Chapter 4

Cell Processes and Energy

CALIFORNIA Standards Preview

S 7.1 All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:

- **d.** Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.
- **e.** Students know cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.
- **f.** Students know that as multicellular organisms develop, their cells differentiate.

S 7.2 A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences. As a basis for understanding this concept:

- **e.** Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.

Sunlight on these maple leaves powers the process of photosynthesis. ▶

Video Preview
Discovery Channel School
Cell Processes and Energy

S 7.1.d

Focus on the BIG Idea

How do cells obtain the energy they need to carry out all their functions?

Check What You Know

Hummingbirds feed on the nectar produced by flowers. Nectar is a sweet liquid composed largely of carbohydrates. What does nectar provide for the cells of the hummingbird?

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

Greek Word Origins

Many English science words come from ancient Greek words. One example is the word *photograph*. The first part of *photograph* comes from the Greek word *photos*, which means "light." The second part comes from *graphos*, which means "written" or "recorded." A photograph is a picture recorded by using light.

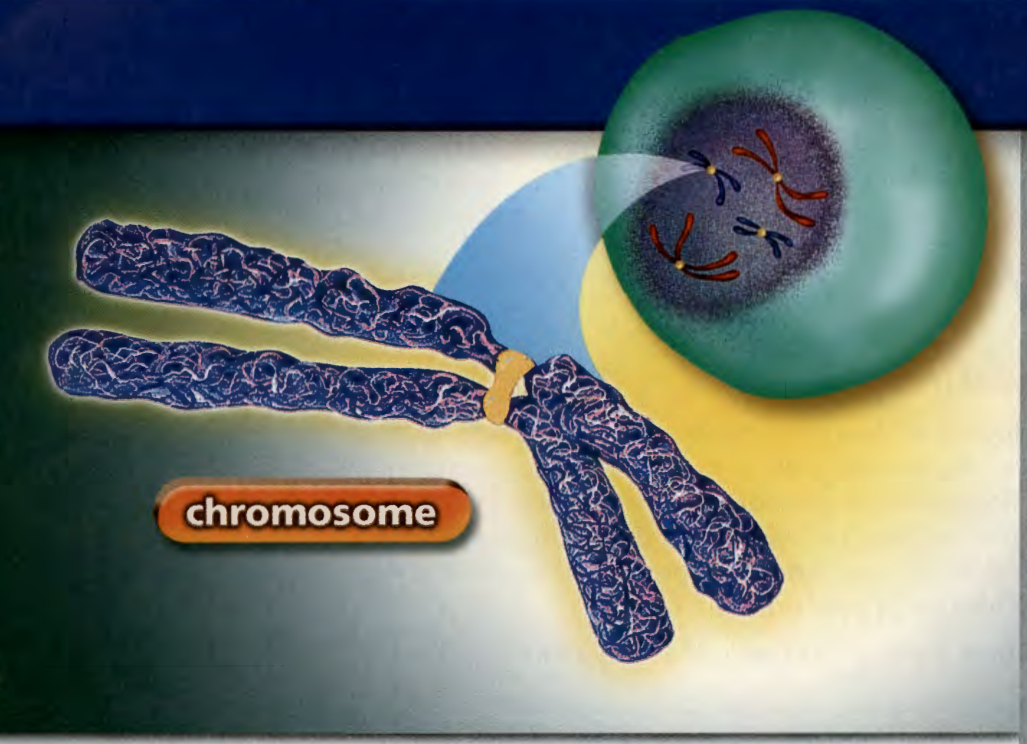
The table below shows three Greek words that are sources of some key terms in this chapter. (Recall from Chapter 3 that prefixes are word parts placed at the beginning of a root word to change its meaning.)

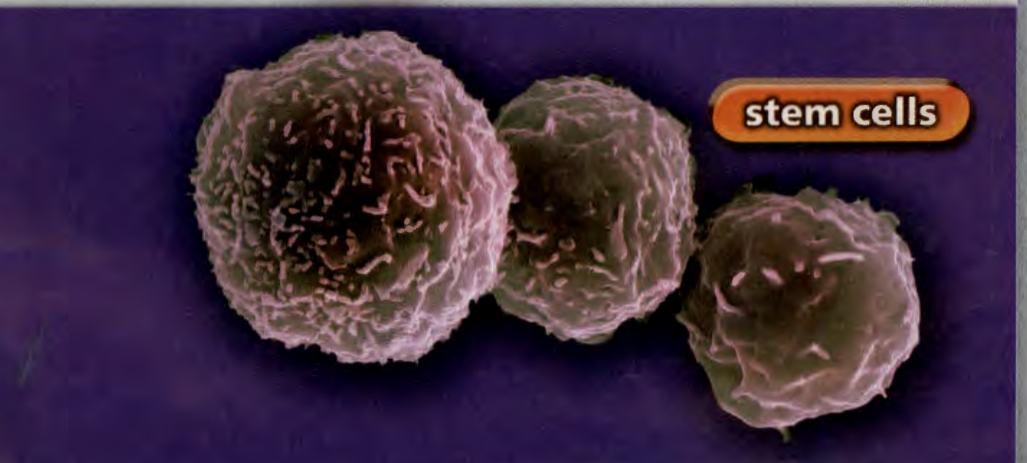
Greek Word	Meaning of Greek Word	Key Term
auto-	self	**autotroph** An organism that makes food for itself
hetero-	other, different	**heterotroph** An organism that depends on other organisms for food
kinesis	motion	**cytokinesis** During cell division, the process in which a cell's cytoplasm divides and organelles move into the two new cells that form

Apply It!

The Greek word *trophe* means "food." What two key terms in the table come from this Greek word? How does the meaning of each of these words put two Greek words together?

Chapter 4 Vocabulary





Section 1 (page 118)
photosynthesis
autotroph
heterotroph
pigment
chlorophyll
stomata

Section 2 (page 123)
respiration
fermentation

Section 3 (page 129)
cell cycle
interphase
replication
mitosis
chromosome
cytokinesis

Section 4 (page 138)
differentiation
stem cell

Interactive Textbook

Build Science Vocabulary *Online*
Visit: PHSchool.com
Web Code: cvj-1040

How to Read Science

Reading Skill

Create Outlines

In an outline, you show the relationship between main ideas and supporting ideas. An outline is usually set up like the example shown below. Roman numerals show the main topics. Capital letters and regular numerals show the subtopics. Use the chapter's headings, subheadings, Key Concepts, and Key Terms to help you decide what to include in your outline.

Look at the outline for the first part of Section 2 in this chapter.

Respiration

I. What Is Respiration?
  A. Respiration—process by which cells get energy from glucose
  B. During respiration, cells
    1. Break down simple food molecules such as sugar
    2. Release the energy in the molecules
  C. Storing and Releasing Energy
    1. Photosynthesis—plants capture sunlight's energy, store as carbohydrates
    2. Respiration—plants use stored energy by breaking down carbohydrates

Apply It!

1. What is the one main topic in the partial outline above? How do you indicate main topics in an outline?
2. How many subtopics appear under **B** in the outline above? What are these subtopics?

When you read Section 2, complete the outline above. Also make an outline of Section 4.

Lab zone

Standards Investigation

S 7.1.d

Shine On!

Every morning when the sun rises, tiny living factories start a manufacturing process called photosynthesis. The power they use is sunlight. In this investigation, you will study how light affects one familiar group of photosynthesizers—plants.

Your Goal

To determine how different lighting conditions affect the health and growth of plants

To complete the investigation, you will

- write up a plan to grow plants under different lighting conditions
- care for your plants daily, and keep careful records of their health and growth for three weeks
- graph your data, and draw conclusions about the effect of light on plant growth
- follow the safety guidelines in Appendix A

Plan It!

Brainstorm with classmates to answer these questions: What different light conditions might you test? What plants will you use? How will you measure health and growth? How can you be sure your results are due to the light conditions? Write up your plan and submit it to your teacher.

Section 1

Photosynthesis

CALIFORNIA Standards Focus

S 7.1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

- How does the sun supply living things with the energy they need?
- What happens during the process of photosynthesis?

Key Terms

- photosynthesis
- autotroph
- heterotroph
- pigment
- chlorophyll
- stomata

Lab zone Standards Warm-Up

Where Does the Energy Come From?

1. Obtain a solar-powered calculator that does not use batteries. Place the calculator in direct light.
2. Cover the solar cells with your finger. Note how your action affects the number display.
3. Uncover the solar cells. What happens to the number display?
4. Now cover all but one of the solar cells. How does that affect the number display?

Think It Over

Inferring From your observations, what can you infer about the energy that powers the calculator?

On a plain in Africa, a herd of zebras peacefully eat the grass. But watch out—the zebras' grazing will soon be harshly interrupted. A group of lions is about to attack the herd. The lions will kill one of the zebras and eat it.

Both the zebras and the lions use the food they eat to obtain energy. Every living thing needs energy. All cells need energy to carry out their functions, such as making proteins and transporting substances into and out of the cell. The zebra's meat supplies the lion's cells with the energy they need, just as the grass provides the zebra's cells with energy. But plants and certain other organisms, such as algae and some bacteria, obtain their energy in a different way. These organisms use the energy in sunlight to make their own food.

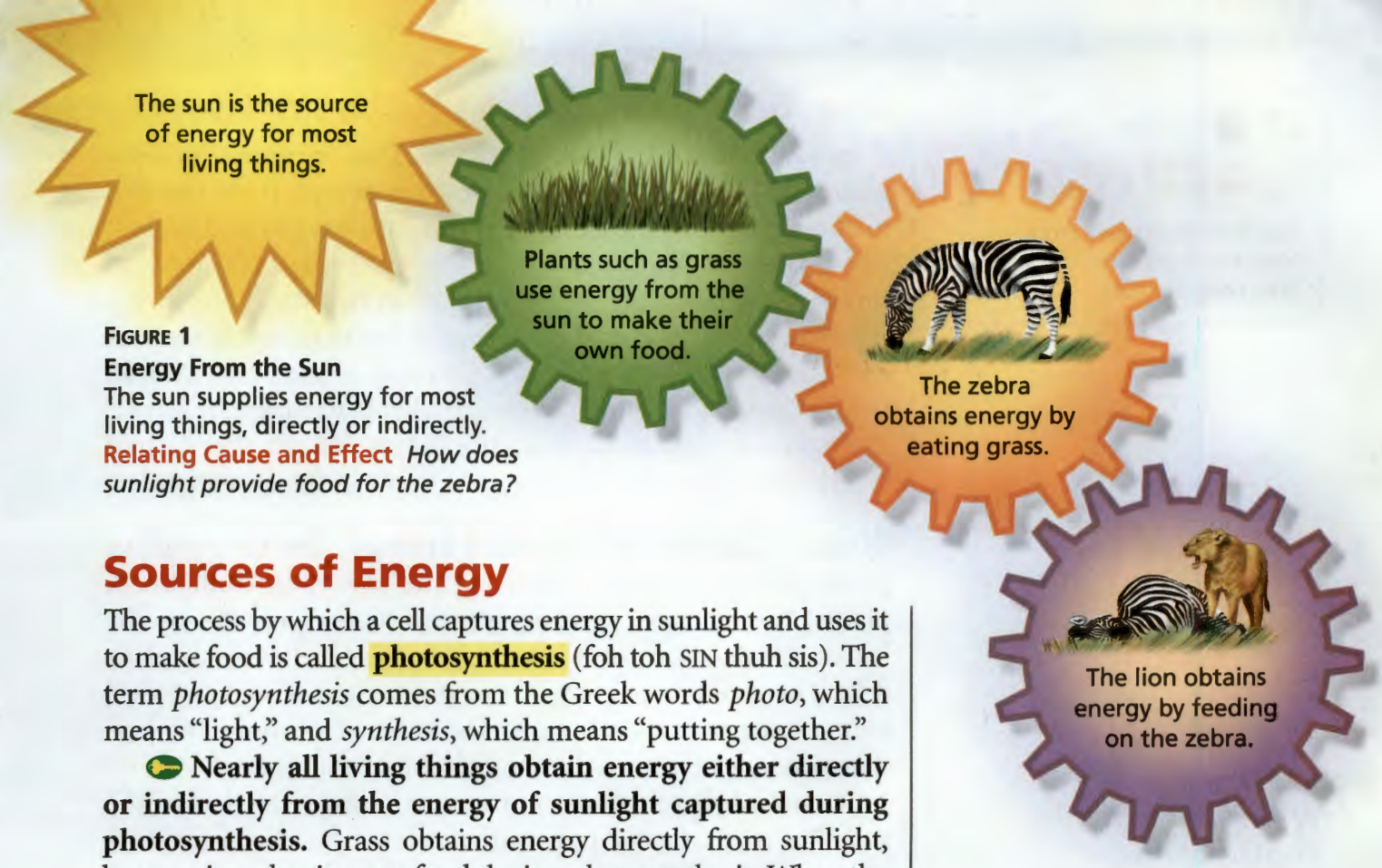


FIGURE 1
Energy From the Sun
The sun supplies energy for most living things, directly or indirectly.
Relating Cause and Effect *How does sunlight provide food for the zebra?*

Sources of Energy

The process by which a cell captures energy in sunlight and uses it to make food is called **photosynthesis** (foh toh SIN thuh sis). The term *photosynthesis* comes from the Greek words *photo*, which means "light," and *synthesis*, which means "putting together."

Nearly all living things obtain energy either directly or indirectly from the energy of sunlight captured during photosynthesis. Grass obtains energy directly from sunlight, because it makes its own food during photosynthesis. When the zebra eats the grass, it gets energy that has been stored in the grass. Similarly, the lion obtains energy stored in the zebra. The zebra and lion both obtain the sun's energy indirectly, from the energy that the grass obtained through photosynthesis.

Plants manufacture their own food through the process of photosynthesis. An organism that makes its own food is called an **autotroph** (AWT oh trohf). An organism that cannot make its own food, including animals such as the zebra and the lion, is called a **heterotroph** (HET ur oh trohf). Many heterotrophs obtain food by eating other organisms. Some heterotrophs, such as fungi, absorb their food from other organisms.

Reading Checkpoint **What are autotrophs?**

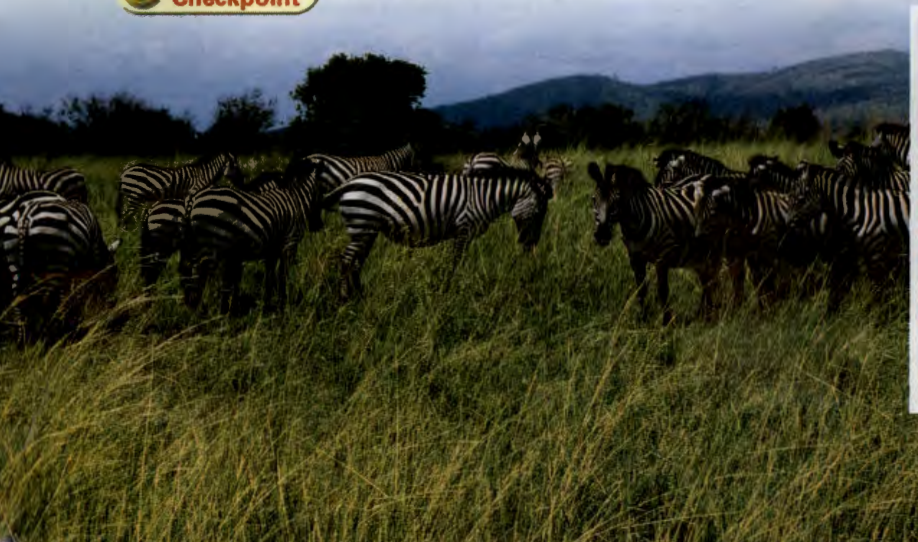


FIGURE 2
Autotrophs and Heterotrophs
Grass, which makes its own food during photosynthesis, is an autotroph. Zebras and lions are heterotrophs, because they cannot make their own food.

Go Online
active art
For: The Photosynthesis Process
Visit: PHSchool.com
Web Code: cep-1042

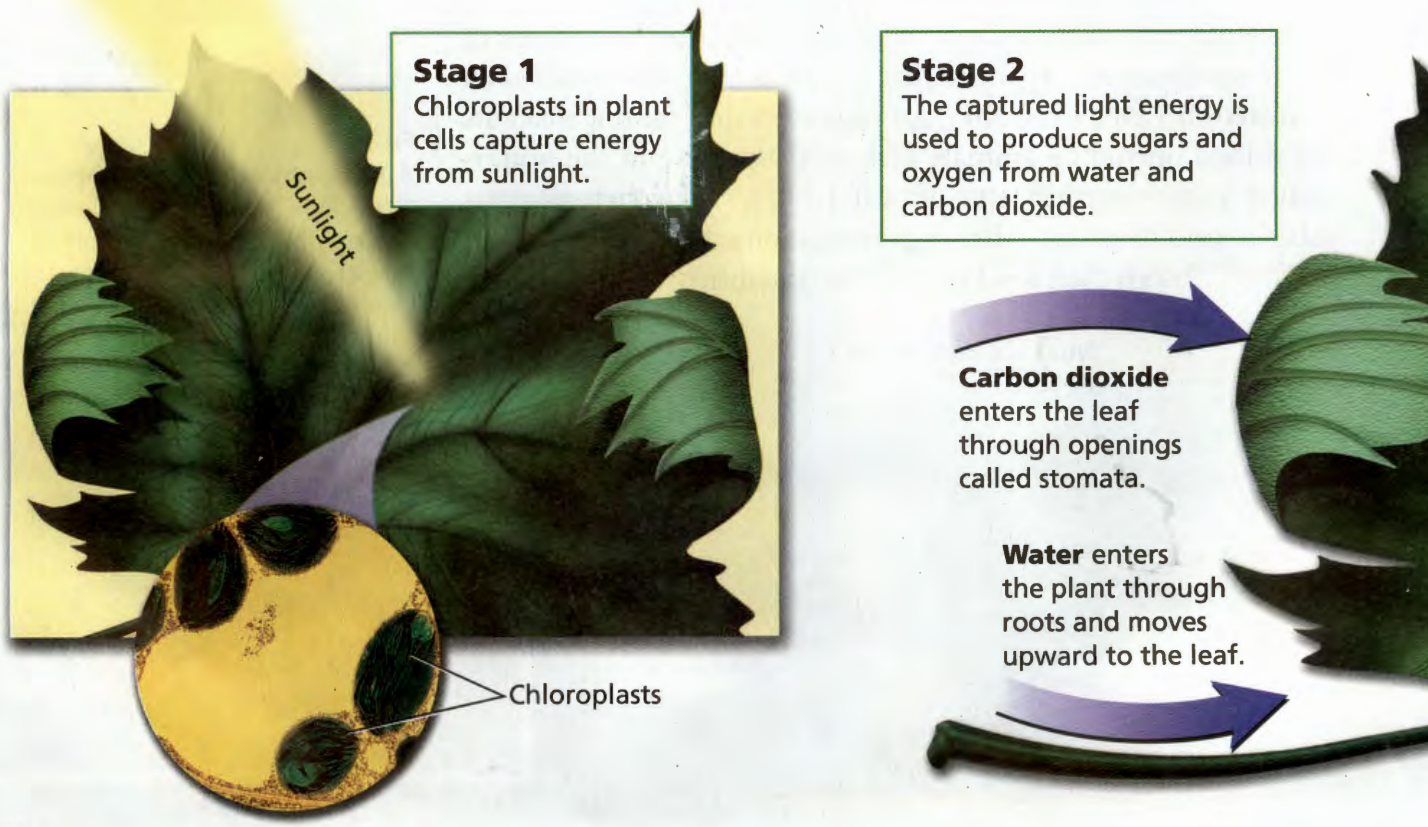
The Two Stages of Photosynthesis

Photosynthesis is a complex process. **During photosynthesis, plants and some other organisms use energy from the sun to convert carbon dioxide and water into oxygen and sugars.** The process of photosynthesis is shown in Figure 3. You can think of photosynthesis as taking place in two stages: capturing the sun's energy and producing sugars. You're probably familiar with many two-stage processes. To make a cake, for example, the first stage is to combine the ingredients to make the batter. The second stage is to bake the batter. To get the desired result—the cake—both stages must occur in the correct order.

Stage 1: Capturing the Sun's Energy The first stage of photosynthesis involves capturing the energy in sunlight. In plants, this energy-capturing process occurs mostly in the leaves. Recall that chloroplasts are green organelles inside plant cells. The green color comes from **pigments,** colored chemical compounds that absorb light. The main photosynthetic pigment in chloroplasts is **chlorophyll** (KLAWR uh fil).

Chlorophyll functions in a manner similar to that of the solar "cells" in a solar-powered calculator. Solar cells capture the energy in light and use it to power the calculator. Similarly, chlorophyll captures light energy and uses it to power the second stage of photosynthesis.

FIGURE 3
Two Stages of Photosynthesis
Photosynthesis has two stages, as shown in the diagram.
Interpreting Diagrams *Which stage requires light?*



Stage 2: Using Energy to Make Food In the next stage of photosynthesis, the cell uses the captured energy to produce sugars. The cell needs two raw materials for this stage: water (H_2O) and carbon dioxide (CO_2). In plants, the roots absorb water from the soil. The water then moves up through the plant's stem to the leaves. Carbon dioxide is one of the gases in the air. Carbon dioxide enters the plant through small openings on the undersides of the leaves called **stomata** (STOH muh tuh) (singular *stoma*). Once in the leaves, the water and carbon dioxide move into the chloroplasts.

Inside the chloroplasts, the water and carbon dioxide undergo a complex series of chemical reactions. The reactions are powered by the energy captured in the first stage. These reactions produce chemicals as products. One product is a sugar that has six carbon atoms. Six-carbon sugars have the chemical formula $C_6H_{12}O_6$. Recall that sugars are a type of carbohydrate. Cells can use the energy in the sugar to carry out important cell functions.

The other product of photosynthesis is oxygen (O_2), which exits the leaf through the stomata. In fact, almost all the oxygen in Earth's atmosphere was produced by living things through the process of photosynthesis.

Reading Checkpoint **What makes plants green?**

Lab zone Try This Activity

Looking at Pigments

You can observe the pigments in a leaf.

1. Cut a strip 5 cm by 20 cm out of a paper coffee filter.
2. Place a leaf on top of the paper strip, about 2 cm from the bottom.
3. Roll the edge of a dime over a section of the leaf, leaving a narrow band of color on the paper strip.
4. Pour rubbing alcohol into a plastic cup to a depth of 1 cm. Stand the paper strip in the cup so the color band is about 1 cm above the alcohol. Hook the other end of the strip over the top of the cup.
5. After 10 minutes, remove the paper strip and let it dry. Observe the strip.
6. Wash your hands.

Inferring What does the paper strip's appearance reveal about leaf pigments?

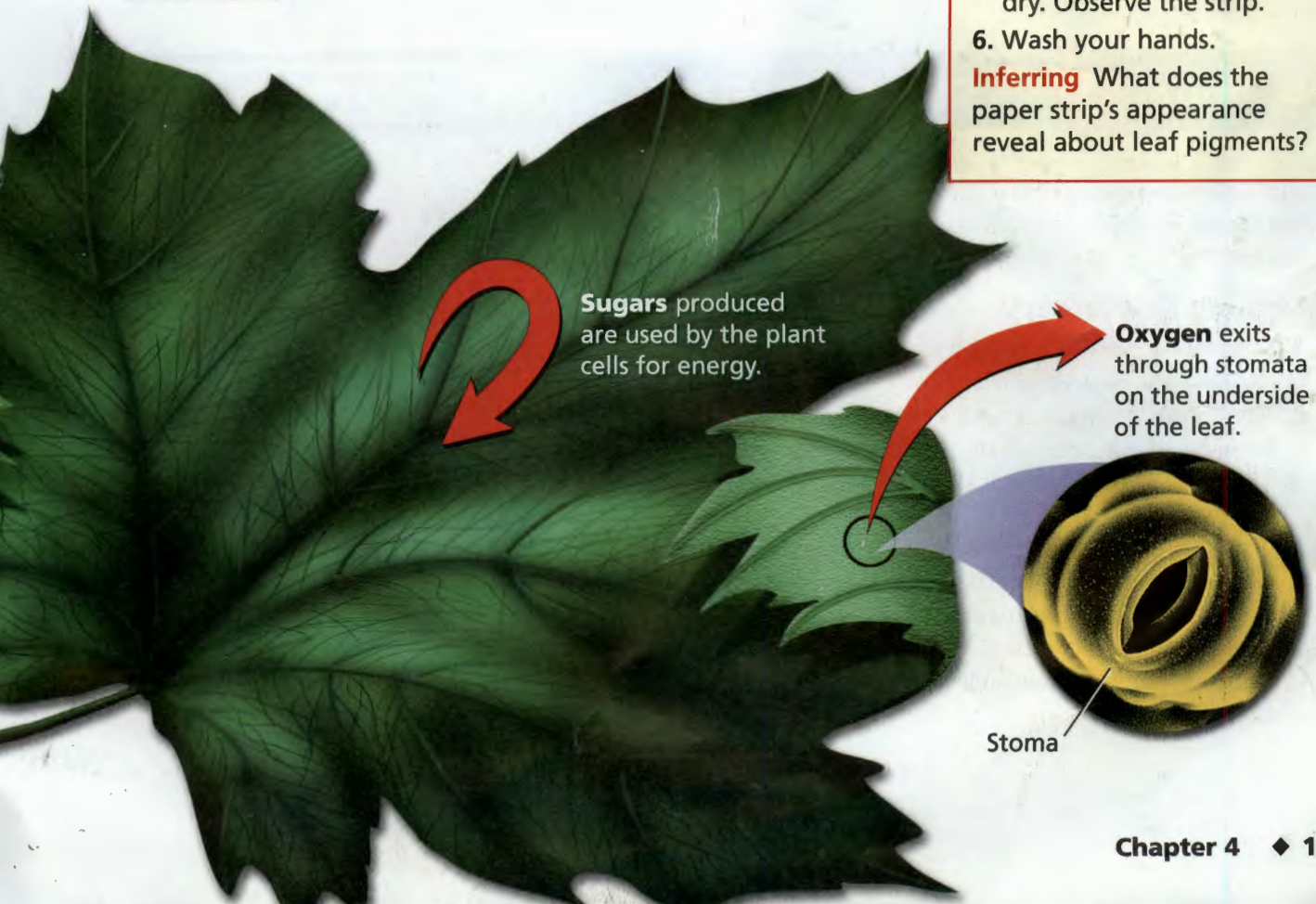


FIGURE 4
Stored Energy
When you eat a carrot, you obtain energy stored during photosynthesis.

The Photosynthesis Equation The events of photosynthesis can be summed up by the following chemical equation:

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6\,O_2$$

carbon dioxide + water → a sugar + oxygen

Notice that the raw materials—six molecules of carbon dioxide and six molecules of water—are on the left side of the equation. The products—one molecule of a sugar and six molecules of oxygen—are on the right side of the equation. An arrow, which you can read as "yields," connects the raw materials to the products. Light energy, which is necessary for the chemical reaction to occur, is written above the arrow.

What happens to the sugar produced in photosynthesis? Plant cells use some of the sugar for food. The cells break down the sugar molecules to release the energy they contain. This energy can then be used to carry out the plant's functions. Some sugar molecules are converted into other compounds, such as cellulose. Other sugar molecules may be stored in the plant's cells for later use. When you eat food from plants, such as potatoes or carrots, you are eating the plant's stored energy.

Reading Checkpoint **In the photosynthesis equation, what does the arrow mean?**

Section 1 Assessment

S 7.1.d, E-LA: Reading 7.1.2, Writing 7.2.0

Build Science Vocabulary Greek Word Origins
What clue in the Key Term **photosynthesis** lets you know that the term has something to do with light?

Reviewing Key Concepts

1. a. **Reviewing** Why do living things need energy?
   b. **Explaining** How do plants obtain energy?
   c. **Applying Concepts** An insect eats a leaf. Explain how the insect depends on the sun for energy.
2. a. **Reviewing** What chemical equation sums up the events of photosynthesis?
   b. **Comparing and Contrasting** What are the substances needed for photosynthesis? What substances are produced during photosynthesis?
   c. **Making Generalizations** Would you expect a plant to produce more oxygen on a cloudy day or a sunny day? Explain.

Writing in Science

Job Qualifications When people apply for jobs, they must describe their qualifications for the job. Suppose that you are a leaf, and that you are applying for a job in a photosynthesis factory. Write a paragraph in which you summarize your qualifications for the job of photosynthesis. Your paragraph should include the following words: *chloroplasts, chlorophyll, light, energy, water, carbon dioxide,* and *stomata*.

Section 2

Respiration

CALIFORNIA Standards Focus

S 7.1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

- What events occur during respiration?
- What is fermentation?

Key Terms

- respiration
- fermentation

Lab zone **Standards Warm-Up**

What Is a Product of Respiration?

1. Put on your goggles. Fill two test tubes half full of warm water. Add 5 mL of sugar to one of the test tubes. Put the tubes in a test-tube rack.
2. Add 0.5 mL of dried yeast (a single-celled organism) to each tube. Stir the contents of each tube with a straw. Place a stopper snugly in the top of each tube.
3. Observe any changes that occur in the two test tubes over the next 10 to 15 minutes.

Think It Over

Observing What changes occurred in each test tube? How can you account for any differences that you observed?

You and your friend have been hiking all morning. You look for a flat rock to sit on, so you can eat lunch. The steepest part of the trail is ahead. You'll need a lot of energy to get to the top of the mountain. That energy will come from food.

Before food can provide your body with energy, it must pass through your digestive system. There, the food is broken down into small molecules. These molecules can then pass into your bloodstream. Next, the molecules travel through the bloodstream to the cells of your body. Inside the cells, the energy in the molecules is released. In this section, you'll learn how your body's cells obtain energy from the food you eat.

FIGURE 5
Energy
Vigorous exercise, such as hiking, requires a lot of energy. All the energy your body uses comes from food.

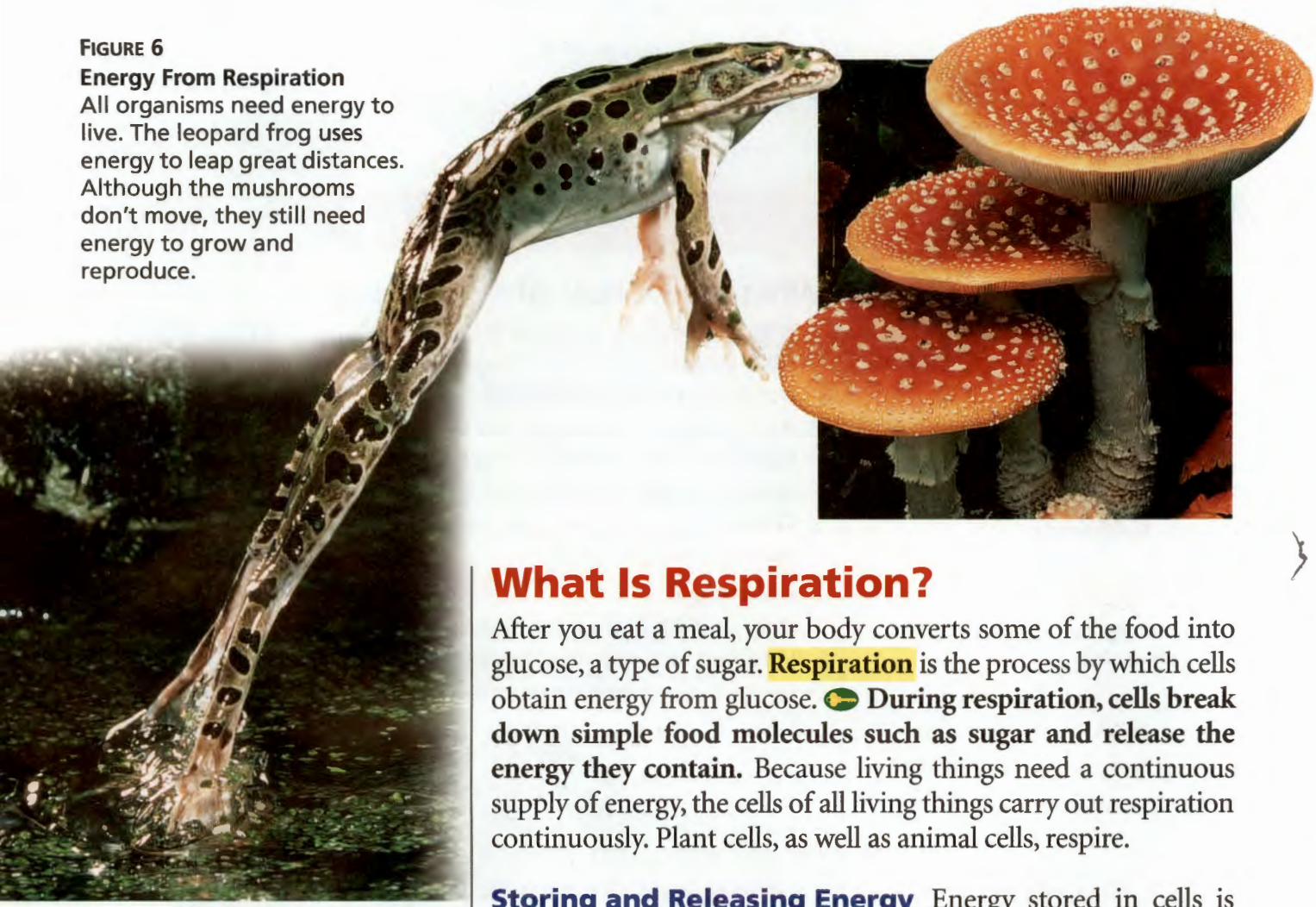


FIGURE 6
Energy From Respiration
All organisms need energy to live. The leopard frog uses energy to leap great distances. Although the mushrooms don't move, they still need energy to grow and reproduce.

What Is Respiration?

After you eat a meal, your body converts some of the food into glucose, a type of sugar. **Respiration** is the process by which cells obtain energy from glucose. **During respiration, cells break down simple food molecules such as sugar and release the energy they contain.** Because living things need a continuous supply of energy, the cells of all living things carry out respiration continuously. Plant cells, as well as animal cells, respire.

Storing and Releasing Energy Energy stored in cells is something like money you put in a savings account in a bank. When you want to buy something, you withdraw some of the money. Cells store and use energy in a similar way. During photosynthesis, plants capture the energy from sunlight and "save" it in the form of carbohydrates, including sugars and starches. Similarly, when you eat a meal, you add to your body's energy savings account. When cells need energy, they "withdraw" it by breaking down the carbohydrates in the process of respiration.

Breathing and Respiration The term *respiration* has two meanings. You have probably used it to mean "breathing," that is, moving air in and out of your lungs. To avoid confusion, the respiration process that takes place inside cells is sometimes called *cellular respiration.* The two meanings of the term *respiration* do point out a connection, however. Breathing brings oxygen, which is usually necessary for cellular respiration, into your lungs.

Reading Checkpoint **What is respiration?**

Lab zone Skills Activity

Predicting

During the winter months, some animals go into a state called hibernation. During hibernation, an animal does not eat, and its body activities are greatly reduced. Predict what will happen to an animal's rate of cellular respiration when the animal goes into hibernation. Explain your prediction.

The Two Stages of Respiration Like photosynthesis, respiration is a two-stage process. Figure 7 shows these two stages. The first stage takes place in the cytoplasm. There, molecules of glucose are broken down into smaller molecules. Oxygen is not involved, and only a small amount of energy is released.

The second stage of respiration takes place in the mitochondria. There, the small molecules are broken down into even smaller molecules. These chemical reactions require oxygen, and they release a great deal of energy. This is why the mitochondria are sometimes called the "powerhouses" of the cell. The energy liberated, or released, by mitochondria is still stored in the form of chemical energy. But now it is stored in molecules that are readily used by the cell.

Two other products of respiration are carbon dioxide and water. The carbon dioxide diffuses out of the cell. In most animals, the carbon dioxide and some water leave the body during exhalation. Thus, when you breathe in, you take in oxygen—a raw material for respiration. When you breathe out, you release carbon dioxide and water—products of respiration.

The Respiration Equation Although respiration occurs in a series of complex steps, the overall process can be summarized in the following equation:

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

sugar — oxygen — carbon dioxide — water

Notice that the raw materials for respiration are sugar and oxygen. Plants and other organisms that undergo photosynthesis make their own sugar. The glucose in the cells of animals and other organisms comes from food they eat. The oxygen comes from the air or water surrounding the organism.

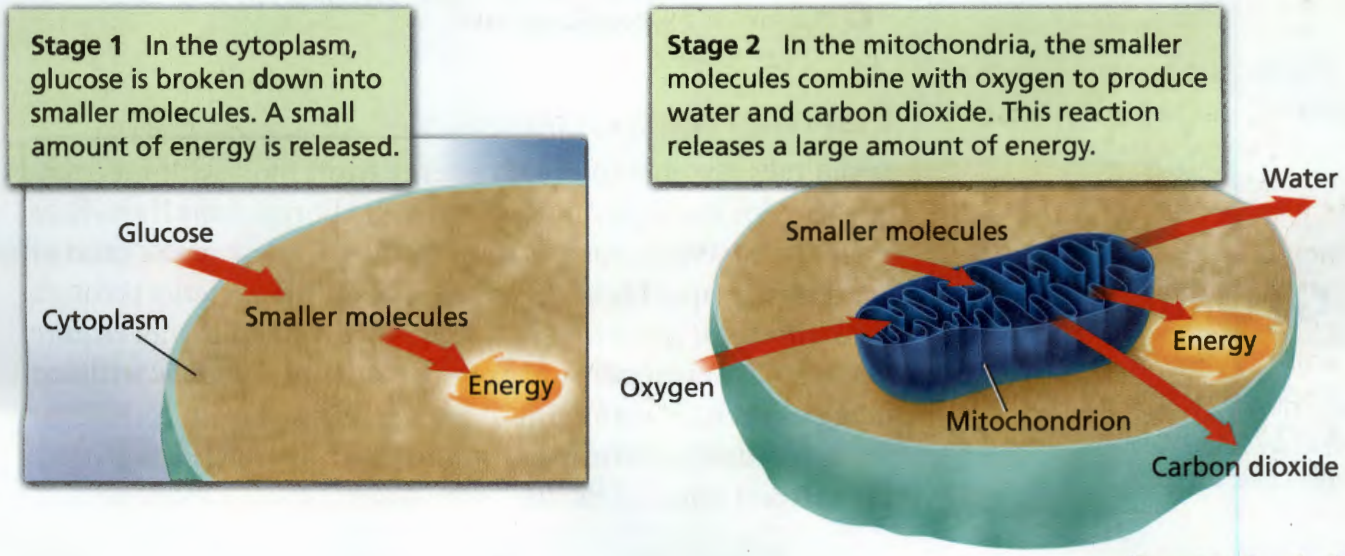


FIGURE 7
Two Stages of Respiration
Respiration, like photosynthesis, takes place in two stages. Note that energy is released in both stages.
Interpreting Diagrams *In which stage of respiration is oxygen used?*

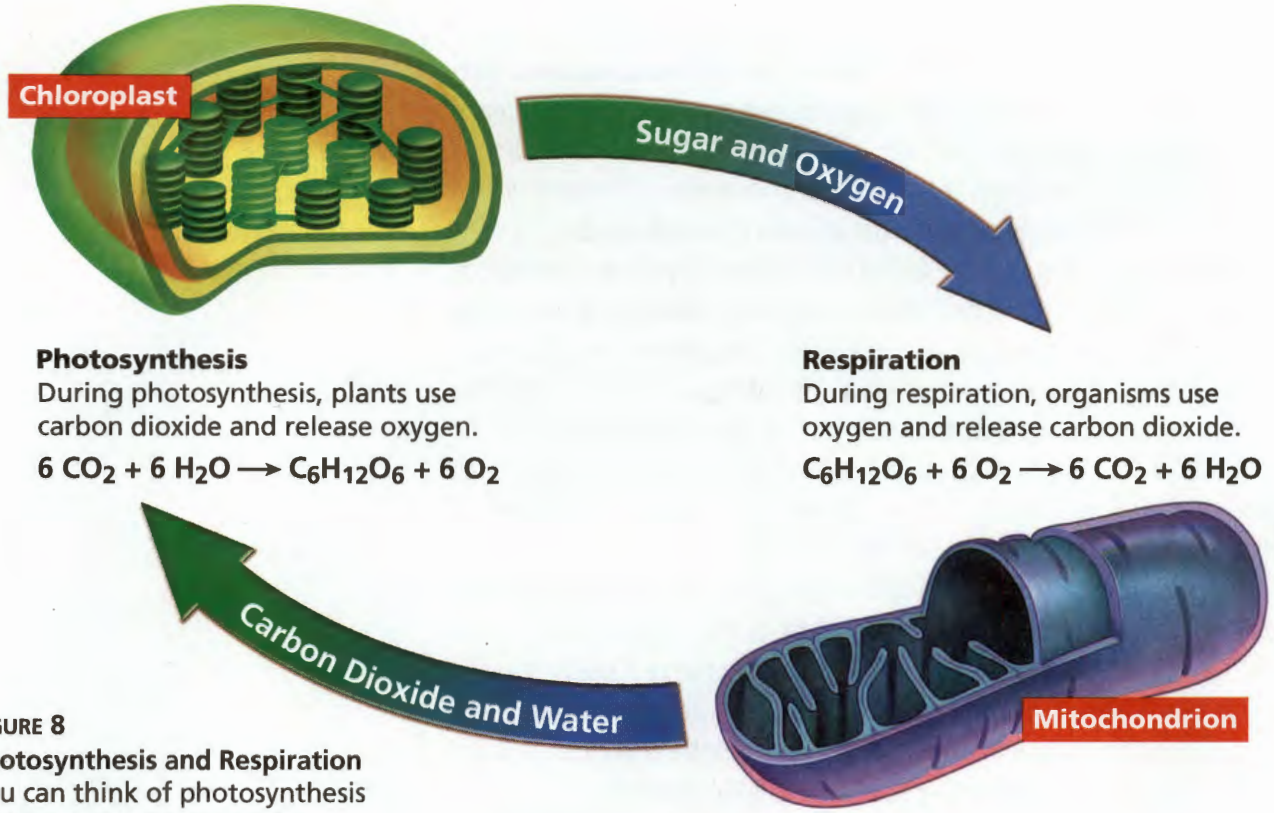


FIGURE 8
Photosynthesis and Respiration
You can think of photosynthesis and respiration as opposite processes.
Comparing and Contrasting
Which process uses oxygen? Which uses carbon dioxide?

Comparing Photosynthesis and Respiration Can you notice anything familiar about the equation for respiration? You are quite right if you said it is the opposite of the equation for photosynthesis. This is an important point. During photosynthesis, carbon dioxide and water are used to produce sugars and oxygen. During respiration, the sugar glucose and oxygen are used to produce carbon dioxide and water. Photosynthesis and respiration can be thought of as opposite processes.

Together, these two processes form a cycle that keeps the levels of oxygen and carbon dioxide fairly constant in Earth's atmosphere. As you can see in Figure 8, living things use both gases over and over again.

Reading Checkpoint **Which process—photosynthesis or respiration—produces water?**

Fermentation

Some cells are able to obtain energy from food without using oxygen. For example, some single-celled organisms live where there is no oxygen, such as deep in the ocean or in the mud of lakes or swamps. These organisms obtain their energy through **fermentation**, an energy-releasing process that does not require oxygen. **Fermentation provides energy for cells without using oxygen.** The amount of energy released from each sugar molecule during fermentation, however, is much lower than the amount released during respiration.

Alcoholic Fermentation One type of fermentation occurs when yeast and some other single-celled organisms break down sugars. This process is sometimes called alcoholic fermentation because alcohol is one of the products. The other products are carbon dioxide and a small amount of energy.

The products of alcoholic fermentation are important to bakers and brewers. The carbon dioxide produced by yeast creates air pockets in bread dough, causing it to rise. Carbon dioxide is also the source of bubbles in alcoholic drinks such as beer and sparkling wine.

Lactic Acid Fermentation Another type of fermentation takes place at times in your body. You've probably felt its effects. Think of a time when you ran as fast as you could for as long as you could. Your leg muscles were pushing hard against the ground, and you were breathing quickly.

No matter how hard you breathed, your muscle cells used up the oxygen faster than it could be replaced. Because your cells lacked oxygen, fermentation occurred. The fermentation supplied your cells with energy. One product of this type of fermentation is an acid known as lactic acid. When lactic acid builds up, you feel a painful sensation in your muscles. Your muscles feel weak and sore.

FIGURE 9
Lactic Acid Fermentation
When an athlete's muscles run out of oxygen, lactic acid fermentation supplies the cells with energy.

Reading Checkpoint **Which kind of fermentation is important to bakers?**

Section 2 Assessment

S 7.1.d, E-LA: Reading 7.2.4

Target Reading Skill **Create Outlines** Use your completed outline to help answer the questions below.

Reviewing Key Concepts

1. a. **Reviewing** What happens during respiration?
   b. **Reviewing** What is the equation for respiration?
   c. **Comparing and Contrasting** Compare the equations for respiration and photosynthesis.
   d. **Relating Cause and Effect** Explain why cellular respiration adds carbon dioxide to the atmosphere, but photosynthesis does not.
2. a. **Identifying** What is the process in which cells obtain energy without using oxygen?
   b. **Inferring** How would athletes be affected if this process could not take place?
   c. **Predicting** Is this process more likely to occur during a short run or a long walk? Explain your answer.

Lab zone At-Home Activity

Make Bread With an adult family member, follow a recipe in a cookbook to make a loaf of bread using yeast. Explain to your family the cellular process that causes the dough to rise. After you bake the bread, observe a slice and look for evidence that fermentation occurred.

Exhaling Carbon Dioxide

S 7.1.d, 7.7

Problem

Is there a relationship between exercise and the amount of carbon dioxide you exhale?

Skills Focus

predicting, controlling variables

Materials

- 2 250-mL beakers
- bromthymol blue solution (0.1% solution), 30 mL
- 2 straws
- stopwatch or watch with second hand
- graduated cylinder, 25 mL
- paper towels

Procedure

PART 1 Testing for Carbon Dioxide

1. Label one beaker "Beaker 1" and the other beaker "Beaker 2." Beaker 1 will be the control in the experiment.
2. Bromthymol blue can be used to test for the presence of carbon dioxide. To see how this works, fill each beaker with 15 mL of bromthymol solution. **CAUTION:** *Bromthymol blue can stain skin and clothing. Avoid spilling or splashing it on yourself.*
3. Note and record the color of the solution in both beakers.
4. Place a straw in Beaker 2. Gently blow through the straw into the solution until the solution changes color. **CAUTION:** *Use the straw to breathe out only. Do not suck the solution back through the straw.* Your partner should begin timing when you first blow through the straw and stop as soon as the solution changes color. Record the time that has elapsed.

PART 2 Exercise and Carbon Dioxide

5. In Part 1 you timed the change of color without exercising first. Predict how long it will take the solution to change color if you conduct the test after you exercise. Design an experiment to test your prediction. Be sure to include a plan for recording your results and steps to review your results.
6. Write down the steps of your experiment and get your teacher's approval. Then, conduct your experiment. **CAUTION:** *Do not over-exert yourself. If you have a medical condition that limits your ability to exercise, do not take part in the exercise portion of this experiment.*

Analyze and Conclude

1. **Measuring** How long did it take for the solution to change color the first time you did the test (without exercising)?
2. **Drawing Conclusions** How did exercising affect the amount of time it took for the solution to change color?
3. **Predicting** What was your prediction in Step 5 based upon? Was your prediction accurate?
4. **Controlling Variables** In Part 2, what variables did you need to control? Explain how you controlled those variables.
5. **Communicating** Write a paragraph that relates the results of your experiment to the process of cellular respiration. Be sure to explain how increased cellular activity affects carbon dioxide output.

More to Explore

Some plants grow in water. If you added bromthymol blue to the water, do you think it would turn color? *(Hint:* What might happen to the carbon dioxide that the plants produce during respiration?)

Section 3

Cell Division

CALIFORNIA Standards Focus

S 7.1.e Students know cells divide to increase their numbers through a process of mitosis, which results in two daughter cells with identical sets of chromosomes.

S 7.2.e Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.

- What events take place during the three stages of the cell cycle?
- How does the structure of DNA help account for the way in which DNA copies itself?

Key Terms

- cell cycle
- interphase
- replication
- mitosis
- chromosome
- cytokinesis

Lab zone Hands-On Warm-Up

What Are the Yeast Cells Doing?

1. Use a plastic dropper to transfer some yeast cells from a yeast culture to a microscope slide. Your teacher has prepared the slide by drying methylene blue stain onto it. Add a coverslip and place the slide under a microscope.
2. Examine the cells on the slide. Use low power first, then high power. Look for what appears to be two cells attached to each other. One cell may be larger than the other. Draw what you see.

Think It Over

Developing Hypotheses What process do you think the "double cells" are undergoing? Develop a hypothesis that might explain what you see.

In the early autumn, many local fairs run pumpkin contests. Proud growers enter their largest pumpkins, hoping to win a prize. The pumpkin below has a mass greater than 600 kilograms! This giant pumpkin began as a structure inside a small flower. How did the pumpkin grow so big?

A pumpkin grows in size by increasing both the size and the number of its cells. A single cell grows and then divides, forming two cells. Then two cells grow and divide, forming four, and so on. This process of cell growth and division does not occur only in pumpkins, though. In fact, many cells in your body are dividing as you read this page.

◀ Prize-winning pumpkin

Video Field Trip
Discovery Channel School
Cell Processes and Energy

Stage 1: Interphase

How do little pigs get to be big pigs? Their cells grow and divide, over and over. The regular sequence of growth and division that cells undergo is known as the **cell cycle.** During the cell cycle, a cell grows, prepares for division, and divides into two new cells, which are called "daughter cells." Each of the daughter cells then begins the cell cycle again. You can see details of the cell cycle in Figure 12. Notice that the cell cycle is divided into three main stages: interphase, mitosis, and cytokinesis.

The first stage of the cell cycle is called **interphase.** Interphase is the period before cell division. **During interphase, the cell grows, makes a copy of its DNA, and prepares to divide into two cells.**

Growing During the first part of interphase, the cell grows to its full size and produces structures it needs. For example, the cell makes new ribosomes and produces enzymes. Copies are made of both mitochondria and chloroplasts.

Copying DNA In the next part of interphase, the cell makes an exact copy of the DNA in its nucleus in a process called **replication.** Recall that DNA is found in the thin strands of chromatin in the nucleus. During interphase, the chromatin appears as a dense mass within a clearly defined nucleus.

DNA holds all the information that the cell needs to carry out its functions. Replication of DNA is very important, since each daughter cell must have a complete set of DNA to survive. At the end of DNA replication, the cell contains two identical sets of DNA. You will learn the details of DNA replication later in this section.

Preparing for Division Once the DNA has replicated, preparation for cell division begins. The cell produces structures that it will use to divide into two new cells. At the end of interphase, the cell is ready to divide.

Lab zone Try This Activity

Modeling Mitosis

Refer to Figure 12 as you carry out this activity.

1. Construct a model of a cell that has four chromosomes. Use a piece of construction paper to represent the cell. Use different-colored pipe cleaners to represent the chromosomes. Make sure that the chromosomes look like double rods.
2. Position the chromosomes in the cell where they would be during prophase.
3. Repeat Step 2 for metaphase, anaphase, and telophase.

Making Models How did the model help you understand the events of mitosis?

FIGURE 10
Bigger Pig, More Cells
The mother pig has more cells in her body than her small piglets.

Stage 2: Mitosis

Once interphase is complete, the second stage of the cell cycle begins. **Mitosis** (my TOH sis) is the stage during which the cell's nucleus divides into two new nuclei. **During mitosis, one copy of the DNA is distributed into each of the two daughter cells.**

Scientists divide mitosis into four parts, or phases: prophase, metaphase, anaphase, and telophase. During prophase, the threadlike chromatin in the nucleus condenses to form double-rod structures called **chromosomes** (KROH muh sohmz). Each chromosome has two rods because the cell's DNA has replicated, and each rod in a chromosome is an exact copy of the other. Each identical rod in a chromosome is called a chromatid. Notice in Figure 11 that the two chromatids are held together by a structure called a centromere.

As the cell progresses through metaphase, anaphase, and telophase, the chromatids separate from each other and move to opposite ends of the cell. Then two nuclear envelopes form around the new chromosomes at the two ends of the cell.

FIGURE 11
Chromosomes
During mitosis, the chromatin condenses to form chromosomes. Each chromosome consists of two identical rods, or chromatids.
Applying Concepts *During which phase of mitosis do the chromosomes form?*

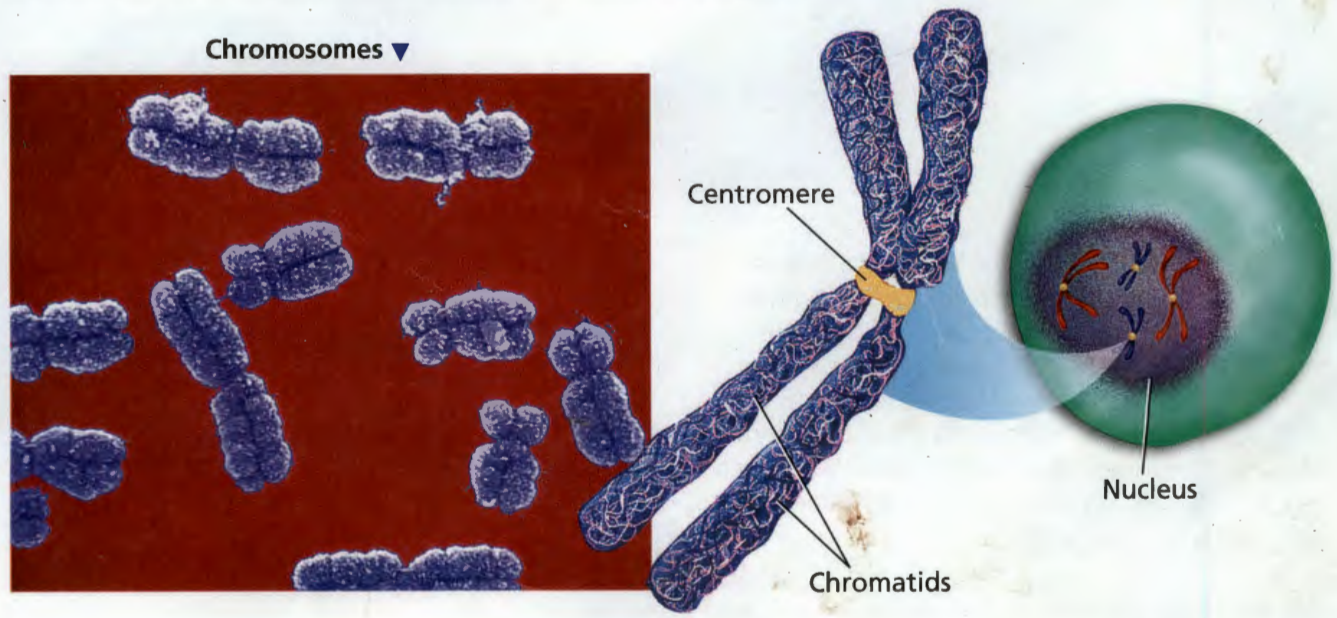
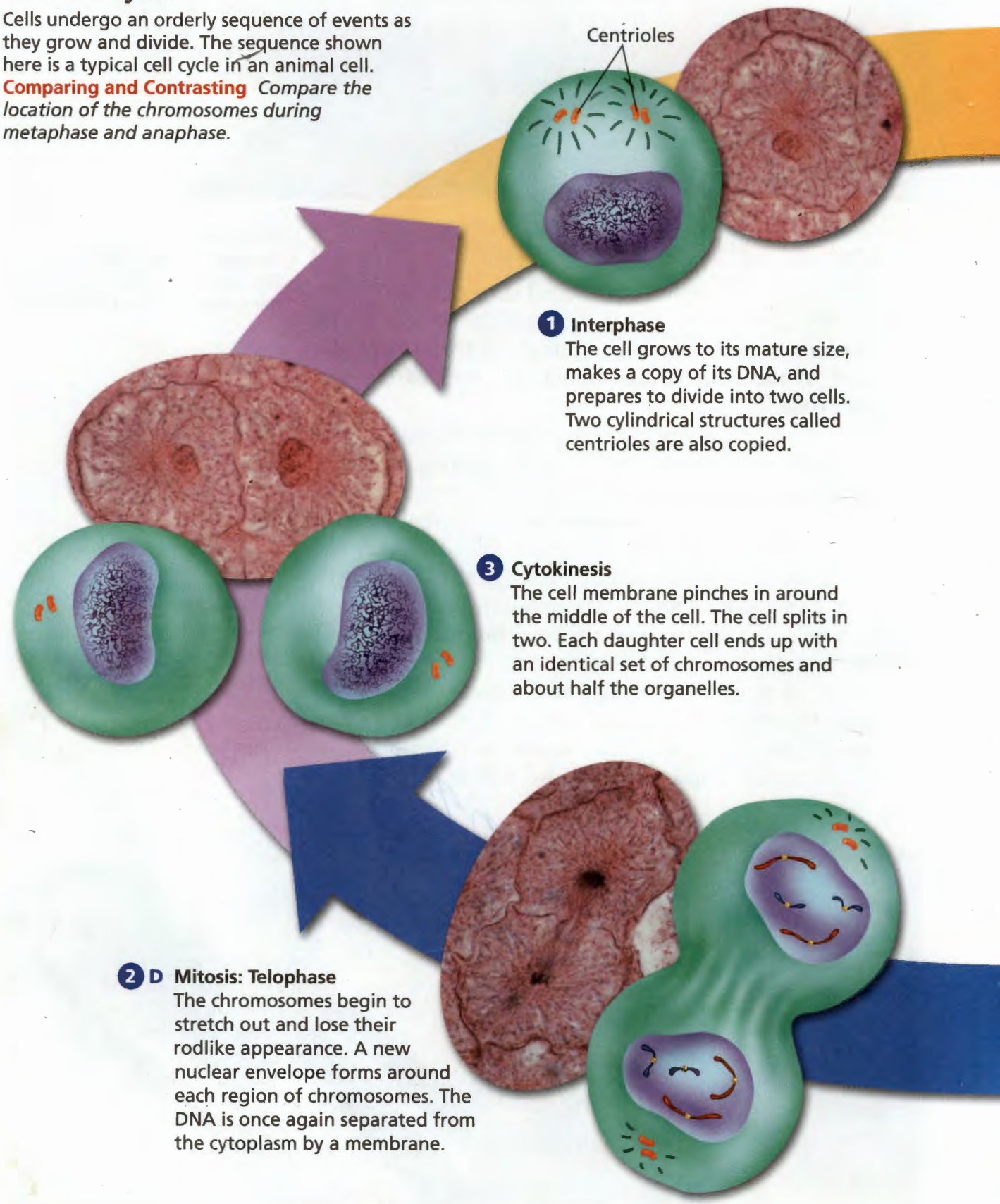


FIGURE 12

The Cell Cycle

Cells undergo an orderly sequence of events as they grow and divide. The sequence shown here is a typical cell cycle in an animal cell.
Comparing and Contrasting *Compare the location of the chromosomes during metaphase and anaphase.*



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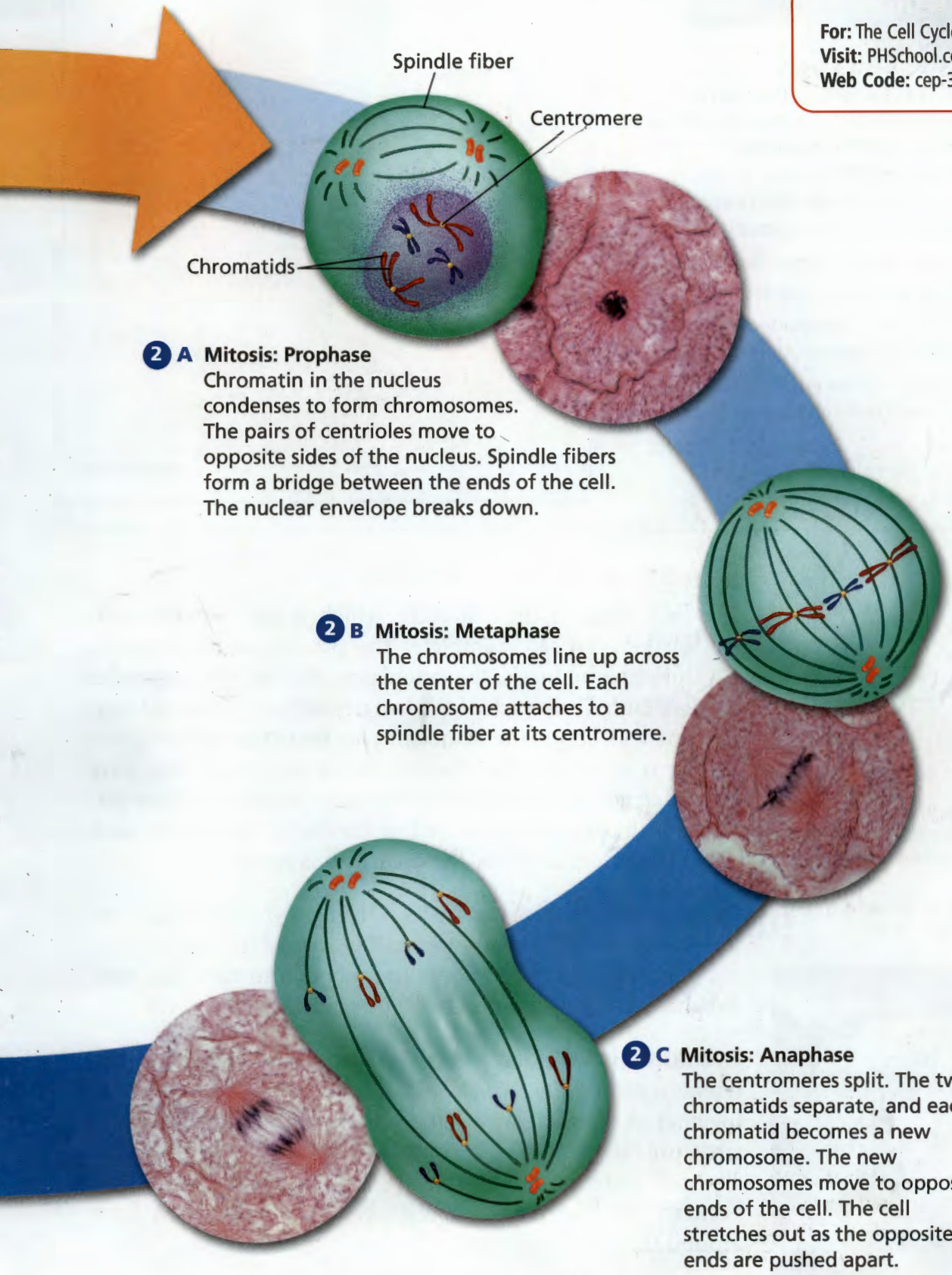


2 A Mitosis: Prophase
Chromatin in the nucleus condenses to form chromosomes. The pairs of centrioles move to opposite sides of the nucleus. Spindle fibers form a bridge between the ends of the cell. The nuclear envelope breaks down.

2 B Mitosis: Metaphase
The chromosomes line up across the center of the cell. Each chromosome attaches to a spindle fiber at its centromere.

2 C Mitosis: Anaphase
The centromeres split. The two chromatids separate, and each chromatid becomes a new chromosome. The new chromosomes move to opposite ends of the cell. The cell stretches out as the opposite ends are pushed apart.

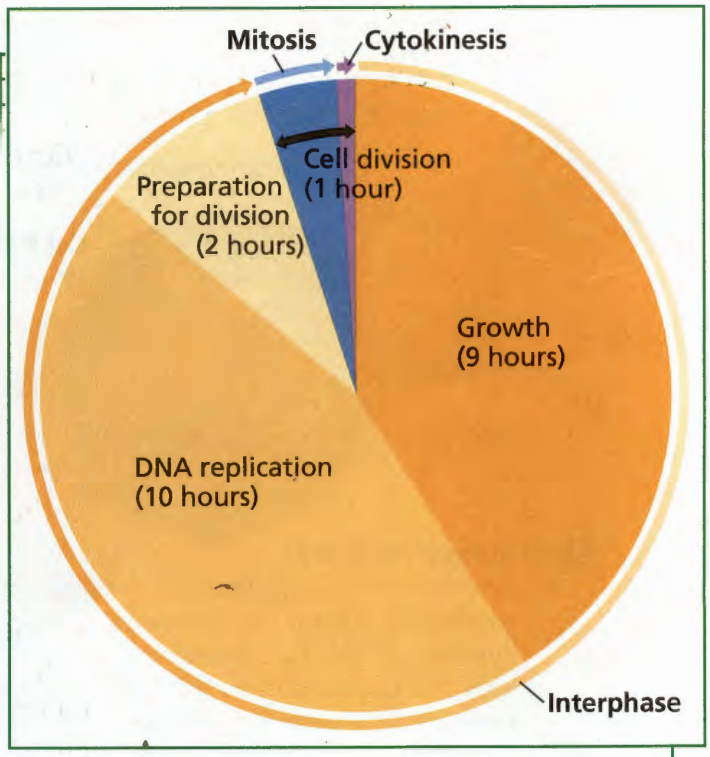
Math: Algebra and Functions 7.1.5

Math Analyzing Data

Length of the Cell Cycle

How long does it take for a cell to go through one cell cycle? It all depends on the cell. A human liver cell, for example, completes one cell cycle in about 22 hours, as shown in the graph. Study the graph and then answer the following questions.

1. **Reading Graphs** What do the three curved arrows outside the circle represent?
2. **Reading Graphs** In what stage of the cell cycle is the wedge representing growth?
3. **Interpreting Data** In human liver cells, how long does it take DNA replication to occur?
4. **Drawing Conclusions** In human liver cells, what stage in the cell cycle takes the longest time?



Stage 3: Cytokinesis

The final stage of the cell cycle, which is called **cytokinesis** (sy toh kih NEE sis), completes the process of cell division. **During cytokinesis, the cytoplasm divides. The organelles are distributed into each of the two new cells.** Cytokinesis usually starts at about the same time as telophase. When cytokinesis is complete, two new cells, or daughter cells, have formed. Each daughter cell has the same number of chromosomes as the original parent cell. At the end of cytokinesis, each cell enters interphase, and the cycle begins again.

Cytokinesis in Animal Cells During cytokinesis in animal cells, the cell membrane squeezes together around the middle of the cell. The cytoplasm pinches into two cells. Each daughter cell gets about half of the organelles.

Cytokinesis in Plant Cells Cytokinesis is somewhat different in plant cells. A plant cell's rigid cell wall cannot squeeze together in the same way that a cell membrane can. Instead, a structure called a cell plate forms across the middle of the cell. The cell plate gradually develops into new cell membranes between the two daughter cells. New cell walls then form around the cell membranes.

Reading Checkpoint **During what phase of mitosis does cytokinesis begin?**

FIGURE 13
Cytokinesis in Plant Cells
During cytokinesis in plant cells, a cell plate forms between the two new nuclei.
Applying Concepts *What is the function of the cell plate?*

Structure and Replication of DNA

DNA replication ensures that each daughter cell will have the genetic information it needs to carry out its activities. Before scientists could understand how DNA replicates, they had to know its structure. In 1952, Rosalind Franklin used an X-ray method to photograph DNA molecules. Her photographs helped James Watson and Francis Crick figure out the structure of DNA in 1953.

The Structure of DNA If you were to unravel a chromosome, you would find that the DNA strands are wound tightly around proteins. The proteins help support the chromosome's structure. Notice in Figure 14 that the strands of the DNA molecule look like a twisted ladder. The two sides of the DNA ladder are made up of molecules of a sugar called deoxyribose, alternating with molecules known as phosphates.

Each rung is made up of a pair of molecules called nitrogen bases. Nitrogen bases are molecules that contain the element nitrogen and other elements. DNA has four kinds of nitrogen bases: adenine (AD uh neen), thymine (THY meen), guanine (GWAH neen), and cytosine (SY tuh seen). The capital letters A, T, G, and C are used to represent the four bases.

The bases on one side of the ladder pair with the bases on the other side. Adenine (A) only pairs with thymine (T), while guanine (G) only pairs with cytosine (C). This pairing pattern is the key to understanding how DNA replication occurs.

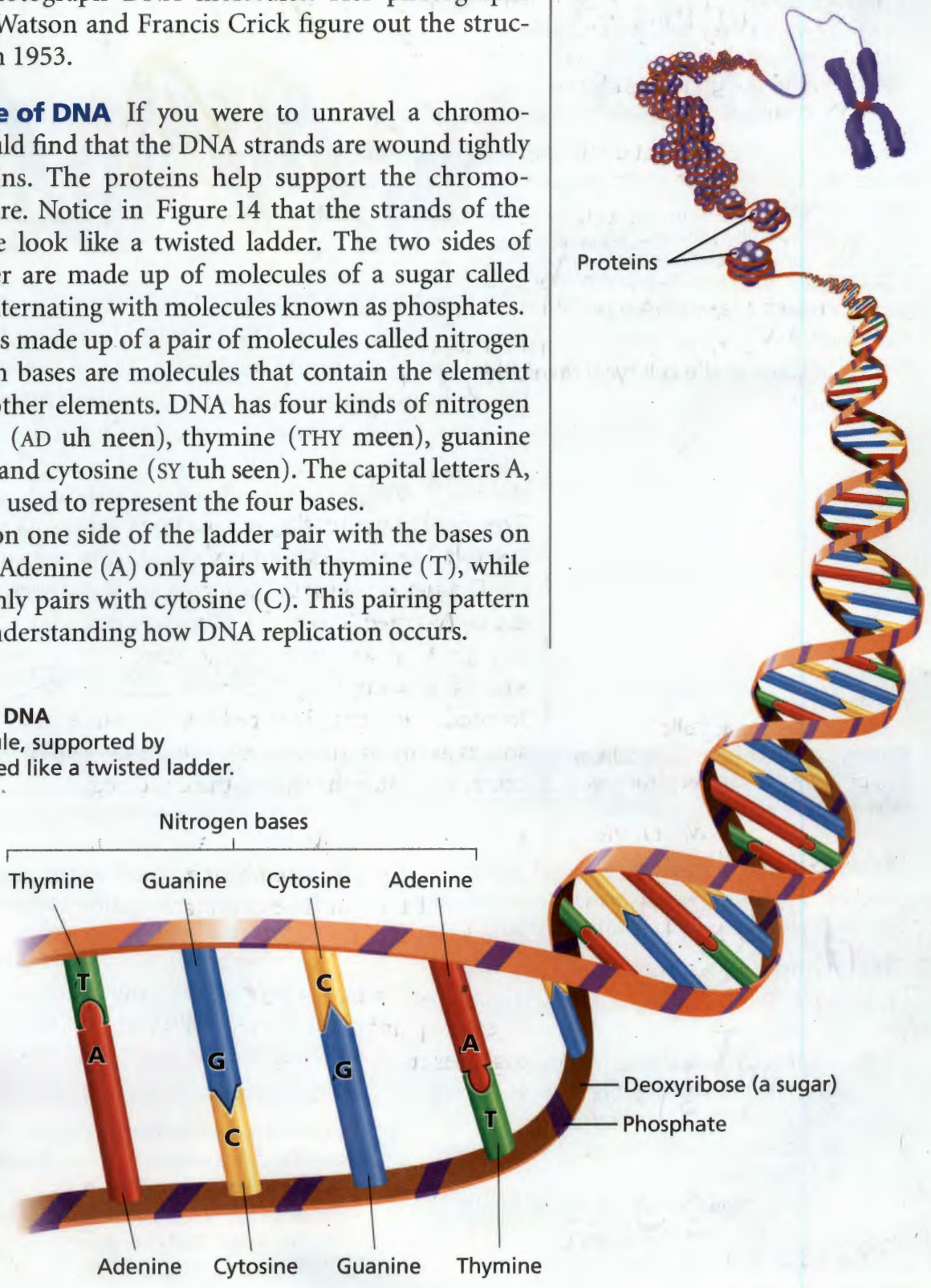


FIGURE 14
The Structure of DNA
The DNA molecule, supported by proteins, is shaped like a twisted ladder.

FIGURE 15
DNA Replication
During DNA replication, a DNA molecule "unzips" between its paired bases. New bases pair with the bases on each old strand. As a result, two identical DNA strands form.

The Replication Process DNA replication begins when the two sides of the DNA molecule unwind and separate, somewhat like a zipper unzipping. As you can see in Figure 15, the molecule separates between the paired nitrogen bases.

Next, nitrogen bases that are floating in the nucleus pair up with the bases on each half of the DNA molecule. **Because of the way in which the nitrogen bases pair with one another, the order of the bases in each new DNA molecule exactly matches the order in the original DNA molecule.** Adenine always pairs with thymine, while guanine always pairs with cytosine. Once the new bases are attached, two new DNA molecules are formed.

Reading Checkpoint **During DNA replication, which base pairs with guanine?**

Section 3 Assessment

S 7.1.e, 7.2.e E-LA: Reading 7.1.2, Writing 7.2.0

Build Science Vocabulary **Greek Word Origins** The Greek word *kinesis* means "motion." During cytokinesis, what motion occurs?

Reviewing Key Concepts

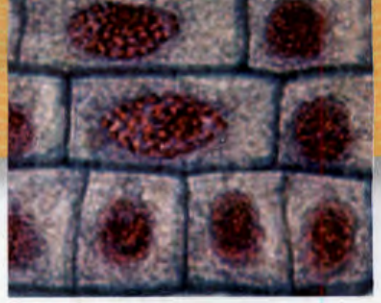
1. a. **Reviewing** What are the three stages of the cell cycle?
   b. **Summarizing** Summarize what happens to chromosomes during the stage of the cell cycle in which the nucleus divides. Include the terms *prophase, metaphase, anaphase,* and *telophase.*
   c. **Interpreting Diagrams** Look at Figure 12. What is the role of spindle fibers during cell division?
2. a. **Listing** List the nitrogen bases in DNA.
   b. **Describing** Describe how the nitrogen bases pair in a DNA molecule.
   c. **Inferring** One section of a strand of DNA has the base sequence AGATTC. What is the base sequence on the other strand?

Writing in Science

Writing Instructions Imagine that you work in a factory where cells are manufactured. Write instructions for newly forming cells on how to carry out cytokinesis. Provide instructions for both plant and animal cells.

Lab zone **Skills Lab**

Multiplying by Dividing



S 7.1.e, 7.7.a

Problem

How long do the stages of the cell cycle take?

Skills Focus

observing, calculating

Materials

- microscope
- colored pencils
- calculator (optional)
- prepared slides of onion root tip cells undergoing cell division

Procedure

1. Place the slide on the stage of a microscope. Use low power to locate a cell in interphase. Then switch to high power, and make a labeled drawing of the cell. **CAUTION:** *Slides and coverslips break easily. Do not allow the objective to touch the slide. If the slide breaks, notify your teacher. Do not touch broken glass.*
2. Repeat Step 1 to find cells in prophase, metaphase, anaphase, and telophase. Then copy the data table into your notebook.
3. Return to low power. Find an area of the slide with many cells undergoing cell division. Switch to the magnification that lets you see about 50 cells at once (for example, 100 ×).
4. Examine the cells row by row, and count the cells that are in interphase. Record that number in the data table under *First Sample*.
5. Examine the cells row by row four more times to count the cells in prophase, metaphase, anaphase, and telophase. Record the results.
6. Move to a new area on the slide. Repeat Steps 3–5 and record your counts in the column labeled *Second Sample*.
7. Fill in the column labeled *Total Number* by adding the numbers across each row in your data table.
8. Add the totals for the five stages to find the total number of cells counted.

Analyze and Conclude

1. **Observing** Based on your observations, did the root tissue have a high rate or low rate of growth? Explain. Which stage of the cell cycle did you observe most often?
2. **Calculating** The cell cycle for onion root tips takes about 720 minutes (12 hours). Use your data and the formula below to find the number of minutes each stage takes.

$$\text{Time for each stage} = \frac{\text{Number of cells at each stage}}{\text{Total number of cells counted}} \times 720 \text{ min}$$

3. **Communicating** Use the data to compare the amount of time spent in mitosis with the total time for the whole cell cycle. Write your answer in the form of a paragraph.

More to Explore

Examine prepared slides of animal cells undergoing cell division. Use drawings and descriptions to compare plant and animal mitosis.

Data Table

Stage of Cell Cycle	First Sample	Second Sample	Total Number
Interphase			
Mitosis:			
Prophase			
Metaphase			
Anaphase			
Telophase			
Total number of cells counted			

Section 4

Cell Differentiation

CALIFORNIA Standards Focus

S 7.1.f Students know that as multicellular organisms develop, their cells differentiate.

- What is differentiation?
- What factors influence how and when cells differentiate within different organisms?

Key Terms

- differentiation
- stem cell

Lab zone **Standards Warm-Up**

How Is It Different?

1. Study the photos above of a growing bean plant.
2. Write your observations about how the plant changes in structure in each stage of its development.

Think It Over

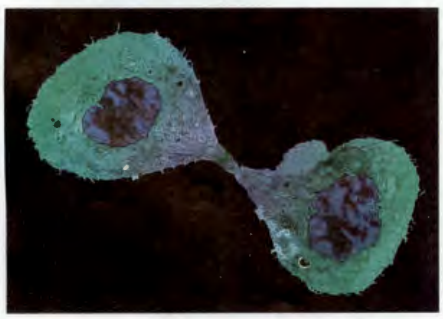
Forming Operational Definitions As the plant grows, its cells divide and undergo a process called differentiation. Based on your observations, what does differentiation mean?

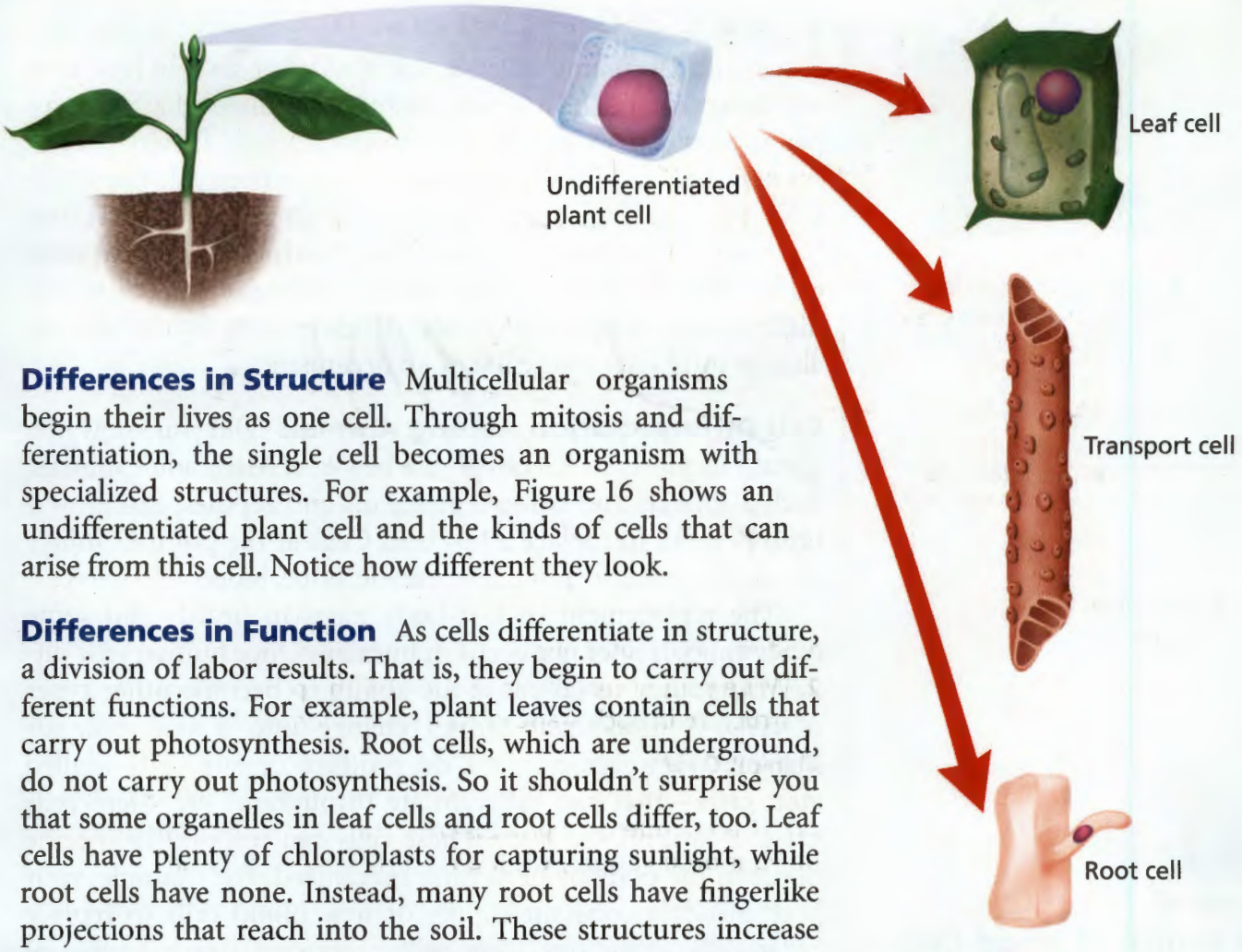
You have learned that the cell theory states that living things are made of cells. Some living things are single-celled, or unicellular, organisms. Other living things are multicellular. They consist of many kinds of cells that differ from one another. The cell theory also says that cells are produced from other cells. When a cell divides by mitosis, it produces two daughter cells with identical sets of chromosomes. So how do cells in multicellular organisms become different from one another?

Differentiation

Cell division alone cannot explain the development of new structures. If cells only divided, the result would merely be a big ball of identical cells. Instead, cells differentiate. **Differentiation** is the process by which cells change in structure and become capable of carrying out specialized functions. **As cells differentiate, they become different from one another. They also form groups made of other, similarly specialized cells. These groups then form tissues and organs.**

A skin cell undergoes mitosis. ▼





Differences in Structure Multicellular organisms begin their lives as one cell. Through mitosis and differentiation, the single cell becomes an organism with specialized structures. For example, Figure 16 shows an undifferentiated plant cell and the kinds of cells that can arise from this cell. Notice how different they look.

Differences in Function As cells differentiate in structure, a division of labor results. That is, they begin to carry out different functions. For example, plant leaves contain cells that carry out photosynthesis. Root cells, which are underground, do not carry out photosynthesis. So it shouldn't surprise you that some organelles in leaf cells and root cells differ, too. Leaf cells have plenty of chloroplasts for capturing sunlight, while root cells have none. Instead, many root cells have fingerlike projections that reach into the soil. These structures increase the amount of water the root cells can absorb from the soil.

Tissues, Organs, and Systems When cells differentiate, they also become organized. At first, they group into tissues. Such cells work together, carrying out specific functions. For example, muscle cells in animals become organized into long strands of muscle tissue that can move legs or arms. Groups of tissues can combine to form organs, such as the roots of a plant or the stomach of an animal. Systems, such as the digestive system, begin to function as organs and tissues work together.

Increasingly Specialized Cells As development continues, more fine-grained differentiation occurs. For example, the retina in your eye consists of two types of cells that are sensitive to light. Rod cells function in dim light but cannot detect color. Cone cells detect color, but require brighter light to function. The cells of your retina differentiated early in your development. Rods and cones differentiated later.

Reading Checkpoint **What is the result of cell differentiation?**

FIGURE 16
Specialized Cells
Plants have undifferentiated cells in their stems and roots that can give rise to different kinds of cells. **Inferring** *Can photosynthesis take place in a root cell? Why or why not?*

How Cells Differentiate

During development, cells become fixed—or set—in how they will differentiate. The instructions that determine what will happen to a cell are coded in the DNA in its nucleus. Differentiation occurs when certain sections of DNA are turned off. The active DNA then guides how the cell develops. **Once a cell's future has been determined, when and how much it changes depends on its DNA, its function, and the type of organism.** Some cells differentiate completely during development. Others do not change until later in the life of an organism.

Cell Differentiation Among Animals Did you know that a lizard that loses its tail can grow a new one? Many adult animals, such as insects and some crustaceans and reptiles, can grow a limb or a tail to replace a lost one. Cells at the point of injury can differentiate, forming new muscle, bone, blood, and nerves.

The replacement of lost body parts in lizards and some other animals does not occur in humans. Once human cells differentiate, they usually lose the ability to become other types of cells. A blood cell cannot change into a skin cell, for instance. However, humans do produce certain cells—called **stem cells**—that can differentiate throughout life. Stem cells exist all around the body. These cells can respond to specific needs in the body by becoming specialized. For example, your body needs a constant supply of new blood cells to replace older cells. Every day, stem cells produce a steady supply of blood cells. These include red cells that carry oxygen, white cells that fight infection, and other cells needed in the blood.

Reading Checkpoint **What kind of cells can stem cells produce in the human body?**

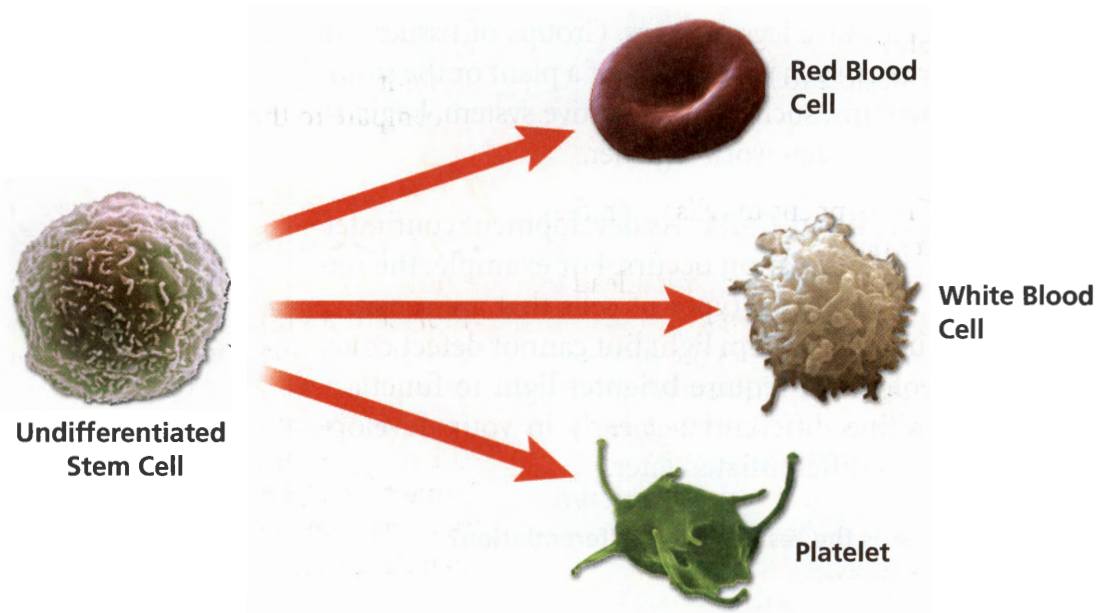


FIGURE 17
A Source of Blood Cells
Different types of blood cells can form when stem cells undergo differentiation.
Observing *How do the structures of red blood cells and white blood cells differ?*

African violet plant

The leaf is cut and transferred to soil.

Cell differentiation leads to new root and leaf tissues.

Cell Differentiation in Plants Cells differentiate in developing plants much the same way they do in animals. Differentiated cells become grouped into the tissues that make up the roots, stems, and leaves. Cells also continue to differentiate further within each kind of organ. For example, some cells in the stem become specialized as the tubes that transport food and water through the plant.

Many plants have the ability to grow throughout their lives. This growth happens because certain cells in the roots and stems of plants are not fixed in their development. These cells can undergo rapid cell division and differentiation, increasing the size of the roots and stems. It can also lead to the growth of new roots, stems, and leaves. For example, if a leaf of an African violet plant is cut off and put into soil or water, its stem will begin to grow roots! Eventually, more cells will differentiate into root cells and stem cells, and a new plant grows. Gardeners use this technique to create many plants from one original plant.

FIGURE 18
A New Plant
The stem of a leaf from an African violet plant gives rise to the structures of a new plant.

Section 4 Assessment

S 7.1.f, E-LA: Reading 7.2.4

Target Reading Skill Create Outlines
Use your completed outline to help answer the questions below.

Reviewing Key Concepts

1. a. Describing What happens to cells when they undergo differentiation?
   b. Explaining How does differentiation lead to tissues and organs in a developing organism?
   c. Applying Concepts How does the phrase *division of labor* relate to differentiation?
2. a. Identifying Name two factors that affect how and when cells differentiate.
   b. Relating Cause and Effect What stimulates human stem cells to differentiate into specialized blood cells?
   c. Comparing and Contrasting How does the ability of cells to differentiate in humans compare to the ability in plants?

Lab zone

At-Home Activity

Model Differences Use a ball of clay to represent a single cell. Divide the "cell" into two smaller ones, and then again into four. Fashion each "cell" into a different shape. Then divide each shape in two, and reshape the new pieces to look like the shape they came from. Explain to a family member how your clay models represent cell differentiation in a developing organism.

Chapter 4 Study Guide

The BIG Idea Cells obtain energy through the processes of photosynthesis and respiration, which are carried out by chloroplasts and mitochondria.

1 Photosynthesis

Key Concepts S 7.1.d

- Nearly all living things obtain energy either directly or indirectly from the energy of sunlight captured during photosynthesis.
- During photosynthesis, plants and some other organisms use energy from the sun to convert carbon dioxide and water into oxygen and sugars.
- The equation for photosynthesis is:

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6\,O_2$$

Key Terms

photosynthesis
autotroph
heterotroph
pigment
chlorophyll
stomata

2 Respiration

Key Concepts S 7.1.d

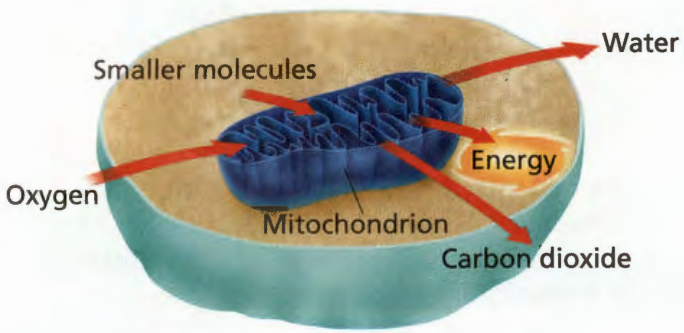
- During respiration, cells break down simple food molecules such as sugar and release the energy they contain.
- The respiration equation is:

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

- Fermentation provides energy for cells without using oxygen.

Key Terms

respiration
fermentation



3 Cell Division

Key Concepts S 7.1.e, 7.2.e

- During interphase, the cell grows, makes a copy of its DNA, and prepares to divide into two cells.
- During mitosis, one copy of the DNA is distributed into each of the two daughter cells.
- During cytokinesis, the cytoplasm divides. The organelles are distributed into each of the two new cells.
- Because of the way in which the nitrogen bases pair with one another, the order of the bases in each new DNA molecule exactly matches the order in the original DNA molecule.

Key Terms

cell cycle
interphase
replication
mitosis
chromosome
cytokinesis

4 Cell Differentiation

Key Concepts S 7.1.f

- As cells differentiate, they become different from one another. They also form groups made of other, similarly specialized cells. These groups then form tissues and organs.
- Once a cell's future has been determined, when and how much it changes depends on the cell's function and the type of organism.

Key Terms

differentiation
stem cell

Review and Assessment

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Target Reading Skill

Create Outlines To help review the structure and replication of DNA, fill in details under **A** and **B** in the partially completed outline at right.

I. Structure and Replication of DNA
A. Structure of DNA

B. Replication of DNA

Reviewing Key Terms

Choose the letter of the best answer.

1. The organelle in which photosynthesis takes place is the
   a. mitochondrion.
   b. chloroplast.
   c. chlorophyll.
   d. nucleus.
2. What process produces carbon dioxide?
   a. photosynthesis
   b. replication
   c. mutation
   d. respiration
3. The process in which a cell makes an exact copy of its DNA is called
   a. fermentation.
   b. respiration.
   c. replication.
   d. reproduction.
4. The stage of the cell cycle when a spindle forms is called
   a. interphase. **b.** prophase.
   c. metaphase. **d.** anaphase.
5. Which of the following is a result of differentiation?
   a. An organism grows larger.
   b. Cells in an embryo increase in number.
   c. Cells in an embryo become different from one another.
   d. An organism reproduces.

Complete the following sentences so that your answers clearly explain the key terms.

6. Chlorophyll is a type of **pigment,** which is _____ .
7. A lion is a **heterotroph,** a type of organism that _____ .
8. Organisms that live in the mud of swamps obtain their energy through **fermentation,** which is _____ .
9. **Cytokinesis** is the stage of the cell cycle in which _____ .
10. Both red blood cells and white blood cells can be produced in the body by **stem cells** because _____ .

Review and Assessment

Checking Concepts

11. Briefly explain what happens to energy from the sun during photosynthesis.
12. Why do organisms need to carry out the process of respiration?
13. How are respiration and fermentation similar? How are these processes different?
14. Explain why cell division is a vital process for organisms.
15. Describe what happens during interphase.
16. How do the events in the cell cycle ensure that the genetic information in the daughter cells will be identical to that of the parent cell?
17. How are stem cells different from other cells in an adult animal?

Thinking Critically

18. **Predicting** Suppose a volcano threw so much ash into the air that it blocked most of the sunlight that usually strikes Earth. How might this affect the ability of animals to obtain the energy they need to live?
19. **Comparing and Contrasting** Explain the relationship between the processes of breathing and cellular respiration.
20. **Relating Cause and Effect** Do plant cells need to carry out respiration? Explain.
21. **Inferring** The diagram below shows part of one strand of a DNA molecule. What would the bases on the other strand be?

22. **Making Generalizations** Why is cell differentiation a necessary process in a developing multicellular organism?

Applying Skills

Use the table below to answer Questions 23–26.

Percentages of Nitrogen Bases in the DNA of Various Organisms

Nitrogen Base	Human	Wheat	*E. coli* Bacterium
Adenine	30%	27%	24%
Guanine	20%	23%	26%
Thymine	30%	27%	24%
Cytosine	20%	23%	26%

23. **Graphing** For each organism, draw a bar graph to show the percentages of each nitrogen base in its DNA.
24. **Interpreting Data** What is the relationship between the amounts of adenine and thymine in the DNA of each organism? What is the relationship between the amounts of guanine and cytosine?
25. **Inferring** Based on your answer to Question 24, what can you infer about the structure of DNA in these three organisms?
26. **Applying Concepts** Suppose cytosine made up 28% of the nitrogen bases in an organism. What percentage of the organism's nitrogen bases should be thymine? Explain.

Lab zone Standards Investigation

Performance Assessment Bring in your plants, recorded observations, and graphs to share with the class. Be prepared to describe your experimental plan and explain your results. How well did you follow your experimental plan? What did you learn about photosynthesis and light from the experiment you performed?

Choose the letter of the best answer.

1. Which of the following statements is true?

A Plants cannot respire because they have no mitochondria.
B Photosynthesis produces carbon dioxide.
C Animals cannot photosynthesize.
D Only plants photosynthesize and only animals respire. **S 7.1.d**

2. Which of the following nitrogen base pairs can be found in DNA?

A A-G **B** T-C
C G-T **D** A-T **S 7.2.e**

3. Which stage of mitosis is represented by the following cell?

A interphase
B anaphase
C telophase
D metaphase **S 7.1.e**

4. Which of the following statements about differentiated cells is false?

A They look different but have the same functions.
B They look different and have different functions.
C They become grouped with similar cells, forming tissues.
D They make up the tissues and organs of multicellular organisms. **S 7.1.f**

5. Which statement best describes chromosomes?

A They carry out respiration.
B They consist mostly of the pigment chlorophyll.
C They consist of tightly coiled strands of DNA and proteins.
D Their structure is only visible during interphase. **S 7.2.e**

Use the table below to answer Questions 6 and 7.

Effect of Temperature on Length of Onion Cell Cycle

Temperature (°C)	Length of Cell Cycle (hours)
10	54.6
15	29.8
20	18.8
25	13.3

6. A scientist performed an experiment to determine the effect of temperature on the length of the cell cycle. On the basis of the data in the table above, how long would the cell cycle last at a temperature of 5°C?

A less than 13.3 hours
B more than 54.6 hours
C between 29.8 and 54.6 hours
D about 20 hours

S 7.1.e

7. The data in the table above show that

A cells divide faster when the temperature is decreased.
B cells divide faster when the temperature is increased.
C the length of the cell cycle is not affected by temperature.
D the length of the cell cycle is inherited.

S 7.1.e

Apply the BIG Idea

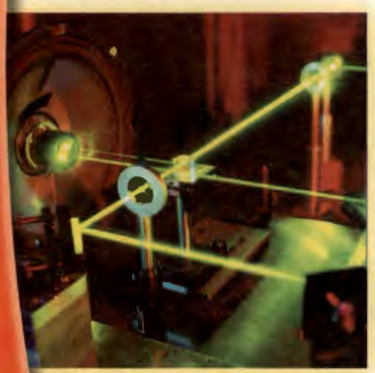
8. Compare and contrast the raw materials and products of photosynthesis with those of respiration. Then explain how the two processes are connected. **S 7.1.d**

Introduction to Life Science
Unit 1 Review

Chapter 1
What Is Life Science?
The BIG Idea

Scientific progress is made by asking meaningful questions and conducting careful investigations.

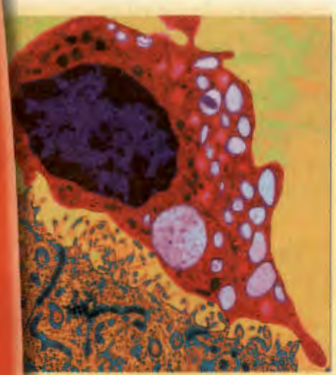
- What skills do scientists use to learn about the world?
- What are some big ideas in life science?
- What is scientific inquiry?
- Why is preparation important when carrying out scientific investigations in the lab and in the field?



Chapter 2
Using Light
The BIG Idea

Light entering the eye is bent by the cornea and lens to form an image on the retina.

- What are the basic properties of waves?
- How does visible light help you see?
- What determines the color of an opaque object?
- What determines the types of images formed by convex and concave lenses?



Chapter 3
Cell Structure and Function
The BIG Idea

Cells are the basic building blocks of all living things. All cells have similar structures and carry out similar functions.

- What is the cell theory?
- What organelles are found in the cytoplasm, and what are their functions?
- How is water important to the function of cells?
- How do most small molecules cross the cell membrane?

Chapter 4
Cell Processes and Energy
The BIG Idea

Cells obtain energy through the processes of respiration and photosynthesis, which are carried out by mitochondria and chloroplasts.

- What happens during the process of photosynthesis?
- What events take place during the three stages of the cell cycle?
- What factors influence how and when cells differentiate within different organisms?

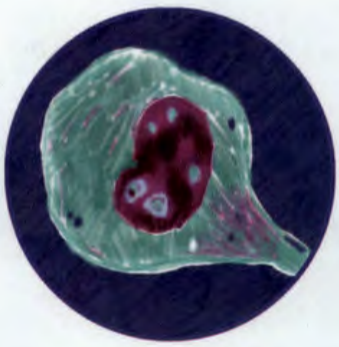
Unit 1 Assessment

Connecting the BIG Ideas

Emily wanted to learn more about cells. She cut a paper-thin leaf from a freshwater plant and used it to prepare a microscope slide. Then she used a cotton swab to get some cells from the inside of her cheek. She used the cheek cells to prepare another slide. Next, she used a chemical to stain the cells so they would be easier to see.

Unfortunately, the slides got mixed up before they could be labeled. Emily used a microscope to see if she could determine which slide held plant cells and which held cheek cells. She observed the structures in cells from each slide and drew diagrams to show what she observed. She noted that the cells on one slide had cell walls, while the cells on the other did not. She observed mitochondria in both samples and chloroplasts in one sample. She also noted that some of the cells with cell walls had chromosomes in their nuclei.

Drawing of slide A



Drawing of slide B

1. Which is an example of a scientific model? *(Chapter 1)*
   - **a.** microscope slides
   - **b.** the microscope
   - **c.** diagrams of cells
   - **d.** mitochondria

2. What forms the enlarged images produced by a microscope? *(Chapter 2)*
   - **a.** lenses
   - **b.** the pupil of the eye
   - **c.** mirrors
   - **d.** slides

3. Which of the following would be found in plant cells but not in cheek cells? *(Chapter 3)*
   - **a.** cell walls
   - **b.** chromosomes
   - **c.** mitochondria
   - **d.** nuclei

4. Where in plant cells does photosynthesis occur? *(Chapter 4)*
   - **a.** cell wall
   - **b.** chloroplasts
   - **c.** mitochondria
   - **d.** nuclei

5. **Summary** Does the Slide A drawing represent plant or cheek cells? How do you know? What process do Emily's observations of chromosomes provide evidence for? Explain why chromosomes were not visible in all the cells on that slide.