LICHENS

The branch of science that deals with the study of lichen is called **lichenology.** "A lichen may be defined as structurally organised entity consisting of the permanent association of a fungus and an alga". The fungal component of a lichen is called **mycobiont** and the algal component is called **phycobiont.** Both mycobiont and phycobiont are associated in symbiotic union in which, the fungus is the more predominant partner and alga is subordinate partner of lichens.

HISTORICAL :

Theophrastus (371–284 B.C.)	–	For the first time used the term 'lichen' to denote a superficial growth on the tree barks.
Morison (1699)	–	Called such plants as 'Musco-fungus'.
Tournefort (1700)	–	Described lichens as plants with shallow cup like fruits but lacking flowers.
Dillenius (1741)	–	Used the term *Lichenoides* for all the lichen-like plants.
Weber (1780)	–	Included lichens as independent group of cryptogams.
Acharius (1798)	–	A Swedish lichenologist known as father of lichenology, divided Cryptogams into '6 families', one of which was Lichens.
Schwendener (1867)	–	Proposed dual hypothesis, which states lichen-thallus to be composed of two components – algae and fungi.
Stahl (1877)	–	Showed that both algae and fungi were of independent origin.
Crombie (1885)	–	Described the association of algae and fungi as a 'Romance of lichenology'.
Reinke (1872)	–	Described the association of algae and fungi as consortium.
De Bary (1879)	–	Proposed the word symbiosis for association of algae and fungi.

Nature of association of mycobiont and phycobiont in lichens :

The association of fungal partner (mycobiont) and algal partner (phycobiont) in a lichen is regarded as best example of **symbiosis**, where both the partners are beneficial to each other. The fungus protects alga from unfavourable conditions *i.e.*, drought, heat, etc. The alga in return supplies organic food to the fungus through diffusion.

Earlier in 1867, Schwendener regarded this association as **fungi parasitising algae.** His assumption was mainly based on – (i) presence of haustoria or appresoria in fungal hyphae which penetrate the algal cells in some lichens, and (ii) the finding that alga grows independently but fungus failed to grow without algae, when the two components were grown separately. This view of host-parasite relationship was opposed by many lichenologists. Reinke (1872) pointed out that both the constituents lead a long healthy life in a lichen, which is not possible if one component parasitises the other. Crombie (1885) described this association as a Romance of Lichenology, where the mycobiont dominates over the phycobiont. The mycobiont acts as tyrant master which keeps algal damsel in its captive. This type of relationship is a kind of symbiosis, called **helotism** (*i.e.*, master and slave relationship).

However, Reinke (1872) holds the view that the relationship between the fungus and the alga is a kind of **consortium** (*i.e.*, both have mutual growth and interdependence). De Bary (1879) gave the term **symbiosis** for the kind of relationship between the fungus and the alga. That means both the partners mutually benefit each other. The fungus holds water, provides protection and ideal housing to the alga. The alga in return supplies carbohydrate food for the fungus. If the alga is capable of fixing nitrogen (*e.g.*, *Nostoc*), it supplies fixed nitrogen to fungus. This kind of mutual interdependence helps lichens to grow on dry, barren rocks, where the other plants fail to exist. Moreover, the algae or the fungi alone can not grow in such places.

OCCURRENCE AND HABIT :

Lichens are world wide in distribution. They include about 500 genera and 1800 species growing from polar regions to the equator on a very wide variety of habitats. They generally do not grow near smoky industrial areas where atmosphere is polluted by the industrial or the population-smoke. They can tolerate the extreme dessication and grow in the direct sunlight or remain buried in snow for long periods without any injury. The most usual habitats of lichens are tree barks, decaying woods, leaves, branches, undisturbed soil rich in humus, sand, stones and rocks. Lichens which grow on stones are called **saxcoles** and those growing on barks of trees are called **corticoles.** A few species of lichens are aquatic and grow in sea water (*Peltigera*), fresh water, standing and running water. *Cladonia rangiferina* commonly known as 'reindeer-moss' grows luxuriantly in Tundras. In India, they occur in Himalayas and other higher hills of South India at an altitude ranging from 4,000 to 10,000 ft.

Lichens are highly pigmented and have various colours. They may be bluish green, grey, yellow, orange, reddish or brownish in colour. Some lichens (*Gyrophora*) are white and black too. The various colours are usually due to pigmentation in algal partners.

COMPOSITION OF PLANT BODY :

Each lichen plant consists of two components – a fungus (**mycobiont**) and an alga (**phycobiont**).

The mycobiont : The fungal component of lichens either belong to Ascomycotina or Basidiomycotina. In only 4 genera, the fungus belongs to basidiomycotina (*e.g., Cora, Corella, Dictyonema*, etc) whereas in the remain-

lichens the fungus belongs to ascomycotina (*e.g.*, *Parmelia, Graphis, Peltigera*, etc.)

The phycobiont : The algal components of lichens usually belong to –

(i) Cyanophyta	–	8 genera of cyanophyceae *viz.*, *Gloeocapsa, Nostoc, Scytonema, Rivularia*, etc.
(ii) Chlorophyta	–	18 genera of chlorophyceae *viz.*, *Coccomyxa, Myrmeia, Trebouxia, Pleurococcus, Trentipohlia, Cladophora*, etc.
(iii) Xanthophyta	–	One genus
(iv) Phaeophyta	–	One genus

CLASSIFICATION

It has been prescribed by International Code of Botanical Nomenclature that the names of lichen species be given on the basis of their fungal components. Therefore, they are classified accordingly on the basis of their algal components.

Hole (1967) divided lichens into 3 classes –

1. Ascolichens
2. Basidiolichens
3. Lichens imperfecti

Ascolichens :

This class includes all those lichens wherein the fungus belongs to Ascomycotina. They reproduce and form the fructifications similar to Ascomycotina. The group includes a large number(major portion) of lichen species which show all the three forms *i.e.*, crustose, foliose and fruticose. The class is further divided into 5 orders – (i) Pseudosphaeriales. (ii) Hysteriales, (iii) Pyrenulales, (iv) Lecanorales and , (v) Caliciales.

Basidiolichens :

This class includes only 4 genera in which the fungus belongs to Basidiomycotina. The common example of basidiolichen is *Cora*, which grows on trees like a bracket fungus. It remains green under wet conditions but becomes bluish-green when dry. The under surface of lichen thallus bears basidia and basidiospores.

Lichens imperfecti :

This class includes all those lichens wherein the fungus lacks sexual or asexual modes of reproduction. The vegetative plant body of these lichen consists of undifferentiated crustose mat of hyphae enclosing colonies of unicellular symbiotic algae, *e.g.*, *Crocynia, Lepraria*, etc.

EXTERNAL FORMS OF LICHENS (Fig. 38 A–C)

The lichens vary in their size and shape. The smallest lichen measures about 1 mm in diameter. They are classified into 3 different forms on the basis of the type of thalli and mode of their occurrence –

(1) Crustose (or Crustaceous) lichens : These lichens have flattened thalli closely attached to the rocks, soil or tree barks in the form of crusts. The thalli may be partially or completely embedded within the substratum

so that sometimes only fruiting bodies are visible above the surface. Examples : *Graphis, Haematomma, Verrucaria, Lecanora, Rhizocarpon*, etc.

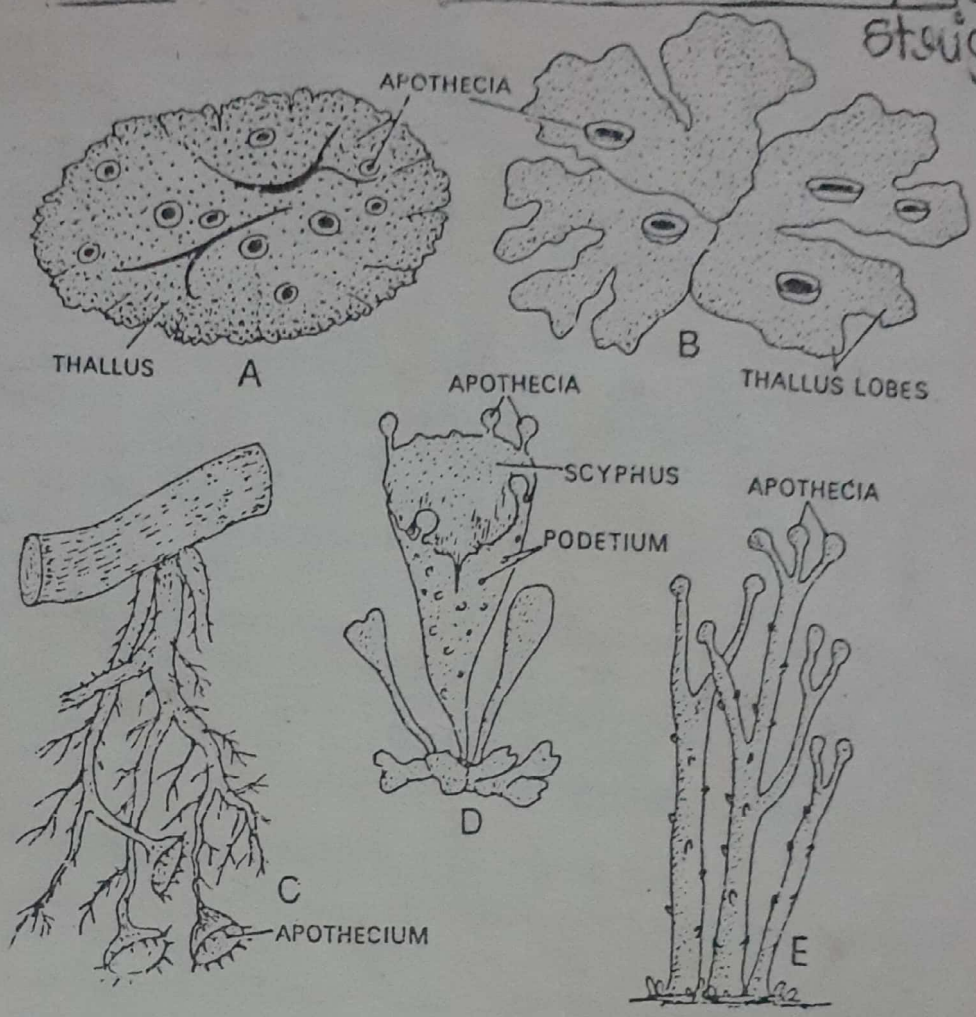

Fig. 38.1 Types of lichen thalli. A. Crustose (*Haematomma puniceum*); B. Foliose (*Parmelia flavicans*); C. Fruticose (*Usnea barbata*); D. Fruticose (*Cladonia*); E. Fruticose (*Cladonia*).

(2) Foliose (or Foliaceous) lichens : These lichens have flat, dorsiventral, expanded, leaf-like appearance of thalli with irregular margins. They look like dried up thalli of liverworts (Bryophytes). The margins of the are free but the remaining portions may be attached to the substratum by means of special rhizoid-like structures, called rhizines. The rhizines are fungal in origin. Examples, *Peltigera, Parmelia, Physcia, Gyrophora, Pellidea* etc.

(3) Fructicose (or Filamentous) lichens : These lichens are flat or cylindrical, much branched and bushy in appearance. They may be erect or pendent, hanging from branches of trees. They are attached to the substratum by means of basal ends. The thallus shows no differentiation of upper and lower surfaces. Examples, *Usnea, Cladonia, Ramalina, Evernia, Alectoria*, etc.

INTERNAL STRUCTURE (Fig. 38.2) :

The internal structure of lichens may be studied by taking their sections. The three different forms of lichens usually show different internal organizations —

(i) Crustose lichen : The internal structure of gelatinous crustose thalli shows no differentiation of layers. The algal cells are scattered irregularly among the fungal hyphae in the gelatinous matrix. Such a structure is called homoiomerous.

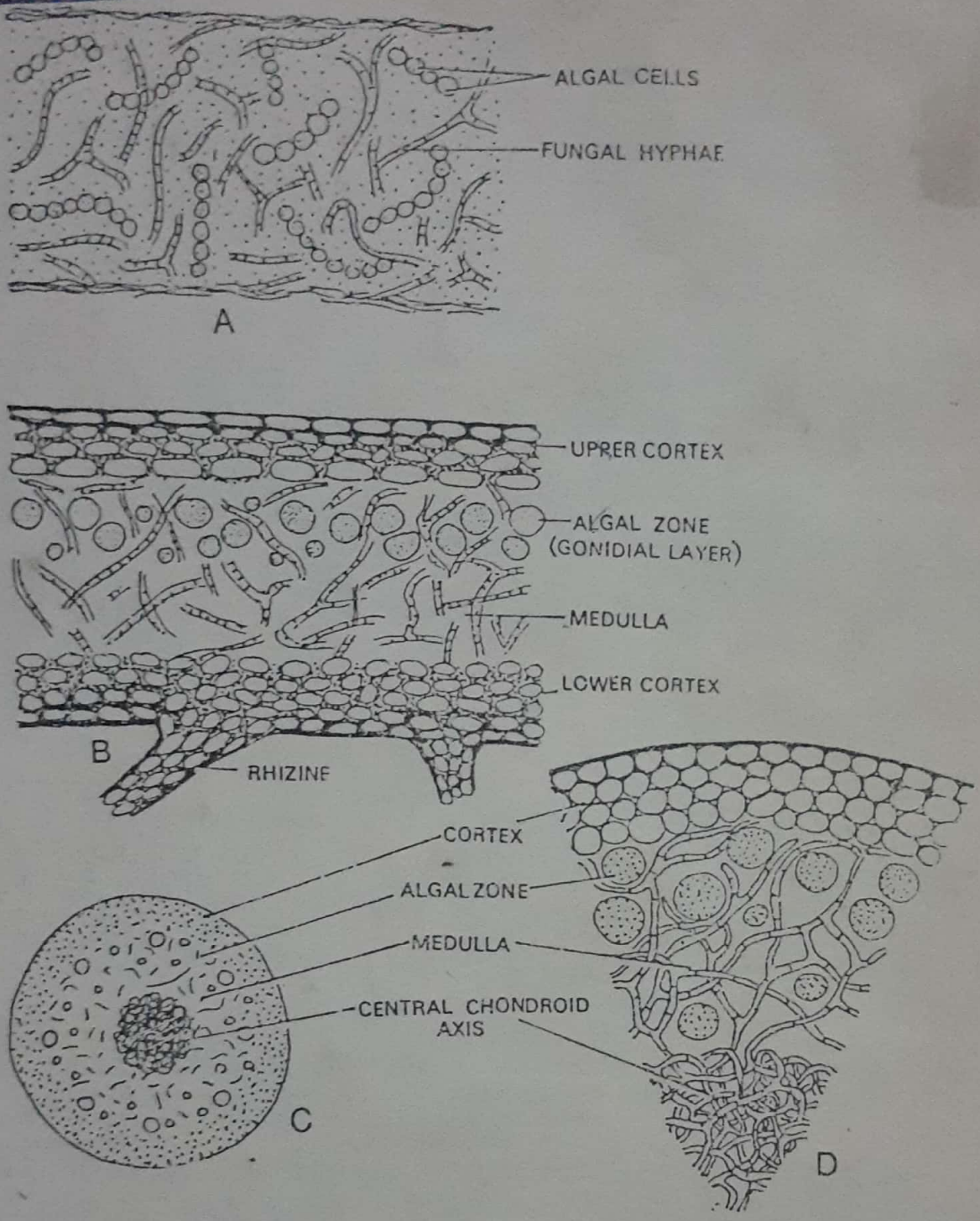

Fig. 2. A. T.S. of a crustose lichen; B. T.S. of a foliose lichen; C. T.S. of a fruticose lichen (diagrammatic); D. A part cellular.

(ii) Foliose lichen : The foliose lichens are usually heteromerous. Sometimes they are homoiomerous (*e.g.*, *Collema*). A vertical section of typical heteromerous foliose lichen (*e.g.*, Parmelia) shows the following 4 distinct regions –

(a) **The upper cortex** – It is the uppermost region of thallus consisting of compactly interwoven fungal hyphae with or without intercellular spaces. The intercellular spaces, if present, are filled with gelatinous material. The

epidermis may or may not be present but sometimes, a felt of thick-walled, septate, branched or unbranched hairs may be present on the upper surface. Sometimes, they develop breathing pores to facilitate gaseous exchange. These pores are called pseudocyphellae.

(b) **The algal layer** – This layer is also called as **gonodial layer** (because of earlier concept to regard this layer consisting of gonidia having reproductive function). It is actually a continuous or discontinuous layer of algal cells mixed with loose fungal hyphae. The algae are mostly terrestrial and multiply by division or sporulation within the lichen. This layer is photosynthetic in function.

(c) **The medulla** – It occupies the middle portion of thallus below the algal layer. It consists of thick-walled, loosely interwoven fungal hyphae.

(d) **The lower cortex** – It is the lower most region of thallus comprising of compact closely packed dark-coloured hyphae. On the underside of lower cortex several hyphal outgrowths, called rhizines, arise and attach thallus with the substratum. The rhizines may be simple or branched and may be unicellular or multicellular.

(iii) Fructicose lichen : A cross section of fruticose lichen shows radial symmetry. The outermost zone consists of compact, thick-walled hyphae forming the pseudocortex. Centre is occupied by medulla. The medullary hyphae are compact and run parallel to the surface. The region between medulla and cortex shows loosely packed interwoven hyphae mixed with algal cells.

SPECIAL VEGETATIVE STRUCTURES (Fig 38.3) :

There are some peculiar vegetative structures found on lichen thallus. Some common ones are briefly given below :

(1) Breathing pores : These are found in the upper cortex of some foliose or fruticose lichens to facilitate gaseous exchange. The compact cortical layer is interrupted by loosely interwoven hyphae at the places of breathing pores.

(2) Cyphellae : These are small pits or depressions found on the ventral surface of some lichens. These pits have definite forms with apical rims. They open into the medulla and meant for aeration in thallus. Simple openings are called **pseudocyphellae** as found in *Parmelia*.

(3) Cephalodia : Sometimes wart-like swellings are found mostly on the upper side of lichen thallus, which enclose algal cells mixed with fungal hyphae. These are called **cephalodia**. They consist of normal fungal hyphae but different algal cells and produced as a reaction of fungus to a foreign algal partner.

(4) Isidia : These are small coral-like, simple or branched stalked outgrowths produced on the upper surface of lichen thallus. They enclose the same alga as present in the thallus and are covered by continuous cortex. Their function is to increase the photosynthesis by increasing the surface area of thallus. Sometimes these bodies are detached and act as means of vegetative reproduction.

(5) Soredia : These are small sac-like bodies consisting of one or more algal cells clasped or surrounded by fungal hyphae. They occur as powdery dust either over the entire surface of thallus or within the definite pustule-like

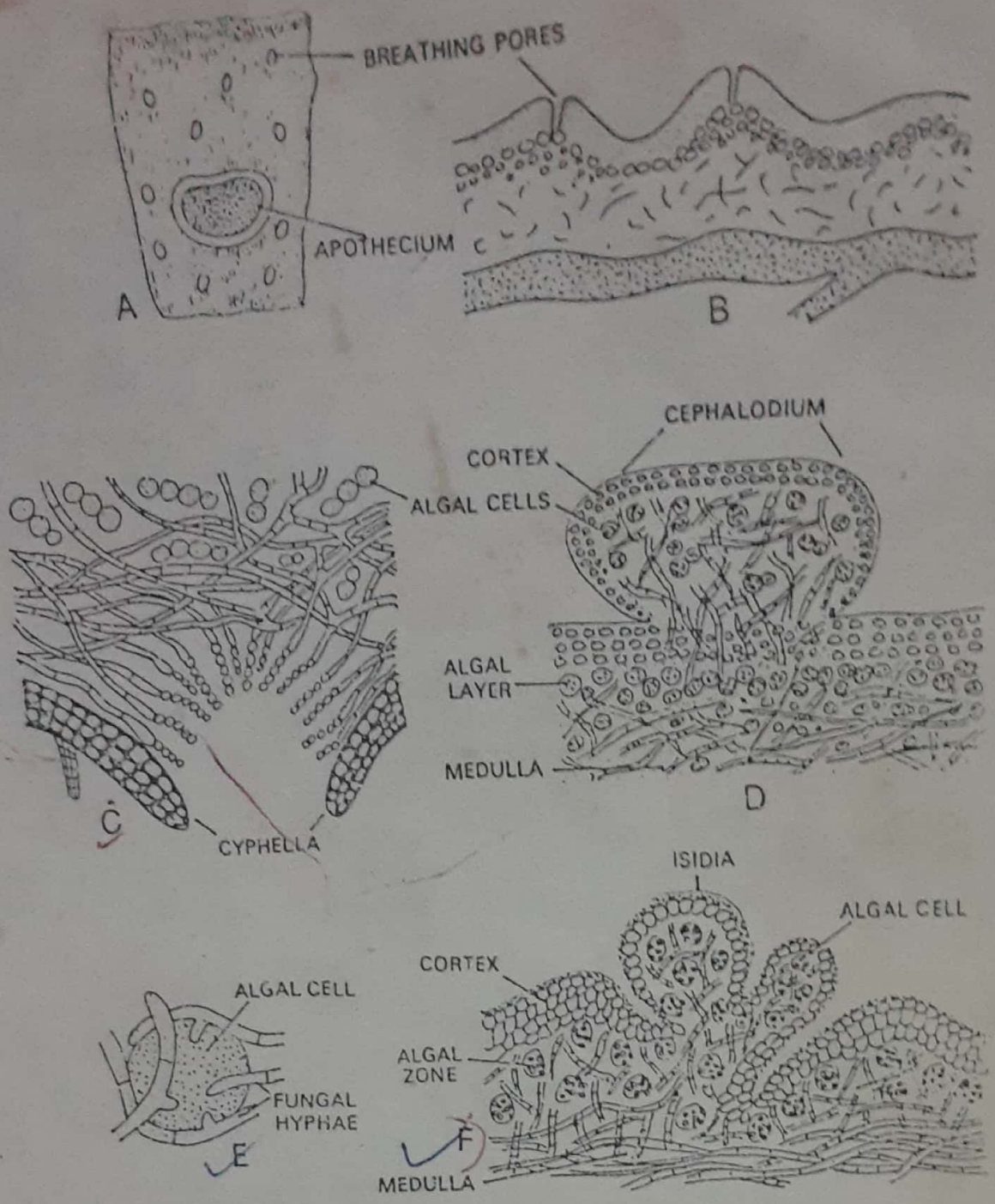

Fig. 38.3. Lichens—Special vegetative structures : A. Surface view of thallus showing breathing pores; B. Section of thallus showing breathing pores; C. Cyphella; D. Cephalodium; E. Soredium; F. Isidia.

structures, called **soralia** (sing-sorelium). Each soredium arises from algal layer below the upper cortex. A hyphal branch grows out and envelops one or more newly divided algal cells. It further grows upwards pushing its way out and breaks open the upper cortex at definite points. Finally it gets detached from its support, disseminated by wind and on getting suitable substratum germinate to give rise new thallus. Thus, they act as means of vegetative reproduction.

REPRODUCTION :

[A] ASEXUAL REPRODUCTION : The lichens reproduce asexually by one or more of the following methods –

(i) **Fragmentation :** Occurs by breaking of thallus into small fragments and each fragment growing into new thallus.

(ii) **Rejuvenation :** By death and decay of the posterior portion of thallus and rejuvenation of branches into new thalli.

(iii) **Isidia :** These are stalked outgrowths formed on the upper surface of lichen thallus. Each one consists of algal and fungal components covered by definite cortex. They detach from parent thallus and grow into new thalli.

(iv) **Sordia :** These are minute, rounded separable bodies produced on the general surface of thallus or inside the pustule-like soralia. Each soredium consists of one or more algal cells clasped and surrounded by fungal hyphae. They get detached from the thallus, disseminate by wind and on falling upon suitable substratum germinate to give rise new plants.

(v) **Formation of asexual spores :** Many lichens produce conidia inside the special reproductive bodies, called pycnidia. The pycnidia are embedded in the dorsal surface of thallus (*e.g., Physica*). It is a flask-shaped body that opens on upper surface by means of a pore, called ostiole. The fungal hyphae lining the inner side of cavity produce many small pycnidiospores (or conidia). The conidia get detached and disseminated by wind. They germinate by giving out germ tubes in all directions. These hyphae produce lichen thallus when come in contact with suitable algal cells.

[B] SEXUAL REPRODUCTION :

As has already been pointed out that the fungal members in lichen either belong to Ascomycotina or Basidiomycotina and consequently the sexual reproduction also correspond to these sub-divisions of fungi –

(1) Sexual reproduction in ascolichens :

The thalli of ascolichen may be dioecious or monoecious. The male sex-organs are spermatia and the female are carpogonia (or ascogonia).

(i) **Spermogonia** (Fig. [illegible].4) : These are flask shaped male sex organs of ascolichens found on the upper surface of thalli. The inner surface of spermogonium is lined by simple, branched or unbranched hyphae called spermatiophores. Each spermatiophore buds off spermatia. The spermatia are non-motile, minute, colourless, uninucleate male sex cells surrounded by definite cell wall. They vary in size and shape.

(ii) **Carpogonia** (or **Ascogonia**) (Fig. [illegible].4) : These are female reproductive organs of ascolichens. Each carpogonium is multicellular elongated and helically coiled structure with elongated trichogyne. They lie embedded in

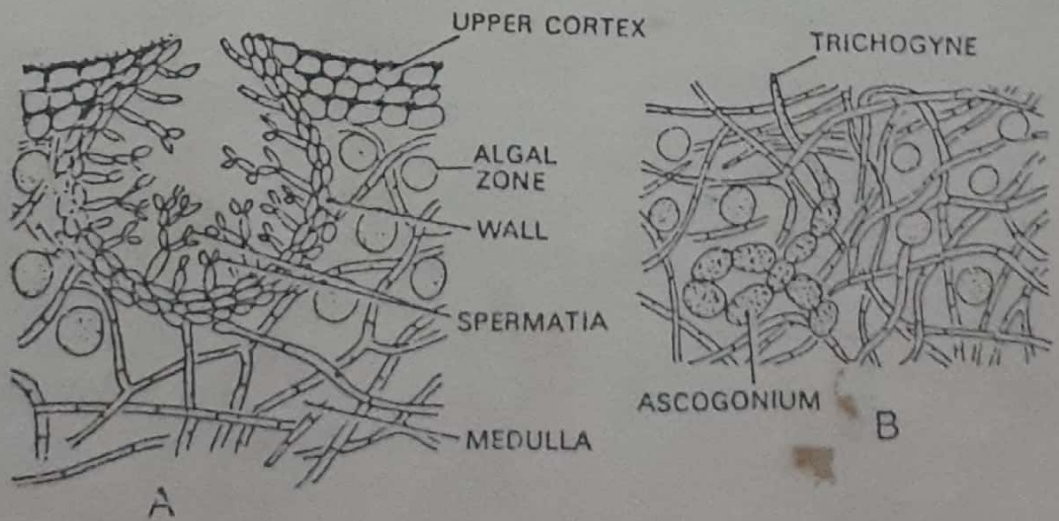

Fig. [illegible].4. Sex organs of ascolichens. A. Spermogonium; B. Ascogonium and trichogyne.

the upper cortex of thalli. The egg nucleus lies in the basal region of carpogonium.

The actual fertilization has not been observed but it is thought spermatia are transferred to carpogonia where fusion of spermatium occurs with the trichogyne. The male nucleus migrates from spermogonium to ascogonium through trichogyne and results in the formation of dikaryon. The dikaryon gives rise many ascogenous hyphae which develop asci and ascospores in the same way as in Ascomycotina. The ascospores of lichen are 2-3 celled. They liberate from asci and germinate during wet weather to give rise germ tubes. They grow to form fungal hyphae which on coming in contact with suitable algae produce lichen thalli. If they fail to get suitable algae they die.

The fruiting bodies (or ascocarps) : The fruiting bodies produced in ascolichens are mainly perithecia and apothecia. The **perithecia** are small flask-shaped bodies with definite openings called ostioles. The inner surface of perithecium is lined with fertile layer – the hymenium, whcih is made up of asci and paraphyses. Structure of perithecium resembles with that of ascomycotina.

The **apothecia** (Fig 38.5) are small cup-shaped or bowl shaped bodies. They measure 0.25 to 10 mm in diameter. The entire inner surface or only the bottom of apothecium is lined with hymenium consisting of asci and

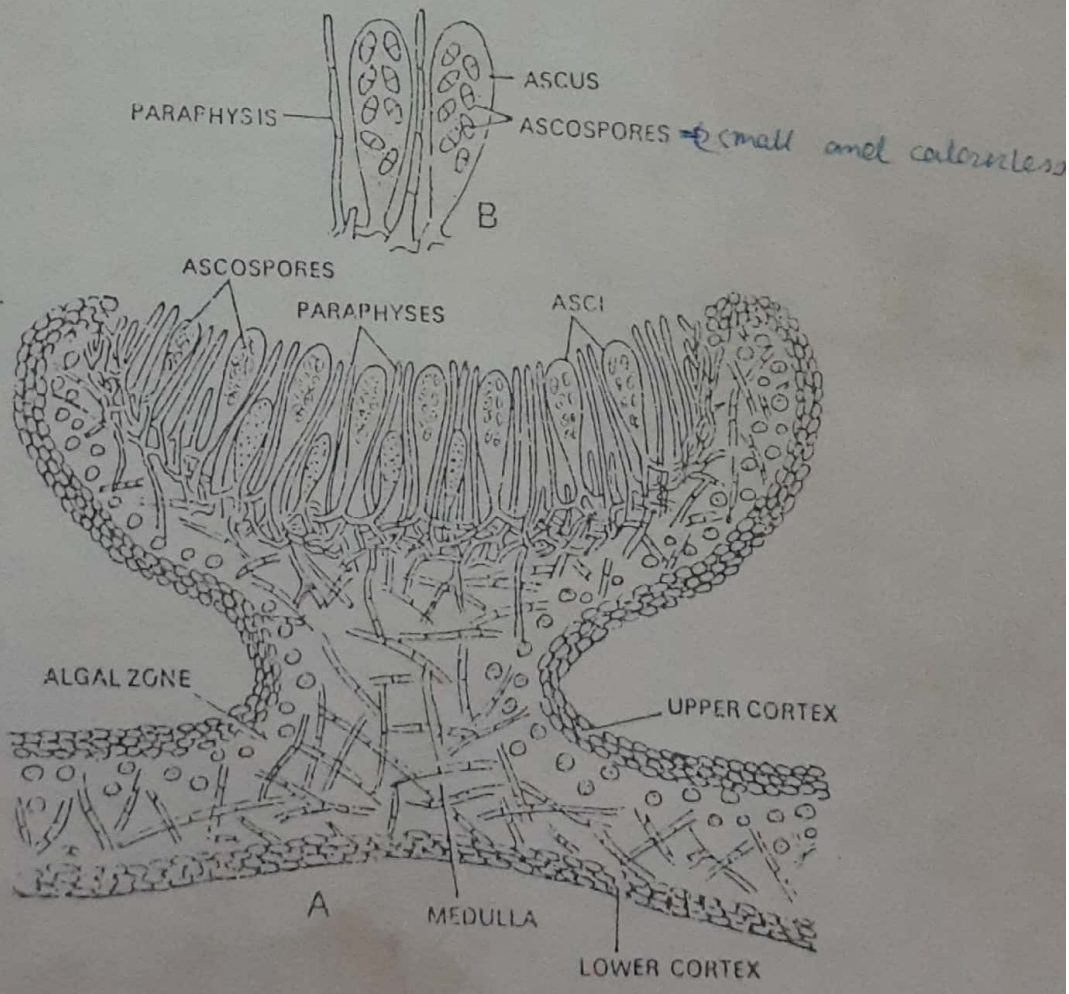

Fig 5 Ascolichen. A. Vertical section of an apothecium; B. A portion of hymenium enlarged showing ascus and ascospores.

paraphyses arranged in palisade like manner. The wall of apothecium is made up of either only fungal hyphae or both algal and fungal layers. Each ascus is club-shaped and usually contains 8 ascospores. Each ascospore becomes 2-3 celled before being discharged. The ascospores are muriform.

(2) Sexual reproduction in basidiolichen :

There are only 4 genera in basidiolichen. The most common among them is *cora* which stand out from the trees as bracket fungus (Fig. 38.6). The thallus is greyish-white to bluish-green in colour. The lichen reproduces sexually by production of basidia and basidiospores.

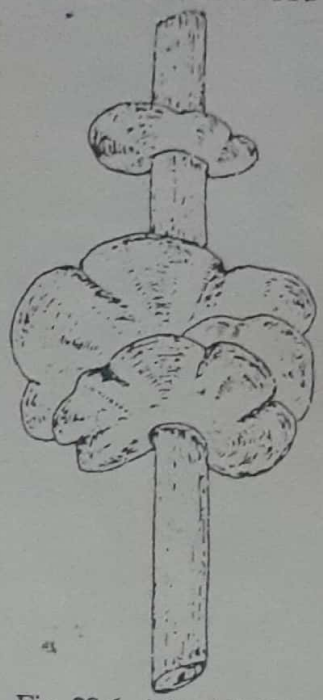

Fig. 38.6. A basidiolichen

COMMON EXAMPLE OF LICHEN : PARMELIA

Parmelia is a **foliose** lichen (Fig. 38.7). It grows profusely on the barks of tall tress or on the exposed rocks intermixed with the mosses. The lichen occurs most commonly at high altitude generally above 4,000 ft.

The plant body of *Parmelia* is flat, thalloid, lobed to deeply incised with irregular margins. The thallus adheres to the substratum by mean of strands of hyphae called **rhizines**. Internally the thallus is heteromerous and consists of 4 zones or layers – **upper cortex, algal zone, medulla** and **lower cortex**. The phycobiont present in the algal zone is green alga – *Pleurococcus*.

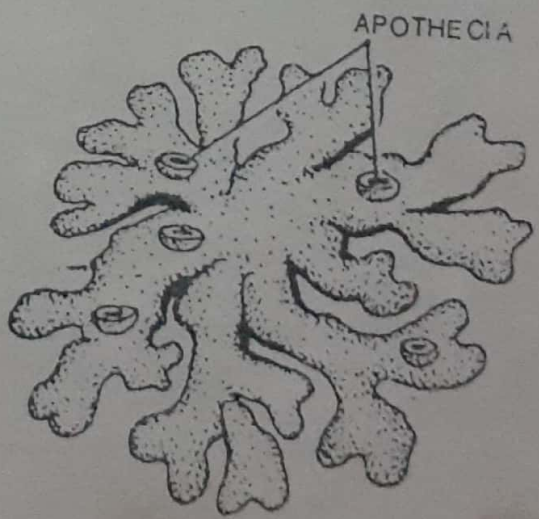

Fig. 38.7. *Parmelia*. Thallus with apothecia.

Vegetative reproduction occurs by fragmentation and also by the formation of **isidia** and **soredia**. Sexual

reproduction occurs by the formation of asci and ascospores in cup-shaped **apothecia**. The apothecia may by sessile or shortly stalked distributed on the upper surface of thallus. They are large and rounded. Each apothecium possesses a large number of club-shaped asci intermixed with long, septate and sometimes branched paraphyses. They arise from colourless hypothecium. Each ascus possesses eight ascospores which are simple and colourless.

A species of *Parmelia* is known as "rathapu" or "rock flower" in Telugu. It is collected during April - May and used as curry by natives in the Bellary district of Tamil Nadu.

LICHEN ECOLOGY :

Lichens are unique plants which can even grow in such situations where no other vegetation can exist. They can grow on exposed, wind-swept and extremely unfavourable habitats, such as, on cold foggy coats, along lake shores, in brooks, between the tide marks at sea shores, on the tree barks and on the barren naked rocks under conditions of drought and starvation. They have ability to withstand complete drying for a very long period and resume growth as soon as they get moisture. Lichens are ecologically most important plants as they **act as pioneer in initiating a xerarch** plant succession on the rocks. The crustose lichens usually appear first in the sequence of xerarch plant succession, followed by foliose and fruticose lichens. They soak up moisture whenever there is occasional shower of rain and retain it over a long dry spell. The growth of lichens is very slow (approx. 1 - 10 nm in radius per year).

The carbon dioxide expired out of lichen thalli during respiration combines with water to form weak carbonic acid

$$CO_2 + H_2O = H_2CO_3$$

The carbonic acid slowly corrodes the underlying rock surface and converts the upper layer into soil. Thus, they play a very important role in **soil formation** to support the growth of other groups of plants.

Lichens are extremely sensitive to atmospheric pollution and, therefore, grow in pollution free atmosphere. Usually they grow away from large industrial town.

ECONOMIC IMPORTANCE OF LICHENS

[A] Useful activities of lichens :

(1) Pioneers of rock vegetation : Many crustose lichens act as pioneers and initiate vegetation on clean bare rocks. They initiate a xerarch plant succession on the rocks. In such a kind of succession the crustose lichens are followed by foliose and fruticose lichens.

(2) Soil farmers : Many lichens act as pioneers and establish themselves on bare rocks. They secrete some acids (lichens acids) which cause weathering of rocks into soil particles. It has been shown that carbon dioxide, expired out by lichens during respiration, combines with water to form carbonic acid. This acid dissolves the upper layers of rocks and converts it into soil.

Moreover, the fungal hyphae of lichen creep inside the crevices of rocks. They die and add organic matter into it. The dead parts of thalli along with some blown off dust particles deposit over the rock surface year after year and form the loam.

(3) Food for insects : Some lichens (*e.g., Lecanora, Aspicilia*) are used as food by catterpillars, wood lice, mites, snails and larvae of insects. They also provide shelter to insects and pests.

(4) Food for animals : The lichens serve as an important source of food and fodder for the animals. The "reindeer moss", *Cladonia rangiferina* of arctic tundra is eaten by caribou reindeer and musk ox. Other reindeer mosses are *Cetraria islandica* and *Stereocaulon* spp. The hare and rabbits like to eat *Evernia prunastri*.

(5) Food for human beings : The lichens are rich in polysaccharides, enzymes and certain vitamins, therefore, they serve as food for human beings. *Cetraria islandica* (a common Iceland-moss) has long been used as human food in Scandinavia and Iceland during periods of deficit and famines. If boiled with water, it yields jelly which can be dried and made into bread. Other lichens which are used as food are – *Lecanora esculenta* (in Israel), *Evernia* spp. (in Egypt) and *Umbilicaria esculenta* (in Japan). Species of *Parmelia* are used as curry-powder in India. Lichens are also used for making delicious chocolates and pastries in bakeries.

(6) Medicinal uses : The lichens have a great significance in medicines and in the treatment of various diseases. Some of their medicinal uses are –

(i) *Peltigera canina* (the dog lichen) is used as a cure for hydrophobia.

(ii) *Lobaria pulmonaria* (the lungwort) is used in the treatment of lung diseases.

(iii) *Evernia furfuracia* is used in cough.

(iv) *Xanthoria parietina* is used for treatment of jaundice.

(v) *Parmelia saxatilis* is used for the treatment of epilepsy.

(vi) *Cladonia* and *Cetraria* are used in intermittent fevers.

(vii) *Acarospora smaragdula* yields an antibiotic compound.

(viii) Usnic acid obtained from lichens mixed with streptomycin is used against tuberculosis.

(7) Uses in perfumery and cosmetics : Some lichens are used to prepare perfumes and cosmetics. *Ramalina* and *Evernia*, having sweet scented thalli, are used in the preparation of **Dhup, Havan Samagri** and **soap.** Perfumes are extracted from *Evernia prunastri* and *Lobaria pulmonaria*.

(8) Uses in tanning and dyeing : The astringent property of *Cetraria islandica* and *Lobaria pulmonaria* makes these lichens useful in tanning. Species of *Roccella* and *Lecanora* yield 'orchill', which is used in the dyeing of woollen and silk fabrics. The 'orcein', a purified product of orchill, is used as a stain in the microscopic preparations. Litmus dye, a chemical indicator, is also obtained from these lichens. *Ramalina calicaris* is used as starch to whiten hair in the dye of wigs.

(9) Uses in brewing and distilling : Some lichens are used in distillaries for the preparation of alcohol. *Cetraria islandica* and *C. rangiferina* are used

in confectioneries because they yield upto 66% of the polysaccharides.

10. Organic acids : Certain lichens yield some useful organic acids. Members of Rocellaceae yeild **lacanoric acid** and **carbonic acid.** *Cetraria juniperina* is used to obtain **pinastrinic acid**, which is used to poison wolves. The **usnic acid** obtained from lichen thalli has antibacterial activity.

11. Some lichens yield poisonous elements such as, selenium (from *Parmelia molliuscula*), beryllium (from *Xanthoria parietina*) and chlorine (from *Evernia furfuracea*). *Lecanora esculenta* living in limestone deserts yields calcium oxalate as much as about 60% of its dry weight.

[B] Harmful activities of lichens :

1. A fruticose lichen – *Usnea* grows abundantly on forest trees. During hot seasons, it becomes dry and highly inflammable. It easily catches fire and causes forest fires.

2. Lichens reduce the market value of glasses, marble stones, sandal wood and fruits by causing damage due to secretion of acids.

3. Some lichens destroy colonies of mosses by direct parasitic attack.