Ecology of Algae

• Algae play comparable role to that of terrestrial plants.
• Oceanic algae are subjected to variations in humidity, temperature, salinity, light, and harsh wave conditions.
Phytoplankton

- Photosynthetic algae + cyanobacteria.
- Base of the food chain.
- Serious human disturbance
  - 'algal blooms' (red or brown tides)

http://serc.carleton.edu/images/microbelife/topics/red_tide_for_ed.jpg

http://www.cop.noaa.gov/_images/stressors/extremeevents/rtdeadfish.jpg
Algae & Climate Change

- Phytoplankton reduce CO$_2$ in the atmosphere.
- Form CaCO$_3$ as they fix CO$_2$.
- CO$_2$ removed from water is replaced by atmospheric CO$_2$, creating a suction effect, known as “CO$_2$ drawdown”.

Dinophyta (Dinoflagellates)

- 2000 – 4000 spp.
- No photosynthetic pigments in many dino’s.
- Peridinin
- Starch as food reserve.
- No flagella (except gametes) or 2 dissimilar (1 transverse, 1 longitudinal).
- Vesicles beneath plasma membrane with or without cellulose plates.
- Predominantly marine + some freshwater.

Dinoflagellates

- Half lack photosynthetic apparatus;
  - Obtain nutrients by ingestion or absorbing DOC’s.
- Chl $a$ & $b$ often masked by peridinin;
  - Accessory pigment typical of chrysophytes.
**Pigmented dino’s occur as symbionts in:**
- Sponges, jellyfish, corals, octupuses & squids

**When symbiotic:**
- Lack armored plates and appear as golden spherical cells
- Zooxanthellae

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**Dinoflagellate stress responses**

- Under low nutrient levels
  - Nonmotile resting cysts that drift to lake or ocean bottom.
  - Under favorable conditions cysts germinate.
  - Cyst production, movement, and germination help explain toxic algal blooms.

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**Pfisteria piscicida**

- Biflagellated cell
- Amoeboid stage (dominate life cycle)
- Amoeboid cyst stage
Euglenoids: Euglenophyta

- ~ 900 spp.
- Paramylon is food reserve.
- 1/3 of genera contain chloroplasts
  - Rest are colorless heterotrophs
- Unicellular
  - No cell wall
  - Pellicle
  - Eyespot
  - Stigma
  - Contractile vacuole

Cryptomonads: Cryptophyta

- ~ 200 spp.
- Starch is food reserve
- Very small (3 to 50 micrometers)
- Very high palatability
- Cold or subsurface waters
- Arose through the fusion of two different eukaryotic cells:
  - Heterotrophic
  - Photosynthetic
- Outermost membrane
  - Chloroplast endoplasmic reticulum
Haptophytes: Haptophyta

• ~ 300 spp.
• Chrysolaminarin is food reserve
• Primarily marine phytoplankton
• Unicellular, colonial flagellates, & non-motile single cells & colonies.
• H’ highest in tropics.

Haptonema

• *Haptein* “to fasten” sense of touch.
• Threadlike structure
  – Bends & coils – cannot beat like a flagellum.
Coccoliths

- Small, flat scales on outer surface of cell.
  - Species with coccoliths are known as coccolithophorids.

Heterokonts

- Means ‘different flagella’
- a.k.a. stramenopiles
  - Flagellum in pairs
    - 1 flagellum long & ornamented with hairs
    - 1 flagellum shorter and smooth

Oomycetes: Oomycota

- ~ 700 spp.
- No photosynthetic pigments
- Glycogen is food reserve
- Reproduce sexually & asexually
  - Asexual zoospores
    - Two flagella (remember)
Sexual Oogamous
Gametes = size & shape
Smaller gamete is male
Non-motile female

Isogamy
(a)

Anisogamy
(b)

Oogamy
(c)

Specific types of Oomycetes

- Water molds
  - *Achlya ambisexualis*
- Terrestrial
  - Sudden oak death
  - Potato blight

*Phytophthora infestans*
Diatoms: Bacillariophyta

• 100,000 spp.
• Chrysolaminarin is food reserve
• Silica is cell wall component
• Marine or freshwater habitats
• Serve as primary source of food for aquatic animals.
• Lack flagella; except on male gametes

Walls of Diatoms

• Two halves
  – Frustules (walls) made of polymerized opaline silica
    \[ \text{SiO}_2 \cdot n\text{H}_2\text{O} \]
  – Fit together like a petri-dish.

Symmetry in Diatoms

• Two types are recognized
  – Pennate diatoms
  – Centric diatoms

1/2 of an Entogonia frustule
Diatom Asexual Reproduction

- Each daughter cell receives ½ of the frustule of its parental cell
  - Constructs a new half
- Thus, one of two new cells is smaller than parent.
- After multiple generations, populations size decreases to a critical level.
- Once this occurs…….

- Centric diatoms
  - Oogamous
- Pennate diatoms
  - Isogamous

- Unfavorable conditions
  - Form resting stages, sinking to the bottom
Chrysophytes: Chrysophyta

- 1,000 spp.
- Chrysolaminarin is food reserve
- No flagella or 2
- No cell wall or silica scales (sometimes cellulose).
- Predominantly freshwater (few marine)

- Primary pigment is fucoxanthin
  - Chrysos = gold
  - Phyton = plant
- Produces brown tides
  - Shellfish
  - Salmon
  - Poor taste of some drinking water

Brown algae: Phaeophyta

- 1,500 spp.
- Laminarin, mannitol is food reserve
- Fucoxanthin pigment
- 2 flagella
- Cellulose cell wall
- Almost all marine
  - Temperate to polar
  - Flourish in cold-water oceans
Basic form

• Thallus
  – Simple, relatively undifferentiated vegetative body.

Kelps & Rockweeds

• *Laminaria*
  - Blade
  - Stipe
  - Holdfast
Internal kelp structure

- Complex
- Elongated cells modified for food conduction
  - > 60 cm / hr.
  - Blades to holdfast regions

Red Algae: Rhodophyta

- 4,000 – 6,000 spp.
- Chl a & phycobillin pigment
- Floridean starch is food reserve
- No flagella
- Cellulose microfibrils & calcium carbonate cell wall components.
- ~100 freshwater species; predominantly marine.
Cells of red algae are unique

- No centrioles or flagellated cells.
- Microtubule organizing centers
  - Polar rings
- Main food reserve is floridean starch
  - Stored in cytoplasm
- Cells are interconnected by
  - Pit connections

Complicated life histories

- Reproduce asexually by discharging spores
- Alternation of generations
  - Gamete-producing gametophyte
  - Spore-producing sporophyte
  - Gametophyte produces spermatangia
  - Female gamete contains carpogonium
  - Carpogonium develops protuberance
    - Trichogyn 
    - Then diploid zygote produces a few diploid carpospores

Polysiphonia
Green algae: Chlorophyta

- 17,000 spp.
- Chl a, b, carotenoids
- Starch is the food reserve
- None or 2 flagella; equal or unequal whiplash
- Glycoproteins, cellulose, or plasmodesmata cell wall.
- Mostly aquatic, many in symbiotic relationships.

Cosmopolitan

- Surface of snow “green snow”
- Tree trunks
- Soil
- Symbiotic relationships with:
  - Lichens
  - Protozoa
  - Sponges
  - Coelenterates
- Very closely related to bryophytes & vascular plants.
Great differences between classes

- Chlorophyceae
  - phycoplast
    - Ensures cleavage furrow passes between daughter nuclei
  - Flagellar roots
- Charophyceae
  - Phragmoplast
    - Cytokinetic microtubules
    - Identical to those present in bryophytes and vascular plants.

nonpersistent mitotic spindle separated by phycoplast

Persistent spindle. Furrowing occurs.

Plant-like phragmoplast. Cytokinesis occurs by cell plate formation.
Chlamydomonas

- Unicellular + Motile
- Two equal flagella
- Polyphyletic
- Sexual & asexual reproduction

Chlorophyceae

- **Volvox**
  - Made of single layer of 500 to 60,000 vegetative, biflagellated cells that serve a photosynthetic function.
  - Undergo repeated mitosis that “hatch” from parental spheroid
    - At first all flagella face hollow center
    - Must turn inside-out before becoming motile.
Volvox carteri

Chlorophyceae
- Chlorococcum
  - Unicellular & non-motile
- Hydrodictyon
  - “Water net” non-motile & colonial
- Oedogonium
  - Unbranched & filamentous

Ulvophytes
- Filamentous or composed of flat sheets
- Alternation of generations
Charophytes

- Unicellular, colonial, filamentous, and parenchymatous genera
- Most closely resemble bryophytes & vascular plants.
- *Spirogyra*
  - Filamentous: often forms slimy floating masses
  - Reproduction occurs by conjugation
Coleochaetales & Charales

- Possess traits found only in bryophytes and vascular plants.
- Oogamous
- Sperm are ultra-structurally similar to bryophytes.

Myxomycota a.k.a slime molds

- 700 spp.
- No photosynthetic pigments
- Glycogen is food reserve
- Usually 2 flagella
- No cell wall on plasmodium
- Terrestrial habitat
• Lack cell wall
  – Mass of naked protoplasm = plasmodium
• Plasmodial growth continues as long as nutrients + water are available
  – Will migrate away from feeding area
  – Crosses roads, lawns, climbs trees.
  – Once stopped, divides into smaller mounds.
Summary

- Kingdom protista are eukaryotic organisms not included in plant, fungal, or animal kingdoms.
- Algae obtain nutrients in a variety of ways
  - Particle feeding
  - Photosynthesis
  - Phagocytosis
- Heterokonts have two flagella:
  - Different length & ornamentation
- Brown algae are most conspicuous seaweeds
- Red algae have complex life histories
- Green algae are recognized on basis of cell division, reproductive cell structure, and molecular similarities.
- Slime molds are heterotrophic protists with similarities to both fungi and protozoa.