Introduction to Algae

What are Algae?

- **Thalloid, chlorophyll-bearing, autotrophic organisms**.
- ✕ No true roots, stems, leaves, vascular tissue.
- Study of algae = **Phycology / Algology**.

A Quick History

- **Linnaeus (1754)** – called mosses, liverworts, seaweeds all “Algae”.
- **A.L. de Jussieu (1789)** – refined → only chlorophyllous thalloid forms.
- **Romans** → “Fucus”
- **Chinese** → “Tsao” (food delicacy)
- **Hawaiians** → “Limu”
- **India** → M.O.P. Iyengar (“Father of Indian Phycology”)

General Features

Feature	Key Points	Example
Body	Thalloid, simple to complex	Chlamydomonas → Laminaria
Cell Type	Prokaryotic (Cyanophyceae) or Eukaryotic	Nostoc vs Volvox
Pigments	Chl-a (universal), Chl-b (green), Chl-c (brown), Chl-d (red), carotenoids, phycobilins	
Storage	Starch, Floridean starch, Laminarin, Paramylon, Cyanophycean starch	
Reproduction	Vegetative, Asexual (spores), Sexual (isogamy → oogamy)	Ulothrix, Spirogyra, Chara

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Ecological Roles

- Base of aquatic **food chains**.
- Release **>50% of Earth’s oxygen**.
- Symbiotic: Lichens (fungi+algae), Anabaena in Azolla, Nostoc in Anthoceros.
- Bioindicators → Oscillatoria in polluted waters.

🔹 Economic Uses 💰

- 🍱 **Food** – Porphyra (nori), Laminaria (kelp), Chlorella (protein tablets).
- 🏭 **Industry** – Agar (lab media), Carrageenan (ice creams 🍦), Alginates (toothpaste).
- 💊 **Medicine** – Antiviral, anticoagulant polysaccharides.
- 🚜 **Farming** – Biofertilizers (Nostoc, Anabaena), seaweed manure.
- 🔬 **Biotech** – Genes for photosynthesis, RuBisCO, biofuel research.

🔹 Mnemonics 💡

- **Storage Products → SFLPC**
  - **S**tarch → Green algae
  - **F**loridean starch → Red algae
  - **L**aminarin → Brown algae
  - **P**aramylon → Euglenoids
  - **C**yanophycean starch → Cyanophyta
- **Economic Uses → FIMBA**
  - **F**ood
  - **I**ndustry
  - **M**edicine
  - **B**iofertilizers
  - **A**quaculture

✨ Exam Capsule:

- Algae = 🌬️ oxygen factory + 🏭 industry source + 🚜 biofertilizer + 🍱 food.
- Linnaeus broadened → Jussieu restricted → Iyengar pioneered India.

📄 Phycologists & Their Contributions 💀🔬📚

◈ World Pioneers 🌍

- **Roth (1797)** – First systematic algal work.
- **Lamouroux (1813)** – Divided algae based on colour (Green, Brown, Red).
- **Agardh (1824–1872)** – Proposed natural classification; described many genera.
- **Thurret & Areschoug** – Studied life histories & reproduction.
- **Harvey** – Known as “Father of Modern Phycology”; authored *Phycologia Australica*.
- **Fritsch (1935, 1948)** – Wrote *Structure and Reproduction of Algae*; standard textbook, proposed 11 classes.

◈ Indian Pioneers IN

- **M.O.P. Iyengar (1886–1963)** 🌿
  - “Father of Indian Phycology.”
  - Specialized in freshwater algae.
  - Established algal culture methods in India.
  - Founded **Phycological Society of India**.
- **T.V. Desikachary (1919–1989)** 🔬
  - World authority on **Cyanophyta (blue-green algae)**.
  - Authored *Cyanophyta* (1959) – landmark in algal taxonomy.
  - Edited proceedings of **1974 Symposium on Algal Taxonomy**.
  - Founder Secretary, **Seaweed Research & Utilization Association**.
- **Randhawa** 📖
  - Worked on Zygnemaceae (filamentous green algae).
  - Contributed to Indian algal flora documentation.
- **R.N. Singh** □
  - Developed concept of **algae as biofertilizers**.
  - Noted for work on nitrogen-fixing cyanobacteria in rice fields.
- **B.N. Prasad & Y. Bhardwaj**
  - Advanced studies in algal cytology, ecology, and physiology.
- **V. Krishnamurthy** 🐊
  - Specialist in **marine algal flora of India**.
  - Developed algal herbarium collections.
- **V.S. Sundaralingam** 🎖

- Focus on taxonomy & ecology.
- Received **Life-Time Achievement Award in Phycology**.

🔹 Mnemonics 💡

- **Indian Phycology Heroes → "I.D.R.S.P.K.S"**
  - **I**yengar – Father of Indian Phycology
  - **D**esikachary – Cyanophyta authority
  - **R**andhawa – Zygnemaceae
  - **S**ingh (R.N.) – Biofertilizers
  - **P**rasad – Cytology/Physiology
  - **K**rishnamurthy – Marine algae
  - **S**undaralingam – Taxonomy & Awards

🔹 Exam Capsule 🎯

- **Harvey** → Modern Phycology.
- **Fritsch** → Classification (11 classes).
- **Iyengar** → Father of Indian Phycology.
- **Desikachary** → *Cyanophyta (1959)*.
- **R.N. Singh** → Cyanobacteria in rice fields (biofertilizers).

📄 3 – General Characters of Algae 🌊🌿

🔹 Thallus Organization □

- **Unicellular motile** → *Chlamydomonas*.

- **Unicellular non-motile** → *Chlorella*.
- **Colonial** → *Volvox, Hydrodictyon*.
- **Filamentous unbranched** → *Spirogyra, Ulothrix*.
- **Filamentous branched** → *Cladophora*.
- **Heterotrichous** → *Ectocarpus*.
- **Siphonaceous (coenocytic)** → *Vaucheria*.
- **Parenchymatous** → *Ulva, Laminaria*.

◈ Cell Types □

- **Prokaryotic (Cyanophyceae)**: No true nucleus, 70S ribosomes, peptidoglycan wall.
- **Eukaryotic (others)**: Nucleus with 80S ribosomes, plastids, pyrenoids.

◈ Plastids & Organelles

- **Chloroplasts** → Contain pigments, pyrenoids (for starch formation).
- **Eye spot (stigma)** → Photoreception in motile algae (Chlamydomonas).
- **Contractile vacuole** → Osmoregulation (freshwater algae).
- **Flagella** → 9+2 microtubule structure, number and type vary by class.

◈ Pigments

- **Chlorophyll a** – Universal.
- **Chlorophyll b** – Green algae, Euglenoids.
- **Chlorophyll c** – Brown algae, Diatoms, Dinoflagellates.
- **Chlorophyll d** – Red algae, some cyanobacteria.
- **Carotenoids** – Carotenes & xanthophylls (Fucoxanthin → brown colour).
- **Phycobilins** – Phycoerythrin (red), Phycocyanin (blue).

◈ Reserve Food Products

- Starch (Green algae).
- Floridean starch (Red algae).
- Laminarin, Mannitol (Brown algae).
- Paramylon (Euglenoids).
- Myxophycean starch (Cyanophyta).

◈ Modes of Nutrition 🍽️

- **Autotrophic** – Photoautotrophs (most algae).
- **Heterotrophic** – Saprophytic, parasitic.
- **Mixotrophic** – Euglena (can photosynthesize + ingest).

◈ Reproduction ♻️

- **Vegetative** – Fragmentation (Spirogyra), cell division (Chlamydomonas).
- **Asexual** – Zoospores, Aplanospores, Hypnospores, Tetraspores.
- **Sexual** –
    - **Isogamy** → Similar gametes (*Ulothrix*).
    - **Anisogamy** → Dissimilar gametes (*Chlamydomonas braunii*).
    - **Oogamy** → Large egg + small motile sperm (*Chara, Vaucheria*).

◈ Ecological Importance 🌍

- O2 producers (~50% of Earth's oxygen).
- Primary producers in aquatic ecosystems.
- Bioindicators of water quality.
- Symbionts in lichens, Azolla-Anabaena, Cycas roots.

◈ Mnemonics 💡

- **Thallus Diversity** → "U-C-F-H-S-P"
    - **U**nicellular
    - **C**olonial
    - **F**ilamentous
    - **H**eterotrichous
    - **S**iphonaceous
    - **P**arenchymatous
- **Pigments → "a-b-c-d-Carotenoids-Phycobilins"** → Remember: *All Boys Can Dance Cool Poses*

◈ Exam Capsule 🎯

- Prokaryotic algae = **Cyanophyceae**.
- **Universal pigment** = Chlorophyll a.
- Storage products vary: **Starch (green), Floridean starch (red), Laminarin (brown)**.
- Thallus ranges from unicell → giant kelp (*Macrocystis*, meters long).

📄 Cell Structure of Algae 🫳

🔷 Cell Types

- **Prokaryotic (Cyanophyta / Blue-Green Algae)**
  - No true nucleus (DNA in centroplasm).
  - Ribosomes: 70S type.
  - **Cell wall**: Peptidoglycan + mucilaginous sheath.
  - **Photosynthetic lamellae**: Thylakoids without stacked grana.

    - **Special features**: Gas vacuoles (for buoyancy), heterocysts (N_2 fixation).
- **Eukaryotic (Green, Brown, Red, Euglenoids, etc.)**
    - True nucleus with nuclear membrane.
    - Ribosomes: 80S in cytoplasm.
    - **Cell wall**: Cellulose, pectins, alginates, silica (diatoms), carrageenan (red algae).
    - Plastids with **thylakoids in grana**.

◈ Cell Wall Composition □

- **Cyanophyceae** → Peptidoglycan + mucilage.
- **Chlorophyceae** → Cellulose, hemicellulose, pectin.
- **Phaeophyceae** → Cellulose + alginic acid.
- **Rhodophyceae** → Cellulose + carrageenan/agar.
- **Bacillariophyceae (Diatoms)** → Silica frustules.

◈ Plastids 🏵

- **Types**: Discoid, cup-shaped, girdle-shaped, reticulate, spiral.
- **Pigments**: Chl-a universal; accessory pigments vary by group.
- **Pyrenoids**: Centers for starch storage & RuBisCO enzyme.
- **Thylakoids**:
    - Cyanophyceae → free, unstacked.
    - Green algae → stacked in grana.

◈ Organelles □

- **Mitochondria** – Powerhouse of eukaryotic algae.
- **Golgi apparatus** – Secretion.
- **Peroxisomes** – Photorespiration.
- **Nucleus** – Prominent in eukaryotes; absent in cyanobacteria.

◈ Eye Spot (Stigma) 👁

- **Photoreceptive structure** in motile algae (e.g., *Chlamydomonas*).
- Types: A–E based on complexity.

- Helps in **phototaxis** (movement towards/away from light).

◈ Flagella 🏳

- **Structure**: 9 + 2 arrangement of microtubules.
- **Types**:
  - Isokont → equal length (Chlamydomonas).
  - Anisokont → unequal length.
  - Heterokont → different morphology (Xanthophyceae, Phaeophyceae).
  - Stephanokont → tuft of flagella (Oedogonium male gametes).
- **Number** varies:
  - 2 in Chlorophyceae (anterior).
  - Many in some gametes (Ulothrix).
  - Absent in Rhodophyceae.

◈ Special Structures 🌟

- **Gas vacuoles** – Cyanobacteria, for buoyancy.
- **Heterocysts** – Specialized cells for nitrogen fixation (Anabaena, Nostoc).
- **Eyespot** – Light-sensitive organelle in motile forms.

◈ Mnemonics 💡

- **Flagella Types** → “I Am Happy Student” (I-A-H-S)
  - **I**sokont
  - **A**nisokont
  - **H**eterokont
  - **S**tephanokont
- **Cell wall key chemicals → C-P-A-S-C**
  - **C**yanophyceae – Peptidoglycan
  - **P**haeophyceae – Alginates
  - **A**gar/Carrageenan – Red algae
  - **S**ilica – Diatoms
  - **C**ellulose – Green algae

◈ Exam Capsule 🎯

- Cyanophyceae → Prokaryotic, peptidoglycan wall, heterocysts, no flagella.
- Eukaryotic algae → True nucleus, plastids with pyrenoids.
- **Eye spot** → Light reception in motile algae.
- **Flagella absent** in **Rhodophyceae**.
- Diatoms → “Glass house” algae (silica frustules).

📄 Pigments in Algae 🎨▫️

◈ Major Pigments

- **Chlorophyll a** → Universal pigment in all algae 🌍.
- **Chlorophyll b** → Green algae, Euglenoids.
- **Chlorophyll c** → Brown algae, Diatoms, Dinoflagellates, Chrysophyceae.
- **Chlorophyll d** → Red algae (*Rhodophyceae*), some cyanobacteria.
- **Chlorophyll e** → Rare, in some *Xanthophyceae*.

◈ Accessory Pigments

- **Carotenoids** (carotenes + xanthophylls)
    - **β-carotene** → orange.
    - **Lutein, Zeaxanthin** → yellow.
    - **Fucoxanthin** → brown (Phaeophyceae).
- **Phycobilins** (phycobiliproteins, water-soluble)
    - **Phycoerythrin (red)** → Rhodophyceae.
    - **Phycocyanin (blue)** → Cyanophyceae.
    - **Allophycocyanin** → accessory in red/blue-green algae.

◈ Algal Group → Pigment Dominance

Group	Dominant Pigments	Example Colour
Cyanophyceae	Chl-a, phycocyanin (blue), phycoerythrin	Blue-green
Chlorophyceae	Chl-a, Chl-b	Green
Phaeophyceae	Chl-a, Chl-c, Fucoxanthin	Brown/olive
Rhodophyceae	Chl-a, d, Phycoerythrin	Red
Euglenoids	Chl-a, Chl-b	Green
Diatoms (Bacillariophyceae)	Chl-a, Chl-c, Fucoxanthin	Golden-brown
Chrysophyceae	Chl-a, Chl-c, Fucoxanthin	Yellow-brown

◈ Role of Pigments

- Capture solar energy for **photosynthesis**.
- Accessory pigments broaden absorption spectrum.
- Phycobilisomes → specialized light-harvesting complexes in Cyanophyta & Rhodophyta.
- Fucoxanthin masks green of chlorophyll → gives brown colour.

◈ Mnemonics

- **Chlorophyll Distribution → "ABCD-E"**
    - **A** → All algae
    - **B** → Green algae, Euglenoids
    - **C** → Brown algae, Diatoms, Chrysophyceae

    - **D** → Red algae
    - **E** → Rare in some Xanthophyceae
- **Phycobilins** → “E-C-A”
    - **E**rythrin → Red
    - **C**yanin → Blue
    - **A**llophycocyanin → Accessory

◈ **Exam Capsule** 🎯

- **Universal pigment** = Chl-a.
- **Fucoxanthin** → hallmark of brown algae & diatoms.
- **Phycoerythrin** → red colour in *Polysiphonia, Porphyra*.
- **Phycocyanin** → blue colour in *Oscillatoria, Nostoc*.
- **Rhodophyceae** = no flagella, rich in **phycoerythrin**.

📄 Storage Products of Algae 🍱

◈ **Overview**

Algae store food in diverse forms depending on their **evolutionary group**. Storage materials act as **taxonomic markers**.

◈ **Major Storage Products**

- **Green Algae (Chlorophyceae)** → **Starch** (in pyrenoids).
- **Red Algae (Rhodophyceae)** → **Floridean starch** (in cytoplasm, not in plastids).
- **Brown Algae (Phaeophyceae)** → **Laminarin** (β-glucan) + **Mannitol** (sugar alcohol).
- **Cyanophyceae (Blue-Green Algae)** → **Cyanophycean starch** (glycogen-like).
- **Euglenoids** → **Paramylon** (β-1,3-glucan, not starch).

- **Chrysophyceae & Diatoms** → **Chrysolaminarin** (oil + polysaccharides).
- **Dinophyceae** → **Starch-like granules** in cytoplasm.

◈ Special Compounds

- **Mannitol** – characteristic of brown algae.
- **Inulin** – rare, in some algae.
- **Trehalose** – energy reserve in cyanobacteria.
- **Floridoside** – osmotic regulator in red algae.

◈ Table for Quick Recall 📊

Algal Group	Reserve Product	Example
Chlorophyceae	Starch (pyrenoids)	*Chlamydomonas, Spirogyra*
Rhodophyceae	Floridean starch (cytoplasm)	*Polysiphonia, Gelidium*
Phaeophyceae	Laminarin + Mannitol	*Fucus, Laminaria*
Cyanophyceae	Cyanophycean starch	*Nostoc, Oscillatoria*
Euglenoids	Paramylon	*Euglena*
Chrysophyceae	Chrysolaminarin	*Chromulina*
Bacillariophyceae	Oil + Chrysolaminarin	*Navicula*

◈ Mnemonics 💡

- **S-F-L-P-C** → Major storage compounds
  - **S**tarch → Green algae
  - **F**loridean starch → Red algae
  - **L**aminarin → Brown algae
  - **P**aramylon → Euglenoids
  - **C**yanophycean starch → Blue-greens
- **Brown Algae** = **"LM"** → **L**aminarin + **M**annitol.

◈ Exam Capsule 🎯

- **Floridean starch** is cytoplasmic (not plastidial).

- **Paramylon** is unique to *Euglena* (β-glucan).
- **Diatoms** → Oil + Chrysolaminarin (reason for their high energy).
- **Cyanobacteria** → Glycogen-like “Cyanophycean starch”.

📄 Physiology & Nutrition in Algae 🔬🌊

🔷 Modes of Nutrition

1. **Autotrophic** 🌞
    - Majority are **photoautotrophs** (use chlorophyll + sunlight).
    - Some are **chemoautotrophic** (rare, cyanobacteria like *Nostoc*).
2. **Heterotrophic** 🍂
    - **Saprobic** – Absorb dissolved organic matter (*Chlorella* in darkness).
    - **Parasitic** – On plants/animals (*Cephaleuros* → red rust of tea).
    - **Auxotrophic** – Require organic vitamins/amino acids (e.g., *Chlamydomonas* needing thiamine).
3. **Mixotrophic** ⚡
    - Combine autotrophy + heterotrophy.
    - Classic example: *Euglena* (photosynthetic + holozoic).

◈ Photosynthesis in Algae

- **Light reactions** → Occur in thylakoid membranes; release ATP, NADPH.
- **Dark reactions** → Calvin cycle (C3), some algae have C4-like pathway.
- **Pigment systems** broaden absorption spectrum → phycobilins (Rhodophyta), fucoxanthin (Brown algae).
- **Unique products**: Glycerol in *Dunaliella* under salt stress.

◈ Nitrogen Metabolism

- Cyanobacteria fix N_2 via **heterocysts** (e.g., *Anabaena*, *Nostoc*).
- Store N in form of **cyanophycin granules** (arginine + aspartic acid polymer).
- Some algae absorb nitrate, ammonium from environment.

◈ Respiration & Fermentation

- **Aerobic respiration** → via mitochondria (Eukaryotic algae).
- **Fermentation** → Some algae (e.g., *Chlamydomonas*) release ethanol, H_2 under anaerobic conditions.

◈ Osmoregulation

- Freshwater algae → **Contractile vacuoles** pump out water (*Chlamydomonas*).
- Marine algae → Produce osmolytes (mannitol, glycerol, floridoside) to resist salinity.

◈ Reproduction (Recap in Physiology)

- **Vegetative**: Fragmentation, cell division.
- **Asexual**: Zoospores, aplanospores, autospores.
- **Sexual**: Isogamy, Anisogamy, Oogamy.

◈ Mnemonics

- **Nutrition Types → "A-H-M"**
    - **A**utotrophic
    - **H**eterotrophic (Saprobic, Parasitic, Auxotrophic)
    - **M**ixotrophic (*Euglena*)

- **Heterocyst = Nitrogen Fixation** → Remember: “H for Heterocyst, H for Haber (N_2 fixation).”

◈ Exam Capsule 🎯

- **Cyanobacteria** = only group fixing nitrogen (heterocysts).
- **Euglena** = model of **mixotrophy**.
- **Cephaleuros** = algal parasite (red rust of tea).
- **Dunaliella** = salt-tolerant, produces glycerol.

📄 Fossil Record of Algae ⏳🌿

◈ Origin of Algae

- **Cyanobacteria (Blue-Green Algae)** = earliest oxygenic photosynthesizers.
- **Stromatolites** → Layered calcareous deposits formed by cyanobacteria, dating back **~2.7 billion years** (Precambrian).
- **First eukaryotic algae** → *Glaucophyta* (prochlorophytes-like plastids).

◈ Geological Record 📜

- **Precambrian (Archean, Proterozoic)**
  - Cyanobacteria abundant.
  - Stromatolites as evidence.
- **Silurian Period**
  - Oldest known **stoneworts (Charophyta)** fossils.
- **Devonian Period**
  - Green algae diversification.

    - Earliest hints of algal contribution to land colonization.
- **Carboniferous**
    - Massive deposits of fossil algae contributed to coal formation.
- **Cretaceous Period**
    - Appearance of **Chrysophyta (Golden algae)** fossils.
    - Diatoms (Bacillariophyceae) diversification.
- **Eocene Period**
    - Fossils of Euglenophyta.
- **Miocene Period**
    - Expansion of **Xanthophyceae (Yellow-green algae)**.

◈ Economic/Scientific Importance of Fossil Algae

- Stromatolites → **evidence of early life** + oxygen buildup.
- Diatomaceous earth (fossil diatoms) → used as **filters, abrasives, insulation, insecticides**.
- Petroleum deposits partly derived from algal remains (dinoflagellates, diatoms).
- Study of algal fossils → insight into **climate change, paleoenvironments**.

◈ Mnemonics 💡

- **Algal Geological Timeline → "Silly Devils Can't Create Enough Magic"**
    - **S**ilurian → Stoneworts
    - **D**evonian → Green algae
    - **C**arboniferous → Coal deposits
    - **C**retaceous → Chrysophyta, Diatoms
    - **E**ocene → Euglenoids
    - **M**iocene → Xanthophyceae

◈ Exam Capsule 🎯

- **Oldest algae** = Cyanobacteria (Stromatolites, 2.7 bya).
- **Diatom fossils** → Diatomaceous earth (economic use).
- **Floridean starch** not fossil marker → but found in red algae.
- Algal fossils critical for **petroleum geology** + **paleoenvironmental studies**.