UNIT 12 LICHENS

Structure

12.1 INTRODUCTION

In this last unit of this block you will study about lichens (pronounced as "lai-ken"), the organisms which are somewhat unusual in structure. They are composed of completely two different organisms – green algae or cyanobacteria (blue-green algae) and colourless fungal hyphae. The unique feature of fungi in lichens is the ability to form lichen thallus which they are incapable of individually. This group of organisms has a distinct morphology and a special character. They are found in all habitats including inhospitable tropical deserts, polar regions and even on the surface of granite boulders. In such regions they represent pioneer and dominant vegetation and are among the oldest living things on earth.

In the following pages you will study the range of structure, anatomy and reproduction in lichens. We will also discuss the symbiotic relationship between fungal algal partners. Lichens are ecologically very useful. They are used for human consumption and for the production of chemicals. Therefore in the last section we will discuss various uses of lichens.

Objectives

After studying this unit you should be able to:

- describe the structure, distribution and anatomy of lichens,
- discuss the various types of reproduction in lichens,
- discuss the algal-fungal partnership in lichens,
- elaborate the role of lichens as pioneers of vegetation, and
- list the various uses of lichens.

12.2 RANGE OF STRUCTURE IN LICHENS

12.2.1 Lichens As Individual Organisms

Lichens represent symbiotic association of a fungal partner with an alga. Although the fungal component – **mycobiont** and the algal component – **phycobiont** can be grown separately lichen thallus develops only when they are together. As individual organisms, lichens show unique morphological and biochemical characters.

Now the term photobiont is used instead of phycobiont for the algal partner as the blue-green algae are in fact prokaryotic bacteria (cyanobacteria).

The mycobiont unlike the phycobiont is unique for each species of lichen. Nearly 98 per cent of lichen fungi are ascomycetes, the rest may have a basidiomycetes or deuteromycetes. The morphology of a lichen is believed to be determined by the fungal partner. Accordingly we have ascolichens, basidiolichens and deuterolichens.

The phycobiont is the photosynthetic partner, which is either a blue-green alga or a green alga.

There are nearly 37 algal genera found in lichens. The commonest partners are green algae *Trebouxia* (Chlorococcales) and – *Trentepohlia* (Chaetophorales) and the Cyanobacterium *Nostoc*. Sometimes more than two or even three algae may be found in the same lichen. Algae fix carbon dioxide by photosynthesis. The blue green algae in addition fix nitrogen and thus provide nutrition to the mycobiont. Laboratory studies show that the algal component can be grown in cultures without the fungus and it does not seem to depend on the fungal partner except for physical protection. The algal and fungal components of lichens can be separated and cultured in test tubes. Most attempts to recombine them were unsuccessful initially. However, it has been possible to reconstruct about 30 species of lichens successfully in the laboratory (Fig. 12.1).

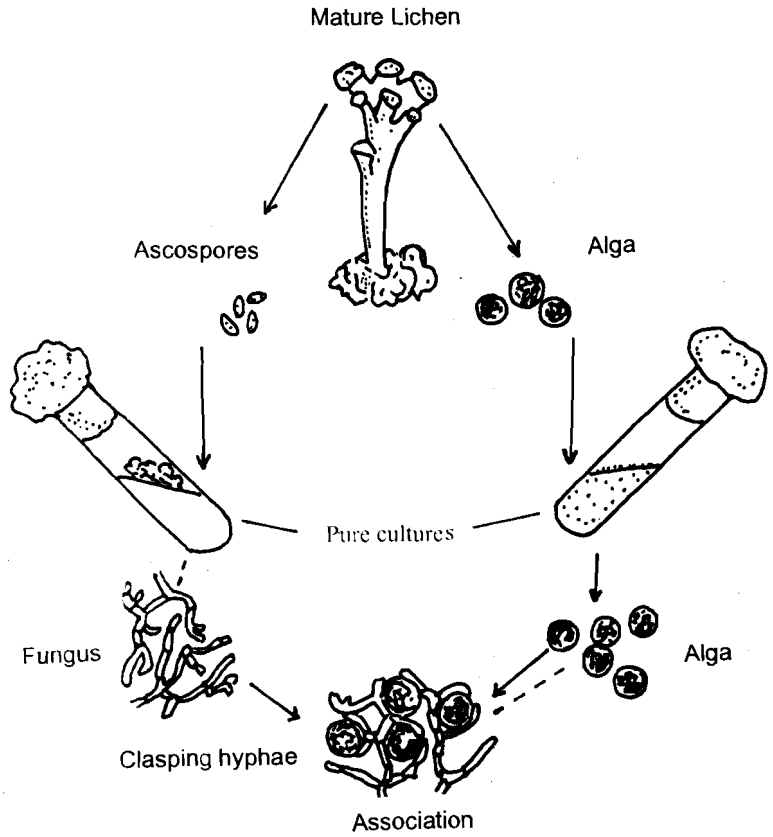

Fig. 12.1: Diagrammatic representation showing separation and culture of lichen components and the reconstruction of lichen from them.

12.2.2 Structure and Anatomy of Lichens

Structure

The plant body in lichen is a thallus that lacks differentiation into stem, roots or leaves. The thalli are generally round in outline between 1 cm to 30 cm in diameter. They may either be scattered or clustered together occupying a large area of substrate. Distinct growth forms and colours can identify the type of lichen.

There are three major morphological forms of lichens.

i) **Crustose** forms like *Graphi*, *Lecidea* and *Haematomma*. Thallus is a crust-like (Fig. 12.2.a) coloured patch growing on bare rocks and tree trunks.
ii) **Foliose** forms genera like *Parmelia, Peltigera, Collema, Parmotrema* and *Gyrophora*. Thallus is leaf-like, flat and dorsiventral with lobed or irregular margins (Fig. 12.2 b). It is loosely attached to the substrate. In cross section it appears differentiated into layers.
iii) **Fruticose** forms like *Usnea*, *Cladonia* and *Ramalina*. Thallus is branched bush-like, shrubby and (Fig. 12.2 c to i) sometimes several metres long hanging from tree branches. It is internally differentiated into layers.

The majority of lichens are of the crustose type.

Besides variable morphology lichens also show striking colours such as grey, yellow, orange, yellowish or bluish green, black or white because of the presence of pigments. .

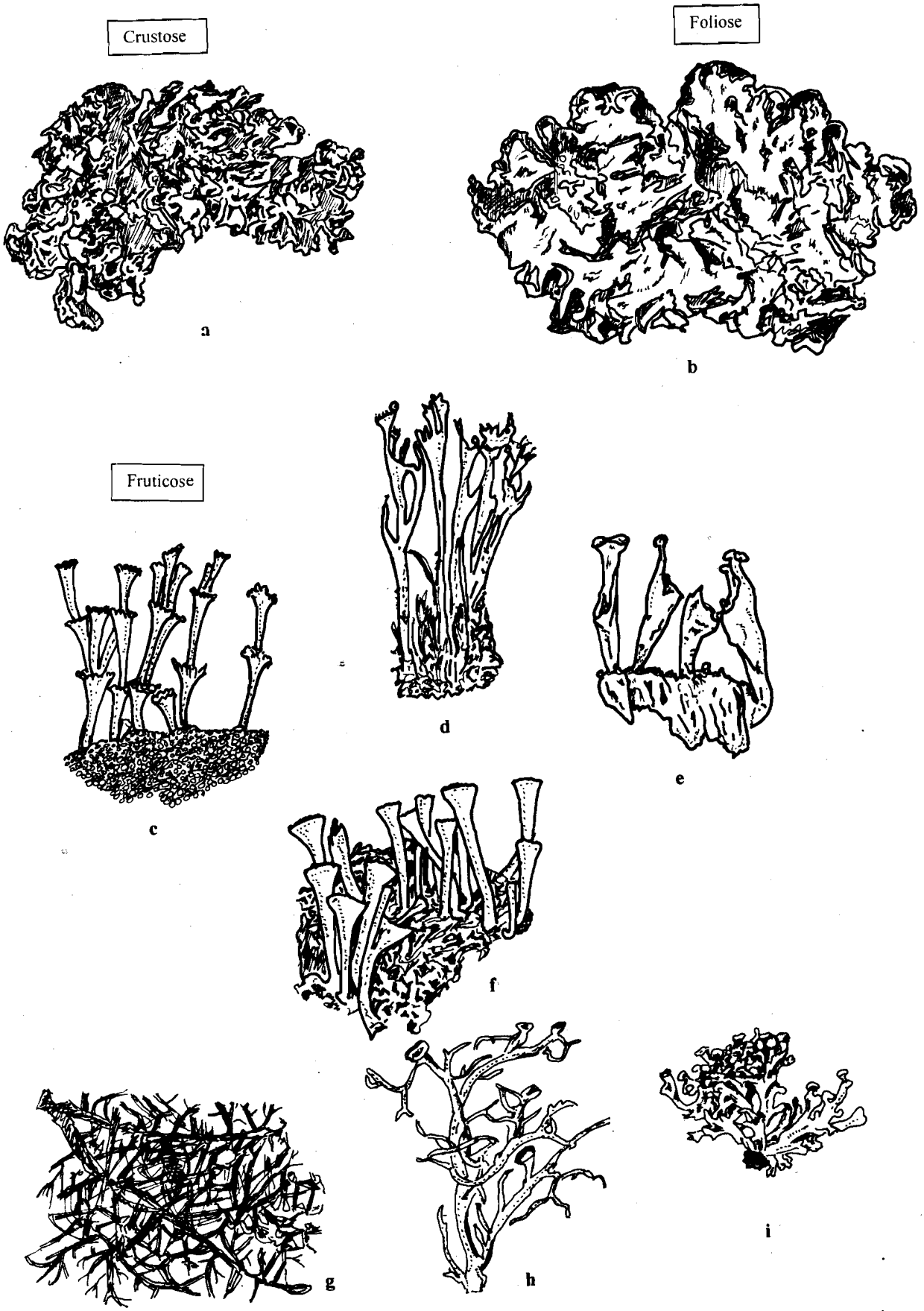

Fig. 12.2: Various morphological forms of lichens: a) crustose form – primary thallus of *Cladonia* sp., b) foliose form – *Parmotrema* sp., c to i) fruticose form – *Cladonia* sp. (i to c), *Usnea sp.* (i to e), *Usnea* sp. (g), *Ramalina* sp. (h and i).

Anatomy

The ability to form thallus is a unique feature of lichen fungi. A vertical section of a foliose lichen when examined under a microscope shows upper and lower **cortex** containing tightly packed fungal hyphae and a central medulla of loose hyphae (Fig. 12.3a). Below the upper cortex are algal cells surrounded by fungal tissue forming a distinct layer. Similar algal layer may also be found on the basal side, above the lower cortex. Rhizoids grow from the lower cortex and attach the thallus to soil, bark or rocks.

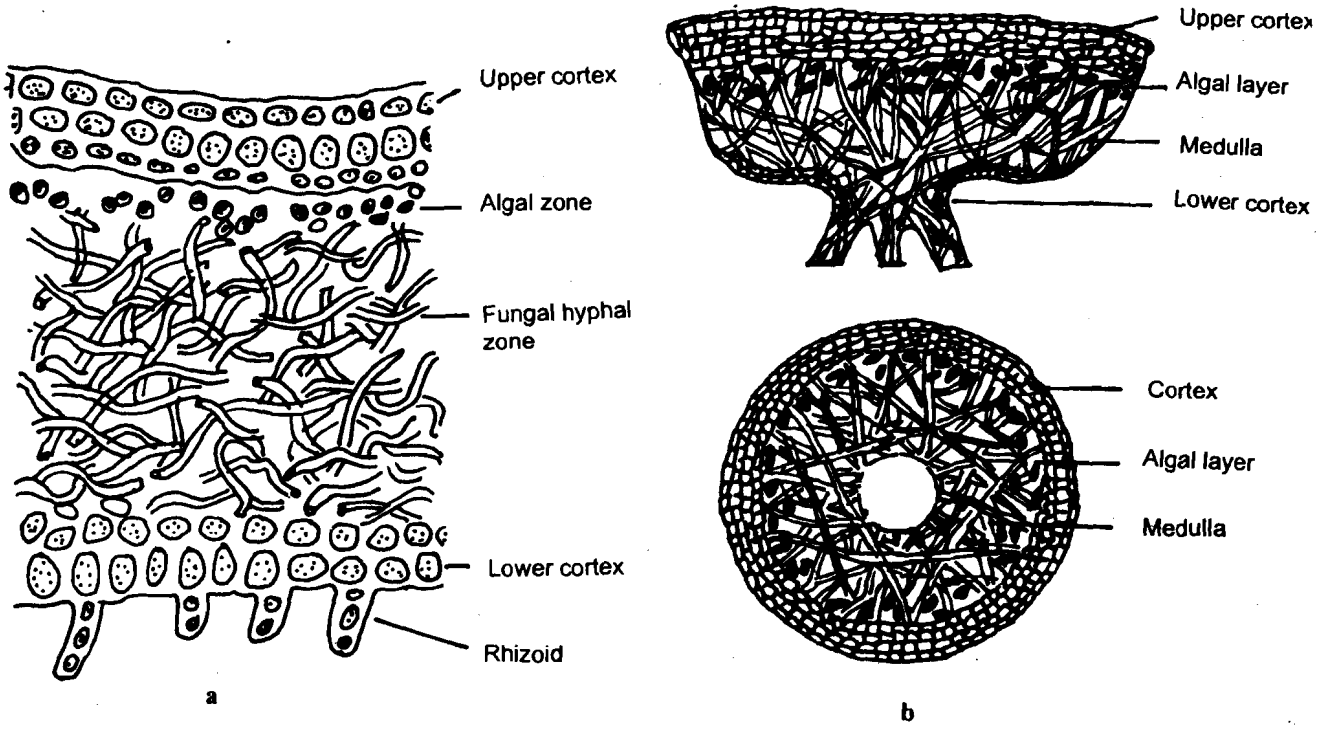

Fig. 12.3: Lichen thalli in cross section, (a) crustose (b) foliose (c) fruticose.

SAQ 12.1

a) In the following statements fill in the blank spaces with appropriate words.

i) The fungal partner in lichen is called ..... and the algal .....

ii) In 98% of the lichen the fungal partners belongs to .....

iii) The algal partner of lichens could be ..... or .....

iv) The upper and lower hyphae of fungal partners in lichen thallus are called ..... and the central loose hyphae are called .....

v) The two most common algae in lichen symbiosis are ..... and .....

vi) The cyanobacteria involved in symbiosis in lichen is ..... .

b) Indicate which of the following statements are true or false. Write **T** for true or **F** for false in the given boxes.

i) The fungal partner of lichen can be grown separately but not the algal partner. ☐

ii) A single lichen may have 2 or 3 algal partners. ☐

iii) Fungal and algal partners can be cultured in the laboratory separately and reconstructed into lichen again. ☐

iv) Lichens are not capable of fixing CO_2. ☐

v) When a lichen has *Nostoc* as an algal partner it can fix CO_2 as well as nitrogen. ☐

12.3 REPRODUCTION IN LICHENS

12.3.1 Vegetative Reproduction

New patches of lichens grow when small pieces of lichen are broken from the main thallus. In addition, a variety of vegetative structures **soredia, cephalodia** and **isidia** arise from the main thallus containing partners, the phycobiont and the mycobiont.

a) **Soredia:** Each soredium consists of algal cells surrounded by fungal hyphae. These can develop into a new thallus (Fig. 12.4 a).
b) **Cephalodia :** These are dark-coloured gall-like outgrowths of the thallus (Fig. 12.4 b).
c) **Isidia:** These are cylindrical finger-like outgrowths on the thallus (Fig. 12.4 c).

Besides the above important structures lichens produce many other specialised bodies for vegetative propagation. It is interesting to note that such structures are absent in the life cycle of the fungal or algal component when grown separately but are produced only when they grow together as lichen.

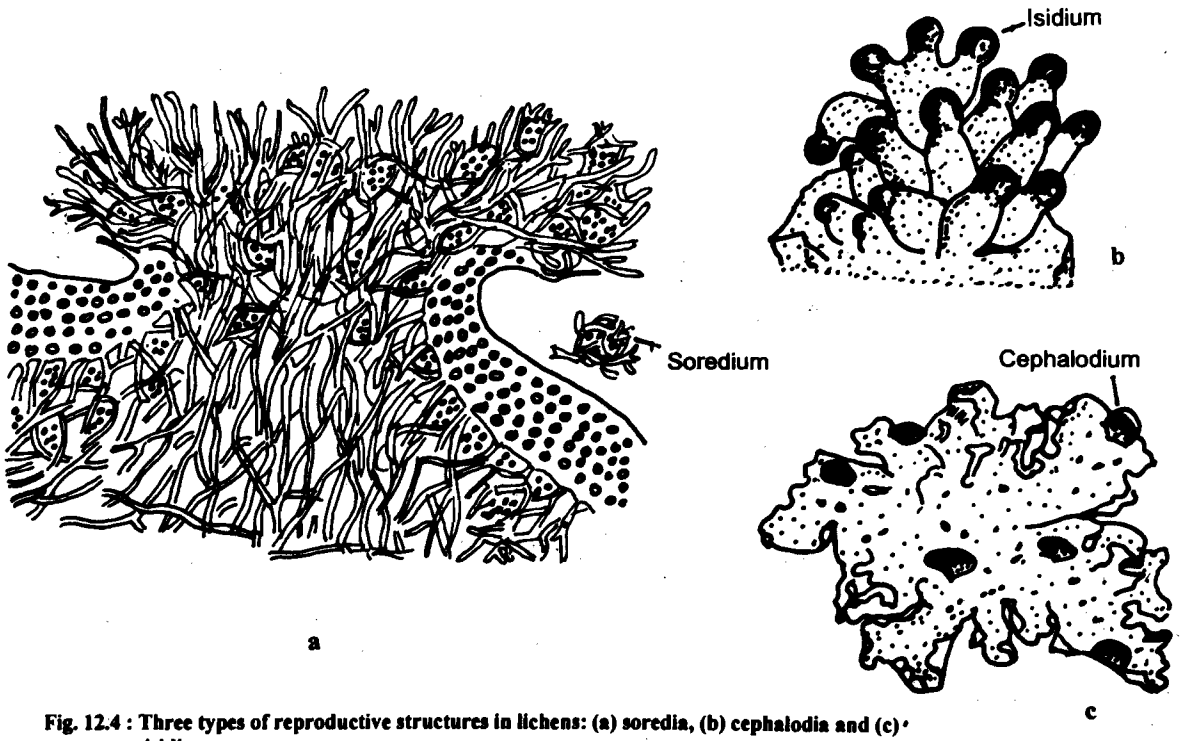

Fig. 12.4 : Three types of reproductive structures in lichens: (a) soredia, (b) cephalodia and (c) isidia.

12.3.2 Asexual Reproduction

Various types of asexual spores, **oidia, pycniospores** and **conidia** are produced like in any fungus and this is the most common method of reproduction.

12.3.3 Sexual Reproduction

Information on this aspect is very limited and is known only in the case of some ascolichens like *Collema*. It is very similar to the sexual process of an ascomycete fungus (recall sexual reproduction in *Neurospora*, ref. to unit 9, section 9.3.3 of this block).

The male sex organs are known as **spermagonia**, which produce small non-motile male cells called **spermatia**.

Reproductive structures in lichens are shown in Fig. 12.5. The female sex organs are called **ascogonia**, which develop from the medulla of the lichen thallus. The ascogonium has terminal long multicellular hair like projection called **trichogyne** and a basal portion which acts as **oogonium**. Fertilisation occurs by the transfer of

spermatium to the tip of trichogyne after which it passes down to the basal portion. A number of ascogenous hyphae (Fig. 12.5 b) are produced which form the ascocarp. The ascocarp is a dish-shaped – **apothecium**. Each **ascus** produces eight **ascospores**. Ascospores germinate and when the hyphae come in contact with suitable algal cells they develop into new lichen thalli.

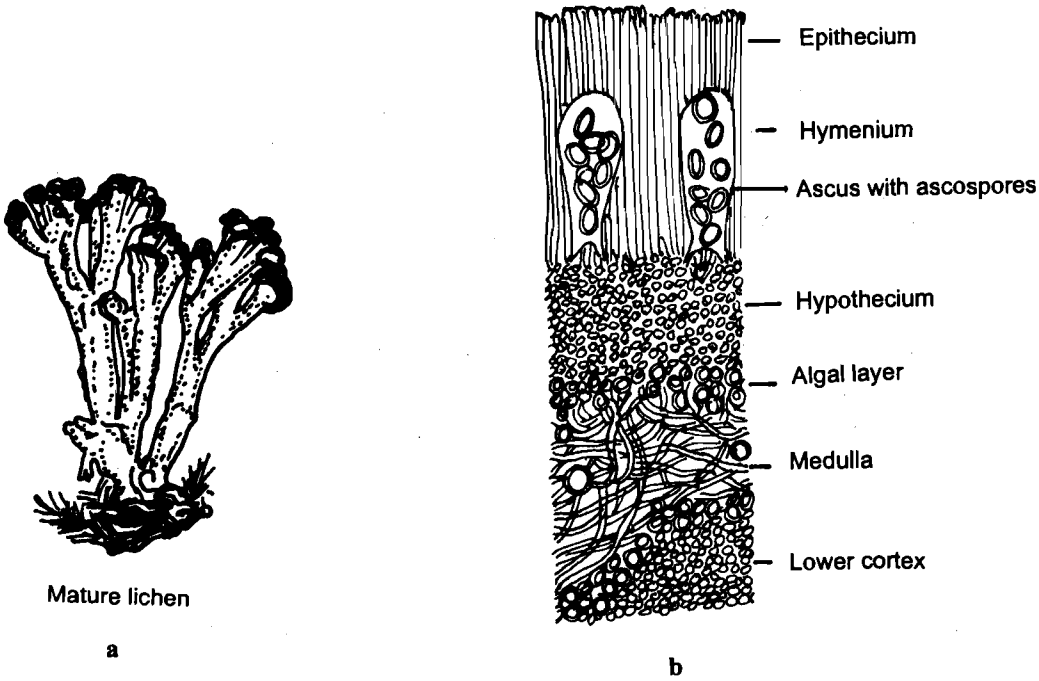

Fig. 12.5: Reproductive structures in lichens: a) apothecia, b) cross section of a typical apothecium.

SAQ 12.2

a) Fill in the blank spaces with appropriate words.
   i) The specialised structures in lichens for vegetative reproduction are ....., ... and ..... .
   ii) The dark-coloured gall-like outgrowths of lichen thallus that can give rise to new thalli are called ..... .
   iii) The cylindrical finger-like outgrowths on the lichen thallus that give rise to new thalli are called ..... .
   iv) The asexual spores produced in lichens may be ..... , ..., or ..... .
   v) The sexual reproduction in ascolichens is similar to ..... .

12.4 LICHEN – A MODEL OF SYMBIOTIC SYSTEM

The nature of fungal algal association in a lichen is considered as symbiosis where both the partners derive equal benefit from each other, also known as mutualism. Though in some lichen it is observed that the algal cells are penetrated by haustoria (as in parasitic fungi) they are not killed or weakened. There seems to be a balance or give and take between the partners.

It has been shown by experiments that nearly 70 to 80 per cent of the total carbon compounds synthesised by the alga (ribitol, mannitol and arabitol) during photosynthesis are passed on to the fungus.

In *Peltigera* where the algal partner is a cyanobacterium (*Nostoc*) which also fixes nitrogen, in addition to carbon compounds, the nitrogen compounds like ammonia are also supplied to the mycobiont. However, it is difficult to say what the alga receives from the fungus in return. Probably the fungal hyphae provide house to the algal cells and protect them from drying, excessive light and other adverse environmental conditions. The loosely interwoven hyphae of the medulla facilitate gas exchange for photosynthesis. However, the opinion about the nature of this association is controversial. Some scientists regard algae as the victims rather than partners imprisoned by the fungal tissue. They consider this association as

'controlled parasitism'. Others believe that it is unique and the finest example of mutualism because of the healthy appearance and long life of algal cells.

12.5 IMPORTANCE OF LICHENS

12.5.1 Ecology of Lichens

Lichens are found growing in many places where other organisms might perish. They are found on bare rocks in tropical, sub-tropical, temperate and freezing polar regions. Some are found to survive on rocks where temperature may reach 50°C.

Most lichens are slow-growing, at the rate of about 1 mm per year but are long-lived. In arctic regions lichen thalli even 4500 years old are found. They have been found on the highest mountains in Himalayas.

On the newly exposed rocks and volcanic regions lichens are the pioneer vegetation as they are the first to inhabit these regions. By their activity they cause the weathering of rocks, build up organic debris, and make the surface suitable for the growth of higher plants. The cyanobacterial lichens contribute nitrogenous compounds also.

Lichens are most abundant in tropical rain forests. Lichens profusely cover tree trunks, branches, and leaves of all plants.

The association between a heterotrophic fungus and a photosynthetic alga is variously termed mutualism or symbiosis. Such an association is highly successful and productive in the ecological sense, and this is reflected in the distribution of lichens in diverse habitats all over the earth.

12.5.2 Lichens as Food

In many inhospitable areas like polar regions, rocks and deserts, the only vegetation available to animals is lichen. *Cladonia rangifera*, known as reindeer moss is widely eaten by arctic animals such as reindeer and caribou. Sheep and land snails browse much on fruticose lichens growing on the soil.

In some countries like the Libyan desert lichen *Lecanora* is collected and eaten by people. In Japan, foliose rock lichen *Umbilcaria* is eaten as salad. In Iceland and Lapland many local lichens are consumed as food.

12.5.3 Lichens as Indicators of Pollution

Lichens can absorb not only water vapour from the atmosphere but also various pollutants including fluoride, ozone, NO_2, PAN and herbicides. They are particularly sensitive to sulfur dioxide and radioactive element strontium and caesium. Nitrogen fixation is most sensitive to SO_2 followed by photosynthesis, and respiration. Consequently, the size of the thallus is reduced, fruiting is suppressed and the colour is also affected. Because of this sensitivity, detailed examination of lichens in an area can determine the degree of atmospheric pollution including radioactive fall-out during nuclear tests.

12.5.4 Other Uses of Lichens

The medicinal value of lichens was recognised in folk medicine long ago and is still being used widely. *Lobaria pulmonaria* is useful for lung diseases, also *Peltigera canina* for hydrophobia.

Many lichen contain antibiotic properties. Usnic acid from *Usnea* is effective against fungi, bacteria and other pathogens of man.

Substances obtained from lichens can also control plant diseases like tomato canker and tobacco mosaic virus.

Before the advent of synthetic dyes, lichens were the source of coloured substances used for dying textiles. *Rocella, Parmelia, Ochrolechia, Evernia* are some of the

lichens used for the extraction of dyes like orchil which can be used to gives shades of red, purple and brown to wool.

Orcein, derived from lichens is used in biological laboratories for staining nucleus in plant and animal cells. Likewise litmus, the acid-base indicator is extracted from the lichen *Rocella*.

Lichens contain various types of essential oils, which are used in the manufacture of perfumes.

SAQ 12.3

a) In the following sentences fill in the blank spaces with appropriate words.
   i) Lichens can survive temperature as high as ..... .
   ii) Lichens are slow-growing. They may grow at the rate of about ..... per year.
   iii) In arctic regions lichen thalli as old as ..... years are found.
   iv) Lichens are sensitive to pollutants like ..... and ..... element ..... and caesium.
   v) The lichen commonly known as moss reindeer eaten by reindeer, caribou and sheep is .....

b) Indicate which of the following statements are true or false with regards to lichens. Write **T** for true or **F** for false in the given boxes and also write the correct statement..
   i) In some lichens when algal cells are penetrated by fungal haustoria they get killed. ☐
   ii) In lichens the algal partner passes carbon compounds to the fungal partner. ☐
   iii) Sexual reproduction in ascolichen is similar to that of ascomycetes fungi. ☐
   iv) The fungal partner provides food and water to the algal partner. ☐
   v) In some lichens *Anabaena* is the algal partner.

12.6 SUMMARY

- In lichens, the heterotrophic non-photosynthetic fungus forms a symbiotic association with green alga or blue-green alga and constitutes a new thallus. The green-thallus thus formed has no resemblance to either fungus or an alga growing separately.
- Lichens can be identified by their striking colours and distinct growth forms. Lichen thallus consists of interwoven hyphae which shelter algal cells and derive nutrition from them. If the fungal partner is a cyanobacterium, it provides nitrogen nutrition in addition to photosynthates..
- Lichens reproduce by special vegetative reproductive structures – soredia, isidia or cephalodia. The asexual spores formed are oidia pycniospores and conidia. In ascolichens sexual reproduction also takes place and it is similar to the fungi belonging to ascomycetes.
- Lichens are ecologically important and pioneer vegetation. They can colonise harsh habitats.
- Lichens are eaten by arctic animals. In some countries they are used as food for humans. Dyes and some other chemicals were formerly extracted from lichens. Lichens are also used for medicinal purposes.
- Lichens are very sensitive to air pollutants and therefore can be used as indicators of pollution for the area where they grow.

12.7 TERMINAL QUESTIONS

1. Write the fungal partners of the following type of lichens
   a) Ascolichen -
   b) Basidiolichen -
   c) Deuterolichens -

2. Give an example of each of the following morphological types of lichen
   1. Crustose -
   2. Foliose -
   3. Fructose -

3. Write the various uses of lichen under the headings listed below.
   Food

   .....

   .....

   Medicine

   .....

   .....

   Dyes

   .....

   .....

4. Explain the role of lichens as pioneers of vegetation.

   .....

   .....

   .....

   .....

5. Name one lichen eaten by human beings.

   .....

12.8 ANSWERS

Self-assessment Questions

12.1a) i) mycobiont, phycobiont/photobiont
ii) ascomycetes
iii) green alga, cyanobacteria
iv) cortex, medulla
v) Trebouxia, Trentepohlia
vi) Nostoc

b) (i) F (ii) T (iii) T (iv) F (v) T

12.2 i) soredia, insidia, cephalodia
ii) cephalodia
iii) isidia
iv) oidia, conidia, pycniospores
v) ascomycetes

12.3a) i) 50°C
ii) 1 mm
iii) 4500
iv) SO_2, PAN, radioactive strontium
v) Cladonia rangiferia

b) i) F
ii) T
iii) T
iv) F
v) F

Terminal Questions

1. The fungal partner would belong to the class
   a) Ascomycetes
   b) Basidiomycetes
   c) Deuteromycetes
2. See section 12.2.2
3. See section 12.5 and list the uses below.
4. When lichen grow on bare rocks and by their activity weathering of rocks takes place. Consequently they build up organic debris which is necessary for the growth of vegetation.
5. *Umbilcaria.*

GLOSSARY

Basidiospore: A haploid spore produced externally on a basidium in basidiomycete fungi, usually after karyogamy and meiosis.

Basidium: An enlarged sexual reproductive cell in basidiomycete fungi in which meiosis occurs, resulting in the formation of basidiospores.

Clamp connection: In basidiomycete fungi, a loop-like structure that connects adjacent hyphal cells and is produced during the formation of new cells by the binucleate hyphae.

Cleistothecium: A spherical ascocarp-type fruting body with no opening in which asci are produced that occurs in some ascomycete fungi.

Dikaryotic hypha: Binucleate filament of fungal cells arising through fusion of plus (+) and minus (–) hyphae without nuclear fusion.

Dikaryotic phase: Phase in the life cycle of some fungi, such as ascomycetes, in which each cell is binucleate as a consequence of the fusion of plus (+) and minus (–) hyphae.

Haustorium: A structure produced by fungal hyphae that penetrates host cells and is adapted for the absorption of water, nutrients, and metabolites from the host cell.

Karyogamy: The fusion of two sex nuclei following the fusion of their protoplasts (plasmogamy).

Karyokinesis: The process of nuclear division that occurs during mitosis.

Perithecium: A flask-shaped fruiting body in which asci are produced in ascomycete fungi.

Pycnidium: A flask-shaped structure in which asexual spores called conidia are formed in some ascomycete fungi and in imperfect fungi.

Scutellum: An appendage of the embryo of a grass, located adjacent to the endosperm in the seed.

Spermagonium: A flask-like structure that bears small, spore-like spermatia (male gametes) in some ascomycetes and rust and smut fungi.

Sterigma: A stalk on the outer surface of a basidium which bears basidiospores in basidiomycete fungi.

Uredospore: One of many binucleate spores produced in a uredosorus-type fruiting body in basidiomycetes known as rusts.

Further Reading

1) Alexopoulos, C.J. and C.W. Minis. 1979, Introductory Mycology, third edition, Wiley Eastern Limited, New Delhi.

2) Ingold, C.T. 1973, The Biology of Fungi, third edition, ELBS low-priced textbook.

3) Vashishta, B.R. 1993, Botany (For Degree Students), Part II Fungi, S. Chand and Company Ltd. New Delhi.