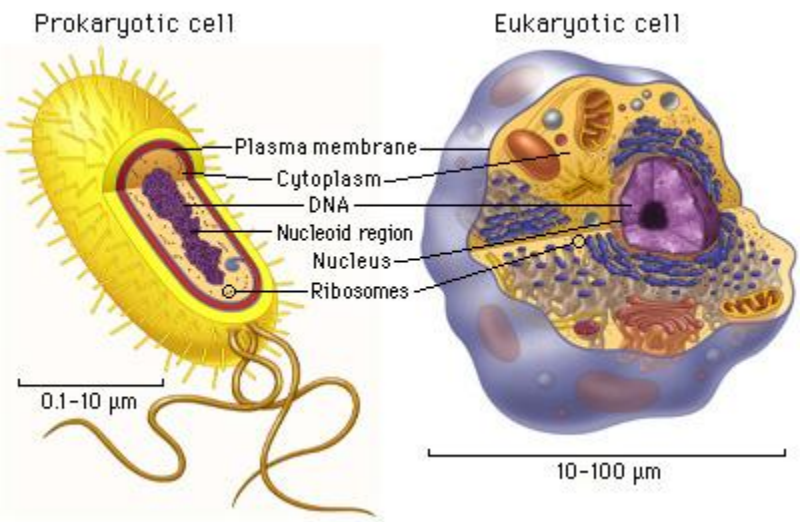
Microbiology Lab
Cyanobacteria, Protozoans, and Algae

Prokaryotic and Eukaryotic Cells



As you know, the building blocks of life are cells. **Prokaryotic** cells are those cells that do NOT have a nucleus. They mostly include bacteria and archaea. These cells do not have membrane-bound organelles. **Eukaryotic** cells are those that have a true nucleus. That would include plant, animal, algae, and fungal cells. As you can see, to the left, eukaryotic cells are typically larger than prokaryotic cells.

Today in lab, we will look at examples of both prokaryotic and eukaryotic unicellular organisms, most of which are commonly found in pond water.

When examining pond water under a microscope, the unpigmented, moving microbes will usually be protozoans. Greenish or golden-brown organisms will typically be algae. Microorganisms that are blue-green will be cyanobacteria.

Cyanobacteria are photosynthetic bacteria (once thought to be algae, so they are sometimes referred to as blue-green alga) that are generally blue-green in color and, in some species are capable of nitrogen fixation.

Protozoans are a large group of single-celled, usually microscopic, eukaryotic organisms, such as amoebas, ciliates, flagellates, and sporozoans.

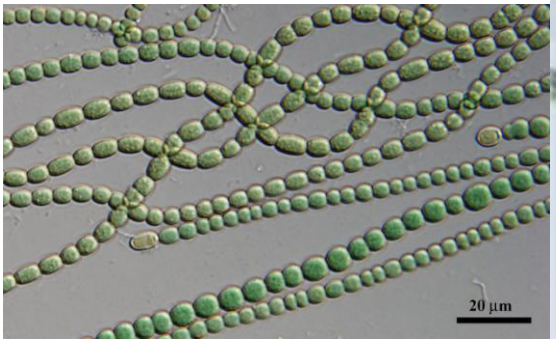
Algae are unicellular or multicellular organisms (formerly classified as plants) that have chlorophyll but lack true stems, roots, and leaves. Algae include the seaweeds, diatoms, and spirogyra.

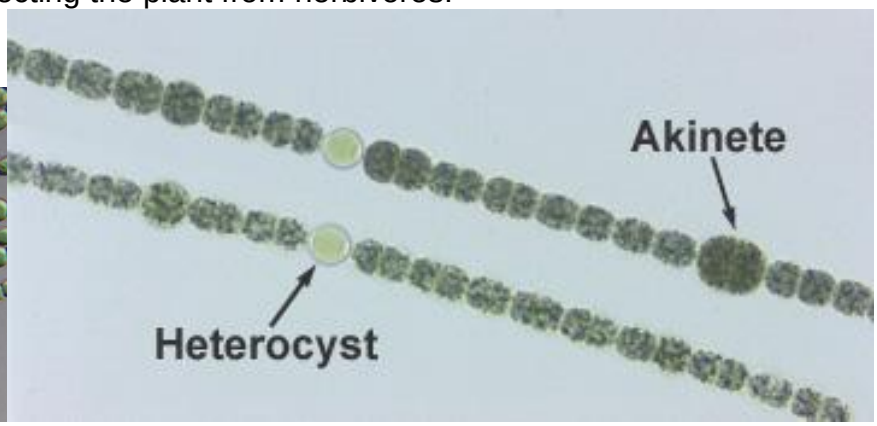
Prokaryotic Organisms - The Cyanobacteria

Cyanobacteria belong to Domain Bacteria. These microscopic organisms lack nuclei. They were once classified as algae because they have **chlorophyll a**. This explains why they are often referred to as the **blue-green algae**. Cyanobacteria do not contain chloroplasts. Over a 1,000 species of cyanobacteria have been reported. They are present in almost all moist environments. We will look at two examples of cyanobacteria:

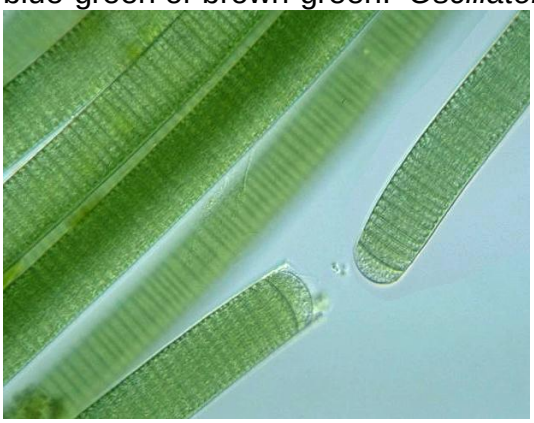
- *Anabaena*
- *Oscilltoria*

Anabaena is a **filamentous cyanobacteria** that exists as plankton. It is known for its **nitrogen fixing** abilities.
Anabaena can develop **akinetes** (thick walled resting cells that can survive in sediments for many years). It possesses **heterocysts,** which, during times of low environmental nitrogen, supply neighboring cells with fixed nitrogen in return for the products of photosynthesis. About one cell out of every ten will differentiate into a heterocyst that can no longer perform photosynthesis. This separation of functions is essential because the nitrogen fixing enzyme in heterocysts, nitrogenase, is unstable in the presence of oxygen.
Some *Anabaena* form symbiotic relationships with certain plants, such as the mosquito fern.
Anabaena are one of four genera of cyanobacteria that **produce neurotoxins**, which are harmful to local wildlife, as well as farm animals and pets. Production of these neurotoxins is assumed to be a part of its symbiotic relationships, protecting the plant from herbivores.





Oscillatoria is a genus of **filamentous cyanobacterium** which is named for the oscillation in its movement. Filaments in the colonies can slide back and forth against each other until the whole mass is reoriented to its light source. It is commonly found in watering-troughs waters, and is mainly blue-green or brown-green. *Oscillatoria* is an organism that reproduces by **fragmentation**.



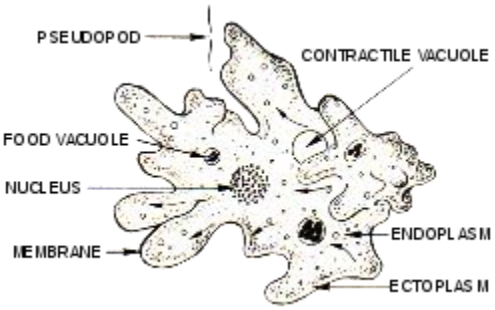
The Protists - Eukaryotic Organisms
Kingdom Protista

Single-celled, eukaryotic organisms are called **protists**. They are grouped together in **Kingdom Protista**. Those protists that are animal-like are put in **Subkingdom Protozoa**, and the protists that are plantlike belong to **Subkingdom Algae**.

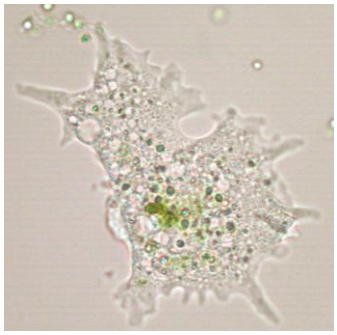
The Protists – Subkingdom Protozoa

Members of Subkingdom Protozoa, known as the **protozoans**, have a cell membrane (the pellicle) but lack cell walls. The nuclei are distinct, and the cells often have specialized organelles such as contractile vacuoles, mitochondria, flagella, and cilia. All protozoans produce **cysts** which are resistant dormant stages that enable the protozoans to withstand drought, heat, and freezing. The protozoans we will look at today include the following:

- Amoebas
- Paramecium
- Plasmodium

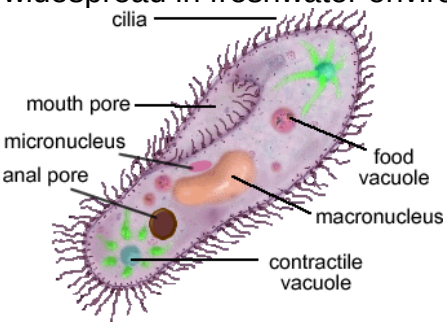


Amoebas are unicellular **heterotrophs** (they must eat food, as all other animals). They obtain food through **phagocytosis**, utilizing **pseudopods** to entrap their meals. Amoebas' most recognizable features include one or more nuclei and a simple **contractile vacuole** to maintain osmotic equilibrium. Like other eukaryotic organims, they reproduce through asexually via mitosis and cytokinesis, not binary fission, which is how prokaryotes reproduce.



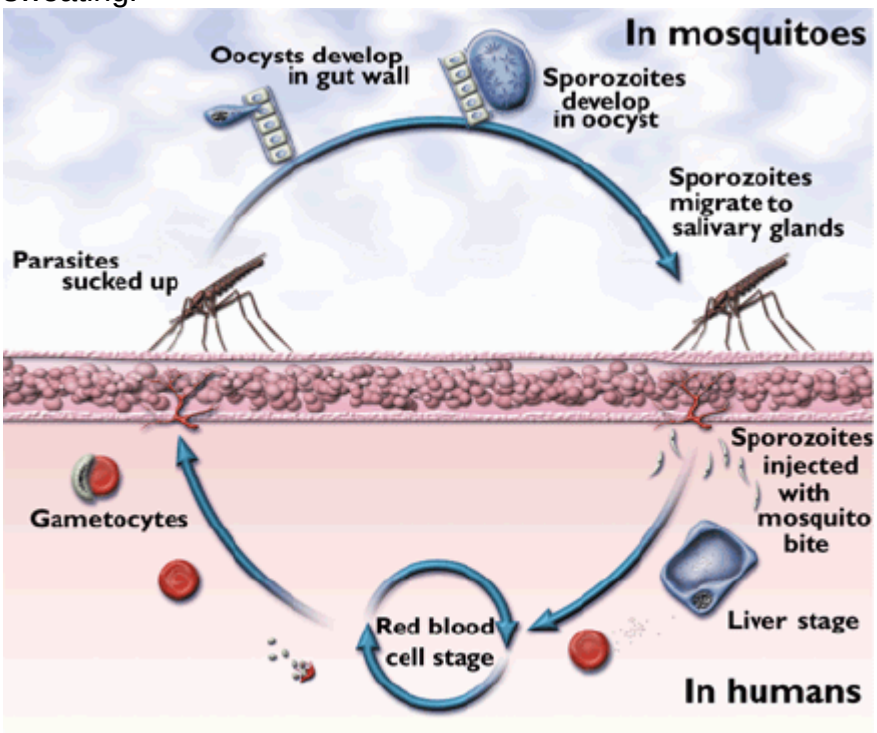
Watch this video of an amoeba in action! http://youtu.be/W6rnhiMxtKU

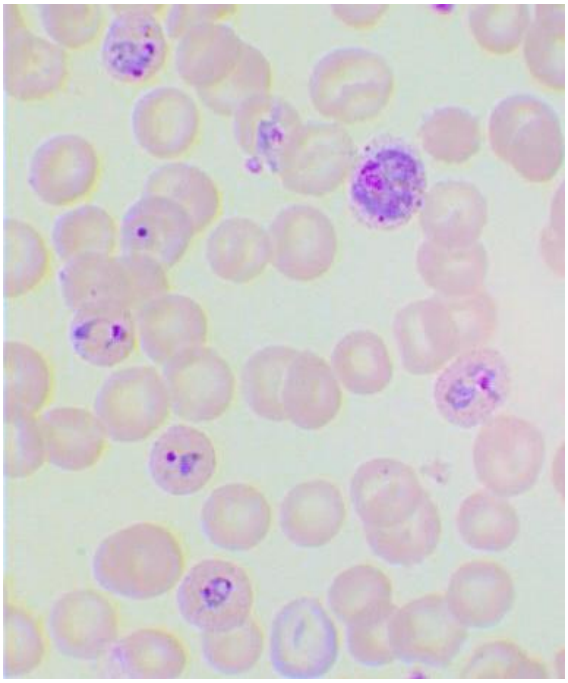
Parmecium are unicellular, ciliated **protozoans** (microscopic animals). Simple **cilia** cover the body, which allow the cell to move with a synchronous motion (like a caterpillar) at speeds of approximately 12 body lengths per second. There is also a deep oral groove containing inconspicuous tongue-like compound oral cilia used to draw food inside. They generally feed on bacteria and other small cells. Osmoregulation is carried out by a pair of contractile vacuoles, which actively expel water from the cell absorbed by osmosis from their surroundings. Paramecia are widespread in freshwater environments.



Watch this video of paramecium in action! http://youtu.be/l9ymaSzcsdY

Plasmodium is a genus of parasitic protists. Humans can become infected with at least 11 species of *Plasmodium*, resulting in **malaria.** Malaria translates literally as "bad air." It was supposed to be due to swam exhalations, but we now know it to be caused by a parasitic protozoan transmitted to humans by *Anopheles* mosquitoes. The protozoan occupies human red blood corpuscles (RBC's), replicates inside them, and then destroys them as they escape to infect new RBC's. This lifecycle results in intermittent or remittent fever characterized by attacks of chills, fever, and sweating.

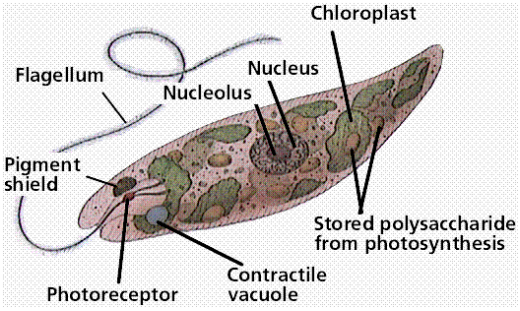




The Protists – Subkingdom Algae

Subkingdom Algae includes all the photosynthetic, eukaryotic protists. Again, they lack the tissue differentiation found in plants. Algae may be unicellular, colonial, or filamentous. Algae have distinct, visible nuclei and chloroplasts. **Chloroplasts** are organelles that contain photosynthetic pigments which harvest the energy of sunlight to form carbohydrates through a process known as **photosynthesis**. There are 7 different divisions of algae, but we will examine only a selection of them:

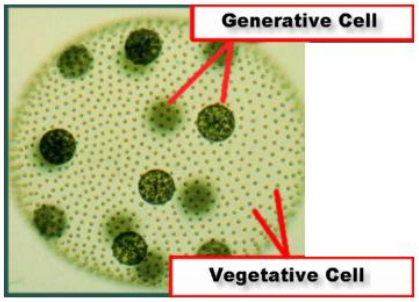
- Euglenophycophyta (the euglenoids) – ex. *Euglena*
- Chlorophycophyta (the green algae) – ex. *Volvox, Ulothrix,* and *Spirogyra*
- Chrysophycophyta (the golden brown algae) – ex. Diatoms and *Vaucheria*



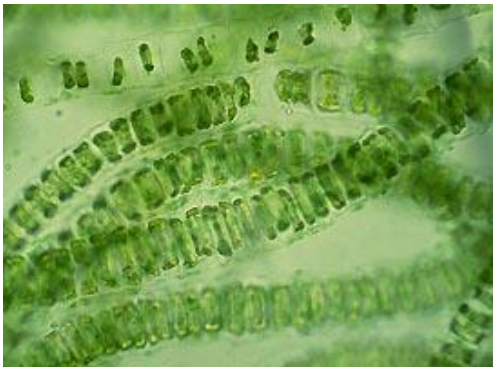
Euglena are unicellular protozoans that almost always have **chloroplasts**. Although they photosynthesize (autotrophy), *Euglena* can also eat food by heterotrophy (like animals). They use a **flagellum** for locomotion.

Watch this video of euglena in action! http://youtu.be/0rNI8Bos_BQ

Volvox is a type of **green algae**. It forms **spherical colonies** of up to 50,000 cells. They live in a variety of freshwater habitats. Each mature *Volvox* colony is composed of numerous flagellate cells embedded in the surface of a hollow sphere. The cells swim in a coordinated fashion, with distinct anterior and posterior poles. The cells have eyespots which enable the colony to swim towards light. The spheres will break up with advanced age. The **generative cells** then grow into new colonies.

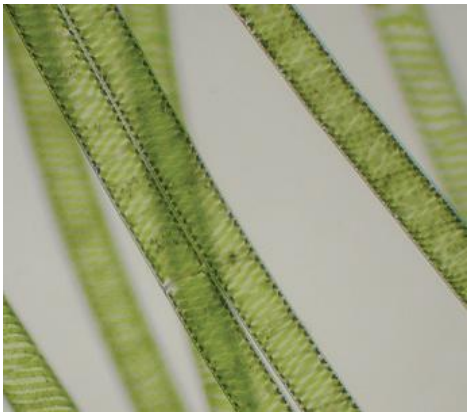


Watch this video of volvox in action! http://youtu.be/He9FSeGRi3A

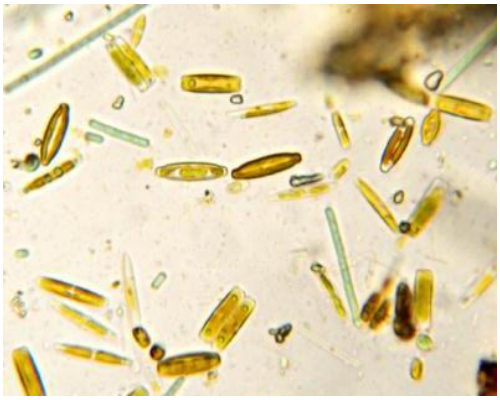


Ulothrix is a **filamentous green algae**, generally found in fresh and marine water. Its cells are normally as broad as they are long, and they thrive in the low temperatures of spring and winter. They become attached to surfaces by a modified holdfast cell.

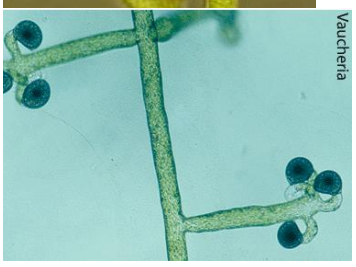
Spirogyra is a **filamentous green algae** of the, named for the helical or **spiral arrangement of the chloroplasts**. It is commonly found in freshwater areas. *Spirogyra* measures approximately 10 to 100µm in width and may stretch centimeters long. This particular algal species, commonly found in polluted water, is often referred to as "pond scum". The cell wall has two layers: the outer wall is composed of **pectin that dissolves in water to make the filament slimy to touch** while the inner wall is of cellulose. The cytoplasm forms a thin lining between the cell wall and the large vacuole it surrounds. The chloroplasts are ribbon shaped, serrated or scalloped, and spirally arranged. In spring *Spirogyra* grows under water, but when there is enough sunlight and warmth they produce large amounts of oxygen, adhering as bubbles between the tangled filaments. The filamentous masses come to the surface and become visible as slimy green mats.



Diatoms are a major group of **golden brown algae**, and are one of the most common types of **phytoplankton** (microscopic plants). Diatoms are **primary producers** within the food chain. Most diatoms are unicellular, although they can exist as colonies in the shape of filaments or ribbons, fans, zigzags, or stellate colonies. Diatom cells are characteristically encased within a unique cell wall made of **silica** (hydrated silicon dioxide) called a **frustule**. These frustules show a wide diversity in form, but **usually consist of two symmetrical sides with a split between them**, hence the group name.



Vaucheria is another **golden brown algae**. *Vaucheria* exhibits apical growth from the tip of filaments forming mats in either terrestrial or freshwater environments. Its filaments form coenocytes with a **large central vacuole** pushing against the surrounding cytoplasm; the vacuole extends along the entire filament except for the growing tip. The chloroplasts are located on the periphery of the cytoplasm with the nuclei aggregating toward the center near the vacuole.



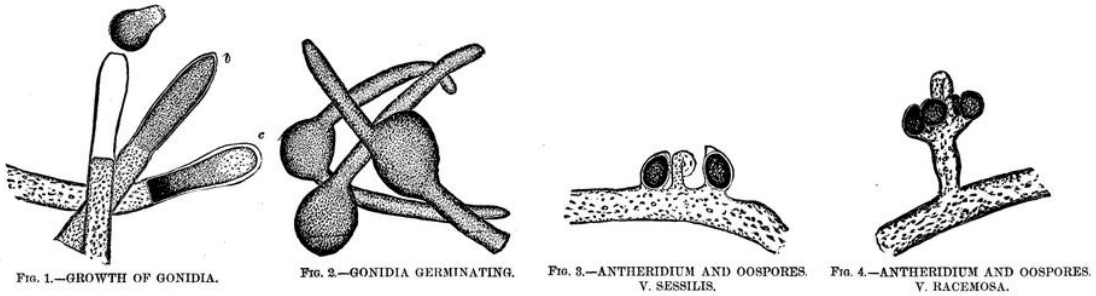


Fig. 1.—GROWTH OF GONIDIA.

Fig. 2.—GONIDIA GERMINATING.

Fig. 3.—ANTHERIDIUM AND OOSPORES. V. SESSILIS.

Fig. 4.—ANTHERIDIUM AND OOSPORES. V. RACEMOSA.