Discovering Cells

Guide for Reading

- What are cells?
- How did the invention of the microscope contribute to knowledge about living things?
- What is the cell theory?
- How do microscopes produce magnified images?

All living things are made of cells. **Cells are the basic units of structure and function in living things.** Most cells are too small to be seen with the naked eye.

The invention of the microscope made it possible for people to discover and learn about cells. A **microscope** is an instrument that makes small objects look larger. Some microscopes do this by using lenses to focus light. A simple light microscope contains only one lens. A light microscope that has more than one lens is called a compound microscope.

One of the first people to observe cells was Robert Hooke. In 1663, Hooke observed the structure of a thin slice of cork using a compound microscope he had built himself. At about the same time, Anton van Leeuwenhoek built simple microscopes and used them to observe tiny objects. Leeuwenhoek called the single-celled organisms he saw *animalcules*.

In 1838, Matthias Schleiden concluded that all plants are made of cells. The next year, Theodor Schwann concluded that all animals are also made of cells. In 1855, Rudolf Virchow proposed that new cells are formed only from existing cells. Schleiden, Schwann, Virchow, and others helped develop the **cell theory.** The cell theory states: All living things are composed of cells; cells are the basic unit of structure and function in living things; all cells are produced from other cells.

For a microscope to be useful, it must combine two important properties—magnification and resolution. Magnification is the ability to make things look larger than they are. **The lenses in light microscopes magnify an object by bending the light that passes through them.** A lens that magnifies is thicker in the center than at the edges and is called a convex lens. Because a compound microscope uses more than one lens, it can magnify an object more than a simple microscope. The total magnification of a compound microscope is equal to the magnifications of the two lenses multiplied together. The ability to clearly distinguish the individual parts of an object is called resolution. Resolution is another term for the sharpness of an image.

Since the 1930s, scientists have developed different types of electron microscopes. **Electron microscopes use a beam of electrons instead of light to produce a magnified image.** Because they use tiny electrons to produce images, the resolution of electron microscopes is much better than the resolution of light microscopes.
Discovering Cells

This section describes how the invention of the microscope led to the development of a theory on cells. The section also explains how a light microscope works.

Use Target Reading Skills

As you read, construct a flowchart showing how the work of Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow contributed to scientific understanding of cells.

An Overview of Cells

1.  What are cells?
Discovering Cells (continued)

First Observations of Cells

2. What did the invention of the microscope make possible?
   ____________________________
   ____________________________

3. An instrument that makes small objects look larger is a(n)
   ____________________________.

4. Is the following sentence true or false? A compound microscope has only one lens.
   ____________________________

5. Complete the following table about the first people to observe cells.

<table>
<thead>
<tr>
<th>The First People to Observe Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questions</strong></td>
</tr>
<tr>
<td>Robert Hooke</td>
</tr>
<tr>
<td>What kind of microscope did he use?</td>
</tr>
<tr>
<td>What did he first look at with the microscope?</td>
</tr>
</tbody>
</table>

Development of the Cell Theory

6. Is the following sentence true or false? Theodor Schwann worked alone to develop the cell theory.
   ____________________________

7. List the three points of the cell theory.
   a. ____________________________
   b. ____________________________
   c. ____________________________
Cell Structure and Function  •  Guided Reading and Study

Light and Electron Microscopes

8. Is the following sentence true or false? Magnification is the ability to make things look larger than they are. ________________________

9. How do the lenses of a light microscope make an object look larger?

________________________________________________________________________
________________________________________________________________________

10. In a convex lens, the ________________________ of the lens is thicker than the ________________________.

11. What is resolution?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

12. A microscope that uses a beam of electrons to examine a specimen is called a(n) ________________________.

13. Circle the letter of the microscope that has better resolution.
   a. light microscope
   b. electron microscope
Discovering Cells

Understanding Main Ideas

Fill in the blanks in the table below.

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ________</td>
<td>One of the first people to observe cells</td>
</tr>
<tr>
<td>Leeuwenhoek</td>
<td>2. ________</td>
</tr>
<tr>
<td>3. ________</td>
<td>Concluded that all plants are made up of cells</td>
</tr>
<tr>
<td>Schwann</td>
<td>4. ________</td>
</tr>
<tr>
<td>5. ________</td>
<td>Proposed that all cells come from other cells</td>
</tr>
</tbody>
</table>

Answer the following questions on a separate sheet of paper.
6. Compare and contrast magnification and resolution.
7. State how an electron microscope differs from a light microscope.
8. Explain how cells are related to living things.

Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the blank beside the term.

9. cell
   a. a widely accepted explanation of the relationship between cells and living things
10. microscope
    b. the basic unit of structure and function in living things
11. cell theory
    c. any instrument that makes small objects look larger
Recent Advances in the Microscope

The tremendous power of magnification of the electron microscope has greatly increased scientists' understanding of living things. However, the electron microscope has a major disadvantage. Biological specimens must be dried, frozen, thinly sliced, and coated with metal before they can be viewed with an electron microscope. The beam of electrons used in an electron microscope also damages living things. For these reasons, the electron microscope cannot be used to view biological specimens that are still alive or even in a natural state.

Two new types of microscope address this problem. One type is the transmission positron microscope, or TPM. Like the transmission electron microscope, or TEM, the TPM sends a beam of atomic particles through a specimen. However, instead of using a beam of electrons, the TPM uses a beam of positrons, which are positively charged atomic particles that do not harm living specimens as electrons do.

Another type of microscope that does not harm living specimens is the acoustic microscope. It uses sound waves instead of beams of atomic particles to “see” an object. As shown in the figure, the echoes of sound waves bouncing off the specimen are translated onto a screen as a microscopic image. Even though the sound waves that are used are very high in frequency, they do no damage to living things. Doctors have used the acoustic microscope to view changes in living cells and to examine living cells for cancer without removing the cells from the body.

Answer the following questions on a separate sheet of paper.

1. Compare and contrast transmission electron microscopes and transmission positron microscopes.
2. Explain how acoustic microscopes work.
3. Why are transmission positron microscopes and acoustic microscopes important tools for understanding how living cells function?
Design and Build a Microscope

Problem
How can you design and build a compound microscope?

Design Skills
building a prototype, evaluating design constraints

Materials
- book
- 2 dual magnifying glasses, each with one high-power and one low-power lens
- metric ruler
- 2 cardboard tubes from paper towels, or black construction paper
- tape

Procedure

Part 1 Research and Investigate
1. Work with a partner. Using only your eyes, examine words in a book. Then use the high-power lens to examine the same words. In your notebook, contrast what you saw with and without the magnifying lens.
2. Hold the high-power lens about 5–6 cm above the words in the book. When you look at the words through the lens, they will look blurry.
3. Keep the high-power lens about 5–6 cm above the words. Hold the low-power lens above the high-power lens.
4. Move the low-power lens up and down until the image is in focus and upside down. (Hint: You may have to move the high-power lens up or down slightly, too.)
5. Once the image is in focus, experiment with raising and lowering both lenses. Your goal is to produce the highest magnification while keeping the image in clear focus.
6. When the image is in focus at the position of highest magnification, have your lab partner measure and record the distance between the book and the high-power lens. Your lab partner should also measure and record the distance between the two lenses.
7. Write a description of how the magnified words viewed through two lenses compares with the words seen without magnification.

PART 2 Design and Build
8. Based on what you learned in Part 1, work with a partner to design your own two-lens (compound) microscope. Your microscope should
   - consist of one high-power lens and one low-power lens, each attached to a tube of paper or rolled-up cardboard
Cell Structure and Function  •  Technology Lab

- allow one tube to fit snugly inside the other tube so the distance between the two lenses can be easily adjusted
- focus to produce a clear, enlarged, upside-down image of the object you observe
- be made from dual magnifying glasses, cardboard tubes, and tape

9. Sketch your design on a sheet of paper. Obtain your teacher’s approval for your design. Then construct your microscope.

PART 3 Evaluate and Redesign

10. Test your microscope by examining printed words or a printed photograph. Then, examine other objects such as a leaf or your skin. Record your observations. Did your microscope meet the criteria listed in Step 8?

11. Examine microscopes made by other students. Based on your tests and your examination of other microscopes, list ways you could improve your microscope.

Analyze and Conclude

1. Observing  Compare the images you observed using one lens with the image from two lenses.

2. Evaluating Constraints  When you used two lenses, how did moving the top lens up and down affect the image? What was the effect of moving the bottom lens up and down?

3. Building a Prototype  Describe how you built your microscope and explain why you built it that way.

4. Evaluating the Impact on Society  Describe some of the ways that microscopes have aided scientists in their work.

Communicate

Imagine it is 1675. Write an explanation that will convince scientists to use your new microscope rather than the single-lens variety used by Leeuwenhoek.
The cell wall is a rigid layer of nonliving material that surrounds the cells of plants and some other organisms. A plant’s cell wall helps to protect and support the cell. The cell wall is made of a strong, flexible material called cellulose, and many materials can pass through it.

In cells that do not have cell walls, the cell membrane is the outside boundary that separates the cell from its environment. All cells have cell membranes. In cells with cell walls, the cell membrane is located just inside the cell wall. The cell membrane controls what substances come into and out of a cell.

Inside a cell are tiny structures called organelles, which carry out specific functions within the cell. The nucleus is a large, oval structure that acts as the “brain” of the cell. You can think of the nucleus as the cell’s control center, directing all of the cell’s activities. The nucleus is surrounded by a protective membrane called the nuclear envelope. Materials pass in and out of the nucleus through small openings, or pores, in the nuclear envelope.

The cytoplasm is the region between the cell membrane and the nucleus. Many cell organelles are found in the cytoplasm. The mitochondria are known as the “powerhouses” of the cell because they convert energy in food molecules to energy the cell can use to carry out its functions. Passageways called the endoplasmic reticulum carry proteins and other materials from one part of the cell to another. Small, grainlike bodies called ribosomes function as factories to produce proteins. Collections of sacs and tubes called Golgi bodies receive proteins and other newly formed materials from the endoplasmic reticulum, package them, and distribute them to other parts of the cell. The Golgi bodies release materials outside the cell. In plants and some other organisms, large, green structures called chloroplasts capture energy from sunlight and use it to produce food for the cell. Large water-filled sacs called vacuoles are the storage areas of cells. A vacuole stores food and other materials needed by the cell. Small, round structures called lysosomes contain chemicals that break down certain materials in the cell.

Plants and animals contain many cells. In a many-celled organism, the cells are often quite different from each other and are specialized to perform specific functions. In many-celled organisms, cells are often organized into tissues, organs, and organ systems. Bacterial cells are smaller and different from plant and animal cells. While a bacterial cell does have a cell wall and a cell membrane, it does not contain a nucleus. The bacterial cell’s genetic material, which looks like a thick, tangled string, is found in the cytoplasm. Bacterial cells contain ribosomes, but none of the other organelles found in plant or animal cells.
Looking Inside Cells

This section describes cell structure and function in plant cells, animal cells, and bacteria.

Use Target Reading Skills

Before you read, preview Figure 12. Then write two questions that you have about the illustrations in a graphic organizer like the one below. As you read, answer your questions.

<table>
<thead>
<tr>
<th>Plant and Animal Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. How are animal cells different from plant cells?</td>
</tr>
<tr>
<td>A.</td>
</tr>
<tr>
<td>Q.</td>
</tr>
<tr>
<td>A.</td>
</tr>
</tbody>
</table>

Introduction

1. What are organelles?

Enter the Cell

2. The rigid layer of nonliving material that surrounds plant cells is the _________________.

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Cell Structure and Function

3. Circle the letter of each sentence that is true about the cell wall.
   a. Cell walls are made of cellulose.
   b. Plant cells have cell walls.
   c. Animal cells have cell walls.
   d. Water and oxygen cannot pass through the cell wall.

4. What does the cell wall do?

5. Where is the cell membrane located in cells that have cell walls?

6. Where is the cell membrane located in cells that do NOT have cell walls?

7. Is the following sentence true or false? The main function of the cell membrane is to control what comes into and out of a cell.

Sail On to the Nucleus

8. Circle the letter of each sentence that is true about the nucleus.
   a. Materials pass in and out of the nucleus through pores in the nuclear envelope.
   b. Chromatin contains the instructions that direct the functions of a cell.
   c. The nucleolus is part of the nuclear envelope.
   d. Ribosomes are made in the nucleolus.

Organelles in the Cytoplasm

9. Circle the letter of the part of the cell that is the region between the cell membrane and the nucleus.
   a. organelle
   b. nucleus
   c. cytoplasm
   d. chromatin
10. In the table below, describe the function of each organelle in the cytoplasm.

<table>
<thead>
<tr>
<th>Organelle</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitochondria</td>
<td></td>
</tr>
<tr>
<td>Endoplasmic reticulum</td>
<td></td>
</tr>
<tr>
<td>Ribosomes</td>
<td></td>
</tr>
<tr>
<td>Golgi bodies</td>
<td></td>
</tr>
<tr>
<td>Chloroplasts</td>
<td></td>
</tr>
<tr>
<td>Vacuoles</td>
<td></td>
</tr>
<tr>
<td>Lysosomes</td>
<td></td>
</tr>
</tbody>
</table>

**Specialized Cells**

11. The structure of each kind of body cell is suited to its ____________.

**Bacterial Cells**

12. Circle the letter of each sentence that is true about bacterial cells.
   a. Bacterial cells are larger than plant or animal cells.
   b. Bacterial cells have a cell wall and a cell membrane.
   c. Bacterial cells do not have a nucleus.
   d. Bacterial cells do not have genetic material.
Cell Structure and Function  

Looking Inside Cells

Understanding Main Ideas
Identify each of the cell structures in the figure.

1. __________________________
2. __________________________
3. __________________________
4. __________________________
5. __________________________

Building Vocabulary
Fill in the blank to complete each statement.

6. __________________________ are tiny cell structures that carry out specific functions within the cell.
7. The rigid layer of nonliving material that surrounds the cells of plants and other organisms is called the ________________________.
8. In cells without cell walls, the ________________________ forms the outside boundary that separates the cell from its environment.
9. The ________________________ is a large, oval structure that directs all of the cell’s activities.
10. The region between the cell membrane and the nucleus is called the ________________________.
11. __________________________ produce most of the energy the cell needs to carry out its functions.
12. A maze of passageways called the ________________________ carries proteins and other materials from one part of the cell to another.
13. __________________________ function as factories to produce proteins.
14. __________________________ receive proteins and other newly formed materials and distribute them to other parts of the cell.
15. Organelles called ________________________ capture energy from sunlight and use it to produce food for the cell.
16. The storage area of a cell is called a(n) ________________________.
17. __________________________ are small, round structures in cells that break down large food particles into smaller ones.
Cell Structure and Function  ·  Enrich

Modeling Cell Structures

The figure below shows a city that is a model for a cell. Study the figure, and use it to respond to the items that follow.

Answer the following questions on a separate sheet of paper.

1. State the function performed by each numbered structure in the figure.
2. Now name a cell structure that performs each of these same functions.
3. Does “Cell City” represent a plant cell or an animal cell? Explain your answer.
Chemical Compounds in Cells

Guide for Reading

- What are elements and compounds?
- What are the main kinds of organic molecules in living things?
- How is water important to the function of cells?

An element is any substance that cannot be broken down into simpler substances. The smallest unit of an element is called an atom. The elements found in living things include carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur. When two or more elements combine chemically, they form a compound. The smallest unit of many compounds is called a molecule.

Many of the compounds found in living things contain the element carbon, which is usually combined with other elements. Most compounds that contain carbon are called organic compounds. Some important groups of organic compounds found in living things are carbohydrates, proteins, lipids, and nucleic acids. Compounds that do not contain the element carbon are called inorganic compounds.

A carbohydrate is an energy-rich organic compound made of the elements carbon, hydrogen, and oxygen. Sugars and starches are examples of carbohydrates. Carbohydrates are important components of some cell parts, including cell walls and cell membranes.

Fats, oils, and waxes are all lipids. Proteins make up much of the structure of cells. Lipids are energy-rich organic compounds made of carbon, hydrogen, and oxygen. Lipids contain more energy than carbohydrates. Cells store energy in lipids for later use.

Proteins are large organic molecules made of carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulfur. Protein molecules are made up of smaller molecules called amino acids. Proteins make up much of the structure of cells. An enzyme is a type of protein that speeds up a chemical reaction in a living thing. Without enzymes, many chemical reactions that are necessary for life would either take too long or not occur at all.

Nucleic acids are very long organic molecules made of carbon, oxygen, hydrogen, nitrogen, and phosphorus. Nucleic acids contain the instructions that cells need to carry out all the functions of life. There are two kinds of nucleic acids: DNA and RNA. Deoxyribonucleic acid, or DNA, is the genetic material that carries information about an organism that is passed from parent to offspring and directs all of the cell’s functions. Ribonucleic acid, or RNA, plays an important role in the production of proteins. RNA is found in the cytoplasm as well as in the nucleus.

Water plays many important roles in cells. Most chemical reactions within cells could not take place without water. Water also helps cells keep their size and shape and keeps the temperature of cells from changing rapidly.
Chemical Compounds in Cells

This section identifies the basic building blocks of cells. It also explains the importance of water to cells.

Use Target Reading Skills

As you read, compare and contrast carbohydrates, proteins, and lipids in the table below.

<table>
<thead>
<tr>
<th>Type of Compound</th>
<th>Elements</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>Carbon, hydrogen, oxygen</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Elements and Compounds

1. A(n) ________________ is any substance that cannot be broken down into simpler substances. Its smallest unit is the ________________.
2. When two or more elements combine chemically, they form a(n) _________________. Its smallest unit is usually called a(n) _________________.

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3. Complete this concept map on organic compounds.

4. Compounds that do not contain carbon are called ______________________.

**Carbohydrates**

5. A carbohydrate is made of carbon, hydrogen, and ______________________.

6. Starch is a kind of carbohydrate. What foods have starch?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

7. How do cells use carbohydrates?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

**Lipids**

8. What are three examples of lipids?
   a. ______________________}
   b. ______________________
   c. ______________________
9. How are lipids like carbohydrates?

________________________________________________________________________
________________________________________________________________________

10. Cells store ________________ in lipids to use later.

Proteins
11. __________________ form parts of cell membranes and many of the cell's organelles.

12. What small molecules make up proteins? ________________

13. What do enzymes do?
________________________________________________________________________

Nucleic Acids
14. Very long organic molecules that contain instructions that cells need to function are called ________________.

15. Is the following sentence true or false? Cells use the instructions in nucleic acids to carry out all life functions. ________________

16. List the two kinds of nucleic acids.
   a. ________________   b. ________________

Water and Living Things
17. List four ways that cells use water.
   a. ______________________________________________________________________
      ______________________________________________________________________
      ______________________________________________________________________
   b. ______________________________________________________________________
      ______________________________________________________________________
      ______________________________________________________________________
   c. ______________________________________________________________________
      ______________________________________________________________________
   d. ______________________________________________________________________
      ______________________________________________________________________
Cell Structure and Function

Chemical Compounds in Cells

Understanding Main Ideas
Fill in the blanks in the table below.

<table>
<thead>
<tr>
<th>Organic Compounds</th>
<th>Type of Compound</th>
<th>Example</th>
<th>Major Roles in Living Things</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carbohydrates</td>
<td>1.</td>
<td>Help form cell walls and membranes; provide energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.</td>
<td>Fats</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.</td>
<td>Help form cell membranes;</td>
</tr>
<tr>
<td></td>
<td>Enzymes</td>
<td>4.</td>
<td>Help form cell membranes and organelles; speed up chemical</td>
</tr>
<tr>
<td></td>
<td>DNA</td>
<td>5.</td>
<td>Direct all the cell’s functions;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.</td>
</tr>
</tbody>
</table>

Building Vocabulary
Match each term with its definition by writing the letter of the correct definition in the blank beside the term.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. element</td>
<td>a. type of nucleic acid that plays an important role in the production of proteins</td>
</tr>
<tr>
<td>8. compound</td>
<td>b. type of nucleic acid that passes from parent to offspring and directs all the cell’s functions</td>
</tr>
<tr>
<td>9. carbohydrate</td>
<td>c. very large organic molecules made of carbon, oxygen, hydrogen, nitrogen, and phosphorus</td>
</tr>
<tr>
<td>10. proteins</td>
<td>d. large organic molecules made of carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulfur</td>
</tr>
<tr>
<td>11. amino acids</td>
<td>e. small molecules that make up proteins</td>
</tr>
<tr>
<td>12. enzyme</td>
<td>f. the chemical combination of two or more elements</td>
</tr>
<tr>
<td>13. lipid</td>
<td>g. type of protein that speeds up chemical reactions in living things</td>
</tr>
<tr>
<td>14. nucleic acids</td>
<td>h. any substance that cannot be broken down into simpler substances</td>
</tr>
<tr>
<td>15. DNA</td>
<td>i. an energy-rich organic compound such as sugar</td>
</tr>
<tr>
<td>16. RNA</td>
<td>j. an energy-rich organic compound such as fat</td>
</tr>
</tbody>
</table>
Amino Acids and Proteins

Though there are only 20 common amino acids, they can be combined in different ways to produce thousands of unique proteins. Proteins that differ in the order or type of amino acids they contain may have very different structures and functions. In fact, a change in even a single amino acid can sometimes affect the way a protein works.

Suppose that proteins could consist of just two amino acids. To see how many unique proteins, each composed of just two amino acids, can be formed from five different amino acids, fill in the spaces in the table below. Some of the spaces have been filled in to show you how. Assume that each letter represents a different amino acid.

<table>
<thead>
<tr>
<th>Amino Acids</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AA</td>
<td>AB</td>
<td>AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>BA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answer the following questions in the spaces provided.

1. What does each letter pair in the table represent?

2. Based on your completed table, how many unique proteins, each composed of just two amino acids, can be formed from five different amino acids?

3. How many unique proteins, each made up of just two amino acids, could be formed from six different amino acids? From 20 different amino acids?

4. Most proteins are made up of not just two, but hundreds or even thousands of amino acids. How does this affect the number of unique proteins that could be formed from just a few amino acids?
Cell Structure and Function • Consumer Lab

Analyze and Conclude
1. Observing
2. Interpreting Data
3. Inferring
4. Communicating

Design an Experiment

*how much*

Obtain your teacher’s permission before carrying out your investigation.
The cell membrane is **selectively permeable**, which means that some substances can pass through it while others cannot. Oxygen, food molecules, and waste products all must pass through the cell membrane. Substances that can move into and out of a cell do so by one of three methods: diffusion, osmosis, or active transport.

**Diffusion** is the main method by which small molecules move across the cell membrane. Diffusion is the process by which molecules tend to move from an area of higher concentration to an area of lower concentration. The concentration of a substance is the amount of the substance in a given volume. Diffusion is caused by molecules moving and colliding. The collisions cause the molecules to push away from one another and spread out. Molecules diffuse through the cell membrane into a cell when there is a higher concentration of the molecules outside the cell than inside the cell.

The diffusion of water molecules through a selectively permeable membrane is called **osmosis**. Because cells cannot function properly without adequate water, many cellular processes depend on osmosis. In osmosis, water molecules move by diffusion from an area where they are highly concentrated through the cell membrane to an area where they are less concentrated.

The movement of dissolved materials through a cell membrane without using cellular energy is called **passive transport**. Diffusion and osmosis are both types of passive transport. When a cell needs to take in materials that are in higher concentration inside the cell than outside the cell, the movement of the materials requires energy. **Active transport** is the movement of materials through a cell membrane using cellular energy. The main difference between passive transport and active transport is that active transport **requires the cell to use its own energy while passive transport does not**. Cells have several ways of moving materials by active transport. In one method, transport proteins in the cell membrane “pick up” molecules outside the cell and carry them in. Another method of active transport is engulfing, in which the cell membrane wraps around, or engulfs, a particle and forms a vacuole within the cell.

Most cells are very small. One reason is related to the fact that all materials move into and out of cells through the cell membrane. Once a molecule enters a cell, it is carried to its destination by a stream of moving cytoplasm. In a very large cell, streams of cytoplasm must travel farther to carry materials from the cell membrane to all parts of the cell.
The Cell in Its Environment

This section tells how things move into and out of cells.

Use Target Reading Skills

After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Introduction

1. The cell membrane is ________________, which means that some substances can pass through it while others cannot.

Diffusion

2. List three ways that substances can move into and out of a cell.
   a. ________________
   b. ________________
   c. ________________

3. In diffusion, molecules move from an area of ________________ concentration to an area of ________________ concentration.

4. Draw molecules on Part B of the diagram below to show how the molecules are distributed inside and outside the cell after diffusion has occurred.
Osmosis

5. In ________________________, water molecules diffuse through a selectively permeable membrane.

Active Transport

6. Two ways of moving things into and out of cells that do NOT need energy are ________________________ and ________________________.
   Moving materials through a cell membrane without using energy is called ________________________ transport.

7. How does active transport differ from passive transport?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

8. List two ways that the cell moves things by active transport.
   a. _________________________________________________________________________
   b. _________________________________________________________________________

9. Is the following sentence true or false? As a cell gets larger, it takes longer for a molecule that has entered the cell to reach the middle of the cell.
   __________________________
The Cell in Its Environment

Understanding Main Ideas
Fill in the blank to identify the process illustrated in each of the following figures.

1. Water moves out of the cells of a saltwater fish and into the ocean.
2. Oxygen moves from the lungs into the bloodstream.
3. Sodium is pumped out of a nerve cell.

Answer the following questions on a separate sheet of paper.

4. Explain how osmosis differs from diffusion.
5. Compare and contrast active and passive transport.
6. Identify two methods of active transport.
7. State one reason that cells are small.

Building Vocabulary
If the statement is true, write true. If the statement is false, change the underlined word or words to make the statement true.

8. Selectively permeable means letting some but not all substances pass through.
9. Osmosis is the process by which molecules tend to move from an area of higher concentration to an area of lower concentration.
10. The process by which water moves across a selectively permeable membrane is called diffusion.
11. Diffusion and osmosis are types of active transport.
12. Passive transport requires the cell’s own energy.
Cell Structure and Function  •  Enrich

The text describes two methods of passive transport: diffusion and osmosis. The diagram below shows another method of passive transport, called facilitated diffusion.

Why is facilitated diffusion needed? Some molecules are unable to pass through the cell membrane even though they are moving from an area of higher to an area of lower concentration. To pass through the cell membrane, these molecules must be facilitated, or helped, by a carrier molecule in the cell membrane. The carrier molecule attaches to a passenger molecule of the substance, carries it through a channel in the cell membrane, and then releases the molecule. The process can carry substances both into and out of cells, as shown in the diagram, and it requires no cellular energy.

Answer the following questions on a separate sheet of paper.

1. Why isn’t cellular energy required for the passenger molecule to be carried across the cell membrane by the carrier molecule?
2. Why do the passenger molecules need to be helped by the carrier molecule?
3. If the substance entering the cell was in higher concentration inside the cell than outside the cell, what type of transport would be required? Explain your answer.
4. What is the difference between facilitated diffusion with the help of a carrier molecule and active transport with the help of a transport protein?
5. Assume a person has defective carrier molecules for a given substance. Explain what effect this would have on the person’s cells.
**Cell Structure and Function • Key Terms**

**Key Terms**

Match each definition on the left with the correct term on the right. Then write the number of each term in the appropriate box below. When you have filled in all the boxes, add up the numbers in each column, row, and two diagonals. The sums should be the same. Some terms may not be used.

A. Acts as the cell’s control center
B. Area between the cell membrane and the nucleus
C. The movement of materials through a cell membrane without using cellular energy
D. An energy-rich compound such as sugar
E. Basic unit of structure and function in living things
F. Process by which molecules move from an area of higher concentration to one of lower concentration
G. Instrument that makes small objects look larger
H. Storage area of the cell
I. Protein that speeds up chemical reactions

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1. cytoplasm
2. active transport
3. microscope
4. enzyme
5. diffusion
6. cell
7. carbohydrate
8. nucleus
9. passive transport
10. mitochondria
11. vacuole
12. lipid

= ___
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= ___
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= ___

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Cell Structure and Function  ·  Connecting Concepts

Connect the Concepts

Develop a concept map that uses the Key Concepts and Key Terms from this chapter. Keep in mind the big idea of this chapter. The concept map shown is one way to organize how the information in this chapter is related. You may use an extra sheet of paper.
**Key Terms**

Match each definition on the left with the correct term on the right. Then write the number of each term in the appropriate box below. When you have filled in all the boxes, add up the numbers in each column, row, and two diagonals. The sums should be the same. Some terms may not be used.

A. Acts as the cell’s control center
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**Answers:**

A. 1. cytoplasm
B. 2. active transport
C. 3. microscope
D. 4. enzyme
E. 5. diffusion
F. 6. cell
G. 7. carbohydrate
H. 8. nucleus
I. 9. passive transport
J. 10. mitochondria
K. 11. vacuole
L. 12. lipid

**Sums:**

- Column A: 1 + 4 + 7 = 12
- Column B: 2 + 5 + 8 = 15
- Column C: 3 + 6 + 9 = 18
- Row A: 1 + 2 + 3 = 6
- Row B: 4 + 5 + 6 = 15
- Row C: 7 + 8 + 9 = 24
- Diagonal: 1 + 5 + 9 = 15
- Diagonal: 3 + 5 + 7 = 15

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