Unit 6 · Algae

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Floral Diversity (Units 4–10 together): 18 of 75 marks; with Ecology and Vegetation a combined 26, at least 3 MCQs, 2 short and 1 long from them
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** short (5): any five characteristics of **Chlorophyceae**; MCQ: red rust of tea, caused by an alga (*Cephaleuros*)
- **MCQ (1 mark)**
  - thallus; phycology
  - class from pigments and stored food (fucoxanthin → brown)
  - pigments shared with land plants (chlorophyll *a*, *b*)
  - pyrenoids; zygospore the only diploid stage; empty "male" filament
- **Short and long (in parts)**
  - algae vs fungi
  - green algae as producers: energy flow
  - features of brown (and green, red) algae
  - vegetative structure of *Spirogyra* with diagram
  - scalariform vs lateral conjugation; a labeled conjugation drawing
  - economic importance; algal blooms: causes and effects

Key terms

Algae (sing. alga; Latin, seaweeds): simple, mostly aquatic, **autotrophic**, non-vascular thallophytes; main **primary producers** in water.

Phycology (*phykos*, seaweed) or algology: study of algae; **F. E. Fritsch**: father of phycology.

Thallus: body not differentiated into root, stem, leaf (even one cell).

Isogamy: gametes alike; **anisogamy**: alike in form, different in size; **oogamy**: large non-motile egg + small motile male gamete.

Conjugation: fusion of the whole contents of two alike cells (gametangia).

Pyrenoid: protein body on the chloroplast; CO_2-fixing enzyme; coated in starch.

Zygospore: thick-walled diploid resting spore after conjugation.

Phytoplankton: tiny drifting algae, cyanobacteria; ~half of Earth's photosynthesis.

Algal bloom: dense growth of algae in nutrient-rich water.

- "algae" is a way of life, not one group: green algae → land plants; red separate; brown nearer water molds, diatoms; "blue-green algae" are **bacteria**
- Whittaker: unicellular algae in **Protista**, multicellular in **Plantae**

Characteristic features

1. **aquatic** (sea, fresh water); damp soil, stones, wood; in lichens, corals, sponges
2. body a **thallus**: single cell (*Chlamydomonas*), colony (*Volvox*), filament (*Spirogyra*), sheet (*Ulva*)
3. covered by **mucilage** (slimy)
4. wall of **cellulose**
5. pigments: **chlorophyll** + **carotenoids** (others in some classes)
6. reserve food: **starch** (not in red, brown)
7. vegetative, asexual, sexual reproduction
8. vegetative commonest: **fragmentation**, budding
9. asexual by **spores**: **motile** (zoospores) or **non-motile** (aplanospores, akinetes)
10. sexual: **isogamous**, **anisogamous**, **oogamous**
11. **no embryo**: zygote grows straight into a new plant

Algae	Fungi
chlorophyll	none
autotrophic	heterotrophic, absorb
wall of **cellulose**	wall of **chitin**
store **starch** (floridean, laminarin in some)	**glycogen**, oil
mostly aquatic	mostly land, damp
thallus of cells	mycelium of hyphae
need light	grow in dark
Spirogyra, *Chlamydomonas*, *Fucus*	*Mucor*, yeast, mushroom

Classification

- by **pigments**, **stored food**, **thallus**, **reproduction**

Chlorophyceae (green algae, Chlorophyta)

- mostly **fresh water**; some on soil, walls, rocks, bark
- unicellular or multicellular
- wall **cellulose** + **pectin**
- **chlorophyll** *a*, *b*, carotenes, xanthophylls (as land plants)
- reserve **starch** (as land plants)
- vegetative, asexual, sexual
- *Spirogyra*, *Ulothrix*, *Chara*, *Chlamydomonas*, *Volvox*

Rhodophyceae (red algae, Rhodophyta)

- among the oldest eukaryotic algae (fossils ~1 billion years)
- mostly **marine**
- unicellular, filamentous, parenchymatous, ribbon-like
- wall cellulose, pectin + **agar** or carrageenan
- **chlorophyll** *a*, carotenoids, **phycobilins**: red **phycoerythrin**, blue phycocyanin
- reserve **floridean starch** (branched like glycogen)
- **no motile cells** at any stage
- *Porphyridium*, *Porphyra* (nori), *Ceramium*, *Gelidium*
- chlorophyll *d* belonged to a cyanobacterium on them (*Acaryochloris*)
- live deep (> 200 m): phycoerythrin absorbs **green and blue** light that reaches the depths, passes energy to chlorophyll *a*

Phaeophyceae (brown algae, Phaeophyta)

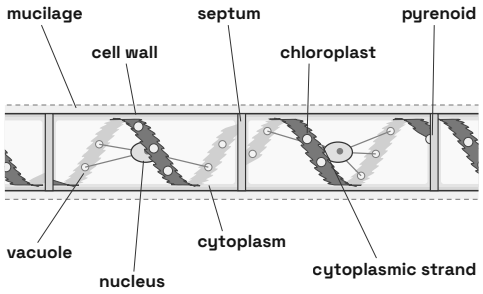
- color: **fucoxanthin** (brown to olive)
- almost all **marine**, cold seas
- filamentous to parenchymatous; **kelps** up to 45 m: **holdfast**, **stipe**, **blades**, gas bladders
- wall cellulose + **alginic acid** (alginates)
- **chlorophyll** *a*, *c*, carotenoids, fucoxanthin
- reserve **laminarin** (not a starch) + **mannitol**
- spores, gametes: **two unequal flagella**
- *Alaria*, *Fucus*, *Laminaria*

	Green	Red	Brown
class	Chlorophyceae	Rhodophyceae	Phaeophyceae
where	mostly fresh water	mostly sea	almost all sea
chlorophylls	*a*, *b*	*a*	*a*, *c*
other pigments	carotenes, xanthophylls	phycoerythrin, phycocyanin	fucoxanthin
reserve food	starch	floridean starch	laminarin, mannitol
wall	cellulose, pectin	cellulose, agar, carrageenan	cellulose, alginates
motile cells	flagella, mostly two equal	none	two unequal flagella
e.g.	*Spirogyra*, *Chlamydomonas*, *Volvox*	*Porphyra*, *Gelidium*, *Ceramium*	*Fucus*, *Laminaria*, *Alaria*

- **pond water (Activity 2.4)**: spiral ribbons → *Spirogyra*; band → *Ulothrix*; cup, darting → *Chlamydomonas*; rolling balls → *Volvox*; glassy golden-brown → diatoms; blue-green, no chloroplasts → cyanobacteria

Spirogyra

- Plantae → Algae (Chlorophyta) → Chlorophyceae → Conjugales (Zygnematales) → Zygnemataceae → *Spirogyra*
- still water: tanks, ponds, ditches, rice fields; **pond scum**, **water silk**
- **unbranched filament** of cylindrical cells in one row, in a **mucilage sheath**; young attached, adult free-floating



Spirogyra cells: wall, mucilage sheath, spiral chloroplasts with pyrenoids, nucleus in the vacuole on cytoplasmic strands.

Cell

- **wall**: inner **cellulose**; outer **pectin** → mucilage
- **plasma membrane**
- **cytoplasm**: thin, **peripheral**, pushed out by large **central vacuole**
- **nucleus**: in the middle of the vacuole, hung on **cytoplasmic strands**
- **chloroplasts**: **ribbon-shaped**, **spiral**, wavy toothed edges; 1–16 (*speira* coil, *gyros* round)
- **pyrenoids** along the chloroplasts: CO_2-fixing enzyme + starch coat

Vegetative: **fragmentation** (commonest; water movement, animals, dead cells)

Asexual (less common; unfavorable conditions)

- **akinetes**: whole cell, thick wall, food-filled
- **aplanospores**: protoplast shrinks, new wall inside old
- **azygospores** (parthenospores): gamete fails to fuse, walls itself

Sexual: conjugation (isogamous; end of season)

a. Scalariform (commonest; two filaments of opposite strains, **heterothallic**)

1. filaments side by side in common mucilage
2. facing cells put out **papillae**

3. tips meet; wall dissolved (**cytase**) → **conjugation tube**; looks like a **ladder** (*scala*)
4. protoplasts shrink → **gametes**
5. "male" (moving) gamete through tube → fuses with female → diploid **zygote**
6. thick wall → **zygospore**; male filament **empty**, zygospores in female filament

b. Lateral (rare; adjacent cells of **one** filament; **homothallic**)

- **indirect**: papillae by the septum → curved **lateral tube**; male passes; **every second cell empty**
- **direct** (primitive, few species): **lower** cell swells (**barrel**), female; **upper** male gamete bores a **pore** in the septum with a **beak**; zygospore in lower cell

Scalariform	Lateral
two filaments	one filament
heterothallic	homothallic
conjugation tubes like a ladder	lateral tube round septum, or pore in septum
one filament all empty	alternate cells empty
commonest	rarer

Zygospore germination

- **diploid**, wall of **three layers**; survives drought, cold

1. nucleus → **meiosis** → 4 haploid
2. **three degenerate**, one functional
3. outer wall bursts; **germ tube**
4. tube → two cells: lower colorless **rhizoidal cell** (holdfast), upper → new filament
5. breaks free, floats

- **zygospore = only diploid stage**; rest haploid

Economic importance

Useful

1. **food**: *Chlorella*, *Porphyra* (nori), *Codium*, *Rhodymenia* (dulse), *Laminaria* (kombu); *Spirulina* (cyanobacterium); high yield per area
2. **fodder**: *Fucus*, *Laminaria*, *Alaria*, *Ascophyllum*
3. **fish farming**: green algae, **diatoms** are fish food; ponds fertilized
4. **industry**
   - **agar** (*Gelidium*, *Gracilaria*): jams, jellies; **culture medium** (Fanny Hesse, 1881; Koch's lab; Petri dish 1887)
   - **carrageenan** (*Chondrus crispus*, *Mastocarpus*): ice cream, toothpaste
   - **alginates** (brown algae): thickeners, wound dressings
   - **iodine** (seaweed ash, 1811)
   - **diatomite**: filters, polishes, insulation
   - **chlorellin** (*Chlorella*): antibiotic
5. **sewage treatment**: algae give O_2 → bacteria break sewage down
6. **oxygen**: phytoplankton ~half of photosynthesis; *Chlorella vulgaris* for astronauts

- **producers and energy flow**: algae trap sunlight → food → herbivores (zooplankton, snails, tadpoles, fish) → carnivores (fish, frogs, birds) → decomposers; energy lost as heat at each step; algae also give O_2

Harmful

1. **poisons**: *Karlodinium*, *Prymnesium parvum* kill fish; cyanobacteria kill cattle, dogs; **parasite**: *Cephaleuros* → **red rust of tea**
2. **fouling of ships**: *Ulva*, *Enteromorpha* on hulls; slow, waste fuel
3. **spoil water**: smell, taste, block filters
4. **algal blooms**
   - cause: water rich in **nutrients** (soap, sewage, fertilizer, rotting leaves), still, warm, lit
   - effect: dying bloom decayed by bacteria → **O_2 used up** → fish suffocate; some poisons
   - Lake Erie, 2014: *Microcystis* poison in Toledo's water
   - **Phewa Lake**: **eutrophic**; **hypereutrophic** in monsoon (2021 study)

COMMON MISTAKES

✗ Blue-green algae are algae
✓ they are **bacteria** (cyanobacteria).

✗ Red algae have chlorophyll *d*
✓ chlorophyll **a** + phycoerythrin; *d* belonged to a cyanobacterium on them.

✗ Brown algae store starch
✓ **laminarin** and **mannitol**.

✗ Red algae have flagellate spores
✓ **no motile cells** at all.

✗ *Spirogyra*'s filament is diploid
✓ only the **zygospore** is diploid.

✗ Male gamete is smaller in *Spirogyra*
✓ gametes alike (**isogamous**); "male" only because it moves.

✗ In scalariform conjugation zygospores form in both filaments
✓ all in the **female** filament.

✗ Algae have an embryo
✓ **no embryo** stage.