**Introduction**

**Prokaryotic** organisms are classified into two domains, **Archea** and **Bacteria**. Typically, their cells are smaller in size compared to eukaryotic cells and lack a true nucleus confining the genetic material. The cells of most prokaryotes are surrounded by a cell wall which contains peptidoglycan. This cell wall aids in maintaining cell shape with three common morphologies possible: coccus (spherical), bacillus (rod shaped) and spiral.

The Archea are probably the least familiar of the two to most people, but include some very important organisms. Prokaryotic **thermopiles**, which can survive extreme temperatures are used in biotechnology (specifically Polymerase Chain Reaction), while others are responsible for ‘marsh gas” (methane) produced as a byproduct of respiration when oxygen levels in moist soils have been depleted (anaerobic conditions).

The Bacteria are more familiar probably due to the **pathogenic** species which we often confront. Strep throat, tuberculosis, and Lyme disease are all caused by bacteria; however not all bacteria are harmful. In addition to parasitic relationships, bacteria may also form **commensal** or **mutualistic** associations with hosts. Others are important **autotrophs**, while yet others function as **decomposers** and play an important role in nutrient cycling.

All eukaryotic life is classified in the domain **Eukarya**. Included in this domain are the **protists**. The term protist is used to describe a diverse assemblage of mostly single-celled eukaryotic organisms. Traditionally, kingdom Protista existed as a single taxon. Recent biochemical data and increasing technology have allowed scientists to separate protists into as many as five separate lineages!! And this classification continues to change.

For this reason, we shall consider the traditional informal (no taxon level) groupings of protists: the **algae** and the **protozoans** and look at the life history of several examples.

The **algae** are a collection of photosynthetic organisms that live in water or extremely moist areas because they lack specialized vascular tissues for water and nutrient transport. Algae may be unicellular, colonial, or multicellular. Large multicellular algae (**macroalgae**) do not form specialized tissues but they do reach considerable sizes. Algae are enormously important in aquatic and marine food chains providing essential carbon fixation and supplying oxygen as a byproduct.

**Protozoans** are heterotrophic single-celled eukaryotes and obtain nutrients by ingestion as they form food vacuoles. Many of these organisms are classified based upon the cellular structures used for locomotion. While many protozoans are free-living, others are important **symbionts** (either as parasites, commensals, or mutualists).
Review Questions:

1. Which of the three domains contains prokaryotic organisms?

2. What is a thermophile?

3. Describe the difference between an autotroph and a heterotroph.

4. List and differentiate between the three forms of symbiosis:

5. List an important ecological benefit of algae.

6. What are the three basic shapes of most bacteria?

7. Where is peptidoglycan found in a bacterial cell?
STATION 1: Introduction to the Cyanobacteria & Protists

Your instructor will review the introductory information at the beginning of lab.

You should also use the time at Station 1 to answer the general information questions above.

Observe the prepared slides under the microscopes to enhance the items discussed below. In addition, you should use the spaces provided to make labeled drawings of the slide as needed.

**Domain Bacteria**

**Cyanobacteria – Example: Nostoc**

Cyanobacteria contain an assortment of photosynthetic pigments including chlorophyll \(a\), a group of yellow to orange pigments called carotenoids, phycocyanin (a blue pigment) and phycoerythin (a red pigment). These pigments are responsible for the characteristic blue-green color of cyanobacteria and allow these bacteria to be the simplest and most primitive organisms able to carry out photosynthesis. *Nostoc*, a filamentous cyanobacterium, occurs in bead-like chains with an occasional enlarged cell termed a heterocyst. **Heterocysts** function in nitrogen fixation, converting atmospheric nitrogen into ammonia. Most other living things do not have the ability to use atmospheric nitrogen, so organisms like *Nostoc* are essential in the nitrogen cycle.

Review Questions:

1. What general color are cyanobacteria?
2. Describe the function of a heterocyst.
3. What domain does *Nostoc* belong to?
4. Why is fixing nitrogen important? Why do living things require nitrogen?
STATION 2: Pond Water Observation

For this exercise you will examine a culture of ‘pond water’. Most aquatic systems are teeming with tiny life forms and many are protists; it is amazing to see what kinds of life can occur in a drop of water.

1. Obtain a clean depression slide
2. Using a pipette, first expel the air form the bulb then place in the pond water culture. Attempt to collect sediment or other suspended materials that may be present.
3. Transfer one drop of the sample to the well on the depression slide. Next, carefully place one drop of Detain ™ in the well on your sample (this will slow the movements of the critters!). Do not overfill the well.
4. Carefully place a clean coverslip over the well.

Using the microscope, examine the sample. Use the spaces below to sketch a few of the organisms you observe. You may also use the laminated protist keys to help identify some of the organisms. When you are finished, rinse and clean your slide and dispose of the coverslip.

Review Questions:

1. Can you identify any algae? How can you tell algae from other life forms seen in the sample?

2. Are all of the organisms seen in the sample protists? How can you tell?

3. Can you identify any protozoans? Why are these protozoans important?
STATION 3A: The Algae

**Euglenoids – Example: *Euglena***
About one third of the euglenoids are photosynthetic, possessing chlorophyll *a*, chlorophyll *b*, and carotenoids. Euglenoids are single-celled with a long whip-like **flagellum** used for locomotion. Because they inhabit freshwater, the euglenoids have star-shaped **contractile vacuoles** to rid the cell of excess water. A common euglenoid, *Euglena*, also possesses an **eyespot (parabasal body)** located near the flagellum that detects light intensity. *Euglena* are unique in that they can alternate between being photosynthetic and heterotrophic. If light is not available, the **chloroplasts** cease to function, and the *Euglena* collects food through its **gullet**. The food is then digested within **food vacuoles** (f.y.i – not seen on model). Identify these structures on the model using the keys provided. Be sure to know their respective functions.

*Euglena* – Using the key provided, label the bold structures listed above.
Green Algae – Example: *Spirogyra*

The green algae include unicellular and colonial microalgae as well as the larger, multicellular macroalgae known as seaweed. Green algae are similar to plants in that they contain chlorophyll $a$, chlorophyll $b$ and carotenoids and use starch as their food storage product. Also, like plants, most green algae have a cell wall composed of cellulose. Therefore, green algae are generally considered to be the evolutionary precursors of plants.

* Spirogyra is a filamentous green algae consisting of cylindrical vegetative cells that contain spiral-shaped chloroplasts. Sexual reproduction in *Spirogyra* occurs through the process of **conjugation** in which a **conjugation bridge** is formed between two **gametangia**, and genetic material is transferred from one cell to another. The fusion of the genetic material results in a football-shaped **zygote** that undergoes meiosis to produce four nuclei, three of which disintegrate. The remaining nucleus develops into a new vegetative filament.

Use the microscope to view the prepared slides of *Spirogyra*. You should be able to identify the vegetative cells containing spiral-shaped chloroplasts as well as those undergoing conjugation. Use the space below to sketch and label your observations. You should use the laminated sheets to aid in your identification of these structures.

![Spirogyra – vegetative cell](image1)

![Spirogyra - conjugation](image2)

Also observe other examples of green algae using the herbarium sheets noting that many may form mats or sheets instead of filaments.
Red Algae
This group consists primarily of multicellular macroalgae. Red algae have chlorophyll $a$, chlorophyll $c$, phycoerythrin and phycocyanin; the combination of these pigments gives them a reddish coloration. The red algae are relatively small, delicate algae with a feathery appearance. They collect calcium salts and are partially responsible for the formation of coral reefs. Use the space below to sketch representative red algae as seen on the herbarium sheet.

Brown Algae
All brown algae are multicellular macroalgae, some growing more than two hundred feet in length. Brown algae contain chlorophyll $a$, chlorophyll $c$ and carotenoids. Because of their size, many large brown algae called kelps provide habitats for other marine organisms. Kelps may have leaf-like blades, stem-like stipes, root-like holdfasts, and gas-filled floats (bladders) that provide buoyancy. Sargassum is a common brown algae on the Texas Gulf-Coast. It is free-floating and drifts on the gulf currents providing an important habitat for a host of marine organisms. Use the space below to make a sketch of and label the brown algae specimens.

Sargassum  Laminaria  Fucus
**Review Questions**

1. Name the structure a Euglena uses for:
   - locomotion -
   - detect light –
   - osmoregulation -

2. Name the structure in a Euglena where the photosynthetic pigments are located.

3. Name the process by which sexual reproduction occurs in *Spirogyra*. Name the structure which allows for the passage of the genetic material.

4. Describe the shape of a *Spirogyra* chloroplast.

5. Are the blades of kelp analogous or homologous to the leaves of plants?

6. Organisms known as kelps belong to which group of algae?

7. Name the structure kelp use to anchor itself to the sea floor.
STATION 3B: The Protozoans

Ciliates – *Paramecium*

Ciliated protozoans such as *Paramecium* are covered with **cilia**. These tiny “hairs” are used for locomotion as they beat rhythmically and propel the organism through the water. *Paramecium* is a heterotrophic, aquatic scavenger that uses an **oral groove** to catch food. Food enters a **food vacuole** and after the nutrients are digested, waste leaves via the **anal pore**. Branched **contractile vacuoles** are used in the removal of excess water. *Paramecium* reproduces like most other protists using binary fission (**mitosis**) however a modified form of sexual reproduction (**conjugation**) is also seen. Each *Paramecium* has a pair of nuclei; a **macronucleus** and a **micronucleus**. During conjugation, two *Parameciums* align laterally and swap micronuclei exchanging genetic information and producing new genetic individuals.

*Paramecium* - label the structures listed in **bold** above.
Amoebas – *Amoeba*

Amoebas are protozoans which are constantly changing their shape. They do this by extending cytoplasm into **pseudopodia** (sing – **pseudopodium** or **pseudopod**) which they use for locomotion as well as prey capture. They move using their pseudopodia until a food item is located (such as **cyanobacteria**). They ingest the food item by **phagocytosis** (**endocytosis**), using their pseudopodia to surround the prey and form a **food vacuole**. Members of the genus *Amoeba* have a single large **nucleus**, while other amoebas are multinucleated. Most amoebas are harmless aquatic predators; however, some are important parasites and pathogens such as *Entamoeba histolytica* which causes amoebic dysentery.

*Amoeba* – Label the structures listed in **bold** above.
Flagellates - *Trypanosoma*

Flagellated protozoans use a **flagellum** for locomotion. There are many different flagellates, some are beneficial mutualistic protists while others are dangerous pathogens. Members of the genus *Trypanosoma* have a single **nucleus** and are deadly pathogens. African sleeping sickness is caused by a trypanosome. The trypanosomes are transmitted from one host to the next by **tse tse flies** (called the **vector** of disease, the vector transmits the disease from one host to the next) and live in the blood. They are able to move in the host’s blood using the flagellum and the **undulating membrane** (resembles a fin on the cell membrane). Use the microscope to examine the trypanosomes in the blood. You should be able to see the **red blood cells** in the sample as well as the flagellated trypanosomes. Use the space below to sketch and label the trypanosomes observed on the slide.
Review Questions

1. Name a pathogenic protozoan and the disease which it causes.

2. List the three structures used for locomotion in the protozoans observed.

3. Are all protozoans heterotrophic?

4. Describe the role of a vector in a disease like African sleeping sickness.

5. What is phagocytosis?

6. What is the function of a contractile vacuole?

7. Give the term for sexual reproduction seen in Paramecium. Briefly describe this process.
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Bacteria
Protists
Nostoc slide demo

Station 2
Pond water observation

Station 3 A
Algae
Spirogyra slide demo
Euglena model
macroalgae herbarium sheets

Station 3B
Protozoans
Paramecium model
Amoeba model
Trypanosoma slide demo