Topic 10: Cyanobacteria & Algae

A. Introduction

Plants are not the only organisms that are photosynthetic. In fact, photosynthetic lineages have popped up here and there throughout the tree of life (see the 7 groups in the phylogenetic tree below). In fact, there are even bacteria that are photosynthetic!!

Organisms called algae are photosynthetic, but are usually morphologically simpler than higher plants such as mosses, ferns, or angiosperms. Some algae are unicellular, but others are large, multicellular organisms like the kelps. Within the algae you can see the major trend in the evolutionary development of multicellularity reflected in the diversity of organismal forms: i.e., unicellular >> one-dimensional multicellular growth (1D) >> two-dimensional multicellular growth (2D) >> three-dimensional multicellular growth (3D).

Algae have been divided into groups based mainly on distinctive plastid accessory pigments. Because of these pigments, many groups of algae have been known by their color: hence red, green, brown, etc. Modern classifications delimit them with many other characters such as cell wall components, reproductive structures, and distinctive food storage molecules.

Algae are the dominant producers in aquatic environments, so they are very important ecologically. The materials available in lab today represent the major algal divisions, along with the cyanobacteria.

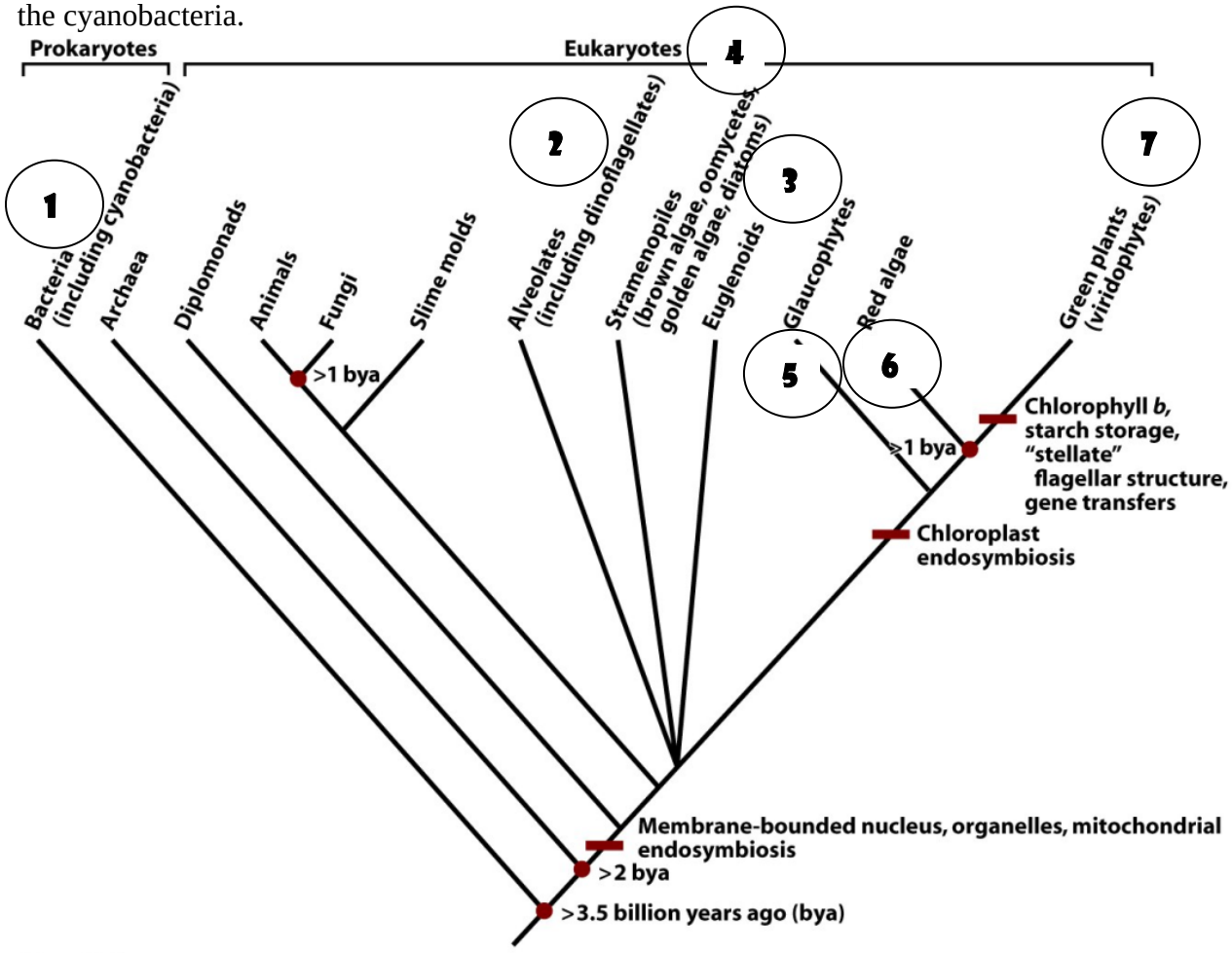

Figure 15-3
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Adapted from Fig. 15-3 in Raven et al. (2007). A phylogenetic tree based on DNA sequences, showing 7 major groups of photosynthetic organisms.

B. Dichotomous Key to Freshwater Algae .

Using the detachable key to freshwater algal genera on the last page of this lab, identify the 10 unknown monocultures of algae to their respective genus. See instructor for the answers at the end of class. Important details are viewed at 200X and 400X (or higher) magnifications.

Steps:

1. First, inspect the mass of algae in the tube. What color is it? A blue-green color should be indicative of a cyanobacterium, a light green color should indicate a green alga (chlorophyte), etc. VIEW THE CULTURE AGAINST WHITE PAPER IF THAT'S EASIER TO DISCERN COLOR.

2. Afterwards, remove a drop and prepare a wet mount on a microscope slide. LABEL THE SLIDE WITH THE NUMBER ON THE TUBE, SO YOU DON'T MIX IT UP.

3. Make your observations with the compound microscope, make drawings, and make your identifications. Record the magnification used as well.

4. Make drawings below and label with genus name and other structures such as **CHLOROPLAST(S), FLAGELLUM(FLAGELLA), PYRENOID(S), EYESPOT,** etc. Also record the color of your algae, as seen with the naked eye.

5. Share your prepared slides with others in your group.

1.	2.
3.	4.

5.	6.
7.	8.
9.	10.

Now, go through the next sections on each "algal" lineage, read, and answer questions pertaining to the algae observed above or additional algal displays in the room.

C. Group 1: Cyanobacteria .

Also known as "blue-green algae", although they are actually bacteria (i.e., prokaryotes). Like algae, these have chlorophyll. Many are unicellular, others are filamentous, while others are colonial.

1. Thought question: If you were to have a unicellular cyanobacterium and a unicellular alga, how might you tell them apart? List at least two ways.

2. You will or did see two species in the freshwater tube cultures from part B. One of *Oscillatoria*, the other of *Anabaena.*

2a. Was Oscillatoria unicellular, filamentous, or colonial?

2b. Did you see any movement in "Oscillatoria"?

2c. Was Anabaena unicellular, filamentous, or colonial?

2d. What color were the masses of algae in the stock culture tubes?

Cross reference these answers to your drawings in part B above.

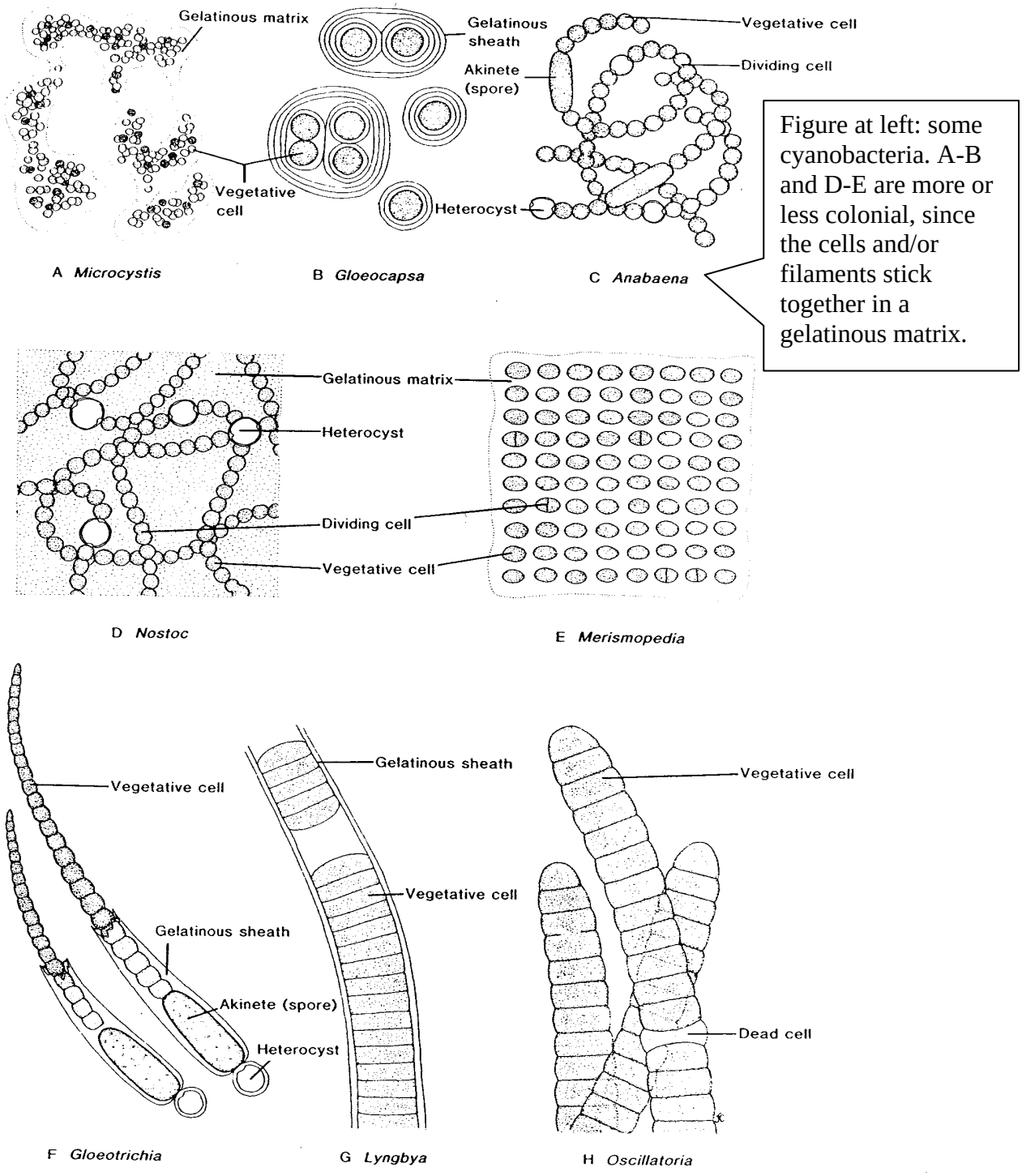

Figure at left: some cyanobacteria. A-B and D-E are more or less colonial, since the cells and/or filaments stick together in a gelatinous matrix.

D. Group 2: Dinoflagellates .

Dinoflagellates are not bacteria but protists. *What does that mean?*

Today, you should find some in your collection from Roddy Pond (compare collections from shallow water vs. deeper water). You will know a dinoflagellate by their olive-brown color (due in part to accessory pigments PERIDININ or FUCOXANTHIN) and their elaborate shapes and ornamentation. Interesting phenomena in nature include bioluminescence and red tides caused by some marine species.

How many cells is each dinoflagellate?

How many flagella do these have and how is each arranged to help them move?

Read in your book about the "armor" or "plates"(p. 334). Are the plates inside or outside the cell(s)? What are they made of? How is this the same or different than a cell wall?

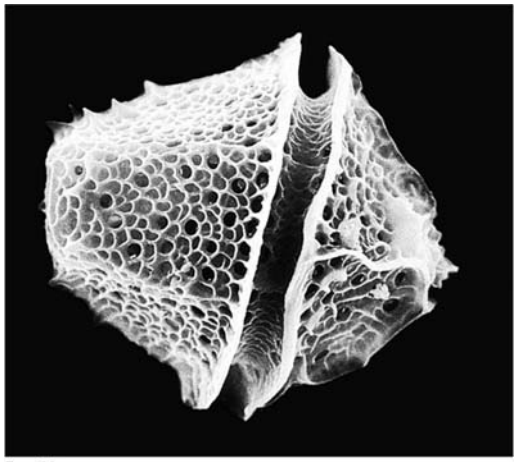

Figure 15-5c
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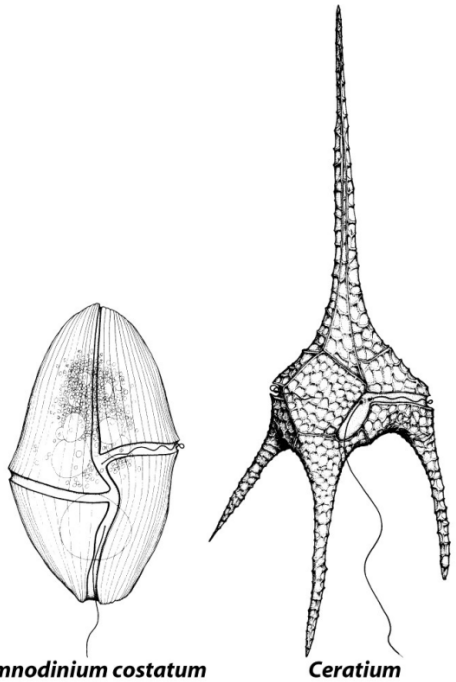

Figure 15-6
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<u>Record your drawings here:</u>

E. Group 3: Euglenoids .

Euglena gracilis is represented today in the freshwater algal cultures from part B. It is just one of many (ca. 800-900) species. They do not have common names like birds or trees, so we have to refer to them by their scientific name.

Euglenoids are interesting because they combine superficial characteristics of both plants and animals. They can make their own food like a plant, but they can also eat other things, like an animal (or, more aptly, an amoeba). They can also swim and move. Scientists argued for years about which Kingdom to put them in, Animalia or Plantae? Right now they are in neither: according to some classifications they are in the Kingdom Protista with other simple (often microscopic) eukaryotes, such as amoeba and paramecium.

A euglena's body is only one cell, so they are very small and you must use a microscope to see them. Sometimes, since they live in water, if there are millions of euglena together, they form a mat on the surface of a pond or marsh that you can see. It looks slimy, a lot like algae. Some people say it looks like "pea soup". It gets in swimming pools too, if they are not cleaned regularly. If you've ever seen water in a marsh that looks red, it is from many euglena. Some species have chemicals in them that make them red. *Euglena gracilis* is not one of those species.

How many flagella did the euglena from the unknown algal cultures above have?

Did the shape of Euglena cells change while you observed them? Or were they rigid?

Any unusual behavior?

F. Group 4: Brown or Golden-brown Algae .

F1. Diatoms

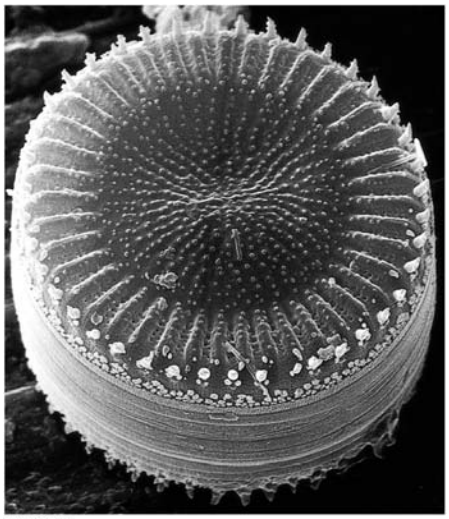
Diatoms are unicellular or colonial organisms that are exceedingly important components of phytoplankton of both marine and freshwater systems.

The walls of diatoms consist of two halves: known as frustules, the walls are made of opaline silica and consist of two halves that fit together like a Petri dish. These frustules are very ornate and these ornamentations are used to distinguish species.

One of the unknowns from the algal culture was a diatom. Was it Synedra or Navicula?

In the station in the back, we have a sample of diatomaceous earth (i.e., diatom fossils). What is diatomaceous earth used for by humans?

What is the connection between oil and diatoms? It's an important one.



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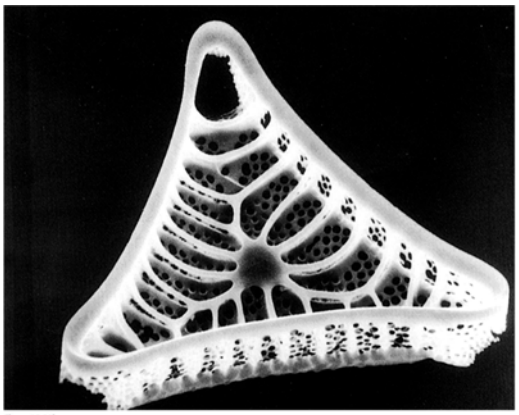

Figure 15-20b
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Above, scanning electron micrographs of a whole diatom (left) and the half of a frustule, showing the inside face (right).

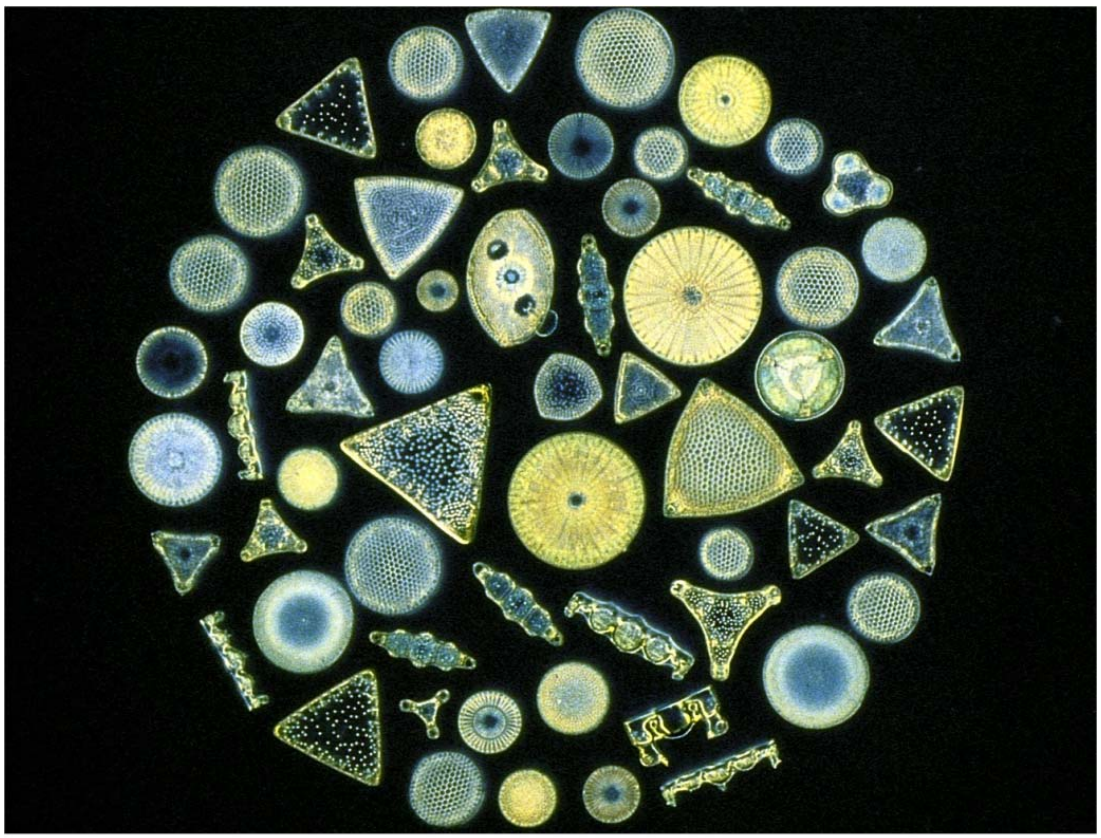

Figure 15-20a
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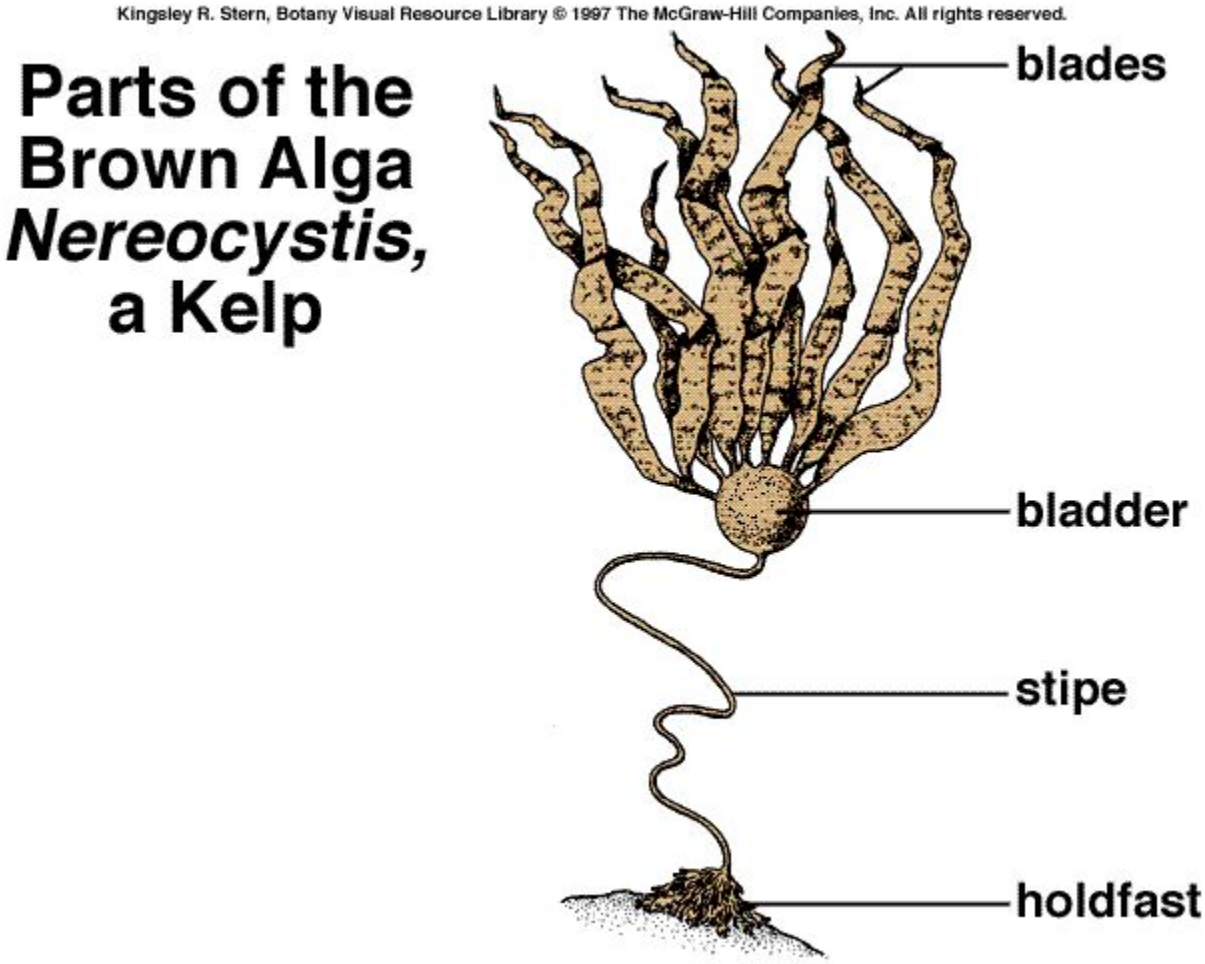
Fig. 15-20a from Raven et al. (2007). An artful representation of many different types of diatoms.

F2. Brown Algae

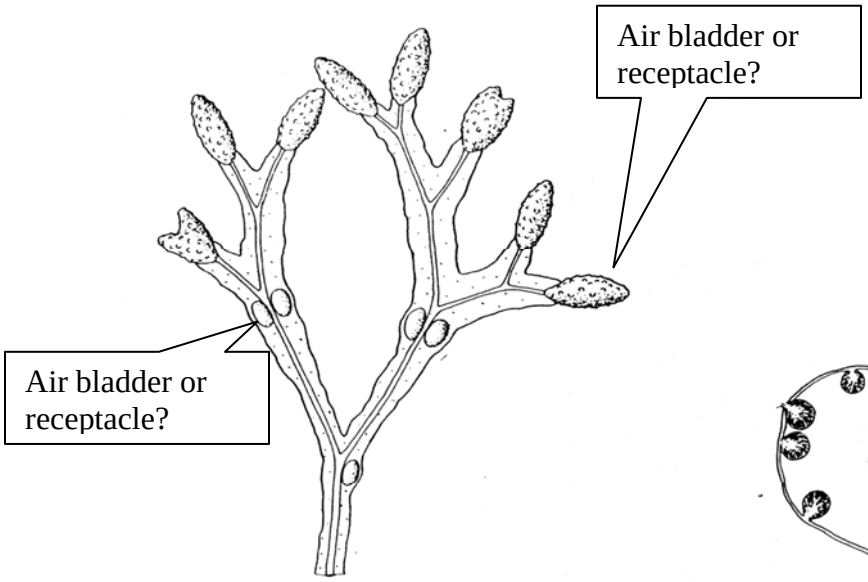
When marine algae get big (macroscopic), they are called seaweeds. Most browns are relatively big, and none are unicellular or colonial. Only 6 of 265 genera occur in freshwater. Although they have chlorophyll, their special carotenoid fucoxanthin (which they share with diatoms and many dinoflagellates) impart a brown color to them.

Well known members include *Fucus* (rockweed), *Laminaria* and *Macrocystis* (the kelps).

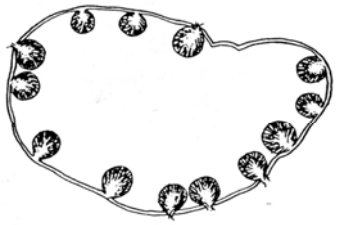
Common structures will include a HOLDFAST, a STIPE, A BLADDER (for buoyancy; aka pneumatocyst), and BLADES to function like "leaves".



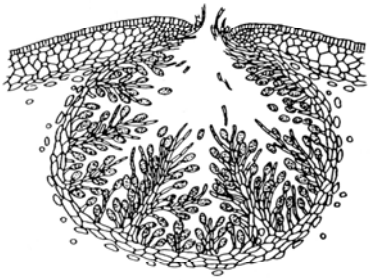
Holdfast Logic Question: *In what way(s) do holdfasts resemble roots, and in which way(s) do they not? HINT: think about function(s).*



A. *Fucus*, plant with receptacles and air bladders.

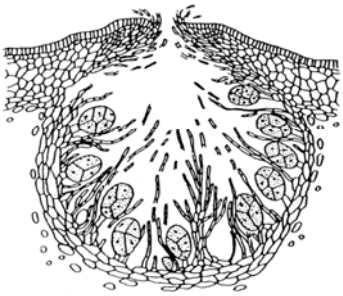


B. x-section of receptacle and smaller conceptacles.

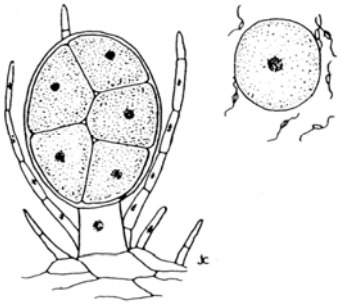


C. Male conceptacle with antheridia.

D. Antheridia with sperm.



E. Female conceptacle with oogonia.



F. Oogonium with eggs.

Above: *Fucus*, illustrations of the plant, as well as the reproductive parts. There are prepared slides along the side or back of the room that have sections of these parts. From your microscopic observations, label the plant illustration above as to which arrow box points to a receptacle, and which points to an air bladder.

G. Group 5: Glaucophytes .

Extremely small group of algae closely related to red and green algae. Will not be covered in lab.

H. Group 6: Red Algae .

The red algae are largely marine and multicellular "seaweeds". A class of accessory pigments (phycobilins) makes them reddish.

OPTIONAL (SEE INSTRUCTOR): Make macroscopic and microscopic observations of the red algae available in lab.

I. Group 7: Green Algae .

The green algae are a very large and diverse group. They range from unicellular organisms such as *Chlamydomonas* or *Chlorella* to colonial organisms such as *Volvox*, to mulicellular organisms such as *Ulva* (sea-lettuce) and *Chara* (stonewort).

Many of the unlabeled monocultures of algae in the lab were green algae. Presumably, you have now identified them all.

I1. Unicellular forms: all three of the algae below were represented in the unknown algal cultures. Which were which?

Chlamydomonas *Chlorella* *Closterium* (this unicell is bilaterally symmetric, with two equal halves and a single chloroplast; it's known as a "desmid")

Which of the algae above is an indicator of polluted fresh or salt waters?

I2. Colonial form: e.g., *Volvox* (also represented in the unknown algal cultures). Can you recognize *Volvox* on-sight?

I3. Filamentous forms: *Spirogyra*, and *Oedogonium* were represented in the unknown algal cultures.

Why is *Spirogyra* named as such?

Can you spot pyrenoids in *Spirogyra* chloroplasts?

How do you distinguish these two genera?

Are there any OOGONIA or ANTHERIDIA present in the *Oedogonium* material?

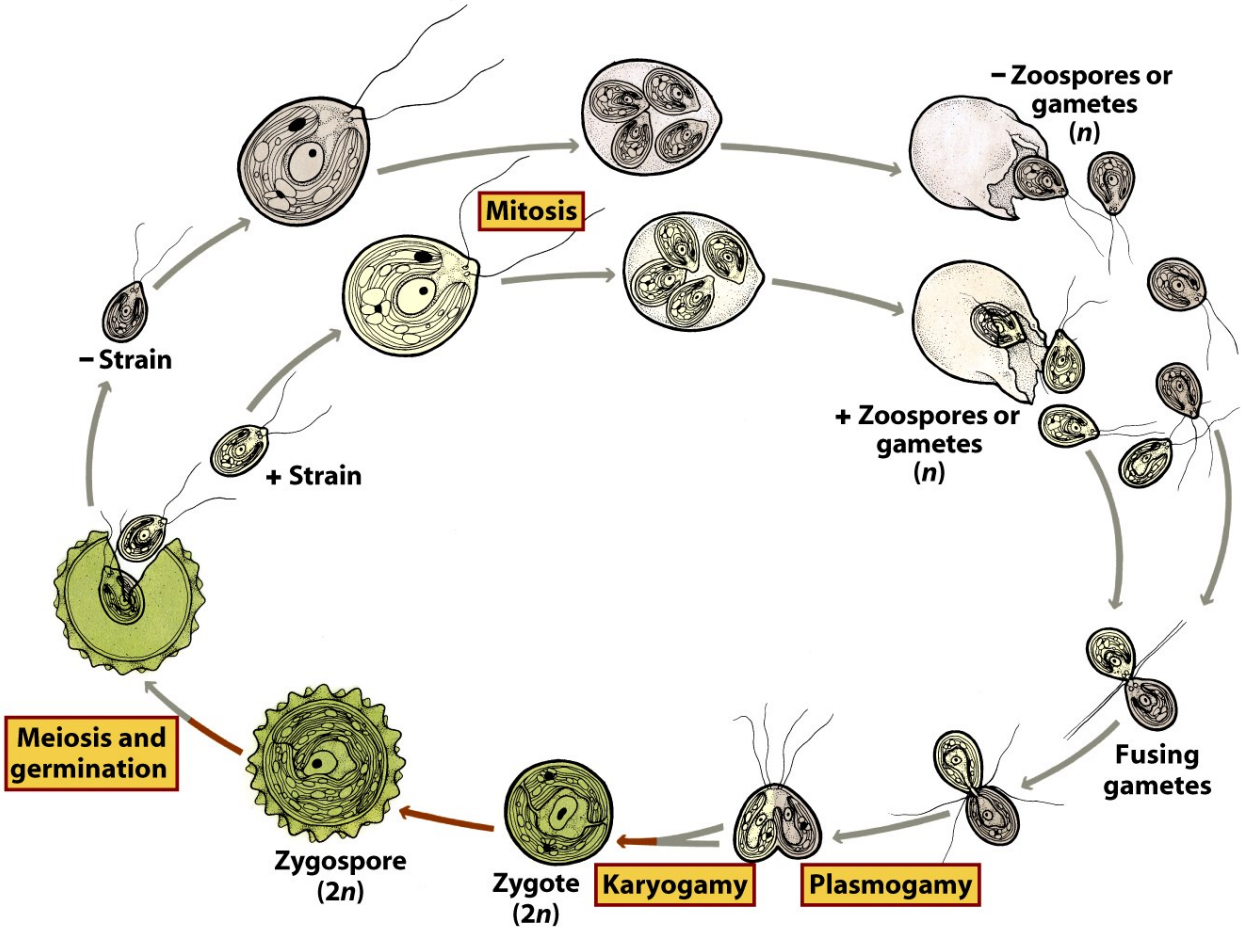
I4. Macroscopic (seaweed) forms (IF AVAILABLE): drawings.

Macroscopic microscopic (paradermal and x-sections; whole many cells thick is *Ulva*?).

Ulva (sea-lettuce) and other species in *Ulva*

I5. Life-cycles of some green algal species.

Below is that of *Chlamydomonas*. Next page is that of *Oedogonium*.



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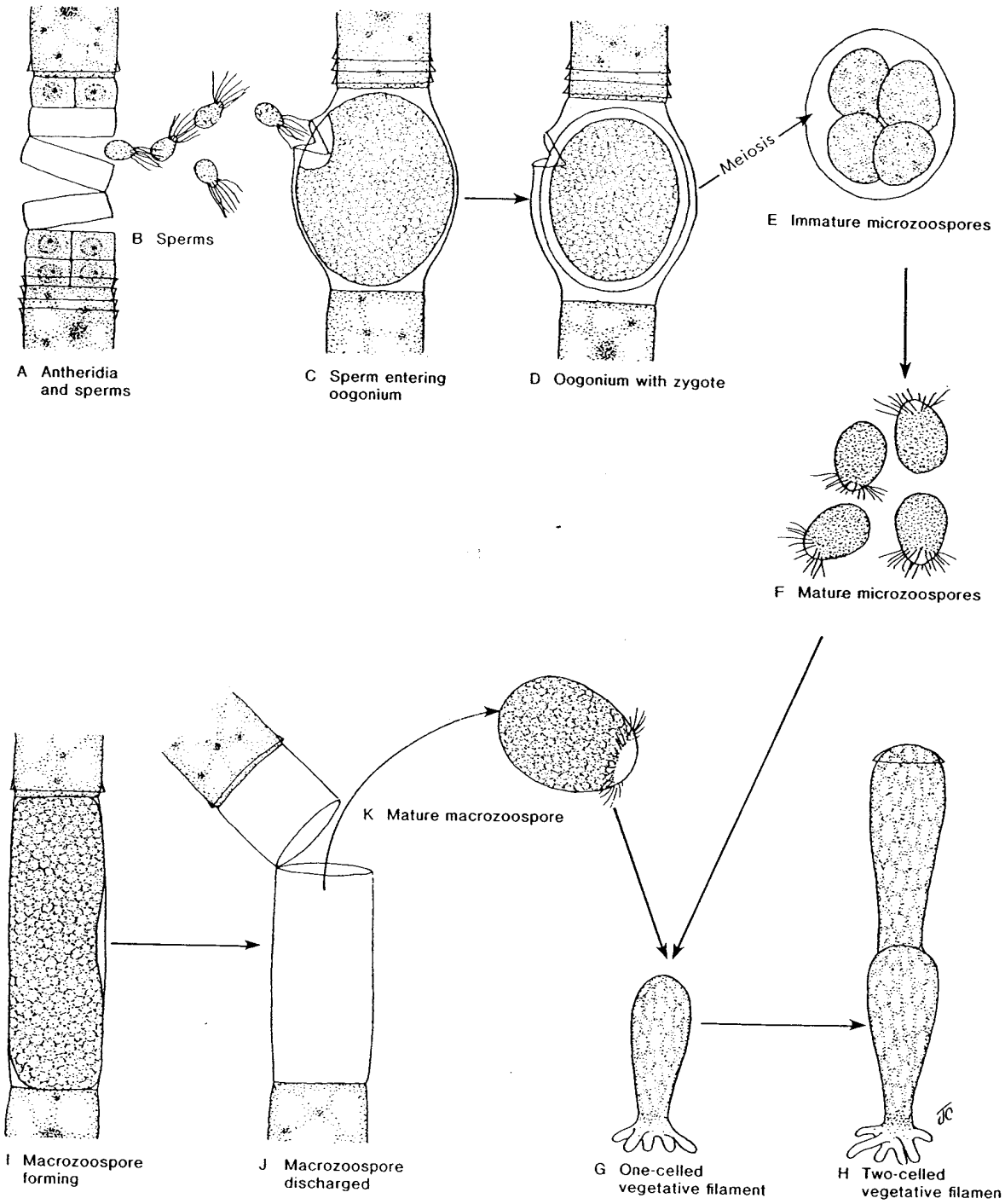
Above: Life cycle of *Chlamydomonas*, a unicellular green alga.

Figure 23.2 *Oedogonium*



Above, life-cycle of the green alga *Oedogonium*.

Detachable Dichotomous Key to 10 Freshwater Algae (© 2008, MU Botany)

1. Cells single; not grouped in a colony or filament..... 2
1. Cells grouped in colony or end to end in a long filament..... 6

2. Cells golden-brown, elliptic (football-shaped) or long and thin with pointy tips (i.e., toothpick-shaped)..... Synedra (Diatom)
2. Cells bright-green and shaped otherwise..... 3

3. Cells narrow (longer than wide)..... 4
3. Cells round or ovoid..... 5

4. Cells apparently not motile; very long, may be slightly crescent-shaped; round vacuoles at each tip may be filled with granules; a row of doughnut-shaped bodies (pyrenoids) runs from the tip to a central clear area..... Closterium (Desmid)
4. Cells motile (1-flagellate)..... Euglena (Euglenoid)

5. Cells ovoid, rather motile, with a groove on the narrower end where two flagella insert; red eye-spot present..... Chlamydomonas (Green Alga)
5. Cells round, not apparently motile (not flagellate)..... Chlorella (Green Alga)

6. Cells grouped into round colonies, bright- or gold-green..... Volvox (Green Alga)
6. Cells grouped into filaments, bright-green or blue-green..... 7

7. Cells blue-green (Cyanobacteria)..... 8
7. Cells bright-green..... 9

8. Filament with constrictions between the cells..... Anabaena (Cyanobacterium)
8. Filament without constrictions between the cells; moving..... Oscillatoria (Cyanobacterium)

9. Cells of filament cylindrical, chloroplast(s) round..... Oedogonium (Green Alga)
9. Cells of filament cylindrical, chloroplast(s) spiral or curved..... Spirogyra (Green Alga)