A View of the Cell

What You’ll Learn
- You will distinguish eukaryotic and prokaryotic cells.
- You will learn the structure and function of the plasma membrane.
- You will relate the structure of cell parts to their functions.

Why It’s Important
A knowledge of cell structure and function is essential to a basic understanding of life.

Reading Biology
Go through the chapter, and note the figures that depict different types of cell structures. For each figure, note the various components of the cell. As you read the text, write the characteristics of each cell type by its name.

Biology Online
To find out more about cells, visit the Glencoe Science Web site. science.glencoe.com

Click Here
Cells are amazingly diverse. Yet for all their diversity, cells such as this nerve cell and the protist Euglena share many common features.
The History of the Cell Theory

Before microscopes were invented, people believed that diseases were caused by curses and supernatural spirits. They had no idea that organisms such as bacteria existed. As scientists began using microscopes, they quickly realized they were entering a new world—one of microorganisms. Through a single-lens microscope, the Dutch scientist Anton van Leeuwenhoek in the mid-1600s was the first person to record looking at water under a microscope. He was amazed to find it full of living things.

Development of light microscopes

The microscope van Leeuwenhoek (LAY vun hook) used is considered a simple light microscope because it contained one lens and used natural light to view objects. Over the next 200 years, scientists greatly improved microscopes by grinding higher quality lenses and creating the compound light microscope. Compound light microscopes use a series of lenses to magnify objects in steps. These microscopes can magnify objects up to 1500 times. As the observations of plants and animals viewed under a microscope expanded, scientists began to draw conclusions about the organization of living matter. With the microscope established as a valid scientific tool, scientists had to learn the size relationship of magnified objects to their true size. Look at Focus on Microscopes to see what specimens look like at different magnifications.
The cell theory

Robert Hooke was an English scientist who lived at the same time as van Leeuwenhoek. Hooke used a compound light microscope to study cork, the dead cells of oak bark. In cork, Hooke observed small geometric shapes, like those shown in Figure 7.1. Hooke gave these box-shaped structures the name cells because they reminded him of the small rooms monks lived in at a monastery. Cells are the basic building blocks of all living things. Hooke published his drawings and descriptions, which encouraged other scientists to search for cells in the materials they were studying.

Several scientists extended Hooke’s observations and drew some important conclusions. In the 1830s, the German scientist Matthias Schleiden observed a variety of plants and concluded that all plants are composed of cells. Another German scientist, Theodore Schwann, Figure 7.1, made similar observations on animals. The observations and conclusions of these scientists are summarized as the cell theory, one of the fundamental ideas of modern biology.

The cell theory is made up of three main ideas:

1. **All organisms are composed of one or more cells.** An organism may be a single cell, such as the organisms van Leeuwenhoek saw in water. Others, like most of the plants and animals with which you are most familiar, are multicellular, or made up of many cells.

2. **The cell is the basic unit of organization of organisms.** Although organisms can become very large and complex, such as humans, dogs, and trees, the cell remains the simplest, most basic component of any organism.

3. **All cells come from preexisting cells.** Before the cell theory, no one knew how cells were formed, where they came from, or what determined the type of cell they became. The cell theory states that a cell divides to form two identical cells.

Development of electron microscopes

The microscopes we have discussed so far use a light source and can magnify an object up to about 1500 times its actual size. Although light microscopes continue to be valuable tools, scientists knew another world existed within a cell that they could not yet see. In the 1940s a new type of microscope, the electron microscope, was invented. This microscope uses a beam of electrons instead of natural light to magnify structures up to 500,000 times their actual size, allowing scientists to see structures within a cell.

There are two basic types of electron microscopes. Scientists commonly use the scanning electron microscope (SEM) to scan the surfaces of cells to learn their three-dimensional shape. The transmission
Measuring Objects Under a Microscope

Knowing the diameter of the circle of light you see when looking through a microscope allows you to measure the size of objects that are being viewed. For most microscopes, the diameter of the circle of light is 1.5 mm, or 1500 µm (micrometers), under low power and 0.375 mm, or 375 µm, under high power.

Refer to Practicing Scientific Methods in the Skill Handbook if you need help with SI units.

Procedure

1. Look at diagram A that shows an object viewed under low power. Knowing the circle diameter to be 1500 µm, the estimated length of object (a) is 400 µm. What is the estimated length of object (b)?

2. Look at diagram B that shows an object viewed under high power. Knowing the circle diameter to be 375 µm, the estimated length of object (c) is 100 µm. What is the estimated length of object (d)?

3. Prepare a wet mount of a strand of your hair. Your teacher can help with this procedure. CAUTION: Use caution when handling microscopes and glass slides. Measure the width of your hair strand while viewing it under low and then high power.

Analysis

1. An object can be magnified 100, 200, or 1000 times when viewed under a microscope. Does the object’s actual size change with each magnification? Explain.

2. Do your observations of the size of your hair strand under low and high power support the answer to question 1? If not, offer a possible explanation why.

Two Basic Cell Types

With the invention of light microscopes, scientists noticed that cells could be divided into two broad groups: those with internal, membrane-bound structures and those without. Cells lacking internal membrane-bound structures are called prokaryotic (proh KER ee oh tik) cells. The cells of most unicellular organisms such as bacteria do not have membrane-bound structures and are therefore called prokaryotes.

Cells of the basic second type, those containing membrane-bound structures, are called eukaryotic (yew KER ee oh tik) cells. Most of the multicellular plants and animals we know have cells containing membrane-bound structures and are therefore called eukaryotes. It is important to note, however, that some eukaryotes, such as some algae and yeast, are unicellular organisms.

The membrane-bound structures within eukaryotic cells are called organelles. Each organelle has a specific function for cell survival.
The invention and development of the light microscope some 300 years ago allowed scientists to see cells for the first time. Improvements have vastly increased the range of visibility of microscopes. Today researchers can use these powerful tools to study cells at the molecular level.

**FOCUS ON**

**Microscopes**

**THIS HISTORIC MICROSCOPE,** housed in a gold-embossed leather case, was designed by English scientist Robert Hooke about 1665. Using it, he observed and made drawings of cork cells. Although the microscope has three lenses, they are of poor quality and Hooke could see little detail.

**THIS EARLY COMPOUND MICROSCOPE,** held by a modern researcher—was designed by Anton van Leeuwenhoek (above). By 1700, Dutch scientist Leeuwenhoek had greatly improved the accuracy of microscopes. Grinding the lenses himself, Leeuwenhoek built some 240 single-lens versions. He discovered—and described for the first time—red blood cells and bacteria, taken from scrapings from his teeth. By 1900, problems with lenses that had once limited image quality had been overcome, and the compound microscope had evolved essentially into its present form.
HOW IT WORKS  The magnifying power of a microscope is determined by multiplying the magnification of the eyepiece and the objective lens.

A **COMPOUND LIGHT MICROSCOPE** (above) uses two or more glass lenses to magnify objects. Light microscopes are used to look at living cells, such as red blood cells (top), small organisms, and preserved cells. Compound light microscopes can magnify up to about 1500 times.

**SCANNING ELECTRON MICROSCOPE**

An SEM sweeps a beam of electrons over the surface of a specimen, such as red blood cells (above), causing electrons to be emitted from the specimen. SEMs produce a realistic, three-dimensional picture—but only the surface of an object can be observed. An SEM can magnify about 60,000 times without losing clarity.

**TRANSMISSION ELECTRON MICROSCOPE**

A TEM aims a beam of electrons through a specimen. Denser portions of an object allow fewer electrons to pass through. These denser areas appear darker in the image. Two-dimensional TEM images are used to study details of cells such as these red blood cells (above). A TEM can magnify hundreds of thousands of times.

**EXPANDING Your View**

1 **THINKING CRITICALLY** Can live specimens be examined with an electron microscope? Explain. Consider how the specimen must be prepared for viewing.

2 **COMPARING AND CONTRASTING** Compare the images seen with an SEM and with a TEM.
Robert Brown, a Scottish scientist, first observed a prominent structure in cells that Rudolf Virchow later concluded was the structure responsible for cell division. We now know this structure as the **nucleus**, the central membrane-bound organelle that manages cellular functions.

**Figure 7.2**
Bacteria and archaeabacteria are prokaryotes. All other organisms are eukaryotes.

**A** A Prokaryotic cell does not have internal organelles surrounded by a membrane. Most of a prokaryote’s metabolic functions take place in the cytoplasm.

**B** This eukaryotic cell from an animal has distinct membrane-bound organelles that allow different parts of the cell to perform different functions.

**Word**

**Origin**

**organelle**

From the Greek words *organon*, meaning “tool” or “implement” and *ella*, meaning “small.” Organelles are small, membrane-bound structures in cells.

Compare the prokaryotic and eukaryotic cells in **Figure 7.2**. Separation of organelles into distinct compartments benefits the eukaryotic cell. One benefit is that chemical reactions that would normally not occur in the same area of the cell can now be carried out at the same time.

**Section Assessment**

**Understanding Main Ideas**

1. Why was the development of microscopes necessary for the study of cells?
2. How does the cell theory describe the organization of living organisms?
3. Compare the light sources of light microscopes and electron microscopes.
4. How are prokaryotic and eukaryotic cells different?

**Thinking Critically**

5. Suppose you discovered a new type of fern. Applying the cell theory, what can you say for certain about this organism?

**Skill Review**

6. Care and Use of a Microscope Most compound light microscopes have four objective lenses with magnifications of 4×, 10×, 40×, and 100×. What magnifications are available if the eyepiece magnifies 15 times? For more help, refer to Practicing Scientific Methods in the Skill Handbook.
**Section 7.2 The Plasma Membrane**

**Maintaining a Balance**

You are comfortable in your house largely because the thermostat maintains the temperature within a limited range regardless of what’s happening outside. Similarly, all living cells must maintain a balance regardless of internal and external conditions. Survival depends on the cell’s ability to maintain the proper conditions within itself.

**Why cells must control materials**

Your cells need nutrients such as glucose, amino acids, and lipids to function. It is the job of the plasma membrane, the boundary between the cell and its environment, to allow a steady supply of these nutrients to come into the cell no matter what the external conditions are. However, too much of any of these nutrients or other substances, especially ions, can be harmful to the cell. If levels become too high, the plasma membrane removes the excess. The plasma membrane also allows waste and other products to leave the cell. This process of maintaining the cell’s environment is called **homeostasis**.

How does the plasma membrane maintain homeostasis? One mechanism is **selective permeability**, a process in which the plasma membrane of a cell allows some molecules into the cell while keeping others out. Thinking back to your home, a screen in a window can perform selective permeability in a similar way. When you open the window, the screen lets fresh air inside and keeps...
most insects out. Some molecules, such as water, freely enter the cell through the plasma membrane, as shown in Figure 7.3. Other particles, such as sodium and calcium ions, must be allowed into the cell only at certain times, in certain amounts, and through certain channels. The plasma membrane must be selective in allowing these ions to enter. Use the Problem-Solving Lab here to evaluate the plasma membrane of a yeast cell.

Structure of the Plasma Membrane

Now that you understand the basic function of the plasma membrane, you can study its structure. Recall that lipids are insoluble molecules that are the primary components of cellular membranes. The plasma membrane is composed of a phospholipid bilayer, which is two layers of phospholipid back-to-back. Phospholipids are lipids with a phosphate group attached to them. The lipids in a plasma membrane have a glycerol backbone, two fatty acid chains, and a phosphate group.
The addition of the phosphate group does more than change the name of the lipid. The phosphate group is critical for the formation and function of the plasma membrane. Figure 7.4 illustrates phospholipids and their place within the structure of the plasma membrane. The two fatty acid tails of the phospholipids are nonpolar, whereas the head of the phosphate molecule is polar.

Water is a key component of living organisms, both inside and outside the cell. The polar phosphate group allows the cell membrane to interact with its watery environment because, as you recall, water is also polar. The fatty acid tails, on the other hand, avoid water. The two layers of phospholipid molecules make a sandwich with the fatty acid tails forming the interior of the membrane and the phospholipid heads facing the watery environment outside the cell. When many phospholipid molecules come together in this manner, a barrier is created that is water-soluble at its outer surfaces and water-insoluble in the middle. Water-soluble molecules will not easily move through the membrane because they are stopped by this water-insoluble layer.
This model of the plasma membrane is called the **fluid mosaic model**. It is fluid because the membrane is flexible. The phospholipids move within the membrane just as water molecules move with the currents in a lake. At the same time, proteins embedded in the membrane also move among the phospholipids like boats with their decks above water and hulls below water. These proteins create a “mosaic,” or pattern, on the membrane surface.

**Other components of the plasma membrane**

Cholesterol, shown in **Figure 7.5**, is also found in the plasma membrane where it helps stabilize the phospholipids. Cholesterol is a common topic in health issues today because high levels are associated with reduced blood flow in blood vessels. Yet, for all the emphasis on cholesterol-free foods, it is important to recognize that cholesterol plays a critical role in the stability of the plasma membrane. Cholesterol prevents the fatty acid chains of the phospholipids from sticking together.

You’ve learned that proteins are found within the lipid membrane. Some proteins span the entire membrane, creating the selectively permeable membrane that regulates which molecules enter and which molecules leave a cell. These proteins are called **transport proteins**. **Transport proteins** allow needed substances or waste materials to move through the plasma membrane. Other proteins and carbohydrates that stick out from the cell surface help cells identify each other. As you will discover later, these characteristics are important in protecting your cells from infection. Proteins at the inner surface of a plasma membrane play an important role in attaching the plasma membrane to the cell’s internal support structure, giving the cell its flexibility.

**Understanding Main Ideas**

1. How is the plasma membrane a bilayer structure?
2. Explain how selective permeability maintains homeostasis within the cell.
3. What are the components of the phospholipid bilayer, and how are they organized to form the plasma membrane?
4. Why is the plasma membrane referred to as a fluid mosaic?

**Thinking Critically**

5. Suggest what might happen if cells grow and reproduce in an environment where no cholesterol is available.

**Skill Review**

6. **Recognizing Cause and Effect** Consider that plasma membranes allow materials to pass through them. Explain how this property contributes to homeostasis. For more help, refer to **Thinking Critically** in the **Skill Handbook**.
When you work on a group project, each person has his or her own skills and talents that add a particular value to the group’s work. In the same way, each component of a eukaryotic cell has a specific job, and all of the parts of the cell work together to help the cell survive.

Cellular Boundaries

When a group works together, someone on the team decides what resources are necessary for the project and provides these resources. In the cell, the plasma membrane, shown in Figure 7.6, performs this task by acting as a selectively permeable membrane. The fluid mosaic model describes the plasma membrane as a flexible boundary of a cell. However, plant cells, fungi, most bacteria, and some protists have an additional boundary. The cell wall is a fairly rigid structure located outside the plasma membrane that provides additional support and protection.
What organelle directs cell activity? Acetabularia, a type of marine alga, grows as single, large cells 2 to 5 cm in height. The nuclei of these cells are in the “feet.” Different species of these algae have different kinds of caps, some petal-like and others that look like umbrellas. If a cap is removed, it quickly grows back. If both cap and foot are removed from the cell of one species and a foot from another species is attached, a new cap will grow. This new cap will have a structure with characteristics of both species. If this new cap is removed, the cap that grows back will be like the cell that donated the nucleus.

The scientist who discovered these properties was Joachim Hämmerling. He wondered why the first cap that grew had characteristics of both species, yet the second cap was clearly like that of the cell that donated the nucleus.

Analysis
Look at the diagram below and interpret the data to explain the results.

Thinking Critically
Why is the final cap like that of the cell from which the nucleus was taken? (HINT: Recall the function of the nucleus.)

The cell wall
The cell wall forms an inflexible barrier that protects the cell and gives it support. Figure 7.7 shows a plant cell wall that is made up of a carbohydrate called cellulose. The fibers of cellulose form a thick mesh of fibers. This fibrous cell wall is very porous and allows molecules to pass through, but unlike the plasma membrane, it does not select which molecules can enter into the cell.

Nucleus and cell control
Just as every team needs a leader to direct activity, so the cell needs a leader to give directions. The nucleus is the leader of the eukaryotic cell because it contains the directions to make proteins. Every part of the cell depends on proteins to do its job, so by containing the blueprint to make proteins, the nucleus controls the activity of the organelles. Read the Problem-Solving Lab on this page and consider how the Acetabularia nucleus controls the cell.

The master set of directions for making proteins is contained in chromatin, which are strands of the genetic material, DNA. When the
cell divides, the chromatin condenses to form chromosomes. Within the nucleus is another organelle called the **nucleolus** that makes ribosomes. **Ribosomes** are the sites where the cell assembles enzymes and other proteins according to the directions of DNA. Unlike other organelles, ribosomes are not bound by a membrane within the cell. Look at some cells as described in the *MiniLab* shown here and try to identify the nucleus in cells of an onion.

For proteins to be made, ribosomes must move out of the nucleus and into the cytoplasm, and the blueprints contained in DNA must be copied and sent to the cytoplasm. **Cytoplasm** is the clear, gelatinous fluid inside a cell. As the ribosomes and the copied DNA are transported to the cytoplasm, they pass through the nuclear envelope—a structure that separates the nucleus from the cytoplasm as shown in *Figure 7.8*. The nuclear envelope is a double membrane made up of two phospholipid bilayers containing small nuclear pores for substances to pass through. Ribosomes and the DNA copy pass into the cytoplasm through the nuclear envelope.

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**MiniLab 7-2**

**Cell Organelles** Adding stains to cellular material helps you distinguish cell organelles.

**Procedure**

CAUTION: Be sure to wash hands before and after this experiment.

1. Prepare a water wet mount of onion skin. Do this by using your finger nail to peel off the inside of a layer of onion bulb. The layer must be almost transparent. Use the following diagram as a guide.

2. Make sure that the onion layer is lying flat on the glass slide and not folded.

3. Observe the onion cells under low- and high-power magnification. Identify as many organelles as possible.

4. Repeat steps 1 through 3, only this time use an iodine stain instead of water.

**Analysis**

1. What organelles were easily seen in the unstained onion cells? Cells stained with iodine?
2. How are stains useful for viewing cells?

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**Figure 7.8**
The transmission electron photomicrograph shows the nucleus of a eukaryotic cell. The large holes in the nuclear envelope are pores.
Assembly, Transport, and Storage

You have begun to follow the trail of protein production as directed by the cell manager—the nucleus. But what happens to the blueprints for proteins once they pass into the cytoplasm?

Structures for assembly and transport of proteins

The cytoplasm suspends the cell’s organelles. One particular organelle in a eukaryotic cell, the endoplasmic reticulum (ER), is the site of cellular chemical reactions. Figure 7.9 shows how the ER is a series of highly folded membranes suspended in the cytoplasm. The ER is basically a large workspace within the cell. Its folds are similar to the folds of an accordion in that if you spread the folds out it would take up tremendous space. But by pleating and folding it up, the accordion fits its surface area into a compact unit. So by folding the membrane over and over again, a large amount of membrane is available to do work.

Ribosomes in the cytoplasm attach to areas on the endoplasmic reticulum, called rough endoplasmic reticulum, where they carry out the function of protein synthesis. The ribosome’s only job is to make proteins. Each protein made in the rough ER has a particular function; it may become the protein that forms a part of the plasma membrane, the protein released from the cell, or the protein transported to other organelles. Ribosomes can also be found floating freely in the cytoplasm where they make proteins that perform tasks within the cytoplasm itself.

Areas of the ER that are not studied with ribosomes are known as smooth endoplasmic reticulum. The smooth ER is involved in numerous biochemical activities, including the production and storage of lipids.

After proteins are produced, they are transferred to another organelle called the Golgi apparatus (GAWL jee). The Golgi apparatus as shown in Figure 7.10 is a flattened system of tubular membranes that modifies the proteins. The Golgi apparatus and membrane-bound structures called vesicles sort the proteins into packages to be sent to the appropriate destination, like mail being sorted at the post office.
Vacuoles and storage

Now let’s look at some of the other members of the cell team important to the cell’s functioning. Cells have membrane-bound spaces, called vacuoles, for temporary storage of materials. A vacuole, like those in Figure 7.11, is a sac surrounded by a membrane. Vacuoles often store food, enzymes, and other materials needed by a cell, and some vacuoles store waste products. Notice the difference between vacuoles in plant and animal cells.

Lysosomes and recycling

Did anyone ever ask you to take out the trash? You probably didn’t consider that action as part of a team effort, but in a cell, it is. Lysosomes are organelles that contain digestive enzymes. They digest excess or worn out organelles, food particles, and engulfed viruses or bacteria. The membrane surrounding a lysosome prevents the digestive enzymes inside from destroying the cell. Lysosomes can fuse with vacuoles and dispense their enzymes into the vacuole,
digesting its contents. For example, when an amoeba engulfs a food morsel and encloses it in a vacuole, a lysosome fuses to the vacuole and releases its enzymes, which helps digest the food. Sometimes, lysosomes digest the cells that contain them. For example, when a tadpole develops into a frog, lysosomes within the cells of the tadpole’s tail cause its digestion. The molecules thus released are used to build different cells, perhaps in the newly formed legs of the adult frog.

Energy Transformers

Now that you know about a number of the cell parts and have learned what they do, it’s not difficult to imagine that each of these cell team members requires a lot of energy. Protein production, modification, transportation, digestion—all of these require energy. Two other organelles, chloroplasts and mitochondria, provide that energy.

**Chloroplasts and energy**

When you walk through a field or pick a vegetable from the garden, you may not think of the plants as energy generators. In fact, that is exactly what you see. Located in the cells of green plants and some protists, chloroplasts are the heart of the generator. Chloroplasts are cell organelles that capture light energy and produce food to store for a later time.

A chloroplast, like a nucleus, has a double membrane. A diagram and a TEM photomicrograph of a chloroplast with an outer membrane and a folded inner membrane system are shown in Figure 7.12. It is within these thylakoid membranes that the energy from sunlight is trapped. These inner membranes are arranged in stacks of membranous sacs called grana, which resemble stacks of coins. The fluid that surrounds the grana membranes is called stroma.

The chloroplast belongs to a group of plant organelles called plastids, which are used for storage. Some plastids store starches or lipids, whereas others contain pigments, molecules that give color. Plastids are named according to their color or the pigment they contain. Chloroplasts contain the green pigment chlorophyll. Chlorophyll traps light energy and gives leaves and stems their green color.
Mitochondria and energy

The food energy generated by chloroplasts is stored until it is broken down and released by mitochondria, shown in Figure 7.13. Mitochondria are membrane-bound organelles in plant and animal cells that transform energy for the cell. This energy is then stored in other molecules that allow the cell organelles to use the energy easily and quickly when it is needed.

A mitochondrion has an outer membrane and a highly folded inner membrane. As with chloroplasts, the folds of the inner membrane provide a large surface area that fits in a small space. Energy-storing molecules are produced on the inner folds. Mitochondria occur in varying numbers depending on the function of the cell. For example, liver cells may have up to 2500 mitochondria.

Although the process by which energy is produced and used in the cells is a technical concept to learn, the Literature Connection at the end of this chapter explains how cellular processes can also be inspiring. Look at the Inside Story on the next page to compare plant and animal cells. Notice how similar they are.

Structures for Support and Locomotion

Scientists once thought that cell organelles just floated in a sea of cytoplasm. More recently, cell biologists have discovered that cells have a support structure called the cytoskeleton within the cytoplasm. The cytoskeleton is composed of a variety of tiny rods and filaments that form a framework for the cell, like the skeleton that forms the framework for your body. However, unlike your bones, the cytoskeleton is a constantly changing structure.

Cellular support

The cytoskeleton is a network of thin, fibrous elements that acts as a sort of scaffold to provide support for organelles. It maintains cell shape similar to the way that poles maintain the shape of a tent. The cytoskeleton is composed of microtubules and microfilaments that are associated with cell shape and assist organelles in moving from place to place within the cell. Microtubules are thin, hollow cylinders made of protein. Microfilaments are thin, solid protein fibers.
Comparing Animal and Plant Cells

You can easily recognize that a person does not look like a flower and an ant does not resemble a tree. But at the cellular level under a microscope, the cells that make up all of the different animals and plants of the world are very much alike.

Critical Thinking Why are animal and plant cells similar?

Animal Cells The centriole is the only organelle unique to animal cells. Animal cells typically have many small vacuoles.

Plant Cells Plant cells, in general, are larger than animal cells and are characterized by a cell wall and chloroplasts. Plant cells usually have one large vacuole.
Cilia and flagella

Some cell surfaces have cilia and flagella, which are structures that aid in locomotion or feeding. Cilia and flagella are composed of pairs of microtubules, with a central pair surrounded by nine additional pairs, as shown in Figure 7.14. The entire structure is enclosed by the plasma membrane. The outer microtubules have a protein that allows a pair of microtubules to slide along an adjacent pair. This causes the cilium or flagellum to bend.

Cilia and flagella can be distinguished by their structure and by the nature of their action. Cilia are short, numerous, hairlike projections that move in a wavelike motion. Flagella are longer projections that move with a whiplike motion. In unicellular organisms, cilia and flagella are the major means of locomotion.

Section Assessment

Understanding Main Ideas

1. What is the advantage of highly folded membranes in a cell? Name an organelle that uses this strategy.
2. What organelles would be especially numerous in a cell that produces large amounts of a protein product?
3. Why are digestive enzymes in a cell enclosed in a membrane-bound organelle?
4. Why might a cell need a cell wall in addition to a plasma membrane?

Thinking Critically

5. How do your cells and the cells of other organisms that are not green plants obtain food energy from the chloroplasts of green plants?

6. Observing and Inferring Some cells have large numbers of mitochondria with many internal folds. Other cells have few mitochondria and, therefore, fewer internal folds. What can you conclude about the functions of these two types of cells? For more help, refer to Observing and Inferring in the Skill Handbook.
Are all cells alike in appearance, shape, and size? Do all cells have the same organelles present within their cell boundaries? One way to answer these questions is to observe a variety of cells using a light microscope.

**Problem**
Are all cells alike in appearance and size?

**Objectives**

*In this BioLab, you will:*

- **Observe**, diagram, and measure cells and their organelles.
- **Hypothesize** which cells are from prokaryotes, eukaryotes, unicellular organisms, and multicellular organisms.
- **List** the traits of plant and animal cells.

**Materials**
- microscope
- dropper
- glass slide
- coverslip
- water
- forceps
- prepared slides of *Bacillus subtilis*, frog blood, and *Elodea*

**Safety Precautions**
Always wear goggles in the lab.

**Skill Handbook**
Use the *Skill Handbook* if you need additional help with this lab.

**Preparation**

1. Copy the data table.
2. Examine a prepared slide of *Bacillus subtilis* using both low- and high-power magnification.

(Note: this slide has been stained. Its natural color is clear.)

**Procedure**

**Data Table**

<table>
<thead>
<tr>
<th></th>
<th><em>Bacillus subtilis</em></th>
<th><em>Elodea</em></th>
<th><em>Frog blood</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Organelles observed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prokaryote or eukaryote</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From a multicellular or unicellular organism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagram (with size in micrometers, µm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CAUTION: Use care when handling slides. Dispose of any broken glass in a container provided by your teacher.

3. Look for and record the names of any observed organelles. Hypothesize if these cells are prokaryotes or eukaryotes. Hypothesize if these cells are from a unicellular or multicellular organism. Record your findings in the table.

4. Diagram one cell as seen under high-power magnification.

5. While using high power, determine the length and width in micrometers of this cell. Refer to Practicing Scientific Methods in the Skill Handbook for help with determining magnification. Record your measurements on the diagram.

6. Prepare a wet mount of a single leaf from Elodea using the diagram as a guide.

7. Observe cells under low and high power magnification.

8. Repeat steps 3 through 5 for Elodea.

9. Examine a prepared slide of frog blood. (NOTE: This slide has been stained. Its natural color is pink.)

10. Observe cells under low- and high-power magnification.

11. Repeat steps 3 through 5 for frog blood cells.

1. Observing and Inferring Which cells were prokaryotes? How were you able to tell?
2. Observing and Inferring Which cells were eukaryotes? How were you able to tell?
3. Predicting Which cell was from a plant, from an animal? Explain your answer.
4. Measuring Are prokaryote or eukaryote cells larger? Give specific measurements to support your answer.
5. Defining Operationally Describe how plant and animal cells are alike and how they differ.

Going Further

Application Prepare a wet mount of very thin slices of bamboo (saxophone reed). Observe under low and high power. Explain what structures you are looking at. Explain the absence of all other organelles from this material.

BIOLOGY Online To find out more about microscopy and cell types, visit the Glencoe Science Web site. science.glencoe.com
You may think of yourself as a body made up of parts. Arms, legs, skin, stomach, eyes, brain, heart, lungs. Your mind controls the whole, and you probably believe that you own all the parts that make up your body. In actual fact, you are a community of living structures that work together for growth and survival.

Your body is made up of eukaryotic cells with organelles that work together for each cell’s survival. Organelles may work closely together, such as a ribosome and the endoplasmic reticulum, or they may perform a unique function within the cell, such as the mitochondrion.

An organism is similar to a cell in that several parts work together. Groups of cells work together as tissues. Several tissues form an organ and many organs form an organ system. For example, in an organ system such as the digestive system, cells and tissues form an organ such as the stomach, but several organs such as the intestines, the pancreas, and the liver, are needed to completely digest and absorb the food you eat.

In the same way, you might also consider how all the organisms in a community are interconnected and how the whole planet Earth is a collection of interdependent ecosystems. Lewis Thomas pondered this thought.

“I have been trying to think of the earth as a kind of organism, but it is no go. I cannot think of it this way. It is too big, too complex, with too many working parts lacking visible connections… I wondered about this. If not like an organism, what is it like, what is it most like? Then, satisfactorily for that moment, it came to me: it is most like a single cell.”

Words are like organelles. Just as a cell is a group of organelles working together, so is a paragraph composed of words that together convey thoughts and ideas. Despite all his technical knowledge, Dr. Thomas, a physician and medical researcher, writes simply and engagingly about everything from the tiny universe inside a single cell to the possibility of visitors from a distant planet.

Medicine, a young science Dr. Thomas grew up with the practice of medicine. As a boy, he accompanied his father, a family physician, on house calls to patients. Years later, Dr. Thomas described those days in his autobiography, The Youngest Science. The title reflects his belief that the practice of medicine is “still very early on” and that some basic problems of disease are just now yielding to exploration.

After you have studied this chapter, write a paragraph using Dr. Thomas’s style to describe how the organelles of a cell work together for cell survival.
**Section 7.1 The Discovery of Cells**

**Main Ideas**
- Microscopes enabled biologists to see cells and develop the cell theory.
- The cell theory states that the cell is the basic unit of organization, all organisms are made up of one or more cells, and all cells come from preexisting cells.
- Using electron microscopes, scientists can study cell structure in detail.
- Cells are classified as prokaryotic or eukaryotic based on whether or not they have membrane-bound organelles.

**Vocabulary**
- cell (p. 175)
- cell theory (p. 176)
- compound light microscope (p. 175)
- electron microscope (p. 176)
- eukaryote (p. 177)
- nucleus (p. 180)
- organelle (p. 177)
- prokaryote (p. 177)

**Section 7.2 The Plasma Membrane**

**Main Ideas**
- Through selective permeability, the plasma membrane controls what enters and leaves a cell.
- The fluid mosaic model describes the plasma membrane as a phospholipid bilayer with embedded proteins.

**Vocabulary**
- fluid mosaic model (p. 184)
- homeostasis (p. 181)
- phospholipid (p. 182)
- plasma membrane (p. 181)
- selective permeability (p. 181)
- transport proteins (p. 184)

**Section 7.3 Eukaryotic Cell Structure**

**Main Ideas**
- Eukaryotic cells have a nucleus and organelles, are enclosed by a plasma membrane, and some have a cell wall that provides support and protection.
- Cells make proteins on ribosomes that are often attached to the highly folded endoplasmic reticulum. Cells store materials in the Golgi apparatus and vacuoles.
- Mitochondria break down food molecules to release energy. Chloroplasts convert light energy into chemical energy.
- The cytoskeleton helps maintain cell shape, is involved in the movement of organelles and cells, and resists stress placed on cells.

**Vocabulary**
- cell wall (p. 185)
- chlorophyll (p. 190)
- chloroplast (p. 190)
- chromatin (p. 186)
- cilia (p. 193)
- cytoplasm (p. 187)
- cytoskeleton (p. 191)
- endoplasmic reticulum (p. 188)
- flagella (p. 193)
- Golgi apparatus (p. 188)
- lysosome (p. 189)
- microfilament (p. 191)
- microtubule (p. 191)
- mitochondria (p. 191)
- nucleolus (p. 187)
- plastid (p. 190)
- ribosome (p. 187)
- vacuole (p. 189)
Chapter 7 Assessment

**UNDERSTANDING MAIN IDEAS**

1. What type of cell would you examine to find a chloroplast?
   - a. prokaryote
   - b. animal
   - c. plant
   - d. fungus

2. Which of the following structures utilizes the sun’s energy to make carbohydrates?
   - a. chloroplast
   - b. cytoskeleton
   - c. plant
   - d. mitochondria

3. Which of the following pairs of terms is NOT related?
   - a. nucleus—DNA
   - b. chloroplasts—chlorophyll
   - c. flagella—chromatin
   - d. cell wall—cellulose

4. Magnifications greater than 10,000 times can be obtained when using ________.
   - a. light microscopes
   - b. metric rulers
   - c. hand lenses
   - d. electron microscopes

5. A bacterium is classified as a prokaryote because it ________.
   - a. has cilia
   - b. has no membrane-bound nucleus
   - c. is a single cell
   - d. has no DNA

6. Which of the following structures is NOT found in both plant and animal cells?
   - a. chloroplast
   - b. cytoskeleton
   - c. ribosomes
   - d. mitochondria

7. Which component is NOT stored in plastids?
   - a. lipids
   - b. pigments
   - c. amino acids
   - d. starches

8. Which is a main idea of the cell theory?
   - a. All cells have a plasma membrane.
   - b. All cells come from preexisting cells.
   - c. All cells are microscopic.
   - d. All cells are made of atoms.

9. Electron microscopes can view only dead cells because ________.
   - a. only dead cells are dense enough to be seen
   - b. a magnetic field is needed to focus the electrons
   - c. the fluorescent screen in the microscope kills the cells
   - d. the specimen must be in a vacuum

10. Ribosomes ________.
    - a. do not have a cell wall
    - b. are not surrounded by a membrane
    - c. do not contain cytoplasm
    - d. all of the above

11. ________ are membrane-bound spaces that serve as temporary storage areas.

12. The small bumps shown in this photomicrograph are the site of ________.

13. The photomicrograph in question 12 was probably taken using a ________ microscope.

14. The ________ maintains a chemical balance within a cell by regulating the materials that enter and leave the cell.

15. Plants are able to grow tall because their cells have rigid ________ that contain a strong network of ________.

16. Smooth ER is different from rough ER in that smooth ER has no ________.

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**TEST–TAKING TIP**

Maximize Your Score

Ask how your test will be scored. In order to do your best, you need to know if there is a penalty for guessing, and if so, how much of a penalty. If there is no random-guessing penalty at all, you should always fill in an answer.
17. Although prokaryotes lack __________, they still contain DNA.

18. Microtubules and microfilaments, which make up the cell cytoskeleton, are composed of __________.

19. A plant cell has a green color due to the presence of __________, a pigment that is embedded in the __________ membranes of the __________.

20. Cilia and flagella are an arrangement of __________ and allow the cell to __________.


22. How does the structure of the plasma membrane allow materials to move across it in both directions?

23. Making Predictions 
   Predict whether you would expect muscle or fat cells to contain more mitochondria and explain why.

24. Concept Mapping 
   Complete the concept map using the following vocabulary terms: cytoplasm, mitochondria, Golgi apparatus, ribosomes, plasma membrane, nucleus.

   - surrounds the
   - which contains

   1. __________
   2. __________
   3. __________
   4. __________
   5. __________
   6. __________

   The diagram below shows the parts of a cell.

   Interpreting Scientific Illustrations 
   Use the diagram to answer the following questions.

   1. The structure labeled C represents the __________.
      a. plasma membrane
      b. nuclear membrane
      c. endoplasmic reticulum
      d. nucleolus

   2. The function of the circular structures on membrane C is to __________.
      a. synthesize cellulose
      b. transform energy
      c. synthesize proteins
      d. capture the sun's energy

   3. The structure labeled B represents the __________.
      a. lysosome
      b. Golgi apparatus
      c. nucleus
      d. vacuole

   4. The type of cell shown is a __________ cell.
      a. plant
      b. fungal
      c. animal
      d. prokaryotic

   5. Sequencing 
   Structures A, B, C, and D are involved in making a product to be released to the outside of the cell. What is the sequence of the production of this product?