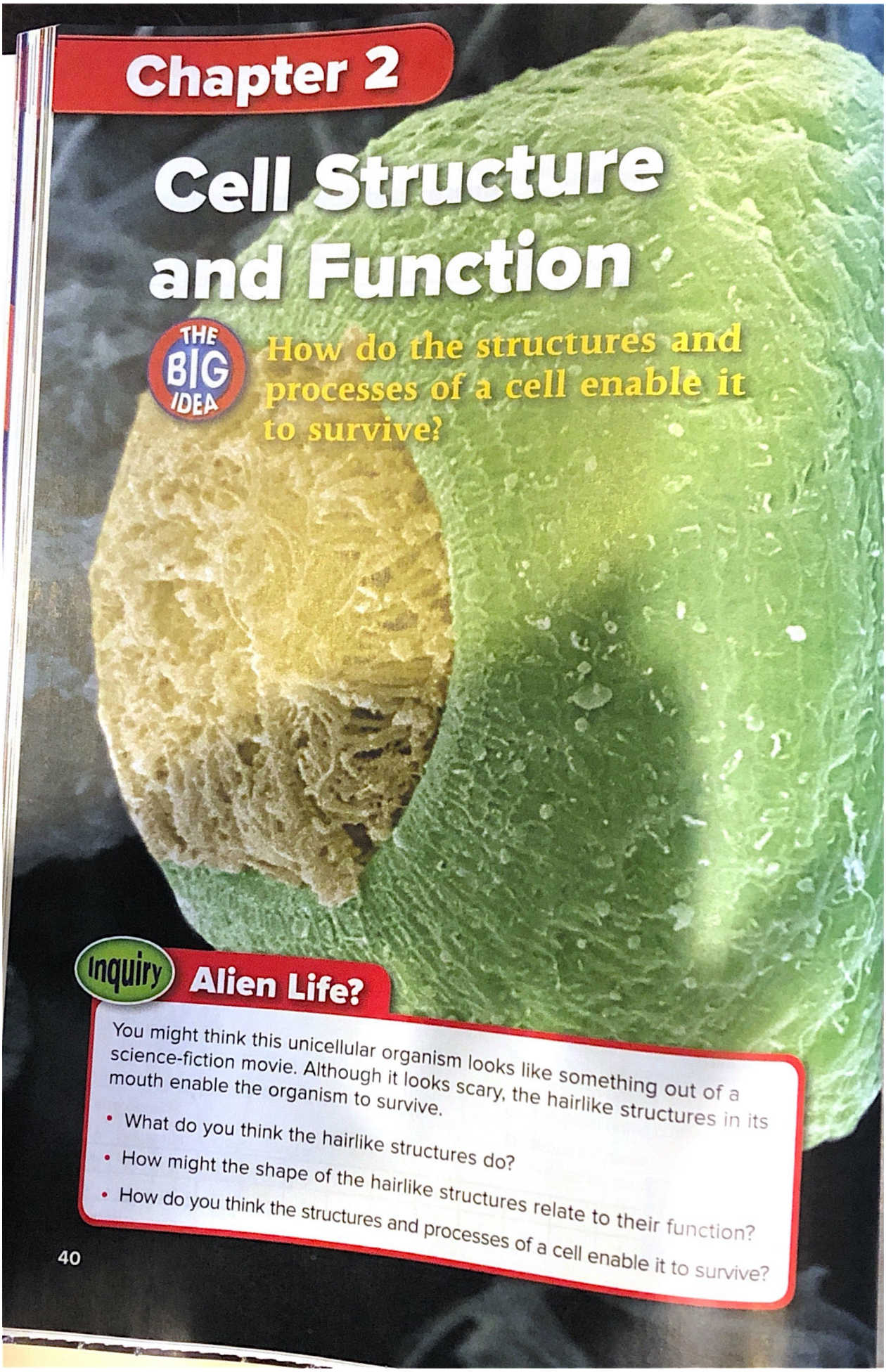
Chapter 2

Cell Structure and Function

THE BIG IDEA

How do the structures and processes of a cell enable it to survive?



Inquiry

Alien Life?

You might think this unicellular organism looks like something out of a science-fiction movie. Although it looks scary, the hairlike structures in its mouth enable the organism to survive.

- What do you think the hairlike structures do?
- How might the shape of the hairlike structures relate to their function?
- How do you think the structures and processes of a cell enable it to survive?

Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

1. Nonliving things have cells.
2. Cells are made mostly of water.
3. Different organisms have cells with different structures.
4. All cells store genetic information in their nuclei.
5. Diffusion and osmosis are the same process.
6. Cells with large surface areas can transport more than cells with smaller surface areas.
7. ATP is the only form of energy found in cells.
8. Cellular respiration occurs only in lung cells.

Lesson 1

Cells and Life

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- How did scientists' understanding of cells develop?
- What basic substances make up a cell?

Vocabulary

cell theory p. 44
macromolecule p. 45
nucleic acid p. 46
protein p. 47
lipid p. 47
carbohydrate p. 47

Multilingual eGlossary

Inquiry Two of a Kind?

At first glance, the plant and animal in the photo might seem like they have nothing in common. The plant is rooted in the ground, and the rabbit can move quickly. Are they more alike than they appear? How can you find out?

Launch Lab

10 minutes

What's in a cell?

Most plants grow from seeds. A seed began as one cell, but a mature plant can be made up of millions of cells. How does a seed change and grow into a mature plant?

1. Read and complete a lab safety form.
2. Use a **toothpick** to gently remove the thin outer covering of a **bean seed** that has soaked overnight.
3. Open the seed with a **plastic knife,** and observe its inside with a **magnifying lens.** Draw the inside of the seed in your Science Journal.
4. Gently remove the small, plantlike embryo, and weigh it on a **balance.** Record its mass in your Science Journal.
5. Gently pull a **bean seedling** from the soil. Rinse the soil from the roots. Weigh the seedling, and record the mass.

Think About This

1. How did the mass of the embryo and the bean seedling differ?
2. **Key Concept** If a plant begins as one cell, where do all the cells come from?

Understanding Cells

Have you ever looked up at the night sky and tried to find other planets in our solar system? It is hard to see them without using a telescope. This is because the other planets are millions of kilometers away. Just like we can use telescopes to see other planets, we can use microscopes to see the basic units of all living things–cells. But people didn't always know about cells. Because cells are so small, early scientists had no tools to study them. It took hundreds of years for scientists to learn about cells.

More than 300 years ago, an English scientist named Robert Hooke built a microscope. He used the microscope to look at cork, which is part of a cork oak tree's bark. What he saw looked like the openings in a honeycomb, as shown in **Figure 1.** The openings reminded him of the small rooms, called cells, where monks lived. He called the structures cells, from the Latin word *cellula* (SEL yuh luh), which means "small rooms."

Figure 1 To Robert Hooke, the cells of cork looked like the openings in a honeycomb.

The Cell Theory

After Hooke's discovery, other scientists began making better microscopes and looking for cells in many other places, such as pond water and blood. The newer microscopes enabled scientists to see different structures inside cells. Matthias Schleiden (SHLI dun), a German scientist, used one of the new microscopes to look at plant cells. Around the same time, another German scientist, Theodor Schwann, used a microscope to study animal cells. Schleiden and Schwann realized that plant and animal cells have similar features. You'll read about many of these features in Lesson 2.

Almost two decades later, Rudolf Virchow (VUR koh), a German doctor, proposed that all cells come from preexisting cells, or cells that already exist. The observations made by Schleiden, Schwann, and Virchow were combined into one **theory**. As illustrated in **Table 1**, *the* **cell theory** *states that all living things are made of one or more cells, the cell is the smallest unit of life, and all new cells come from preexisting cells.* After the development of the cell theory, scientists raised more questions about cells. If all living things are made of cells, what are cells made of?

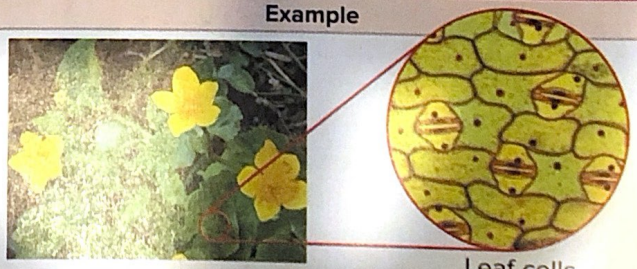
Key Concept Check How did scientists' understanding of cells develop?

REVIEW VOCABULARY

theory
explanation of things or events based on scientific knowledge resulting from many observations and experiments

Table 1 Scientists developed the cell theory after studying cells with microscopes.

Table 1 The Cell Theory

Principle	Example
All living things are made of one or more cells.	 Leaf cells
The cell is the smallest unit of life.	This unicellular amoeba is surrounding an algal cell to get food and energy.  Amoeba Algal cell
All new cells come from preexisting cells.	 Existing cell Cell dividing New cells

Basic Cell Substances

Have you ever watched a train travel down a railroad track? The locomotive pulls train cars that are hooked together. Like a train, many of the substances in cells are made of smaller parts that are joined together. *These substances, called* **macromolecules,** *form by joining many small molecules together.* As you will read later in this lesson, macromolecules have many important roles in cells. But macromolecules cannot function without one of the most important substances in cells–water.

WORD ORIGIN

macromolecule
from Greek *makro–*, means "long"; and Latin *molecula*, means "mass"

The Main Ingredient—Water

The main ingredient in any cell is water. It makes up more than 70 percent of a cell's volume and is essential for life. Why is water such an important molecule? In addition to making up a large part of the inside of cells, water also surrounds cells. The water surrounding your cells helps to insulate your body, which maintains homeostasis, or a stable internal environment.

The structure of a water molecule makes it ideal for dissolving many other substances. Substances must be in a liquid to move into and out of cells. A water molecule has two areas:

- An area that is more negative (–), called the negative end; this end can attract the positive part of another substance.
- An area that is more positive (+), called the positive end; this end can attract the negative part of another substance.

Examine **Figure 2** to see how the positive and negative ends of water molecules dissolve salt crystals.

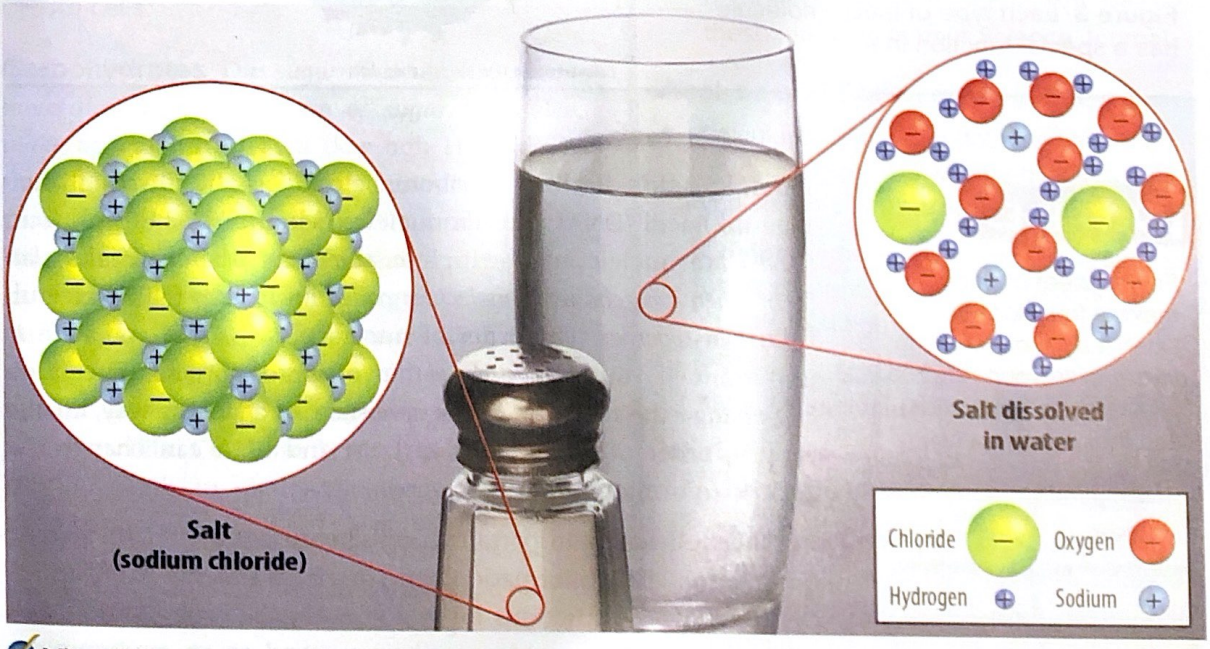


Figure 2 The positive and negative ends of a water molecule attract the positive and negative parts of another substance, similar to the way magnets are attracted to each other.

Visual Check Which part of the salt crystal is attracted to the oxygen in the water molecule?

Macromolecules

Although water is essential for life, all cells contain other substances that enable them to function. Recall that macromolecules are large molecules that form when smaller molecules join together. As shown in **Figure 3**, there are four types of macromolecules in cells: nucleic acids, proteins, lipids, and carbohydrates. Each type of macromolecule has unique functions in a cell. These functions range from growth and communication to movement and storage.

Cell Macromolecules

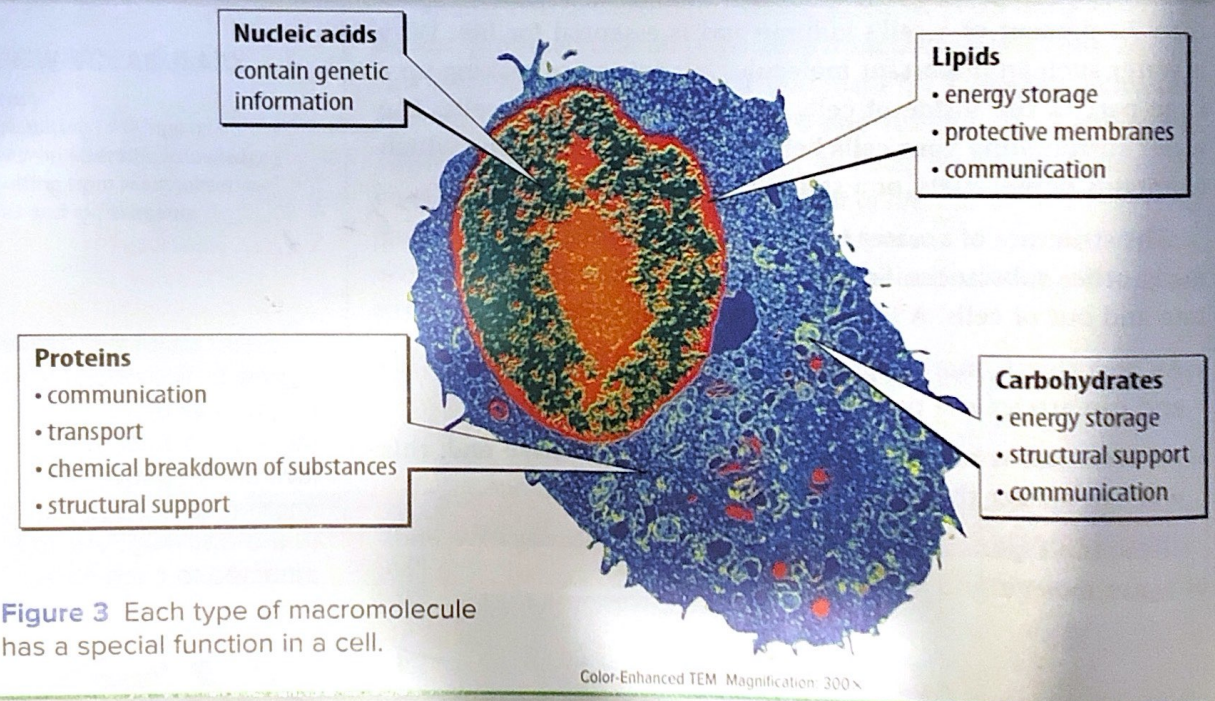
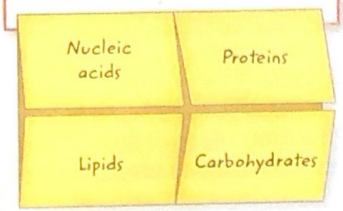


Figure 3 Each type of macromolecule has a special function in a cell.

FOLDABLES

Fold a sheet of paper to make a four-door book. Label it as shown. Use it to organize your notes on the macromolecules and their uses in a cell.



Nucleic Acids Both deoxyribonucleic (dee AHK sih ri boh noo klee ihk) acid (DNA) and ribonucleic (ri boh noo KLEE ihk) acid (RNA) are nucleic acids. **Nucleic acids** *are macromolecules that form when long chains of molecules called nucleotides* (NEW klee uh tidz) *join together.* The order of nucleotides in DNA and RNA is important. If you change the order of words in a sentence, you can change the meaning of the sentence. In a similar way, changing the order of nucleotides in DNA and RNA can change the genetic information in a cell.

Nucleic acids are important in cells because they contain genetic information. This information can pass from parents to offspring. DNA includes instructions for cell growth, cell reproduction, and cell processes that enable a cell to respond to its environment. DNA is used to make RNA. RNA is used to make proteins.

Proteins The macromolecules necessary for nearly everything cells do are proteins. **Proteins** *are long chains of amino acid molecules.* You just read that RNA is used to make proteins. RNA contains instructions for joining amino acids together.

Cells contain hundreds of proteins. Each protein has a unique function. Some proteins help cells communicate with each other. Other proteins transport substances around inside cells. Some proteins, such as amylase (AM uh lays) in saliva, help break down nutrients in food. Other proteins, such as keratin (KER uh tun)–a protein found in hair, horns, and feathers–provide structural support.

Lipids Another group of macromolecules found in cells is lipids. *A* **lipid** *is a large macromolecule that does not dissolve in water.* Because lipids do not mix with water, they play an important role as protective barriers in cells. They are also the major part of cell membranes. Lipids play roles in energy storage and in cell communication. Examples of lipids are cholesterol (kuh LES tuh rawl), phospholipids (fahs foh LIH pids), and vitamin A.

Reading Check Why are lipids important to cells?

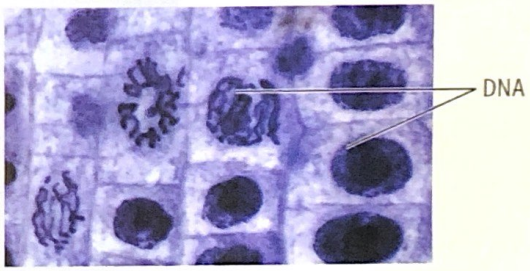
Carbohydrates *One sugar molecule, two sugar molecules, or a long chain of sugar molecules make up* **carbohydrates** (kar boh HI drayts). Carbohydrates store energy, provide structural support, and are needed for communication between cells. Sugars and starches are carbohydrates that store energy. Fruits contain sugars. Breads and pastas are mostly starch. The energy in sugars and starches can be released quickly through chemical reactions in cells. Cellulose is a carbohydrate in the cell walls in plants that provides structural support.

Key Concept Check What basic substances make up a cell?

MiniLab 25 minutes

How can you observe DNA?

Nucleic acids are macromolecules that are important in cells because they contain an organism's genetic information. In this lab, you will observe one type of nucleic acid, DNA, in onion root-tip cells using a compound light microscope.



1. Read and complete a lab safety form.
2. Obtain a **microscope** and a **slide** from your teacher. Use care and properly handle your microscope.
3. Observe the **onion root-tip cells** at the magnifications assigned by your teacher.
4. Determine the approximate number of cells in your field of view and the number of cells with visible DNA. Record these numbers in your Science Journal.

Analyze and Conclude

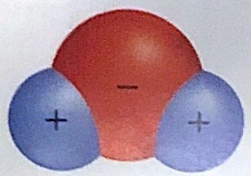
1. **Calculate** Using your data, find the percentage of cells with visible DNA that you saw in your microscope's field of view.
2. **Compare** your results with the results of other students. Are all the results the same? Explain.
3. **Create** a data table for the entire class that lists individual results.
4. **Calculate** the total percentage of cells with visible DNA at each magnification.
5. **Key Concept** Did looking at the cells at different magnifications change the percentage of cells with visible DNA? Explain.

Lesson 1 Review

Online Quiz

Visual Summary

The cell theory summarizes the main principles for understanding that the cell is the basic unit of life.



Water is the main ingredient in every cell.

A nucleic acid, such as DNA, contains the genetic information for a cell.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

1. Nonliving things have cells.
2. Cells are made mostly of water.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. The _____ _____ states that the cell is the basic unit of all living things.
2. **Distinguish** between a carbohydrate and a lipid.
3. **Use the term** *nucleic acid* in a sentence.

Understand Key Concepts

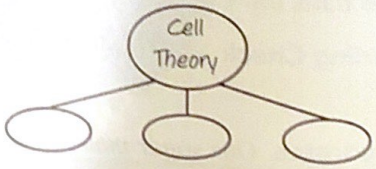
4. Which macromolecule is made from amino acids?

   A. lipid **C.** carbohydrate
   B. protein **D.** nucleic acid

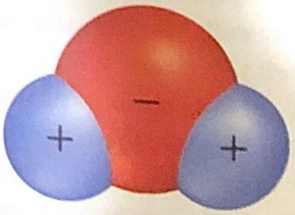
5. **Describe** how the invention of the microscope helped scientists understand cells.
6. **Compare** the functions of DNA and proteins in a cell.

Interpret Graphics

7. **Summarize** Copy and fill in the graphic organizer below to summarize the main principles of the cell theory.



8. **Analyze** How does the structure of the water molecule shown below enable it to interact with other water molecules?



Critical Thinking

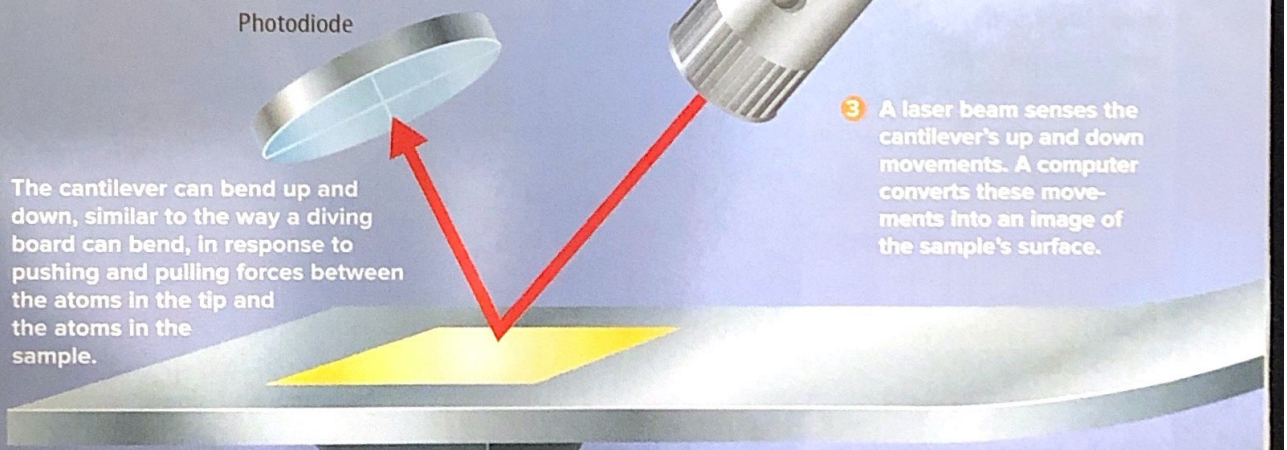
9. **Summarize** the functions of lipids in cells.
10. **Hypothesize** why carbohydrates are found in plant cell walls.

A Very Powerful Microscope

HOW IT WORKS

Using technology to look inside cells

If Robert Hooke had used an atomic force microscope (AFM), he would have observed more than just cells. He would have seen the macromolecules inside them! An AFM can scan objects that are only nanometers in size. A nanometer is one one-billionth of a meter. That's 100,000 times smaller than the width of a human hair. AFM technology has enabled scientists to better understand how cells function. It also has given them a three-dimensional look at the macromolecules that make life possible. This is how it works.



2 The cantilever can bend up and down, similar to the way a diving board can bend, in response to pushing and pulling forces between the atoms in the tip and the atoms in the sample.

3 A laser beam senses the cantilever's up and down movements. A computer converts these movements into an image of the sample's surface.

1 A probe moves across a sample's surface to identify the sample's features. The probe consists of a cantilever with a tiny, sharp tip. The tip is about 20 nm in diameter at its base.

It's Your Turn

RESEARCH NASA's Phoenix Mars Lander included an atomic force microscope. Find out what scientists discovered on Mars with this instrument.