M.Sc. First Year – Phycology / Algae

Detailed Easy-Language Notes – Unit 1 & Unit 2

Syllabus covered: Introduction to Algae; reproduction, life cycles and alternation of generations; algae in human welfare; basis of classification and nomenclature; F.E. Fritsch (1945) and Parker (1982) classifications up to class/subclass; comparative characters of major algal groups.

UNIT 1 – INTRODUCTION TO ALGAE

1. Definition of Algae

Algae are predominantly photosynthetic, chlorophyll-bearing organisms that generally have a simple plant body called a **thallus**. The thallus is not differentiated into true roots, stems and leaves and lacks the vascular tissue system of higher plants. Algae occur mainly in aquatic habitats, although many also live on moist soil, rocks, tree bark and other surfaces.

Easy meaning: Algae are mostly simple photosynthetic organisms. Their body is called a thallus instead of a true root–stem–leaf plant body.

2. Occurrence and Habitat

- **Freshwater:** ponds, lakes, streams, rivers, reservoirs and temporary pools. Examples: Spirogyra, Chlamydomonas, Volvox.
- **Marine:** seas and oceans, especially coastal and intertidal regions. Examples: Sargassum, Laminaria, Ulva and many red algae.
- **Terrestrial/subaerial:** moist soil, tree bark, walls, rocks and other damp surfaces. Examples include Trentepohlia and some cyanobacteria.
- **Edaphic habitats:** algae may occur in soil and contribute to soil fertility and carbon fixation.
- **Extreme habitats:** some algae or cyanobacteria tolerate high salinity, low temperature, high temperature or other stressful conditions.
- **Symbiotic habitats:** photosynthetic partners occur in lichens and in associations with some animals and microorganisms.

3. General Characters of Algae

- Mostly aquatic, but terrestrial and symbiotic forms are also known.
- Body is generally a thallus and is not differentiated into true root, stem and leaves.
- Most algae are autotrophic and photosynthetic; pigments vary among groups.
- Chlorophyll **a** is the principal photosynthetic pigment in oxygenic photosynthetic algae, while accessory pigments differ among groups.
- Body organization ranges from unicellular and colonial to filamentous, siphonaceous, parenchymatous and highly differentiated seaweeds.
- Cell walls commonly contain cellulose, but wall composition varies; some groups have silica, alginates, agar-like substances or other characteristic materials.
- Reserve food varies with the group: starch, floridean starch, laminarin, mannitol, oils and other substances occur.
- Reproduction may be vegetative, asexual or sexual.
- Sexual reproduction may be isogamous, anisogamous or oogamous.
- Life cycles show haplontic, diplontic or diplohaplontic patterns.
- Motile stages, where present, generally use flagella of characteristic number and structure.
- Algal cells may contain pyrenoids associated with carbon fixation and/or storage in many groups.

4. Thallus Organization – Basic Types

- **Unicellular motile:** Chlamydomonas.
- **Unicellular non-motile:** Chlorella.
- **Colonial:** Volvox.
- **Filamentous:** Spirogyra, Ulothrix.
- **Branched filamentous:** Cladophora.
- **Heterotrichous:** Stigeoclonium.
- **Siphonaceous/coenocytic:** Vaucheria, Caulerpa; multinucleate cytoplasm with few or no regular cross walls.
- **Parenchymatous:** larger seaweeds such as Ulva and Sargassum show complex tissue-like thalli.

5. Similarities and Differences between Algae, Fungi and Bryophytes

Similarities

- Algae, fungi and bryophytes are generally simple in body organization compared with vascular plants.
- They can reproduce by sexual and asexual methods.
- All can occur in moist or aquatic environments, although fungi and bryophytes are predominantly terrestrial.
- None has the typical vascular-tissue system of higher vascular plants.
- Several members of these groups have important ecological and economic roles.

Major Differences

Character	Algae	Fungi	Bryophytes
Nutrition	Mostly photosynthetic	Heterotrophic, absorptive	Photosynthetic
Chlorophyll	Present in photosynthetic algae	Absent	Present
Body	Thallus; very diverse	Hyphae forming mycelium in most	Gametophyte differentiated into simple structures
Cell wall	Variable; often cellulose-rich	Usually chitin-rich	Mainly cellulose and related materials
Main habitat	Mostly aquatic	Mostly terrestrial	Mostly moist terrestrial
Vascular tissue	Absent	Absent	Absent
Reserve food	Varies with algal group	Usually glycogen/oils	Usually starch
Sexual reproduction	Isogamy/anisogamy/oogamy	Various fungal reproductive modes	Archegonia and antheridia in traditional bryophyte de

6. Reproduction in Algae

Algae reproduce by **vegetative, asexual and sexual** methods. The relative importance of each method differs among taxa.

A. Vegetative Reproduction

- **Fragmentation:** the thallus breaks into pieces and each fragment grows into a new plant. Common in filamentous algae such as Spirogyra.
- **Cell division:** common in unicellular forms; daughter cells develop into new individuals.
- **Special propagules:** some algae produce specialized structures that detach and grow into new plants.

B. Asexual Reproduction

- **Zoospores:** motile, usually flagellated spores that swim before developing into new thalli.
- **Aplanospores:** non-motile spores.
- **Autospores:** non-motile daughter cells resembling the parent cell, as in some green algae.
- Other specialized spores occur in particular groups.

C. Sexual Reproduction

- **Isogamy:** fusion of morphologically similar gametes.
- **Anisogamy:** fusion of dissimilar gametes, usually differing in size and/or behaviour.
- **Oogamy:** fusion of a small male gamete with a large non-motile egg. Chara and Sargassum show oogamy.
- Fertilization produces a diploid zygote. The timing of meiosis determines the life-cycle pattern.

7. Life Cycle and Alternation of Generations

A **life cycle** is the sequence of developmental stages from one generation to the next, including haploid (n) and diploid (2n) phases. **Alternation of generations** refers specifically to regular alternation between multicellular haploid and multicellular diploid generations.

A. Haplontic Life Cycle

The main plant body is **haploid (n)**. Fertilization forms a diploid zygote, which undergoes meiosis to restore the haploid condition. The zygote is therefore usually the principal diploid stage. Example: Spirogyra.

B. Diplontic Life Cycle

The main plant body is **diploid (2n)**. Meiosis occurs during formation of gametes, and the gametes are haploid. There is no free-living multicellular haploid plant body. Example: Fucus; Sargassum is also commonly described as diplontic.

C. Haplodiplontic / Diplohaplontic Life Cycle

Both multicellular haploid and diploid phases are present. The **gametophyte** is haploid and the **sporophyte** is diploid. Meiosis produces spores from the sporophyte, while fertilization restores diploidy. Example: Ulva.

Important: In a true alternation of generations, both the haploid and diploid phases are multicellular and distinct. Not every life cycle with both ploidy levels has an equally prominent free-living generation.

8. Algae in Human Welfare

- **Food:** edible seaweeds such as Porphyra/Pyropia, Ulva and Laminaria are consumed in various regions.
- **Hydrocolloids:** agar from certain red algae is used in microbiology, biotechnology, food and pharmaceutical applications.
- **Alginate:** obtained mainly from brown algae and used as a thickener, stabilizer and gelling material in food, pharmaceutical and industrial products.
- **Carrageenan:** a polysaccharide obtained from certain red algae and used as a thickener/stabilizer.
- **Biofertilizers:** cyanobacteria such as Nostoc and Anabaena can contribute nitrogen fixation in appropriate agricultural systems; Azolla–cyanobacterium associations are especially important in rice cultivation.
- **Wastewater treatment:** algae can assimilate nutrients and contribute to biological treatment systems.
- **Oxygen and carbon fixation:** photosynthetic algae contribute significantly to aquatic primary production and global carbon cycling.
- **Animal feed:** algal biomass can be used as feed or feed supplement in suitable systems.
- **Bioactive compounds:** algae are sources of pigments, antioxidants, polysaccharides and other compounds investigated for pharmaceutical and nutraceutical uses.
- **Research:** algae and microalgae are used in photosynthesis studies, biotechnology and biofuel research.
- **Environmental monitoring:** algal responses can help indicate changes in water quality, although interpretation requires proper ecological methods.

UNIT 2 – CLASSIFICATION OF ALGAE

1. Basis of Algal Classification and Nomenclature

Algae are extremely diverse, and no single character is sufficient for reliable classification. Classical systems used combinations of morphology, pigments, reserve food, cell wall composition, flagella and reproduction. Modern classifications also use ultrastructure, biochemistry, molecular sequences and evolutionary relationships.

Important classical criteria

- **Photosynthetic pigments:** types and relative proportions of chlorophylls and accessory pigments.
- **Reserve food:** chemical nature and location of stored carbohydrates and other reserves.
- **Cell wall:** composition and special components such as silica or alginates.
- **Chloroplast:** number, shape, position, membrane organization and presence/absence of pyrenoids.
- **Flagella:** number, position, length and ultrastructural characteristics in motile stages.
- **Eyespot/stigma:** presence, position and organization in motile cells.
- **Thallus organization:** unicellular, colonial, filamentous, siphonaceous, parenchymatous, etc.
- **Reproduction and life cycle:** type of gametes, spores, fertilization and alternation patterns.
- **Cell ultrastructure and molecular data:** particularly important in modern classifications.

Nomenclature – Basic Idea

Nomenclature means the formal naming of organisms according to accepted rules. Scientific names provide a universal system independent of local/common names. Algal nomenclature has a complex history because some algal groups have undergone major taxonomic changes.

- Scientific names are generally based on the binomial system at species level: *Genus species*.
- The International Code of Nomenclature for algae, fungi and plants (ICN) governs names in the relevant botanical nomenclatural framework.
- Classification tells us *where an organism belongs*; nomenclature tells us *what name is used for it*.

2. F.E. Fritsch (1945) – Classical Classification

F.E. Fritsch's classical system was based on combinations of pigments, reserve products, flagella, thallus organization, reproduction and other structural features. It recognized major algal classes in a historical framework.

Class in Fritsch's scheme	Representative examples	Key idea
Myxophyceae	Nostoc, Anabaena	Blue-green, prokaryotic cyanobacteria in older algal treatment
Chlorophyceae	Chlamydomonas, Volvox, Spirogyra	Green algae
Xanthophyceae	Vaucheria	Yellow-green algae
Chrysophyceae	Synura	Golden algae
Bacillariophyceae	Navicula, Pinnularia	Diatoms
Cryptophyceae	Cryptomonas	Cryptomonads
Dinophyceae	Ceratium, Peridinium	Dinoflagellates
Chloromonadineae	Vacuolaria	Chloromonads
Euglenineae	Euglena	Euglenoids
Phaeophyceae	Sargassum, Laminaria	Brown algae
Rhodophyceae	Polysiphonia, Gelidium	Red algae

Note: Fritsch's classification is a classical historical system. In modern biology, cyanobacteria are treated within Bacteria rather than as true algae, and several eukaryotic algal groups are distributed among different evolutionary lineages.

3. Parker (1982) – Classification: Study Approach

University syllabi sometimes cite **Parker (1982)** as a classical/teaching classification and may differ in the exact rank names or arrangement used in a particular textbook edition. For examination purposes, students should follow the precise class/subclass sequence prescribed by their university's reference text. The comparative account below emphasizes the major algal groups and the characters usually used to distinguish them.

Major teaching groups commonly compared: Cyanophyceae/Myxophyceae, Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Dinophyceae, Euglenophyceae/Euglenineae, Phaeophyceae and Rhodophyceae, with cryptophytes and other flagellate groups treated separately in broader schemes.

4. Comparative Account of Major Algal Classes

The following table is a high-yield comparison. Pigments and reserve foods are given in simplified textbook form; exceptions exist within individual taxa.

Group	Major pigments	Reserve food	Cell wall	Chloroplast	Eyespot	Flagella
Cyanophyceae / Myxophyceae*	Chlorophyll a, phycocyanin, often phycoerythrin	Cyanophycean starch/glycogen-like reserves	Peptidoglycan-containing bacterial wall	No true membrane-bound chloroplast	Usually absent as a true eukaryotic eyespot	No flagellated cells
Chlorophyceae	Chlorophyll a, b; carotenoids	Starch	Usually cellulose	Green; variable shape; pyrenoids common	Present in many motile green algal cells	Usually 2 or 4 equal whipl
Xanthophyceae	Chlorophyll a, c; xanthophylls; little/no fucoxanthin	Oil and chrysolaminarin-like reserves	Cellulose/pectic materials; variable	Yellow-green	Present in some motile forms	Typically 2 unequal flagell
Chrysophyceae	Chlorophyll a, c; carotenoids, fucoxanthin variable	Chrysolaminarin and oils	Often silica/scales in some taxa; variable	Usually one or more; highly variable	Present in some motile forms	Often 1–2 flagella; diversit
Bacillariophyceae	Chlorophyll a, c; fucoxanthin and carotenoids	Chrysolaminarin and oils	Silica-rich frustule	Plastids usually golden-brown	Generally absent	Most vegetative cells non-
Dinophyceae	Chlorophyll a, c; peridinin common in many	Starch and oils	Cellulosic plates in many thecate forms; others naked	Usually golden-brown; variable	Often present in photosynthetic forms	Two flagella, usually trans
Euglenineae	Chlorophyll a, b in photosynthetic forms; carotenoids	Paramylon	No rigid cellulose wall; pellicle	Green plastids in photosynthetic species	Usually present	Usually 1–2 flagella arisin
Phaeophyceae	Chlorophyll a, c; fucoxanthin	Laminarin and mannitol	Cellulose + alginates and other polysaccharides	Brown plastids	Generally absent	Motile reproductive cells c
Rhodophyceae	Chlorophyll a; phycobilins, especially phycoerythrin	Floridean starch	Cellulose + galactan polysaccharides such as agar/carrageenan in many	Red plastids; phycobilisomes; no true motile chloroplast-bearing cells	Absent	No flagellated cells

*Cyanophyceae/Myxophyceae is retained here because it occurs in classical algal classifications. Modern classification places cyanobacteria in Bacteria.

5. Detailed Notes on Important Comparative Characters

A. Pigments

- **Green algae:** chlorophyll a and b are prominent, giving a green colour.
- **Brown algae:** chlorophyll a and c plus fucoxanthin; fucoxanthin masks the green chlorophyll and produces a brown colour.
- **Red algae:** chlorophyll a plus phycobiliproteins, especially phycoerythrin and phycocyanin.
- **Diatoms and many golden groups:** chlorophyll a/c and carotenoids, with fucoxanthin important in many taxa.
- **Euglenoids:** photosynthetic members generally contain chlorophyll a and b.

B. Reserve Food

- Green algae: mainly starch.
- Brown algae: mainly laminarin and mannitol, with other reserves also occurring.
- Red algae: floridean starch.
- Diatoms: chrysolaminarin and oils.
- Euglenoids: paramylon.
- Cyanobacteria: cyanophycean starch/glycogen-like reserves.

C. Cell Wall

- Cell wall chemistry is a major taxonomic character.
- Green algae commonly have cellulose-rich walls.
- Brown algae have cellulose plus alginates and other polysaccharides.
- Red algae commonly have cellulose plus sulfated and non-sulfated galactans; agar and carrageenan are characteristic products of particular groups.

- Diatoms have a silica-rich frustule made of two overlapping valves.
- Euglenoids lack a conventional rigid cellulose cell wall and have a protein-rich pellicle.
- Cyanobacteria possess a bacterial-type peptidoglycan-containing wall.

D. Chloroplast

- Chloroplast structure, number, shape, position and pyrenoids are useful comparative characters.
- Green algal chloroplasts show great diversity in shape and commonly contain pyrenoids.
- Brown and many golden algal plastids are generally brown/golden because of accessory pigments.
- Red algal plastids contain phycobiliproteins and have a characteristic red coloration.
- Diatom plastids are usually golden-brown.

E. Eyespot / Stigma

An **eyespot** is a light-sensitive structure, often associated with motile cells. It helps the organism respond to light direction. It is especially familiar in Chlamydomonas and Euglena, while its occurrence and structure vary among algal groups.

F. Flagella

- Flagella are locomotory organelles in many algal motile stages.
- Green algal motile cells commonly have equal, smooth/whiplash-type flagella.
- Xanthophycean and some other heterokont groups characteristically have unequal flagella, one often bearing fine hairs.
- Dinoflagellates generally have two flagella arranged in transverse and longitudinal positions.
- Brown algal reproductive cells commonly have two unequal lateral flagella.
- Red algae lack flagellated stages.
- Cyanobacteria do not possess eukaryotic flagella.

6. High-Yield Comparison for Examinations

Group	Colour clue	Reserve food	Special feature
Chlorophyceae	Green	Starch	Chlorophyll a+b; common pyrenoids
Xanthophyceae	Yellow-green	Oil/chrysolaminarin-like	Unequal flagella in motile stages
Chrysophyceae	Golden	Chrysolaminarin + oils	Golden pigments; diverse flagellates
Bacillariophyceae	Golden-brown	Chrysolaminarin + oils	Silica frustule
Dinophyceae	Brown/golden	Starch + oils	Two characteristic flagella
Euglenineae	Green in photosynthetic forms	Paramylon	Pellicle; eyespot common
Phaeophyceae	Brown	Laminarin + mannitol	Fucoxanthin; alginates
Rhodophyceae	Red	Floridean starch	Phycobilins; no flagella
Cyanophyceae*	Blue-green	Cyanophycean reserve	Prokaryotic; no true chloroplast/flagella

7. Important Examination Questions

- Define algae and discuss their occurrence and habitat.
- Describe the general characters of algae.
- Compare algae with fungi and bryophytes.
- Explain vegetative, asexual and sexual reproduction in algae.
- Explain haplontic, diplontic and haplodiplontic life cycles with examples.

- What is alternation of generations? Distinguish it from a simple alternation of ploidy.
- Discuss the economic importance of algae in human welfare.
- Explain the major bases used in algal classification.
- Write an account of F.E. Fritsch's classification of algae up to classes.
- Discuss Parker's classification as prescribed in your university syllabus.
- Compare algal classes on the basis of pigments, reserve food, cell wall and chloroplast.
- Explain the taxonomic importance of eyespot and flagella.
- Differentiate Chlorophyceae, Phaeophyceae and Rhodophyceae.
- Differentiate Xanthophyceae, Bacillariophyceae and Euglenineae.

8. Quick Memory Aids

Green algae: Green colour → chlorophyll a+b → starch. **Brown algae:** Brown colour → fucoxanthin → laminarin + mannitol. **Red algae:** Red colour → phycoerythrin → floridean starch → no flagella.

Diatoms: think *silica box*. **Euglena:** think *pellicle* + *eyespot* + *paramylon*. **Dinoflagellates:** think *two differently positioned flagella*. **Rhodophyceae:** think *red* + *no flagella*.

Important caution: Classical classifications are historical teaching systems. Modern algal taxonomy is phylogenetic and changes as molecular and ultrastructural evidence improves. For university examinations, reproduce the classification exactly as prescribed in your department's textbook/syllabus.