Unit- III
(Algae and Lichens)

Part – A

Short answer type questions :

1. Who is known as father of Indian Phycology / Algology?

Ans: M. O. P. Lyengar.

2. What is Fritsch's classification of algae?

Ans: Fritsch divided algae into 11 classes based on their physiological and morphological features. His work was published in his book titled, 'Structure and Reproduction of Algae' in two volumes.

3. What is the name of the book written by F.E. Fritsch?

Ans : Felix Eugen Fritsch (1935, 48) was the first who proposed a most comprehensive and authentic classification of algae in his book "The Structure and Reproduction of the Algae".

4. Which alage is called as 'rolling algae"?

Ans: Volvox

5. Write name of plants formed by association of algae and fungi.

Ans: Lichens

6. Plakea stage is found in which algae?

Ans: Volvox

7. What types of life cycle is found in Polysiphonia?

Ans: Haplo-diplo-diplontic life cycle

8. Which lichen is used in the formation of litmus paper?

Ans: *Roccella tinctoria*

9. Name two algae which are the source of agar-agar.

Ans:S *Gelidium* and *Gracilaria*

10. Give an example of algae having prokaryotic cell.

Ans *Nostoc* and *Oscillatoria*

11. Which type of chlorophyll is common in all algae?

Ans chlorophyll **'a**'

12. "Hormogonia" present in which alga?

Ans – *Nostoc* and *Oscillatoria*

13. Write the name of two unicellular algae.

Ans – Chlamydomoas and euglena.

14. In which algae Gongrosira stage is present?

Ans – Vaucheria

15. Name any edible lichen.

Ans - *Cetraria islandica* (Iceland moss) in Northern Europe cooked as bread, pudding, soup, or salad. *Bryoria fremontii* was an important food in parts of North America. *Parmotrema reticulatum* (Rimelia reticulata) In India,The Middle East popular ingredient of many spice, such as garam masala,

16. Write the name of photosynthetic pigments and food material of Chlorophyceae.

Ans - Pigments – Pigments. Presence of Chlorophyll a and b, carotenoid and xanthophylls.
Reserve food – Starch. Chloroplast usually has pyrenoids.

17. Write the name of photosynthetic pigments and food material of Xanthophyceae.

Ans - Pigments - Chl- a and chl-e, β-carotene and xanthophylls.
Reserve food – Leucosin and oil droplets. Chloroplasts are without Pyrenoids.

18. Write the name of photosynthetic pigments and food material of Phaeophyceae.

Ans - Pigments – Fucoxanthin (brown color)and vialoxanthene is dominant, chl-a, chl-c and β-carotene.
Reserve food – Laminarin starch (polysaccharide), manitol (alcohol) and fats.

19. Write the name of photosynthetic pigments and food material of Rodhophyceae.

Ans - Pigments – r-Phycoerythrin (red colour) and r-Phycocyanin, chl-a, d, carotene and xanthophylls.
Reserve food – Floridean starch (a polysaccharide with amylopectin). Pyrenoid are present.

20. Write the name of photosynthetic pigments and food material of Cynophyceae.

Ans - Pigments – c-Phycocyanin (dominant for blue-green color) and c-Phycoerythrin, chl-a, β-carotene and myxoxanthene. Reserve food – Cyanophycean starch and cyanophycean granule (protein).

21. What is akinete?

Ans - During unfavorable conditions the vegetative cell of some cyanobacteria like Nostoc after storage of food materials covered with a thick wall are called as akinetes.
These are resting cells and during favorable conditions, it germinates to give rise a new thallus.

22. What is oogamous?

Ans - Oogamous reproduction is a most advanced type of sexual reproduction in many algal species.
In this type of reproduction, the female gamete (big, non motile) fusion / fertilized by the male gamete (tiny motile) and form diploid zygote is known as oogamy.
e.g., Chara, volvox, vaucheri, polysiphonia, Oedogonia, Coleochaete.

23. What are cryophytic algae? Give two examples.

Ans - Algae growing on ice or snow provides attractive colours to snow-covered mountains.
Haemotococcous nivalis [the alpine and arctic mountains become red]
Chlamydomonas yellowstonensis [green snow in Europe mountains]
Scotiella nivalis and *Raphidonema brevirostri* [cause black colouration of snow].

24. What are lethophytic algae? Give two examples.

Ans - Algae growing on the moist surface of rocks and stones are lithophytic e.g., *Nostoc*, *Gloeocapsa*, *Batrachospermum etc.*

25. What are thermophytic algae? Give two examples.

Ans - Algae growing in hot water springs (50- 70°C) where normal life is not possible.
Many blue-greens (e.g., *Oscillatoria brevis, Oscillatoria terebriformis , Synechococcus elongates, Heterohormogonium sp., Scytonema* etc.) are capable of growing at very high temperature because of unorganized nucleus.

26. What are epiphytic algae? Give two examples.

Ans - Algae growing on other algae and plants are called epiphytic algae e.g., Polysiphonia, Oedogonium, spirogyra are found growing on other algae, bryophytes and aquatic angiosperms.

27. What are parasitic algae? Give example.

Ans – Some algae can be found as parasites on plants and animals e.g., *Cephaleuros* ***virescens*** is found on leaves of tea and coffee plants and causes red rust.
Polysiphonia fastigiate is semi-parasitic on algae Ascophyllum.

28. Name the bryophyte in which nostoc colony is present.

Ans – Antheroceros

29. What are water algal blooms? Name two algae which form water bloom.

Ans An algal bloom or algae bloom is a rapid increase or accumulation in the population of algae in freshwater or marine water systems. Algal bloom commonly refers to the rapid growth of microscopic unicellular algae, not macroscopic algae.

30. What are synzoospores?

Ans - The zoospore of **vaucheria** is a compound structure which is formed by the failure of the protoplast within the zoosporangium to divide into uninucleate, biflagellate zoospore. It is also known as Synzoospore or conidiospores and these spores generally develop in aquatic forms of vaucheria.

Part – B

Long answer type questions :

1. Write a detailed account of the general characters of algae?

Ans - General / Diagnostic Characters of Algae are following:-

1. They are Pioneer of plant on land /earth.
2. Algae are chlorophyll-bearing autotrophic thalloid plant body.
3. They are autotrophic organisms (synthesise their own food using light energy - Photosynthesis).
4. They are Cosmopolitan (present everywhere) / Ubiquitous but they are mostly found in aquatic habitats (freshwater or marine); while, few algae are adaptable for terrestrial habitats and unusual habitat like grow on snow, on rocks, on trees and into hot water springs.
5. Suitable to grow in moist, shady, humid and cool places.
6. Algae have a thalloid plant body. Not differentiate in root, stem and leaf.
7. The thallus may be unicellular to large robust multicellular structure. (Microscopic to macroscopic)
8. The multicellular complex thalli lack vascular tissue and mechanical tissue system.
9. Thallus lack Physiological division of labour. Each cell is independent.
10. The cells are Prokaryotic and Eukaryotic type.
11. Cell wall is thick and cellulosic. In few algae class like **Cyanophyceae** cell wall is made up of peptidoglycan / mucopeptide.
12. **Photosynthetic Pigments** – they have large variety, main P.S. pigments is chlorophyll and other accessory pigments are carotenoids (carotene and xanthophyll), billiproteins (phyco cyanin and phyco erythrine).
13. **Reserve food** - in form of Starch (polysaccharides), and in few as lipids and oil droplets.
14. **Flagella** – for motility they have uni, bi and multiflagellate. Whiplash and tinsel flagella are found.
15. Reproduction of diverse algae groups accur as vegetative, asexual and sexual method.
16. **Vegetative reproduction methods** – Vegetative growth occurs by simple mitosis division, by binary fission, by fragmentation etc.
17. **Asexual reproduction methods** – By zoospores, by aplanospores, by daughter colony etc
18. **Sexual reproduction methods** – Occurs by Isogamous, Anisogamous and Oogamous.
19. The sex organs are generally unicellular and naked (non-jacketed).
20. Zygote (2n) is formed by fussion of two gametes (n).
21. Once zygote is formed, no embryos are produced.
22. After dispersal, the zygotes during favourable climate condition they give raise their parental plants.
23. Mostly algae are haploid and Gametophyte (Dominant and long live) and few are diploid and sporophyte (recesive and short live in life cycle).
24. Both gametophyte (n) and sporophyte (2n) generations - when present in the life cycle are independent.
25. Only advanced algae show distinct alternation of generations.

2. Write a detailed account of the various types of habitat of the algae?

Ans - The algae are simple plant group in plant kingdom on land.
These are Autotrophic, chlorophyllous, Non-Vascular and unicellular to multicellular thallus.
Based on habitat the algae may be categorized as:

1) Aquatic habitat algae.

2) Terrestrial habitat algae
3) Unusual habitat algae / Algae of remarkable habitats.

1) Aquatic Algae:

Mostly algae are aquatic habitat 80%. Are of following types:-

I- The fresh water habitat algae:

Aquatic algae may be fresh water (when salinity is as low-as 10 ppm is 10%).

The fresh water algae usually grow in ponds, lakes, tanks, ditches etc.

The very common fresh water algae are *Chlamydomonas, Volvox, Ulothrix, Chara, Spirogyra* etc.

II- The marine habitat algae:

The marine water algae (when salinity is as up as 10 ppm and is 33-40%).

Some of the very common marine algae are *Sargassum, Laminaria, Ectocarpus, Polysiphonia, Caulerpa, Bangia, Padina* etc.

III- The Halophyte habitat algae:

They grow in the highly concentrated salt lakes. (Salinity is as up as 10 ppm and is 33-40%)

Eg- *Chlamydomonas ehrenbergli, Dunaliella* and *Stephanoptera sp*.

2) Terrestrial Habitat Algae:

- Some algae are found to grow in terrestrial habitats like moist soil, rocks, logs etc.
  Saprophytes - The algae that grow on the surface of the soil.
- *eg. Vaucheria geminate, Botrydium sp. and Phormidium sp. Fritschiella sp.* etc.
  Cryptophytes - Many blue-greens, on the other hand, grow under the surface of the soil.
- eg. *Nostoc, Oscillatoria sancta, Chlorella lichina, Fritschiella sp. etc*

3) Unusual habitat algae / Algae of remarkable habitats:

some algae also habitat to grow in uncommon / unusual habitats and termed as:

1. **Halophytic Algae (or Eurhaline):**
   - They grow in the highly concentrated salt lakes, and include
   - *Chlamydomonas ehrenbergli, Dunaliella and Stephanoptera sp.*
2. **Cryophytic Algae:**
   - This group of algae habitat to growing on ice or snow
   - The alpine and arctic mountains become red due to the growth of the *Haemotococcous nivalis*.
   - Green snow in Europe is due to the growth of *Chlamydomonas yellowstonensis*.
   - *Scotiella nivalis* and *Raphidonema brevirostri* cause black colouration of snow.
3. **Thermophytes or Thermal Algae:**
   - This group of algae occurs in hot water springs (50- 70°C) where normal life is not possible.
   - Many blue-greens (*e.g., Oscillatoria brevis, Synechococcus elongates, Heterohormogonium sp*.)
4. **Lithophytes:**
   - They grow on the moist surface of stones and rocks, e.g., Nostoc,. Gloeocapsa, Enteromofpha, *Batrachospermum etc.*
5. **Epiphytic Algae:**
   They grow on other plants including other algal members. **They are following types:**
   a. **Algae on Algae:**
      e.g., *Ptilota plumosa* and *Rhodymenia pseudopalmatta* on *Laminaria hyperborean*
   b. **Algae on Bryophytes:**
      Blue-green algae like *Nostoc, Oscillatoria,* like Achnanthes etc. grow on different bryophytes.
   c. **Algae on Angiosperms:**

Trentepohlia grows on the different angiospermic plants, very common in Darjeeling (India).

6. **Endophytic Algae:**
   These algae are microscopic and grow inside the tissues of other plants.
   e.g. *Nostoc sps*. Grow inside the *Anthoceros*, *Anabaena sps*. Grow in *cycas.*
7. **Epizoic Algae:**
   The algae growing on animals like fish, snail etc.
   e.g., Stigeoclonium are found in the gills of fishes.
8. **Endozoic Algae:**
   They grow inside the tissues of animals, e.g., *Zoochlorella sp*. is found in *Hydra viridis.*
9. **Symbiotic Algae:**
   The best examples of symbiotic association consisting of algae and fungi is called lichen.
   The Alga member is called Phycobiont are *Nostoc, Gloeocapsa, Rivularia*; the members of Cyanophyceae and *Chlorella, Cytococcus, Pleurococcus*; the members of Chlorophyceae.
10. **Parasitic Algae:**
    Some algae grow parasitically on different plants and animals.
    Cephaleuros virescens (Chlorophyceae) is parasitic on the leaves of tea and coffee which causes Red rust disease.

3. Describe the various methods of asexual and sexual reproduction in algae.

Ans - The three modes of reproduction in algae. The methods are:

1. Vegetative Reproduction 2. Asexual Reproduction 3. Sexual Reproduction

1. Asexual Reproduction method:-

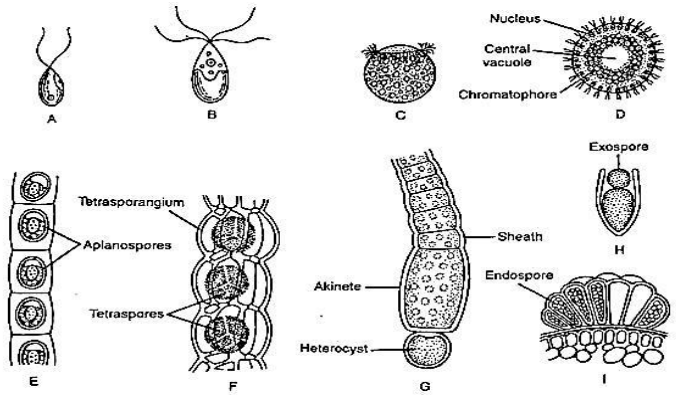
- Asexual reproduction involves the formation of certain type of spores - either naked or newly walled.
- It is a process of rejuvenation of the protoplast without any sexual fusion. Each and every spore germinates into a new plant. **The asexual spores may be of various types:**

(i) Zoospores:-

- The zoospores are flagellated asexual structures. The zoospores are formed in reproductive body the zoosporangium. These are motile naked spores provided with two, four or many flagellate zoospores.
- But the multinucleate and multiflagellate zoospores as found in Vaucheria are called synzoospores.
- After liberation of the zoospores by the disintegration of the zoosporangial wall or by the formation of an apical pore on the zoosporangium, they germinate into new plants thallus.
- eg., Biflagellate zoospores are found in Chlamydomonas, Ulothrix, Ectocarpus, Oedogonium etc.

(ii) Aplanospores:-

- Aplanospores are non- motile spores. These spores are formed either singly or its protoplast may divide to form many aplanospores inside sporangium during unfavourable conditions, especially in drought or unfavorable conditions.
- The aplanospores may also be formed in certain algae of semiaquatic habitat.



- They are formed to overcome prolonged period of desiccation. With the onset of favourable condition the hypnospores either directly germinate into a new individual.
- (e.g., Ulothrix , Microspora).

(iii) Daughter colony:-

- The daughter colony of a volvox is the offspring of the volvox can reproduces sexually or asexually through the formation of daughter colony.
- Special gonidium cells divide to form daughter colonies that are as small clones versions of the parents.
- They develop inside the volvox and eventually burst out, killing the parent cell.

(iv) Tetraspores:-

- Diploid plants of some algae e.g., Polysiphonia, produce a special type of haploid aplanospores, called tetraspores, formed within tetrasporangium.
- The diploid nucleus of a tetrasporangium divides meiotically to form four haploid nuclei which — with little amount of protoplasm are developed into four tetraspores
- After liberation the tetraspores germinate to form male and female gametophytes.

(v) Akinetes:-

- The vegetative cells of certain filamentous algae develop into elongated thick-walled spore-like structures with abundant food reserves, called akinetes.
- They can tide over the unfavourable conditions. With the onset of favourable condition they germinate into new individuals. e.g., Gloeotrichia.

(vi) Exospores:-

- In some algae, spores are regularly cut off at the exposed distal end of the protoplast in basipetal succession, called exospores. These spores aggregate in groups and develop new colonies, e.g., Chamaesiphon.

(vii) Endospores:-

2. Sexual Reproduction:

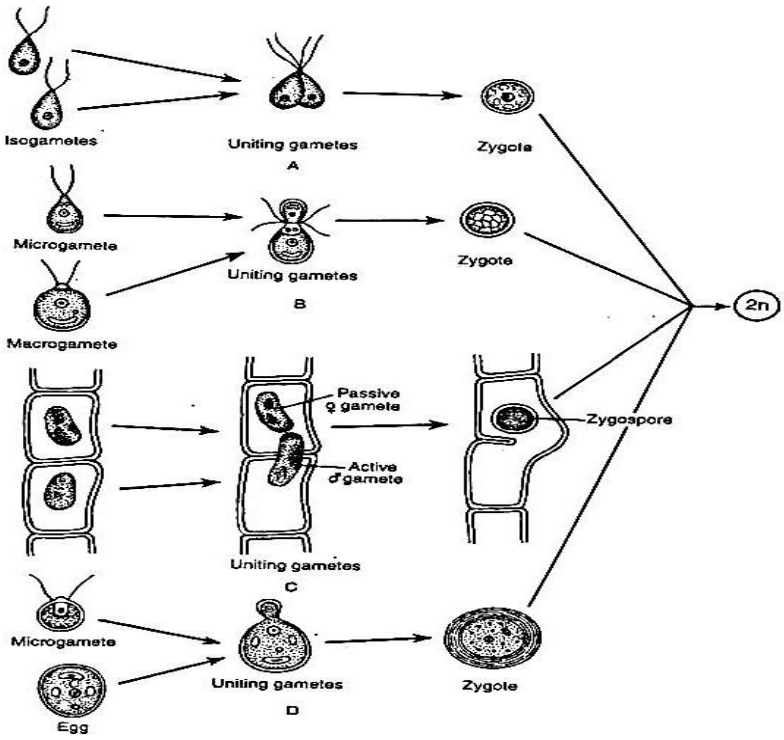
- Sexual reproduction takes place by fusion of gametes of different sexuality to form **Zygote**. The gametes are formed in gametangia by simple Mitotic division or by Meiosis division.
- All algae except the members of the class Cyanophyceae reproduce sexually.
- **Depending on the structure, physiological behaviour and complexity of sex organs, sexual reproductions are of the following five types:**

Autogamy: In this process the fusing gametes are developed from the same mother cell and after fusion they form zygote. Autogamy does not show the introduction of any new characteristic, e.g., Diatom.

Hologamy: In some unicellular alga the vegetative cells of different strains (+ and -) behave as gametes and after fusion they form zygote. New genetic combinations are developed by this process. e.g., Chlamydomonas.

Isogamy: In this process the fusing gametes are morphologically and physiologically similar. after fusion they form zygote. The gametes are called isogametes. Usually they are flagellate, e.g., Chlamydomonas eugametos, Ulothrix and Zygnema etc.

Anisogamy: In this process the fusing gametes are morphologically and physiologically different. The smaller and more active one is the microgamete or zoospore (male), whereas the larger and less active one is the macrogamete or aplanospore (female), e.g., Chlamydomonas braunii.



Oogamy: It is an advanced process where fertilisation takes place between a small motile (non-motile in Rhodo- phyceae) male gamete (sperm or antherozoides) with a large non-motile female gamete (egg or ovum).Male gametes develop within antheridium, whereas the female gamete within the oogonium. Antherozoids (male) and Oogonium (female) gametes are fuse to form zygote (2n) e.g., Oedogonium, Vaucheria, Chara, Sargassum, Polysiphonia, Batrachospermum etc.

4. What are the criteria used in classification of algae? Give outline of Fritsch's classification ?

Ans : Felix Eugen Fritsch (1935, 48) was the first who proposed a most comprehensive and authentic classification of algae in his book **"The Structure and Reproduction of the Algae".**

His classification of algae is mainly based upon characters of pigments, flagella and reserve food material.

Fritsch classified the algae into eleven (11) classes in division Thallophyta are following:

Class - 1. Chlorophyceae (Isokontae, green algae):

Cell wall – Cells are eukaryotic and cell wall is mainly composed of cellulose.
PS Pigments – Pigments. Presence of Chlorophyll a and b, carotenoid and xanthophylls.
Reserve food – Starch. Chloroplast usually has pyrenoids.
Flagella – Flagella are equal in length and are situated anteriorly. Whiplash type.
Reproduction – It takes place by vegetative, asexual and sexual methods.
Sexual reproduction may be iso-, aniso- and oogamous type.
e.g., Chlamydomonas. Volvox, Ulothrix, Oedogonium, Chara etc.

Class -2. Xanthophyceae (Heterokontae, yellow green algae):

Cell wall – Cells are eukaryotic and cell wall is composed of pectic substance.
P. S. Pigments – Chl- a and chl-e, β-carotene and xanthophylls.
Reserve food – Leucosin and oil droplets. Chloroplasts are without Pyrenoids.
Flagella – Flagella are two, unequal in length and are situated anteriorly.
Reproduction – It takes place by vegetative, asexual and sexual methods.
Sexual reproduction may be iso-, aniso- and oogamous type.
e.g., Vaucheria, Botrydium, Microspora.

Class -3. Chrysophyceae (Golden brown algae):

Cell wall – Cells are eukaryotic and cell wall is silicified or calcified (cellulose absent).
PS Pigments – Phycochrysin (dominating pigment for yellow orange color) & Chl-a, Chl-b
Reserve food – Crysolaminarin starch and lucosin. Chromatophores have naked pyrenoid.
Flagella – The motile cells have two flagella (either equal or unequal) inserted anteriorly.
Reproduction – By vegetative and sexual means. Sexual reproduction if prs only isogamous type.
e.g., Crysodendron, Chrysosphaera, Chrysoclonium.

Class -4. Bacillariophyceae (Diatom, yellow brown algae):

Cell wall – Cellulosic and pectic; consist of two halves, which are bilaterally symmetrical.
P. S. Pigments –Fucoxanthin, diatoxanthin and diadinoxanthin, Chl-a, Chl-c & α-carotene.
Reserve food – fat and volutin. Chromatophore has pyrenoids.
Flagella – Motile cells have single or two flagella or absent.
Reproduction – Takes place by cell division and auxospore formation, Sexual very rare.
e.g., Cyclotella, Pinnularia, Denticula.

Class -5. Cryptophyceae:

Cell wall – The cells are eukaryotic in nature.
PS Pigments – The dominant pigments are xanthophylls (give red or brown colour), Chl-a, Chl-c.
Reserve food – Starch and/or oil. Pyrenoid-like bodies are present
Flagella – Motile cells have two unequal flagella. (Heterokontae)
Reproduction – By Cell division, Sexual reproduction is rare and isogamous type only.
e.g., Cryptomonas, Tetragonidium.

Class -6. Dinophyceae (Dinoflagellates):

Cell wall – The cells are eukaryotic in nature
PS Pigments – Chl-a, Chl-c and Xanthophylls (dominant for dark yellow or brown color)
Reserve food – Starch and Fat. Cells contain many discoid chromatophores.
Flagella – Motile cells have two equal flagella. (Isokontae)
Reproduction – By Cell division, Sexual reproduction is rare and isogamous type only.
e.g., Desmocapsa, Dinophysis, Phalacroma.

Class -7. hloromonadineae:

Cell wall – Cells are eukaryotic in nature
PS Pigments – Xanthophylls (dominant for bright green color present in excess), Chl-a, Chl-c
Reserve food – Fat and oil droplets. Cells have numerous discoid chromatophores without pyrenoid.
Flagella – Motile forms are with two equal flagella.
Reproduction - It takes place by cell division. Sexual reproduction is absent.
e.g., Vacuolaria, Trentonia.

Class -8. Euglenoineae:

Cell wall – Eukaryotic in nature. Cellwall is absent. Pellicle layer is present.
PS Pigments – Chl-a, Chl-b (pure green).
Reserve food – Paramylon starch and fat. Cells have numerous chromatophores with pyrenoid.
Flagella – Cells have one or two flagella. Whiplash type situated anteriorly.
Reproduction - It takes place by cell division. Sexual reproduction if present is of isogamous type.
e.g., Euglena, Ascoglena.

Class -9. Phaeophyceae (Brown algae):

Cell wall – Cell wall is composed of cellulose along with alginic and fucinic acid.
PS Pigments – Fucoxanthin (brown color)and vialoxanthene is dominant, chl-a, chl-c and β-carotene.
Reserve food – Laminarin starch (polysaccharide), manitol (alcohol) and fats.
Flagella – Zoospores are biflagellated, unequal flagella, one of which is tinsel type.
Reproduction - Sexual reproduction ranges from isogamy to oogamy.

e.g., Ectocarpus, Laminaria, Macrocystis, Fucus, Sargassum.

Class -10. Rhodophyceae (Red algae):

Cell wall – Eukaryotic in nature. Cell wall is composed of outer pectic and inner cellulose.
PS Pigments – r-Phycoerythrin (red colour) and r-Phycocyanin, chl-a, d, carotene and xanthophylls.
Reserve food – Floridean starch (a polysaccharide with amylopectin). Pyrenoid are present.
Flagella – Non flagellates, Reproductive cells are non-motile.
Reproduction - Sexual reproduction is of advanced oogamous type.
e.g., Polysiphonia, Gelidium, Gracilaria, Nemalion, Batrachospermum.

Class -11. Myxophyceae /Cyanophyceae (blue green algae):

Cell wall – The cells are prokaryotic in nature. The cell wall is composed of mucopeptide.
PS Pigments – c-phycocyanin and c-phycoerythrin, chl-a, β-carotene and myxoxanthene.
Reserve food – Cyanophycean starch and cyanophycean granule (protein).
Flagella – Non motile and non flagellates.
Reproduction - Reproduction takes place by both vegetative (cell division, fragmentation etc.) and Asexual means (exospore, endospore, heterocysts etc.).
e.g., Nostoc, Oscillatoria.

5. With the help of suitable diagrams, describes the thallus structure and reproduction in Nostoc.

Ans - Systematic position of Nostoc:-

Class : Cyanophyceae
Order : Nostocales
Family : Nostacaceae
Genus : *Nostoc*

Nostoc Occurrence:

Nostoc is called star jelly and a genus of cyanobacteria as they are Photosynthetic.

The Nostoc is present in the form of bluish-green ball like colony enveloped by a gelatinous sheath.

Nostoc is found in various environments and surroundings that are composed of different cells.

The Nostocs are Terrestrial or fresh water and can be found as free-living colonies or attached in soil, on moist rocks, at the bottom of lakes and springs. Rarely in marine habitats.

Nostoc Filament Structure & Morphology:

The body of Nostoc is called thallus. Thalli are present in the form of ball like colonies.

Colony is enveloped by a gelatinous sheath of greenish to bluish-green in colour.

Each colony contains thousands of thread like stc. are called trichomes.

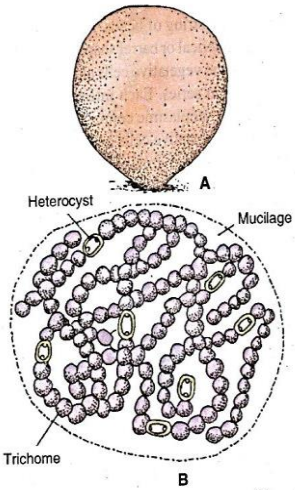


Fig : (A) Nostoc Ball, (B) Portion of filament as seen under microscope

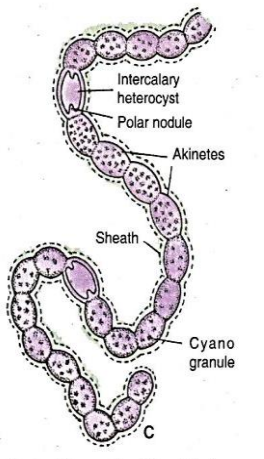


Fig : (C) A single filament with a trichome.

Each Trichomes are unbranched and composed of many spherical shaped cells arranged in a beaded manner. In the filament intercalary or terminal some large, spherical, thick-walled, colourless cells are present called Heterocysts.

These cells perform two functions, reproduction and Nitrogen Fixation.

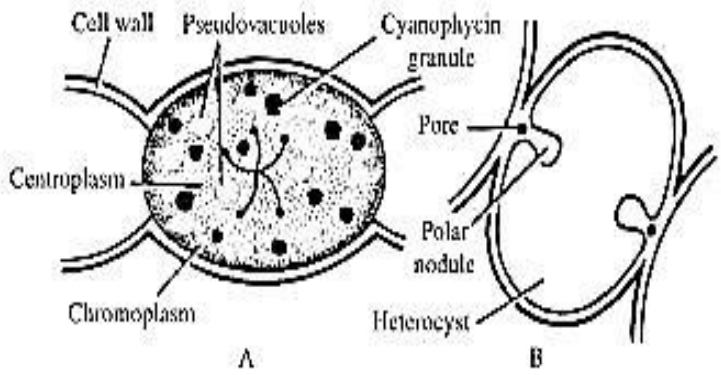
Trichomes mostly break near heterocyst and forms hormogonia and thus help in fragmentation.

A Single Cell of Nostoc: -

All cells in the trichome are similar (spherical or cylindrical) in structure and show prokaryotic organization.

All cells have a well-developed cell wall. The cell wall consists of Peptidoglycans.

Ultrastructure of cell shows that the well-defined nucleus is absent. Mitochondria, endoplasmic reticulum, and Golgi bodies are so absent.



The protoplasm consists of peripheral pigmented chromoplasm and central colourless centroplasm.

The **CHROMOPLASM (**outer pigmented) contains photosynthetic lamellae which contain photosynthetic pigments like chlorophyll a, carotenes, xanthophyll's and phycobilins (C-phycocyanin, C-phycoerythrin).

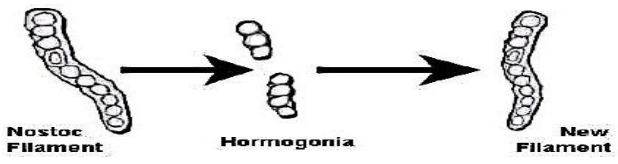
Cyanophycean starch, Glycogen and few oil droplets as reserve food and several small granules are also present.

The **CHROMOPLASM (**outer pigmented) represents the incipient nucleus called Genophore. It is represented by DNA fibrils, RNA, 70'S' ribosomes and enzymes.

Reproduction in Nostoc: -

In Nostoc, the reproduction takes place only by vegetative methods. Sexual reproduction is absent in Nostoc. These are following methods:

1. **By Hormogonia OR by Fragmentation:-**

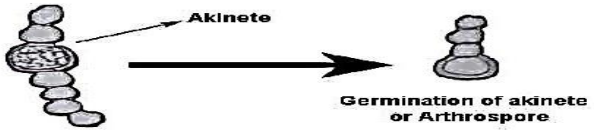


It is the most common method in Nostoc.

Hormogonia are formed by Fragmentation.

The filament breaks at different points and each broken filament is called hormogonia.

The filament breaks due to decay and death of ordinary cells. Heterocyst may form the breaking



point.

Each hormogonium grows into a new filament.

2. By Arthrospores or by Akinetes Formation:-

During unfavorable conditions, some cells of filament become enlarge and they are covered by a thick wall, they are called Akinetes or Arthrospores or Resting Spores.

They also store food material.They germinate during favorable conditions into new filaments.

3. By Heterocyst:-

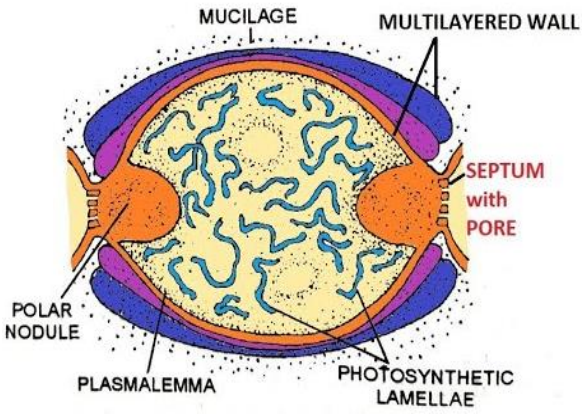
Nostoc bacteria also reproduce by heterocysts.

In some species (e.g., N. commune), the heterocyst may occasionally function as a spore.

In filaments, there are some colorless spherical or barrel shaped empty cells called heterocysts.

The heterocyst is slightly larger and has thicker walls than the adjacent vegetative cells.

They are generally intercalary but sometimes terminal.



Each intercalary heterocyst has two polar nodules.

The polar nodules of the heterocysts are formed by the thickening of the inner layer of cellulose.

At the time of reproduction, the heterocysts are separated from Nostoc filament.

These heterocysts are changed into a normal reproductive cell.

By the process of cell division, a new colony of nostoc is created.

6. Describe the Sexual reproduction of vaucheria with the help of labelled diagrams.

Ans : In Vaucheria sexual reproduction is of advanced oogamous type. The male and female sex organs are antheridia and oogonia, respectively.

The antheridia and oogonia develop close to each other on special side branches with a terminal antheridium and a number of lateral oogonia.

Structure of Antheridium:

The mature antheridia may be cylindrical, tubular, straight or strongly curved. The antheridium is separated from main filament by a septum. The antheridia can be sessile (without stalk) arising directly from main branch. The young antheridium is usually green in colour. It contains cytoplasm, nuclei and chloroplasts. The mature antheridia are yellow and contain many spindle shaped antherozoids. The antherozoids are liberated through a terminal pore.

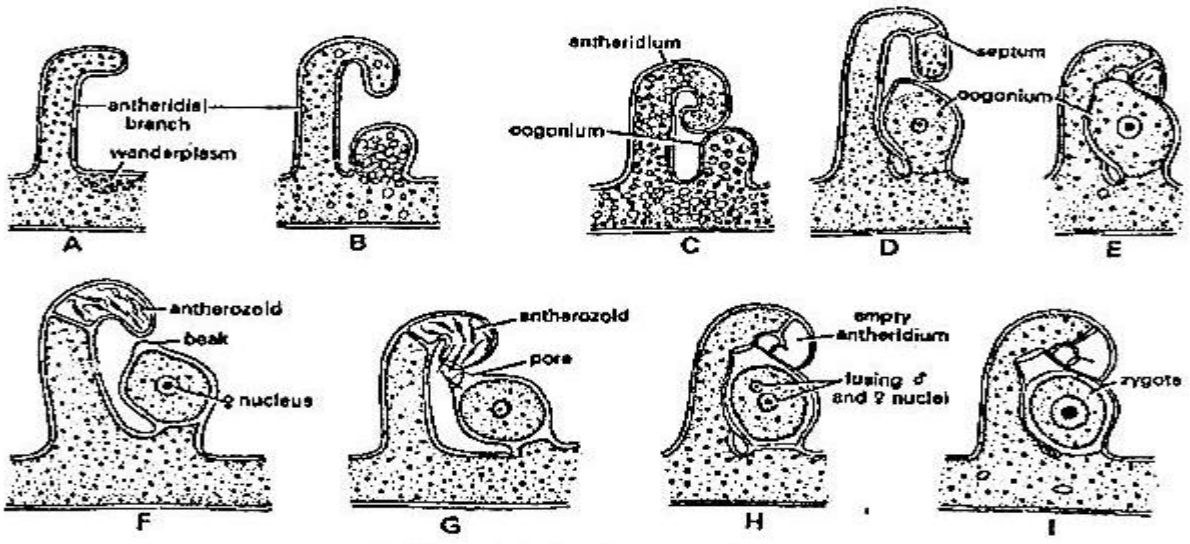


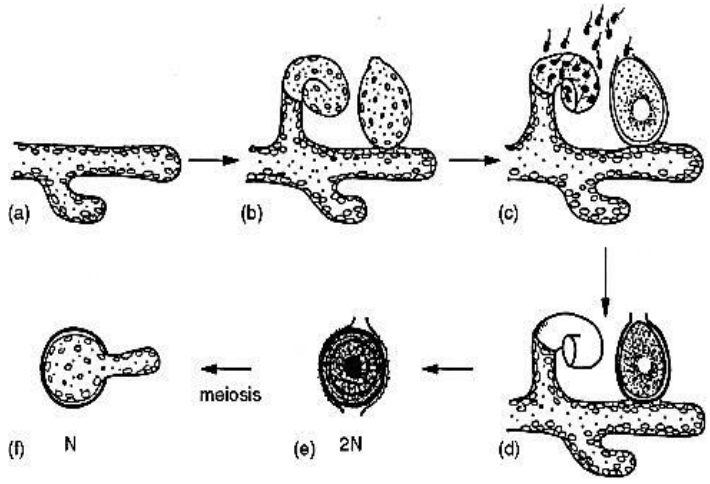
Fig. 6. (A–I). *Vaucheria*. Sexual reproduction in *V. sessilis*.

Structure and Development of Oogonium:

- The oogonium development starts with accumulation of colourless multinucleate mass of cytoplasm near the base of antheridial branch. This accumulated cytoplasm has been termed as **"wanderplasm".**
- The wanderplasm enters into the outgrowth or bulging of the main filament. This outgrowth is called as oogonial initial.
- Large amount of cytoplasm and nuclei enter into oogonia, making it a large globular structure called as oogonium.
- As the oogonium matures, it gets separated from main branch by the development of septum at its base.
- The mature oogonium is uninucleate structure. The nucleus of oogonium with protoplasm develops into a single female egg.

Fertilization:

- The oogonium secretes a gelatinous drop through a pore near the beak.
- Mean while the large number of liberated antherozoids stick to the drop. Many antherozoids push into the oogonium. The antherozoids strike violently, fall back and push forward again and fall back. Only one antherozoid enters into the oogonium.
- After its entry the membrane develops at the pore to stop the further entry of antherozoids.
- The male nucleus increases in size and fuses with the egg nucleus to make diploid zygote.



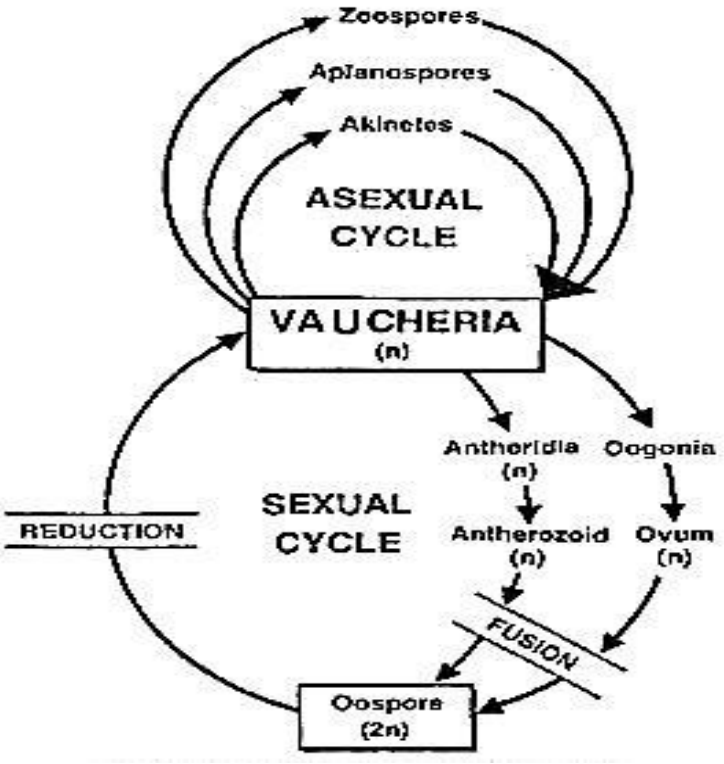
- The zygote secretes a thick 3-7 layered wall and is now called as oospore.
- The chromatophores degenerate and lie in the centre of the cell.

Germination of oospore:

- The oospore undergoes a period of rest before germination. During favourable season the oogonial wall disintegrates and the oospore is liberated. The oospore germinates directly into new filaments.
- Although the exact stage at which the reduction division takes place in Vaucheria is not clear, it is believed that reduction division occurs in first nuclear division in the germinating oospore.
- The oospore germinates to make haploid thallus of Vaucheria.

7. With help of suitable diagrams explains in detail the life-cycle in Vaucheria.

Ans- The life cycle of Vaucheria is haplontic, the oospore being the only diploid structure in life cycle.



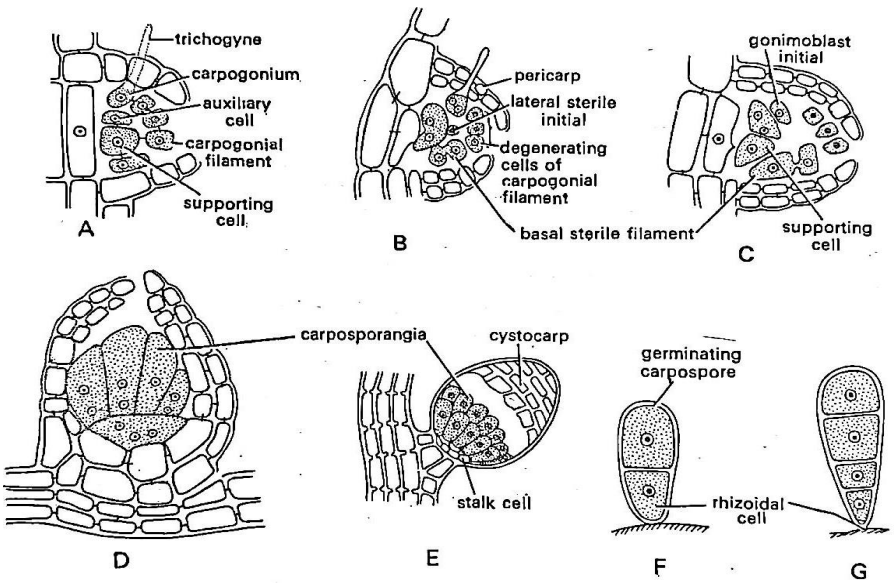
- Vaucheria thallus is haploid. It is aseptate, branched, tubular and coenocytic structure.
- During favourable conditions Vegetative reproduction takes place by fragmentation. Asexual reproduction takes place by zoospore in aquatic species and by aplanospores in terrestrial species.
- During un-favourable conditions the sexual reproduction is advanced oogoinous type, the male and female sex organs are antheridia and oogonia. Most of the species are homothallic, some are heterothallic.
- After fertilization, a diploid zygote is formed which converts into oospore and undergoes a period of resting.
- During favourable conditions the oospore under goes meiosis division and formed haploid meiozoospores. By germination they give rise to a new haploid thallus.
- Life cycle is monophasic. No clear alternation of generation occours.
- Haplontic life cycle is present in vaucheria.

8. With the help of suitable diagrams explains in detail the Post-fertilization changes in life cycle of Polysiphonia.

Ans: After fertilization man y changes take place within and around the female reproductive structure.

- At the starting of this phase, the supporting cell divides transversely to form an auxiliary cell between itself and the carpogonium.
- A tubular protoplasmic connection is then developed between the auxiliary cell and carpogonium called **Ooblast**.
- The Carpogonial diploid nucleus \ Zygote nucleus divides mitotically into two nuclei, of which one is, migrates into the auxiliary cell and the other one nucleus remains in the carpogonium.

- The haploid nucleus of the auxiliary cell degenerates and it then contains diploid nucleus only.
- Gradually the trichogyne shrivels at this time.
- The carpogonium, auxiliary cell and supporting cell fuse and form irregular shaped placental cell.
- The diploid nucleus of the auxiliary cells divide mitotically form two (2n) nuclei; one in supporting cell and one migrate in outgrowth called gonimoblast initials, arise from the placental cell.
- A number of gonimobalst initial arise and forms a two-three celled diploid gonimoblast filament.
- The terminal cell of the gonimoblast filament is pyriform and develops into a carposporangium which forms a single diploid carpospore.



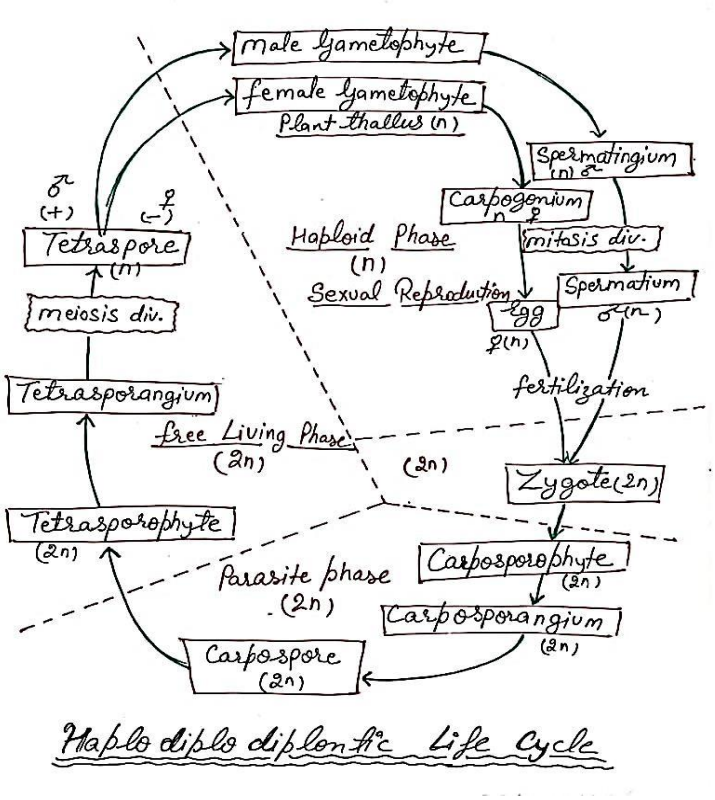
- Simultaneously, the lateral sterile filament increases in length (4-10 celled) by cell division as well as elongation and the basal sterile initial divides to form 2-4 celled sterile filaments.
- During this development the auxiliary cell, supporting cell, carpogonium and some cells of basal and sterile filaments fuse together and form an irregular cell, the placental cell.
- The placental cell, gonimoblast filament and carpogonia are covered by many vegetative filaments and form an urn-shaped structure, the cystocarp. The outer covering of cystocarp is called pericarp.

9. With help of suitable diagrams explain in detail the life cycle in polysiphonia.

Ans : The life cycle of Polysiphonia exhibits triphasic alternation of generation.

- In the life cycle of Polysiphonia consists of three distinct phases:
- 1. Gametophyte phase (n) 2. Carposporophyte (2n) 3. Tetrasporophyte (2n)
- The main vegetative thallus of polysiphonia is haploid, dioecious, gametophyte and free living.
- The male gametophytic plants develop male gametes inside spermatangia and female gametophytic thallus develops female gametes inside carpogonigia.

- The Spermatia male and Egg female gametes after fertilization form Zygote in carpogonium.
- The diploid zygote develops the carposporophyte phase of life cycle without resting phase.
- With gradual development carposporangia and carpospores are developed inside a composite structure, the carposporophyte.
- Diploid carpospore on germination produces the diploid tetrasporophyte thallus structure.
- The tetrasporophytic plant bears tetra sporangia and complete asexual reproduction.
- The diploid tetra sporangial nucleus divides meiotically to form four haploid Tetraspores.
- Out of 4 tetraspores, two male tetraspores develop male gametophyte thallus and two female tetraspores develop into female Gametophyte thallus.
- In alternation of generation of Polysiphonia two diploid phase's carposprophyte and tetra sporophyte alternate with one haploid gametophytic phase.



- The life cycle of Polysiphonia is a triphasic and can be called as Haplo-diplo-diplontic / Haplo-diplo-biontic life cycle.

10. What are the general characters of lichen? Explain different types and structure of lichen with examples.

Ans : Lichens are a small group of organisms of composite nature, consisting of two dissimilar organisms, an alga-phycobiont (phycos — alga; bios — life) and a fungus-mycobiont (mykes — fungus; bios — life); living in a symbiotic association.

The term lichen was coined by Theophrastus (370-285 B.C.).

Characteristics of Lichens:

- Lichens are a group of plants having composite thalloid nature, formed by the association of algae and fungi.
- Lichens are widely distributed in all over the world in varied habitat.
- They live symbiotically, where both the partners are equally benefitted. The fungal member absorbs water and mineral from atmosphere and substratum, make available to the alga and also protects algal cells from adverse conditions like temperature etc. The algal member synthesises organic food (carbohydrate) sufficient for both of them.

- Lichens often grow in most inhospitable and uninhabited places like barren rocks, cooled volcanic lava, icy tundra or alpines, sand dunes, roofs, walls, window panes, tree bark, leaves, etc. They commonly live under humid and exposed conditions but can tolerate extreme desiccation.
- Based on the morphological structure of thalli, they are of three types crustose, foliose and fruticose.
- Lichen reproduces by all the three means – vegetative, asexual, and sexual.
  (i) Vegetative reproduction: It takes place by fragmentation, decaying of older parts, by soredia and isidia.
  (ii) Asexual reproduction: By the formation of oidia.
  (iii) Sexual reproduction: By the formation of ascospores or basidiospores. Only fungal component is involved in sexual reproduction.
  (a) Ascospores are produced in Ascolichen.
  (b) The male sex organ is flask-shaped spermogonium, produces unicellular spermatia.
  (c) The female sex organ is carpogonium (ascogonium), differentiates into basal coiled oogonium and elongated trichogyne.
  (d) The fruit body may be apothecial (discshaped) or perithecial (flask-shaped) type.
- Asci develop inside the fruit body containing 8 ascospores. After liberating from the fruiting body, the ascospores germinate and, in contact with suitable algae, they form new lichen.
- Basidiospores are produced in Basidiolichen, generally look like bracket fungi and basidiospores are produced towards the lower side of the fruit body.
- The growth of lichen is very slow; they can survive in adverse conditions with high temperature and dry condition.
- They grow abundantly in forest areas and also considered as “pollution indicator.”

Habit and Habitat of Lichens:

- Lichens are widely distributed in all over the world in varied habitat.
- The plant body have composite thalloid structure; generally grows on bark of trees, leaves, dead logs, bare rocks etc., in different habitat. They grow luxuriantly in the forest areas with free or less pollution and with abundant moisture.
- Some species like Cladonia rangiferina (reindeer moss) grows in the extremely cold condition of Arctic tundras and Antarctic regions.
- In India, they grow abundantly in Eastern Himalayan regions. They do not grow in the highly polluted regions like Industrial areas. The growth of lichen is very slow.
- They grow abundantly in forest areas and also considered as “pollution indicator.”
- **Depending on the growing region, the lichens are grouped as:**
- **Corticoles:** Growing on bark of trees, mainly in the sub-tropical and tropical regions.
- **Saxicoles:** Growing on rocks, in cold climate.
- **Terricoles:** Growing on soil, in hot climate, with sufficient rain and dry summer.

Associated Members of Lichens:

- The composite thalloid plant body of lichen consists of algal and fungal members.
- The algal members belong to Chlorophyceae (Trebouxia, Trentepohlia, Coccomyxa etc.), Xanthophyceae (Heterococcus) and also Cyanophyceae (Nostoc, Scytonema etc.).
- The fungal members mainly belong to Ascomycotina and a few to Basidiomycotina.
- Ascomycetes that forms mycobiont is called Ascolichen.
- Basidiomycetes that forms mycobiont is called Basidiolichen.

Type of Lichens:

- The plant body of lichen is thalloid with different shapes.
- They are usually grey or greyish green in colour, but some are red, yellow, orange or brown in colour.
- Based on the external morphology, general growth and nature of attachment:
- There are of three main types or forms of lichens (crustose, foliose and fruticose).

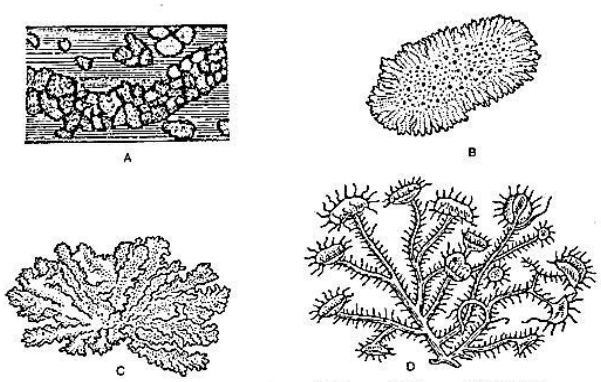


Fig. 4.112 : Different forms of lichen : A. Leprose, B. Crustose, C. Foliose and D. Fruiticose

Crustose lichens:

- These are encrushing lichens where thallus is inconspicuous, flat and appears as a thin layer or crust on substratum like barks, stones, rocks etc.
- They are either wholly or partially embedded in the substratum, e.g., Graphis, Lecanora, Ochrolechia, Verrucaria, Lecidia etc.

Foliose lichens:

- These are leaf-like lichens, where thallus is dorsiventral, flat, horizontally spreading and with lobes.
- They are attached to the substratum by a specialized structure called rhizines, (hyphal outgrowth) developed from the lower surface.
- e.g., Parmelia, Physcia, Peltigera, Hypogymnia, Xanthoria, Gyrophora, Collema etc.

Fruticose lichens (Frutex, Shrub):

- These are shrubby lichens, where thalli are well developed, cylindrical branched, shrub-like, either grow erect (Cladonia) or hang from the substratum (Usnea).
- They are attached to the substratum by a basal disc e.g., Cladonia, Usnea, Letharia, Alectonia etc.

Internal Structure of Thallus:

- Based on the distribution of algal member inside the thallus, the lichens are divided into two types. Homoisomerous or Homomerous and Heteromerous.

Homoisomerous:

- Here the fungal hyphae and the algal cells are more or less uniformly distributed throughout the thallus.
- The algal members belong to Cyanophyta. This type of orientation is found in crustose lichens.
- Both the partners intermingle and form thin outer protective layer, e.g., Leptogium, Collema etc.

Heteromerous:

- Here the thallus is differentiated into four distinct layers upper cortex, algal zone, medulla, and lower cortex.
- The algal members are restricted in the algal zone only. This type of orientation is found in foliose and fruticose lichens e.g., Physcia, Parmelia etc.

The detailed internal structure of Heteromerous lichens:

(a) Upper Cortex:

- It is a thick, outermost protective covering, made up of compactly arranged interwoven fungal hyphae located at right angle to the surface of the fruit body.
- Usually there is no intercellular space between the hyphae, but if present, these are filled with gelatinous substances.

(b) Algal Zone:

- The algal zone occurs just below the upper cortex. The algal cells are entangled by the loosely interwoven fungal hyphae.
- The common algal members may belong to Cyanophyta like Gloeocapsa (unicellular); Nostoc, Rivularia (filamentous) etc. or to Chlorophyta like Chlorella, Cystococcus, Pleurococcus etc.
- This layer is either continuous or may break into patches and serve the function of photosynthesis.

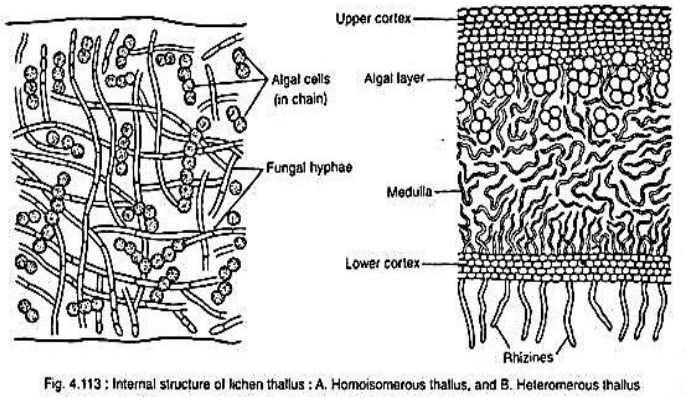


Fig. 4.113 : Internal structure of lichen thallus : A. Homoisomerous thallus, and B. Heteromerous thallus

Medulla:

- The medulla is situated just below the algal zone, comprised of loosely interwoven thick-walled fungal hyphae with large space between them.

Lower Cortex:

- It is the lowermost layer of the thallus. This layer is composed of compactly arranged hyphae, which may arrange perpendicular or parallel to the surface of the thallus.
- Some of the hyphae in the lower surface may extend downwards and penetrate the substratum which helps in anchorage, known as rhizines.
- The internal structure of Usnea, a fruticose lichen, shows different types of orientation.
- Being cylindrical in cross-section, the layers from outside are cortex, medulla (composed of algal cell and fungal mycelium) and central chondroid axis (composed of compactly arranged fungal mycelia).

11. What are the Reproduction method and Economic importance of lichens? with examples.

Ans: Lichen reproduces by all the three means, **vegetative, asexual, and sexual.**

Vegetative Reproduction:

1. **Fragmentation:**
   It takes place by accidental injury where the thallus may be broken into fragments and each part is capable of growing normally into a thallus.

2. **By Death of Older Parts:**

The older region of the basal part of the thallus dies, causing separation of some lobes or branches and each one grows normally into new thallus.

Asexual Reproduction:

1. Soredium (pi. Soredia):

- These are small grayish white, bud-like outgrowths developed on the upper cortex of the thallus.
- They are composed of one.or few algal cells loosely enveloped by fungal hyphae.
- They are detached from the thallus by rain or wind and on germination they develop new thalli.
- When soredia develop in an organised manner in a special pustule-like region, they are called Soralia, e.g., Parmelia Physcia etc.

2. Isidium (pi. Isidia):

- These are small stalked simple or branched, grayish- black, coral-like outgrowths, developed on the upper surface of the thallus. The isidium has an outer cortical layer continuous with the upper cortex of the mother thallus which encloses the same algal and fungal elements as the mother.
- They are of various shapes and may be coral-like in Peltigera, rod-like in Parmelia, cigar-like in Usnea, scale-like in Collema etc. It is generally constricted at the base and detached very easily from the parent thallus. Under favourable condition the isidium germinates and gives rise to a new thallus.

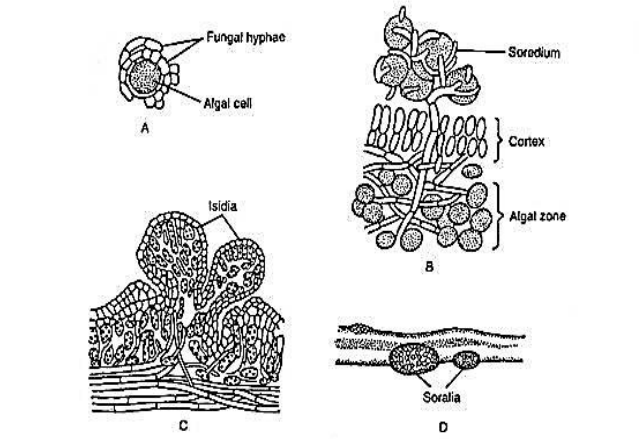


Fig. 4.115 : Asexual reproductive structures : A. Soredium of *Physcia pulverulenta* with single algal cell, B. Soredium of *Parmelia* with many algal cells, C. Isidia of *Peltigera* and D. Soralia on thallus

- In addition to asexual reproduction, the isidia also take part in increasing the photo- synthetic area of the thallus.

3. Pycniospore:

- Some lichen develops pycniospore or spermatium inside the flask-shaped pycnidium.
- They usually behave as gametes, but in certain condition they germinate and develop fungal hyphae.
- These fungal hyphae, when in contact with the appropriate algal partner, develop into a new lichen thallus.

Sexual Reproduction:

- Only fungal partner of the lichen reproduces sexually and forms fruit bodies on the thallus. The nature of sexual reproduction in ascolichen is like that of the members of Ascomycotina, whereas in Basidiolichen is like that of Basidiomycotina members.
- In Ascolichen, the male sex organ is the spermogonium (pycnidium) and the female sex organ is called carpogonium. The spermogonium mostly develops close to carpogonium.

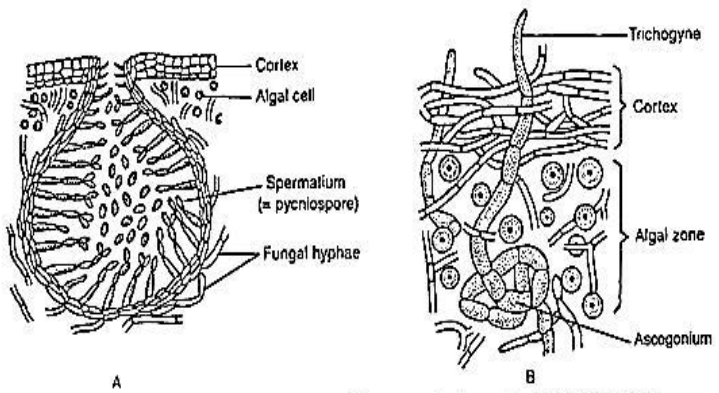


Fig. 4.116 : Sexual reproductive structures : A. Spermogonium (= pycnidium), B. Carpogonium

Spermagonium : The spermagonia are flask-shaped structures embedded in the upper surface of the thallus. They open outside by a small pore known as ostiole. The fertile hyphae in the cavity of spermagonium abstract minute rounded cells at its tip. These male cells are called spermatia. The spermatia behave as male gametes.

Carpogonium : The carpogonium is multicellular and is differentiated into basal / lower coiled multicellular portion called ascogonium and the upper, long, straight, thread like portion called trichogyne. The ascogonium remains embedded in the algal zone, but the trichogyne projects out beyond the upper cortex.

Fertilization in Lichens:

- The spermatia, after liberating from the spermogonium, gets attached with the trichogyne at the sticky projected part. On dissolution of the common wall, the nucleus of spermatium migrates into the carpogonium, fuses with the egg and form diploid nucleus (2n).
- After fertilization, trichogyne withers, and the ascogonium produces many freely branched acrogenous hyphae develop from the basal region. These hyphae produce asci at their ends. All these structures are surrounded by the sterile hyphae. It results in the formation of fruiting body which is either apothecium or perithecium type.
- Internally, the cup-like grooved region of a mature apothecium consists of three distinct parts; the middle thecium (= hymenium), comprising of asci and paraphyses, is the fertile zone covered by two sterile zones — the upper epitheca and lower hypotheca. The region below the cup is differentiated like the vegetative thallus into outer cortex, algal zone and central medulla.
- Usually the asci contain eight ascospores. The ascospores may be unicellular or multicellular, uninucleate or multinucleate, and are of various shapes and sizes.

Germination in Lichens :

- After liberating from the ascus, the ascospore germinates in suitable medium and produces new hypha. The new hypha, after coming in contact with proper algal partner, develops into a new lichen thallus.

Economic Importance of Lichens:

- The lichens are useful as well as harmful to mankind. The useful activities are much more than harmful ones. They are useful to mankind in various ways: as food and fodder, as medicine and industrial uses of various kinds.

As Food and Fodder:

- Lichens are used as food by human being in many parts of the world and also food for invertebrates like snail, catterpiliars, slugs, termites etc. They contain polysaccharide, lichenin; cellulose, vitamins and certain enzymes.

As Food:

- Some species of Parmelia are used as curry powder in India, Endocarpon miniatum is used as vegetable in Japan, Evernia prunastri for making bread in Egypt, and Cetraria islandica (Iceland moss) as food in Iceland.
- Lichens like *Lecanora saxicola* and *Aspicilia calcarea* etc. are used as food by snails, caterpillars, termites, slugs. etc.

As Fodder:

- *Cladonia rangiferina* (reindeer moss) also known as reindeer moss is the main food for reindeers and muskox in polar countries.
- *Cetraria islandica* is used as fodder for horses.

As source of Medicines:

- Lichens are medicinally important due to the presence of lichenin and some bitter or astringent substances. They have been used in the treatment of jaundice, diarrhoea, fevers, epilepsy, hydrophobia and skin diseases.
- Cetraria islandica and Lobaria pulmonaria are used for tuberculosis and other lung diseases; Parmelia sexatilis for epilepsy; Parmelia perlata for dyspepsia. Cladonia pyxidata for whooping cough; Xanthoria parietina for jaundice.
- Usnic acid, a broad spectrum antibiotic obtained from species of Usnea and Cladonia, are used against various bacterial diseases.

As in Industrial Uses:

- Lichens of various types are used in different kinds of industries.

Tanning Industry:

- Some lichens like Lobaria pulmonaria and Cetraria islandica are used in tanning leather.

Brewery and Distillation:

- Lichens like Lobaria pulmonaria are used in brewing of beer. In Russia and Sweden, Usneaflorida, Cladonia rangiferina and Ramalina fraxinea are used in production of alcohol due to rich content of **"lichenin",** a carbohydrate.

Preparation of Dye:

- The brown dye obtained from Parmelia omphalodes is used for dyeing of wool and silk fabrics.
- The red and purple dyes are available in Ochrolechia androgyna and O. tartaria.
- The blue dye "Orchil", obtained from Cetraria islandica , is used for dyeing woollen goods. Orcein, the active content of orchil-dye, is used extensively in laboratory during histological studies and for dyeing coir.
- Litmus, an acid-base indicator dye, from *Roccella tinctoria, R. montagnei* and also from *Lasallia pustulata.*

Cosmetics and Perfumery:

- The aromatic compounds available in lichen thallus are extracted and used in the preparation of cosmetic articles and perfumes. Essential oils extracted from species of Ramalina and Evernia are used in the manufacture of cosmetic soap.
- Ramalina calicaris is used to whiten hair of wigs.
- Species of *Usnea* have the capacity of retaining scent and are commercially utilised in perfumery.
- Evernia prunastri and Pseudevernia furfuracea are used widely in perfumes.

Harmful Activities of Lichens:

- Some lichens like Amphiloma and Cladonia parasitise on mosses and cause total destruction of moss colonies.
- Different lichens, mainly crustose type, cause serious damage to window glasses and marble stones of old buildings.
- Letharia vulpina (wolf moss) are highly poisonous. Vulpinic acid is present in this lichen.

Ecological Importance of Lichens:

- Lichens have some ecological importance.

Pioneer of Rock Vegetation:

- Lichens are pioneer colonisers on dry rocks. Due to their ability to grow with minimum nutrients and water, the crustose lichens Lecanora saxicola grows first, secrete some acids which disintegrate the rocks. After the death of the lichen, it mixes with the rock particles and forms thin layer of soil. The soil provides mosses like Crtmmia pulvinata to grow on it as the first successor.

Sensitivity to Air Pollutants:

- Lichens are very much sensitive to air pollutants like **SO_2, CO, CO_2** etc.; For the above facts, the lichens are markedly absent in cities and industrial areas. Thus, lichens are used as "pollution indicators".