

## CRYPTOGAMS

- Flowerless or seedless plants
- Lower and more primitive plants
- 3 main groups i.e. Thallophyte, Bryophyte and Pteridophyte
- Thallophytes include: Algae, fungi, Bacteria and lichens
- Bryophytes include liverworts, horned liverworts and mosses
- Pteridophytes include ferns and their allies.

### Reproduction

- Members may take one or more of 3 methods of reproduction including vegetative, asexual and sexual
- Vegetative by cell division or fragmentation
- Asexual is through production of various types of spores
- Sexual takes place by fusion of two gametes
- Degree of sexuality passes through progressive stages including isogamy, anisogamy to oogamy
- Isogamy takes place in primitive cryptogams where two gametes of similar shape, size and behavior (isogametes) occurs
- In anisogamy the two gametes, may be slightly different in size and behavior (Anisogametes)
- In advanced cryptogams the two gametes become differentiated into male i.e. microgametes or antherozoids as spermatozoa and the female i.e. megagametes, the egg cell or oosphere or ovum
- The egg cell is housed in structures including oogonium
- The antherozoids are housed in antheridium
- In oogamous cryptogams, the male gamete is usually small, ciliated or flagellated, active and initiative
- The egg cell is large, non-motile, non ciliated, passive and receptive
- Alternation of generation occurs in higher algae, liverworts, mosses, ferns and related pteridophyte
- Here, life history is completed in two alternative stages or generations
- These two generations differ in both morphological characteristics and mode of reproduction
- One generation i.e. the sporophytic generation or asexual generation reproduces asexually by means of spores
- While the other generation, i.e. the gametophytic or sexual generation reproduces by means of male and female gametes.
- To complete the life cycle, one generation gives rise to the other i.e. the gametophyte to sporophyte and the sporophyte to the gametophyte
- The gametophyte is  $n$  (haploid) while the sporophyte is  $2n$  (diploid)
- At the time of reproduction meiosis occurs in the sporophyte to produce haploid ( $n$ ) spores
- The spores germinate and develop into haploid ( $n$ ) gametophyte
- Therefore the spores represent the beginning of the gametophytic generation
- Each of the haploid gametes (male & female) from the gametophyte fuse to form the ( $2n$ ) zygote
- The zygote develops into the sporophyte
- The zygote therefore is the beginning of the sporophytic stage

## **ALGAE**

- Green thallophytes containing chlorophyll
- Other algae except the green algae have characteristic pigment in addition which often masks the green pigment
- They are autotrophic plants
- The body of an algae is composed of true parenchymatous tissue
- Cell wall is composed of true cellulose
- Algae live in water as well as in wet substrata
- Reserve carbohydrate is starch

## **CLASSIFICATION**

### **CLASS**

- Myxophyceae or Cyanophyceae: blue green algae e.g Nostoc, anaebena
- Euglenophyceae (Euglenoids) e.g. Euglena
- Chlorophyceae: green algae volvox, chlamydomonas, spirogyra, zygnuma
- Bacillariophyceae or golden-brown algae e.g. Diatoms
- Phaeophyceae or brown algae e.g fucus, laminaria, sargassum
- Rhodophyceae or red algae e.g. Rhodophyceae

### **CHLOROPHYCEAE**

- Presence of chlorophyll in definite plastids
- Mostly fresh water algae. Marine and terrestrial forms exist
- Exhibit variety of forms e.g. (i) unicellular, motile or non-motile (ii) multicellular either filamentous or thaloid (iii) Coenocytic
- Well organized protoplast with definite nucleus and one or more distinct chloroplasts of varying shapes
- Shape of chloroplast range from cup-shape, plate, stellate, spiral, oval, spherical with one or more pyrenoid. These are rounded protein bodies surrounded by starch cover.
- Cell wall made of cellulose with a layer of pectose
- May have gelatinous sheath or proof
- Unicellular and colonial forms have cilia or flagella
- These are restricted to the zoospores and zoogametes

### **REPRODUCTION**

- (1) Vegetative reproduction by cell division or fragmentation
- (2) Asexual reproduction by spores of various types (i) Aplanospore-non ciliate, non motile, spore produced from within the mother cell with a distinct wall of its own (ii) zoospores motile ciliate spores (iii) Akinete or modified vegetative cell acting as a spore having no wall of its own but the wall of the mother cell.

(3) Sexual reproduction

- By isogamy, anisogamy or oogamous. Some species are homothallic (i.e pairing gametes come from one parent) while others are heterothallic (i.e pairing gametes come from separate parents)  
Gametes can grow parthenogenetically into a new plant without fusion with another gamete. In this case the gamete behaves as a spore called parthenospore or azygospore. Gametes may have no cilia in some species such as spirogyra. This is called aplanogamete
- A complete differentiation of gametes and gametangia into male and female is found in advanced green algae. The union of such differentiated gametes is called oogamy. The gametangia are simple celled.

### CYANOPHYCEAE

- Small group of primitive algae
- Have blue pigments i.e. phycocyanin in addition to chlorophyll
- Simple body and construction
- Not clearly differentiated protoplast
- Simple method of reproduction
- Unicellular to filamentous to colonial forms abound
- Fresh water dwellers often in stagnant water, wet ground
- In cell structure, no definite nucleus, no plastids
- Protoplast differentiated into a peripheral coloured zone, i.e. the chromoplasm
- And inner colourless portion i.e. central body
- Cell wall is of cellulose and pectic substances
- Carbohydrate is in form of glycogen. Starch is absent
- Cells are enveloped in gelatinous sheath which makes them shiny
- No sexual reproduction and no ciliated body
- Common form of reproduction is cell division in unicellular ones and breaking up of the colony in colonial forms and fragmentation of filament into shorter pieces called hormogonia
- Akinete, a vegetative cell acting as resting spore may occur in filamentous forms e.g. *Anaebena*
- Within the vegetative body, the Heterocyst, one or more enlarged vegetative cells with transparent contents and thick walls may be seen in filamentous forms such as in *Anaebena* and *Nostoc*
- Blue green algae are supposed to have originated from non-ciliate, unicellular ancestors
- Cyanophyceae seems to be related with bacteria with some characteristics in common
- Gelatinous sheath may be present or not
- Most unicellular forms have 2-4 cilia for cell motility
- Cilia in chlorophyceae algae are of uniform length especially in lower members
- In higher members the cilia are restricted to the reproductive bodies i.e. zoospores and zoogametes

## REPRODUCTION

### (i) Vegetative Reproduction

By cell division or fragmentation

### (ii) Asexual Reproduction

- By means of various spores
  - (a) zoospore (motile, ciliate spores)
  - (b) aplanospore (non-motile, non-ciliate) with a distinct wall produced within a mother cell
  - (c) akinete (vegetative cell acting as a spore with no wall of its own the wall of the mother cell acts as the wall of the spore)

### (iii) Sexual reproduction

- By isogamy, anisogamy or oogamy depending on the species
- Some species are homothallic (i.e. pairing gametes is from the same parent) while some are heterothallic (i.e. pairing gametes come from two separate parents)

## PATHENOGENESIS

- Gametes can grow parthenogenetically (without fusion with another gamete) into new plants
- Therefore gametes can behave as a spore type called parthospore or a zygospore
- Some times as in Sprogyra the gamete has no cilia (i.e. aplanogamete)

## BACILLARIOPHYCEAE (Golden Brown Algae)

### General Description

Bacillariophyceae, commonly called Diatoms constitute a big isolated group of mostly one celled algae. They are of many beautiful forms. The simple ones may occasionally form filaments and colonies.

- Universally distributed in fresh and salt water and wet ground
- In some oceans of the world, they exist in large assemblage as floating plankton
- Mostly free floating

### STRUCTURE:

- May be boat shaped, rod-shaped, disc shaped, wedge shaped, spindle shaped, circular, oval or rectangular etc
- Wall made of 2 halves (valves)
- The outer epithelia (older) fits closely over the other (younger) hypothelia just like a soap case
- Valves made of pectin impregnated with silica

- There is ornamentation of fine dotted lines characteristically on the diatom valves
- The diatoms could be (i) centric diatoms (centrates) common in the ocean or (2) elongated or pinnate (pennates) which are fresh water dwellers
- There are ingrowth of walls called nodules. There are central modules & polar modules according to their position
- A longitudinal line or raphe or slit extends from the central to polar module in many diatoms
- Streaming cytoplasmic movement of the cytoplasm occur along the raphe
- The protoplasm is thin peripheral layer lying first within the cell wall
- Golden-brown plastid of various shapes and sizes and centrally suspended nucleus occur in the cell with a conspicuous central vacuole. The colour is due to the presence of a golden-brown pigment called diatomin in addition to chlorophyll
- The reserve food is fat globules and some organic complex called volutin. No starch is formed in diatoms

## REPRODUCTION

Diatoms may reproduce vegetatively by cell division, asexually (by auxospores) and sexually by conjugation of gametes

### VEGETATIVE REPRODUCTION

- Protoplast grows followed by separation of two valves
- Each of two half cells form a new valve against the old one fitting into it
- Division and valve formation continues. The auxospores which are special kinds of cell help in reproduction
- The auxospores may be formed in variety of ways
- Auxospores can divide into two with each acquiring new valves
- Protoplast divides with two thus acting like an auxospores each daughter auxospores acquire new valves

### SEXUAL

- At times protoplast from two cells escape and fuse to form a zygote. This later behaves as auxospores
- Two contiguous diatom cells form two gametes each. These fuse in pairs forming two zygote which act as auxospores. The auxospore grows and help the diatoms return to its original size

## FUNGI

- (i) Myxcomycetes – slime fungi
- (ii) Phycomycetes – alga-like fungi
- (iii) Ascomycetes – sac fungi
- (iv) Basidiomycetes – club fungi
- (v) Deuteromycetes – fungi imperfecti

### GENERAL CHARACTERISTICS

- Group of thallophytes lacking chlorophyll but may have other pigments in the cell wall
- Have infinite variety of shapes and sizes
- Lead a heterotrophic mode of life either as saprophytes or parasites
- Carbohydrate stored in form of glycogen
- Fungal parasites are either obligate (entire life on host) or facultative
- They live on host and can live a saprophytic life e.g. smuts
- The plant body is made of interwoven mass of hyphae collectively called mycelium with few exceptions
- The wall of firm is of chitin or prune cellulose

## REPRODUCTION

### Vegetative Reproduction

- By means of (i) fragmentation of the body of fungus or (ii) detachment of part of it (iii) or budding or in some cases (iv) through special bodies called sclerotium (this is a compact often hard and rounded, mass of hyphae occasionally with dark outer fruit covering without any spore. They are of different sizes) which give rise to mycelium or fruit-body

### Asexual Reproduction

- Takes place by means of spores of varying nature including: Ciliate spores or zoospores
- (i) Ordinary spores in large numbers in a case called sporangium
- (ii) Conidia formed singly or in chains by specialized hyphae or conidiophores at their tip by abstractions
- (iii) Chlamydo spores thick-walled resting spores formed singly or in chains by certain vegetative hyphae (these are transformed to vegetative cell)
- (iv) Oidia – short segments of vegetative hypha functioning as spores
- (v) Ascospores – mostly 8 in number and formed in a sac or ascus
- (vi) Basidiospore – spores usually 4 in number formed externally by a club-shaped basidium or short slender stalk called sterigmata

Sexual reproduction

Goes through 3 distinct places

(i) Plasmogamy:

- Fusion of two protoplast mostly without fusion of the two nuclei involved
- Two haploid nuclei of opposite sexes are brought together in one cell (called dikaryon). This is a dikaryotic condition.
- Dikaryotic condition may persist for sometime as in higher fungi or the two nuclei (+ -) may fuse immediately as in lower fungi

(ii) Karyogamy

- Fusion of the two nuclei (+ -) of a dikaryon resulting in a diploid (2n) zygote nucleus
- Meiosis follows sooner or later to revert to haploid condition

(iii) With the development of gametangia, sexual reproduction may be isogamous or oogamous or anisogamous

### CHARACTERISTICS OF MAIN GROUP

(1) **Phycomycetes** (i) oomycetes (Biflagellate reproduction is oogamous e.g. *Pythium*, *Phytophthora*, *Peronospora*) (ii) zygomycetes reproduction is isogamous e.g. *Mucor*, *Rhizopus*

- uniseptate and coenocytic mycelium
- sporangia with many sporangiospores which may be zoospores or aplanospores
- sexual reproduction is oogamous in the oomycetes and isogamous in zygomycetes
- biciliate zoospores are produced by many species
- the zygote is unicellular and simple

(2) **Ascomycetes**

- Mycelium is septate. There are two types
- There is primary mycelium which is uni or multinucleate. Ascogenous hyphae—a secondary mycelium is always binucleate
- Conidia formation is common in the asexual stage
- Ascus usually with 8 ascospores
- Sexual reproduction is reduced to fusion of compatible nuclei (+ and -) i.e. karyogamy in the young ASCUS
- Gradual suppression of sex organs or gametangia
- Karyogamy immediately followed by meiosis resulting in 8 ascospores within ascus
- Motile cells absent
- The Ascocarp is the fruiting body. It bears the ASCI
- It is multicellular and complex
- Ascocarp is of three types

- (i) Apothecium – open either cup or saucer shaped
- (ii) Perithecium – oval or flask shaped with small apical opening
- (iii) Cleistothecium – completely closed
- Hook or crozier mechanism is common

### **(3) Basidiomycetes**

- Mycelium septate
- Primary mycelium is multinucleate while secondary mycelium is binucleate
- Conidia not common
- Basidium usually with 4 basidiospores formed exogenously
- Sexual reproduction is reduced to fusion (karyogamy) of two compatible nuclei (+ and -) in young basidium
- No sexual organ except spermatia and receptive hyphae in rusts
- Karyogamy immediately followed by meiosis resulting in 4 basidiospores borne exogenously by the basidium
- motile cells absent
- Basidiocarp (fruiting body) is multicellular and complex bearing basidia
- Basidiocarp is often open and sometimes closed
- The lower member such as the rusts and smuts have no basidiocarp
- Clamp connection is common

Hook or crozier method in ascomycetes and clamp connection in basidiomycetes bring together (dikaryotisation) the reproductive nuclei of two opposite structure.

### **HOOK OR CROZIER METHOD OF ASCUS FORMATION**

- Ascus is formed by hook or crozier method
- Tip of ascogenous hyphae elongates and bends over forming a sort of hook
- The ascogenous hyphae originates from ascogonium after pairing of nuclei male-female (dikaryotic condition)
- Ascogenous hyphae contains pair of nuclei received from the ascogonium
- Tip of hyphae also contains complementary pair
- These 2 nuclei undergo mitosis
- One pair of daughter cells lie close together near the bend
- While one nucleus, either male or female lies towards tip of hook and another lies toward the basal septum
- Two septa appear resulting in 3 cells
- The middle or hook cell is binucleate. This is the ascus mother cell
- The two other cells are uninucleate.
- Karyogamy i.e fusion of two nuclei takes place in the young ascus. The 2n zygote is formed.
- Meiosis takes place in the Ascus- mother cell resulting in the formation of 8 ascospores.

### **CLAMP CONNECTION**

- This mechanism is found in secondary mycelium which usually consists of binucleate cell
- The binucleate condition arises from fusion of two uninucleate cells of two primary hyphae without karyogamy
- Clamp connection is usually formed in terminal cells of the hyphae
- In some cases it occurs in mostly of the cells of the secondary hyphae
- A short branch arises between the nuclei forming a sort of hook (clamp cell)
- One nucleus passes into the clamp cell
- Both nuclei divide simultaneously
- The clamp cell bands area and its end touches the wall
- This bridge-like short connection (branch) is called clamp connection. Now, one nucleus of each pair approaches the other evidently passing through the bridge (t)
- A septum is formed at the base of the clamp cell and another septum below the bridge, thus separating a pair of nuclei one for each parent cell

### ***PHYTOPHTHORA INFESTANS***

- Fungal parasite of potato plants causing late blight disease of potato plants
- All parts of the plant including stem, leaves and tubers are susceptible
- Symptoms of the disease on potato include black patches (mostly at the undersurface) of leaves, wilting of leaves, tuber-rotting
- Other plants such as tomato, egg-plants are also susceptible to phytophthora attack
- The fungus structure is composed of uniseptate coenocytic mycelia that branches through the internal tissues of the leaves stems and tubers
- The mycelia possess haustorium or sucking parts by which the pathogen suck nutrients from the host tissue
- Special branched hyphae from the mycelial growth often grow out of the host tissue to the exterior especially through the stomata
- These special hyphae are the sporangiophores bearing as their tips oval shaped sporangia
- The plant reproduces asexually and seldomly sexual
- In the asexual reproduction, the whole sporangium which is dispersed by wind can germinate during the hot period or season by germ tube production which penetrates the host tissue
- At cold seasons the contents of the sporangium divide and produces many biciliate zoospores
- The zoospores swim and upon getting a host they lose their cilia and develop a germ tubes by which they can penetrate the host stoma
- Sexual reproduction in some cases-two separate hyphae can develop the oogonium (female reproduction organ) and club-shaped antheridium (male reproductive organ)
- The male nucleus from the antheridium fuses with egg-nucleus from the oogonium to form the vegetative hyphae after germination

- Heterothalism occurs in most fungi in this case sexual reproduction occurs only between two physiologically different hyphae behaving as two sexes. They are designated -strain (female) and + strain (male). The two hyphae are morphologically the same but the + strain grow vigorously more than the – strain.

However, in some fungi conjugation occurs between hyphae of some mycelium thus homothalism.

The gametangia of some species do not fuse during conjugation but develop directly parthenogenetically into the a zygosporangia

### **HOOK OR CROZIER METHOD**

The ascus in a majority of the ascomycetes is formed by the hook or crozier method. The tip elongates and bends over, forming a sort of hook. (b) The ascogonoid hyphae itself originates from the ascogonium after the pairing of nuclei (dikaryotic condition (a)). The ascogenous hyphae contains pairs of nuclei received from the ascogonium. In each pair, one nucleus is male and the other female. The tip of the hypha contains a complementary pair of nuclei (dikaryon). These two nuclei undergo mitotic division simultaneously with the two spindles standing parallel to each other in the vertical direction. (c) one pair of daughter nuclei (one male and one female) lies close together near the bend while one nucleus (either male or female) of one spindle lies towards the tip of the hook and another nucleus (of opposite sex) of the other spindle lies towards the basal septum of the ascogenous hyphae and another (d) now two septa appear, resulting in three cells. The middle or the hook cell is binucleate (one male and female). This is the ascus mother cell. The two other cells are uninucleate (one male and the other female). The binucleate ascus mother cell soon develops into Ascus. Karyogamy (fusion of the two nuclei) takes place in the young ascus and the zygote that is formed contains a diploid nucleus (e) the zygote nucleus undergoes division the first being meiotic (f). Usually division ceases when two nuclei are formed. Each nucleus closes itself with a wall and becomes converted into an ascospore. The ascus simultaneously grows and elongates, containing the ascospores (g) several asci may be formed from repeatedly branched ascogenous hyphae.

### **CLAMP CONNECTION**

This is a common feature in most types of basidiomycetes except the rusts. It is a special mechanism by which the sister nuclei of a dikaryon get separated into two daughter cells. This mechanism is found in secondary mycelia which usually consists of binucleate cells. The binucleate condition arises from the fusions of two uninucleate cells of two primary hyphae without, any karyogamy (i.e without fusion of nuclei). Clamp connection is usually formed in the terminal cells of the hyphae. In some cases however, it occurs in most of the cells of the secondary hyphae, and in some other only in some cells here and there. A short branch arises, between the nuclei forming a sort of hook (clamp cell). One nucleus passes into the clamp cell, and now both the nuclei divide simultaneously. The clamp cell bends one, and its end touches the wall. This bridge-like short connection (branch) is called clamp connection. Now one nucleus of each part approaches the other, passing

through the bridge. After this migration, a septum is formed at the base of the clamp cell and another septum below the bridge, thus separating a pair of nuclei, one from each parent cell.

## LICHENS

- The association of different fungi and algae give rise to distinct species
- They occur either as grayish-green, green-white or brightly coloured incrustations, one to several cm in diameter, on the stems and branches of shrubs and trees wooden posts, logs, rocks, stores, old walls and the ground, some may hang as tufts
- Many lichens grow under extreme conditions of humidity and temperature and may survive long periods of desiccation
- They are extensively distributed both in cold and hot zones especially in the tropical rain forests
- In lichens, fungi and algae live together in an intimate relationship leading to a symbiotic life. Fungi absorb water and mineral matter from the substratum and supply to the algae. The algae in turn prepare food and supply it to the fungi

Classification of lichens into two major groups depends on the nature of the fungi

(A) Ascolichens

- Fungi members are Ascomycetes reproducing by means of ascospores

(B) Basidiolichens

- Fungi members are Basidiomycetes

## THALLUS

The thallus of lichens have three growth patterns or forms namely (a) crustose lichens (b) foliose lichens (c) fruticose lichens

- (a) The crustose types form hard granular crusts and they adhere very tenaciously to rocks, barks of shrubs and trees and also certain soils. E.g. *Gyrophysa* species and *Lecanora* species
- (b) The foliose types form definite, flattened leaf-like thalli with lobed margins and adhere to walls of tree trunks, rocks and ground by means of delicate rhizoids (rhizomes) e.g. *Parmelia* species and *Physcia* species. Unlike the crustose forms, the foliose lichens show differentiation into upper and lower surface.
- (c) The fruticose types form much branched shrub-like bodies which remain attached by their narrowed basal portion only. They may stand erect (as in *Cladonia* spp) or hang on the branches of shrubs and trees (as in *Usnea* species)

**General structure:**

Main framework of lichen thallus is made of interwoven mass of the hyphae of a fungus, usually an ascomycete (ascolichen) or in few cases, a basidiomycete (Basidiolichen). The Ascolichens enclose mostly unicellular, blue-green algae e.g. chlorococcus, Gleocapsa species (unicellular) Nostoc, Rivularia (filamentous) or certain green algae of chlorella and Pleurococcus.

The Basidiolichens enclose similar blue-green algae. The fungus and algae types in association are always constant. In some lichens, the algae are scattered in the thallus while in others, they occur in 1 or 2 layers.

**REPRODUCTION:**

Reproduction is either through vegetative, asexual or sexual. These varieties of reproduction are mostly fungal in nature.

**(A) VEGETATIVE REPRODUCTION**

- (i) By Soredia : tiny granular bodies on the upper surface of the thallus as a greyingly powdery coating. Each soredium is made up of one to many algal cells wrapped up in a network of hyphae. The Soredia are dispersed by wind and they germinate into the lichen thallus when in a favourable condition. This is the commonest form of vegetative reproduction.
- (ii) By Isidium
  - minute outgrowth in some lichens
  - Consists of both algal cells and fungal hyphae surrounded by a layer of cortex.
  - They are photosynthetic in function once detached, they can grow and develop into new thalli.
- (iii) Oidia: Short fungal segments from hyphae that have broken up. Each oidium geminates like a spore to produce normal hyphae.
- (iii) Fragmentation of thallis into long or short fragments. Each fragment may grow to the size of the parent thallus

**(B) ASEXUAL REPRODUCTION:**

**(i) In Ascolichens**

Asexual reproduction is effected by means of spores formed by the fungal partner. The spores germinate and sends out hypae in different directions. Upon coming into contact with the requisite alga, the hypha branches freely and covers up the algal cell. The combined body now grows into the lichen thallus.

In some cases some Ascolichens produce pycnidiospores in flask-shaped cavities called pycnidia. Each pycnidium appears as black spots or dots on the surface of the lichen thallus. The pycnidiospore germinate to produce the hypha which when in contact with combined body. This can now grow to form a lichen thallus.

(ii) In Basidiolichens:

This type of lichens reproduce asexually by means of Basidiospores as in Agaricus species.

- It is to be noted that the pyniodiospores may behave as male gametes known as the Spermatid.

(c) SEXUAL REPRODUCTION:

The fungal member above takes part in this process. Sexual reproduction results in formation of an ascocarp which may be an apothecium or sometimes perithecium. The female sex organ is the carpogonium which is composed of the Ascogonium and a tube-like trichogyna. The male sex organ is called the spermagonium which is flasked shaped. It produces non-motile male cells called the spermatia.

Fertilization is effected when a spermatium comes in contact with the trichogyne which serves as a wute for the male nucleus into the ascogonium. The spermatium fuses with the nucleus of the ascogonium. Several ascogenous hyphae is given off from where many Asci with ascosporic are followed.

**USES OF LICHEN**

- (i) Disintegration of soil
- (ii) food for animals
- (iii) medicine (source of dyes)
- (iv) production of cosmetics
- (v) brewing industries
- (vi) sources of tannins used in converting hide into leather.