Cells and Cell Structure

All organisms are composed of units called **cells**, which are, with few exceptions, such as the yolk of the ostrich egg, too small to be seen with the unaided human eye. Some organisms are composed of just one cell. This one cell must be able to do all of the functions characteristically performed by living organisms. In contrast, most multicellular organisms are composed of a variety of specialized groups of cells called “tissues” which form tissue systems and organs, each of which does specialized functions for the organism as a whole.

You will observe cells from a number of different organisms to get a glimpse at the variety of cell types and structures that exist in our living world. Although we will focus on cells from eukaryotic organisms, we will also observe some prokaryotic organisms for comparison.

**Materials Required**

From the Room Stock Supplies
- Immersion oil
- Flat toothpicks
- Forceps
- Clean microscope slides
- Coverslips
- Lens paper
- Probes (dissecting needles)
- Sharp single-edge razor blades
- Pipettes

Available From The Lab Cart
- Onion bulb
- Potato tuber
- Egg
- Pear
- Red Pepper
- *Tradescantia* flower stamen hairs
- *Vallisneria* plants
- Volvox colonies
- *Azolla* plants
- *Oscillatoria* culture
- Pond Water

For Each Lab Table:
- Dropper bottles of:
  - Iodine stain
  - Dilute methylene blue stain
  - Distilled water
  - 10% Salt solution

For Each Student:
- Compound microscope

**Exercise I: Onion Epidermis Cells**

An onion bulb is composed of a series of fleshy, nutrient storing, modified leaves. The outer part of each leaf, composed of a single layer of cells, is the epidermis, whose function is protection.

1. Remove a piece of an onion leaf from a section of an onion bulb.
2. Snap the piece of onion leaf in half as shown in the diagram. The outer epidermis layer should be easy to separate from the rest of the leaf.

Preparation of Onion Epidermis Wet Mount
3. Place the epidermis layer flat on a slide. Wrinkles will trap air bubbles and obscure your observations.
4. Add a drop of iodine solution and a coverslip.
5. Observe your slide with your microscope, remembering to locate a good region of the epidermis with the scanning (4x) lens before observing details of cell structure with the higher magnifications. Your onion epidermis cells should resemble those of the photomicrograph below. Make a sketch of your onion cells.

![Onion Epidermis cells](image)

Identify the visible structures of the onion cells.

Why is the stain, iodine, useful? What are disadvantages of adding a stain to the slide preparation?

When you have completed your observations of the onion epidermis, thoroughly wash and dry your slide and coverslip for the next exercise. If you want to save the slide for later comparisons remember to allow time at the end of the laboratory to clean several slides.

**Exercise II: Human Cheek Cell Epithelium**
The epithelial tissue of animals is comparable in many respects to the protective epidermis tissue of plants. In this exercise you will have the opportunity to observe some cells of the epithelial layer which lines your cheek.

1. Gently scrape the inside of your cheek with the broad end of a toothpick. (You won’t need to puncture your cheek to obtain a good supply of cells.)
2. Smear your cheek scrapings on a clean slide. Wrap your toothpick in a dry paper towel and immediately dispose of it in the wastebasket.
3. Make a wet mount of your cheek cells by adding a drop of dilute methylene blue stain to the slide. If the stain is too intense you may have to add a drop of water as well.
4. Add a coverslip and observe the slide with the scanning lens and very low light intensity.
5. When you locate some cheek cells, center them in the field of view and rotate the low power (10x) into position. Re-focus and center your cheek cells and then view them with the high power (45x) objective lens. Your cheek cells under high power should resemble those in the photomicrograph below.
6. When you have completed your observation of your cheek cells, dispose of your slide and coverslip in the slide morgue provided.
Make a sketch your cheek cells.

Compare your cheek cells with the cells of the onion epidermis. What structures are visible in both cells?

What conspicuous cell structure of the onion epidermis cell is lacking in the cheek cell? Why do you think the cells of your cheek appear in loose clumps rather than in the regular rows of the onion?

What structure of the cheek cell absorbed the methylene blue stain most intensely?

**Exercise III: Egg Cells**

Egg cells contain many nutrients and have a large volume relative to most cells. Many are macroscopic. The egg you may have eaten for breakfast is one cell. The egg cell of the starfish (more properly called a sea star) has a very large nucleus, called the germinal vesicle. The nucleolus is also highly visible.

Obtain a prepared slide of a starfish egg and observe its nucleus and nucleolus. Do you see other structures within the cytoplasm? How does the starfish egg cell compare in size to your cheek cells?

Observe at the bird egg on display. The cytoplasmic disk, the clear area on the surface of the yolk, contains the nucleus and most organelles. They yolk is nutrient material. The egg cell is comprised of the yolk and cytoplasmic disk. The “white” of the egg is secreted exterior to the plasma membrane and also contains nutrients.
**Exercise IV: Support Tissue in Plants**
Organisms have a variety of ways to provide structural support. We are familiar with the exoskeletons of invertebrates, the internal bony skeleton of most vertebrates and hydrostatic skeletons of many invertebrates. Plants provide support for each cell with the cell wall; the collective walls provide the structural support for the plant. However, plants have a tissue specialized to provide strength and support: **sclerenchyma**. Sclerenchyma cells are characterized by having very thick secondary walls. The cells die at maturity, leaving a narrow lumen (the internal space that contained the cytoplasm during the cell development) surrounded by their thick walls. Woody plants have lots of sclerenchyma tissue, primarily in the conducting tissues of leaves, stems and roots. There are two types of sclerenchyma: elongated narrow diameter cells, called **fibers**, found throughout plants where ever support is needed, and **sclerids**, relatively short, often isodiametric sclerenchyma cells. Sclerids are common in seed coats and hard fruits.

**Sclerids in pear fruit tissue**
The gritty texture of pears results from sclerids. Make a wet mount of a small amount of pear tissue. Look for clusters of sclerids using low power. When a cluster is found, switch to high power to observe the sclerids in detail. Note the thick secondary walls for strength.

**Exercise V: Storage Cells**
**Human Adipose Tissue**
Humans can store a starch–like polysaccharide, glycogen, in the liver and in muscle tissue to provide short-term fuel storage (about 24 hours) but that is very limited. For our reserve fuel we store a type of fat, called adipose, in adipose tissue. We have long-term fuel storage for those times when our food supply does not meet our energy demands. On those occasions when we take in more calories than we need, our bodies automatically convert the surplus, no matter what the source, to adipose for storage.

Observe a prepared slide of adipose tissue. Can you see any fat droplets within the cells?
Storage Cells of the Potato Tuber
A tuber is an underground stem used for the storage of nutrients during plant dormancy. Dormancy, a period of greatly reduced metabolic activity, allows many plants to survive an unfavorable environmental period, such as winter’s cold temperatures or a desert drought. The nutrient reserve provides the energy for new growth when conditions for growth are favorable. Starch is the common nutrient stored by plants. In contrast humans store adipose, a type of fat, for our reserve fuel. (We also lack the ability to go into dormancy; we can't shut down our metabolism when we don’t like the winter weather and start over in the spring

1. Use a sharp razor blade to slice a very thin section from the potato tuber. Do not use the “skin” portion.
2. Make a wet mount of your section using a drop of water. If your coverslip is balancing precariously on the section rather than “floating” uniformly on the surface, your section is too thick.
3. Once you have your section focused clearly with the high power objective, use the fine adjustment knob to observe the internal structures of the fairly large, thin walled and loosely packed storage cells. The cells should be filled with several unpigmented egg-shaped structures. These are commonly called starch grains. Recall from your text and lecture that the plant organelles that store things are called plastids. The starch grain is an example of an unpigmented plastid. Plastids are typically named for what they store, so the starch grain is properly called an amyloplast. (A common form of starch is amylose, hence the name amyloplast.) Unpigmented plastids, as a category, are also known as leucoplasts.
4. Add a drop of iodine to the edge of the coverslip. What happens to the starch grains (amyloplasts) as they come into contact with the iodine?
5. Are there ways in which the starch storage cells of the potato resemble the adipose cells?

Exercise VI: Chromoplasts
Plants also store pigments in plastids. The yellow, orange and scarlet carotenoid pigments are found in chromoplasts.

1. Obtain a small piece of red pepper. Petals of bright gold or orange flowers, such as marigold flowers, are also excellent sources of chromoplasts.
2. Use a sharp razor blade to slice a very thin section of your carrot or pepper and make a wet mount of your section. If your coverslip is balancing precariously on the section rather than “floating” uniformly in a film of water, your section is too thick.
3. Once you have your section focused clearly with the high power objective, observe the internal structures of the cells. The cells should be filled with several tiny oval, gold-pigmented chromoplasts. You may have to adjust your light level to see them.

How do the chromoplasts compare to the amyloplasts you observed previously in the potato?
Exercise VII: Chloroplasts in Leaf Cells

The leaves of some aquatic plants and most mosses are just a few cells thick, so that an entire leaf can be observed with the microscope. In addition to seeing some of the larger organelles, many processes of the intact cell can readily be observed. We will try to observe two cell phenomena: cyclosis and plasmolysis, using an aquatic plant leaf.

1. Prepare a wet mount of a piece of a healthy *Vallisneria* leaf. Keep the aquatic plants in their water container. They dehydrate rapidly when removed from water. If no *Vallisneria* is available, you can try using a leaf from the aquatic fern, *Azolla* or a moss leaf.

2. Observe the leaf with your microscope. What structures can you identify once you have focused the leaf under high power magnification?

3. What are the oval, green-pigmented plastids that are abundant in each cell? What is the function of these organelles?

*Note:* *Azolla*, an aquatic fern, often has a cyanobacterium endosymbiont, *Nostoc*. You may be able to see this prokaryotic organism within the *Azolla* leaf cells, too.

Azolla plant (Note O₂ being released)

Vallisneria

Cyclosis In Leaf Cells

As the your leaf preparation becomes exposed to the light and heat from the microscope light you should be able to observe the chloroplasts moving along the perimeter of cells. The internal movement of cytoplasm within the cell is called **cyclosis**. The contractile microfilaments of the cytoskeleton generate the movement that carries organelles and molecules throughout the cytoplasm. Cyclosis occurs in most cells, but is not always easy to see. Cyclosis is restricted to the perimeter of the leaf cells because the center of each cell contains the large central plant vacuole. Since the vacuole contains translucent fluids (mostly water), it can’t be seen.

You may also be able to observe cyclosis in the stamen hairs of *Tradescantia* flowers later in the laboratory (Exercise VII).
Plasmolysis of Leaf Cells
As you have read, a hypertonic environment, one that has a higher proportion of solutes than found inside a cell, will cause water to leave the cell. Salt water, for example, is hypertonic to the cells of many organisms. Cells of terrestrial or fresh-water organisms placed in sea water will lose water and shrivel, a phenomenon called plasmolysis. Any hypertonic solution will have a similar effect on cells. We can observe the phenomenon of plasmolysis with the Vallisneria leaves. (We can also observe plasmolysis with human cells, such as red blood cells, but it is easier to “sacrifice” a leaf than it is to get a fresh blood sample.)

Replace the tap water on your leaf slide with a 10% salt solution by placing a piece of paper towel on one side of the coverslip while adding a few drops of the salt solution to the opposite edge of the coverslip. The salt will be drawn under the coverslip as the water is wicked up by the paper towel. Repeat this 2 or 3 times.

What physical changes do you observe in the cells of your leaf? Why haven’t the cell walls collapsed? What role does the salt play in the physical changes you are observing?

Try to reverse the process of plasmolysis in the leaf cells by replacing the salt solution with distilled water. Did your leaf revive?

Make diagrams of several of your leaf cells below showing their appearance before and after plasmolysis occurred.

Elodea leaf in Water
Elodea leaf in 10% salt
Leaf at Turgor Plasmolyzed Leaf
**Exercise VIII: Cyclosis in *Tradescantia* Stamen Hairs**

Stamen hairs of the *Tradescantia* flower are ideal for observing cyclosis. The stamen is the male reproductive structure of a flower, consisting of an anther, usually bright yellow, which contains pollen, and a thread-like stalk, the filament. The purple filaments of the *Tradescantia* stamens are covered with many hairs. The hairs are chains of single cells that are purple in color and contain a large water-filled central plant vacuole. The cytoplasm and its contents are concentrated near the perimeter of the cells. A short video clip of cyclosis in *Tradescantia* stamen hairs is also available. Ask your instructor.

1. Using fine forceps, remove 1 or 2 hairs from a stamen filament of a *Tradescantia* flower.
2. Make a wet mount of your stamen hair. Using very low light locate the hair with low power magnification and then focus with high power. The hair should resemble a chain of lavender pearls. The anthocyanin pigments that are responsible for the purple color are water soluble. They are stored in the central plant vacuole. The entire cell looks purple because the vacuole occupies as much as 90% of the cell’s volume.
3. Look for cyclosis. You should see thread-like “rivers” moving along what appears to be the surface of each cell.
4. If you have been fortunate enough to observe cyclosis, carefully switch to the oil immersion lens, using the procedure outlined in the microscope laboratory exercise. Some of the granular specks now visible with the oil immersion magnification are mitochondria, the organelles in which aerobic cell respiration occurs. The mitochondria are carried along with the cytoplasmic stream. If you rotate the fine adjustment knob you will also be able to see the many striations in the cell wall of the *Tradescantia* stamen hair cells.
5. When you have completed your observations clean the objective lenses, slide, coverslip and microscope stage with lens paper to be sure that all traces of immersion oil have been removed. You may need to use a drop of xylene (an organic solvent) on the lens paper.

![Tradescantia Stamen Hair](image)

**Exercise IX: Protists – “Single-celled” Organisms**

1. Make a wet mount using 1 or 2 drops from the pond water available or from culture jars of assorted protists. Add the coverslip carefully.
2. Locate an organism with the scanning objective. You may need to search the area under the coverslip thoroughly using low light intensity. These are motile organisms and move rapidly through the field of view. While most of the organisms you will see are single-celled protists, there may be some small multicellular plants or animals in the cultures, as well as some colonial protists.
3. Don’t worry about identifying the individual organisms. Delight in the diversity of life you are viewing through the microscope!
**Volvox**
Now make a wet mount of Volvox. Volvox is a spherical motile colonial green alga comprised of more than 100 cells, each cytoplasmically connected to adjacent cells in the colony. Daughter colonies form in the interior of the sphere. The daughter colonies are a form of asexual reproduction. Some references classify green algae in the Plant Kingdom; others in the Protist Kingdom.

![Volvox Colonies](image)

**Exercise X: Prokaryotic Cell Structure**
As you recall, the prokaryotic cell has no internal membrane-bounded structures. Its DNA is not contained within a nucleus. The most abundant prokaryotes, the bacteria, are among the tiniest of living organisms. Without the use of oil immersion magnification they appear as tiny spots under the microscope.

**Bacteria Cells**
1. Obtain a prepared slide of *Bacillus megatherium* or other bacterium from the side table or lab cart.
2. After focusing and centering the slide at low and high power, switch to the oil immersion lens. (Follow the oil immersion procedure previously learned).

How does the appearance of the bacterial cell compare with the eukaryotic cells observed previously? What is the shape of the *Bacillus* cells? Do you see any organelles?

When you have completed your observations, carefully remove all traces of oil from the slide and the microscope. Use xylene if needed to clean the slide.

![Bacillus bacteria (Compound Microscope)](image) ![Electron Micrograph of Bacterium](image)
**Oscillatoria – A Cyanobacterium**

The cyanobacteria are photosynthetic prokaryotes. In contrast to the “true” bacteria, they have photosynthetic pigments located on a series of thylakoid membranes that are dispersed throughout the cytoplasm of the cell. Cyanobacteria may be unicellular, colonial or filamentous. They secrete a slime sheath that helps cells adhere to each other. *Oscillatoria* is a filamentous cyanobacterium. *Oscillatoria* exhibits a nearly unique form of movement, called Oscillatorian movement.

1. Make a wet mount of a portion of *Oscillatoria*. You may need to use a probe to transfer a portion of the *Oscillatoria* culture to your slide.
2. After locating and focusing under lower magnifications, observe your strands of *Oscillatoria* under high power. Locate in particular tips of filaments. As you watch, you may see what appears to be “spontaneous” floating movement of some of the filaments. This is the Oscillatorian movement.

How does the size of *Oscillatoria* cells compare to the size of the *Bacillus* cells that you previously observed? How does its cell size compare to the eukaryotic cells observed in this laboratory?

Many cyanobacteria fix nitrogen and are important endosymbionts and root associates for higher plants, providing a source of nitrogen for plant growth. In the Pacific Northwest, Alder trees have cyanobacteria associates. The *Azolla* fern that you may have observed earlier also has cyanobacteria endosymbionts.

When all of the exercises have been completed, clean your microscope and return it to its location in the cabinet, with the scanning objective in position and the cord safely tucked in.

Return all of your clean slides and coverslips to the appropriate boxes and clean your lab area. Be sure that no tissue fragments, coverslips or lens paper have been inadvertently left in the sink.

In addition to your observations of cell structures, review the cell diagrams and models available as well as the electron micrographs in your textbook. You should be able to recognize all of the eukaryotic cell organelles and list the function(s) for each.