Division: Chlorophyta

I. Taxonomy
II. Unifying Characteristics
III. Distinguishing Classes
IV. Classes in Detail

16,000 species, only about 1,600 marine

Easiest division of Chlorophyta from other algae:
- usually bright green, grassy color

Exceptions?
I. Algal Taxonomy

Hierarchichal system of classification:

<table>
<thead>
<tr>
<th>Level</th>
<th>Suffix</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td></td>
<td>Eukaryote</td>
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<tr>
<td>Kingdom</td>
<td></td>
<td>Plantae</td>
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<tr>
<td>Phylum/Division</td>
<td>phyta</td>
<td>Chlorophyta</td>
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<tr>
<td>Class</td>
<td>phyceae</td>
<td>Ulvophyceae</td>
</tr>
<tr>
<td>Genus</td>
<td></td>
<td>Ulva</td>
</tr>
<tr>
<td>species</td>
<td></td>
<td>lactuca</td>
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</table>
Morphological Concept of Classification

- Primitive unicells evolved structural complexity over time
- Morphological divergence distinguishes groups
Chlorophyta

- Chlorophyceae: freshwater, some marine
- Trebouxiophyceae: mostly freshwater/terrestrial
- Ulvophyceae: marine/macros

- Prasinophyceae: marine/freshwater flagellates
- Charophytes: freshwater, terrestrial

Prasinophyceans are unicells but.....

Charophyta

Chlorophyceae, Ulvophyceae, Ulvophyceae

Chlorophyta
II. Unifying features of the Chlorophyta

1. Flagellate cells = typically possess 2 flagellae, equal length

- multiples of two
- stellate arrangement at flagellar base

Flagellar Phototaxis

1. light sensation (stigma)
2. Ca2+ influx
3. 1 more active, 1 less
4. orientation to light
2. Mitochondria

flattened cristae

advantages?

3. Plastids

all contain at least 1 plastid
multiple, discoid plastids = land plants
in comparison with other heterotrophic eukaryotes green algae have large variety of forms
as in land plants synthesize and store starch
main photopigments = chlorophyll a and b, β-carotene

A Chlamydomonas, B Chlorella, C Asterochloris, D Acrochaete, E Spirogyra, F Enteromorpha, G Pseudocodium
4. Pyrenoids

sites of carbon fixation often within the chloroplast of algal cells
= also found in euglenoids and dinoflagellates
concentration of carbon dioxide
not found in higher land plants

III. Bases for distinction between classes

1. Cell division
   A. Mitotic spindle

   closed
   metacentric centrioles
   open

   nucleus = dumbbell shaped

Chlorophyceae
Treubouxiophyceae
Ulvophyceae
Prasinophyceae
Charophytes
Land Plants

Prasinophyceae = variable
Trebouxiophyceae = only ones with unusual metacentric
= how does the spindle apparatus form?
1. Cell division
   B. phycoplast vs phragmoplast

   **Phycoplast:** tubules parallel to plane
   **Phragmoplast:** tubules perpendicular to plane

   - Chlorophyceae
   - Trebouxiophyceae
   - Ulvophyceae
   - Prasinophyceae
   - Charophytes
   - Land Plants

   - unclear in Prasinophyceae & Trebouxiophyceae
     = centrioles non-persistent

1. Cell division
   C. furrowing vs cell plate formation

   - Furrowing: most algae
   - Cell plate formation = Charophytes and land plants
2. ONE basal body per flagellum, located at the flagellar base, anchoring into the cell
   - basal body pairing may vary
     parallel opposed clockwise counter clockwise

Chlorophyceae
Trebouxiophyceae
Ulvophyceae
Prasinophyceae
Charophytes
Land Plants

3. Cell covering
   Scales – made of complex polysaccharides, secreted from golgi, Prasinophyceae
   Cell wall – usually cellulose, other green algae and land plants

Chlorophyceae
Trebouxiophyceae
Ulvophyceae
Prasinophyceae
Charophytes
Land Plants
Some new concepts and review of old ones

1. Levels of Complexity - Chlorophyta are most diverse in growth forms, some microscopic (unicellular), some up to 8m long

A. Unicellular forms
*Chlamydomonas, Chlorella, Dunaliella, desmids*

B. Colonial forms
Unicells form large interconnected groups
*Pandorina, Pediastrum, Volvox*

C. Filamentous forms
Colonial form where single algal cells form long visible chains, threads, *Cladophora, Ulothrix*

D. Thallous forms
Composed of plates or cells arranged into tree-like forms, *Ulva*

E. Coenocytic forms
A multinucleate mass enclosed in a single cell wall
*Caulerpa, Codium*
2. Sexual Fusion

**Isogamy** - fusion between flagellated gametes that are similar in size and shape

Anisogamy - fusion between flagellated gametes of distinctly different sizes

Oogamy - fusion between a flagellated and non-flagellated gamete

3. Generations

Sporophyte - diploid (2n), multicellular, produces spores through meiosis

=> releases spores during alternation of generations

Gametophyte - haploid (n), multicellular, may be microscopic, produces gametes through mitosis, generally the visibly dominant form
IV. Classes in Detail – The Chlorophyte Diversity

- Chlorophyceae
- Trebouxiophyceae
- Ulvophyceae
- Prasinophyceae
- Charophytes
- Land Plants
Class Prasinophyceae

Unicellular, may be flagellar

- open or closed cell division
- phycoplast or phragmoplast
- division by furrowing

- basal bodies opposite
- large golgi body b/w basal bodies

Cell covering

extrusomes

Reproduction mainly asexual – may produce resting stages or “cysts” (nucleus-mitosis-flagellate cells-wall rupture)

Mostly marine, some freshwater

- one chloroplast (cup shaped), single pyrenoid

Least advanced of the Chlorophyta
**Class Chlorophyceae**

Unicellular, colonies, filaments, coenocytes

- Closed cell division
- Phycoplast
- Division by furrowing
- Basal bodies clockwise

- Cell wall out of cellulose
- Mostly freshwater, some marine species
- Anisogamous, isogamous and oogamous
Genus: *Chlamydomonas*

Unicellular, terrestrial, fw, marine, even in snow

Cup-shaped chloroplast, orange eyespot

can grow in total darkness acetate as alternate carbon source

deprivation of nitrogen = diploid zygospore

haplontic = somatic cells with haploid cell numbers

Haplontic - sexual reproduction in unfavorable conditions only

Hypnozygote = resting stage
<table>
<thead>
<tr>
<th>Genus: <em>Tetraspora</em></th>
<th>Genus: <em>Dunaliella</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Colonial, cell body spherical, 2 or more flagellae</td>
<td>Unicellular, cells often ovoid, distinctly mucilaginous</td>
</tr>
<tr>
<td>Colony with gelatinous bag</td>
<td>Chloroplast single, generally cup shaped</td>
</tr>
<tr>
<td>Single chloroplast, cup-shaped with pyrenoid</td>
<td>plastids packed with β carotene</td>
</tr>
<tr>
<td>uses in cosmetics, food supplements, aquaculture</td>
<td></td>
</tr>
</tbody>
</table>
Class Trebouxiophyceae

Unicells, filaments, blades

- metacentric cell division
- phragmoplast
- division by furrowing
- basal bodies counterclockwise
- cell wall out of cellulose
- mostly freshwater/terrestrial, some marine species
Genus: *Chlorella*

- Unicellular, generally spherical
- Freshwater species may be endosymbiotic
- Single chloroplast
- Melvin Calvin
- High in protein, minerals and vitamins

![Image of Chlorella cells]

![Image of Chlorella with a bottle of Chlorella capsules]

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**Evolutionary Tree**

- **Chlorophyceae**
- **Trebouxiophyceae**
- **Ulvophyceae**
- **Prasinophyceae**
- **Charophytes**
- **Land Plants**
**Class Ulvophyceae**

Unicells, filaments, blades

- Closed cell division
- Phycoplast
- Division by furrowing
- Basal bodies counterclockwise
- Cell wall out of cellulose
- Mostly marine macroalgae

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**Diverse Morphologies**

![Image of diverse morphologies]
Thallus Composition

- no organized “distinct” parts
- some analogous structures to vascular plants
- holdfast = anchor
- stipe = support to the blades
- blades = photosynthetic

Genus: *Ulva*

- Blade-like
- Often ephemeral in intertidal
- Fast growing, tasty to herbivores
- Some species euryhaline - tolerate freshwater
Genus: *Ulothrix*

- Filamentous, unbranched uniserate
- Cells closely adherent
- Simple or rhizoidal basal cells
- Single napkin ring-shaped chloroplast, partially or completely encircling cell circumference
- Pyrenoids single generally in more mature cells
- Sexual reproduction by isogamous, biflagellate gametes
Genus: *Codium*

**Coenocytic/siphonous construction:**

- Multinucleate, no division of cytoplasm with cell walls
- "clotting compounds" to quickly repair wounds

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**Uniaxial and multiaxial construction**

*Bryopsis*  
*Codium "dead man's fingers"*
Utricles - peripheral portions of the siphons may be inflated and aggregated to form a coherent outer surface gametangium (reproductive structure) originate from them.

*Codium the size of an apple = ~30 km of siphons

Codium Scallop Interactions

Attach and grow on scallops
**Kleptoplastids**

- Sacoglossan radula adapted to host alga (length of tooth ~ thickness of siphon)
- Common in siphonous greens
- Pierce and suck out insides
- Stolen chloroplasts can last up to a month or so

**Genus: Caulerpa**

- Uniaxial, but with trabeculae for support
- Trabecula = ingrowth of wall material
- Unicellular, coenocytic
- Rhizoids with specific attachment mechanisms = vitronection

Siphons form rhizoidal holdfast, too
The Caulerpa Invasion

- native in Australia (non-native strains have invaded)
- 1st introduced as a non-native in Mediterranean (1984)
- introduced at 2 sites in S. California (Carlsbad, Huntington Harbor)

Genus: *Halimeda*

- anisogamous, dioecious = separate sexes
- Holocarpic reproduction
- gametes migrate

Day 1 1600 hour  
Day 2 0600 hour  
Day 3 0600 hour  
Day 3 0630 hour

Gametangial phase  
Spawning  
Death
Calcification as defense against herbivores

Calcification

(decalcify *Halimeda*, just a mass of enormous siphons)

Both chemical and structural defense common in tropical spp

*Elysiella* instead eats young growth and converts toxic compounds into its defenses