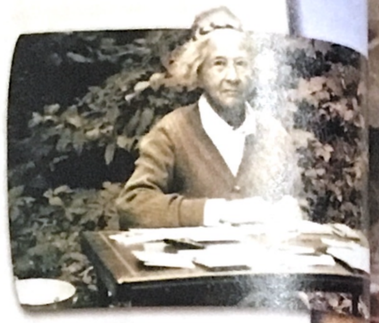
Science Ch. 2

Cells

Biography

Ynes Mexia

Plants have been used to treat illnesses for hundreds of years. What treatments and cures are locked in the thousands of plants yet to be discovered? That's one of the questions Ynes Mexia wanted to explore.



Mexia's interest in plants began in 1920 when Mexia was 50 years old. She started taking field trips with the Sierra Club to explore the variety of flowers growing in the hills around San Francisco. To learn more, she entered the University of California to study botany—the science of plants.

Armed with greater knowledge and endless curiosity, Mexia made her first major expedition in 1925 to western Mexico. Over the next 13 years, she explored many different environments in search of new plant species. She climbed the slopes of Mt. McKinley in Alaska. She trekked through the deserts of the American Southwest. She even rafted and canoed thousands of kilometers up the Amazon River to explore the rain forests of South America.

Mexia collected thousands of specimens, including some that were important sources of medicines. She also discovered new species. Because of her work, we know more about the amazing variety and uses of plants.

Lab zone **Take-Home Activi**

Ynes Mexia carefully drew and photograp her specimens for others to study. Are you a keen observer? Take a field trip near yo home or in a park. Draw, photograph, or describe several kinds of plants. Display y work for others to enjoy.

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Chapter 2

Cells

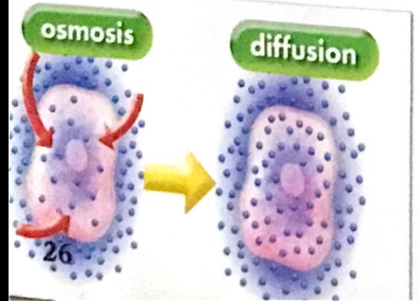
You Will Discover

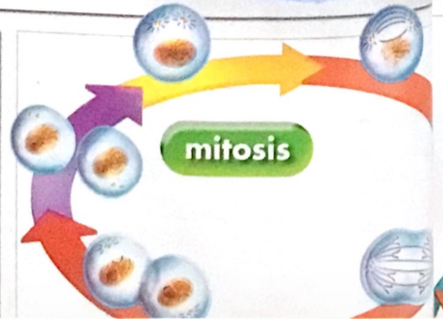
- how scientists learned about cells.
- what the function is of some common cell parts.
- how cells make new cells.

Build Background

What are the parts of a cell?

Chapter 2 Vocabulary





You Are There!

The summer sun warms your face as you gaze into the pond. You see plenty of plant life—giant water lilies, grasses, and tiny duckweed plants. But is there anything else? Nothing appears to be moving. Could it be that only these plants live here? Now look closer—through a microscope. What are all those things zooming through the water?

AudioText

What is a cell?

What do plants, earthworms, dogs, and people have in common? All living things, no matter how large or how small, are made of cells.

Algae

Paramecium

Spirogyra

Jobs of Cells

In what ways are the organisms in the pictures alike? They all live in pond water, and like all living things, they are made of cells. A cell is the smallest unit that can carry out the activities of life.

Some organisms are made of only a single cell. The single-celled organisms shown on this page look very different. Yet each must perform the same tasks to stay alive. They must obtain nutrients and energy, remove waste products, grow, and reproduce.

Most single-celled organisms are too small to be seen without a microscope. Even though they are tiny, each cell is made of many parts that do a variety of jobs. For example, single-celled green algae absorb sunlight. They use the energy of sunlight to make food. The paramecium has hairlike structures that help it swim. In these one-celled organisms, each part of the cell performs a different task.

Larger organisms are made of many cells. Another way to say this is that larger organisms are multicellular. In multicellular organisms, different cells can do special tasks. In your body, for example, muscle cells are specialized for movement. Your skin cells, however, are specialized for protection. Since each type of cell does a different job, a multicellular organism can do many tasks efficiently.

1. **Checkpoint** How are cells in single-celled and multicellular organisms similar? How are they different?
2. **Math in Science** Because cells and their parts are so small, scientists measure them in micrometers, μm. Find out how large a micrometer is.

Using Microscopes to See Cells

Today scientists know a lot about cells. But for much of history, people didn't even know that cells existed. Because they are so small, cells were not discovered until the invention of the microscope.

Hooke saw dead cork cells through his microscope.

The first person to describe cells was Robert Hooke. Born in England in 1635, Hooke made a simple microscope with a series of lenses within a tube. Hooke used his microscope to examine thin layers of cork. Cork is the bark of the cork tree and is made of cells that are no longer alive. When Hooke looked at the cork through his microscope, what he saw looked like tiny rectangular rooms. Hooke called these structures "cells." Hooke wrote that in a cubic inch of the cork were more than 12 hundred million cells, which he described as "incredible."

About the same time Hooke was making his discovery, Dutch scientist Anton van Leeuwenhoek was building small, hand-held microscopes, each containing a single lens. He used his microscopes to look at pond water. In the water, he observed single-celled organisms, which he called "very little animalcules." Although his microscopes were small, they were powerful enough to see individual blood cells and bacteria.

The Cell Theory

Over hundreds of years, scientists learned more about cells. In 1838, Matthias Schleiden, a German scientist, concluded that all plants are made of cells. The next year, Theodore Schwann said that all animals are made of cells. Soon these scientists announced that all living things are made of cells.

Although the discoveries of Schleiden and Schwann added important knowledge to the field of science, scientists still didn't know where cells came from. Then in 1855, Rudolf Virchow, a German doctor, stated that all new cells come only from already existing cells. The observations of these and other scientists form the cell theory. You can read the three parts of the cell theory in the time line. Today scientists continue to learn more about cells as their microscopes become more powerful.

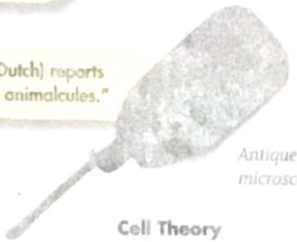
Lesson Checkpoint

1. Why was the development of the microscope important to the discovery of cells?
2. What are the three parts of the cell theory?
3. **Writing in Science** **Narrative** Write a journal entry as Hooke might have written it on the day he discovered cells. Be sure to use words that show Hooke's excitement.

Learning About Cells

1663 Robert Hooke (English) discovers cells.

1683 Anton van Leeuwenhoek (Dutch) reports observations of "very little animalcules."



Antique microscope

Cell Theory
- All living things are made of one or more cells.
- Cells are the basic units of living things.
- All cells come from existing cells.

1831 Robert Brown (Scottish) discovers the cell nucleus.

1838 Matthias Schleiden and Theodor Schwann (German) propose the cell theory.

1855, 1857 Rudolf Virchow (German) states that cells could come only from other living cells.

Albrecht von Kölliker (Swiss) finds mitochondria in muscle cells.

1865 Julius von Sachs (German) shows that chlorophyll is located in chloroplasts.

1875 Microscopes similar to those used today are in common use.

1931 Ernst Ruska and Max Knoll (German) invent the electron microscope

1953 George E. Palade (Romanian-American) describes ribosomes.

Lesson 2

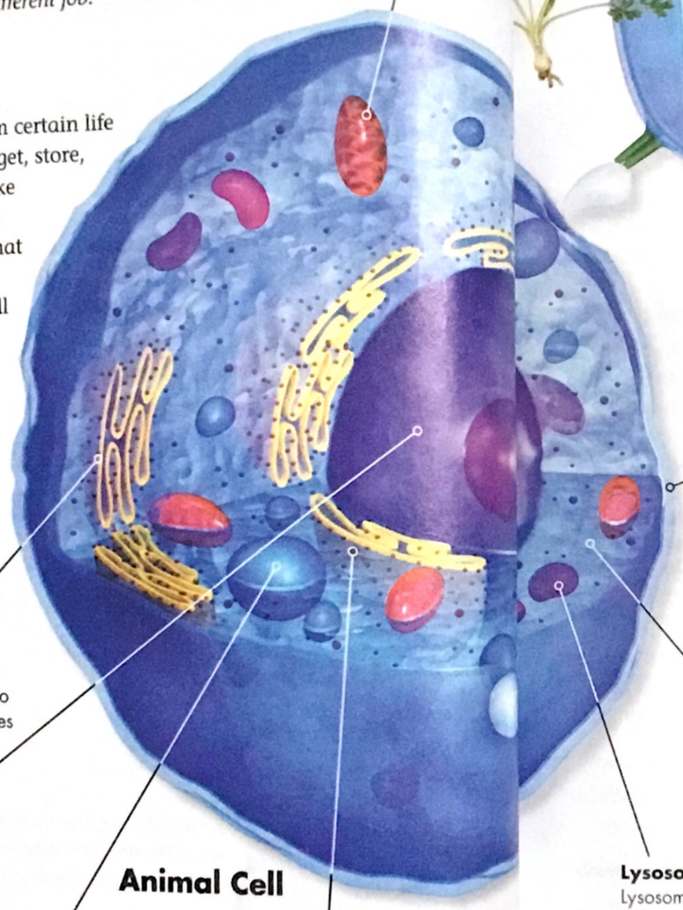
What are the functions of organelles?

Cells share common features, but they also show striking differences. Each cell part performs a different job.

Parts of a Cell

To stay alive, all cells must perform certain life functions. For example, a cell must get, store, and release energy. It must also make proteins, release wastes, and recycle materials. A cell needs to control what enters and exits it. Finally, a cell needs a "control center" to direct cell activities and store information.

These life tasks are performed by cell organelles. **Organelles** are structures that perform specific functions within the cell. As you read and study the diagram of an animal cell, notice the function of each organelle.



Mitochondrion
Mitochondria convert the chemical energy of food into a form that the cell can use.

Endoplasmic reticulum (ER)
The **endoplasmic reticulum** is a network of folded membranes. It serves as the cell's transportation system. It also helps make proteins and other substances needed by the cell.

Nucleus
The nucleus directs the cell's activities. It contains the cell's operating instructions and stores information that will be passed along to new cells.

Vacuole
A vacuole contains fluid and is surrounded by a membrane. Vacuoles store water and nutrients, and help the cell digest food.

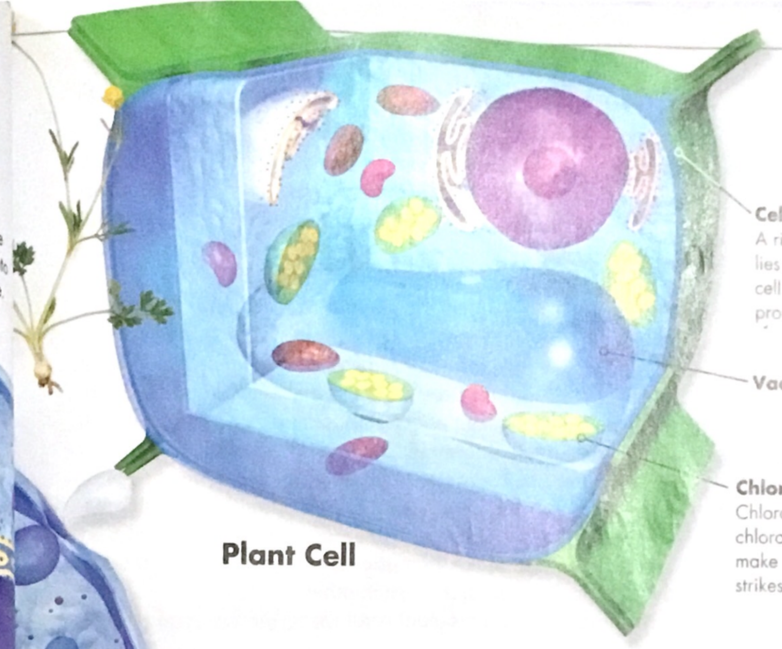
Ribosome
Ribosomes begin the process of making proteins.

Cell membrane
The cell membrane maintains the internal environment of the cell. It allows food to enter the cell and wastes to exit.

Cytoplasm
The cytoplasm is the fluid substance containing the organelles. It lies between the nucleus and the cell membrane.

Lysosome
Lysosomes contain powerful chemicals that break down harmful molecules and recycle worn-out cell parts.

Animal Cell



Cell wall
A rigid cell wall lies just outside the cell membrane. It provides support.

Vacuole

Chloroplast
Chloroplasts contain chlorophyll. Plants make food when sunlight strikes chlorophyll.

Plant Cell

In a multicellular organism, different kinds of cells have different roles. Cells with different functions may have different organelles or a different number of organelles. For example, your muscle cells have many mitochondria—sometimes hundreds or thousands of them—because muscle cells need a lot of energy to cause movement. Skin cells do not have as many mitochondria.

You may have guessed that plant cells and animal cells differ in some ways. Plants cells contain chloroplasts, the organelles that contain chlorophyll. Plants need chlorophyll to carry on photosynthesis.

Compare the plant and animal cells. Do you notice any other differences between the two cells? Most plant cells have one large vacuole. Animal cells have many smaller vacuoles. Now look at the outside of the plant cell. It has a cell wall, which animal cells do not have.

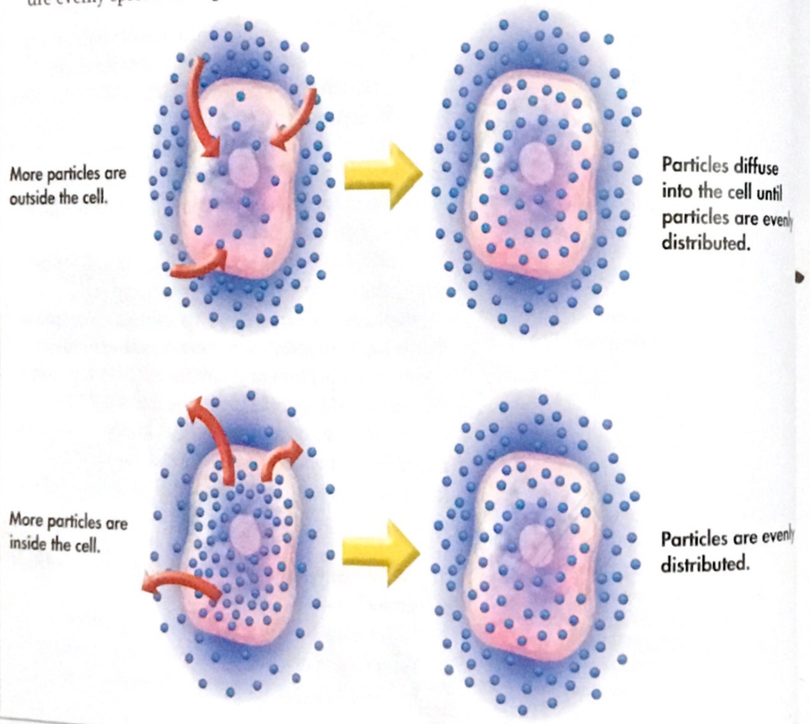
1. **Checkpoint** How are animal cells and plant cells similar? How are they different?
2. **Make Inferences** A brain cell contains thousands of mitochondria. What can you infer from this information about the brain's need for energy?

Diffusion

You already know that a cell has many organelles. But did you know that a cell—especially its cytoplasm—is mostly water? In fact, about two-thirds of the mass of a cell is water. Substances needed by the cell, such as nutrients or salts, are dissolved in the water. Where do these dissolved substances come from?

In most cases, a substance moves from an area where it is plentiful to other areas where it is less plentiful. For example, think about dropping a sugar cube into a glass of iced tea. What happens? Even if you don't stir it, individual particles of sugar slowly move away from those in the cube. Eventually, all of the sugar particles will diffuse, or spread, throughout the iced tea. The movement of a substance from an area of its higher concentration to an area of its lower concentration is called **diffusion.** Some substances enter and leave a cell through this process. The diagram below shows what happens during diffusion.

Diffusion occurs because the particles that make up matter are always moving. As they move, the particles bump into each other and move apart. Over time, the particles will spread out until they are evenly spread throughout the area.



The Cell Membrane

The cell needs many substances. The cell membrane controls the environment inside the cell. Only some substances can pass through a cell membrane by diffusion. Many substances that are made of small particles, such as oxygen, water, and carbon dioxide, can diffuse through the cell membrane. Larger particles, such as salts and proteins, cannot.

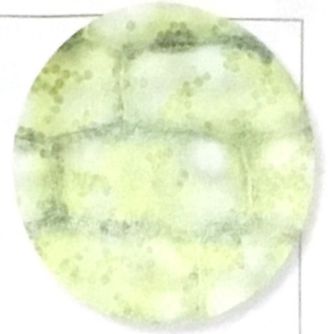
Here's how diffusion works in a cell. Cells of living things are surrounded by water, and they contain a lot of water. The water both inside and outside the cell contains many dissolved substances, including oxygen. The cell constantly uses oxygen, so more oxygen particles usually are in the water surrounding a cell than inside the cell. The particles of oxygen move through the cell membrane from outside the cell—where there are more of them—into the cell—where there are less.

Diffusion of Water

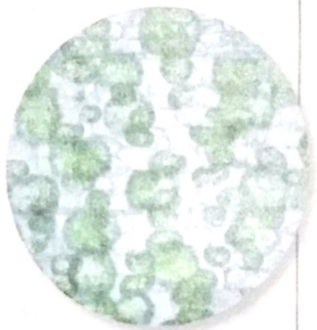
Because cells can't function without water, the movement of water through the cell membrane is very important. The diffusion of water across the cell membrane is called **osmosis.**

You can see in the pictures what can happen if a cell doesn't have enough water. It will shrink. Can you see in the photos how the cytoplasm has pulled away from the cell wall? When that happens, the pressure on the cell wall is reduced. The result is that the cell walls of the plant can't support the plant, and the plant wilts.

Too much water can be a problem—especially for animal cells. If too much water moves into the cell, it can burst. The cell membrane helps the cell keep a proper balance of all the materials inside the cell.



Normal plant cells



Cells in a wilted plant

A plant wilts when its cells lose water.

Lesson Checkpoint

1. What important function does the cell membrane have in the cell?
2. Use the following words in a sentence: *water, osmosis, cell, cell membrane.*
3. Writing in Science **Descriptive** Write a paragraph to describe the parts and processes in a cell by comparing them to a factory. For example, the nucleus might be the supervisor of the factory, who makes important decisions.

Lesson 3

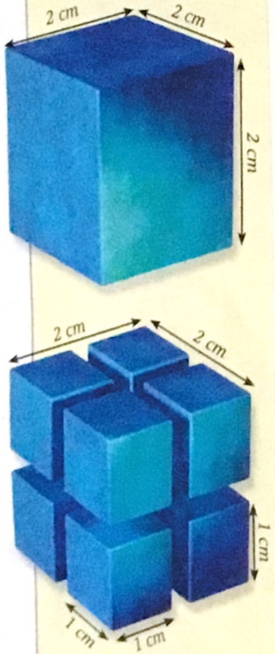
How do cells grow and divide?

As multicellular organisms grow in size, their cells increase in number. New cells also form to replace old or damaged cells. Cells make new cells through the processes of mitosis and cell division.

Surface Area

As a cell gets larger, it needs more food and produces more wastes. During growth, both the cell membrane and the organelles within it get larger. But the volume of the materials inside the cell grows faster than the surface area—the area of the cell membrane. Sooner or later there isn't enough cell membrane to allow enough materials into and out of the cell.

To see how this works, look at the diagram. The total amount of material inside the eight smaller cells is equal to the amount in the large cell. But which has more surface area—the eight smaller cells or the larger one?



Cell Size and Growth

All living things—no matter how large or how small—are made of cells. Some cells are long and narrow, some are thin and flat, and others are round. Some cells, such as red blood cells, are even donut-shaped. But when it comes to size, all cells are similar—they are small.

To understand why cells are small, think about a cell's needs. To stay alive, a cell must take in oxygen, absorb food, and release wastes. These materials and others must move through all parts of the cell. Throughout the cells, materials constantly move between the cell membrane and organelles. Materials also move from organelle to organelle.

As a cell gets larger, the trip from the cell membrane to other cell parts gets longer. A particle of sugar would have to travel farther in a large cell than in a small cell. Wastes, too, would have to travel farther to exit the cell. If a cell grew too large, materials would not be able to move fast enough throughout the cell for life functions to continue. If that happened, the cell would die.

Chromosomes are made up of coils of DNA. Like beads on a string, the DNA is wrapped around proteins that help to form a coil. The coiled DNA is protected from damage during cell division.

A cell's chromosomes contain the instructions to build all of the cell's proteins.

Cell Division

If cells can only get so large, how do organisms grow? Single-celled organisms divide into two new cells when they get too large. For a multicellular organism to grow, its cells must also divide into two new cells. Each cell will be a copy of the old cell. As new cells form, the organism grows larger. Cell division also makes new cells to replace old cells that are damaged or worn out.

Cell division begins with **mitosis,** the process in which the cell nucleus divides. The cell's nucleus contains **DNA,** a material that stores coded information about how an organism will grow and develop. The cell needs this information to make proteins, which control chemical reactions in the cell. Usually you don't see the DNA in cells. But when mitosis begins, DNA coils tightly to form bodies called **chromosomes.** You can see the cell's chromosomes as rod-shaped structures like those in the photo above.

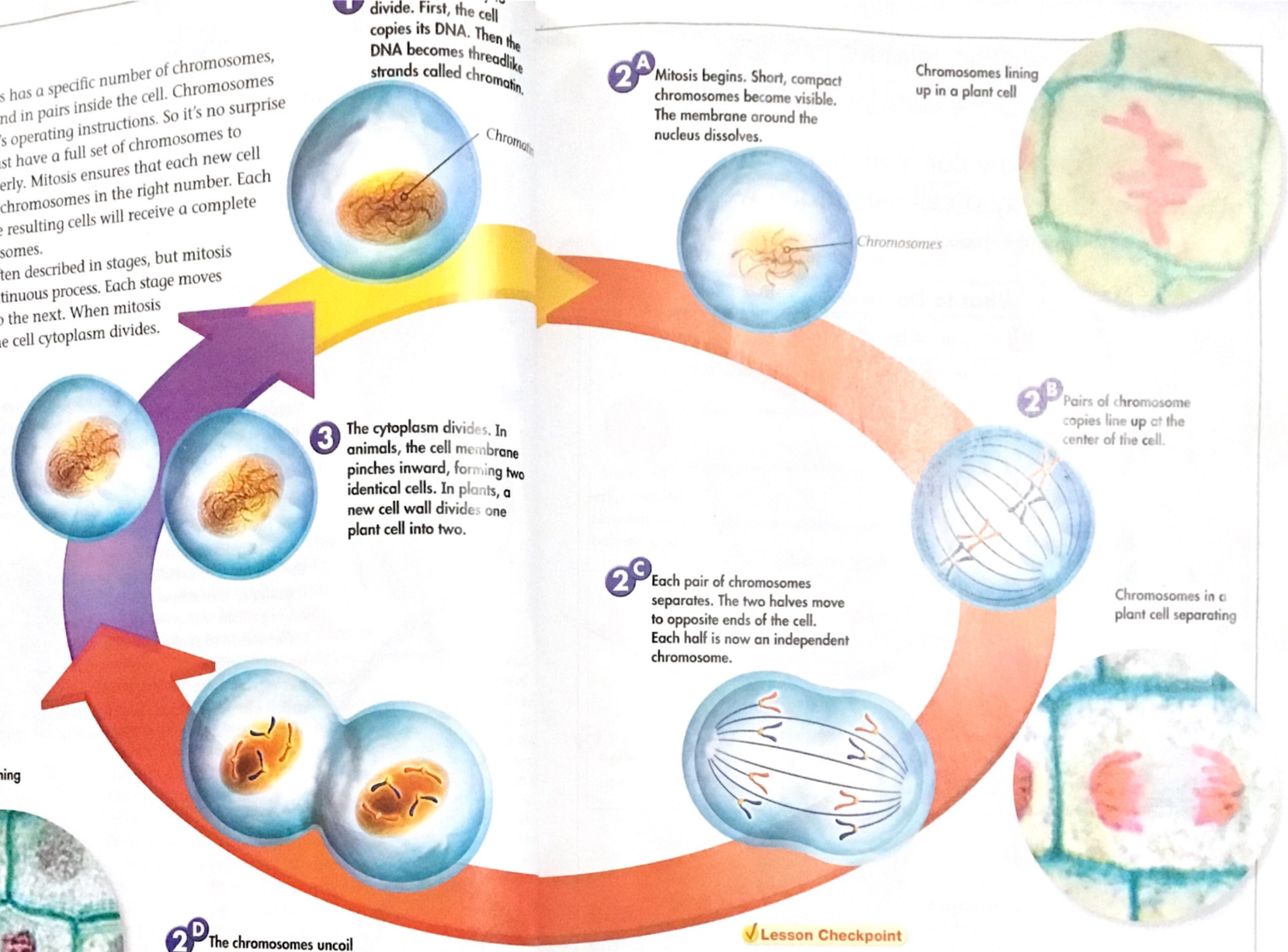
DNA is often compared to a ladder.

1. **Checkpoint** Why can a cell get only so large?
2. **Make Inferences** The roots of a tree are growing. What process is going on in the root cells to make this happen?

Mitosis

Every species has a specific number of chromosomes, which are found in pairs inside the cell. Chromosomes contain a cell's operating instructions. So it's no surprise that a cell must have a full set of chromosomes to function properly. Mitosis ensures that each new cell gets the right chromosomes in the right number. Each nucleus in the resulting cells will receive a complete set of chromosomes.

Mitosis is often described in stages, but mitosis is really a continuous process. Each stage moves smoothly into the next. When mitosis is finished, the cell cytoplasm divides.



Chromosomes lining up in a plant cell

Chromosomes in a plant cell separating

Cell wall forming in plant cell

Lesson Checkpoint

1. Why is it important that a cell copy its DNA before mitosis takes place?
2. How does cell division in animals differ from cell division in plants?
3. Writing in Science **Narrative** Write a first-person narrative of the events of cell division from the viewpoint of a cell undergoing mitosis.

Math in Science

Measuring Cells

Most cells are very small—too small to be seen without any scientific instrument. A bacteria cell is about 0.000001 m (1 millionth of a meter) long. A human white blood cell is only about 0.000012 m in diameter.

Rather than writing small numbers with so many zeros, scientists use prefixes to make more appropriate units for discussing cell sizes. You have already worked with some of these prefixes, such as *milli-*, *centi-*, and *deci-*. You have also worked with the unit kilometer for measuring longer lengths or distances.

The most common unit used for the size of cells is the micrometer. The prefix *micro-* is abbreviated μ (μ is the Greek letter *mu*). The prefix *micro-* means "one millionth." You already know how large a meter is. A micrometer is one millionth of a meter or one thousandth of a millimeter.

Instead of writing the size of a bacteria cell as 0.000001 m or 0.001 mm, we can write it as 1 μm. A white blood cell is about 12 μm in diameter. Frog eggs are cells that are nearly 1,000 times as long as bacteria cells, so they measure about 1,000 μm, or 1 mm.

ORGANISM	SIZE
Average animal cell	10 μm
Euglena	50 μm
Volvox colony	100 μm
Ceratium	500 μm

1. The largest known cell is the yolk of an ostrich egg. It is about the size of a baseball. Which unit would be most appropriate and convenient to use to measure an ostrich egg yolk?
   A. kilometer
   B. centimeter
   C. millimeter
   D. micrometer

2. Use the chart on page 44 to list these microscopic organisms in order from smallest to largest: Volvox colony, average animal cell, Euglena, Ceratium.

3. Red blood cells carry oxygen. Look at the chart of red blood cell sizes of some mammals.

Mammal	Size of Red Blood Cell
Human	7.5 μm
Elephant	9.2 μm
Gerbil	6.1 μm
Zebra	5.1 μm
Orca	6.8 μm

Write the data in sequential order, starting with the smallest red blood cell. Can you conclude that the larger the animal, the larger their red blood cells will be? Explain.

4. Flea egg cells are about 0.5 mm long. Human platelet cells, which help blood clot, are about 2 μm long. Which is longer? Explain how you know.

Enlarged frog egg

Enlarged white blood cell

Lab zone Take-Home Activity

Measure the length of five or more objects at home. Use each of the following units at least once: meter, centimeter, millimeter. Be sure to use an appropriate unit for the object being measured. Make a list of the objects and the length of each.

Chapter 2 Review and Test Prep

Use Vocabulary

chromosome (p. 39)	**mitochondria** (p. 34)
diffusion (p. 36)	**mitosis** (p. 39)
DNA (p. 39)	**organelle** (p. 34)
endoplasmic reticulum (p. 34)	**osmosis** (p. 37)
	ribosome (p. 34)

Match each definition with a term from the box.

1. The diffusion of water across a cell membrane
2. Cell organelle that begins the process of making proteins
3. Structure in the nucleus made up of long, threadlike DNA coils
4. The process in which the cell nucleus divides during the production of two cells with identical DNA
5. The movement of a substance from an area of its higher concentration to an area of its lower concentration
6. Cell organelles that convert the chemical energy of food into a form the cell can use
7. The material that stores coded information about how an organism will grow and develop
8. A network of folded membranes in the cell's cytoplasm that transports materials and assembles proteins and other substances needed by the cell
9. Structure that performs a specific function within a cell

Explain Concepts

10. What are the three parts of the cell theory?
11. Explain how organelles are specialized to perform various tasks in a cell.

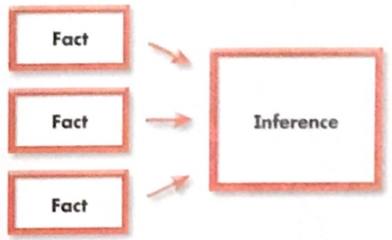
Process Skills

12. **Classify** You look at a cell under the microscope and note that it has a nucleus, a large vacuole, a cell wall, and chloroplasts. Does this cell belong to a plant or animal? How do you know?
13. **Predict** A new cell forms. The cell continues to grow but does not divide. Predict what will happen to the cell and explain why.
14. **Model** Make a diagram to show the process of osmosis.

Make Inferences

15. Read the paragraph. Then complete the graphic organizer to make an inference to answer this question: Where does photosynthesis take place in a plant?

> Plants have many kinds of cells, and each kind of cell has a different job. Leaf cells are packed with chloroplasts. The chloroplasts contain chlorophyll, which absorbs sunlight. Plants use the energy in sunlight to make glucose during photosynthesis. Root cells, however, usually do not have chloroplasts.



Test Prep

Choose the letter that best completes the statement or answers the question.

16. A cell with chloroplasts is probably specialized for
    - Ⓐ transmitting nerve impulses.
    - Ⓑ storing food.
    - Ⓒ absorbing sunlight.
    - Ⓓ movement.
17. Which organelle provides support to help plants stand upright?
    - Ⓕ cell membrane
    - Ⓖ chloroplast
    - Ⓗ nucleus
    - Ⓘ cell wall
18. Which activity occurs in a mitochondrion?
    - Ⓐ Energy the cell can use is released.
    - Ⓑ Water and nutrients are stored.
    - Ⓒ Proteins are made.
    - Ⓓ Worn-out cell parts are recycled.
19. Explain why the answer you chose for Question 16 is best. For each of the answers you did not choose, give a reason why it is not the best choice.
20. **Writing in Science** **Descriptive** Suppose that you are a travel agent. You are planning a tour of a cell. Write a brochure describing some of the features that travelers will see on their tour.