Chapter - 10

THALLOPHYTA : FUNGI, PLANT PATHOLOGY AND LICHENS

FUNGI

The fungi are achlorophyllous, heterotrophic organisms of very diverse forms, size physiology and mode of reproduction. They have cell wall usually composed of fungal chitin and the reserve food is glycogen. The study of fungi is known as mycology (*Mykes* = Mushroom. *Logos* = discourse). Most familiar fungi are mushrooms, toadstools yeast, molds etc. They show progressive complexity of the vegetative body with the gradual degeneration of visible sexuality. Various mycologists classified fungi in various ways; however, the classification followed in this book is as given by **G. M. Smith** (1955).

GENERAL CHARACTERS OF ASCOMYCETEAE

Occurrence

There are about 1800 genera and 15000 species of Ascomycetae which occur in wide range of habitats; in soil, on dung, in marine as well as in fresh water. A few are entirely hypogean (developing and remaining underground). Some of them grow either as obligate parasites on living plants and animals and may cause them diseases or as saprophytes on dead and decaying plants parts such as logs, leaves, etc.

Thallus Structure

1. Thallus is either unicellular (as in yeasts) or multicelluar. In multicellular forms the thallus is a **mycelium** which is made up of profusely branched **septate hyphae.** These hyphae may grow superficially on the surface of host or may grow within the host. The hyphae growing within the host are either intercellular or intracellular.
2. The septa are perforated with single simple pore in the centre through which cytoplasmic connections are maintained from cell to cell. The pores are wide enough to allow even cell organelles to pass through them.
3. The cell wall is made of two layers. In yeasts, mannans and β -1, 3 glucans are the principal cell wall polysaccharides and chitin is present in very small amount. In hyphal forms chitin and β -1, 3 glucans are the principal cell wall polysaccharides.
4. Each cell is **uninucleate** or **multinucleate**. The other living cell organelles are endoplasmic reticulum, mitochondria, ribosomes, dictyosomes, centrioles, etc. The reserve food material is in the form of **glycogen**.
5. The somatic hyphae are often organized into somatic tissues like sclerotia, stromata and mycelial strands. The **sclerotia** (sing. sclerotium) are firm aggregations of modified somatic hyphae which serve as resting bodies to overcome adverse environment. On germination, they form stroma bearing reproductive bodies or

directly give rise to mycelium. The **stromata** (sing. stroma) are compact somatic structures which bear spores or fructifications. They are formed with or without the association of the host tissue. **Mycelial strands** are the **rhizomorphs** which are sterile linear hyphae capable of unlimited growth in one direction.

Nutrition

1. The superficial and intercellular hyphae send short absorbing organs called **haustoria** into the host tissue and absorb nourishment from the host. The absorbed food is then circulated throughout the mycelium. The intracellular hyphae grow within the host tissue get nourishment directly from the host cells.

2. Saprophytic forms grow on dead and decaying organic matter. Their hyphae secrete enzymes into the organic matter which convert complex organic matter into simple food. The hyphae then absorb it and circulate throughout the mycelium. Thus, in saprophytic forms, the digestion is **extracellular**.

Asexual Reproduction

1. In yeasts, asexual reproduction takes place by budding or by fission. In *Sachharomyces*, new individuals are produced by budding or budding spores called **blastospores.** In *schizosachharomyces*, **fission** (division of cell) takes place to form two cells of equal size.

2. In mycelia forms asexual reproduction takes place most frequently by formation of spore called **conidia.** These are formed in acropetal succession at the free ends of conidiophores which arise from somatic hyphae. Some genera have conidiophores that stand free from one another and are either branched or unbranched. In some forms, conidiophores are in groups forming continuous conidia forming structures called **synnemata** (sing. synnema). In some other forms, conidia are formed in special structures called pycnidia (sing. pycnidium), acervuli (sing. acervulus) or sporodochia (sing. sporodochium). **Pycnidium** is ostiolate, spherical or flask-shaped structure whose inner wall is lined with short conidiophores. Spore forming within a pycnidium are generally called **pycnospores** instead of conidia. **Acervulus** is a disc shaped flattened stromatic mass of hyphae formed beneath the cuticle from which arise vertical, short conidiophores. The **sporodochium** consists of cushion-shaped stroma bearing conidia externally. The conidia are produced in large scale and are disseminated by wind, insect or by other means suitable for quick and wide spreading of the organism.

3. Instead of forming spores (conidia) at the end of conidiophores, there may be a simultaneous formation of them throughout the length of the hypha. Spores formed in this manner are called **oidia**. Sometimes mycelium forms large thick walled spores called **chlamydospores** which are produced singly or in short chains.

Sexual Reproduction

1. The process of sexual reproduction is extremely variable in Ascomycetes. During the process, usually male and female sex organs are formed which are morphologically similar or dissimilar. If dissimilar, the male sex organs are called **antheridia** and female sex organs are called **ascogonia.**

2. During the sexual process, the cytoplasm of male and female sex organs fuse with each other, the process is called **plasmogamy.** In lower Ascomycetes, it is immediately followed by fusion of haploid male and female nuclei, the process is called **karyogamy.** However, in higher forms, karyogamy does not take place immediately so that male and female nuclei remain together to form dikaryon (a cell with two haploid nuclei).

3. From this dikaryotic cell, dikaryotic hyphae called **ascogenous hyphae** are given out. In penultimate cell of each ascogenous hypha, karyogamy takes place to form diploid ... This cell is now called **ascus mother cell.** Its diploid nucleus

undergoes meiosis and mitosis to form eight haploid ascospores and the cell is now called **ascus** (pl. asci).

4. In lower Ascomycetes, asci are not enclosed in the fruiting body called ascocarp; in higher Ascomycetes, asci are enclosed in **ascocarp**. These are of three types, viz. **cleistothecium** (spherical in shape and closed that is without any ostiole), **perithecium** (flask-shaped with an ostiole) and **apothecium** (cup or saucer-shaped with wide opening).

5. At maturity, the ascospores are liberated from asci and ascocarp and germinate to produce mycelium.

Economic importance

Ascomycetes are of great economic importance as our lives are affected directly or indirectly by them on account of their both beneficial as well as harmful activities. They are useful as food, for commercial production of alkaloids and vitamins, in brewing and baking industries and useful even in academic studies. On the other hand, they cause diseases to economically important crop plants. The beneficial and harmful activities of Ascomycetes are described below :

Beneficial activities of Ascomycetes

As food

Ascomycetes which are used as food include morels and truffles.

Morchella, commonly known as **morel** or black mushroom is very famous and highly prized for its superiority in texture and delicacy of flavor over the truffles. In India, it is popularly called Gucchi.

Different species of *Tuber*, commonly called **truffles** produced their fruiting bodies underground. They are also highly prized and famous for their texture and delicacy of flavor.

Morel and truffles have high protein content and low carbohydrates and fat content. They are rich in vitamins and minerals. Hence, they not only form 'slimming diet' but also form very good diet for diabetic and heart patients.

In Industries

Alcoholic beverages : Yeast strain (*Sacchromycse cerevisiae*) is used in the production of wine, beer, whisky, rum and gin. Industrial alcohol produced by yeast is used as solvent.

Baking industry : In baking industries, bread, biscuits, cakes, etc., are prepared by using baker's yeast. A yeast strain, *Saccharomyces cereviciae*, is used for raising (fermentation) of maida flour dough. Yeast releases zymase complex (Zymase, Maltase and Amylase) which acts upon the starch present in dough and converts it into simple sugars. These sugars are further acted upon by yeast complex into ethyl alcohol and carbon dioxide. The latter starts bubbling out and gets hold in a strong and elastic gluten network of the flour. Due to this, the dough rises and makes the products soft and fluffy. Flavour and quality of product is attained by selecting different strains of yeast.

Production of enzymes : Various enzymes such as amylase, endoglucanase, endoxylanase, β- glucosidase, etc. are produced by 30 species of fresh water Ascomycetes. Wood rotting *Xylaria* secretes enzymes laccase, cellulose, lipase, pectinase, peroxidases, etc.

Production of vitamins : Vitamin Riboflavin (vitamin B2) is produced by filamentous yeast *Ashbya gosspii* and yeast *candida flaveri.*

In Medicines

Production of antibiotics : Antibiot...

Production of alkaloids : The sclerotia (ergot) of *Clavicps purpurea* contain number of alkaloids, which are used in medicine for the preparations of abortifacients and are also useful in controlling haemorrhage during child-birth. It is used in the treatment of migraine.

Ephedrine is also an alkaloid extracted by yeast from benzaldehyde. Yeast converts benzaldehyde into L-actylphenyl carbinol, which is, by amination, converted into L-ephedrine. It is used for the relief of asthma and in the treatment of allergic conditions.

In academic studies

Cytological, genetical and biochemical studies : Geneticists and biochemists who studied mutants of *Neurospora*, established the one-gene–one-enzyme theory, thus contributing to the foundation of modern genetics. Yeast is particularly used in studies on eukaryotic genetics and the study of its genetics is known to have practical significance. In 1996, yeast became the first eukaryotic organism known to have its complete set of chromosome entirely sequenced and became a useful source in genetics.

Harmful activities of Ascomycetes

Cause disease to plants

Many of the diseases of cultivated plants are caused by Ascomycetes. In crop plants these include the leaf spot of alfalfa, the ear rot of corn, powdery mildew of cereals and grasses, ergot of grains and grasses and foot rot of various grains. In fruit trees these include the brown rot of stone fruit, apple scab, chestnut blight and peach leaf curl.

ERYSIPHE

Systematic Position

Division	:	**Eumycophyta**	i)	Fungi with definite cell wall throughout all stages of vegetative development.
			ii)	Mycelium is aseptate or septate, with uni, bi or multinucleate cells.
Class	:	**Ascomycetae**	i)	Septate mycelium.
			ii)	Distinct sporangium called ascus which produces 8 ascospores endogenously.
Sub-class	:	**Euascomycetae**	i)	Asci are produced on ascogeneous hyphae.
			ii)	A fruiting body called ascocarp is produced.
Series	:	**Plectomycetes**	i)	Ascocarp is of cleistothecium type, without definite ostiole.
			ii)	Asci are scattered at various levels within the cleistothecium or at the base of the cleistothecium.
Order	:	**Erysiphales**	i)	Asci are parallel; in single layer arise from the base of the cleistothecium.
Family	:	**Erysiphaceae**	i)	Aerial mycelium white in colour.
			ii)	Large number of conidia is produced giving powdery appearance on the host surface.
Genus	:	***Erysiphe***	i)	Cleistothecium shows appendages.

Occurrence

Erysiphe is an obligate parasite occurring on the aerial parts of many flowering plants. There are about 10 species of genus *Erysiphe*. They cause 'powdery mildew' disease on the surface of leaves (ectoparasite) and sometimes on stem and fruits also. Some of the common hosts are pea, bean, cereals (wheat, oat, barley, etc.), cucurbits and some grasses.

Erysiphe polygoni causes powdery mildew disease of peas (*Pisum sativum*). The species is widely distributed all over the world and has been reported on 352 hosts. *E. graminis* causes powdery mildew of cereal crops such as wheat, barley, rye, oats and many other grasses. *E. cichoracearum* is the causal agent of powdery mildew of cucurbits.

Fig. 10.1 : *Erysiphe* : Infected leaf

Structure of Mycelium

The fungus has external, superficial mycelium, which spreads over the surface of the host. The mycelium consists of delicate persistent well branched septate hyphae which interlace to form web-like covering. They are attached to the leaves by means of special out growths called **appresoria**. The cells of the hyphae are short and uninucleate. The cytoplasm is vacuolate. At intervals, **haustoria** arise as narrow tubes from the appresoria.The reserve food is in the form of glycogen. The cytoplasm contains extensive sheets of endoplasmic reticulum, mitochondria and microbodies just behind the hyphal tip.

Nutrition

The fungus is ecto-obligate parasite. It absorbs food with the help of special structures, the haustoria. The food absorption takes place probably through the tubular invaginations of the sheath membrane. Each haustorium penetrates the epidermal cell; and swells into lobed, globular sacs within the cell. The haustorium usually occupies the vacuole of host cell and absorbs the food from the cell. The haustorium of *E. graminis* is peculiar. It shows finger-like processes on the sides.

Ultra-structure of haustorium

The haustorium is formed of tubular neck and swollen body which is uninucleate. The body remains enclosed in a sheath. Between the body and the sheath is present a matrix. The sheath remains in contact with the tonoplast of the host cell. The sheath membrane shows many invaginations. In the tubular lobe of the haustorium are present endoplasmic reticulum and mitochondria. The neck of the haustorium is surrounded by thick collar.

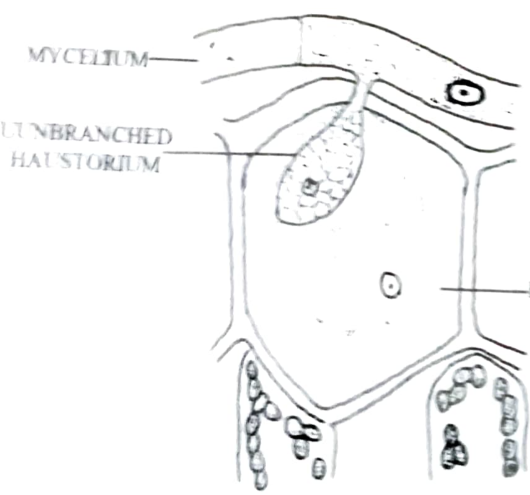


Fig. 10.2 : *Erysiphe* : Haustorium

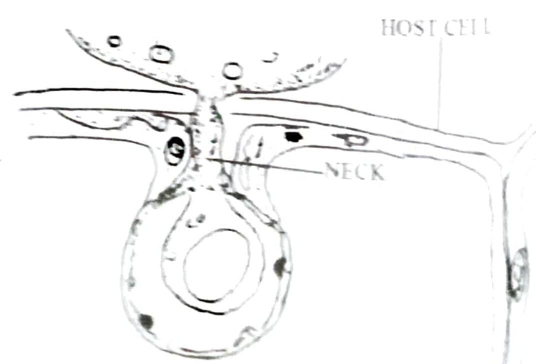


Fig. 10.3 : *Erysiphe* : Ultrastructure of haustorium

Reproduction

The fungus reproduces by asexual as well as by sexual means.

Asexual Reproduction

With the establishment of the fungal mycelium and ...

. These are the conidiophores. The conidiophore consists of a basal, long stalk hort terminal generative cell. This terminal cell produces conidia in chains. The e produced by abstriction from the tip of the conidiophore, in **basipetal** . They are produced in abundance in relatively cool, moist environment.

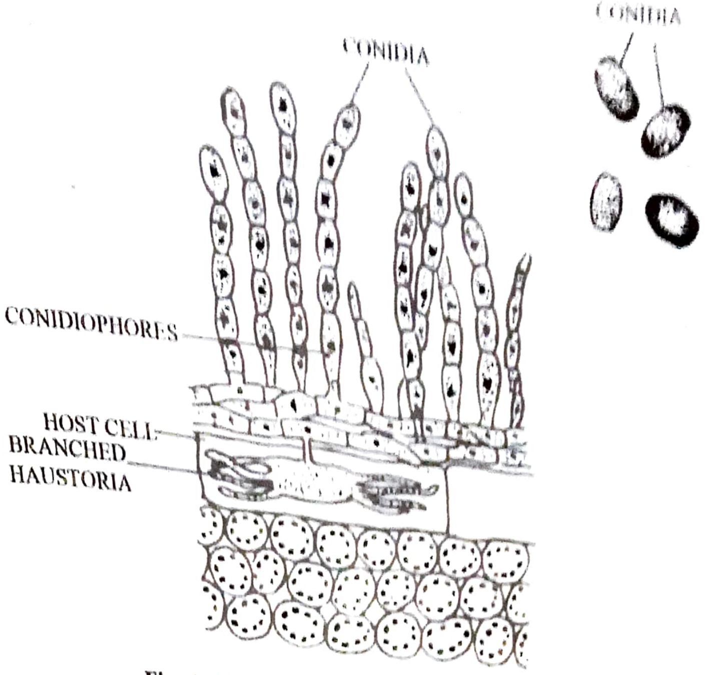


Fig. 10.4 : *Erysiphe* : Condiophores with conidia

Each mature conidium is an elliptic, barrel-shaped, hyaline, one-celled and uninucleate asexual spore. A waxy material is present on the surface. The conidia are readily dispersed by air currents in dry weather, thus spreading the disease widely in summer.

When the conidium falls on a suitable host, it germinates immediately to produce a germ tube, which later on establishes well branched, septate mycelium on the surface of the host leaf. The cycle is thus repeated again in the same way.

Sexual Reproduction

At the end of the conidial stage, the sexual reproduction starts. It takes place in late summer. Most of the species (*Erysiphe polygoni*) are homothallic while a few are heterothallic. The male and female sex organs are called antheridia and ascogonia respectively. The sex organs develop in close proximity of each other from the erect branches, which arise near each other in pairs. The sex organs lie closely parallel to or twisted around each other.

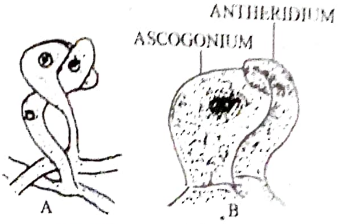


Fig. 10.5 : *Erysiphe* : Young antheridium and ascogonium intertwined Mature sex organs

a) **Antheridium :** It is small and cylindrical. The terminal, uninucleate cell functions as antheridium, and a lower supporting cell is called the stalk cell.

b) **Ascogonium :** It is large and ovoid structure. It is the uninucleate, swollen and club-shaped terminal cell of the female branch. It is borne on a basal stalk cell.

Plasmogamy

At maturity the antheridium comes in close contact of the ascogonium at its apex. The walls at the point of contact dissolve thus forming a pore. The male nucleus along with its cytoplasm passes through the pore into the ascogonium, and the latter becomes binucleate. Thus, a dikaryon is established by plasmogamy. **Allen** (1936) and some others have proposed that the fusion of the male and female nucleus (Karyogamy) is delayed until the ascus mother cell is formed.

Post plasmogamic changes

At this stage sterile hyphae grow up from the stalk cell of the ascogonium and form a sheath called **peridium** around the sexual apparatus. The sheath or peridium consists of three to many layers of compacted hyphae. The round, ball-like structure thus formed is an ascocarp called **cleistothecium**.

The two nuclei (of different genetical constitution) of the ascogonium divide by mitosis and it becomes multicellular. The ascogonium now elongates and divides by cross walls into a row of 4 to 5 cells. **Ascogenous hyphae** develop from the penultimate cell of the row of cells. These ascogonous hyphae branch and form a mass of hyphae within the periderm. 5 to 20 binucleate intercalary cells of ascogenous hyphae function as **ascus mother cells**. The two unlike nuclei in each ascus mother cell fuse **(Karyogamy)** and a **synkaryon** is formed. This cell is the **young ascus**, and the nucleus is a diploid **zygotic nucleus**. The diploid nucleus of the ascus undergoes meiosis (first and second division) followed by a third division which is mitotic. This results into an **eight nucleate ascus**. Later by wall formation, eight haploid ascospores are developed in each ascus. The ascospores are elliptic, hyaline, one-celled, uninucleate structures. They are retained in the asci within the cleistothecium till they become mature i.e. in next spring season.

Structure of the cleistothecium

As a result of sexual reproduction, the **ascocarps** of the fungus, called **Cleistothecia**, appear in dry weather. They are seen as sharp, black specks scattered on the surface of the white mycelium. The cleistothecia are globose structures without ostiole. The **peridium** of the cleistothecium consists of 2 to 3 layers of cells, the outer one becoming dark brown in colour. The component cells are polygonal in shape. Long, filamentous, unbranched, myceloid **appendages** develop from the outer layer. The inner layers of the peridium are nutritive in function. There are **2 to 8 asci** within the cleistothecium. All the asci arise from the base of the cleistothecial cavity and are arranged somewhat in a layer. The asci of *E. polygoni* are ovate and almost sessile. The number of **ascospores** in each ascus varies from **2 to 8.**

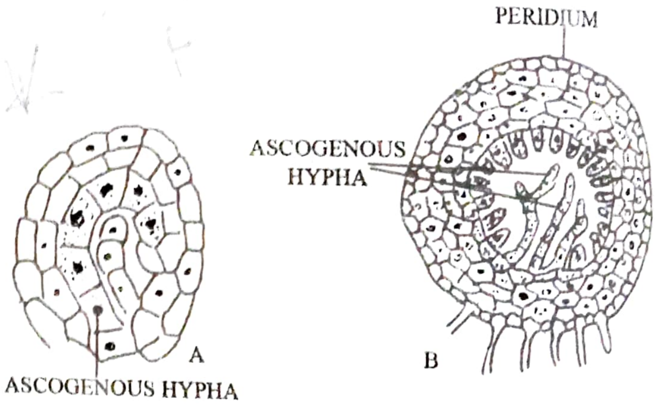


Fig. 10.6 : ***Erysiphe*** **: (A) Division of ascogonium (B) Ascogeneous hyphae**

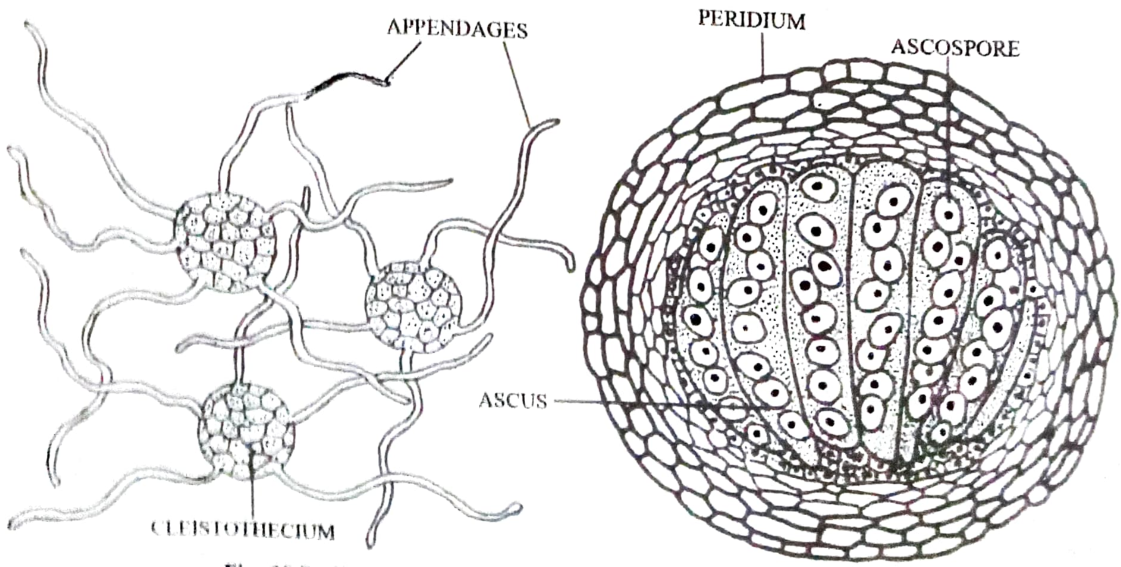


Fig. 10.7 : ***Erysiphe*** **: Entire cleistothecium and V. S. of cleistothecium**

Dehiscence of Cleistothecium

The mature cleistothecium remains dormant during adverse conditions (winter) due to the presence of thick peridium. In the spring season, the inner contents of cleistothecium, particularly asci, absorb water and swell. This causes irregular rupture of the upper portion of the peridium. The asci are then exposed; the ascus wall bursts, and the ascospores are shot out with sufficient force. They are thus hurled out in the air, and are dispersed by wind. The liberated ascospore germinates immediately on falling on a suitable host. It produces a germ tube which develops into a well-branched superficial mycelium, thus infecting the host leaf.

Many workers are of the opinion that the fungus overwinters in the cleistothecial stage. **Mundkur** (1964) reported that the disease perpetuates through the dormant mycelium. The primary infection in the field is started due to the dormant mycelium in the pea seeds.

Economic Importance

Erysiphe causes the disease called powdery mildew. It causes disease in Pea, Grapes, Cucurbits, Cereals, Barley, Apples, Shisham, Mango, Beak-rose etc. Though the host plant never dies, the yield is considerably reduced.

Life Cycle

The entire life cycle of *Erysiphe* is diagrammatically represented as follows :

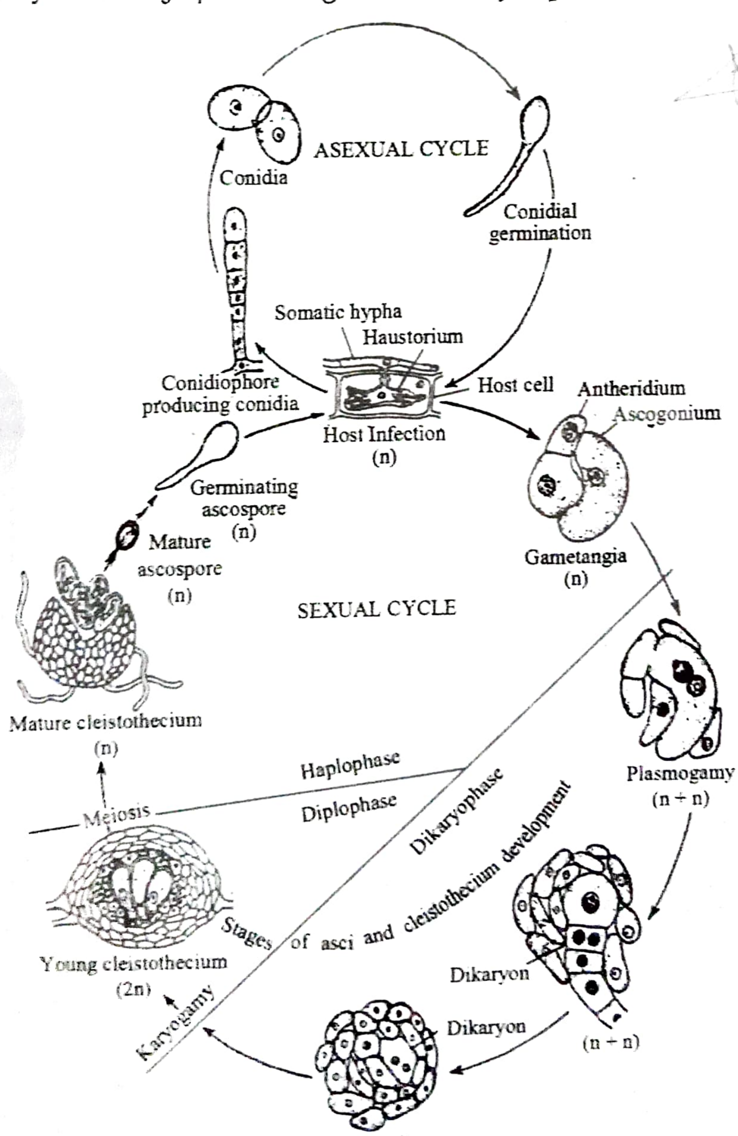


Fig. 10.8 : *Erysiphe* : Life cycle

XYLARIA

Systematic Position

Division	:	**Eumycophyta**	i)	Fungi with definite cell wall throughout all stages of vegetative development.
			ii)	Mycelium is aseptate or septate, with uni, bi or multinucleate cells.
Class	:	**Ascomycetae**	i)	Septate mycelium.
			ii)	Distinct sporangium called ascus which produces 8 ascospores endogenously.
Sub-class	:	**Euascomycetae**	i)	Asci are produced on ascogeneous hyphae.
			ii)	A fruiting body called ascocarp is produced.
Series	:	**Pyrenomycetes**	i)	Ascocarp is of perithecium type, with the upper end is prolonged into a neck terminating into a circular ostiole.
			ii)	Asci are elongated, cylindrical arising from the base of the perithecium and are arranged in a parallel series.
Order	:	**Sphaeriales**	i)	Saprophytic, parasitic or coprophilous fungi.
			ii)	Perithecia are produced directly from a loose mass of mycelium (non-stromatic) or are associated with a well developed strong stroma standing on top or sunken.
			iii)	Ascospores are usually eight in number per ascus and are usually liberated forcibly from apical pore of the ascus.
Family	:	**Xylariaceae**	i)	These occur as saprophytes chiefly on wood and are characterized by free, superficial stromata (*sing*. stroma).
			ii)	The stromata are true as they are entirely made up of fungal tissue.
			iii)	The perithecia are arranged just below and at right angle to the surface of stroma in a single layer.
			iv)	Ascospores are dark coloured but with hyaline germ slit running the length of the spore.
Genus	:	***Xylaria***	i)	Stromata are erect, stalked, fusiform, cylindrical or club-shaped, simple or branched, sometimes forked, leathery, fleshy or woody, dark brown or black outside but mostly white internally.

Occurrence

The species of *Xylaria* are saprophytic on woody substrates as tree branches, logs and stumps, causing white wood rot. From India, about 40 species of *Xylaria* have been reported. Of these, *X. hypoxylon* and *X. polymorpha* occur more frequently.

Vegetative structure and nutrition

The mycelium consists of profusely branched, septate and multinucleate hyphae which unite into thick strands and appears as black-zone lines within the substrate. These hyphae show an intense heliotropism so that even when under the wood, they easily come to the outer surface. They are first differentiated into a black pseudoparenchymatous rind and a light fibrous core and then gradually develop into dark coloured stroma. Thus, most of the mycelium is involved in the formation of stroma of the fungus. The stroma is erect, stalked, fusiform, cylindrical or club-shaped, simple or branched, sometimes forked, leathery, fleshy or woody, dark brown or black outside but mostly white internally. *Xylaria polymorpha* is commonly known as "dead man's finger" for the shape of its stroma.

The nutrition is **extra-cellular.** Being saprophytic, the fungus secretes extra-cellular enzymes outside its body in the substrate which break down complex organic food material of the substrate into simple one. This simple food material is then absorbed by the hyphae and is circulated throughout the mycelium.

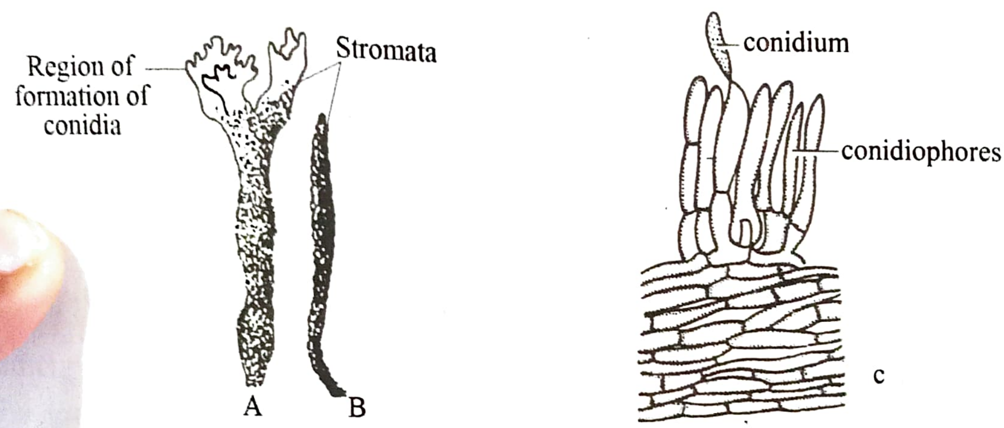


Fig. 10.9 : *Xylaria* : (A) – (B) Stroma, (C) Formation of Conidia

Asexual Reproduction

Towards the growing tip of the stroma, some cells of the outer layers of stromatal hyphae produce small conidiophores arranged into compact palisade-like layers forming hymenium. Each conidiophore produces small, oval conidia in large numbers. The stroma is thus covered by a white powdery mass of conidia which is in marked contrast to the exposed black lower portion of the stroma, hence the name "candle-snuff fungus".

Sexual Reproduction

According to **Luttrell** (1951), the female sex organs called ascogonia are developed within the stroma. Hyphae from the basal cells of each ascogonium or adjacent hyphae surround the ascogonium to form the wall of the perithecium. The perithecium becomes pyriform with the upper end prolonged into a neck due to growth of the hyphae in the apical region. The neck develops periphyses and terminates into an ostiole. In mature stroma, ostioles of the perithecia are visible from outside with naked eye. Thus many perithecia are developed just below and at right angle to the surface of the stroma in a single layer. From each ascogonium, enclosed by the wall of the perithecium, ascogenous hyphae are developed on which asci are developed. The asci are cylindrical and clavate, each with 8 ascospores and with a narrow pore at the apex. Asci are mixed with paraphyses. Ascospores are ellipsoidal, inequilateral (i.e., with one side more curved than other), unicellular, dark brown or black in colour, with hyaline germ slit running the length of the spore.

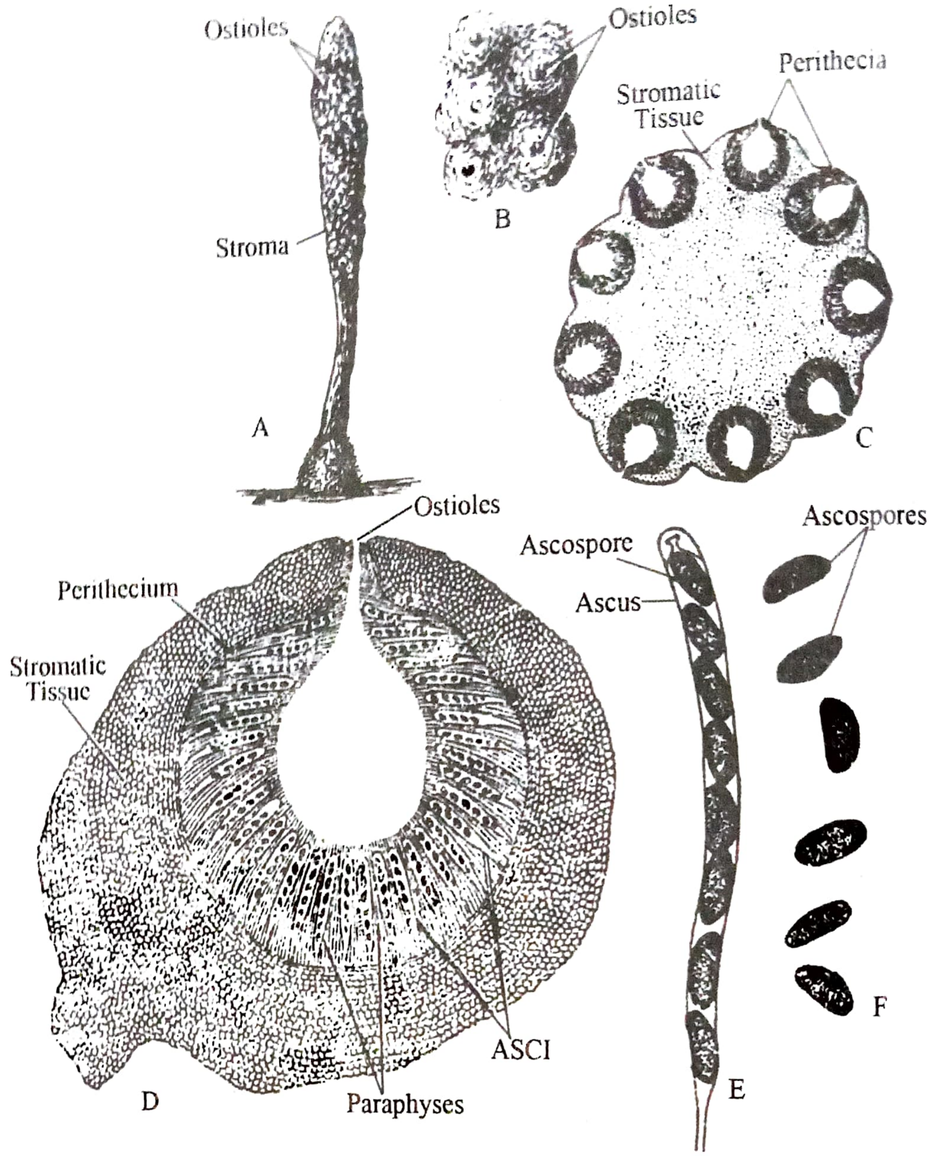


Fig. 10.10 : Xylaria : (A) Mature sroma, (B) Surface view of ostioles, (C) T.S. of stroma showing perithecia, (D) V.S. of Perithecium, (E) An ascus with ascospores, (F) Ascospores

At maturity, ascospores are liberated first from the asci through apical pores and then from theostiooples of perithecia. When fall on the suitable substratum, they germinate to produce mycelium.

PLANT PATHOLOGY

The word pathology is derived from two Greek words *pathos* = suffering and *logos* = discourse. Thus, plant pathology is concerned with the study of the suffering of plants. The plant pathologist is concerned with the science of plant pathology such as symptoms, nature and cause of plant disease, diagnosis and control of plant disease.

In India, the mycological work was started in middle of the 19th century and **E. J. Butler** is considered as founder of Mycology and Plant pathology in India. Post 1930 period saw eminent plant pathologists like **K. C. Mehta, V. P. Bhide, Thirumalachar, Mundkur, R. N. Tandon, K. S. Thind** and so on.

Powdery mildew

It is caused by various members of family Eryshpaceae to a wide range cereals and grasses including wheat, oat, barley, rye, *Agropyron*, *Poa*, etc. The causal organisms are obligate parasites and highly specialized in their choice of hosts. The damage caused to the hosts is difficult to assess since the hosts are not usually destroyed. The disease discussed here is caused by *Erysiphe*.

Symptoms

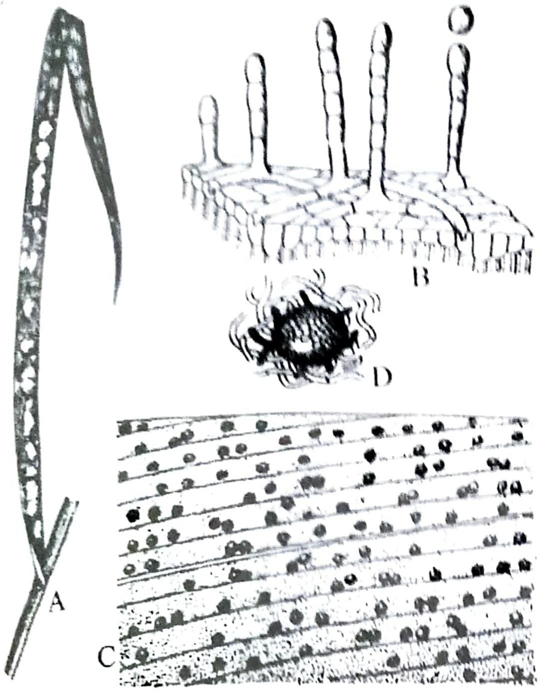


Fig. 10.11 : Powderly mildew of cereals and grasses : (A) Grass leaf with Powderly mildew patches, (B) Conidiophores and conidia on the host surface, (C) Cleistothecia on the host surface, (D) Cleistothecium

Early symptom of the disease is the appearance of white mildew areas on aerial part of the host. Gradually, these areas are enlarged and coalesce producing powdery effects on the infected plant parts. The disease gradually spreads to the inflorescence. The infection results in temporary stimulation of respiratory activity of the host tissue and chlorosis of infected areas. In extreme cases, the leaves are wrinkled, twisted and variously deformed and the inflorescence may droop down and wither. The activity of mycelium declines with the rise in the summer heat. Conspicuous green spots appear in the infected host surface. The mycelium turns grey and microscopic, dark-spherical bodies (cleistothecia) appear which remain scattered on the mycelial weft without being attached to the host. The disease fails to infect the plants that are suffering from Nitrogen deficiency.

Causal Organism

The powdery mildew disease is caused by *Erysiphe graminis.* Its mycelium is septate and branched. It produces **conidiophore,** which are club shaped and at right angle to the mycelium. Each conidiophore produces 10–12 **conidia,** in **basipetal chain.** The conidia are hyaline, unicellular, uninucleate and spherical or elliptical in shape. The sexual stage is represented by **cleistothecia,** which are spherical, **without** definite **ostiole,** have **appendages** and contains elongated asci at the base. Each ascus contains **8 ascospores.**

In its parasitism, *E. graminis* breaks up into distinctive physiological races that are specialize to genera, species and even varieties of the host plant, e.g. *E. graminis avenae* on *Avena sativa* (oat), *E. graminis hordei* on *Hordeum vulgare* (barly), *E. graminis secalis* on *Secale cerale* (rye), *E. graminis poae* on *Poa* and *E. graminis agropyri* on *Agropyron.*

Disease Cycle of Casual Organism

The fungus penetrates the host, especially the leaves in the form of dense, brown mycelial mat, in the winter season. The mycelium produces **conidia** in the following spring, forming the source of primary inoculum. The conidia are dispersed by the wind and germinate on susceptible host. As the conidial formation slows down, the mycelium produces male and female sex organs called **antheridia** and **ascogonia** respectively. As a result of sexual reproduction, fruiting bodies called **cleistothecia** are produced which are spherical, **without,** definite **ostile,** have **appendages** and contain elongated **asci** at the base. Each ascus contains **8 ascospores.** The asci are surrounded by **peridium** (the wall made up of sterile hyphae). At maturity, the peridium withers and the asci liberate ascospores which reinfect the plant in the next growing season.

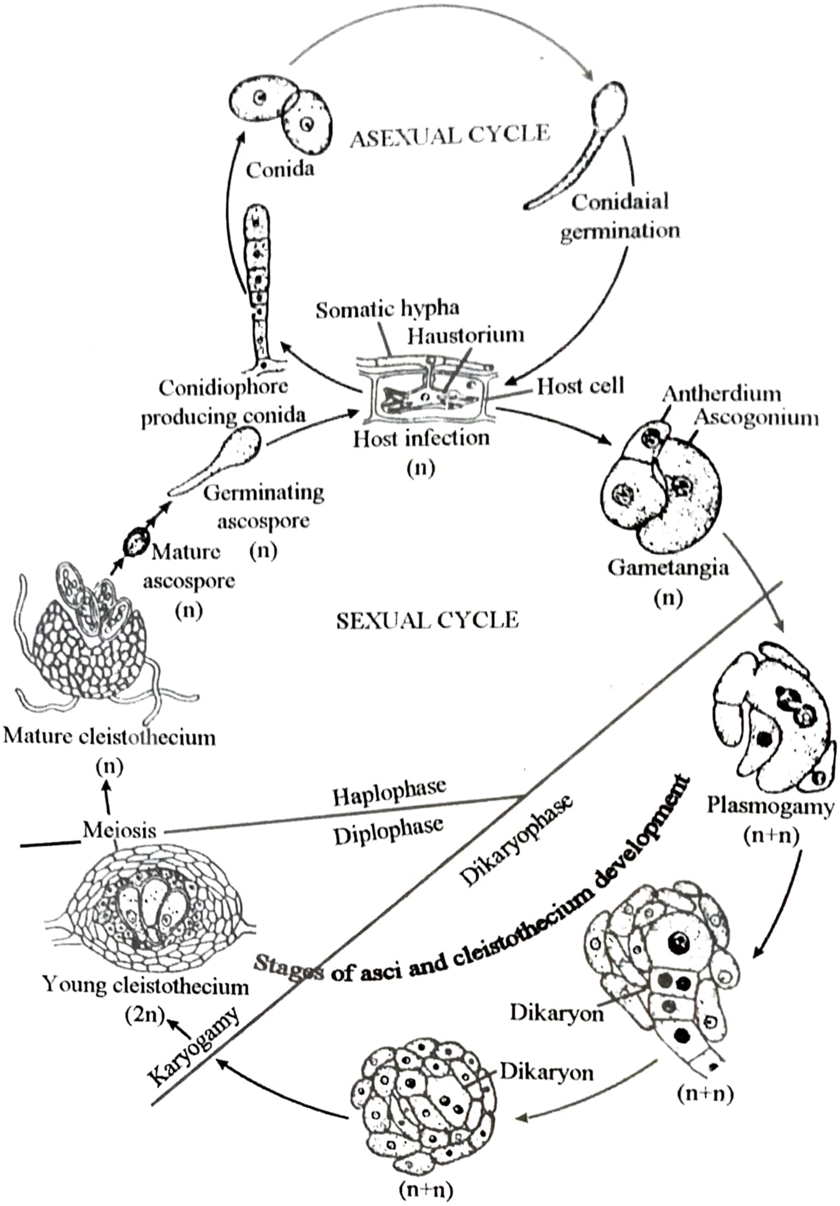


Fig. 10.12 : Disease cycle of *Erysiphe sp.*

Control Measures

1. **Rogueing** (uprooting) of the diseased plants and burning them in the field help to remove the source of primary inoculum.
2. Because of the superficial habit of the disease, it can be easily controlled by **dusting with sulphur** (25 to 30 lbs per acre), which acts both as an eradicant and as a protectant. However, use of sulphur should be avoided on hot afternoons to prevent plant injury. The use of '**Karathane'** also gives good results.
3. Certain **organic fungicides** are effective control measures for powdery mildews. Since the mycelium is superficial, the fungicides do not have to penetrate plant tissue. The fungicides are effective also because conidia of most powdery mildews do not germinate in a film of water. Some systemic fungicides applied through roots e.g., procaine hydrochloride and 6–azauracil show good control. Antibiotic like griseofulvin and cycloheximide also show systemic activity against powdery mildew.
4. Use of nitrogen compounds as fertilizers should be avoided as the plant becomes susceptible to the disease more. Phosphate compounds do not harm the plant.
5. Growing susceptible varieties of cereals should be avoided. The crop rotation minimizes the chances of infection.
6. As the fungus is an obligate parasite and consists of specialized races each restricted to a particular host (host specific), growing **resistant varieties** of crop plant provides the best control of the disease.

Late Blight of Potato

This is one of the most serious diseases of potato which at one time caused a severe epidemic on the European continent. It is probably originated in South America the native home of potato. It was introduced into Europe and North America between 1830 and 1840. In succeeding years it became most severe epidemic disease on the European continent in 1845. The notable Irish famine of 1845 and 1846 was caused due to destruction of potato crop by the late blight of potato disease.

Symptoms

The early symptoms of the disease consist of brownish to purplish-black lesions on leaflets, petioles and on the stem. The lesions are not delimited in size and under favourable weather conditions enlarge rapidly so as often to involve the whole surface and the entire crown may fall over in a rotten pulp in a few days. However, in dry, clear weather infection is limited and the lesions remain small, brown and dry, and the stem may escape altogether. If the weather becomes warm and humid, the colour of the lesions rapidly changes to black, the lesions become wet, the stems are quickly attacked and a pronounced pungent smell of decaying vegetable matter is given off. This characteristic odour is a helpful diagnostic character in identifying the disease. The fungus forms a whitish layer on the infected host tissue consisting of sporangiophores bearing sporangia in large number. In dry weather this growth is scanty or even absent and the disease area turns darker and may become dry, blackened and shriveled. With the return of favourable conditions the fungus becomes active and the corresponding symptoms reappear.

Fig. 10.13 : Late blight of Potato : (A) Infected leaf, (B) Infected potato tuber, (C) Sporangiospore with sporangia passing through stomata, (D) T.S. of infected leaf showing sporangiapores passing through stomata, (E) A sporangiospore with sporangia

The underground parts, especially tubers are also affected. A brown to purple discolouration of the skin followed by brownish dry rot extends to about ½ inch below the surface of the affected tubers. The dry rot does not soften the tissues, but causes rusty brown markings just below the skin and extends inwards for a variable distance in an irregular fashion. In moist atmosphere, white tuft of mycelium and sporangiophores of the fungus appear on the surface of the infected tubers which may decay even before harvest.

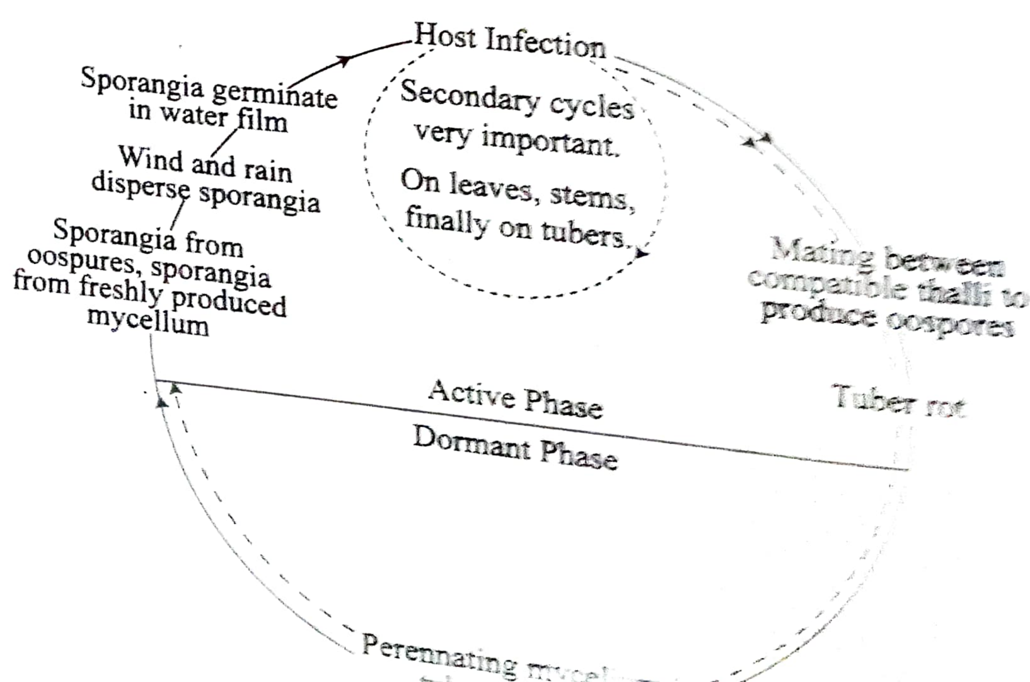
The loss due to late blight is of two types: actual reduction in the yield due to attack on foliage and stem and damage to tubers and/or if the foliage and stems are blighted before the crop matures the tubers are prevented from reaching normal size and the yield is reduced proportionately.

Causal Organism

The disease late blight of potato is caused by *Phytophthora infestans*. The mycelium of the pathogen ramifies in the host tissue both intra and intercellularly. It produces rudimentary haustoria in foliage cells but in tuber cells haustoria are more elaborate, club-shaped, hooked or spirally twisted. The sporangiophores arise directly from the internal mycelium, emerging from the leaf through the stomata in groups. In the tuber they may arise from the lenticels or from the abrasions in the rind. The sporangia are colourless, papillate, lemon-shaped. In favourable conditions, the sporangia germinate to produce biflagellate secondary zoospores. After a swarming period they come to rest and germinate by germ tubes which penetrate through stomata or directly through epidermis. Otherwise sporangia behave like conidia and directly germinate by germ tubes. Sexual reproduction is oogamous as a result of which oospores are formed. The fungus is heterothallic.

Disease Cycle of Casual Organism

Primary inoculum of the disease in the field comes from the planning of the infected tubers and from oospores in the previous year's plant debris. On planning the diseased tubers, the enclosed mycelium renews active growth, passing into the tissues of the young sprouts chiefly between the cells of cortex and producing sporangiospores and sporangia on the sprouts above the ground if the weather conditions are favourable. The most favourable temperature for the production of sporangia is between 18°C and 22°C and the humidity should be about 97 per cent. The rate of mycelia growth in the host tissues is directly proportional to the water content of the host tissue. The law amount of nitrogen also favours the mucelial growth. The sporangiospores emerge through the stomata or through the epidermis. On the tubers they mainly arise from lenticels or broken rind.



If the weather conditions are favourable, the sporangia as condia and germinate directly to produce germ tubes. These constitute the secondary inocula. The germ tubes from oospores or from sporangia enter the host tissue through stomata or even penetrate the unbroken epidermis. In tuber infection, the entrance is probably through lenticels. These induce host infection and secondary cycles. During sexual reproduction oospores are formed which constitute primary inoculum for next year's crop.

Control Measures

1. **Sanitary Measures :** Previous year's plant debris should be thoroughly removed to cut the source of primary inoculum.
2. **Use of diseased free seeds :** Since the pathogen parennates as mycellium in the tuber, seed tubers should be used raised from disease free fields.
3. **Improvement of storage of seed potato :** Seed tubers should be disinfected with 0.1 percent mercuric chloride immediately after harvest. They should be stored at 40°F and in dry, well ventilated place.
4. **Soil Management :** (a) Frequently earthing-up of growing crop at four to six inches ridging diminishes the risk of tuber infection. (b) Sparying of soil with 10 to 20 percent sulphuric acid or 5 percent of copper sulphate cuts down the infection rate.
5. **Use of fungicides :** The best method of control of the disease incidence is foliage sparying with suitable fungicides before appearance of the disease and when plants are 6 to 8 inches tall or about 6 weeks old. Spraying should be repeated every 10 to 15 days. Bordeaux mixture is the most effective spray material. Commercial copper fungicides such as cupravit, Fycol 8E, Blitox-50, etc., are also used in foliar spray. These can be replaced by more effective fungicides such as Dithane D-14, Dithane Z-78 and Dithane M-22.
6. **Use of resistant varieties :** Potato varieties in which *demissum* resistance has been fixed produce prominent results.

LICHENS

Theophrastus coined the term 'Lichens'. The lichens are associations of fungi and algae which have formed a new morphological entity completely different from either of their separate components. The term 'Lichenized Fungi' is often used synonymously with lichens to reflect the fact that the greater part of the mass of the most lichen thalli is composed of fungal hyphae with algae restricted to a thin layer near the surface. The fungal component of an association is called the **mycobiont** and the algal component is called the **phycobiont**. The relation between the two partners is **symbiotic**. Both the partners derive mutual benefit from their close association. The fungal partner derives food from the algal partner while alga gets moisture and shelter from the fungal partner. Many lichens grow in habitats where neither the alga nor the fungus could grow alone. The lichen association seems to have developed a physiological system to scavenge essential minerals as well as organic requirements from its nutrient-poor habitats like rocks and tree trunks, where other forms of life are unable to gain foothold.

The algal component in the association generally belongs to Cyanophyceae or Chlorophyceae. Algal plant may be filamentous or non-filamentous. In most of the lichens the alga is unicellular. Common Cyanophycean algae found in association are *Nostoc, Stegonema, Rivularia* and *Gloeocapsa*. The unicellular green alga (Chlorophyceae) is *Trilouxia*. The fungal partner is generally an Ascomycetae. Only two or three genera of Basidiomycetae form the fungal component of lichen thallus.

The systematic position of Lichen has been a controversial problem. This is because of the different evolutionary line of two partners the alga and the fungus. Later, few Botanists included lichen in Eumycophyta while **Smith, Bold,** etc.; suggest a separate group.

Nature of the association

There are different views regarding the nature of the algal and fungal association.

According to one school of thought, the alga is a mere victim of the fungus, i.e., the fungus lives as a **parasite** on the alga. The parasitism is of a mild nature and hence the algal cells survive. This view is supported by two facts. The first fact is that the fungal hyphae in some lichens give out haustoria, which penetrate the algal cells and absorb food material. The second fact is that when the partners of the lichen are separated, the fungal partner perishes but the algal partner survives.

The second school of thought believes that both the partners benefit in the association and hence this association is **symbiotic**. The rhizoids of the fungus absorb water and minerals from the substratum. This is passed on to the algal cells. The algal cells photosynthesize and prepare organic food material (carbohydrates), which is passed on to the fungal partner. The algal cells also get shelter and protection. This hypothesis of mutualism is supported by autoradiography. In this experiment 14C-labelled Sodium bicarbonate provides the source of carbon dioxide for photosynthesis. The carbohydrate having 14C was first found in algal cells and after sometime in the fungal hyphae. This indicates the passage of material from the alga to the fungus.

There is one more view. According to this view the relationship is symbiotic but the fungal partner has an upper hand. This is described as **helotism**.

Classification of Lichens

The classification of Lichens is based on the nature of fungal elements and kinds of fructifications, or on the basis of habitats.

On the basis of fructification, Lichens are classified into two groups (1) **Ascolichens** and (2) **Basidiolichens** (**Hymenolichens**). In an **Ascolichen**, the fungal partner belongs to **ascomycetae**. The algal components belong to two main divisions of algae, namely Cyanophyceae and Chlorophyceae. The ascolichens are further divided into two groups depending on the types of ascocarp (a) **Gymnocarpeae** in which the ascocarp is an apothecium, and (b) **Pyrenocarpeae** in which the ascocarp is perithecium type. In **Basidiolichen**, the fungal partner belongs to **Basidiomycetae** and particularly to Thelephoraceae. The algal partner belongs to Cyanophyceae. The lichen thalli appear like small, thin bracket fungi.

On the basis of habitat, the lichen fall into various categories:

a) **Arboreal (Corticoles) :** They grow on wood, barks and leaves as epiphytes.

b) **Terricolous :** They grow on grounds.

c) **Saxicolous :** They are found on rocks.

d) **Omnicolous :** They exist in most varied habitat, and

e) **Localized :** Communities.

Distribution (Occurrence)

Lichens are one of the most widely distributed groups of the plants. They are found in region from far north to far south. They are equally at home in equatorial forests. Lichens are found on rocks, tree trunks, fences, roofs and in water. Few lichens are marine. *Verrucaria* is a marine lichen which forms a distinct black band above the high tide mark. They are also found in the arctic region on frozen ice.

In India, they are found all over Himalayas. They are also found in the higher hills of Peninsular India. Plenty of lichens with beautiful colours are found in Darjeeling and Gangtok (Sikkim). In Maharashtra, lichens are found in hill stations like Mahabaleshwar.

External Thallus Structure of Lichens / Types of lichens

The plant body is thalloidal having irregular shape and greenish colour. Some of the thalli are strongly pigmented and appear red, yellow or orange in colour. There are three types of lichen thalli. They are : (1) Crustose (crustaceous) (2) Foliose (foliaceous) and (3) Fructicose lichen.

Crustose lichen

The thallus of crustose lichen is flat, thin and of insignificant size. It is just a crust (thin layer) closely attached to rocks or barks by its entire lower surface. The surface of the thallus is divided into hexagonal areas called the **areolae**; e.g., *Graphis*, *Rhizocarpon*, *Haematomma*, etc.

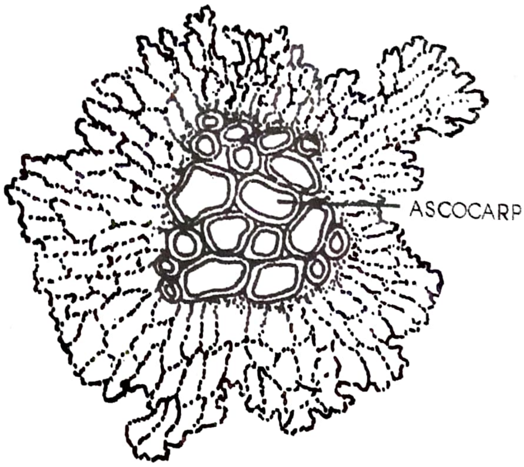


Fig. 10.15 : Crustose lichen

Foliose lichen

The thallus is leaf-like, flat, broad and much lobed. It has distinct upper and the lower surfaces. The lower surface is sooty or white in colour. The thallus is attached to rocks and twigs by rhizoid-like outgrowths called the **rhizinae.** The free ends of rhyizinae often broaden to form disc-like structure which secret mucilage; e.g., *Physcia*, *Peltigera*, *Parmelia*, etc.

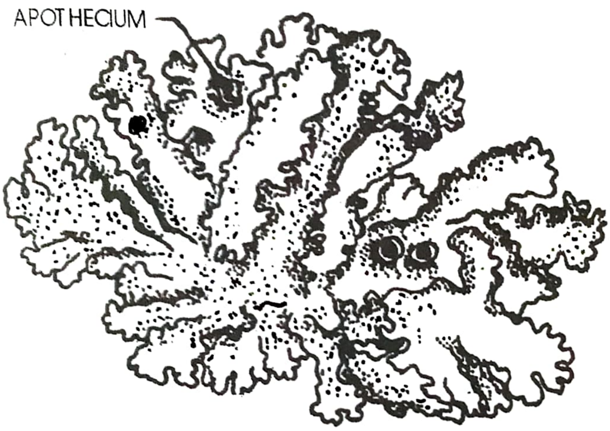


Fig. 10.16 : Folise (Foliaceous) lichen

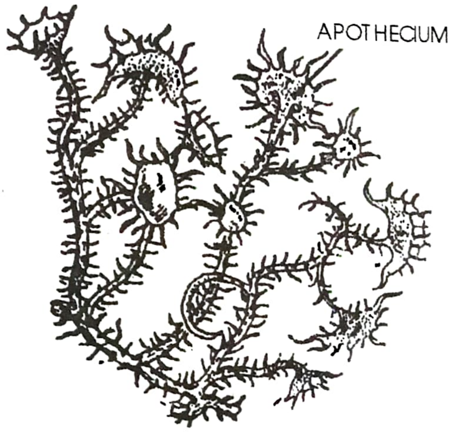


Fig. 10.17 : Fruticose lichen

Fruticose Lichen

The thallus is conspicuous, complex and much branched. The branches are slender, cylindrical and ribbon-like. The thallus is attached to the substratum only at the base by a flattened disc. The thallus shows no differentiation of upper and lower surfaces; e.g., *Usnea*, *Cladonia*, *Evernia*, etc.

Internal Thallus structure of Lichen

The structure of lichen thallus on the basis of its internal structure, is divided into two groups viz., (1) Homoiomerous and (2) Heteromerous.

Internal Structure of Homoiomerous Thallus

The thallus of fruticose lichen exhibits a simple structure with little differentiation. It consists of loosely arranged fungal hyphae in which algal cells are equally distributed throughout; e.g., *Collema*, *Leptogium*.

Internal Structure of Heteromerous Thallus

The thallus belonging to this category exhibits considerable differentiation. The algal component is restricted to a specific region. If the vertical section is observed, the thallus can be distinguished into four zones. They are : (a) Upper cortex, (b) Algal zone, (c) Medulla and (d) Lower cortex.

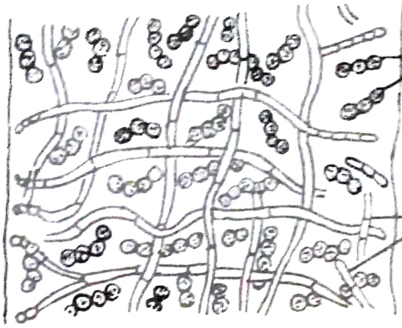


Fig. 10.18 : Internal structure of homoiomerous thallus

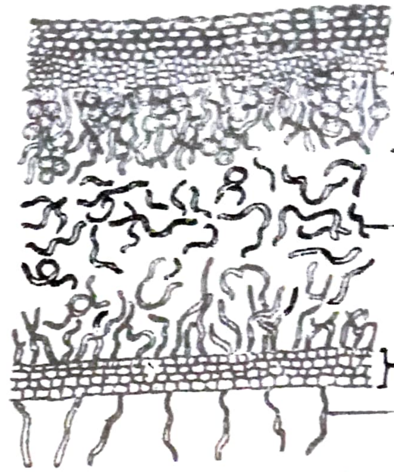


Fig. 10.19 : Internal structure of hetermerous thallus

a) **Upper cortex :** It forms the upper surface of the thallus. It is thick and protective in nature and consists of fungal hyphae. The fungal hyphae are compactly interwoven to produce a tissue-like layer (plectenchyma) without any intercellular spaces.

b) **Algal zone :** It is a zone beneath the upper cortex and is formed of algal cells belonging to Cyanophyceae or Chlorophyceae intermingled with the fungal hyphae. The algal region is the photosynthetic region of lichen. Earlier it was known as gonidial layer. In some species the fungal hyphae send haustoria into the algal cells.

c) **Medulla :** It is the central core of the thallus consisting of loosely arranged fungal hyphae with intercellular spaces. The hyphae run parallel to the long axis. The walls of hyphae are strong and thick.

d) **Lower cortex :** It is formed of densely grouped hyphae which run perpendicular to the surface. The bundles of hyphae (rhizinae) arise from the lower surface and penetrate the substratum functioning as anchoraging and absorbing organs. In some lichens the lower cortex is absent and its place is taken by a sheet of hyphae forming hypothallus.

In certain foliose lichens, the upper cortex is interrupted at intervals by breathing pores. In this region the fungal hyphae are loosely arranged and are medullary in nature. The main function of breathing pores is aeration.

Special Structures

a) **Cyphella :** These are cup-like structures present on the lower side of some foliose lichens. Their function is aeration. These cup-like structures are formed of loosely arranged fungal hyphae which are medullary in nature. The hyphae abstrict empty, rounded cells in a spore-like manner at their tips.

b) **Cephalodia :** These are small, dark-coloured gall-like swellings. Present on the upper surface of the lichen thallus. cephalodium contains same fungal hyphae as in the thallus but the algal component always differs; e.g., *Peltigera*.

c) **Isidia :** These are small finger-like outgrowths on the upper surface of the thallus and are meant for increasing the surface area for photosynthesis. Isidia have the same fungal and algal components as those of the thallus. The isidia vary in form in different lichen species. They may be rod-shaped (*Parmelia*), corolloid (Coral-like, *Peltigera*), cigar-shaped (*Usnea*), etc.

d) **Soredia :** are small granule-like or bud-like outgrowths on the upper surface of the thallus. Each soridium is formed of one to a few algal cells surrounded by closely arranged fungal hyphae which are produced by branching of a hypha from the algal region.

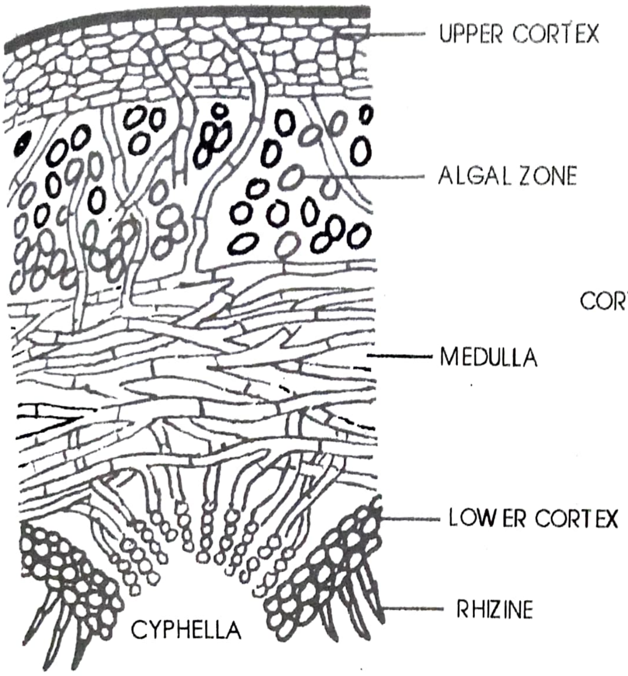


Fig. 10.20 : V. S. of thallus showing cyphella

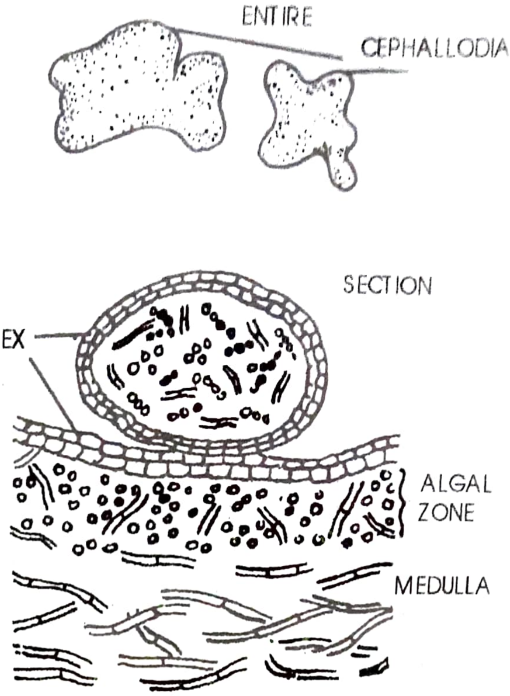


Fig. 10.21 : V. S. of thallus showing cephalodium

e) **Soralia :** These are found in more advanced lichens. These are pustule-like structures and are seen as white area on the upper surface of the thallus. Their structure is similar to that of soredia.

Isidia, soredia and soralia are detached from the parent plants, carried away by wind or rain and on being deposited on suitable substratum, germinate to give rise to new lichen thalli.

Reproduction

The reproduction is vegetative, asexual and sexual.

Vegetative Reproduction

Vegetative reproduction is by fragmentation. Fragmentation is accomplished either by accidental separation or by death and decay of older portions. The broken off portions of thallus develop into new lichen thalli provided they have both the components.

Asexual Reproduction

a) It is by the formation of special reproductive structures called soredia, soralia and isidia, which possess both the partners of the thallus. They are detached from the parent plants, carried away by wind or rain and on being deposited on suitable substratum, germinate to give rise to new lichen thalli.

b) Many lichens produce conidia in pycnidia immersed in the thallus. The conidia are dispersed and under favourable conditions germinate to send out hyphal branches in all the directions. If these hyphae come in contact with the appropriate algal cells, they branch further and ultimately produce lichen thallus.

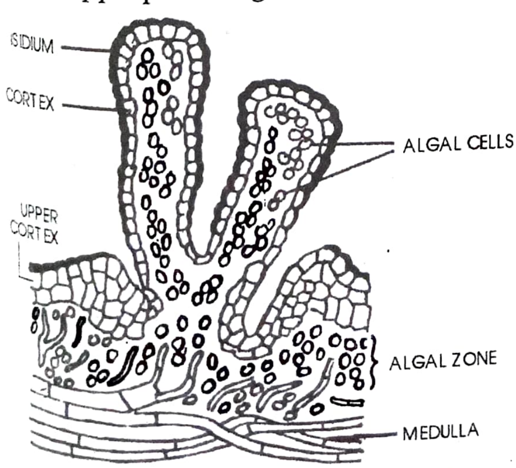


Fig. 10.22 : V. S. of thallus showing isidia

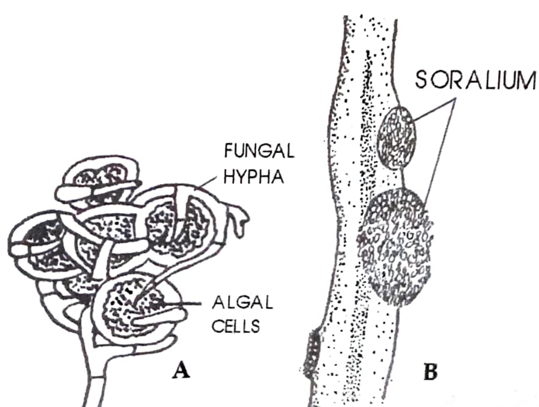


Fig. 10.23 : (A) Soredium, (B) Soralium

Sexual reproduction

Sexual reproduction is present only in the fungal partner of the association, and typical of Ascomycetae.

The male reproductive organ is called **speromogonium** and the female **carpogonium**. The spermogonia are developed as flask-shaped cavities on the upp surface of the thallus. Each spermogonium opens outside by an ostiole. The inner walls the cavity develop a number of branched or unbranched, septate or aseptate hyphae few of them are sterile and a few are fertile. Fertile hyphae are called **spermatiophores** From the tips of the sermatiophores, **spermatia**, the non-motile male cells devel continuously. The carpogonium consists of basal coiled portion, the **ascogonium** straight upper portion, the **trichogyne.** It is projected beyond the upper, surface of thallus. It is multicellular and it tip is stickly. The ascogonium is embedded in the thall of varying depths near the cortical region. It is also multicellular and each cell is uni multinucleate.

Spermatia on dissemination come in contact with the tip of trichogyne. The conta wall between the two dissolves and nucleus from spermatium migrates into the cell trichhogyne. This nucleus migrates down to the ascogonium.

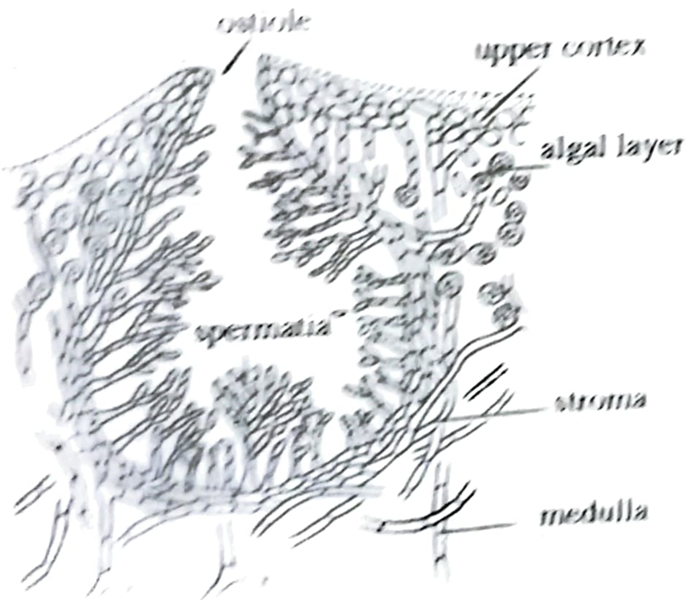


Fig. 10.24 : V. S. of thallus showing spermogonium

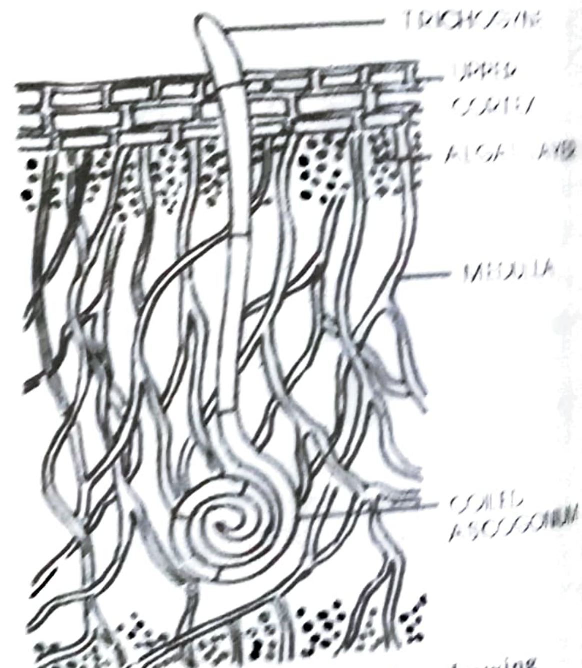


Fig. 10.25 : V. S. of thallus showing carpogonium.

After fertilization, the cells of the trichoghye get collapsed and numerous ascogenou ... fertilized cells of the ascogonium. The penultimate cells of the ... similar to that in highe

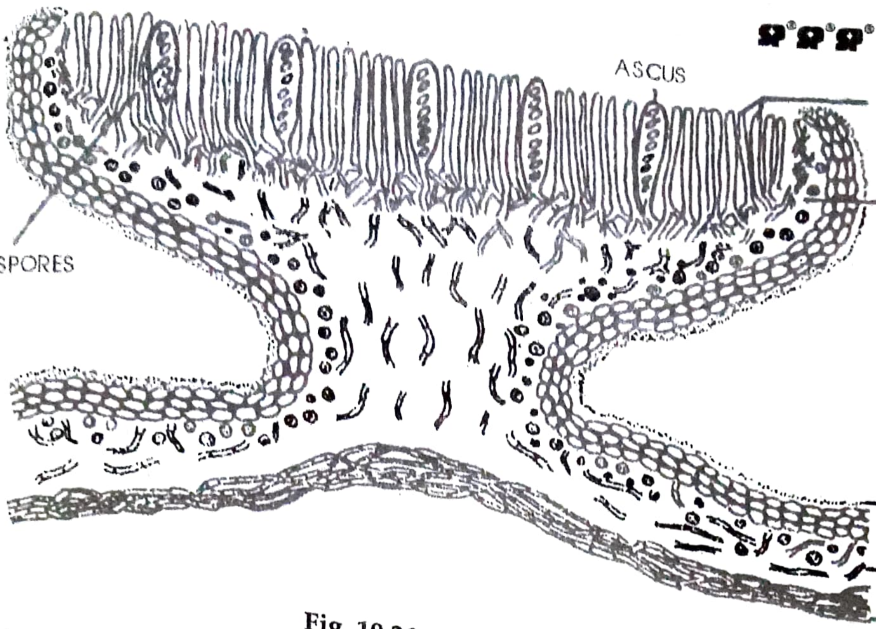


Fig. 10.26 : V. S. of apothecium

...sidiolichens

The fungal partner of basidiolichens belongs to Basidiomycetae and particularly to ...elephoraceae. The algal partner belongs to Cyanophyceae. The thalli appear like small ...d thin bracket fungi.

The cortex is generally absent. The algal cells are present at the base of the upward ...anches and are surrounded by thin walled, short celled hyphae which are interwoven ...to a kind of cellular tissue.

The medulla is formed of loose hyphae. The medulla hyphae pass over to the lower ...rtex producing uneven lower surface. The spores are formed from the lower surface ...ogenously from the basidia. The continuous layer of basidia is known as hymenial layer ...fertile layer. Each basidium develops four sterigmata. Each sterigma produces single ...sidiospore.

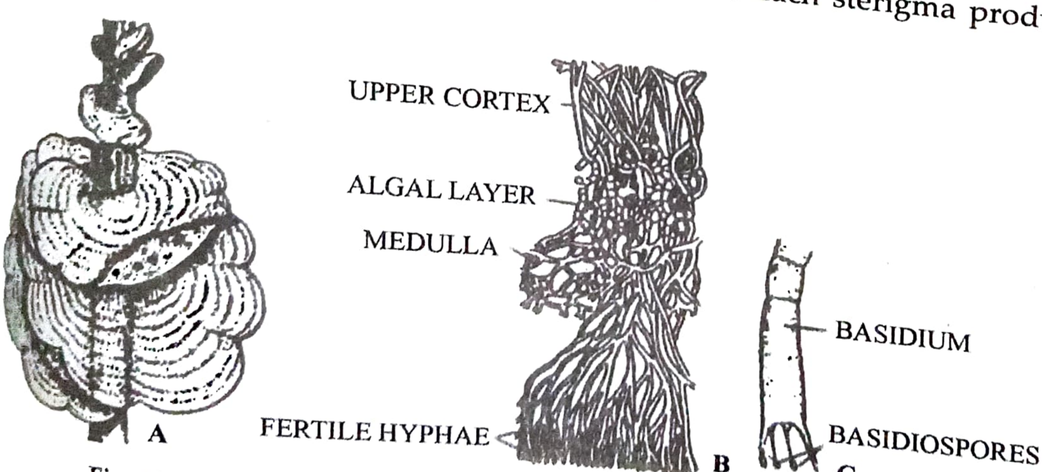


Fig. 10.27 (A) A Basidiolichen thallus of *Cura pavonia*; (B) Section of thallus; (C) Basidium with basidiospores.

...onomic Importance of Lichen

Food

Certain species of lichen (*Cladonia, Peltigera, Certaria sp.*) in the Arctic regions are used ...fodder for reindeers and caribou. They are also known as reindeer moss. Some species ...lichens are also used as food by man. The Berber tribe in the deserts of Libya grazes ...ir sheep on crustose lichens (*Lecanora*).

Lichens contain **lichenin**, a carbohydrate very much similar to starch. But no true ...rch or cellulose is present in the lichen thallus. *Cetraria islandica*, the commercial

'Iceland Moss' supplied from Sweden, Norway or Iceland is used as food by man. After removing the bitter principle by soaking in a weak solution of sodium or potassium carbonate, it is dried and reduced to powder. The powder, when boiled in water, yields a jelly which forms the basis of various soups or other dishes prepared by boiling in milk. The Egyptians have used *Evernia prunasi* in baking, when yeast as fermentative agent was not known to them. In India, a species of *parmelia* (rock flower) has been used as food generally prepared as curry by the natives. It is also used in condiment. In Japan, *Endocarpon miniatum* which they name in English as 'stone mushroom,' is sold in the market like vegetables.

2. Medicinal Use

Lichens owe their repute as curative herb to the presence of lichenin and of some bitter or astringent substances, which, in various ailments, proved of real service to the patient, though they have now been discarded in favour of more effective drugs. Various medicinal benefits of lichens have been ascribed since Pre-Christen times. Lichens have been used in the treatment of jaundice, diarrhoea, fevers, epilepsy, hydrophobia, and skin disease. In Iceland, lichen is used as laxative. Lichen is also used as an ingredient in culture media for bacteria. Several species of *Pertusaria, Cladonia* as well as *cetraria* were recommended in case of interminttent fever; species of *Usnea* were used as astringents in hemorrhages; and *Cladonia pyxidata* was found especially valuable in whooping cough. *Lobaria pulmonaria* is used for the treatment of lung diseases. Many of the lichen products are antibiotic in nature. Gram negative bacteria (rod-shaped), as a rule, are resistant to all lichen acids, but gram positive bacteria and *Tuberculosis bacillus* are inhibited by Steric acid, Usnic acid, etc. Usnic acid is widely used in European countries as a chemotherapeutic drug for external application.

3. Perfume

The extract of *Evernia, Parmelia* and *Ramalina* species contain various essential oils that are used extensively as soap-scents, perfume and dhoop (incense). Oak moss (lichen) is used as a fixative for perfumes in southern Europe. The thalli of species of *Usnea* possess the power of retaining scent, and are profitably utilized in perfumery. Powdered thallus of *Ramalina calicaris* is often used in perfumery.

4. Preparation of Dyes

Some lichens produce dyes that have been used since Pre-Christian times, for colouring fabrics and paints; among them is Orchil a beautiful blue dye. The value of *Roccella* as a dye yielding lichen has been recognizes from the time of **Theophrastus.** The product extracted from its thallus was called **orseille** for which the English name is orchil or archil and **orcein** is a purified product of orchil. Litmus solution is made by grinding the lichen *Roccella tinctroria*, and extracting the coloring matter, after which paper is soaked in the neutralized solution and is then known as litmus paper.

Ecological Importance of Lichen

The ecological importance of lichens is twofold as described below :

1. Pioneer initiators of rock vegetation

Lichens are of considerable ecological significance as pioneers in colonization of rocky habitats. In adverse conditions of temperature and water, the lichen thalli become dry and contract. In rainy season, they absorb water and grow in bulk occupying more space. This causes pressure on the rock and after a long time the rock gives away and breaks. Besides lichens secrete some organic acids, which gradually dissolved the rock and disintegrate it. This further help in soil formation. Carbon dioxide liberated during respiration of lichens get dissolved in water, forming cabonic acid. It corrodes the rock surface and adds to the process of weathering. The crustose species of lichens such as *Rhizocarpon, Lecanora* are subjected to this struggle.

lichens indicates the pollution in the atmosphere.