INTRODUCTION TO CELLS: PROKARYOTES AND EUKARYOTES

Cells can be classified into two main categories: **eukaryotes** and **prokaryotes**. Eukaryotic cells have a nucleus and other internal structures separated by membranes (**membrane-bound organelles**). In addition, eukaryotic cells are much larger and have significant differences in the organization of their DNA. Prokaryotic cells lack a nucleus; have no membrane-bound organelles, and have a single, circular piece of DNA. All members of the **Domains Bacteria and Archaea** have prokaryotic cells, most are unicellular, but a few are simple multicellular chains. By contrast, all of the other organisms in the world are made of eukaryotic cells. Here is an overview of the basic classification system used for all living organisms:

Type of Cell	Domain	Kingdom	Example
Prokaryotic	Archaea	***Not Used***	Prokaryotic organisms found in extreme environments
Prokaryotic	Bacteria	***Not Used***	common bacteria, cyanobacteria
Eukaryotic	Eukarya	Protists	algae, *Paramecium*, *Amoeba*, *Euglena*
Eukaryotic	Eukarya	Fungi	mushrooms, mold, *Penicillium*
Eukaryotic	Eukarya	Animals	vertebrates, insects, nematodes, sponges
Eukaryotic	Eukarya	Plants	moss, ferns, redwoods, flowering plants

Biologists try to create a classification system in order to organize the vast diversity of living organisms. The **Three Domain Classification System** that divides the Eukarya into four Kingdoms is the most commonly used system today. All organisms are placed in one of the six categories based on their possession of unique characteristics.

In this lab we will examine members of the **Prokaryotic Domain Bacteria** and compare them to **Eukaryotic** cells. The Domain Bacteria is composed of the common bacteria and cyanobacteria. Common bacteria are unicellular with the distinctive characteristics of the prokaryotes (see above). These bacteria are the most numerous organisms on earth; they may be heterotrophic or autotrophic; they are ecologically important in nutrient cycles, as decomposers, as mutualistic symbionts, as well as pathogens that cause disease. Cyanobacteria are autotrophic, unicellular, colonial, or form simple multicellular chains. Some cyanobacteria are able to fix nitrogen (convert N_2 to NH_3) and are therefore important in making nitrogen available in both aquatic and terrestrial habitats.

GOALS AND OBJECTIVES FOR THE CELL PORTION OF THE LAB

1. Know the difference between eukaryotic and prokaryotic cells.
2. Know the System of Domains and Kingdoms, including identifying characteristics and examples.
3. Know the meaning and examples of the vocabulary highlighted in bold.
4. Know the distinguishing characteristics of the Domain Bacteria.
5. If you are shown a bacterium, an animal cell, or a plant cell, be able to identify the Domain and Kingdom to which it belongs and why.
6. For the bacteria, know the method of acquiring food/energy.
7. Know the important ecological roles of bacteria and cyanobacteria.
8. Be able to identify organelles and other cell structures in prokaryotic and eukaryotic cells.

PROKARYOTES

There are two different groups of prokaryotes that scientists think are different enough that they should be put into separate domains: the Bacteria and the Archaea.
In today's lab we will examine only the Domain Bacteria.

Domain Bacteria: these are the majority of bacteria including those that inhabit your gut, are used in yogurt formation, live in most soils, and have the following characteristics:

- Small size (1 -10µm)
- One circular strand of DNA in a region called the nucleoid
- Cell walls made of unique material – peptidoglycan
- No membrane-bound organelles – therefore they lack a nucleus, mitochondrion, etc.
- Small ribosome – site of protein synthesis
- Cytoplasm refers to the material inside the plasma membrane, excluding the DNA

– Bacteria: Prepared slides

Observe the mixed bacteria noting the variety of shapes and types. In some cases you may see bacteria connected in chains. Note that these represent bacterial cells that divided, but failed to separate. Chains of cells form among many types of heterotrophic bacteria.

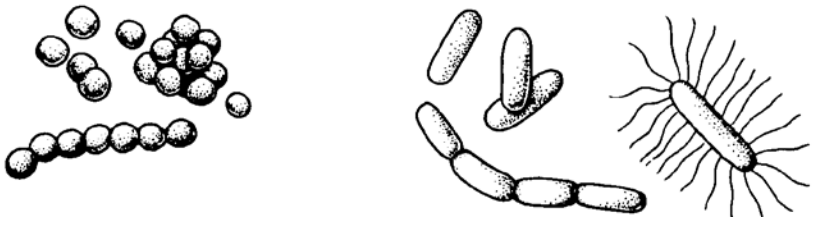
1. List three ecological roles of **heterotrophic** bacteria:

   1.

   2.

   3.

Some Typical Bacteria Shapes:



Coccus
(Spherical)

Bacillus
(Rod-Shaped)

Cyanobacteria: *Gloeotrichia*, *Anabaena* or ***Oscillatoria*** (to be determined by instructor**)**

Cyanobacteria are **autotrophic** bacteria often found in ponds and streams (you may see them in your pond water observations). They differ from heterotrophic bacteria by possessing the pigment **chlorophyll** (also found in plants); thus cyanobacteria obtain nutrients by **photosynthesis**. Some are also able to **fix nitrogen** in specialized cells called **heterocysts**.

A. Obtain a prepared slide of a cyanobacterium (*Gloeotrichia, Anabaena, or Oscillatoria)*

B. Observe the slide using the 4X, 10X, and finally the 40X lens.

C. Note the chains of bacteria and that these forms of prokaryotic organisms are technically multicellular. In some species, you should be able to observe specialized cells. These cells are involved in storage (akinete) and nitrogen fixation (heterocyst), and reproduction.

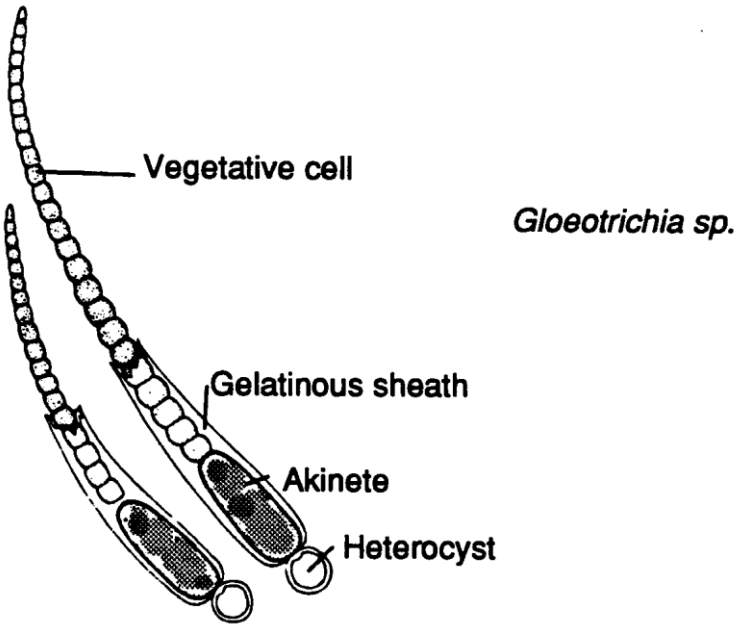
D. Compare your specimen to the diagram below.

1. To what Domain do cyanobacteria belong?

2. What is their mode of obtaining nutrients?

3. What pigment is involved in gaining nutrients?

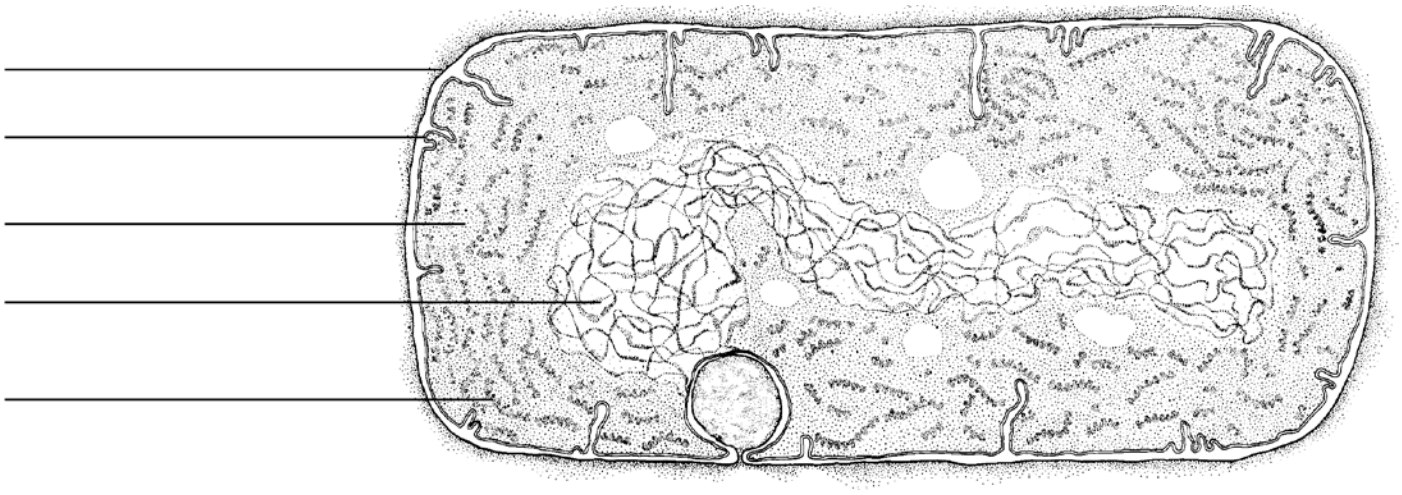
4. What is the function of the heterocyst? How is it ecologically important?



Basic Prokaryotic Cell Structure: Bacteria

Examine mixed bacteria slides and compare eukaryotic with prokaryotic cell structure. Be able to list the major difference between eukaryotic and prokaryotic cells.

1. Which type of cell evolved first (is the most primitive)?
2. List the two domains of organisms that have prokaryotic cells.
   1.
   2.
3. Name the four basic structures that both prokaryotic and eukaryotic cells have in common.
   1.
   2.
   3.
   4.
4. How does the arrangement of DNA in prokaryotic cells differ from that seen in eukaryotic cells?
5. What is the unique substance that makes up the cell walls of bacteria?
6. Label the cell wall, plasma membrane, circular DNA, cytoplasm, and ribosomes on the diagram below.



PROKARYOTIC CELL

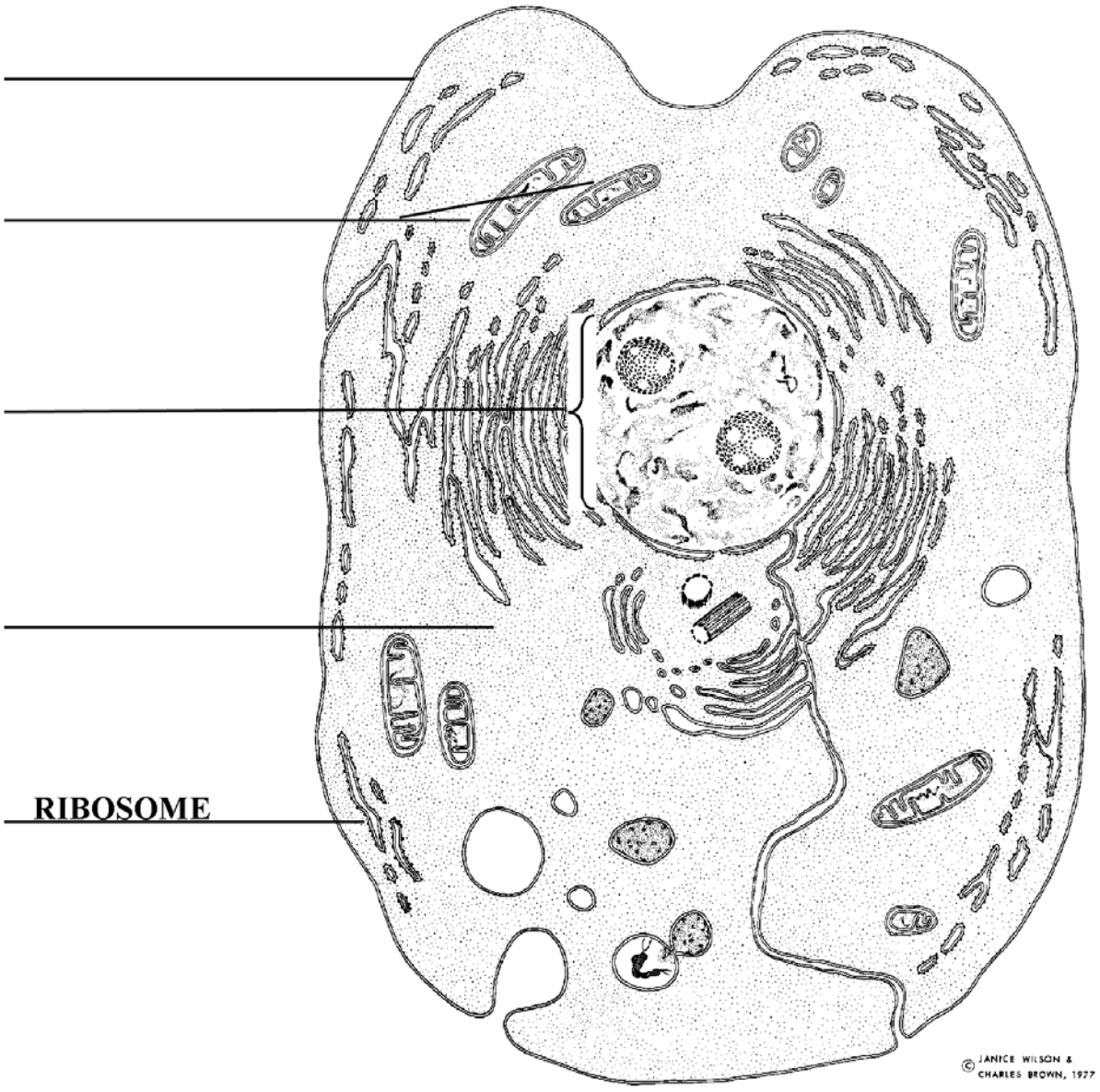
EUKARYOTES

Basic Eukaryotic Cell Structures: Animals and Plants

Be able to identify parts of the eukaryotic animal cell and plant cells (diagrams follow).

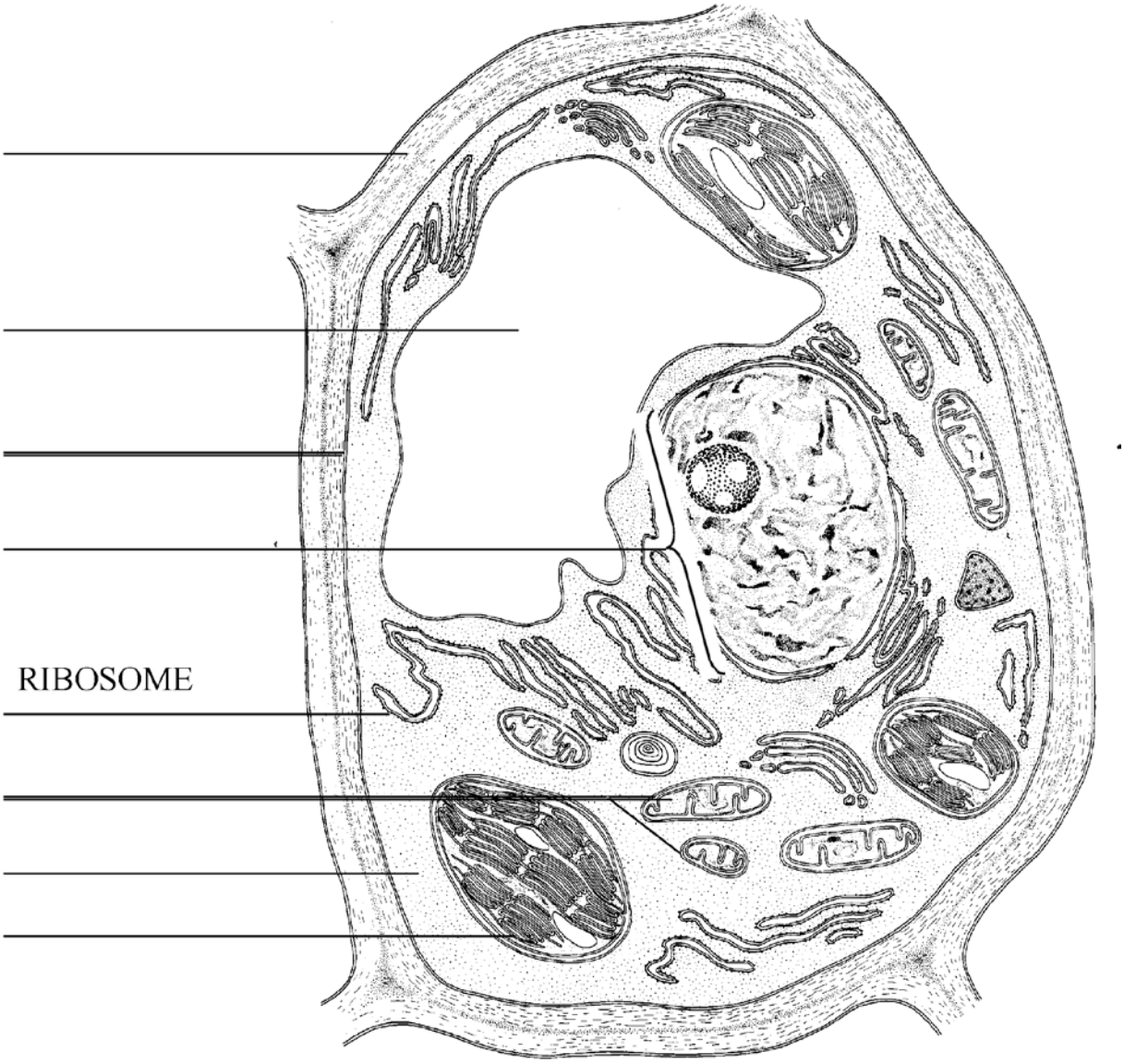
Animal Cell:

Using your book and lecture notes, label the plasma membrane, nucleus (containing DNA), cytoplasm, and mitochondria. The ribosomes (labeled for you) in eukaryotic cells are larger than in prokaryotic cells.



Plant Cell:

Using your book and lecture notes, label the plasma membrane, nucleus (containing DNA), cytoplasm, central vacuole, mitochondria, cell wall, and chloroplast. The ribosomes are labeled for you.



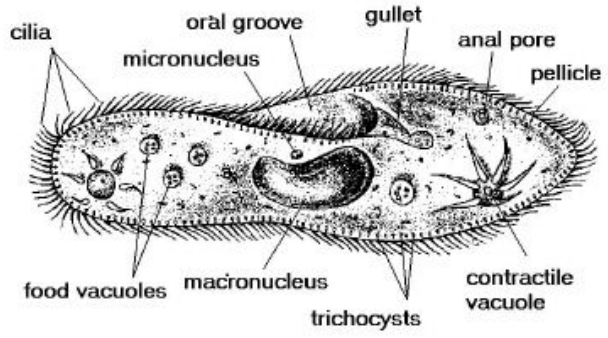
Name three structures or organelles found in this plant cell that do not occur in animal cells (refer to the animal cell diagram).

1. 3.
2.

Specialized Cells and Functions

In multicellular organisms, cells can become very specialized. For example, human red blood cells have no nucleus or DNA. They have developed an indentation in the middle which increases their surface area and their capacity to carry oxygen. In plants, some cells die at maturity to become hollow tubes that transport water and nutrients. Many plant root cells are specialized for food (starch) storage. As you previously observed, even among prokaryotic organisms a form of multicellularity and specialization may occur.

Compare prepared slides of *Paramecium*, *Amoeba* and human blood cells. If available, you will also be able to view members of the Kingdom Protists as live specimens and also view specialized plant cells; onion and potato cells. Make sure that you add a drop of methyl cellulose (Protoslo) to your live *Paramecium* slides. This will slow down their movement, making observations easier. Draw the cells and list observations on the hand-out sheet. Make certain that you can estimate cell sizes and include a scale bar. If you're not sure how to do this, ask your instructor.



Paramecium is a member of the Protist Kingdom. These are eukaryotic, single-celled organisms. Note that the structures are similar to those in animal cells. However, there is a special (contractile) vacuole. It expels excess water when the environment is **hypotonic** (has less dissolved ions) than the cell's cytoplasm.

1. Using this lab book and your text compare the two cell types in the following table.

	Prokaryotic cell	**Eukaryotic cell**
1. Type of Cell	Bacteria	*Paramecium*
2. Domain		
3. Kingdom	(Not Used)	
4. Location of DNA (nucleus, etc)		
5. Presence of membrane-bound organelles?		
6. Presence of ribosomes?		
7. Presence of cell wall?		

Summary questions:

1. Name one structure found in plant cells, but missing from animal cells.
2. What structure represents the major difference between eukaryotic and prokaryotic cells?
3. Are cyanobacteria autotrophic or heterotrophic?
4. Are cyanobacteria prokaryotes or eukaryotes?
5. Why do plants have a cell wall in addition to a plasma membrane?
6. How is the concave shape of red blood cells (erythrocytes) appropriate to their function?
7. What missing organelle allows red blood cells to achieve their concave shape?
8. What is the function of the contractile vacuole in *Paramecium*?