

Lab 3: Cells: Structure and Function

This lab is designed to give you an opportunity to see for yourself that organisms are, in fact, composed of cells. First, you will examine living plant and animal cells, plus some organisms that exist as single cells. Then, using prepared slides, you will see how specialized cells are organized into tissues and tissues into organs.

As you proceed with your investigation, consider the fact that you are a living organism, composed of the very things you are observing, i.e. you are literally 'cells looking at cells'.

Prokaryotic Cells

Cells, the smallest individual units of life, are divided into two basic categories: **prokaryotic** cells, and **eukaryotic** cells. The cheek cells that you looked at last week, and cells of every other organism except bacteria are eukaryotic. Only bacteria and cyanobacteria (also called blue-green algae) have prokaryotic cells.

Prokaryotic cells differ from eukaryotic cells in that **they lack a membrane-bound nucleus and organelles**. Prokaryotic cells are simpler in structure and are thought to have evolved before eukaryotic cells. However, both prokaryotic and eukaryotic cells share many similarities. Both have a cell membrane, cytoplasm, DNA, ribosomes, and similar enzyme systems. And, like plants and fungi, many prokaryotes also have a cell wall. Prokaryotic cells are much smaller than eukaryotic cells, and thus require higher magnification to see (about 1000X). Because of this, there are no prokaryotic cells on display in the lab, though you can be sure that there are millions of prokaryotic cells in the room with us. You should consult the text and lecture notes for information on prokaryotic cells beyond that presented below.

Bacteria

Bacteria can be classified by shape into several groups, three of which are: **cocci** (spherical bacteria); **bacilli** (rod-shaped bacteria); and **spirilla** (corkscrew-shaped bacteria). Additionally, cocci and bacilli can be classified by the structure of their cell wall. Bacteria that have a thick layer of a substance called "peptidoglycan" in their cell wall will pick up a crystal violet (Gram) stain and are thus called "**Gram-positive**" bacteria. These bacteria appear dark blue or purple under the light microscope because the peptidoglycan traps a violet stain. Gram negative bacteria have a much thinner peptidoglycan layer that is surrounded by an outer membrane and, in some, a gelatinous protective capsule. Thus, the violet stain washes off, and only a second red stain is retained. These bacteria appear pink or red under a microscope. Many gram negative bacteria are serious pathogens (disease-causing organisms) because the complex cell wall, which resists the violet stain, also interferes with a host's immune response and the effect of antibiotics.

Cyanobacteria

Cyanobacteria (blue-green algae) are prokaryotic cells, often living in aggregated colonies, that perform photosynthesis to obtain energy in fundamentally the same way that chloroplasts (the photosynthetic organelles in plants) do. The photosynthetic pigment, chlorophyll *a*, is contained in organized membranous systems called thylakoids.

Eukaryotic Cells

Eukaryotic cells have a membrane-bound nucleus and organelles. Today we will look at three examples of eukaryotic cells with the microscope: human cheek cells, plant cells, and unicellular organisms in pond water. However, first you should use the diagrams provided and the descriptions below to become familiar with cell structure prior to looking at cells with the microscope.

Cell Membrane

The cell membrane surrounds each cell and regulates which materials enter and leave the cell. It consists of a double layer of phospholipid molecules, and may appear as a thin double line on electron micrographs. (In addition to the cell membrane, some eukaryotic cells, such as plant cells, also have a rigid cell wall surrounding the cell membrane. This serves a structural function.

Nucleus

The nucleus is a membrane-bound structure that contains the genetic material (deoxyribonucleic acid, or DNA) of eukaryotic cells. Also present in the nucleus are one or more **nucleoli** (singular, nucleolus) which are where the molecular components of ribosomes are manufactured. These components are transported across nuclear membrane and the ribosomes are assembled in the cytoplasm.

Ribosomes

Ribosomes are the sites of protein synthesis in both prokaryotic and eukaryotic cells. They are sometimes free in the interior of the cell, but most are bound to internal cellular membranes. The membrane most commonly bound to ribosomes is called the **endoplasmic reticulum**. Areas of the endoplasmic reticulum that have many associated ribosomes are called “rough” endoplasmic reticulum. Smooth endoplasmic reticulum lacks attached ribosomes. The vesicles formed by the endoplasmic reticulum contain enzymes and other proteins produced by the ribosomes. The endoplasmic reticulum then transports the proteins to another structure, the Golgi Apparatus.

Golgi Apparatus

The Golgi apparatus (or complex) is also a system of membranes that form small vesicles or cisternae. It is in these vesicles that the proteins are modified and transported.

Vacuoles

Some organelles consist of little more than a membranous sac. These are vacuoles. In plant cells, vacuoles are numerous, and occupy most of the cell's interior. In plants, vacuoles contain water, sugars, and salts, and serve as storage sites as well as structural functions. In animal cells, vacuoles carry waste and food molecules, as well as other macromolecules and water.

Chloroplasts

The organelles that perform photosynthesis in plants are called chloroplasts. Chloroplasts take the energy from the sun and store it in organic molecules (carbohydrates) with the help of a pigment called chlorophyll. The chlorophyll is found in membranous thylakoids (remember the cyanobacteria?) inside each chloroplast.

Mitochondria

Although animals lack chloroplasts, both animals and plants have mitochondria. Mitochondria are the organelles that use the carbohydrates (produced during photosynthesis, and ingested by the animals) to release energy.

Cytoplasm

The cytoplasm of the cell is everything enclosed by the cell membrane, except the nucleus. The fluid portion of the cytoplasm (everything outside of the membrane bounded organelles) is called the **cytosol**. The cytosol contains different types of fibers called the **cytoskeleton**. The cytoskeleton contributes to the cell's shape, helps to move the organelles around within the cytoplasm (this movement is called cytoplasmic streaming, or cyclosis), and plays an important role during cell division.

Animal Cells: Human Cheek Cells

Prepare a wet mount of your cheek cells using the same technique you used last week. Observe the stained cells under high power. Find the nucleus, cytoplasm, and location of the cell membrane. Can you see any other organelles? If so, what might they be?

Draw a well-labeled diagram of the cheek cells on the paper provided. Be sure to provide the magnification, and estimate the size of the cells, and the size of the nucleus.

Plant Cells: *Elodea* Cells

Now you will examine a typical plant cell, from the leaf of the aquatic plant *Elodea*.

1. Gently remove one leaf from near the tip of an *Elodea* stalk.
2. Place the leaf on a clean slide, and add a drop of water and a coverslip.
3. Return to your microscope and examine the leaf tip under low power.


Once you have centered the tip of the leaf in the field of view under low power, switch to the next highest power objective.

How do the cells of the plant differ from the human cheek cells? Try to find the **cell wall** (a rigid structure that surrounds the cell and encloses the cell membrane), and the **chloroplasts** (organelles that contain the green pigment, chlorophyll, and perform photosynthesis).


Are the chloroplasts moving? If not, move towards the center of the leaf and watch for movement of the chloroplasts (you may have to focus up and down through the leaf until you find some moving chloroplasts....remember that the leaf is 3-dimensional and the microscope has a limited depth of focus).

If you can find some chloroplasts that are moving, what you are seeing is an example of cytoplasmic streaming (also called cyclosis). **Cytoplasmic streaming** is the movement of cytoplasm from one part of the cell to another part of the same cell. It serves to transport different molecules to all parts of the cell, maintain optimal light and temperature conditions, and (in some cases, although not in plants) cytoplasmic streaming serves to help the cell move. All cells exhibit cytoplasmic streaming.

Note that the chloroplasts are moving around the outside of the cell, instead of moving around near the interior. This is because most plant cells have a large central **vacuole** filled mainly with water. You will probably not be able to see this vacuole directly, but you can infer its existence by noting the position of the chloroplasts. Additionally, because of the central vacuole, the nucleus of plant cells is not located in the approximate center of the cell, as it was in your cheek cells. Although you may not be able to see the nucleus either (because it requires staining to see easily) you might be able to find its location by noting an area in the cell where the moving chloroplasts seem to slide over an invisible “bump” next to the cell wall.

 **Draw the cell(s) you see on the paper provided.** Be sure to label the area of the central vacuole, the chloroplasts, the cell membrane, cell wall, and the area where the nucleus lies (if you can find it). Additionally, include the magnification you used, and estimate the size of the plant cells (both length and width), as well as the size of the central vacuole and chloroplasts.

Like cheek cells, plant cells are also bound by a cell membrane. In normal plant cells, this membrane is pressed tightly against the inside of the cell wall (because of the pressure from the water in the central vacuole), and is impossible to pick out. However, if we can cause water to move out of the central vacuole, the volume inside the cell will decrease and the cell membrane will pull away from the cell wall. Let’s try it.

 Take your slide and put a drop of 10% saline solution (salt water) on the edge of the coverslip just like you did with the stain and your cheek cells. Now, like before, pull the saline solution under the coverslip with a piece of Kimwipe. Return to your microscope and examine the slide under 100X.

✎ Where are the chloroplasts located?

✎ What do you think has happened? Can you hypothesize about what has caused the change in appearance?

Adjust the aperture disk until you get an excellent image. Can you see the cell membrane (plasma membrane), or infer its presence from the distribution of the chloroplasts?

✎ ***Draw and label your observation of Elodea cells in 10% saline solution.*** Be sure to include the magnification, and the approximate sizes of the cells, the central vacuole, and the chloroplasts.

Single-Celled Organisms: Pond Water

Now that you have seen examples of eukaryotic cells from multicellular organisms, we will look at examples of organisms that are composed of single eukaryotic cells (i.e. single-celled eukaryotic organisms).

Make a wet mount of pond water, using a drop or two of water from near the bottom of the dish (be sure to get some “gunk” from the bottom....you will then have plenty to see). Before adding the cover slip, add a drop of methylcellulose (Proto-slow) to your slide. This is a syrupy liquid that will slow the organisms down enough for you to be able to observe them more easily.

Return to your microscope, and examine your pond water under low power. Scan all over the slide, especially near the edges of the coverslip and near any debris that you may have included. Be patient. There are undoubtedly several organisms on your slide, if you take the care and time to look for them. Although you will not be tested on names, try to identify as many of the organisms as you can. Use the figures provided to help you. Many of the organisms that you see moving in the water do so by flicking a long whip-like structure called a flagellum. Other organisms use hundreds of cilia. Although shorter and more numerous, cilia are identical to flagella when viewed under an electron microscope. Cilia work in synchrony and produce smooth movement through the water.

✎ Once you have found an interesting organism, switch to high power. ***Draw what you see in the space provided.*** Be sure to include the magnification and an estimate of the organism’s size.

Tissues: Examination of Mammalian Intestine

One common method of observing tissues and cells is by preparing very thin slices, called sections, such that light can pass through. As an example of the organization of cells into tissues, you will examine a cross-section of mammalian intestine. The intestine is part of the **alimentary canal** (alimentary or digestive system) which functions in the processing of food material from ingestion (eating) to egestion (defecating). You will learn more about the alimentary system later.

Obtain a slide labeled “mammalian intestine”. Use Figure 1 as a guide to help you find the structures described below. Note that the section of intestine on the slide looks like a washer. Because the intestine is tubular in shape, a cross-section (i.e. a section resulting from passing a plane perpendicular to the long axis) is in the form of a circle.

Examine the section under low power and notice the **staining reaction** of the various cells. The nuclei are clearly differentiated from the cytoplasm (nuclei are purple, cytoplasm pink). In addition to differentiation of the nuclei and cytoplasm, note that several different types of cells can be identified on the basis of overall size and shape, nuclear size and shape, position relative to one another, and differences in staining reaction.

The “hole” in the center of the tissues is the **lumen** of the intestine. Digested and undigested material is passed from the stomach into this region and the products of digestion are absorbed (e.g. simple sugars, amino acids, etc.). Because the alimentary canal is a tube passing through the body from the mouth to the anus, the lumen is a space continuous with the external environment.

Now, see if you can identify the various layers (tissues). Begin with the layer of cells that lines the lumen, and work your way toward the outside.

Mucosa - the innermost layer of the intestine is the mucosa. It consists of columnar **epithelial cells** lining the lumen. Epithelial cells typically form sheets lining or covering various surfaces (your cheek cells were epithelial cells). The epithelium lining and the lumen of the intestine is organized into many fingerlike projections called **villi** (singular, villus). The villi provide a much larger surface for absorption and secretion than would a simple flat sheet of cells three regions. Below the epithelial cells lies connective tissue and muscle tissue – all part of the mucosa.

Submucosa - Surrounding the mucosa is a layer of connective tissue, the submucosa, containing blood and lymph vessels, and nerve cells (not easily identified). Nervous tissue is involved with the conduction of information (more later).

Muscularis - a double layer of smooth muscle that surrounds the submucosa. The inner layer is circular in orientation (running around the intestine) and thus the cells appear spindle-shaped with elongated nuclei. The outer layer runs longitudinally along the intestine and thus the cells appear round with round or elliptical nuclei. These two layers are collectively called the muscularis and are responsible for the peristaltic muscle contractions of the intestine.

Serosa - The outermost layer of the intestine is the serosa. It is composed of connective tissue and squamous (flat) epithelium. The serosa secretes a small amount of **serous fluid** that lubricates the surface of the viscera, reducing friction the organs rub against one another.

Draw and label your observation of the mammalian intestine in the space provided below.

Stained human cheek cells

Elodea cells in fresh water

Elodea cells in salt water

pond water organisms