning system that may evolve as an even more complex composite organism. Lichens may be long-lived, with some considered to be among the oldest living things.They are among the first living things to grow on fresh rock exposed after an event such as a landslide. The long life-span and slow and regular growth rate of some lichens can be used to date events (lichenometry).

Lichens grow in a wide range of shapes and forms (morphologies). The shape of a lichen is usually determined by the organization of the fungal filaments. The nonreproductive tissues, or vegetative body parts, are called the thallus. Lichens are grouped by thallus type, since the thallus is usually the most visually prominent part of the lichen. Thallus growth forms

typically correspond to a few basic internal structure types. Common names for lichens often come from a growth form or color that is typical of a lichen genus.

TYPES OF LICHENS

Common groupings of lichen thallus growth forms are

fruticose– growing like a tuft or multiple-branched leafless mini-shrub, upright or hanging down, 3- dimensional branches with nearly round cross section (terete) or flattened

foliose – growing in 2-dimensional, flat, leaf-like lobes

crustose– crust-like, adhering tightly to a surface (substrate) like a thick coat

of paint squamulose – formed of small leaf-like scales crustose below but free

at the tips leprose – powdery

gelatinous – jelly-like

filamentous – stringy or like matted

hair byssoid – wispy, like teased

wool

There are variations in growth types in a single lichen species, grey areas between the growth type descriptions, and overlapping between growth types, so some authors might describe lichens using different growth type descriptions.

When a crustose lichen gets old, the center may start to crack up like old-dried paint, old-broken asphalt paving, or like the polygonal "islands" of cracked-up mud in a dried lakebed. This is called being rimose or areolate, and the "island" pieces separated by the cracks are called areolas. The areolas appear separated, but are (or were)[citation needed] connected by an underlying "prothallus" or "hypothallus". When a crustose lichen grows from a center and appears to radiate out, it is called crustose placodioid. When the edges of the areolas lift up from the substrate, it is called squamulose.

These growth form groups are not precisely defined. Foliose lichens may sometimes branch and appear to be fruticose. Fruticose lichens may have flattened branching parts and appear leafy. Squamulose lichens may appear where the edges lift up. Gelatinous lichens may appear leafy when dry.

Structures involved in reproduction often appear as discs, bumps, or squiggly lines on the surface of the thallus. The thallus is not always the part of the lichen that is most visually noticeable. Some lichens can grow inside solid rock between the grains (endolithic lichens), with only the sexual fruiting part visible growing outside the rock. These may be dramatic in color or appearance.Forms of these sexual parts are not in the above growth form categories.The most visually noticeable reproductive parts are often circular, raised, plate-like or disc-like outgrowths, with crinkly edges.

Color

Lichens come in many colors. Coloration is usually determined by the photosynthetic component.Special pigments, such as yellow usnic acid, give lichens a variety of colors, including reds, oranges, yellows, and browns, especially in exposed, dry habitats. In the absence of special pigments, lichens are usually bright green to olive gray when wet, gray or grayish-green to brown when dry. This is because moisture causes the surface skin (cortex) to become more transparent, exposing the green photobiont layer. Different colored lichens covering large areas of exposed rock surfaces, or lichens covering or hanging from bark can be a spectacular display when the patches of diverse colors "come to life" or "glow" in brilliant displays following rain.

Different colored lichens may inhabit different adjacent sections of a rock face, depending on the angle of exposure to light. Colonies of lichens may be spectacular in appearance, dominating much of the surface of the visual landscape in forests and natural places, such as the vertical "paint" covering the vast rock faces of Yosemite National Park. Color is used in identification. The color of a lichen changes depending on whether the lichen is wet or dry. Color descriptions used for identification are based on the color that shows when the lichen is dry. Dry lichens with a cyanobacterium as the photosynthetic partner tend to be dark grey, brown, or black.

The underside of the leaf-like lobes of foliose lichens is a different color from the top side (dorsiventral), often brown or black, sometimes white. A fruticose lichen may have flattened "branches", appearing similar to a foliose lichen, but the underside of a leaf-like structure on a fruticose lichen is the same color as the top side. The leaf-like lobes of a foliose lichen may branch, giving the appearance of a fruticose lichen, but the underside will be a different color from the top side.

Internal structure and growth forms

A lichen consists of a simple photosynthesizing organism, usually a green alga or cyanobacterium, surrounded by filaments of a fungus. Generally, most of a lichen's bulk is made of interwoven fungal filaments, although in filamentous and gelatinous lichens this is not the case. The fungus is called a mycobiont. The photosynthesizing organism is called a photobiont. Algal photobionts are called phycobionts. Cyanobacteria photobionts are called cyanobionts.

The part of a lichen that is not involved in reproduction, the "body" or "vegetative tissue" of a lichen, is called the thallus. The thallus form is very different from any form where the fungus or alga are growing separately. The thallus is made up of filaments of the fungus called hyphae. The filaments grow by branching then rejoining to create a mesh, which is called being "anastomose". The mesh of fungal filaments may be dense or loose.

Generally, the fungal mesh surrounds the algal or cyanobacterial cells, often enclosing them within complex fungal tissues that are unique to lichen associations. The thallus may or may not have a protective "skin" of densely packed fungal filaments, often containing a second fungal species, which is called a cortex. Fruticose lichens have one cortex layer wrapping around the "branches". Foliose lichens have an upper cortex on the top side of the "leaf", and a separate lower cortex on the bottom side. Crustose and squamulose lichens have only an upper cortex, with the "inside" of the lichen in direct contact with the surface they grow on (the substrate). Even if the edges peel up from the substrate and appear flat and leaf-like, they lack a lower cortex, unlike foliose lichens.
Filamentous, byssoid, leprose, gelatinous, and other lichens do not have a cortex, which is called being ecorticate.

cross section of foliose lichen

a) The cortex is the outer layer of tightly woven fungus filaments (hyphae)

b) This photobiont layer has photosynthesizing green algae

c) Loosely packed hyphae in the medulla

d) A tightly woven lower cortex

e) Anchoring hyphae called rhizines where the fungus attaches to the substrate

Fruticose, foliose, crustose, and squamulose lichens generally have up to three different types of tissue, differentiated by having different densities of fungal filaments. The top layer, where the lichen contacts the environment, is called a cortex. The cortex is made of densely tightly woven, packed, and glued together (agglutinated) fungal filaments. The dense packing makes the cortex act like a protective "skin", keeping other organisms out, and reducing the intensity of sunlight on the layers below. The cortex layer can be up to several hundred micrometers (μm) in thickness (less than a millimeter).The cortex may be further topped by an epicortex of secretions, not cells, 0.6–1 μm thick in some lichens. This secretion layer may or may not have pores.

Below the cortex layer is a layer called the photobiontic layer or symbiont layer. The symbiont layer has less densely packed fungal filaments, with the photosynthetic partner embedded in them.The less dense packing allows air circulation during photosynthesis, similar to the anatomy of a leaf. Each cell or group of cells of the photobiont is usually individually wrapped by hyphae, and in some cases penetrated by a haustorium. In crustose and foliose lichens, algae in the photobiontic layer are diffuse among the fungal filaments, decreasing in gradation into the layer below. In fruticose lichens, the photobiontic layer is sharply distinct from the layer below.

The layer beneath the symbiont layer called is called the medulla. The medulla is less densely packed with fungal filaments than the layers above. In foliose lichens, there is usually, as in Peltigera, another densely packed layer of fungal filaments called the lower cortex. Root-like fungal structures called rhizines (usually) grow from the lower cortex to attach or anchor the lichen to the substrate. Fruticose lichens have a single cortex wrapping all the way around the "stems" and "branches".The medulla is the lowest layer, and may form a cottony white inner core for the branchlike thallus, or it may be hollow. Crustose and squamulose lichens lack a lower cortex, and the medulla is in direct contact with the substrate that the lichen grows on.

In crustose areolate lichens, the edges of the areolas peel up from the substrate and appear leafy. In squamulose lichens the part of the lichen thallus that is not attached to the substrate may also appear leafy. But these leafy parts lack a lower cortex, which distinguishes crustose and squamulose lichens from foliose lichens. Conversely, foliose lichens may appear flattened against the substrate like a crustose lichen, but most of the leaf-like lobes can be lifted up from the substrate because it is separated from it by a tightly packed lower cortex.

A lichen is a composite organism that emerges from algae or cyanobacteria living among the filaments (hyphae) of the fungi in a mutually beneficial symbiotic relationship. The fungi benefit from the carbohydrates produced by the algae or cyanobacteria via photosynthesis. The algae or cyanobacteria benefit by being protected from the environment by the filaments of the fungi, which also gather moisture and nutrients from the environment, and (usually) provide an anchor to it.
Although some photosynthetic partners in a lichen can survive outside the lichen, the lichen symbiotic association extends the ecological range of both partners, whereby most descriptions of lichen associations describe them as symbiotic. Both partners gain water and mineral nutrients mainly from the atmosphere, through rain and dust. The fungal partner protects the alga by retaining water, serving as a larger capture area for mineral nutrients and, in some cases, provides minerals obtained from the substrate. If a cyanobacterium is present, as a primary partner or another symbiont in addition to a green alga as in certain tripartite lichens, they can fix atmospheric nitrogen, complementing the activities of the green alga.

REPRODUCTION OF LICHENS

Vegetative reproduction

Xanthoparmelia sp. with dark-colored reproductive structures (disc-like apothecia) at center, surrounded by a pale coloured vegetative thallus.

Many lichens reproduce asexually, either by a piece breaking off and growing on its own (vegetative reproduction) or through the dispersal of diaspores containing a few algal cells surrounded by fungal cells. Because of the relative lack of differentiation in the thallus, the line between diaspore formation and vegetative reproduction is often blurred. Fruticose lichens can easily[citation needed] fragment, and new lichens can grow from the fragment (vegetative reproduction).[citation needed] Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns. Soredia (singular: "soredium") are small groups of algal cells surrounded by fungal filaments that form in structures called soralia, from which the soredia can be dispersed by wind Isidia (singular: "isidium") are branched, spiny, elongated, outgrowths from the thallus that break off for mechanical dispersal. Lichen propagules (diaspores) typically contain cells from both partners, although the fungal components of so-called "fringe species" rely instead on algal cells dispersed by the "core species".

Sexual reproduction

Structures involved in reproduction often appear as discs, bumps, or squiggly lines on the surface of the thallus. Though it has been argued that sexual reproduction in photobiont is selected against, there are strong evidence that suggest meiotic activities (sexual reproduction) in Trebouxia. Many lichen fungi reproduce sexually like other fungi, producing spores formed by meiosis and fusion of gametes. Following dispersal, such fungal spores must meet with a compatible algal partner before a functional lichen can form. Some lichen fungi belong to Basidiomycetes (basidiolichens) and produce mushroom-like reproductive structures resembling those of their nonlichenized relatives.

Most lichen fungi belong to Ascomycetes (ascolichens). Among the ascolichens, spores are produced in spore-producing structures called ascomata. The most common types of ascomata are the apothecium (plural: apothecia) and perithecium (plural: perithecia). Apothecia are usually cups or plate-like discs located on the top surface of the lichen thallus. When apothecia are shaped like squiggly line segments instead of like discs, they are called lirellae. Perithecia are shaped like flasks that are immersed in the lichen thallus tissue, which has a small hole for the spores to escape the flask, and appear like black dots on the lichen surface.

The three most common spore body types are raised discs called apothecia (singular: apothecium), bottle-like cups with a small hole at the top called perithecia (singular: perithecium), and pycnidia (singular: pycnidium), shaped like perithecia but without asci (an ascus is the structure that contains and releases the sexual spores in fungi of the Ascomycota).

The apothecium has a layer of exposed spore-producing cells called asci (singular: ascus), and is usually a different color from the thallus tissue. When the apothecium has an outer margin, the margin is called the exciple. When the exciple has a color similar to colored thallus tissue the apothecium or lichen is called lecanorine, meaning similar to members of the genus Lecanora. When the exciple is blackened like carbon it is called lecideine meaning similar to members of the genus Lecidea. When the margin is pale or colorless it is called biatorine.

Most lichens produce abundant sexual structures. Many species appear to disperse only by sexual spores. For example, the crustose lichens Graphis scripta and Ochrolechia parella produce no symbiotic vegetative propagules. Instead, the lichen-forming fungi of these species reproduce sexually by self-fertilization (i.e. they are homothallic). This breeding system may enable successful reproduction in harsh environments.

Taxonomy and classification

Lichens are classified by the fungal component. Lichen species are given the same scientific name (binomial name) as the fungus species in the lichen. Lichens are being integrated into the classification schemes for fungi. The alga bears its own scientific name, which bears no relationship to that of the lichen or fungus. There are about 13,500–17,000 identified lichen species. Nearly 20% of known fungal species are associated with lichens.

"Lichenized fungus" may refer to the entire lichen, or to just the fungus. This may cause confusion without context. A particular fungus species may form lichens with different algae species, giving rise to what appear to be different lichen species, but which are still classified (as of 2014) as the same lichen species.

Formerly, some lichen taxonomists placed lichens in their own division, the Mycophycophyta, but this practice is no longer accepted because the components belong to separate lineages. Neither the ascolichens nor the basidiolichens form monophyletic lineages in their respective fungal phyla, but they do form several major solely or primarily lichen-forming groups within each phylum. Even more unusual than basidiolichens is the fungus Geosiphon pyriforme, a member of the Glomeromycota that is unique in that it encloses a cyanobacterial symbiont inside its cells. Geosiphon is not usually considered to be a lichen, and its peculiar symbiosis was not recognized for many years. The genus is more closely allied to endomycorrhizal genera. Fungi from Verrucariales also form marine lichens with the brown algae Petroderma maculiforme, and have a symbiotic relationship with seaweed like (rockweed) and Blidingia minima, where the algae are the dominant components. The fungi is thought to help the rockweeds to resist desiccation when exposed to air In addition, lichens can also use yellow-green algae (Heterococcus) as their symbiotic partner.

The fungal component of a lichen is called the mycobiont. The mycobiont may be an Ascomycete or Basidiomycete. The associated lichens are called either ascolichens or basidiolichens, respectively. Living as a symbiont in a lichen appears to be a successful way for a fungus to derive essential nutrients, since about 20% of all fungal species have acquired this mode of life.

Thalli produced by a given fungal symbiont with its differing partners may be similar,[citation needed] and the secondary metabolites identical,[citation needed] indicating[citation needed] that the fungus has the dominant role in determining the morphology of the lichen. But the same mycobiont with different photobionts may also produce very different growth forms.Lichens are known in which there is one fungus associated with two or even three algal species. Two or more fungal species can interact to form the same lichen

Classification of Lichens

Many scientists classify the lichens on the basis of

(i) The nature of the fungal element, and

(ii) The kind of the fructification.

On this basis, the lichens are divided into the following two groups

1. Ascolichens in which the fungal component is an Ascomycete.

The Ascolichens are subdivided into two sub-groups

(a) Gymnocarpeae in which the ascocarp is of an apothecium type.

(b) Pyrenocarpeae in which the ascocarp is perithecium type.

G.L.Chopra (1934) in his monograph on the “Lichens of Darjeeling and the Sikkim. Himalayas” described 80 species belonging to 38 genera of Ascolichens. The list includes one new species, three new varieties and a new genus Chaudhuria, with one species C. indica.

2. Basidiolichens

In this group are placed the Lichens in which the fungal partner is a Basidiomycete.

The branch of Botany which is concerned with the study of lichens is called Lichenology. A scientist who has specialized in the study of lichens is called a Lithenologist.

Basidiolichens and Lichens

Features of Lichens

1. The Lichens are dual or composite organism.

2. The thallus-like plant body is made up of a Fungus and an Alga living in closest association. The nature of association between the two partners is the best example of symbiosis in the plant kingdom.

3. Fungus provides the body of the organism whereas Alga synthesizes carbohydrate food for itself and the Fungus.

4. The Lichen thalli are generally of three kinds, crustose, foliose and fruticose.

5. Internally the thallus particularly in the foliose lichens consists of four regions namely, the upper cortex, the algal layer, the medulla and the lower cortex.

6. Asexual reproduction by asexual spores and sexual reproduction are entirely the functions of the fungal partner.

7. The carpogonium is a coiled, multicellular filament.

8. It consists of a coiled, multicellular ascogonium and a straight, multicellular trichogyne.

9. There is a pore in the centre of each septum between the cells of the trichogyne.

10. The antheridia which are flask-shaped receptacles are sunk in the upper surface of the thallus.

11. Male cells or spermatia are non-motile. Each has a cell wall around it.

12. The ascus fruit in many species is of apothecium type and in others of perithecium type.

13. The contents of each ascus are fashioned into eight haploid ascospores. The ascospores may be simple or septate.

14. Each ascospore under suitable conditions germinates to produce a fungal hyphae which if it comes in contact with a proper alga, develops into a new lichen. If the fungal hypha fails to find an appropriate alga, it perishes.

Nature of the Association (Physiology)

Two different hypotheses have been put forth to explain the nature of the association in this plant complex. According to one hypothesis, the alga is considered a mere victim of the fungus. In other words, the fungus lives as a parasite on the algal partner.The parasitism, of course, is of a mild nature as it permits most of the algal cells to live. In addition the fungal hyphae, which form the body of the lichen, provide shelter to the alga. They thus protect it from intense light, drought, and other adverse weather conditions. The duty of alga is to synthesize the necessary carbohydrates with the help of its green chloroplasts and in the case of cyanophycophilous lichens, nitrogen as well. This it does both for itself and also for the fungus. The alga, therefore, provides food to the fungus. In the course of providing food to the fungal partner, a few of the algal cells may be exhausted. They may perish. The bulk of them, however, live. They grow and multiply within the thallus.

Habitat of Lichens

The lichens grow in a wide variety of habitats. They are commonly found growing on the walls and roofs of houses, leaves, tree bark, bare earth and even barren, unpromising rocky surfaces.
Generally they are xerophytic in nature and thus can withstand long periods of drought. Consequently, they thrive and multiply in habitats where other vegetation is non-existent such as sand dunes, deserts and bare rocks. Here they live happily under conditions of drought and apparent starvation. Usually they are attached firmly to the substratum. However, they derive little of their inorganic requirements from the substratum. Rather they depend on the rain or spray. They absorb, whatever substances they require through the whole surface of the thallus from those dissolved in the rain water. Many species are able to withstand low temperature. They are abundant on high mountain elevations, and grow in extremely cold regions such as the arctic tundras where conditions are unfavourable for the growth of other plants.

Many lichens grow in the tropics and subtropics. These mesophytic lichen species grow in the abundance of moisture. Some aquatic species occur only on the sea shore. According to their habitat, Lichenologists divide the lichens into three categories, saxicolous, corticolous and terricolous. The saxicoles are predominantly stone or rock lovers. They grow on firm substratum in cold regions. The corticoles are generally bark lovers. They are mostly confined to the tropics and subtropics where there is abundance of moisture. Here they grow on the leaves and bark of trees as epiphytes depending on their hosts for anchorage only. The terricolous species are terrestrial and thus inhabit the soil. The factors favouring lichen growth are direct light, moderate or cold temperature, pure atmosphere, firm substratum and sufficient atmospheric moisture. The conditions unsuited for the growth of lichens are scanty precipitation, hot and dry summer. The growth in lichens is very slow.

Distribution of Lichens

Lichens are one of the most widely distributed groups of plants. They are found all over the globe from the Arctic to the Antarctic and all regions in between and in diverse habitats.

The factors which help in their worldwide distribution are

1. Their symbiotic life.

2. Their prolific methods of vegetative propagation and efficient means of dispersal.

3. Resistance to extremes of temperature and moisture which enables them to grow at all places where life can be supported at all.

They are found far north and far south than any other plants of the arctic region. Here they along with mosses comprise the entire vegetation of the place. Far north lie the tundras of Iceland, Lapland, Greenland and Canada and other subarctic regions.

The lichens are also met with at higher altitudes on land surfaces than any other plants. Here they colonize the fresh rocky surfaces. The lichens are equally at home in the equatorial jungles.

In India they are very common all over the Himalayas particularly the Eastern side. They are also found in the higher hills of Peninsular India.

Ecological Importance of Lichens

The lichens are of considerable ecological importance. They are slow but efficient soil farmers. They are the pioneer plants to grow on barren, naked, rocky surfaces where no other plants can grow.
Crustaceous forms are usually the first to appear. They are followed by the foliaceous and eventually the fruticose types. They live there happily for years under conditions of drought and apparent starvation. When there is occasional shower of ram the lichen thalli soak it up like a blotting paper and retain it to support a more active life over long dry spells. Their other requirements are met with by the substances dissolved in rain water which is absorbed through the entire surface of the thallus. The continuous growth of the lichen thalli brings about gradual disintegration of the rocks immediately beneath. The lichen thalli secrete certain organic acids which gradually dissolve and disintegrate the rocks to which they cling. The disintegration is also helped by the stresses and the strains caused by the expansion and the contraction of the gelatinous lichen thalli.

The rock particles together with the decaying and dead lichen thalli form a soil fertile enough for other plants to make appearance. The successors are the mosses. Sooner or later flowering plants begin to grow in this soil.

Importance Of Lichens

Lichens hold a great economic importance and are essential for the environment in several ways. Some species of lichens are regarded with the conversion of rocks into the soil, helps in the formation of soil, improving the quality of the soil and also by enriching the soil required for the
plants' growth. Lichens also plays an important role in the nitrogen cycle by fixing nitrogen from the atmosphere. Lichens serve as an important source of food for humans across the world. The Iceland moss is an important source of food in certain parts of both Northern Europe and American continents. Based on the size of these lichens, Petrologists and Geologists are able to study and find the age and other features of rocks and their surfaces. Since ancient times, these species are well known for their various colouring agents and dyes. They are a good source of natural dyes. The litmus test, pH indicator and other dyes used in laboratories are extracted from different species of lichens.

Lichens also serve as a Biodegradation, by the degradation of polyester, lead, copper, radionuclides and other pollutants, polluting the planet earth.

Apart from the pharmaceutical industries, lichens are widely used by various cosmetic industries and are also a natural medicine for various types of skin diseases and rashes. Some species of lichens are used for degradation of pathogens and other environmental reservoirs, which causes certain dreadful infectious diseases both in plants, animals and also in humans.

They are also a great source of food for many aquatic organisms and are widely used as anti- infective agents in pharmaceutical industries to produce antibiotics, anti-mycobacterial, antiviral, anti-inflammatory products.

Crustose lichen

Fruticose lichen

Foliose Lichen