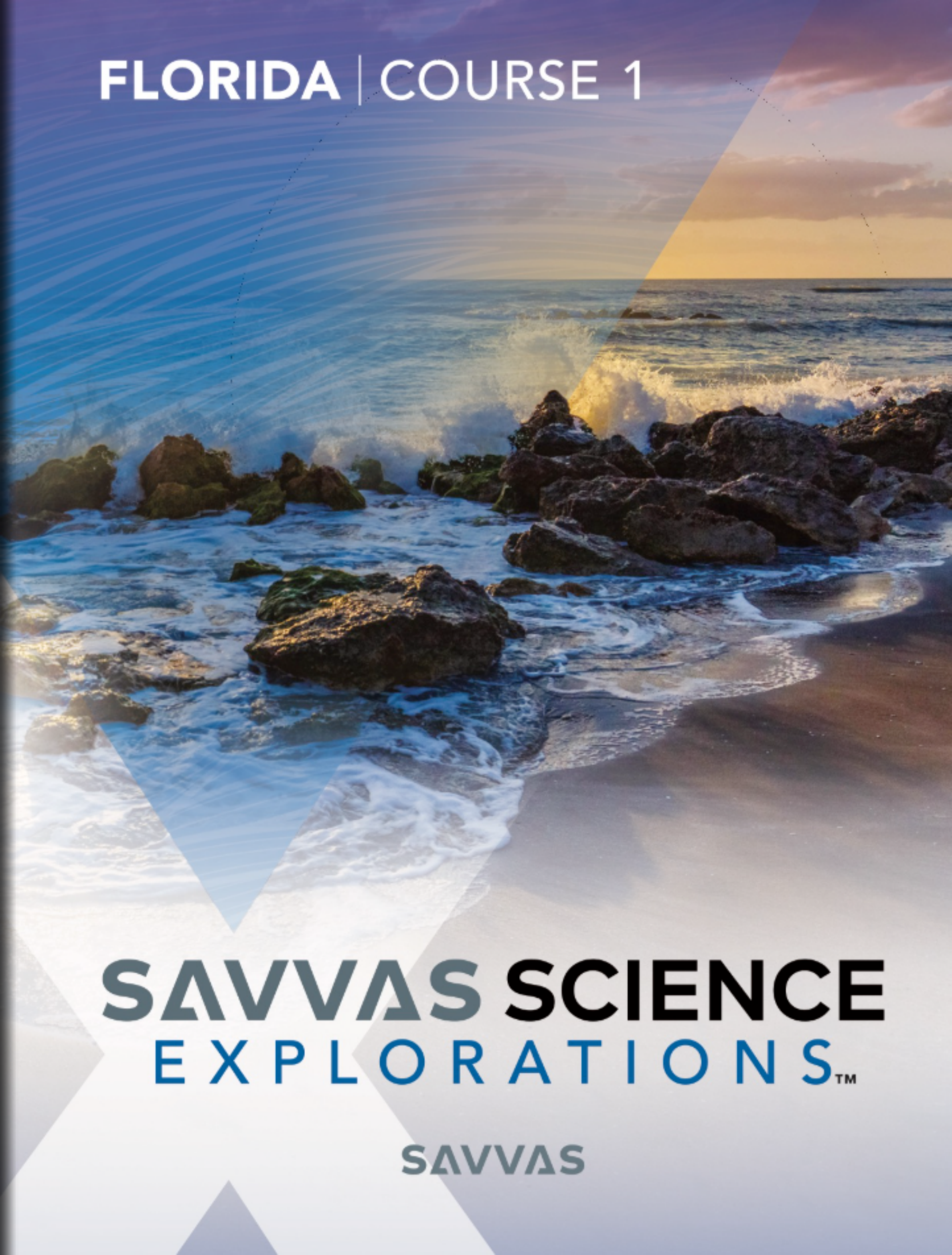
FLORIDA | COURSE 1



SAVVAS SCIENCE EXPLORATIONS™

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FLORIDA | COURSE 1

SAVVAS SCIENCE EXPLORATIONS

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Cover: The cover shows a sunset over the rocky shore of the Gulf of Mexico at Caspersen Beach in Venice, Florida.
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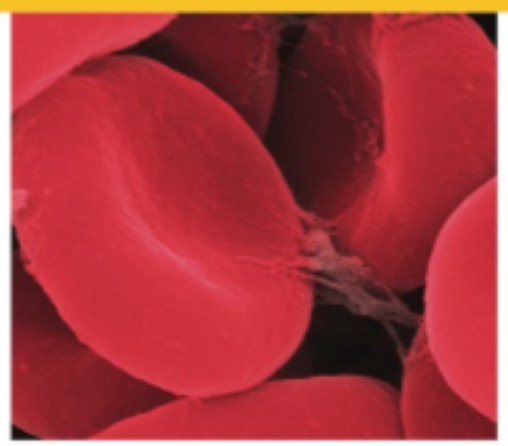

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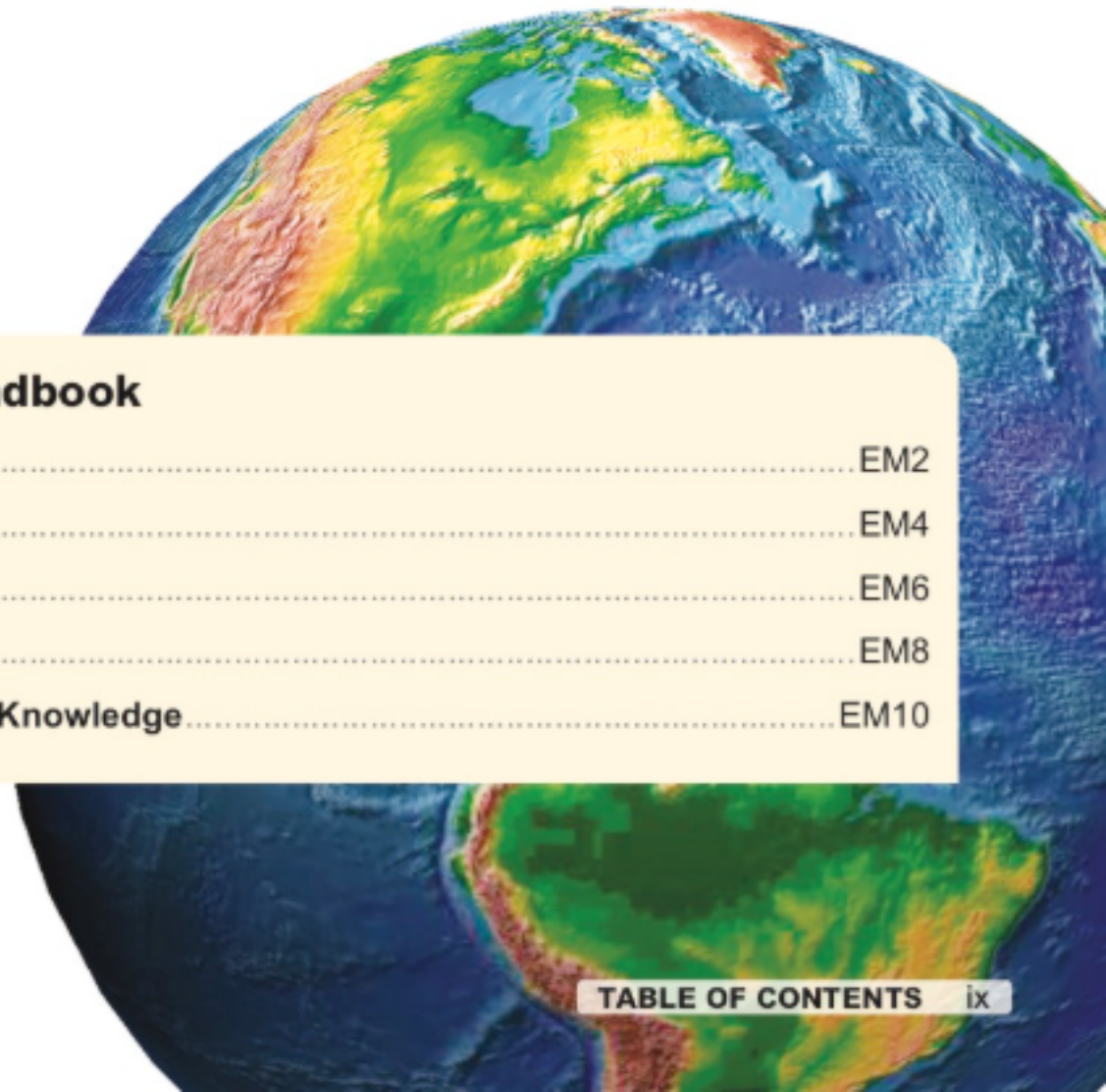


Nature of Science Handbook

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Earth's Spheres and Their Interactions

I can...

- differentiate the spheres that make up the Earth system.
- show how Earth's spheres interact.

Vocabulary

atmosphere biosphere cryosphere feedback geosphere hyrdosphere system

Phenomenon How do warmer air temperatures result in rising sea levels?

Pisa photography/Shutterstock

Make a Claim Explain how warmer air temperatures can cause sea levels to rise. Identify the Earth spheres involved in this scenario and explain how they interact to cause the phenomenon.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Interaction Actions

You will…

- model and observe common interactions between animals and objects.
- draw conclusions about how different parts of Earth interact.

What You Need to Know

The sun's energy affects all forms of matter on Earth. For example, the heat you feel on your face when the sun is shining is an example of how energy from the sun flows to Earth. In this way, the sun and its thermal energy can be said to interact with Earth.

Earth's matter can be classified into five main spheres. The **biosphere** includes all life on Earth. The **geosphere** includes all Earth's rock. The **hydrosphere** is made up of all the water on Earth, including the frozen water in the **cryosphere**. The **atmosphere** includes the air surrounding Earth. Each of these spheres is part of the Earth system.

In this activity, you will make observations and draw conclusions about how different spheres of Earth interact.

Materials

Several plastic jars containing a variety of objects (one object per jar), as follows:

- ordinary soil
- chunk of granite
- soil
- quartz crystals
- water
- ice
- ladybugs
- earthworms
- grass
- small twig with leaves
- dandelions (or any type of weed)
- violets

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Take care when handling live animals.


Wear safety goggles.


Wear a lab coat or apron.


Wear gloves.


Wash your hands when you complete the activity.

Procedure

1. Examine the objects in each of your jars.
2. Sort the jars into groups, according to the object each jar contains. Each of your groups should contain objects that have a major characteristic in common.
3. Look at the objects in the jars. As a group, identify two or more objects from separate jars to place together in a single jar and observe.
4. Write down the names of the objects you choose. Then, obtain permission from your teacher to place your objects in one jar. Record your observations.

Observations

Objects in jar:

Analyze and Interpret Data

1. **Describe** What objects did you pick to place together in a jar? How did the objects interact with each other?

2. **Predict** Look at the objects you placed in your jar. If you placed the jar in direct sunlight, how might the sun's energy affect the objects?

3. **Define** Earthworms belong to a sphere on Earth called the *biosphere*. Use this information to write a definition of *biosphere*.

4. **Construct Explanations** Earthworms need soil to keep their skin moist. Soil is part of Earth's *geosphere*. What would happen to earthworms if all the soil on Earth disappeared? What does this tell you about how different spheres on Earth interact?

5. **Nature of Science** A model is a representation of an object, process, or phenomenon. Scientists often use models to study different systems. Graphs, diagrams, globes, and other three-dimensional representations are examples of models.

   Describe the kind of model you developed. What was the role or purpose of your model? How did your model help you understand how different spheres on Earth can interact?

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Rising Sea Levels

You will…

- describe how Earth's spheres interact when melting ice raises sea levels.

What You Need to Know

Florida, a semi-tropical paradise far from the northern latitudes, might seem to have nothing to do with Greenland, an island of ice between the Atlantic and Arctic oceans. Florida, however, is surrounded by water, with the longest coastline in the continental United States.

About 82 percent of Greenland is covered by an ice sheet. In recent years, this ice sheet has been melting at an advanced rate due to warming air and sea temperatures. When ice on land melts and runs into the ocean, it has the potential to raise sea levels around the world. Sea levels have risen at an average rate of 1.5 cm every decade for the last century. But during the last 25 years, that rate has doubled, mostly because of ice melting in Greenland and Antarctica. Higher sea levels result in coastal flooding, which threatens lives and property.

The map shows land in Florida that will be underwater if the sea level rises 6 meters. Study the map, and then answer the questions that follow.

Analyze and Interpret Data

1. **Identify** Which of these cities will not be underwater if the sea level rises 6 meters: Panama City, Orlando, or Jacksonville?

2. **Identify** According to the data on the map, which region of Florida will experience the greatest impact from flooding if the sea level rises 6 meters?

3. **Calculate** Based on the map, how far inland from the Atlantic coast will South Florida be underwater?

4. **Cause and Effect** Earth is made up of different parts, or spheres. The atmosphere is the air surrounding Earth. The biosphere includes all life on Earth. The hydrosphere includes all the water on Earth, and cryosphere includes all the frozen water. The geosphere is made up of the Earth's rock and land.

   Describe how rising sea levels in the hydrosphere might affect Earth's biosphere.

Earth's Spheres and Their Interactions

1 A **system** is a group of parts that work together as a whole. A car is a system because it is made up of different parts. The motor, wheels, brakes, and other parts all function to safely move people from one place to another. Earth is also a system because it is made up of different parts that interact and work together.

The Earth System

2 Matter and energy flow through the Earth system. In the water cycle, water evaporates from the ocean and other bodies of water on Earth. Then it rises into the air and eventually falls back to Earth's surface as precipitation. Rain and meltwater flow to rivers, lakes, and the ocean. Eventually, the water cycles back into the air.

3 Rock also cycles through the Earth system. Hot molten material inside Earth, called magma, flows up through cracks in Earth's crust. This new material loses energy as it cools to form solid rock. Over time, the rock can be eroded into small pieces. If enough small pieces collect, they may get packed together to form new rock.

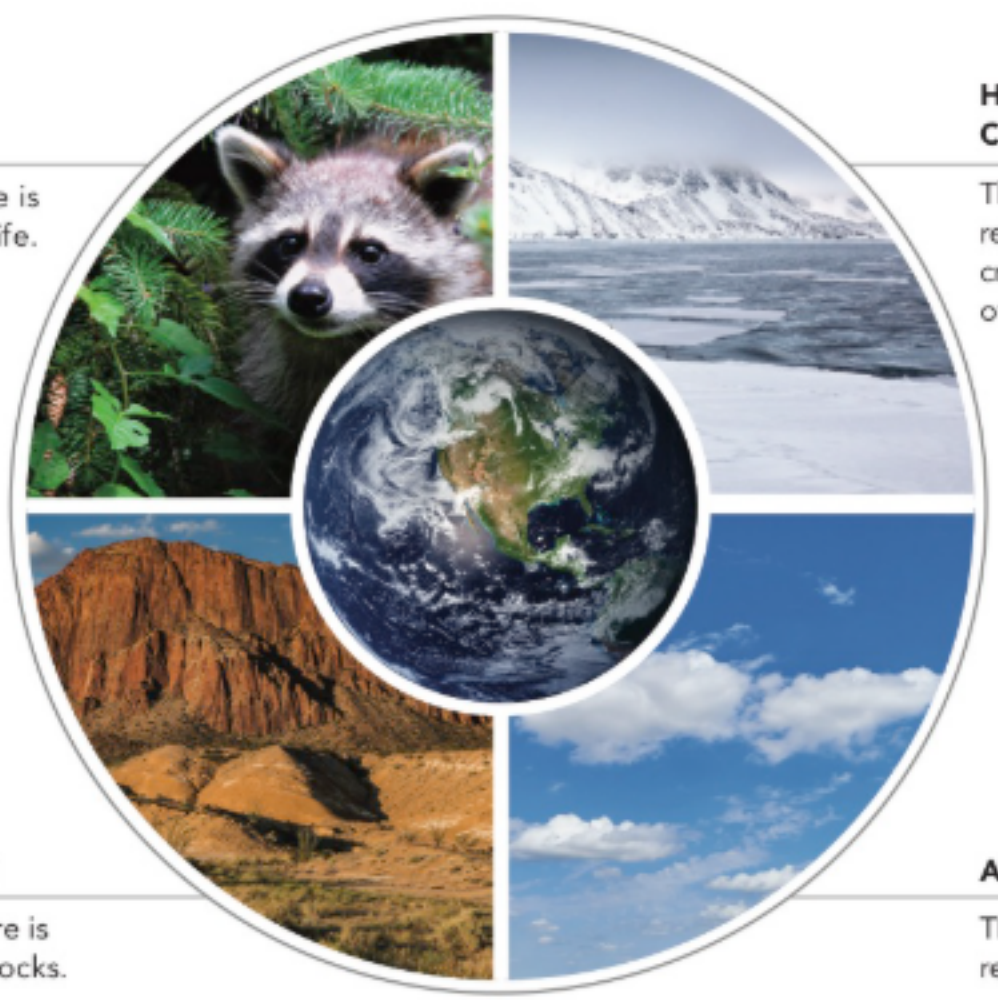
Earth as a System Lake Okeechobee is part of a water system in southeastern Florida. Disruptions to the cycling of water in this system can lead to algae blooms, which affect the proper function of the system.

4 The constant flow, or cycling, of matter through the Earth system requires energy, which is the ability to do work or cause change. Water in a lake, for example, requires energy to evaporate. Solid rock requires energy to become molten rock. The Earth system has two main sources of energy: heat from the sun and heat from Earth's interior. These energy sources drive cycles of matter in the Earth system.

Earth's Spheres

5 The Earth system is made up of five interacting spheres, or subsystems, that cycle energy and matter, as well as shape Earth's surface over time. These spheres are the biosphere, geosphere, atmosphere, hydrosphere, and cryosphere.

▶ **The Parts of Earth** Earth is classified into five spheres: the biosphere, geosphere, atmosphere, hydrosphere, and cryosphere. These spheres are individual parts of the Earth system that interact with each other.



The Atmosphere

6 Earth's **atmosphere** is the relatively thin envelope of gases that forms Earth's outermost layer. We call it *air*. It is a mixture of gases including nitrogen, oxygen, water vapor, and carbon dioxide—and dust particles. It contains Earth's weather, and it is the foundation for the different climates around the world.

7 As Earth's outermost layer, the atmosphere receives energy in the form of sunlight that passes through it and from heat that rises from Earth's surface, including the ocean. The warming of parts of the atmosphere by heat rising from Earth's surface creates wind, which distributes energy and water through the atmosphere.

Literacy Support

Reread the paragraphs about the atmosphere. Identify evidence in the text that supports the idea that the atmosphere affects Earth's climate.

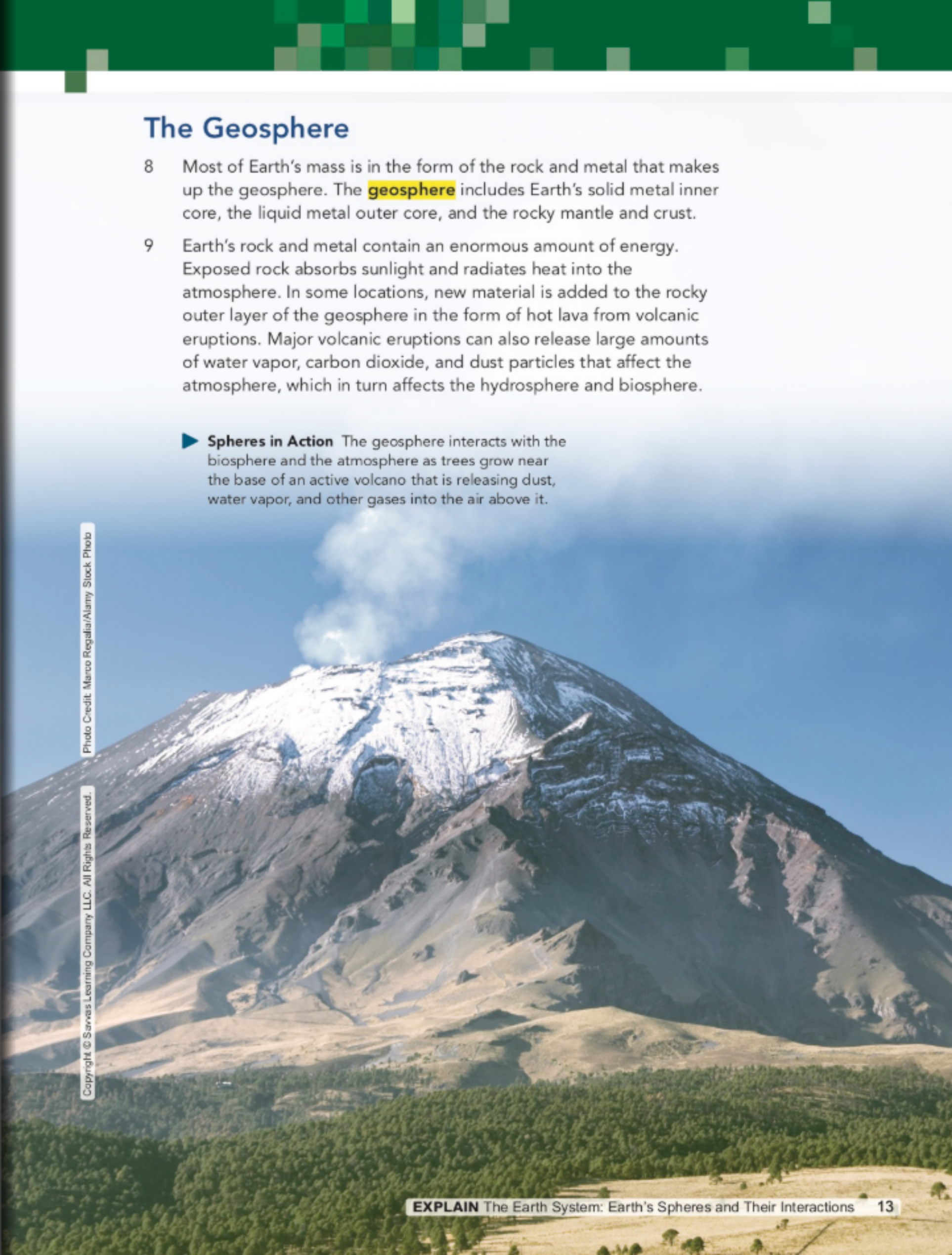
Protecting Earth The atmosphere is like a jacket wrapped around the planet. The air in the atmosphere contains oxygen, which many organisms in the biosphere need to live.

The Geosphere

8 Most of Earth's mass is in the form of the rock and metal that makes up the geosphere. The **geosphere** includes Earth's solid metal inner core, the liquid metal outer core, and the rocky mantle and crust.

9 Earth's rock and metal contain an enormous amount of energy. Exposed rock absorbs sunlight and radiates heat into the atmosphere. In some locations, new material is added to the rocky outer layer of the geosphere in the form of hot lava from volcanic eruptions. Major volcanic eruptions can also release large amounts of water vapor, carbon dioxide, and dust particles that affect the atmosphere, which in turn affects the hydrosphere and biosphere.

Spheres in Action The geosphere interacts with the biosphere and the atmosphere as trees grow near the base of an active volcano that is releasing dust, water vapor, and other gases into the air above it.



The Hydrosphere and Cryosphere

10 All of Earth's water, including water that cycles through the atmosphere, makes up the **hydrosphere**. The **cryosphere** is the frozen component of the hydrosphere. It is made up of all the ice and snow on land, plus sea and lake ice.

11 Liquid water on Earth absorbs energy from sunlight, which moderates the climate. When the air in the atmosphere is cold, heat from the ocean can keep the temperature above freezing. When the atmosphere is warm, the ocean absorbs some heat, making coastal communities cooler. Snow and ice reflect sunlight, which otherwise would be absorbed by water, soil, trees, and rock. Without water in all of its forms, Earth would experience extreme changes in temperature.

Water on Earth The hydrosphere, cryosphere, and biosphere interact as a polar bear walks on ice floating in the waters of the Arctic Ocean.

The Biosphere

12 Life has been found in virtually every part of Earth, from deep below the continental ice shelf of Antarctica to high up in the Himalayan Mountains. The parts of Earth that contain all living organisms are collectively known as the **biosphere**.

13 Living things, including animals, plants, bacteria, and fungi, interact with each other within the biosphere. As living things, humans are an important part of the biosphere. Humans interact with other components of the biosphere when they consume plants or animals for energy. When living things die, their nutrients are absorbed by the roots of plants or broken down by bacteria or other living things. These complex systems within the biosphere support all life on Earth.

Life on Earth The biosphere and atmosphere interact as a frog breathes in oxygen from the atmosphere that was produced by plants and released into the air.

Interacting Spheres

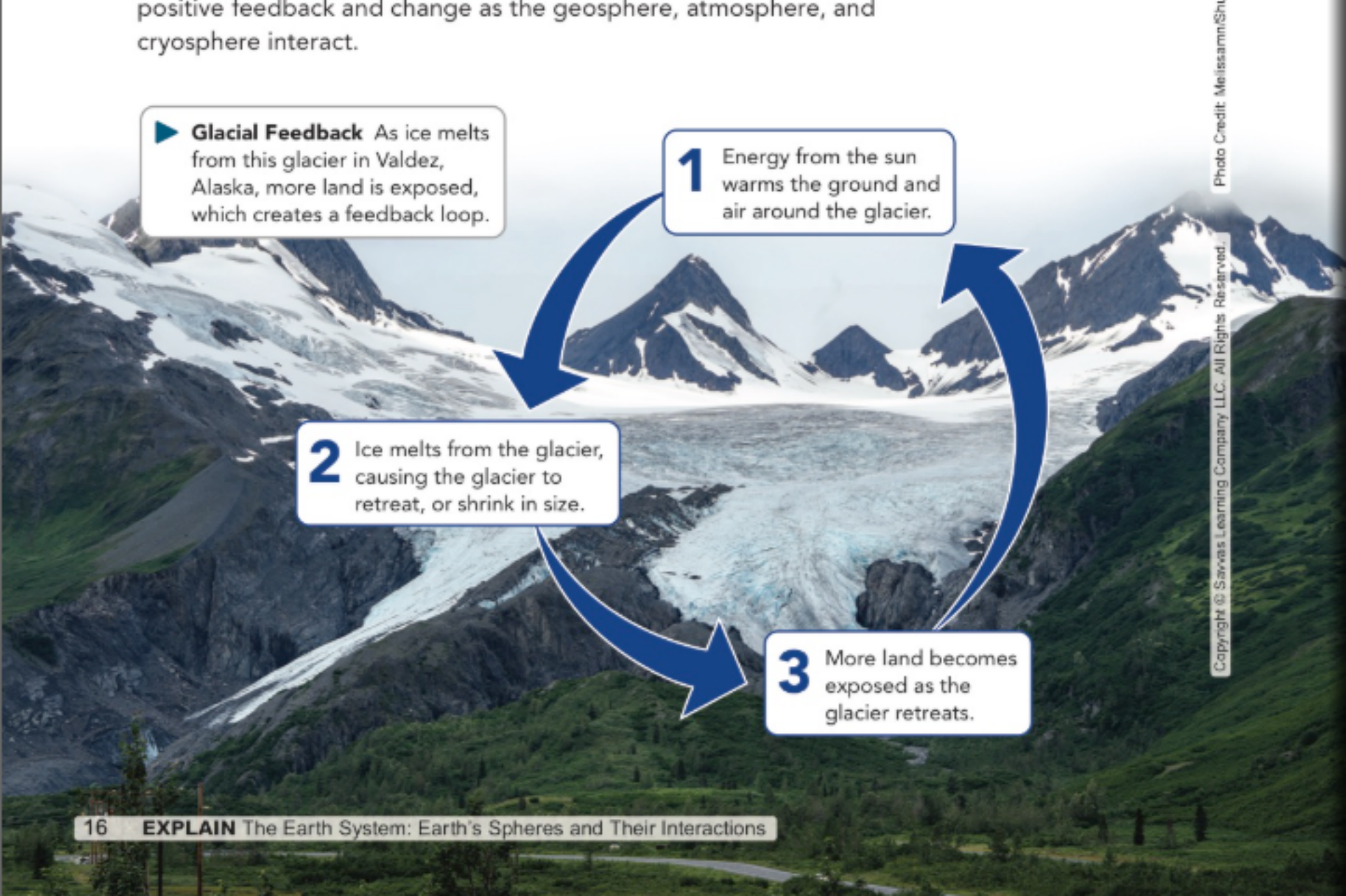
14 As you've read, Earth's spheres are part of a system, and they interact with each other. An event in one sphere can affect another, which in turn can affect the other spheres. For example, glaciers are part of the cryosphere. They are large blocks of ancient ice, usually found near mountains and in polar regions. Like a freezer pack in a cooler, a glacier keeps the surrounding air and land cool.

15 Many glaciers are melting around the world due to warmer air temperatures. As glaciers melt, they lose mass and volume and turn into liquid water that drains away or evaporates. This allows the land underneath to absorb more sunlight, which causes the surrounding air and land to get warmer. The warmer air makes glaciers melt even faster. This is an example of **feedback**. The system returns, or feeds back, energy into itself, and that energy results in change.

16 Sometimes feedback is negative: it causes a process to slow down or go in reverse. Other types of feedback are positive: they reinforce, speed up, or enhance the process that's already underway. Feedback may result in conditions becoming stable or it may cause more change. The melting glaciers are an example of positive feedback and change as the geosphere, atmosphere, and cryosphere interact.

Vocabulary Support

Feedback involves a loop in which a signal or action triggers another signal or action. How is this similar to getting feedback from a teacher on a project?



Glacial Feedback As ice melts from this glacier in Valdez, Alaska, more land is exposed, which creates a feedback loop.

NAME _____ CLASS _____ DATE _____

Reading Check

Earth's Systems and Their Interactions

Answer the following questions after you have completed reading the Read About It.

1. In paragraph 1, you read about systems. Why is Earth considered a system?

_____

_____

_____

2. In paragraphs 2–4, you read about the flow of matter through the Earth system. Identify the **two** sources of energy that drive most of the cycling of matter.

   A. the sun

   B. small pieces rock

   C. Earth's interior

   D. the water cycle

3. In paragraph 6, you read about Earth's atmosphere. What are the components of the atmosphere?

   A. all living things on Earth

   B. the thin envelope of gases that surround Earth

   C. the rock that makes up Earth

   D. all the water on Earth

4. In paragraph 8, you read about the geosphere. What are the components of the geosphere?

_____

_____

_____

5. In paragraph 10, you read about the hydrosphere and cryosphere. Place an X in the correct column to identify whether the component in each row is part of the hydrosphere or cryosphere.

	Hydrosphere	Cryosphere
liquid water in the ocean		
frozen ice in glaciers		
running water in a river		

6. In paragraph 11, you read about liquid and frozen water. How does energy from the sun affect liquid water differently than frozen water like snow and ice?

7. In paragraph 12, you read about the biosphere. Identify **two** components of the biosphere.

   A. air

   B. plants

   C. animals

   D. soil

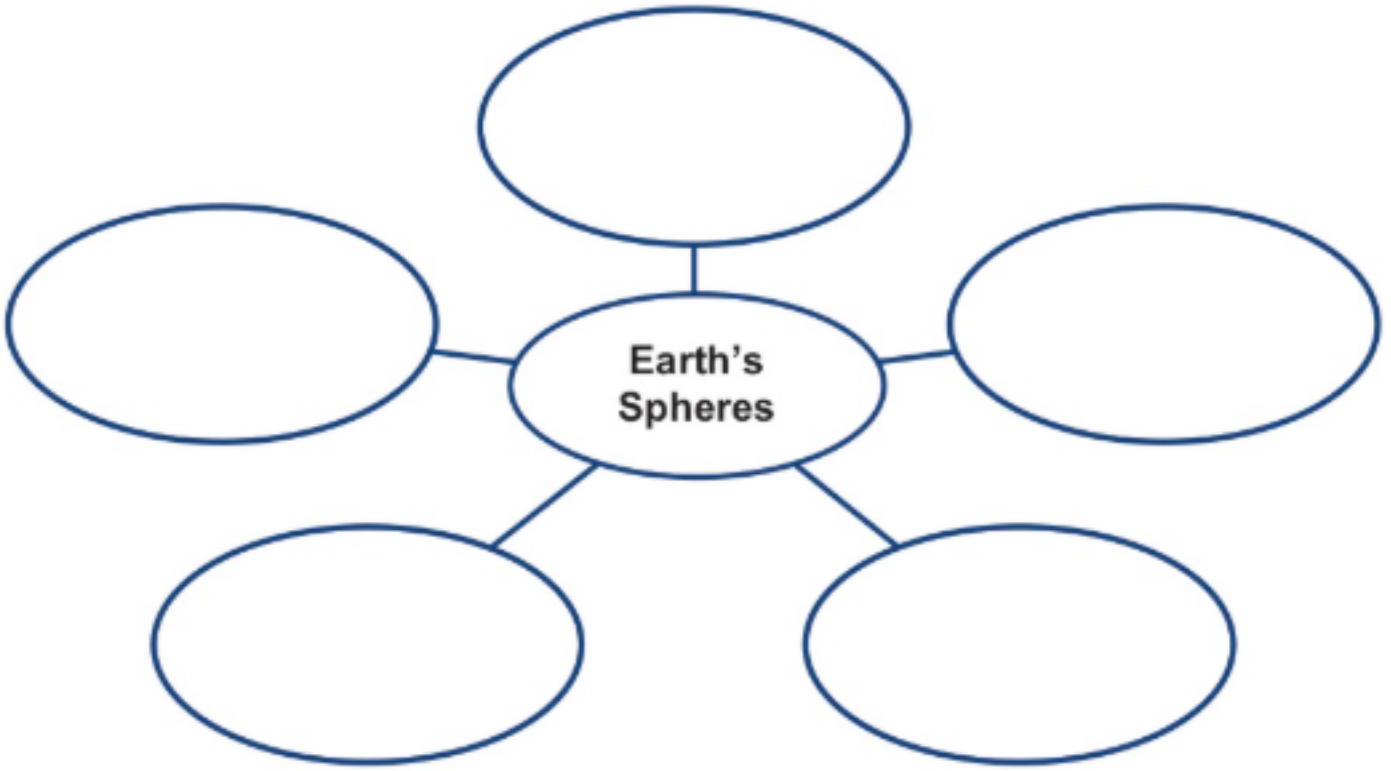
8. **Vocabulary** In paragraphs 15–16, you read about positive and negative feedback. What does the term *feedback* mean?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Earth's Spheres and Their Interactions

1. **Model** Use a graphic organizer to differentiate among Earth's spheres. Identify and briefly describe each of Earth's spheres.



2. **Apply** The island of Hawaii is home to four active volcanoes. During a volcanic eruption, hot, molten rock flows over the land and can meet the ocean, where it is cooled by the water and hardens into solid rock. Dust, ash, and gases are released into the air and can settle on the ground. These effects of an eruption also harm plant and animal life, as well as human life and property. What are some ways in which Earth's spheres interact during a volcanic eruption?

NAME _____ CLASS _____ DATE _____

Lesson Review

Earth's Spheres and Their Interactions

Choose the best answer to each question.

1. Which of the following descriptions of Earth's sphere is correct?

   A. The geosphere is made up of Earth's living things.

   B. The hydrosphere is all the frozen water on Earth.

   C. The biosphere includes Earth's rock.

   D. The atmosphere is all the air surrounding Earth.

2. After heavy rains, loose rock and soil slide down the side of a mountain, destroying a small forest at the base of the mountain. Which of Earth's spheres are interacting in this situation?

   A. biosphere and geosphere

   B. hydrosphere, geosphere, and biosphere

   C. atmosphere and geosphere

   D. cryosphere, geosphere, and atmosphere

3. Which of the following is an example of positive feedback as part of an interaction between two of Earth's spheres?

   A. Walking outside in hot weather makes a person warm. They begin to perspire, which cools their body.

   B. Warm weather causes clouds to form. This shades the ground from the sun and causes the temperature to cool.

   C. Warm air melts sea ice, exposing more sea water to sunlight. The water becomes too warm to freeze into ice.

   D. Flowers in a field absorb sunlight and rain, grow tall, and then produce seeds, which fall to the ground and become new plants.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Earth's Surface and Landforms

I can...

- describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.
- recognize a variety of landforms on Earth's surface.

Vocabulary

chemical weathering coastline delta deposition dune erosion glacier lake landform mechanical weathering mountain river sediment significant topography

Phenomenon How did this giant hole form?

Make a Claim Explain how the hole formed by describing the processes that change Earth's surface.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Raindrops Falling

You will…

- develop a model of a river delta.
- describe the processes on Earth's surface that form deltas.

What You Need to Know

The Mississippi River Delta is North America's largest delta. The delta is a landform made up of sand, clay, and organic material deposited by the Mississippi River as it flows into the shallow waters of the Gulf of Mexico.

Your class has been asked to participate in the RESTORE the Mississippi River Delta campaign to help rebuild and protect the delta. Human activity and natural disasters have threatened the existence of the delta, which serves as a natural protective barrier to coastal damage. You will model how deltas form and observe the processes that are responsible for transporting sediment to the delta. Be prepared to predict how the land surface may change over time under specific conditions.

Materials

- paint tray or tray liner
- foam cup with a hole in the bottom
- 75 mL of water
- pitcher of water
- 250 mL of sand
- 2 rulers
- books

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Procedure

1. Rest the shallow end of the paint tray on the books (about 10 cm high).
2. Fill the deep part of the paint tray with water from the pitcher until it reaches the shallow incline of the tray.
3. Place the 250 mL of sand in the dry end of the tray.
4. Use the two rulers to support the foam cup on top of the pile of sand. It is okay if the cup rests on the sand.
5. Pour the 75 mL of water into the foam cup. It should flow out in a slow trickle onto the sand.
6. As the water and sand are flowing downslope, record your observations.
7. Draw your delta in the space given and label the following: tray, water, land, shoreline, river mouth, deltaic plain (sediment above the waterline), subaqueous deltaic plain (sediment below the waterline), and distributary channels that may have formed in the deltaic plain.

Observations

Diagram

Analyze and Interpret Data

1. **Identify** Erosion is a process that carries away rock particles, sand, soil, and other sediments. Where did you observe the process of erosion in your model?

2. **Identify** Deposition is a process that occurs when agents of erosion, such as a river, deposit, or lay down, sediment. Where did you observe the process of deposition in your model?

3. **Predict** How could you adjust your model to make the delta grow larger?

4. **Cause and Effect** What environmental factors could affect the rate at which a delta forms?

5. **Construct an Explanation** Prepare a short explanation for the campaign directors of how a delta is formed. Be sure to refer to your model.

6. **Nature of Science** Meet with another group. Discuss and compare your models, observations and results, and the explanations you wrote for the previous question. Revise your explanation as needed based on your discussion.

NAME _____ CLASS _____ DATE _____

Graphing Activity

Comparing Weathered Limestone

You will…

- graph and analyze data about the weathering of limestone.

What You Need to Know

Weathering is a geological process that breaks down rock and other materials. Heat, cold, water, and ice all contribute to weathering. Some types of weathering involve physically breaking down rock. Others involve chemical changes.

Limestone is a rock composed of calcium and carbon. You might be familiar with a kind of limestone called chalk. Limestone is the source of lime (calcium oxide), a substance used in the manufacturing and production of steel, plastic, and paper products. The rock is a durable, or strong, material. However, it absorbs water easily and can weather quickly when exposed to even mildly acidic rainwater.

The data table shows how much rock was broken down by weathering for two identical pieces of limestone in two different locations.

Weathering Rates of Limestone

Time (years)	Thickness of Limestone Lost (mm)	
	Sample A	Sample B
200	1.75	0.80
400	3.50	1.60
600	5.25	2.40
800	7.00	3.20
1000	8.75	4.00

Analyze and Interpret Data

1. **Construct Graphs** Use the data to make a double-line graph. Decide how to make each line look different on the graph. Be sure to provide a title. Label the axes and each graph line. Choose an appropriate interval for each axis.

2. **Patterns** What happens to the limestone thickness as time increases?

3. **Evaluate** Which sample of limestone weathered at a faster rate? Explain.

Earth's Surface and Landforms

1 If you drove across the United States, you would observe many changes in topography. **Topography** is the shape of the land. Land can be described using elevation, relief, and landforms.

2 The height of a point above sea level on Earth's surface is its elevation. The difference in elevation between the highest and lowest points of an area is its relief. An area's relief is the result of the different landforms found there. **Landforms** are features such as coastlines, dunes, and mountains. Different landforms have different combinations of elevation and relief.

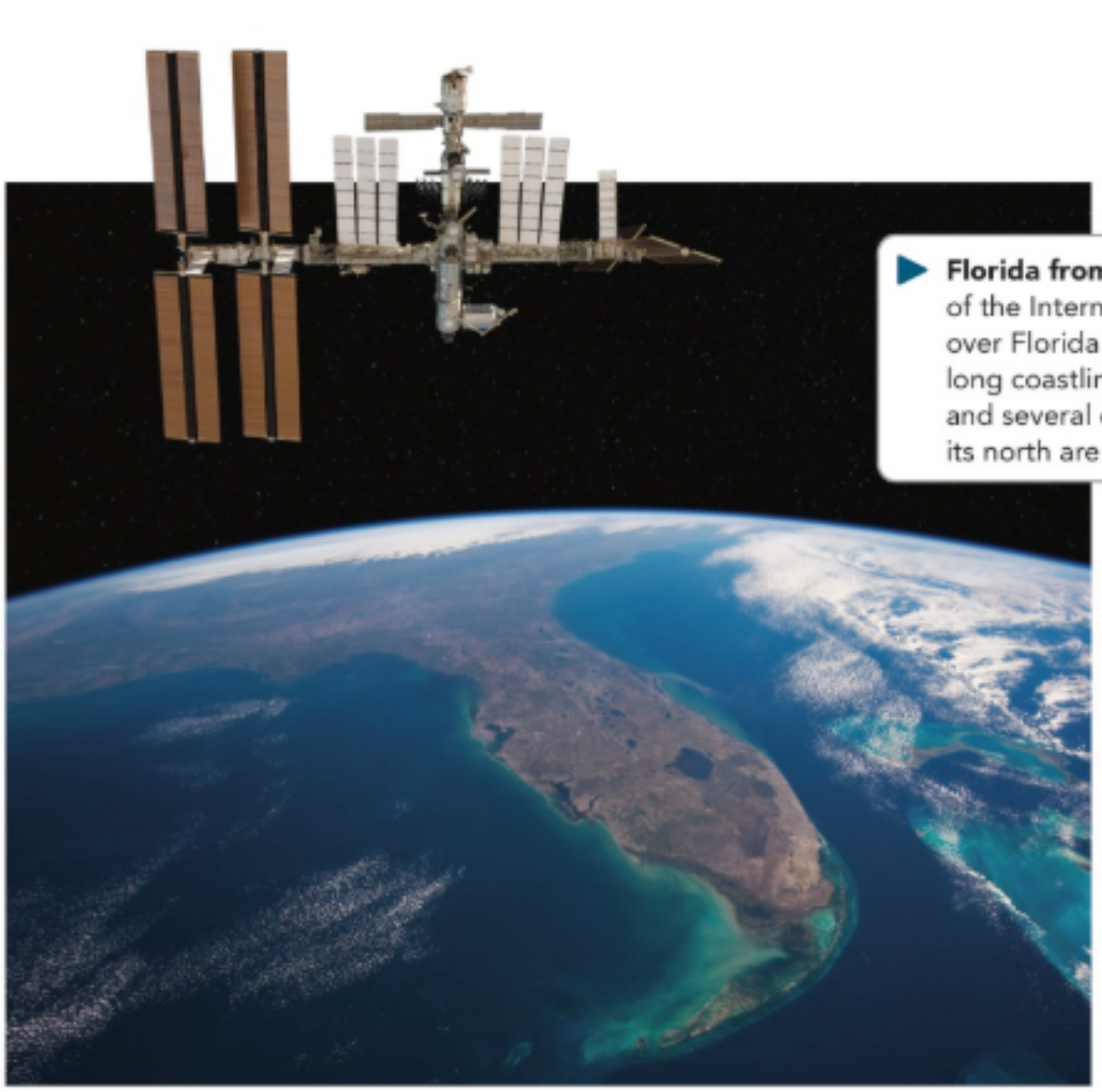
Many Landforms The topography of the United States includes many different land features such as mountains, rivers, and plains.

Types of Landforms

3 There is a variety of landforms on Earth because Earth's surface differs from place to place. A **mountain** is a landform with both high elevation and high relief. Landforms that have high elevation and low relief are called plateaus, while landforms that have low elevation and low relief are called plains. A coastal plain is a plain that lies along a seacoast. In North America, the Atlantic coastal plain extends from Florida all the way up to Cape Cod in Massachusetts.

4 The boundary between the land and the ocean or a lake is a **coastline**. The mainland of Florida has a coastline measuring about 2,170 kilometers. The land that extends from a coastline may be rocky cliffs, sandy beaches, or dunes. A **dune** is a hill of sand deposited and piled up by the wind on a coastline or in a desert.

5 A lake is a landform made up of water that collects in hollows or low-lying areas. The water in lakes is usually supplied by rainfall, melting snow and ice, and runoff. Florida has over 30,000 freshwater lakes across the state. Lake Okeechobee, the state's largest lake, is known as Florida's "inland sea."

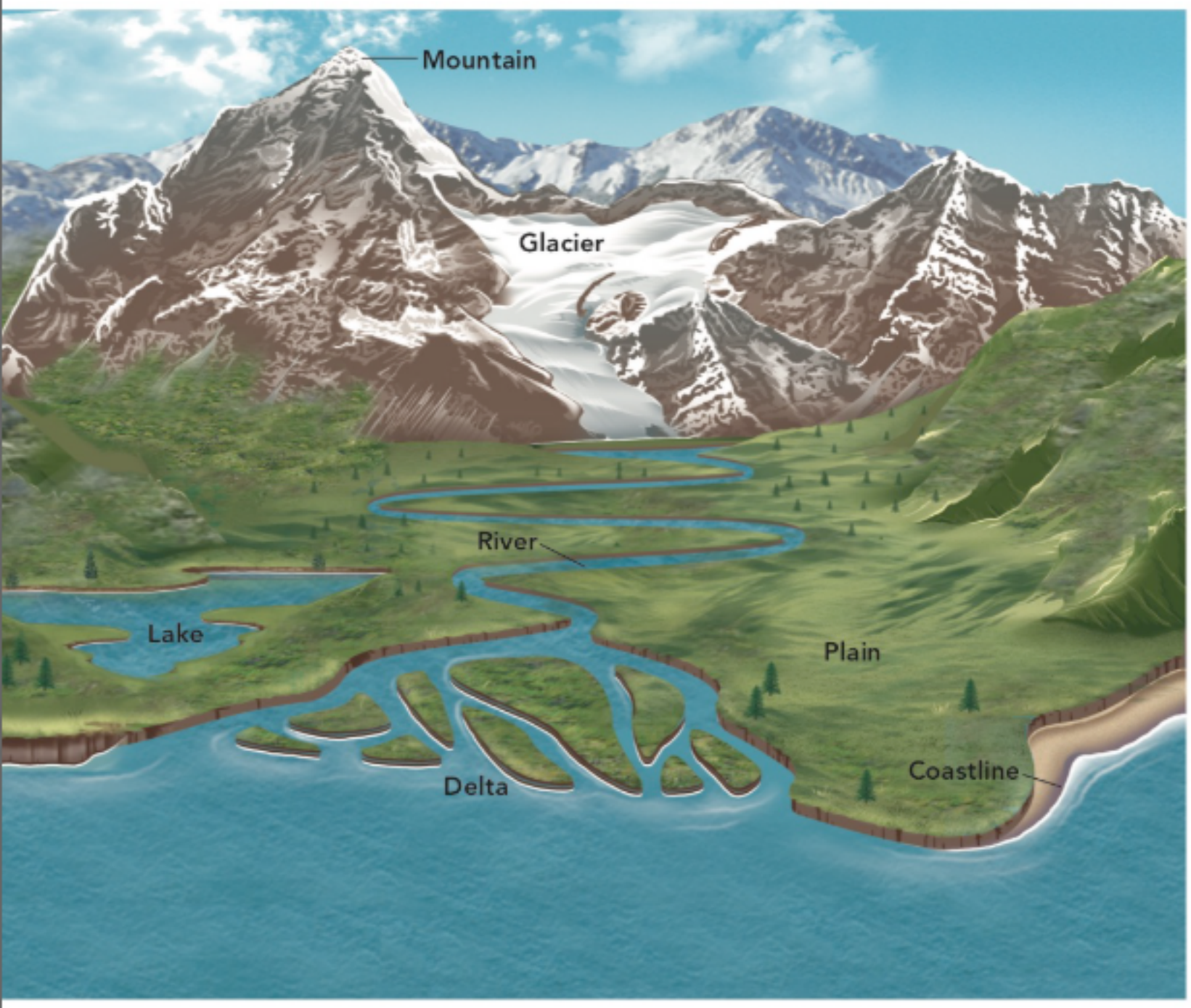


Florida from Space This image of the International Space Station over Florida highlights the state's long coastline. Lake Okeechobee and several other smaller lakes to its north are visible.

6 A **river** is a natural stream of water that flows into another body of water such as an ocean, lake, or another river. When the water in a river slows, small pieces of sand and soil in the water sink. The sediment deposited where a river flows into an ocean or lake builds up a landform called a **delta**. In Florida, the Apalachicola River supplies sand to St. Vincent's Island, a wildlife refuge.

7 A **glacier** is a large mass of ice that moves slowly over land. They only form in places where more snow falls than melts, so they occur in the coldest places on Earth. Over time, the particles of snow press together so tightly that they form solid blocks of ice.

Different Landforms There are many different types of landforms on Earth's surface.



Weathering, Erosion, and Deposition

8 The topography of Earth's surface is constantly being created and destroyed by competing forces. Forces that construct, or build up, land are called constructive forces. Forces that destruct, or tear down, land are called destructive forces. The geological processes of weathering, erosion, and deposition act together in a continuous cycle that wears down and builds up Earth's surface over time.

9 The process of weathering breaks down rock and other substances. Heat, cold, water, ice, and gases all contribute to weathering. The type of weathering in which rock is physically broken into smaller pieces is called **mechanical weathering**. Mechanical weathering usually happens over very long periods of time. The natural agents of mechanical weathering include freezing and thawing, release of pressure, plants, animals, and abrasion.

10 A second type of weathering, called chemical weathering, also breaks down rock. **Chemical weathering** is the process that breaks down rock through chemical changes. Chemical weathering can happen over relatively short periods of time. The process often produces new minerals as it breaks down rock. Water, oxygen, carbon dioxide, living organisms, and acid rain are agents of chemical weathering. When carbon dioxide dissolves in water, carbonic acid forms. This weak acid easily weathers certain types of rock, such as marble and limestone.

Literacy Support

As you read, use a Venn diagram to help you compare and contrast the processes of mechanical and chemical weathering.

Mechanical Weathering This unusual rock formation is the result of mechanical weathering. Sand and other small particles are blown across the rock, which slowly wear it away.

Chemical Weathering The holes in this limestone rock are the result of chemical weathering. Acid rain reacts with the minerals in the limestone.

11 **Erosion**, which is another destructive force, is the removal of rock particles by wind, water, ice, or gravity. The process of erosion moves material called **sediment**. Sediment is formed in the process of weathering and may consist of pieces of rock or soil, or the remains of plants and animals. Gravity, water and waves, ice, wind, and living things are all agents of erosion. Glaciers and moving water of the hydrosphere are the primary agents of the erosion that has shaped Earth's land surface, the geosphere, for billions of years.

12 **Deposition**, which is a constructive force, occurs where the agents of erosion deposit, or lay down, sediment. Like erosion, deposition changes the shape of Earth's surface. Agents of deposition include wind, which can form sand dunes, and water, which can form river deltas.

Mississippi River Delta Over thousands of years, sediment carried by the Mississippi River has been deposited where it meets the Gulf of Mexico, forming the delta seen here.

The Grand Canyon Over millions of years, the water in the Colorado River has eroded rock and carved a path through the land, forming the Grand Canyon.

Karst Topography

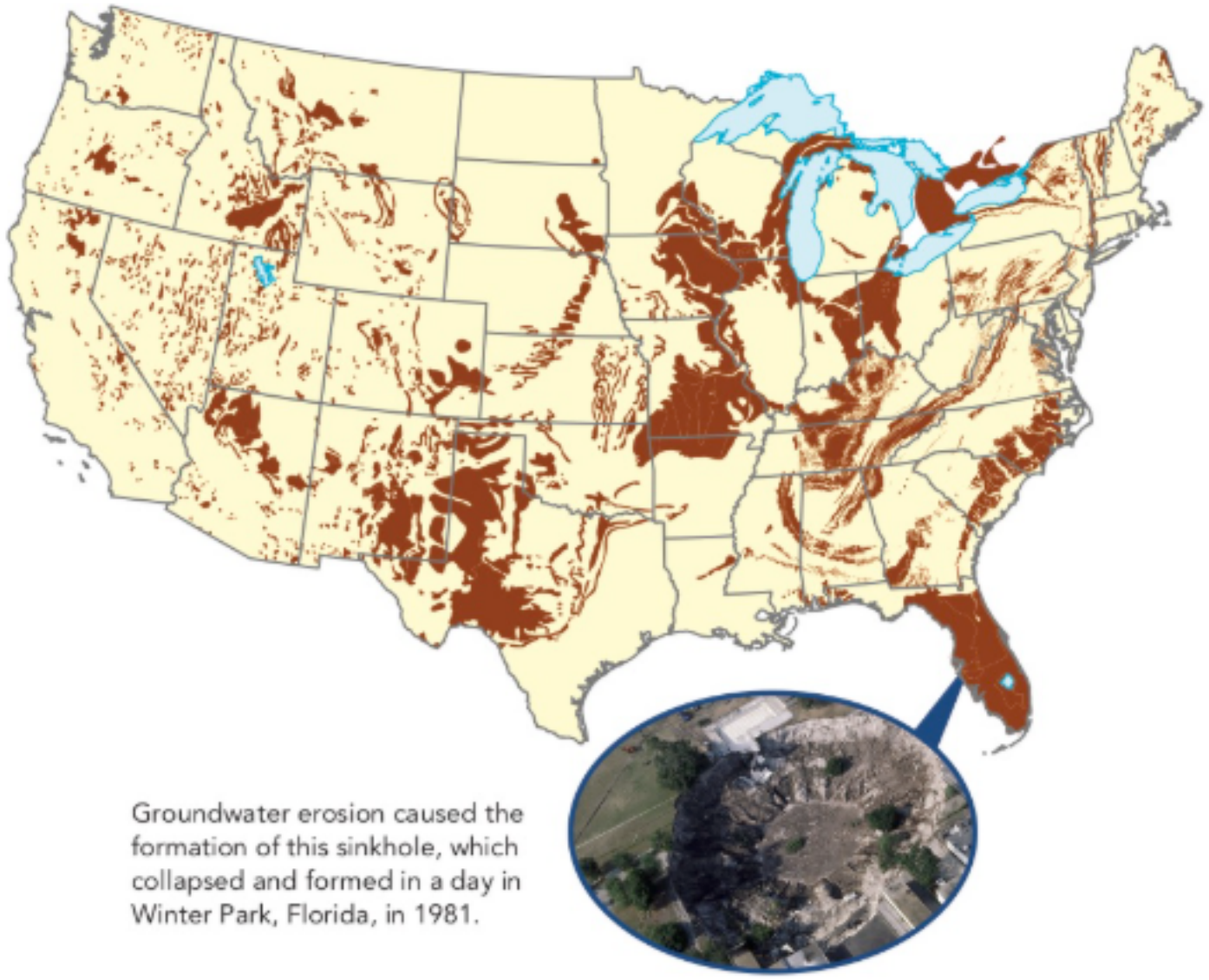
13 In rainy regions like Florida where there is a layer of limestone near the surface, water erosion can **significantly** change the shape of Earth's surface. Deep valleys and caves commonly form. If the roof of a cave collapses because of limestone erosion, the result is a depression called a sinkhole. This type of landscape is called karst topography.

14 The formation of karst topography happens over small to large areas and over short to very long time periods. Chemical weathering starts with a single drop of water that dissolves a microscopic amount of limestone in seconds. This weathering, combined with the process of erosion, might take thousands to millions of years to form a deep valley or huge cave system hundreds of kilometers long. The roof of a cave may very slowly erode over hundreds of years but collapse within minutes to form a small or large sinkhole.

Vocabulary Support

Something that is called *significant* is usually great or important enough to be worthy of people's attention. What are some things or events you think are significant?

▶ **Karst in the United States** The shaded areas on the map indicate areas of karst topography.



Groundwater erosion caused the formation of this sinkhole, which collapsed and formed in a day in Winter Park, Florida, in 1981.

NAME _____ CLASS _____ DATE _____

Reading Check

Earth's Surface and Landforms

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraph 1, you read about topography. What does the term *topography* mean?

2. In paragraph 3, you read about mountains and plateaus. How does a mountain differ from a plateau in terms of elevation and relief?

3. In paragraphs 3–7, you read about a variety of landforms. Which of the following landforms is **not** found in Florida?

   A. glacier

   B. lake

   C. river

   D. coastline

4. In paragraphs 5–6, you read about lakes, rivers, and deltas. How are the three landforms related?

   A. Deltas provide water for rivers, which often flow into lakes.

   B. Lakes and deltas are landforms that form rivers.

   C. A river can flow into a lake and create a delta where it enters the lake.

   D. Both rivers and lakes are different types of deltas, but they form in different places on Earth's surface.

5. In paragraph 8, you read about the forces that shape Earth's surface. What is a destructive force? What is a constructive force?

6. In paragraphs 9–10, you read about the different types of weathering. Place an X in the correct column to identify whether each example involves mechanical weathering or chemical weathering.

	Mechanical	Chemical
over a long time, a tree's roots grow and slowly break down rock in the ground		
acid rain falls and slowly wears away limestone rock in the ground		
water gets inside cracks in a rock, and as it freezes and thaws, it wears away the rock and makes the crack larger		

7. In paragraphs 11–12, you read about erosion and deposition. Identify the **two** statements that correctly identify these geological forces.

   A. Erosion is a constructive force that involves building up sediment in an area.

   B. Erosion is a destructive force in which rock particles are removed by wind, water, ice or gravity.

   C. Deposition is a destructive force that involves the removal of sediment.

   D. Deposition is a constructive force that occurs where the agents of erosion lay down sediment.

8. In paragraphs 13–14, you read about karst topography. What is karst topography?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Earth's Surface and Landforms

1. **Model** Use a graphic organizer to identify and describe three different landforms on Earth's surface that are found in Florida.

Florida Landforms		

2. **Apply** Provide one example of a way in which Earth's surface is built up. Then provide one example of a way in which Earth's surface is torn down. For each example, describe the process and identify whether mechanical weathering, chemical weathering, erosion, or deposition is involved.

NAME _____ CLASS _____ DATE _____

Lesson Review

Earth's Surface and Landforms

Choose the best answer to each question.

1. Erosion and deposition are often discussed together. Which statement most accurately describes their differences?

   A. Erosion wears away material, and deposition moves it.

   B. Erosion moves weathered material, and deposition resettles it.

   C. Erosion wears away material, and deposition resettles it.

   D. Erosion builds up material, and deposition resettles it.

2. What is a dune?

   A. a hill of sand piled up by the wind

   B. the boundary between land and a body of water

   C. a landform with both high elevation and relief

   D. a stream of natural water that flows into another body of water

3. Which of the following statements about mechanical and chemical weathering is correct?

   A. Mechanical weathering involves chemical changes that break down rock into smaller pieces. Chemical weathering involves physically breaking down rock into smaller pieces.

   B. Both mechanical and chemical weathering break down rock, but mechanical weathering breaks down rock into smaller pieces than chemical weathering.

   C. Mechanical and chemical weathering occur in different places and to different types of rock.

   D. Mechanical weathering can occur due to the actions of animals or plants. Chemical weathering can occur when acidic water dissolves rock.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Energy in the Earth System

I can…

- differentiate the ways heat is transferred through Earth's system.
- explain how energy provided by the sun influences temperature differences between air, water, and land.

Vocabulary

absorb conduction convection electromagnetic wave greenhouse effect radiation thermal energy wind

Phenomenon Why does wind come from opposite directions on the two coasts?

Develop a Model Draw a model with labels and captions to explain why wind comes from opposite directions on Florida's two coasts.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Heating Earth's Surface

You will…

- observe how different parts of Earth's surface absorb and release the sun's energy at different rates.

What You Need to Know

You are swimming at the beach on a sunny day. When you get out of the cool water and walk across the sand, it is so hot! As you quickly run back into the water, you wonder why the sand is hot but the water is cool. You decide to conduct an experiment to find out how different materials can heat up and cool off at different rates.

Materials

Several plastic jars containing a variety of objects (one object per jar), as follows:

- thermometers or temperature probes
- beakers
- sand
- water
- lamp with 100-watt bulb
- metric ruler
- clock or stopwatch
- string
- scissors
- ring stand and 2 ring clamps

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Wear safety goggles.


Wear a lab coat or apron.

Procedure

1. Make observations about the sand and water you will use. Record your observations in the space provided at the end of this Procedure section, or you may use your lab journal or science notebook.

2. Work with your partner to develop a model to compare how fast sand and water heat up and cool down. Plan to use the equipment and materials provided. Design the model so that you will be able to test the temperatures of sand and water as they heat and cool over time. Consider the following in your design:

   - It will take about 15 minutes for the temperature of your materials to increase using a 100-W bulb that is 20 cm away. It will take another 15 minutes for them to cool down.
   - When comparing the rates of temperature change, you will need to know two things: the temperatures of the materials and the time frame during which the temperatures changed. Plan on using a thermometer and a stopwatch or clock to collect and record temperature changes over time.

3. Describe your set-up and write a detailed procedure for your investigation. Use the space provided below, or you may use your lab journal or science notebook. Your procedure should list the equipment and materials you will use.

4. In the Observation section that follows, construct a data table in which to record your results. Your data table should include columns for both temperature and time.

5. Obtain and set up the materials you need. Have your teacher check your set-up, procedure, and data table before proceeding.

6. Follow your procedure and make observations using the thermometers and stopwatch or clock.

7. Collect data to provide evidence of different heating rates of different surfaces of Earth. Record your data in your data table.

Observations

Analyze and Interpret Data

1. **Construct Graphs** Use the data from your table to make a double-line graph. Decide how to make each line look different on the graph. Be sure to provide a title, and label the axes and each graph line. Choose an appropriate interval for each axis. Your graph should show the temperature change of sand and water over time.

2. **Analyze Data** Which material heated at a faster rate? Which cooled faster?

3. **Identify Variables** What was the independent variable in your experiment? What was the dependent variable?

4. **Determine Differences** Calculate the total change in temperature for each material. Which material had the greater increase in temperature? Which had the greater decrease?

5. **Construct Explanations** Using data from this investigation to support your claims, write an explanation about how different parts of Earth's surface absorb and release the sun's energy at different rates.

6. **Evaluate Your Model** What were the advantages of using your model? What were the limitations?

Energy in the Earth System

1 Most of the energy that is moving within Earth's atmosphere and across Earth's surface comes from the sun. The sun's energy travels to Earth as electromagnetic radiation, a form of energy that can move through the vacuum of space. **Electromagnetic waves** consist of an electric field and a magnetic field. Most of the electromagnetic waves that travel from the sun and reach Earth are in the form of visible light and infrared radiation. A smaller amount arrives as ultraviolet (UV) radiation.

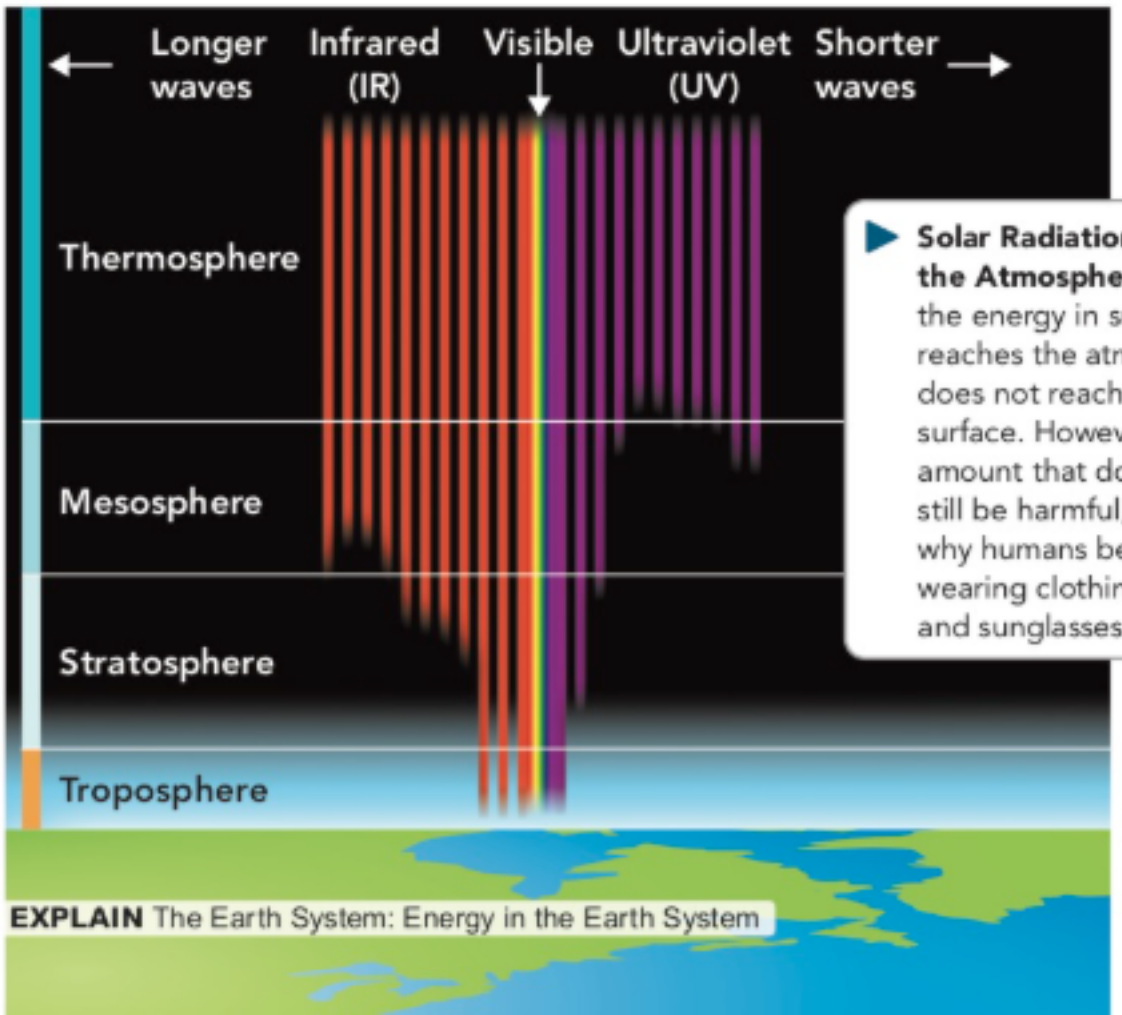
Vocabulary Support

Absorb means "to take in or soak up." What are some other things that are absorbed?

The Structure of the Atmosphere

2 In order for the sun's energy to reach Earth's surface and sustain life, it must first get through the atmosphere. Earth's atmosphere is divided into layers based on temperature. Some sunlight is **absorbed** or reflected by the different levels of the atmosphere before it can reach the surface.

3 Some UV wavelengths are absorbed by the topmost layer of the atmosphere, called the thermosphere. More UV energy, along with some infrared energy, is absorbed in the next layer, the mesosphere. Below that, in the stratosphere, ozone absorbs more infrared and UV energy. By the time sunlight reaches the troposphere, there is some infrared radiation, some UV radiation, and visible light. Some light is reflected into space by clouds.



Solar Radiation Through the Atmosphere Much of the energy in sunlight that reaches the atmosphere does not reach Earth's surface. However, the amount that does can still be harmful, which is why humans benefit from wearing clothing, sunscreen, and sunglasses.

Earth's Energy Budget

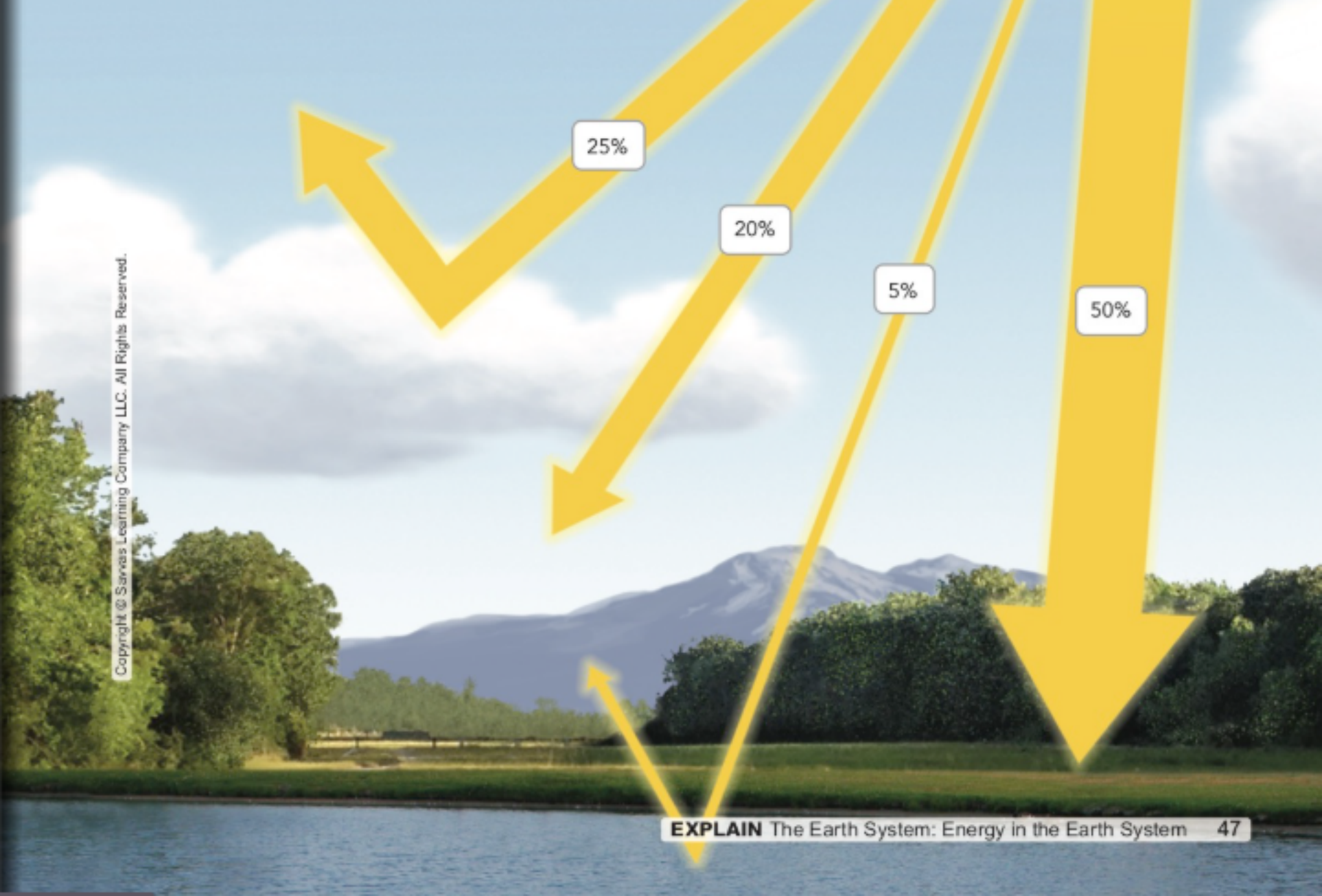
4 Of the sun's radiation that travels through the troposphere, only about 50 percent is absorbed by land and water and converted, or transformed, to heat. The rest is reflected by clouds and other particles in the atmosphere (25%), absorbed by gases and particles (20%), or reflected by the surface itself (5%). Snow, ice, and liquid water also reflect some sunlight back into the atmosphere.

5 Only a tiny fraction of the visible light that reaches Earth's surface is transformed to chemical energy in plants and other photosynthetic organisms. The rest is absorbed by Earth and re-emitted into the atmosphere as infrared radiation. Earth's surface absorbs and re-emits equal amounts of energy so that its energy remains in balance over time.

Literacy Support

As you proceed through the lesson, keep track of how energy moves and changes by identifying relevant sentences.

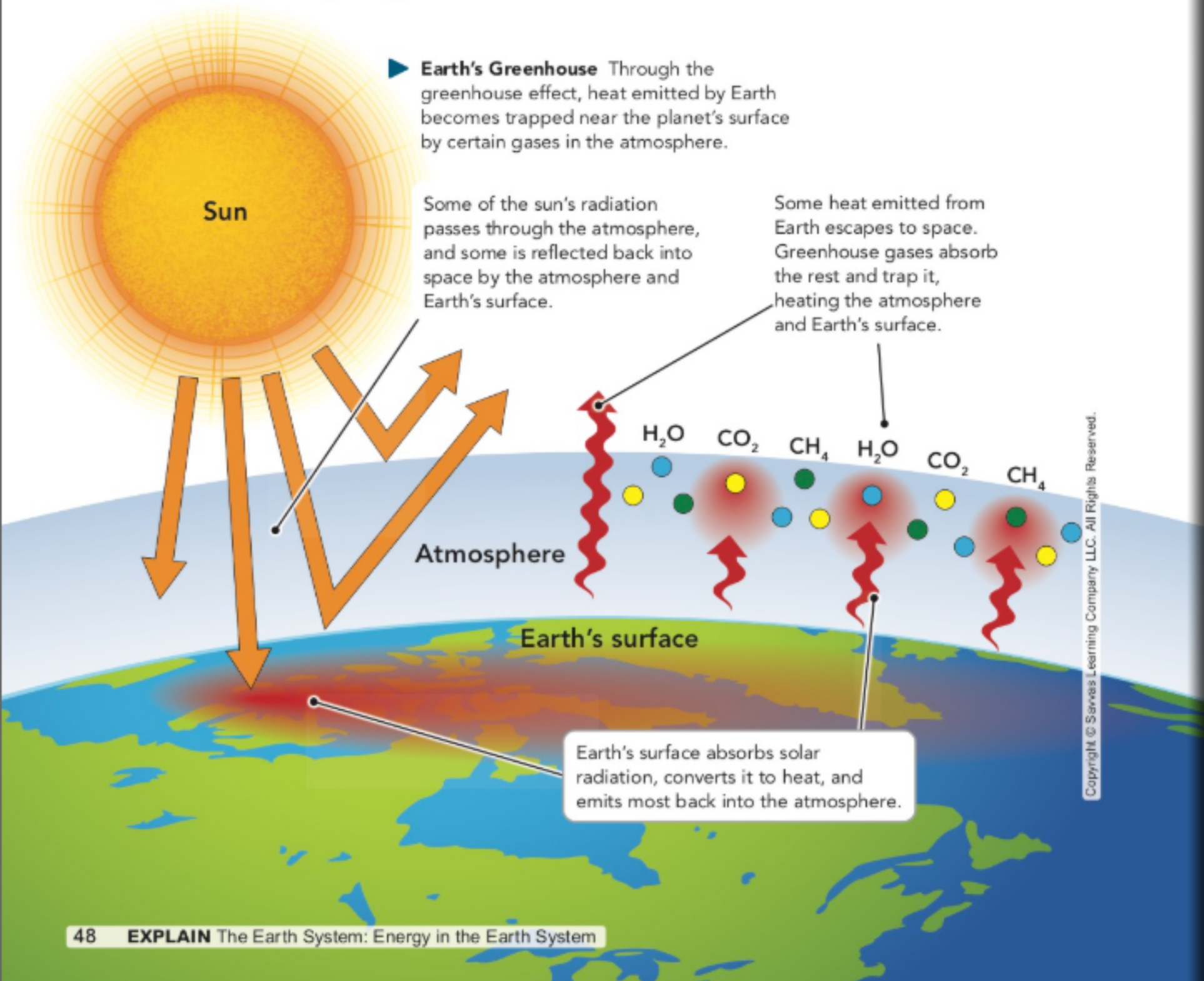
▶ **Solar Energy Near Earth's Surface** Only about 55 percent of all the sun's radiation that reaches the troposphere strikes Earth's surface. The rest of the energy is absorbed or reflected by the atmosphere and clouds.



The Greenhouse Effect

6 Earth's atmosphere plays a role similar to the glass walls of a greenhouse. Sunlight is absorbed and transformed into heat within the atmosphere and in the materials at Earth's surface, such as rock and water. The surface reradiates the energy, and Earth's total energy remains in balance over time. In a process called the **greenhouse effect**, gases in the atmosphere trap some of the heat near Earth's surface, while some heat escapes into space.

7 Overall, the atmosphere keeps Earth within a stable temperature range that is adequate to support life. As a result, surface features such as sea level and the amounts of ice trapped in glaciers have been relatively constant for thousands of years. However, changes to the composition of the atmosphere can result in changes in temperature, causing changes to otherwise stable surface features.



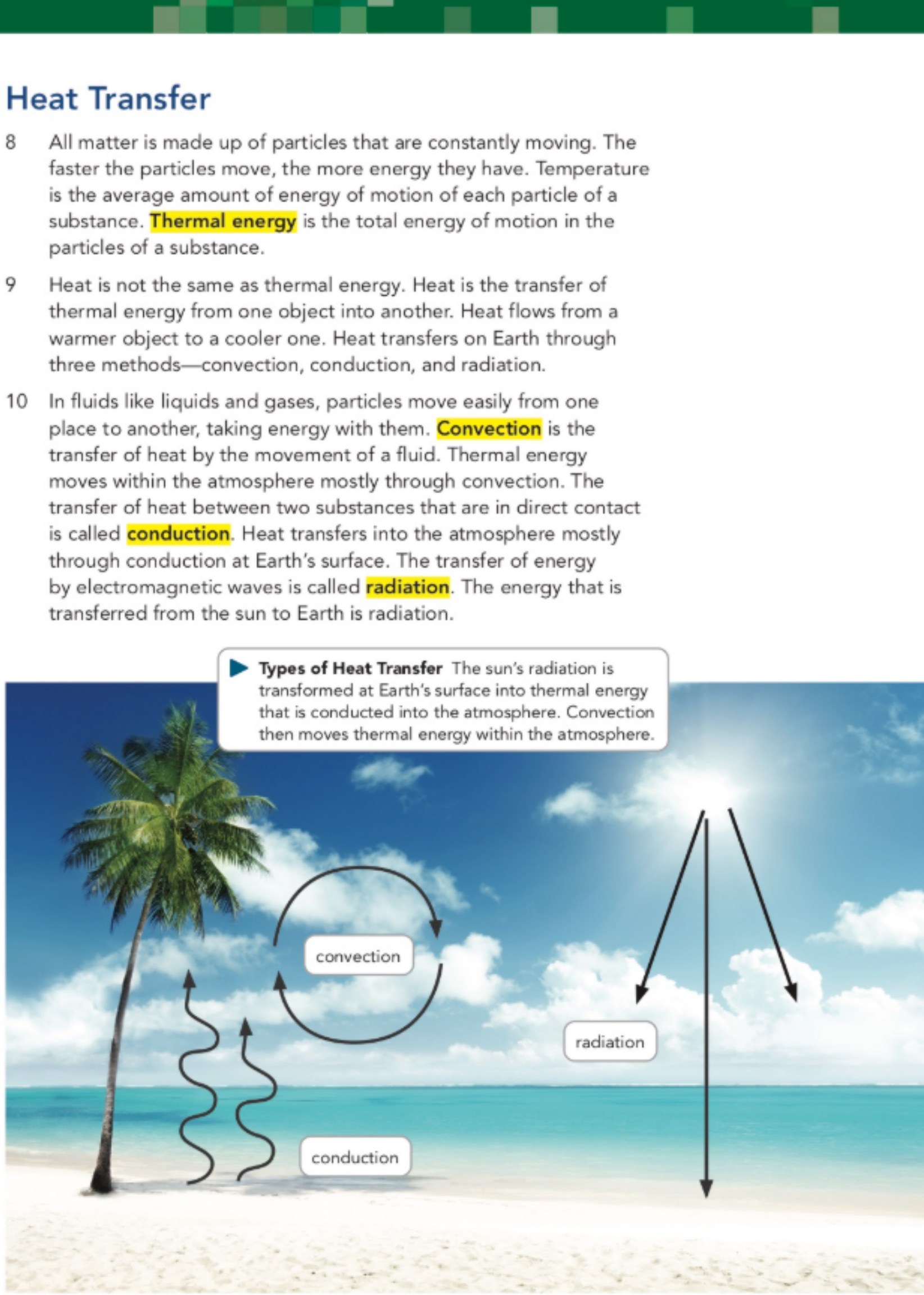
Earth's Greenhouse Through the greenhouse effect, heat emitted by Earth becomes trapped near the planet's surface by certain gases in the atmosphere.

Heat Transfer

8 All matter is made up of particles that are constantly moving. The faster the particles move, the more energy they have. Temperature is the average amount of energy of motion of each particle of a substance. **Thermal energy** is the total energy of motion in the particles of a substance.

9 Heat is not the same as thermal energy. Heat is the transfer of thermal energy from one object into another. Heat flows from a warmer object to a cooler one. Heat transfers on Earth through three methods—convection, conduction, and radiation.

10 In fluids like liquids and gases, particles move easily from one place to another, taking energy with them. **Convection** is the transfer of heat by the movement of a fluid. Thermal energy moves within the atmosphere mostly through convection. The transfer of heat between two substances that are in direct contact is called **conduction**. Heat transfers into the atmosphere mostly through conduction at Earth's surface. The transfer of energy by electromagnetic waves is called **radiation**. The energy that is transferred from the sun to Earth is radiation.



Types of Heat Transfer The sun's radiation is transformed at Earth's surface into thermal energy that is conducted into the atmosphere. Convection then moves thermal energy within the atmosphere.

Causes of Winds

11 The unequal heating of the atmosphere by the sun's energy results in areas of the atmosphere with different air pressure. Warm air expands, becomes less dense, and rises. As the warm air rises, its air pressure decreases.

12 Meanwhile, if another area is not heated as much, then the air in that area is cooler and denser. The denser air sinks and air pressure increases. The air with a higher pressure then flows across the surface to replace rising, less dense air in the area with lower air pressure. This flow of air is **wind**, which is the movement of air parallel to Earth's surface. Scientists measure wind speed and direction using devices called anemometers.

13 Winds that blow over short distances are called local winds. Land and sea breezes are two types of local winds that are commonly experienced in communities that live near large bodies of water, like the ocean. Temperature differences between air, water, and land cause these local winds. These temperature differences occur because Earth's land generally warms faster than water and cools down more quickly. The temperature of the water and land influence the temperature of the air above them. These temperature differences cause air to move from the water to the land or the land to water, depending on the time of day.

▶ **Sea and Land Breezes** Many people in Florida live or work near the ocean. Communities near large bodies of water like the ocean often experience sea and land breezes due to the temperature differences between the air, water, and land.

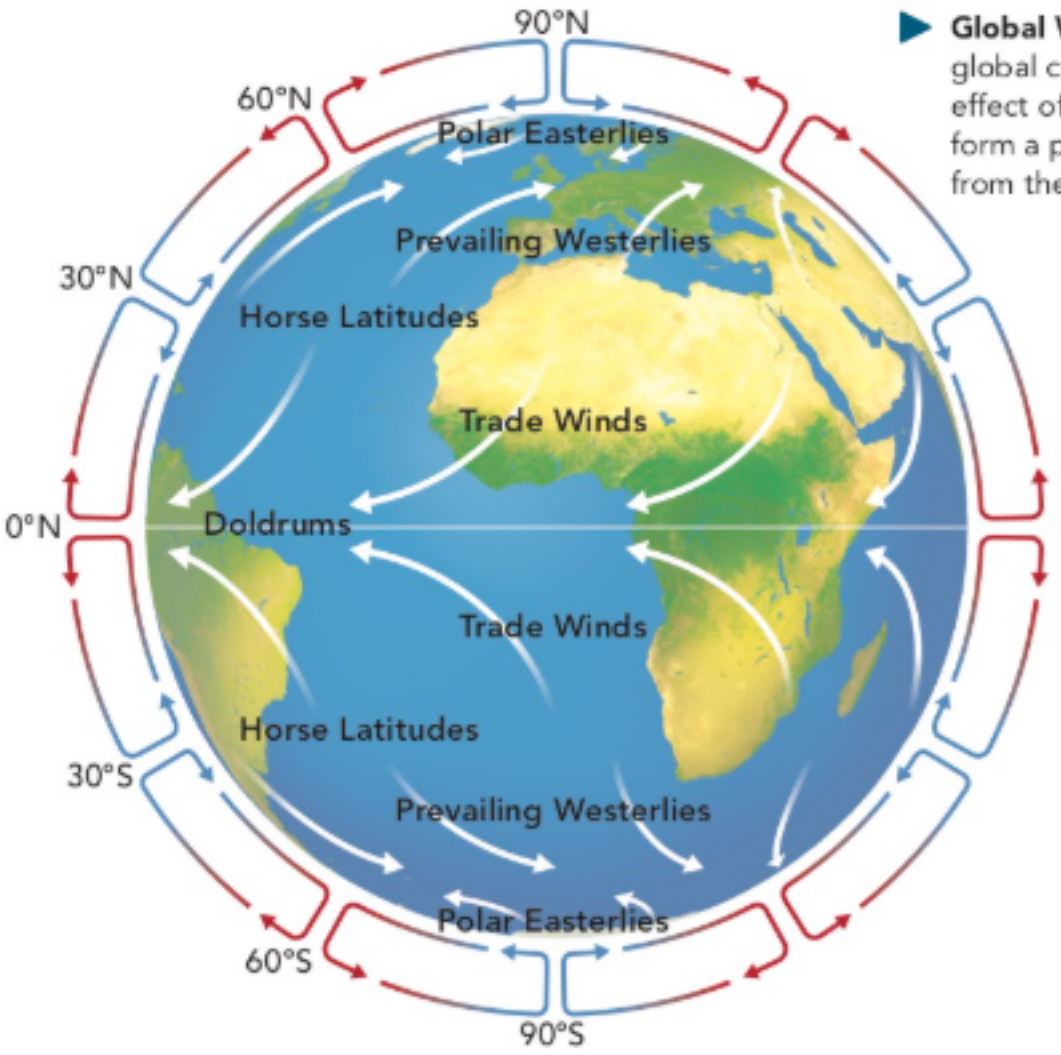
During the day, sea breezes occur as solar radiation warms land faster than water.

At night, land breezes occur as land cools faster than water.

Global Atmospheric Patterns and Winds

14 The effects of Earth's rotation and global convection currents in the atmosphere combine to produce patterns of atmospheric movement that flow around Earth. These patterns of movement are called global winds. Like local winds, global winds are created by the unequal heating of Earth's surface. However, unlike local winds, global winds occur over a large area. They occur as direct rays from the sun heat Earth's surface intensely near the equator at midday. Near the poles, however, the sun's rays strike Earth's surface less directly. The sun's energy is spread out over a larger area, so it heats the surface less. As a result, temperatures near the poles are much lower than they are near the equator.

15 The temperature differences produce giant convection currents in the atmosphere. Warm air rises at the equator, and cold air sinks at the poles. Therefore, air pressure tends to be lower near the equator and greater near the poles. This difference in pressure causes winds at Earth's surface to blow from the poles toward the equator. Away from Earth's surface, the opposite is true. Higher in the atmosphere, air flows away from the equator toward the poles. Those air movements produce global winds, which affect the weather and climate we experience on Earth.



Global Winds The combination of global convection currents and the effect of Earth's rotation interact to form a pattern of global wind belts from the equator to the poles.

NAME _____ CLASS _____ DATE _____

Reading Check

Energy in the Earth System

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraph 2, you read that sunlight is absorbed by the atmosphere. What does the word *absorb* mean?

   A. to take in

   B. to remove

   C. to enhanced

   D. to reflect

2. In paragraphs 2–7, you read about the influence of the sun's energy on Earth and its atmosphere. Describe the atmosphere's role in moderating the amount of electromagnetic radiation necessary to sustain life on Earth.

3. In paragraph 8, you read about thermal energy. Which has more thermal energy: a 1-kilogram block of ice or a 1-kilogram volume of water vapor? Why?

4. In paragraph 9, you read about thermal energy and heat. What is the difference between thermal energy and heat?

5. In paragraph 10, you read about convection. Explain how a pot of heated water could demonstrate convection.

6. In paragraphs 11–12, you read about wind. What causes wind?

7. In paragraph 13, you read about local winds. How do differences in the temperature of the land, water, and air result in sea breezes?

   A. At night, the land is warmer than the water. The air above the land rises and moves toward the water, creating a sea breeze.

   B. During the day, the land is cooler than the water. The air above the land sinks and rising air above the water moves to the land, creating a sea breeze.

   C. At night, the land is cooler than the water. The air above the water rises and sinking air above the land moves to the water, creating a sea breeze.

   D. During the day, the land is warmer than the water. The air above the land rises and sinking air above the water moves to the land, creating a sea breeze.

8. In paragraphs 14–15, you read about global winds. How does the diagram help you understand the text about global patterns of air movement in the atmosphere?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Energy in the Earth System

1. **Model** Use a graphic organizer to differentiate among radiation, convection, and conduction. Provide an example of each method of heat transfer.

Method of Heat Transfer	Description and Example
radiation	
convection	
conduction	

2. **Apply** Explain how energy from the sun influences the Earth system. How are global patterns of atmospheric movement affected by the sun's energy? How does the interaction between energy from the sun and the Earth system result in temperature differences between the water, air, and land?

NAME _____ CLASS _____ DATE _____

Lesson Review

Energy in the Earth System

Choose the best answer to each question.

1. Ozone can damage lungs and lead to a type of pollution called smog. At the same time, it is beneficial to organisms. Which statement explains why this is the case?

   A. Ozone absorbs harmful ultraviolet radiation before it reaches Earth's surface, where it can harm or kill living things.

   B. By allowing heat to escape, ozone keeps temperatures from getting too warm on Earth.

   C. Ozone allows visible light to pass through the atmosphere, which allows organisms to see their surroundings.

   D. Ozone enhances the greenhouse effect, keeping temperatures from getting too cold on Earth.

2. Which of the following describes an example of conduction?

   A. how energy travels from a campfire to your body

   B. how energy is transferred from a flame to a pot on a stove

   C. how most of the energy from the sun travels to Earth

   D. how energy moves with rising particles of carbon dioxide in the air

3. Which statement best explains how global winds form?

   A. Due to the uneven heating of Earth by the sun's energy, warm air sinks near the equator and cool air rises near the poles. This causes global winds.

   B. Earth's rotation causes air in the atmosphere to move from the equator to the poles as Earth's surface drags on the atmosphere.

   C. Air above the ocean rises and sinks over land, which causes global winds to form.

   D. The sun does not evenly heat Earth, so the atmosphere is warmer at the equator and cooler at the poles. This results in differences in air pressure that cause global winds.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

The Water Cycle

I can...

- differentiate between weather and climate.
- demonstrate how the water cycle affects weather and climate.

Vocabulary

climate condensation cycle dew point evaporation precipitation water cycle

Phenomenon Why is it humid in Florida?

Photo Credit: Tom Salyer/Alamy Stock Photo

Develop a Model The photo shows a foggy morning in Florida where there is so much moisture in the air that dew forms on spider webs throughout a field. Draw a model that explains why the air is usually humid in Florida.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Water in the Air

You will…

- observe the condensation of water.
- investigate the conditions necessary for condensation to occur.

What You Need to Know

The atmosphere contains water in the form of water vapor. But water vapor is an invisible gas. In this activity, you will bring about the conditions that will make water vapor change into liquid water.

Materials

- glass beaker, 400-mL
- cold water
- tongs
- ice cubes
- clock

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Handle glass equipment with care.

Procedure

1. Pour water into the beaker until it is half full.
2. Observe the outside of the beaker for one minute.
3. Add ice cubes to the water.
4. Let the beaker stand unobserved for five minutes. Observe the outside of the beaker. Record your observations.

Observations

Analyze and Interpret Data

1. **Observe** How did the outside of the beaker change after you added the ice cubes to the water?

2. **Infer** Where do you think this substance came from? How do you think it formed?

3. **Develop an Explanation** Why did the substance appear only after you added the ice cubes?

The Water Cycle

1 During a humid day, the air around you may feel moist. On a clear, cloudless day, the air may feel dry. The difference between these feelings is caused by the amount of water in the air. Water is always moving between the surface of Earth and the atmosphere. This process is known as the **water cycle**. A **cycle** is any series of events that repeat in the same order over and over again.

Vocabulary Support

Reread the last two sentences of the first paragraph. What other cycles might you experience or observe in a typical day?

Water in the Atmosphere

2 In one phase of the water cycle, water vapor enters the atmosphere through a number of processes. One of these processes is **evaporation**. During evaporation, molecules of liquid water in oceans, lakes, and other bodies of water are heated by the sun. The energy of the sun causes the water molecules to speed up and collide more often. As the molecules collide, some of them "escape" and enter the surrounding air.

3 Plants and animals also release water vapor into the air. In plants, water enters through the roots, rises to the leaves, and is released into the air as water vapor. This is known as transpiration. Animals (and people!) release water vapor into the air every time they breathe out, or exhale. This is known as respiration.

Water Enters the Atmosphere Water is released into the atmosphere as water vapor from bodies of water such as a stream, and living things, such as grass and cattle.

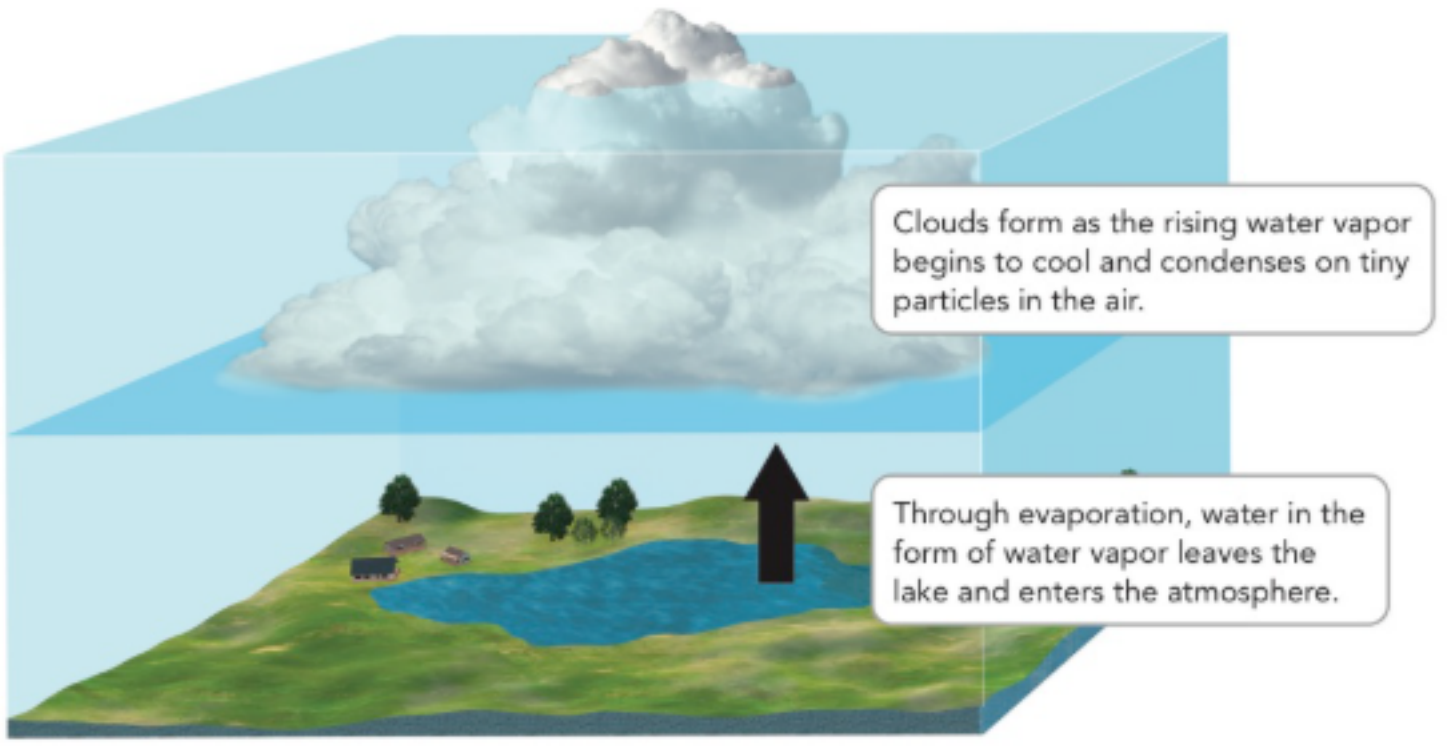
Condensation

4 Recall that water vapor is a gas mixed in with the rest of the air. **Condensation** occurs when water vapor changes into liquid water. For condensation to occur, tiny particles must be present in the atmosphere so that the water has a surface on which to condense. Most of these particles are salt crystals, dust from soil, bacteria, or particles contained in smoke. During condensation, molecules of water vapor mix with these particles.

5 Temperature is also a major factor in condensation. Warm air can hold more water vapor than cold air can. Therefore, as warm air cools, the amount of water vapor it can hold decreases, and the water vapor starts to condense. Liquid water that condenses from the air onto a cooler surface is called dew. The temperature at which condensation begins is called the **dew point**. If the dew point is above freezing, the water vapor forms droplets. If the dew point is below freezing, the water vapor may change directly into ice crystals called frost.

6 One result of condensation of water vapor in the atmosphere is cloud formation. Clouds form when water vapor in the air condenses to form liquid water or ice crystals. When you look at a cloud, you are seeing millions of these tiny water droplets or ice crystals. When water vapor condenses near ground level, it can take the form of fog. Water can condense as dew on any solid surface, such as a blade of grass or a windowpane.

Cloud Formation Clouds are the result of the evaporation and condensation of water, cycling it between the hydrosphere and atmosphere.



Water Leaving the Atmosphere

7 Water is continually evaporating and condensing in the atmosphere, and this process forms clouds. When enough condensation occurs within a cloud, water droplets form. At first, the droplets are very small, but they grow larger as condensation continues.

8 Depending on temperature and other conditions in the atmosphere, the droplets may grow heavy enough that gravity pulls them down toward Earth's surface. When this happens, precipitation occurs. **Precipitation** is any form of water that falls from clouds and reaches Earth's surface.

9 The most common kind of precipitation is rain. Rain comes in various forms depending on the size of the water droplets that form. Rain starts out as cloud droplets. When cloud droplets grow a bit bigger, they become mist. If condensation continues, the mist droplets will continue to grow until they fall to Earth's surface in the form of rain.

▶ **Thunderstorm Over Lake Monroe, Florida** Thunderstorms are often accompanied by lots of rain. Rain is the most common type of precipitation in Florida.

10 Temperature is a very important factor in determining the type of precipitation an area may get at any given time. In warm climates, precipitation is almost always rain. However, there are many other types of precipitation. In colder regions, precipitation often falls as snow or ice. Besides rain, common types of precipitation include freezing rain, hail, sleet, and snow.

11 Raindrops sometimes freeze when they hit a cold surface. This kind of precipitation is called freezing rain. Freezing rain can occur when the temperature of the air is above 0°C but the temperature of the ground is below 0°C. However, when raindrops fall through a cold layer of air below 0°C and freeze into ice before they hit the ground, sleet can form.

12 Hail can fall during a storm when the temperature of the air is below 0°C but the temperature of the ground is above 0°C. Hail starts as tiny ice pellets inside a cold region of a cloud. Strong updrafts of wind carry the pellets up through the cold region many times, adding layers of ice to the outside of them. Eventually the hail becomes heavy enough for gravity to pull it to the ground.

▶ **Snow** When the temperature of the air and ground are below 0°C, snow can form as water vapor in a cloud forms ice crystals that clump together into snowflakes.

The Cycling of Water

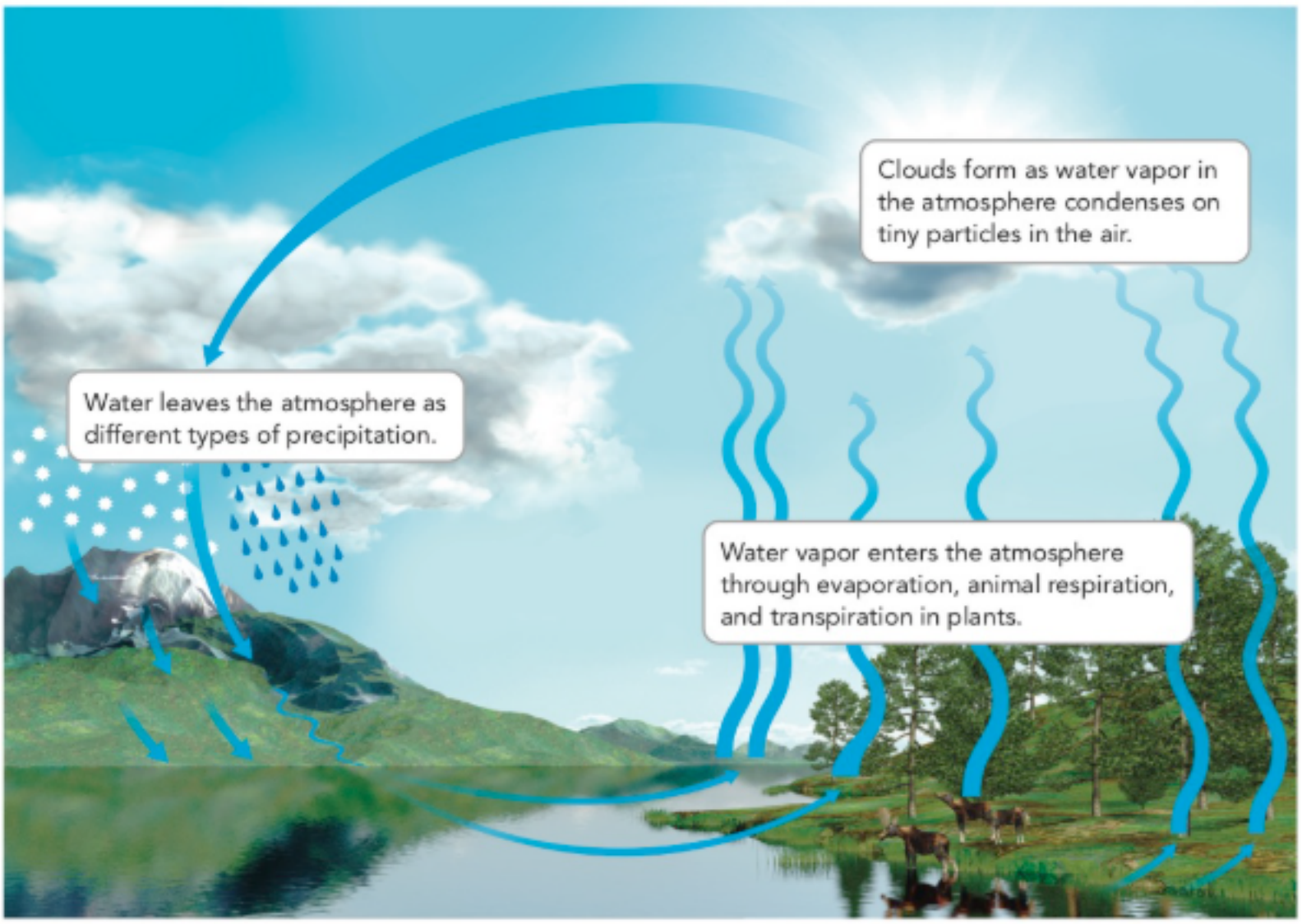
13 The water cycle describes the way that water moves through Earth's systems and affects our lives in many ways. As the sun heats the land, ocean, lakes, and other bodies of water, its energy changes the amount of water in the atmosphere.

14 Through evaporation, transpiration, and respiration, water rises up and forms clouds. Rain, snow, and other forms of precipitation fall from the clouds toward Earth's surface. The water then runs off the surface or moves through the ground, back into lakes, streams, and eventually the ocean. Gravity and energy from the sun together drive water molecules through this never-ending cycle.

Literacy Support

As you read, identify the sentences that contain information you consider important to remember.

▶ **The Water Cycle** The cycling of water on Earth is driven by energy from the sun and involves many processes between Earth's atmosphere, hydrosphere, biosphere, and geosphere.



The Water Cycle and Climate

15 The amount of water that moves through the water cycle influences local weather and climate. Dry areas usually have little water moving through the cycle, while wetter areas tend to have more water moving through the cycle.

16 While weather describes the short-term conditions in an area, **climate** is the long-term weather pattern in an area. Specifically, climate refers to the average, year-after-year conditions of temperature, precipitation, wind, and clouds. So, while "it's hot" or "it's snowing" can describe the weather, you would need more information to describe the climate. For example, information about the amount and type of precipitation that falls in a year describes the climate of an area.

17 The water cycle is related to climate patterns. For example, year-round freezing temperatures in Antarctica prevent snow from melting and limit evaporation from the ocean. As a result, Antarctica has a cold, dry climate. Another example is California's Mojave Desert, where the limited precipitation evaporates rapidly. The climate there is hot and dry. But, if you move west from the Mojave Desert toward California's coast, you will notice a cooler, more humid climate. This is because climate is affected by latitude, altitude, distance from large bodies of water, ocean currents, and global prevailing winds. These factors are not constant; they continuously change. If the factors change too drastically, an area's overall climate could change as well.

Cold and Dry Antarctica has a "dry" climate despite being covered in snow and surrounded by ocean. The continent's extremely low temperatures limit the cycling of water.

NAME _____ CLASS _____ DATE _____

Reading Check

The Water Cycle

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraph 1, you read about the water cycle. What is the water cycle? Why is it referred to as a *cycle*?

_____

_____

_____

2. In paragraphs 2–3, you read about water vapor entering the atmosphere. Which processes allow water vapor to enter the atmosphere?

Process	Allows water vapor to enter atmosphere?
oceans and lakes warmed by the sun	
transpiration by plants	
respiration by organisms	
rain falling from clouds	

3. In paragraphs 4–6, you read about condensation and cloud formation. How do clouds form?

   A. cool droplets of liquid water high in the air combine and grow larger

   B. warm water vapor high in the air cools and condenses to form liquid water or ice crystals

   C. ice crystals high in the air warm and condense into water vapor

   D. cool water vapor near the ground warms and condenses, and then rises in the air

4. In paragraphs 7–9, you read about water leaving the atmosphere. What is precipitation and how does it occur?

5. In paragraphs 10–12, you read about the types of precipitation. Identify the **two** most important factors that determine the type of precipitation an area will get.

   A. ground temperature.

   B. time of day

   C. wind speed

   D. air temperature

6. In paragraphs 13–14, you read about the water cycle. Use the diagram to trace the path a molecule of water takes through the cycle.

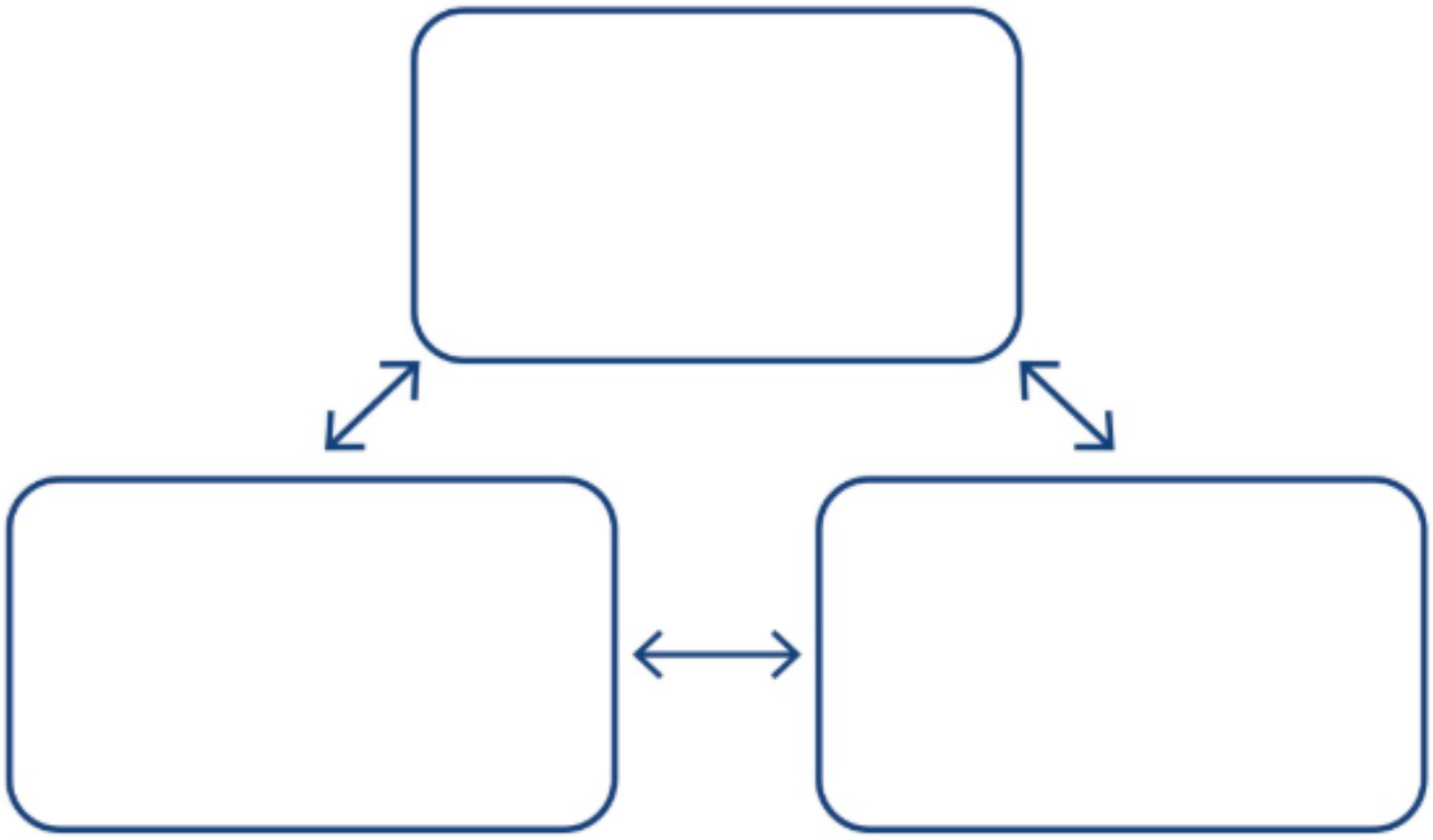
7. In paragraphs 15–17, you read about the water cycle and climate. How is the water cycle related to climate patterns?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

The Water Cycle

1. **Model** Complete the flowchart to show how water cycles between the atmosphere, geosphere, and hydrosphere.



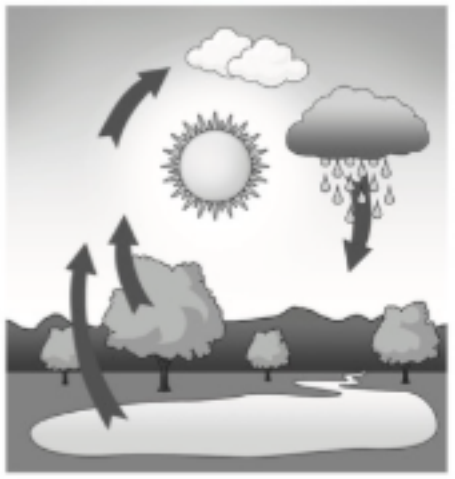
2. **Apply** Distinguish between weather and climate by describing both the weather and climate of the area in which you live.

NAME _____ CLASS _____ DATE _____

Lesson Review

The Water Cycle

The diagram shows the typical weather and cycling of water around a lake fed by a mountain stream. Use the diagram to answer questions 1 and 2.



1. Which statement best describes the process indicated by the upward arrows?

A. Water vapor rises by transpiration from the land into the warmer air.

B. Water evaporates from the lake and trees into the air to form clouds.

C. Water changes to vapor by transpiration and evaporation and then rises.

D. Water vapor moves by evaporation and transpiration from lakes to the clouds.

2. Which combination of factors is necessary to produce the cloud?

A. water vapor in the air, warm air temperature, and solar energy

B. water vapor in the air, warm air mass, and small particles in the air

C. water vapor in the air, cool air temperature, and small electrical charges

D. water vapor in the air, cool air temperature, and small particles in the air

3. Which statement refers to weather rather than climate?

A. A thunderstorm is expected today.

B. The temperature is usually around 24°C (75°F).

C. This area usually has a relative humidity lower than 50 percent.

D. Precipitation amounts have increased over the last several years.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Global Atmospheric Patterns and Ocean Currents

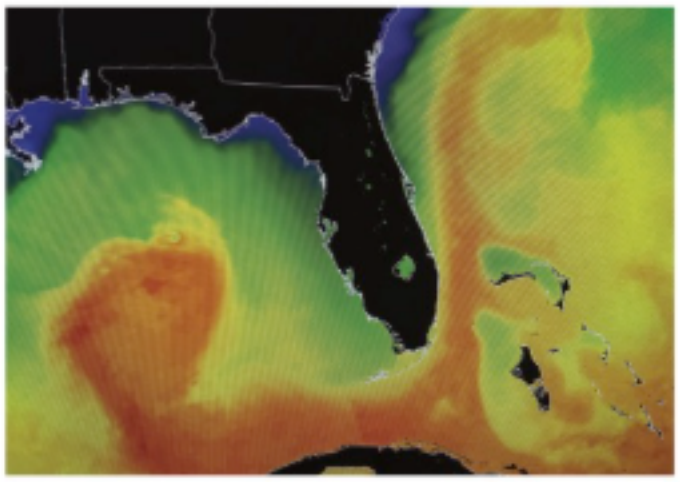
I can…

- explain how global patterns in the atmosphere affect local weather.
- describe how ocean currents influence local weather.

Vocabulary

air mass humidity jet stream prevailing weather front

Phenomenon Why does the Gulf Stream prevent Florida from getting too hot?



Make a Claim Write an explanation for how the ocean currents around Florida, such as the Gulf Stream, affect the weather in Florida.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Weather Fronts

You will…

- model colliding air masses.
- investigate the behavior of air masses at a front.

What You Need to Know

You have a beach volleyball tournament coming up, but the meteorologist is predicting stormy and changeable weather. The weather maps show colliding air masses, but what does that mean? In this activity, you will use water and oil to model how air masses act along fronts.

Materials

- 2 beakers, 250-mL
- plastic container with divider
- wooden block
- chilled tap water
- blue food coloring
- vegetable oil
- plastic spoon

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Wear safety goggles.


Wear a lab apron.

Procedure

1. Place the plastic container on a wooden block so it is tilted. Place the plastic divider in the plastic container, dividing it in half across the slope of the container.
2. Fill one beaker with 200 mL of chilled water. Add 5 drops of blue food coloring and stir with the plastic spoon.
3. Fill the other beaker with 200 mL of vegetable oil.
4. Pour the chilled water into the lower side of the plastic container.

5. Pour the oil slowly into the higher side of the container.

6. Carefully remove the plastic divider and observe at eye level what happens to the oil and water. Draw what you see and record any other observations you make.

Observations

Analyze and Interpret Data

1. **Analyze Data** What happened to the water and the oil when the divider was removed?

2. **Use Models** What do the water and oil represent in your model?

3. **Construct an Explanation** Use your model to help explain what happens at both a warm front and a cold front?

4. **Synthesize Information** Which do you think is more dense, cold air or warm air? How then does the sun's energy influence the behavior of air masses at different fronts?

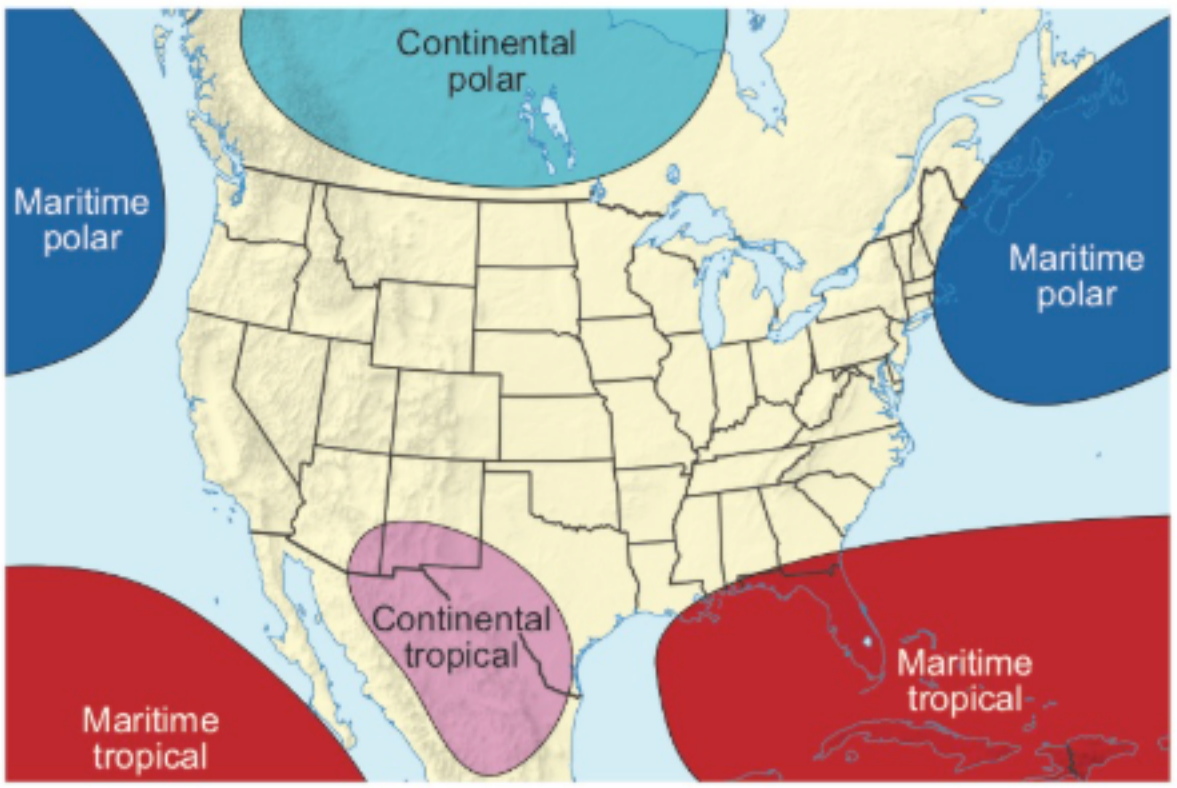
Global Atmospheric Patterns and Ocean Currents

1 The weather you see each day is happening due to the movement and interaction of air masses. An **air mass** is a huge body of air that has similar temperature, humidity, and air pressure at any given height. **Humidity** is a measure of how much water vapor is in the air. The ability of air to hold water vapor depends on temperature. Warm air can hold more water than cool air. Scientists classify air masses based on temperature and humidity. Global atmospheric patterns and ocean currents move these air masses and influence local weather as a result.

Air Masses

2 The characteristics of an air mass depend on the temperature and moisture content of the region over which the air mass forms. Whether an air mass is humid or dry depends on whether it forms over water or dry land. The temperature of an air mass also depends on the region over which the air mass forms. Warmer air masses form closer to the equator, and cooler air masses form closer to the poles.

Air Masses All local weather in North America is influenced by one of four major types of air masses: maritime tropical, continental tropical, maritime polar, and continental polar.



Continental polar form over cold land and are cold and dry.

Maritime polar form over cold ocean waters and are cool and humid.

Continental tropical form over hot land and are hot and dry.

Maritime tropical form over warm ocean waters and are warm and humid.

How Air Masses Move

3 Air masses are always on the move. In the continental United States, air masses are commonly moved by the **prevailing** westerlies and jet streams.

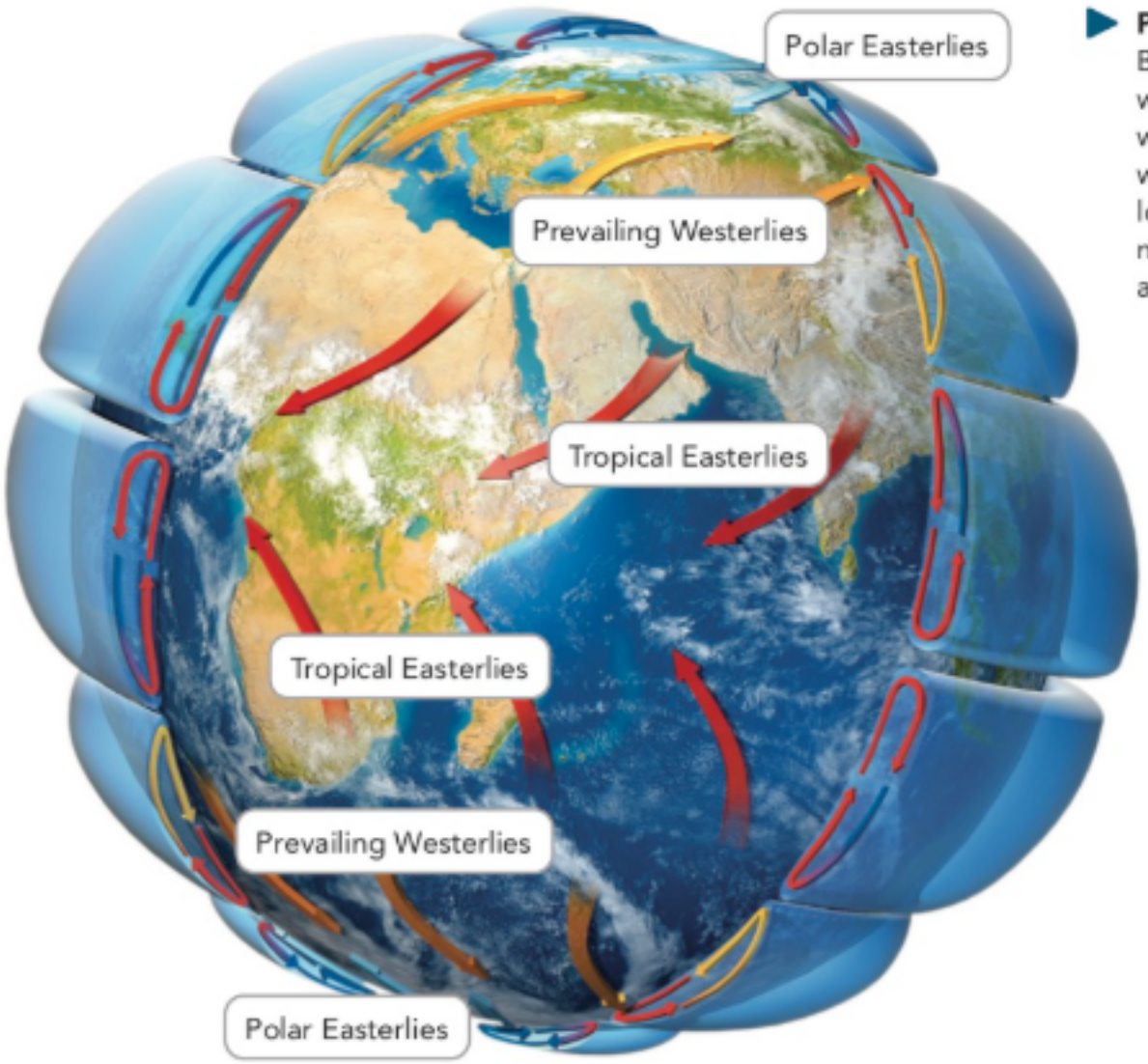
4 Prevailing winds are winds that usually blow in one direction over large distances on Earth. These winds are organized into belts that can move air masses with different temperatures and humidity over long distances. The amount of water vapor an air mass carries affects how much precipitation it can produce.

5 Jet streams help to move air masses and weather systems around the globe. While the weather may be warm and sunny one day, a jet stream can push a cold, moist air mass into the area and change the forecast to cooler, stormy days.

6 In general, the major wind belts over North America, known as the prevailing westerlies, push air masses from west to east. Embedded within the prevailing westerlies are jet streams. A **jet stream** is a band of high-speed winds about 6 to 14 km above Earth's surface. As jet streams blow from west to east, the surface air masses beneath them are carried along. The movement of these air masses and their interactions have a great impact on weather.

Vocabulary Support

Think about the meaning of *prevailing* in terms of wind. Keeping this in mind, what might be the prevailing noise at a concert?



Prevailing Winds Belts of prevailing winds and jet streams within the prevailing westerlies influence local weather by moving air masses across Earth's surface.

Influence of Ocean Currents

7 Ocean currents move warm and cold water around the world, which helps keep cold places from getting too cold and warm places from getting too hot. These streams of water within the ocean move in regular patterns caused by different amounts of solar energy striking Earth at different latitudes.

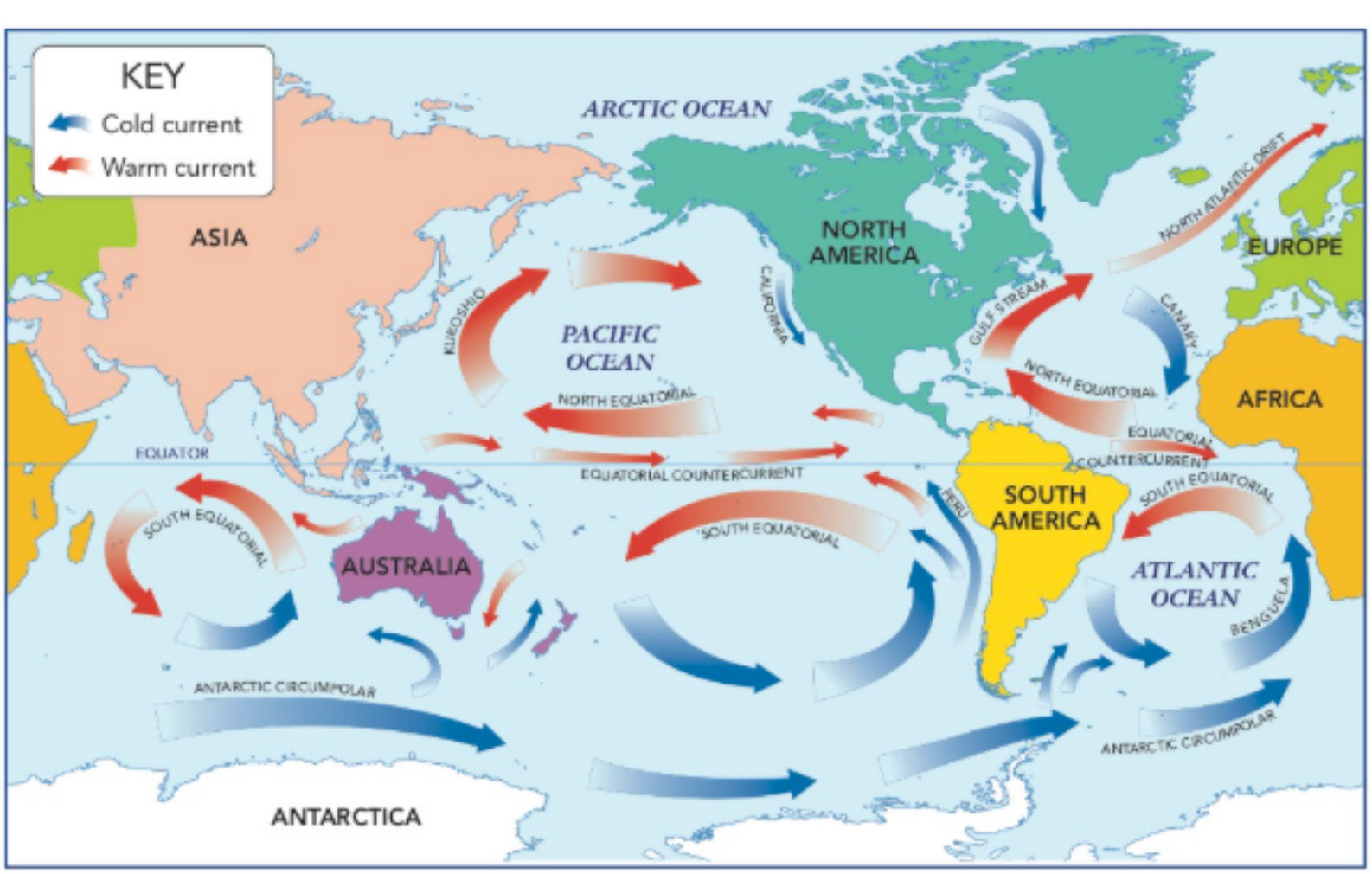
8 Ocean currents affect local air temperatures and precipitation, and they also cause changes in wind speed and direction. Warm ocean currents cause the air masses above them to become warmer, while cold currents lower the temperature of air masses above them.

9 Most warm ocean currents move warm water from the equator toward the poles. Conversely, cold currents move cold water from the poles toward the equator. Cold currents affect climate by carrying cold water from the polar zones toward the equator, cooling local air masses.

Literacy Support

Identify the portion of the text that relates to the image. How does the image add to the information you gained by reading the text? How does it support what you have read?

Major Ocean Currents Major currents circulate warm and cold ocean water between the poles and the equator.



Weather Fronts

10 Global winds like jet streams move air masses. When two air masses with different temperatures and humidity meet, they do not mix. The boundary where two different air masses meet is called a **weather front**. There are four main types of fronts.

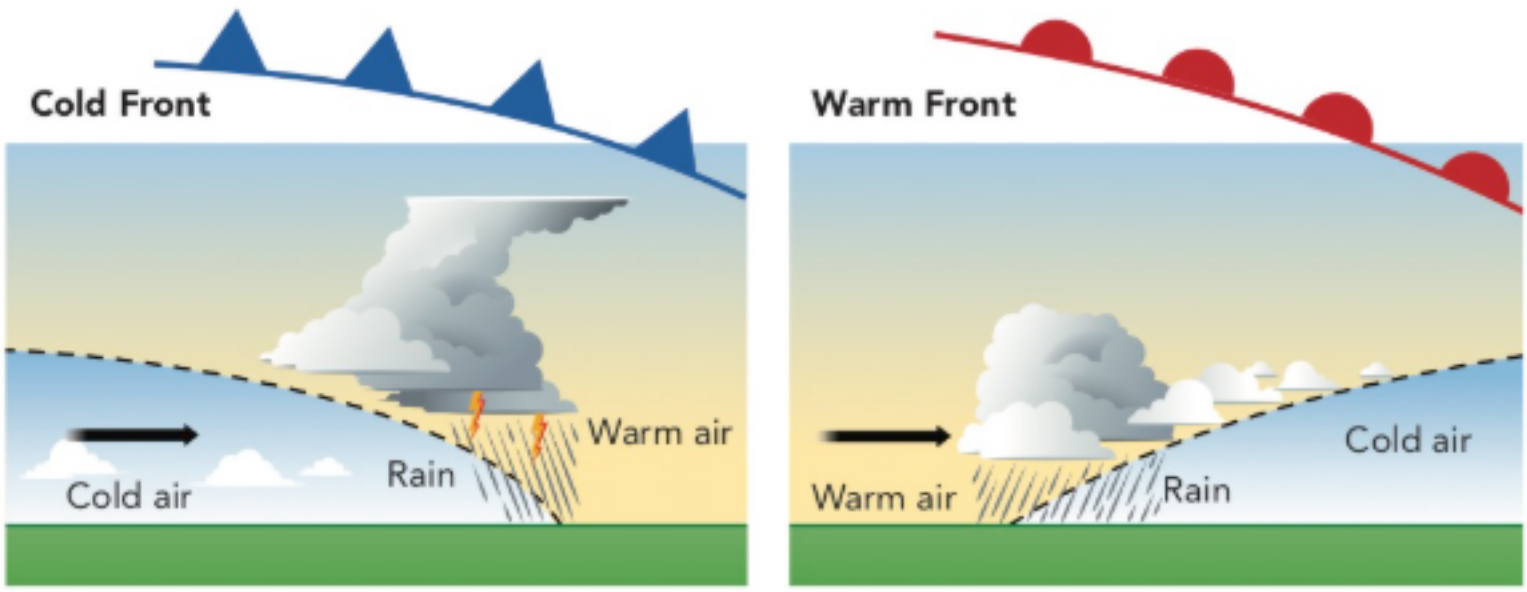
11 A cold front occurs when a cool air mass moves into a warm air mass. The warm air mass rises. As the warm air rises and cools, water vapor in the air condenses and forms clouds. A cold front causes abrupt weather changes, including thunderstorms. After the front passes, colder, drier air moves in.

12 A warm front occurs when a warm air mass moves into a cool air mass. The warm air mass rises above the cool air mass. As it rises and cools, water vapor condenses and clouds form. Light rain or snow may fall. The weather can be cloudy and rainy for days, but warmer weather usually follows.

13 A stationary front is when a cold air mass and a warm air mass meet, but neither moves much. Along this front, weather can include long periods of rain, snow, fog, or clouds.

14 Sometimes, a warm air mass is caught between two cool air masses. When this happens, an occluded front occurs. As the warm air rises and cools, the weather may turn cloudy, and rain or snow might fall.

▶ **Cold and Warm Fronts** The type of front that develops depends on the air masses and the direction in which they move.



When a faster cold air mass runs into a slower warm air mass, the dense cold air slides under the lighter warm air. If the rising warm air is humid and condenses, it forms clouds and precipitation.

When a fast-moving warm air mass overtakes a cold air mass, the warm air moves up and over the denser cold air. If the air is humid, clouds form and precipitation can fall.

NAME _____ CLASS _____ DATE _____

Reading Check

Global Atmospheric Patterns and Ocean Currents

Answer the following questions after you have completed reading the Read About It.

1. In paragraph 1, you read about air masses. What **three** factors are used to classify an air mass?

   A. humidity

   B. pressure

   C. altitude

   D. temperature

2. In paragraph 2, you read about the air masses that influence weather in North America. Identify the characteristics of each type of air mass by placing an X in the correct column.

Air Mass Type	Cold and Dry	Cool and Humid	Hot and Dry	Warm and Humid
continental polar				
continental tropical				
maritime polar				
maritime tropical				

3. **Vocabulary** In paragraphs 3–4, you read about prevailing winds. What does the term *prevailing* mean?

_____

_____

4. In paragraphs 5–6, you read about jet streams. What is a jet stream and how does it influence weather?

5. In paragraphs 7–9, you read about ocean currents. Which statement about ocean currents is correct?

   A. Ocean currents help move air masses around the planet.

   B. Ocean currents affect the temperature of the air masses above them.

   C. Cold ocean currents move warm water from the equator to the poles.

   D. Ocean currents only affect wind speed and direction.

6. In paragraph 10, you read about weather fronts. What is a weather front?

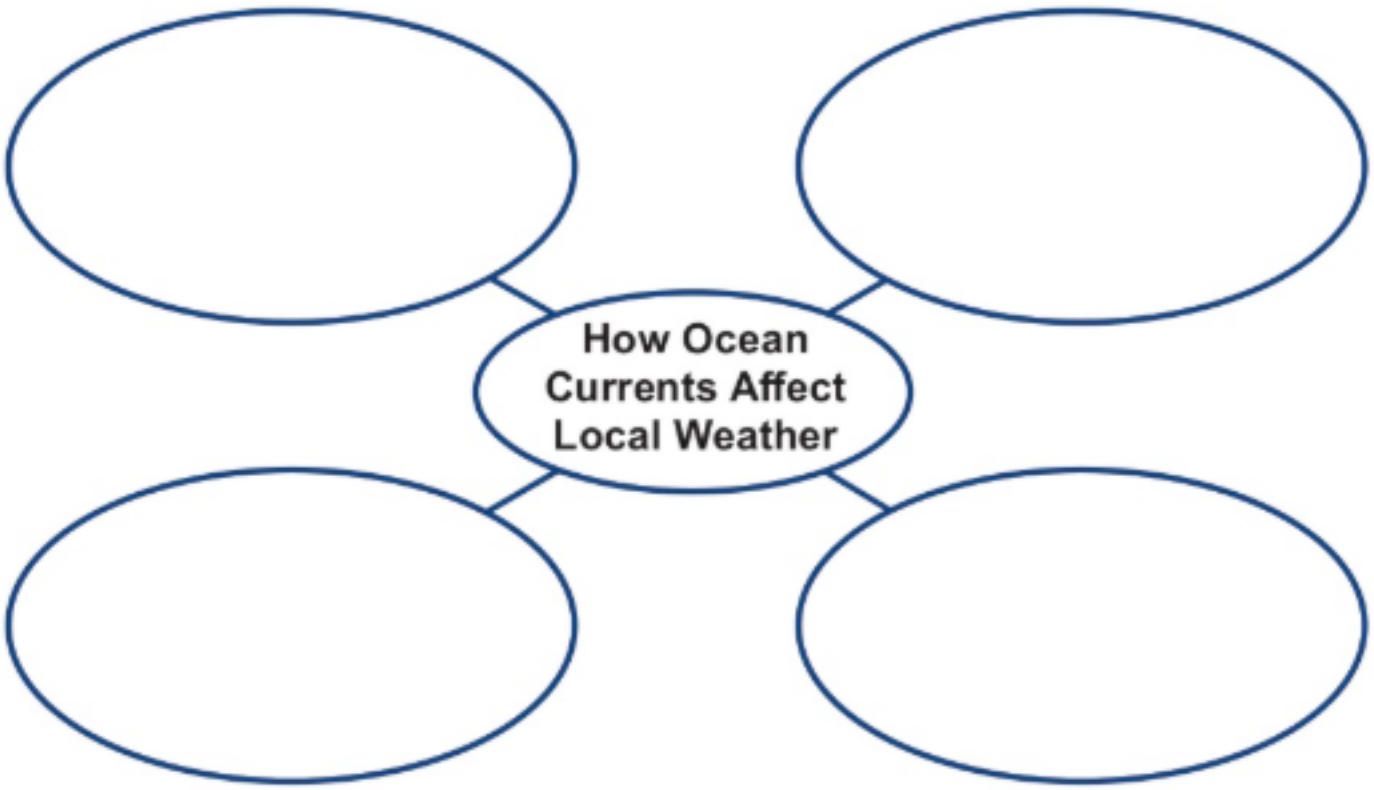
7. In paragraphs 11–14, you read about the different types of weather fronts. What is a cold front? How does it influence weather? What is a warm front, and how does it influence weather?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Global Atmospheric Patterns and Ocean Currents

1. **Model** Complete the concept map with some examples of how ocean currents affect the weather in an area.



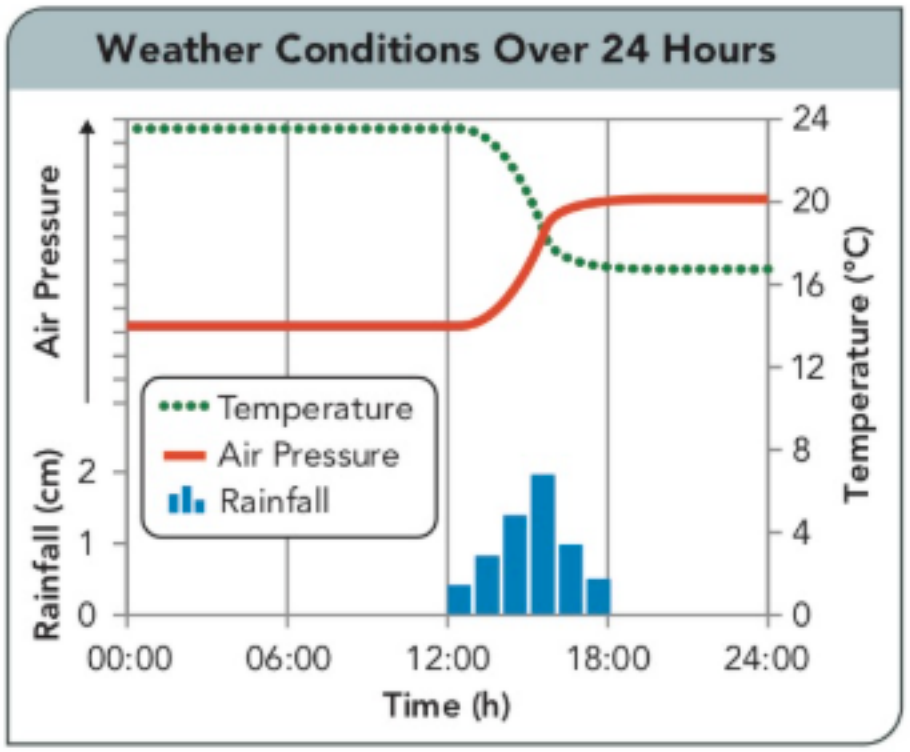
2. **Apply** Describe how global atmospheric patterns help determine the weather in Florida.

NAME _____ CLASS _____ DATE _____

Lesson Review

Global Atmospheric Patterns and Ocean Currents

The graph shows changes in air temperature, air pressure, and precipitation during a 24-hour period at a certain location. Use the graph to answer questions 1 and 2.



1. Which statement best describes the weather during this 24-h period?

   A. A cold low-pressure air mass moved in to replace a warm, high-pressure one.

   B. A warm high-pressure air mass moved in to replace a cold, low-pressure one.

   C. A cold front moved through with stormy weather at the air-mass boundary.

   D. A warm front moved through with steady rain at the air-mass boundary.

2. Which weather conditions were most likely present at the end of the 24-h period?

   A. clear sky, low humidity, and cold temperature

   B. clear sky, low humidity, and warm temperature

   C. cloudy sky, high humidity, and cold temperature

   D. cloudy sky, high humidity, and warm temperature

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Natural Disasters

I can...

- analyze how natural disasters have affected human life in Florida.
- describe ways that humans can protect themselves in hazardous conditions.

Vocabulary

approximate flood hurricane storm storm surge thunderstorm tornado

Phenomenon Why does flooding often occur in Florida during a hurricane?

Photo Credit: Alan Klehr/Danita Delimont/Alamy Stock Photo

Make a Claim Write an answer that explains why many areas in Florida are prone to flooding during a hurricane. Describe how people can protect themselves from the type of flooding that occurs.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

History of Hazardous Weather

You will…

- collect and analyze data about hazardous weather in the United States.

What You Need to Know

Tornadoes can be very destructive. Their high winds can break windows, tear roofs off of buildings, and snap tree branches. Sometimes in advance of a tornado, skies become gray and wind gusts begin to kick up. Other times, there is little warning before a tornado hits.

The table shows historical data about tornadoes in the United States. The top row lists the first letter of each month of the year (beginning with January). The data represent the average number of tornadoes that occurred in each location during each month.

Data

Average Number of Tornadoes in the United States, by Region (1990–2010)

U. S. Regions	J	F	M	A	M	J	J	A	S	O	N	D
Pacific	1	2	2	2	5	3	0	4	2	1	1	2
Rocky Mountain	0	0	2	4	32	60	36	19	5	4	0	0
Central Plains	3	1	13	32	79	65	25	10	8	8	4	2
Southwest	13	8	26	51	81	36	7	6	14	20	21	10
Great Lakes	0	0	5	20	35	66	33	19	8	6	3	1
Southeast	15	16	32	37	38	23	18	19	29	20	28	9
Northeast / Mid-Atlantic	0	0	0	4	7	10	18	8	9	2	2	0

Analyze and Interpret Data

Part A: Interpreting Weather Data in a Table

1. **Analyze Data** Which region had the most tornadoes, on average, in a single month? How many tornadoes occurred, on average, and in what month?

2. **Construct Graphs** Construct a bar graph that shows the total number of tornadoes that occurred in each region during an average year. *(Hint: Assume an average year consists of the twelve average months shown in the data table.)*

3. **Construct Graphs** Construct a bar graph that shows the total number of tornadoes that occurred in each month, on average, in the United States.

4. **Read Graphs** Which month had the highest average number of tornadoes? How many tornadoes occurred that month, on average, in the United States?

5. **Read Graphs** Which region had the greatest total number of tornadoes in an average year? How many tornadoes did this region have?

6. **Recognize Patterns** Describe the pattern of tornado occurrences over the course of a year. In your answer, explain how tornado frequency changed from month to month.

7. **Apply Scientific Reasoning** Suppose you live in the Rocky Mountain region, and it is June. A weather report comes on the news forecasting dark cloud cover and light winds. What do the historical data tell you about how you should react? How would you prepare?

8. **Draw Conclusions** How can analyzing hazardous data help meteorologists make predictions about future hazardous weather?

Part B: Collecting and Analyzing Local Weather Data

Research data about hazardous weather in your local area. For example, perhaps you live in a region that experiences hurricanes, flash floods, or drought. Focus on one or two variables that you can graph, such as precipitation amounts or average temperature. Also, choose a time period to focus on. Construct a data table to organize and record the data from the period of time you have chosen. Once your data table is complete, use the information to make a graph. Be sure to include labels, a title, and the proper scale for each axis.

9. **Predict** Use your graph to make a prediction about a future weather event in your local area. Provide support for your prediction by explaining with evidence from your graph you used.

10. **Connect to Society** Suppose a public service announcement about the weather event you chose is going to be broadcast in your town. What advice to the public would you want to include about how people should prepare for this weather event?

11. **Connect to Technology** What questions might meteorologists ask to identify technologies that would help people to stay safer during severe weather events in your region? *(Hint: Your questions can focus on weather conditions that occur during specific types of severe weather events. Your questions can also focus on how specific types of severe weather events cause loss of life or destruction to structures such as roads and bridges.)*

12. **Connect to Science** Look at the questions you wrote above. How might your questions help to guide the development of technologies that meteorologists need for preparing people for hazardous weather?

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Florida Hurricanes

You will…

- analyze data on hurricanes that have struck the Gulf and Atlantic coasts of the United States.
- determine ways that Floridians can address the continual threat of hurricanes.

What You Need to Know

Hurricanes usually form far out at sea over warm ocean water, but many of them eventually make their way toward land. Florida's exceptionally long coastline and tropical location make it a prime target for hurricanes. The map shows the Atlantic and Gulf coasts and locations where hurricanes have made landfall. The numbers in the circles indicate the number of years between hurricanes making landfall in that location. The average summer temperature of the different areas of the ocean is also shown.

Florida can't change its location. Therefore, officials and residents in the state are working hard to find ways to lower the risks. These plans include issuing new rules for storm-resistant structures and spending more money on disaster planning so that communities will be better prepared for future storms.

Analyze and Interpret Data

1. **Analyze Data** What do the lower numbers represent? What do the higher numbers represent?

2. **Patterns** What patterns do you notice in the data? Which locations in Florida tend to experience hurricanes most frequently? Which locations experience hurricanes least frequently?

3. **Construct Explanations** What conditions in the ocean and atmosphere do you think contribute to the patterns you identified?

4. **Solve Problems** Besides the solutions mentioned in What You Need To Know, what do you think Floridians might do to address the continual threat of hurricanes?

Natural Disasters

1 Natural disasters, like severe storms and heat waves, can threaten human life in Florida and around the rest of the world. Most of these disasters are caused by hazardous weather that can destroy property and injure or kill people and animals. That is why human beings must protect themselves from dangerous weather and sun exposure, even when the weather is nice and sunny.

Vocabulary Support

Think about the meaning of *approximate*. What is the difference between an *approximate* and an exact number?

Severe Storms

2 In October 2016, Hurricane Matthew struck the Caribbean and the United States with heavy rains and strong winds with **approximate** speeds of 250 km/h. It was one of the strongest storms ever to hit the United States. The storm caused extreme property damage along with about 40 casualties in the United States and many more in the Caribbean. Many areas were battered by winds and flooded for days. Buildings were blown down and roads washed away.

3 A hurricane is one example of a severe storm. A **storm** is a violent disturbance in the atmosphere. Storms involve sudden changes in air pressure, which cause rapid air movements and often precipitation. There are several types of severe storms: winter storms, thunderstorms, hurricanes, and tornadoes.

Hurricane Matthew This satellite image shows Hurricane Matthew as it moved north of Cuba and began to cover Florida.

Winter Storms and Thunderstorms

4 In the winter in the northern United States, most precipitation is in the form of snow. Large winter storms can produce lots of snow. Heavy snow can block roads, trap people in their homes, and delay emergency vehicles. Very cold temperatures can cause water pipes to burst.

5 Florida is more likely to experience thunderstorms than winter storms. A **thunderstorm** is a localized storm that often has heavy precipitation, frequent thunder, and dangerous lightning. It usually forms when warm air carrying lots of moisture is forced upward along a cold front. The warm, humid air rises quickly, forming dense clouds. Thunderstorms can bring heavy rain and hail.

6 Thunderstorms can also cause serious damage. Their heavy rains may flood low-lying areas. High winds or large hailstones ruin crops and damage property, such as cars and windows. They can injure or kill people and animals out in the open. Lightning strikes start fires and damage structures or sometimes just the electrical equipment inside structures. If lightning strikes a person, it can cause unconsciousness, serious burns, and even death.

Thunder and Lightning Thunderstorms are very common in Florida. Lightning strikes can cause severe damage and injury during thunderstorms.

Hurricanes

7 A **hurricane** is a powerful, rotating storm around a low-pressure center with winds that exceed 119 km/h. Hurricanes usually form in the tropics. They can stretch more than 600 kilometers across and may have winds as strong as 320 km/h. In the western Pacific Ocean, these storms are called typhoons. When they occur in the Indian Ocean, they are known as cyclones.

8 Hurricanes often result in severe flooding, which in turn contaminates drinking water supplies. Wind damage and severe flooding can make travel after a storm difficult and cause power outages. Residents of hurricane-prone areas are encouraged to prepare for the aftermath of a storm. They should stock a three-day supply of drinking water, ready-to-eat food, and other necessary items, such as medications or diapers.

9 When a hurricane makes landfall, it often brings high waves, severe flooding, and wind damage. A hurricane's low pressure and high winds can raise the level of the water in the ocean below it by as much as 6 meters above normal sea level. The result is a **storm surge**, a "dome" of water that sweeps across the coast where the hurricane is traveling. Storm surges can cause great damage, destroying human-made structures as well as coastal ecosystems.

Literacy Support

Textual evidence is information or clues that reinforce or support an idea. Reread the paragraphs on this page. Identify the evidence that hurricanes are hazardous weather events that human beings must protect themselves from.

Storm Surge In communities near the ocean, strong winds during severe storms like hurricanes can result in heavy damage from flooding caused by storm surge.

Tornadoes, Floods, and Heat Waves

10 Thunderstorms can lead to something even more dangerous than heavy rains or hail. Under certain conditions, they can cause flooding and produce dangerous tornadoes. A **tornado** is an extremely fast spinning column of air extending from the base of a thunderstorm to Earth's surface. Tornadoes tend to be brief, intense, and destructive. A tornado may affect the ground for 15 minutes or less and be only a few hundred meters across. But its wind speed can exceed 300 km/h.

11 Tornado damage comes from strong winds and flying debris. Tornadoes can move large objects and scatter debris many miles away. Meteorologists use the Fujita Scale to categorize tornadoes. The scale is based on the kind of damage tornadoes cause to trees and human-made structures. Only about one percent of tornadoes are ranked as F4 or F5, the strongest types.

12 Flooding is a serious danger during severe storms. A **flood** is an overflowing of water in a normally dry area. Some floods happen when excess water from rain or melting snow overflows a stream or river. In urban areas, floods occur when the ground can't absorb any water because of the pavement.

13 The excessive heat caused by heat waves can also be harmful to people. Lengthy exposure to heat and the sun can cause skin damage, heat stroke, and dehydration. To prevent overexposure to the sun, wear protective clothing, sunglasses, and sunscreen. Avoid spending long periods of time in direct sunlight.

Tornado Damage Meteorologists use the Fujita Scale to categorize the strength of tornadoes by looking at the damage caused to trees and human-made structures. The damage shown here was caused by a very strong F4 tornado.

Fujita Scale	Types of Damage
F0	Branches broken off trees
F1	Mobile homes overturned
F2	Trees uprooted
F3	Roofs torn off
F4	Houses leveled
F5	Houses carried away

Protecting Ourselves from Hazardous Weather

14 Pay attention to your local news and weather reports for information about potentially dangerous weather. When dangerous storms are likely, weather announcements indicate when areas are under a storm "watch" and where there is a storm "warning." A watch means that conditions are right for producing severe weather, but the severe weather has not yet developed. A warning means that severe weather is approaching. People should seek shelter and take proper safety measures.

▶ **Severe Storm Safety** People must protect themselves from the harmful effects of severe weather. Different types of severe weather require different types of safety measures.

Tornado If you hear a tornado warning, go to a safe area quickly. Move to the middle of the ground floor. Stay away from windows and doors.

Winter Storm Winter storms can limit your vision and make it easy to get lost. Strong winds cool bodies rapidly. Stay or get indoors, and keep a supply of water and food on hand in case of a power outage.

Thunderstorm Get and stay indoors. If you are in a car, it's safe to stay there. But if you are outside, find a low area away from trees, fences, and poles. If you are swimming or in a boat, get to shore and find shelter.

Hurricane Today, weather satellites can track and warn people well in advance of an approaching hurricane. You should be prepared to evacuate, or move away temporarily. If you hear a hurricane warning and are told to evacuate, leave the area immediately.

NAME _____ CLASS _____ DATE _____

Reading Check

Natural Disasters

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraph 2, you read that Hurricane Matthew contained winds with approximate speeds of 250 km/h. What does the word *approximate* mean?

   A. powerful

   B. estimated

   C. dangerous

   D. exact

2. In paragraphs 5–6, you read about thunderstorms. How do thunderstorms affect human life in Florida?

3. In paragraph 7, you read about hurricanes. Identify the characteristics of a hurricane by placing an X in the correct column.

	Wind speeds over 119 km/h	Low pressure	Snow and ice	Tropical
hurricane				

4. In paragraph 8, you read about the effects of a hurricane. How can people in a hurricane-prone area prepare for the possibility of these storms?

5. In paragraph 9, you read about storm surge. What is a storm surge and why is it dangerous to human life?

6. In paragraph 10, you read about tornadoes. Identify **two** conditions that are not associated with a tornado.

   A. storm surge

   B. destructive winds

   C. snow

   D. thunderstorms

7. In paragraph 12, you read about floods. What are two ways that flooding can occur?

8. In paragraph 14, you read about hazardous weather. What do you think is the most important thing you can do to protect yourself from hazardous weather?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Natural Disasters

1. **Model** Complete the T-chart to explain the different ways you would prepare your home for a hurricane and for a tornado.

Hurricane Safety	Tornado Safety

2. **Apply** Describe or draw a diagram to show how hurricanes can affect the local environment at a beach town.

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Lesson Review

Natural Disasters

The table shows the average number of tornadoes each year by land area in each state. Use the table to answer questions 1 and 2.

State	Number per year	Number per year per 1,000 square miles
Florida	66	1.23
Illinois	54	0.97
Kansas	96	1.17
Oklahoma	62	0.90
Texas	155	0.59

1. Based on the data in the table, which statement about tornadoes in these states is most accurate?

   A. Encountering a tornado is most likely in Texas.

   B. Encountering a tornado is most likely in Florida.

   C. Encountering a tornado is least likely in Illinois.

   D. Encountering a tornado is least likely in Oklahoma.

2. What additional information would you need to compare the estimated risk of human deaths and injuries from tornadoes for these states?

   A. population size of each state

   B. number of cities in each state

   C. number of houses in each state

   D. length of tornado season in each state

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Phenomenon Activity

Kinetic and Potential Energy

I can...

- describe the nature of work, kinetic energy, and potential energy.
- understand different forms of energy.
- explain energy transformations and energy transfer.

Vocabulary

chemical energy elastic potential energy electrical energy electromagnetic radiation energy gravitational potential energy kinetic energy mechanical energy potential potential energy thermal energy work

Phenomenon Why does the pendulum stop moving at the end of its swing?

Develop Models Draw a model with labels and captions to explain how the motion of the pendulum depends on its starting position.

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Hands-On Lab

Mass, Speed, and Kinetic Energy

You will…

- model how speed changes when mass changes and kinetic energy remains fixed.
- describe the mathematical relationship between mass and kinetic energy.

What You Need to Know

Look around you. You will probably see objects in motion, such as other students writing, someone walking down the hallway, or a pencil falling. If two students with different weights walk at the same speed, do they have the same amount of **kinetic energy**? In this activity, you will observe how constant kinetic energy affects velocity when mass varies.

Materials

- skateboard or toy truck
- three large books
- spring scale
- string
- meter stick
- stop watch

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Procedure

1. Find a large empty space on the floor. Place one book on the skateboard. Attach one end of the spring scale to the skateboard. Attach the other end of the spring scale to a string.
2. Hold the skateboard stationary and pull the string to apply a force to the skateboard. Let the skateboard go, and observe its motion. Adjust the force of the scale until the skateboard reaches a safe, moderate speed.
3. Using the same force to put the skateboard in motion, measure the speed of the skateboard. Repeat the measurement.
4. Place a second book on the skateboard. Use the same force to put the skateboard in motion, and measure its speed. Repeat the measurement.
5. Place a third book on the skateboard. Use the same force to put the skateboard in motion, and measure its speed. Repeat the measurement.

Observations

	Trial 1	Trial 2
1 book		
2 books		
3 books		

Analyze and Interpret Data

1. **Compare Data** What can you infer about the magnitude of the kinetic energy of the skateboard in your various trials? Explain.

2. **Compare Data** How do the speeds in the trials compare? Explain.

3. **Identify Variables** What quantity was kept constant in this experiment? What quantities varied?

4. **Use Mathematics** The equation below expresses the relationship between an object's kinetic energy, mass, and speed.

$$\text{Kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

Did your observations agree with the equation?

5. **Predict** Suppose you determined the skateboard's speed while carrying 1, 2, and 3 books. Then suppose you constructed a line graph with mass (number of books) on the *x*-axis and velocity on the *y*-axis. What do you think the graph line would look like? Explain.

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Data Analysis Activity

Analyzing Kinetic Energy

You will…

- evaluate mathematical expressions.
- apply mathematical concepts.

What You Need to Know

Moving objects have kinetic energy, and there is a clear mathematical relationship between KE, mass, and speed. The formula:

$$\text{Kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

You will apply the formula to two moving objects, a girl and her dog. The dog has a mass of 20 kg. The girl has a mass of 45 kg.

Analyze and Interpret Data

1. **Evaluate Expressions** Suppose both the dog and the girl run at a speed of 3 m/s. Evaluate the expression for kinetic energy to find both of their kinetic energies.

   Kinetic energy of dog =

   _____

   Kinetic energy of girl =

   _____

2. **Calculate** Suppose the dog speeds up and is now running at a speed of 6 m/s. Calculate the dog's new kinetic energy.

   New kinetic energy of dog =

   _____

3. **Calculate** Suppose the dog slows down and is now running at a speed of 1 m/s. Calculate the dog's new kinetic energy.

   New kinetic energy of dog =

4. **Apply Mathematical Concepts** When the dog's speed falls to a third of its value, what is the ratio of the new KE to the former KE? Explain why the KE did not drop to a third of its value.

5. **Distinguish Relationships** Which variables are proportional: kinetic energy and mass, or kinetic energy and speed?

6. **Calculate** Suppose the girl picks up the dog and carries it at 3 m/s. Write two ways to find the total kinetic energy.

   KE =

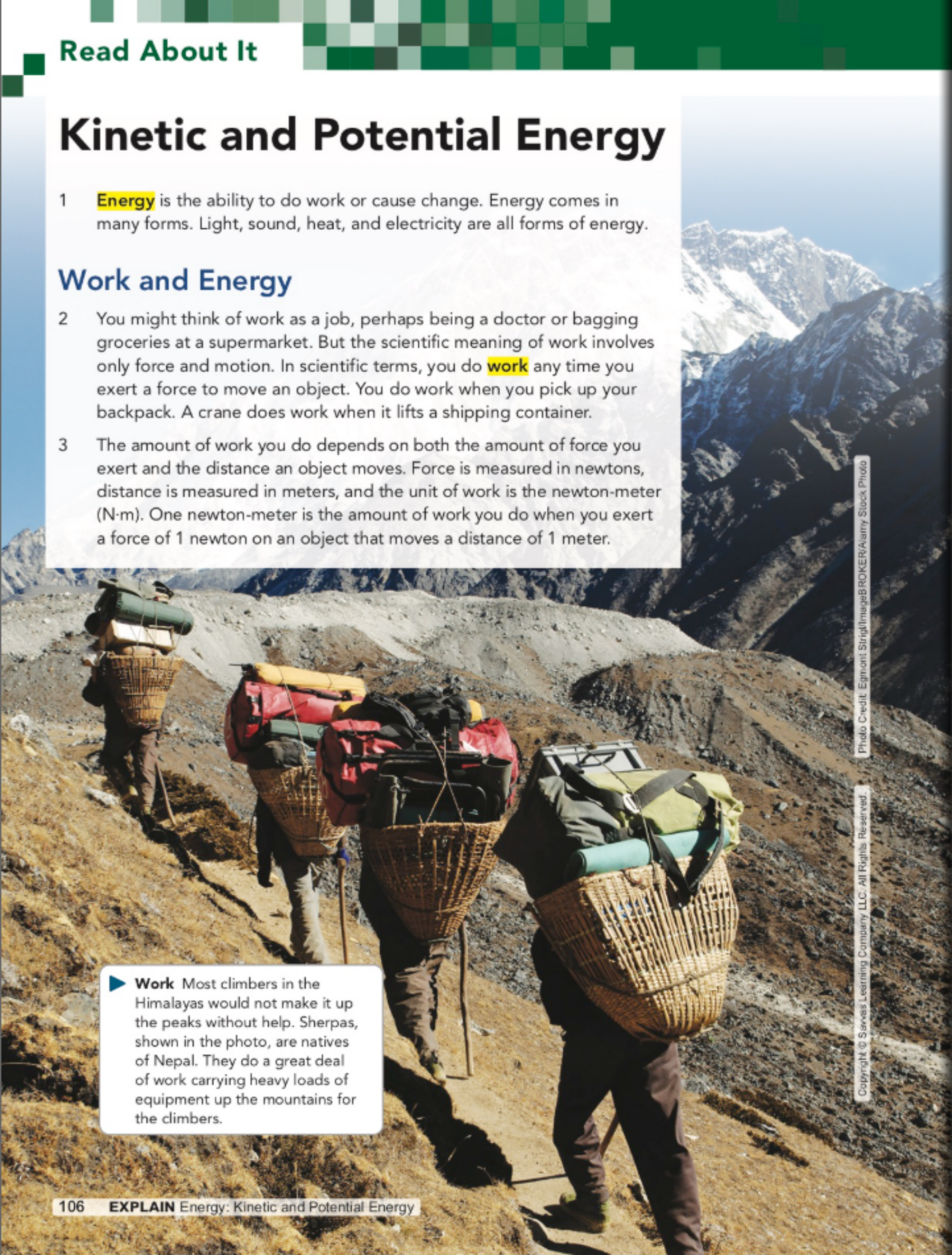
Kinetic and Potential Energy

1 **Energy** is the ability to do work or cause change. Energy comes in many forms. Light, sound, heat, and electricity are all forms of energy.

Work and Energy

2 You might think of work as a job, perhaps being a doctor or bagging groceries at a supermarket. But the scientific meaning of work involves only force and motion. In scientific terms, you do **work** any time you exert a force to move an object. You do work when you pick up your backpack. A crane does work when it lifts a shipping container.

3 The amount of work you do depends on both the amount of force you exert and the distance an object moves. Force is measured in newtons, distance is measured in meters, and the unit of work is the newton-meter (N·m). One newton-meter is the amount of work you do when you exert a force of 1 newton on an object that moves a distance of 1 meter.



Work Most climbers in the Himalayas would not make it up the peaks without help. Sherpas, shown in the photo, are natives of Nepal. They do a great deal of work carrying heavy loads of equipment up the mountains for the climbers.

Kinetic Energy

4 A newton-meter is also called a joule (J). Recall that the ability to do work or cause change is called energy. When you do work on an object, you add energy to that object. Both energy and work are measured in joules.

5 You can do work to lift an object, and you can also do work to change the motion of an object. If you push your younger brother on a swing, he will start moving. The harder you push, and the farther you push, the greater will be his energy. The energy of a moving body is **kinetic energy** (KE). Earth revolving around the sun, a basketball soaring through the air, and the tiniest particle of matter vibrating within a solid object all have kinetic energy. As you sit at your desk, you give your hands kinetic energy every time you turn a page in a book or type on a keyboard.

▶ **Faster** Pushing someone on a swing takes work—you have to use a force to move their weight through a distance. The farther you push and the harder you push, the faster they will go. More work produces more kinetic energy.

6 The kinetic energy of an object depends on both its speed and its mass. The faster an object moves, the more kinetic energy it has. For example, if a tennis ball moves at great speed, it has more kinetic energy than if the ball is softly lobbed over the net. Kinetic energy also increases as mass increases. A wheelbarrow full of dirt has more kinetic energy than an empty wheelbarrow has, due to its greater mass.

7 You can use the following equation to solve for the kinetic energy of an object:

$$\textbf{Kinetic energy} = \frac{1}{2} \times \textbf{mass} \times \textbf{speed}^2$$

Kinetic energy is measured in joules, and 1 joule (J) = $1 kg \cdot m^2/s^2$.

For example, suppose a girl with a mass of 50 kg is jogging at a speed of 2 meters per second (m/s).

$$\text{Kinetic energy of girl} = \frac{1}{2} \times 50 \text{ kg} \times (2 \text{ m/s})^2$$
$$= 100 \text{ kg} \cdot \text{m}^2/\text{s}^2 = 100 \text{ J}$$

In the formula, the exponent 2 that follows speed tells you that the speed is multiplied twice. Notice that doubling the mass of an object doubles its KE, whereas doubling its speed increases KE by a factor of 4.

Causing Change The kinetic energy of a meteor that struck the Arizona desert 50,000 years ago caused visible changes in the landscape.

8 Moving objects are not the only examples of kinetic energy—there are also other forms of kinetic energy. For example, the heat you feel against your skin is due to moving particles of air hitting your skin. That type of kinetic energy is called **thermal energy**. When the kinetic energy of the particles of matter increases, thermal energy and temperature also increase.

9 Sound, electricity, and **electromagnetic radiation** are other examples of kinetic energy. Sound is a wave that transfers energy through materials. Electromagnetic radiation is a form of kinetic energy that travels through space in waves. Light waves travel through a vacuum and through matter. Like other waves, light transfers energy without a transfer of matter. Visible light is the type of electromagnetic radiation that you know best.

Moving Energy Heat, light, and sound are all forms of kinetic energy.

Potential Energy

10 Think about a landslide. The dirt and rocks are moving, so they have kinetic energy. Yet, only a few moments earlier, the dirt and rocks were not moving. At that stage, they did not have kinetic energy, but they did have potential energy. **Potential energy** (PE) is energy due to the position or shape of an object. Potential energy has the **potential** to change into kinetic energy.

11 One type of potential energy is **gravitational potential energy** (GPE), which is the energy an object has due to its position relative to Earth's surface. The dirt and rocks had GPE before the landslide began. The amount of gravitational potential energy an object has is proportional to the mass of the object and its height above Earth's surface—the amount of work needed to lift the object. You can calculate an object's gravitational potential energy using this equation:

Gravitational potential energy = weight × height above ground

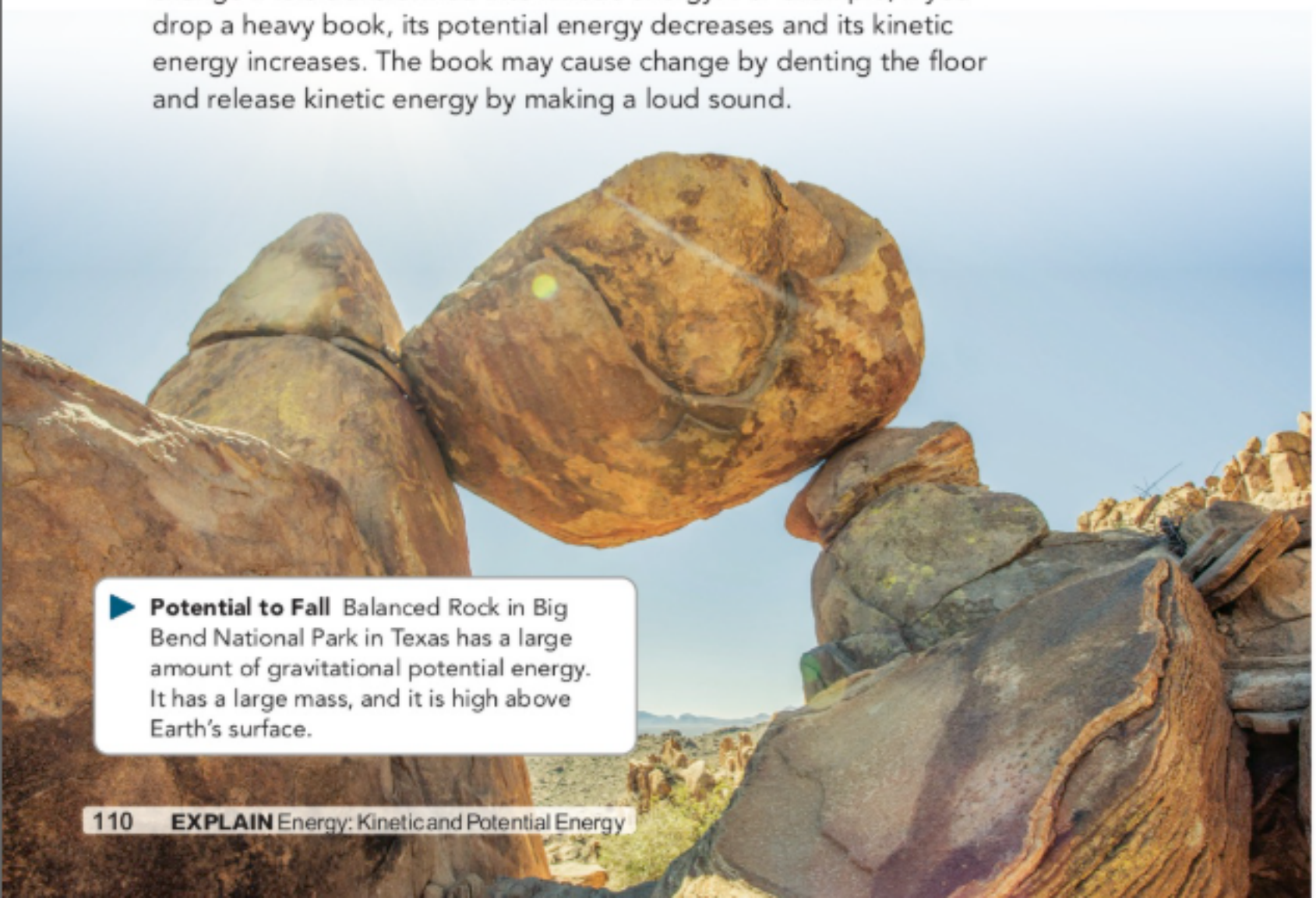
For example, suppose a cat with a weight of 40 newtons is lifted 2 meters off the ground.

Gravitational potential energy = 40 N × 2 m = 80 N·m, or 80 J

12 The difference between potential energy and kinetic energy is that potential energy cannot cause change on its own. But it can cause change if it is transformed into kinetic energy. For example, if you drop a heavy book, its potential energy decreases and its kinetic energy increases. The book may cause change by denting the floor and release kinetic energy by making a loud sound.

Vocabulary Support

The word *potential* refers to something that is possible but not yet actual. In terms of motion, potential energy has the ability to cause motion. In other usage, a person might have the potential to be a great singer, but they need more practice. In what areas do you have potential?



Potential to Fall Balanced Rock in Big Bend National Park in Texas has a large amount of gravitational potential energy. It has a large mass, and it is high above Earth's surface.

13 **Elastic potential energy** is energy a material stores due to a change in shape. A change in shape is also called a deformation. Elastic potential energy can be stored in such objects as rubber bands, bungee cords, and springs. A drawn bow or a trampoline can store a large amount of elastic potential energy.

14 Compression and elongation are common forms of deformation. During compression, a material is pressed together. When you squeeze a jack-in-the-box closed, you store energy as you compress its spring. In elongation, a material is stretched. Elongation occurs when a tennis ball hits a racquet and stretches the strings. The strings store energy as they stretch. When the strings release their stored energy, they give the ball kinetic energy, and it flies off the racquet.

Literacy Support

In your notebook, sketch an object with elastic potential energy.

Stored Energy When the woman pushes down on the trampoline, the springs around the rim stretch, and they gain elastic potential energy. When the woman bounces off the trampoline, the stored energy is transferred from the trampoline to the woman, sending her upward.

At her lowest point, the woman has no kinetic energy. The springs store potential energy.

At her highest point, the woman again has no kinetic energy. She only has gravitational potential energy.

Chemical and Electrical Energy

15 **Mechanical energy** is a type of energy that includes gravitational and elastic potential energy, as well as kinetic energy. But energy can take many other forms as well. Some of those forms of energy are associated with the atoms and molecules that make up objects.

16 An airplane's engine provides the power to move the plane. But the engine gets its power from the stored energy in fuel. Jet fuel and other fuels, as well as the food you eat, contain potential energy. It is **chemical energy**, which is the energy stored in chemical bonds. Chemical bonds are the forces that hold molecules together. When those bonds are broken, energy is released.

17 Like fuel and food, batteries store chemical energy. Chemical reactions convert the chemical energy into electricity, which is a form of kinetic energy. The electricity then can be used to run your phone, flashlight, or remote control.

18 **Electrical energy** is the energy of electric charges. Electric charges attract and repel each other, so moving them around takes work. That work can be stored as electric potential energy, which is the energy of stationary electric charges. If the charges are allowed to move, the potential energy can be converted to electricity that powers devices such as lights, computers, and audio systems.

Generators This bicycle dynamo, driven by a spinning wheel, transforms enough energy to power a headlight. Bigger dynamos, driven by the water from a river, can power a city.

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Reading Check

Kinetic and Potential Energy

Answer the following questions after you have completed reading the Read About It.

1. In paragraphs 2–4, you learned about work. Suppose you used a force of 5 N to move an object 7 m. How much work did you do? Show your calculations.

_____

_____

2. In paragraphs 5–7, you learned about kinetic energy. A running deer has a mass of 100 kg and is moving at a speed of 8 m/s. What is the deer's kinetic energy, in joules?

_____

3. In paragraphs 8 and 9, you learned about types of kinetic energy. Which of the following is true of increasing the thermal energy of a material?

   A. The speed of the particles increases.

   B. The number of particles increases.

   C. The mass of the particles increases.

   D. The density of the material increases.

4. In paragraphs 10–12, you learned about potential energy. Suppose you have a birdbath in the yard of your house. You need to carry the birdbath to the attic. You can climb a ladder to an attic window or staircases inside the house. The ladder is much steeper than the stairs. Will you do more work if you take the birdbath up the stairs or if you climb the ladder? Explain.

_____

_____

_____

_____

_____

5. In paragraphs 10–12, you learned about potential energy. As Emily is hanging a calendar on her wall, she accidentally drops it. Which statement describes how the energy of the calendar is transformed as it falls to the floor?

   A. Energy is created as potential energy is transformed into kinetic energy.

   B. Energy is destroyed as potential energy is transformed into kinetic energy.

   C. Potential energy is transformed into kinetic energy, but energy is not created or destroyed.

   D. Kinetic energy is transformed into potential energy, but energy is not created or destroyed.

6. In paragraphs 10–12, you learned about potential energy. You have two identical weights swinging on strings of the same length. At the lowest point in their paths, Weight A moves three times as fast as Weight B. Which ball will swing to a higher point, and how much higher will it go?

   A. The two weights will reach the same height.

   B. Weight A will go three times as high as Weight B.

   C. Weight A will go six times as high as Weight B.

   D. Weight A will go nine times as high as Weight B.

7. In paragraphs 13–14, you learned about elastic potential energy. What is the difference between gravitational potential energy and elastic potential energy?

   A. Gravitational potential depends on height and weight. Elastic potential depends on shape.

   B. Gravitational potential depends on height and shape. Elastic potential depends on weight.

   C. Gravitational potential depends on weight and shape. Elastic potential depends on height.

   D. Gravitational potential depends on shape. Elastic potential depends on height and weight.

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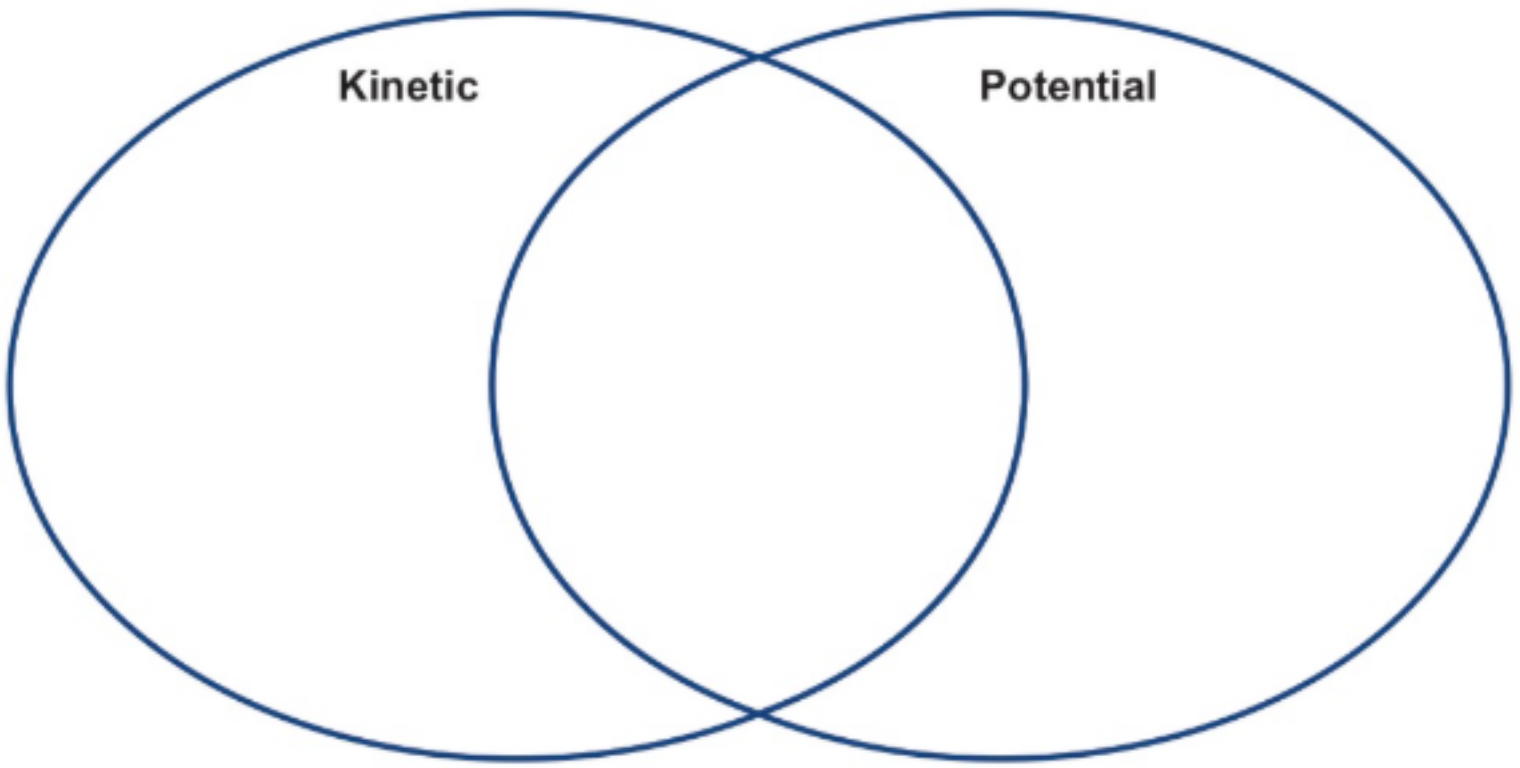
Extend and Enrich Activities

Kinetic and Potential Energy

1. **Model** Make a Venn diagram for the types of energy in this Topic.



2. **Apply** Identify similarities and differences between kinetic and potential energy.

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Lesson Review

Kinetic and Potential Energy

The diagram below shows four penguins ready to go fishing. Use the diagram to answer questions 1 and 2.

1. Assuming the penguins in the figure have similar masses, which penguin has the least gravitational potential energy?

   A. penguin farthest to left

   B. penguin second from left

   C. penguin third from left

   D. diving penguin

2. When the diving penguin reaches the water, what will be true?

   A. The penguin's speed will be twice what it is now.

   B. The penguin's KE will be twice what it is now.

   C. The penguin's PE will be twice what it is now.

   D. The penguin's PE will be four times what it is now.

3. Which of the following is not a form of kinetic energy?

   A. thermal energy

   B. electromagnetic energy

   C. chemical energy

   D. sound

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Phenomenon Activity

Conservation of Energy

I can...

- understand the law of conservation of energy.
- explain how energy conservation applies in different situations.

Vocabulary

law of conservation of energy pivot

Phenomenon Where does a "sleeping" yo-yo get the energy to come back up?

Photo Credit: Kelly Redinger/Design Pics/Getty Images

Make a Claim Explain how the energy differs when the yo-yo is in the person's hand compared to when the yo-yo is sleeping.

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Hands-On Lab

Energy Conversion and Conservation

You will…

- investigate the energy conversion that makes a mechanical device work.
- describe how energy is conserved in a mechanical device.
- observe how a mechanical device is affected by gravitational potential energy.

What You Need to Know

When **energy** flows through systems, it can be transformed from one type to another. In this descriptive investigation, you will construct a simple mechanical device to demonstrate how energy is conserved in a system. You also will investigate how **gravitational potential energy** affects the device's motion.

Materials

- empty oatmeal-type container with a cardboard bottom and plastic lid
- rubber band
- 3 steel ½-inch nuts
- 2 nails
- pipe cleaners or twist ties
- flat board (wood or stiff cardboard)
- blocks

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Wear safety goggles.

Use caution when punching holes in the container with the nail, as nails have sharp points.

Procedure

1. Use pipe cleaners to tie the nuts to the middle of the rubber band.
2. Use a nail to punch one hole in the center of the bottom of the container and another hole in the center of the lid. Use a pencil to make the holes large enough to thread the rubber band through them.

3. Slip one end of the rubber band through the hole in the bottom of the container. Next, slide a nail through the rubber band to secure it on the outside. Repeat the process for the lid. The rubber band should reach both ends without being stretched too tightly.

4. Write a hypothesis that describes what you think will happen when you roll the "comeback can."

5. Gently roll the can away from you on a hard, level floor, and let it go.

6. Record your observations.

7. Prop one end of the board up with blocks to create a ramp.

8. Place the can at the higher end of the ramp. Let it roll down the ramp, and record your observations.

Analyze and Interpret Data

1. **Develop Explanations** How is energy transformed from elastic potential energy and kinetic energy as the can rolls away from you and then rolls back?

2. **Analyze** How did the can's gravitational potential energy affect its motion when it rolled down the ramp?

3. **Cause and Effect** Consider how changing the incline of the ramp affects the can's gravitational potential energy (GPE) and kinetic energy (KE).

Cause	Effect on GPE	Effect on KE
Increasing incline of the ramp		
Decreasing incline of the ramp		

4. **Energy and Matter** How is energy conserved when you roll the can on a level surface? How is energy conserved when you roll the can down the ramp?

Conservation of Energy

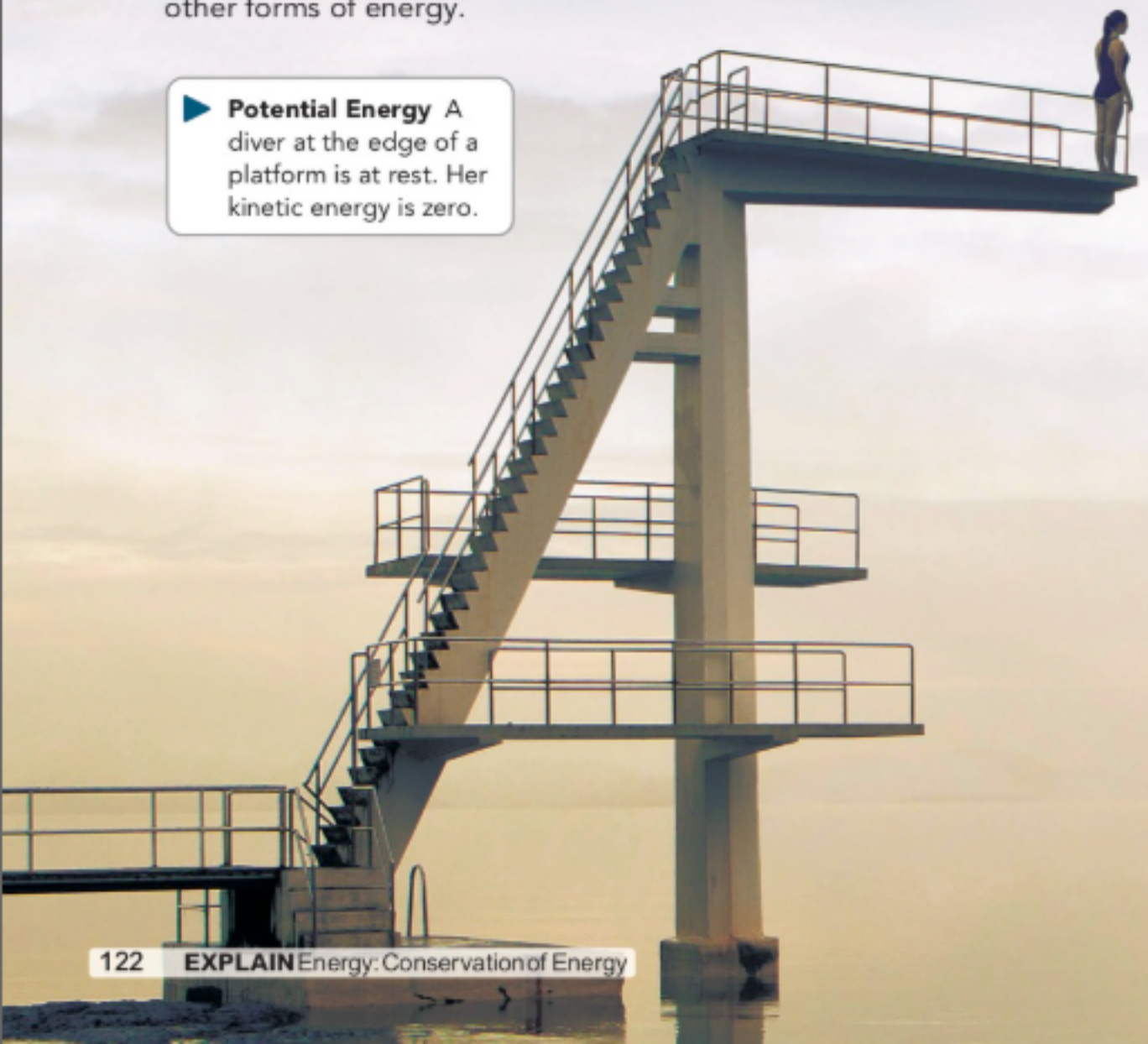
1 In everyday life, energy conservation means using less energy, which saves money and benefits the environment. In physics, however, *conservation* does not mean reducing the amount of energy used.

The Law of Conservation of Energy

2 The **law of conservation of energy** states that energy cannot be created, nor can it be destroyed. The amount of energy in a closed system always remains the same. When one object loses energy, other objects must gain it. In science, a law describes what will happen, but not why or how. Because energy is conserved, it can only be transferred from one object to another or transformed from one form to another. Energy transfer occurs when energy moves from one place to another, such as when two objects collide or when electricity flows. Energy transformation occurs when energy changes form, such as when the gravitational potential energy of a diver becomes kinetic energy. All forms of energy can be transformed into other forms of energy.

Literacy Support

Paraphrase the sentences that explain the difference between energy transfer and energy transformation.



Potential Energy A diver at the edge of a platform is at rest. Her kinetic energy is zero.

Mechanical Energy

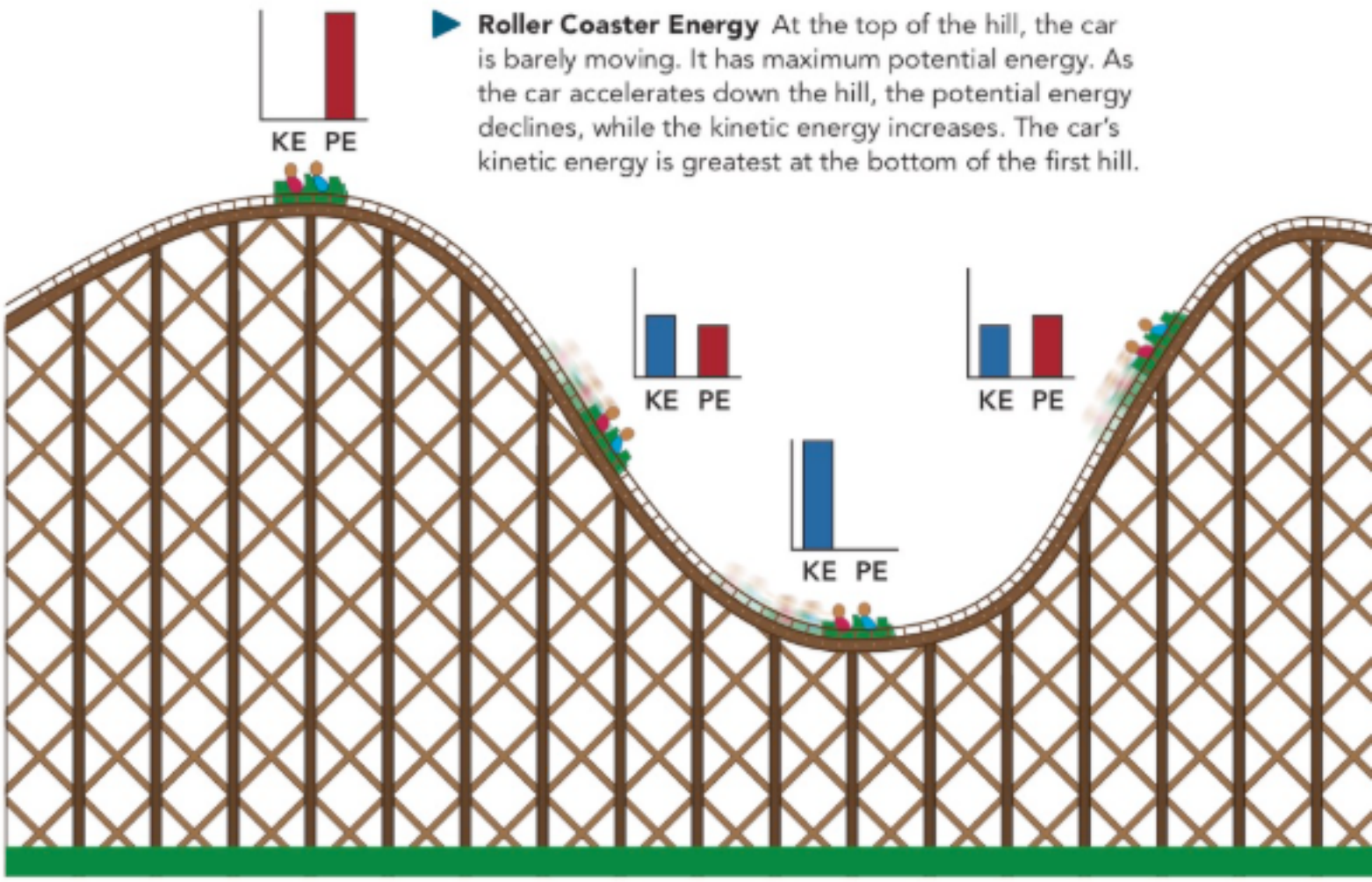
3 In systems influenced only by gravity, mechanical energy is the sum of gravitational potential energy and kinetic energy. When the kinetic energy of an object increases, that is because potential energy is transformed to kinetic energy, and so potential energy decreases. When the potential energy of an object increases, that is because kinetic energy is transformed to potential energy, and so kinetic energy decreases.

4 As an example, consider a roller coaster. Did you know that roller coaster cars do not have motors? A motor below the track drives a chain that pulls the car up the first hill on the track. After that, the roller coaster car moves only because of gravity. Follow along the path of the coaster in the figure and note the changes that occur in the car's kinetic and potential energy.

5 A pendulum also shows the relationship between kinetic and potential energy. You may have seen pendulums without recognizing them as such. Any object that is suspended from a **pivot** and swings back and forth can be considered a pendulum. Recall that the weight of an object and its height above the ground determine its gravitational potential energy. Potential energy is greatest at the top, or end, of the pendulum's swing. The kinetic energy and the speed of the pendulum are greatest at the bottom, or midpoint, of the swing.

Vocabulary Support

A *pivot* is a point around which something turns. The term is used in describing the action of a basketball player who keeps one foot firmly in place while moving the other foot. What other things in everyday life might pivot?



Roller Coaster Energy At the top of the hill, the car is barely moving. It has maximum potential energy. As the car accelerates down the hill, the potential energy declines, while the kinetic energy increases. The car's kinetic energy is greatest at the bottom of the first hill.

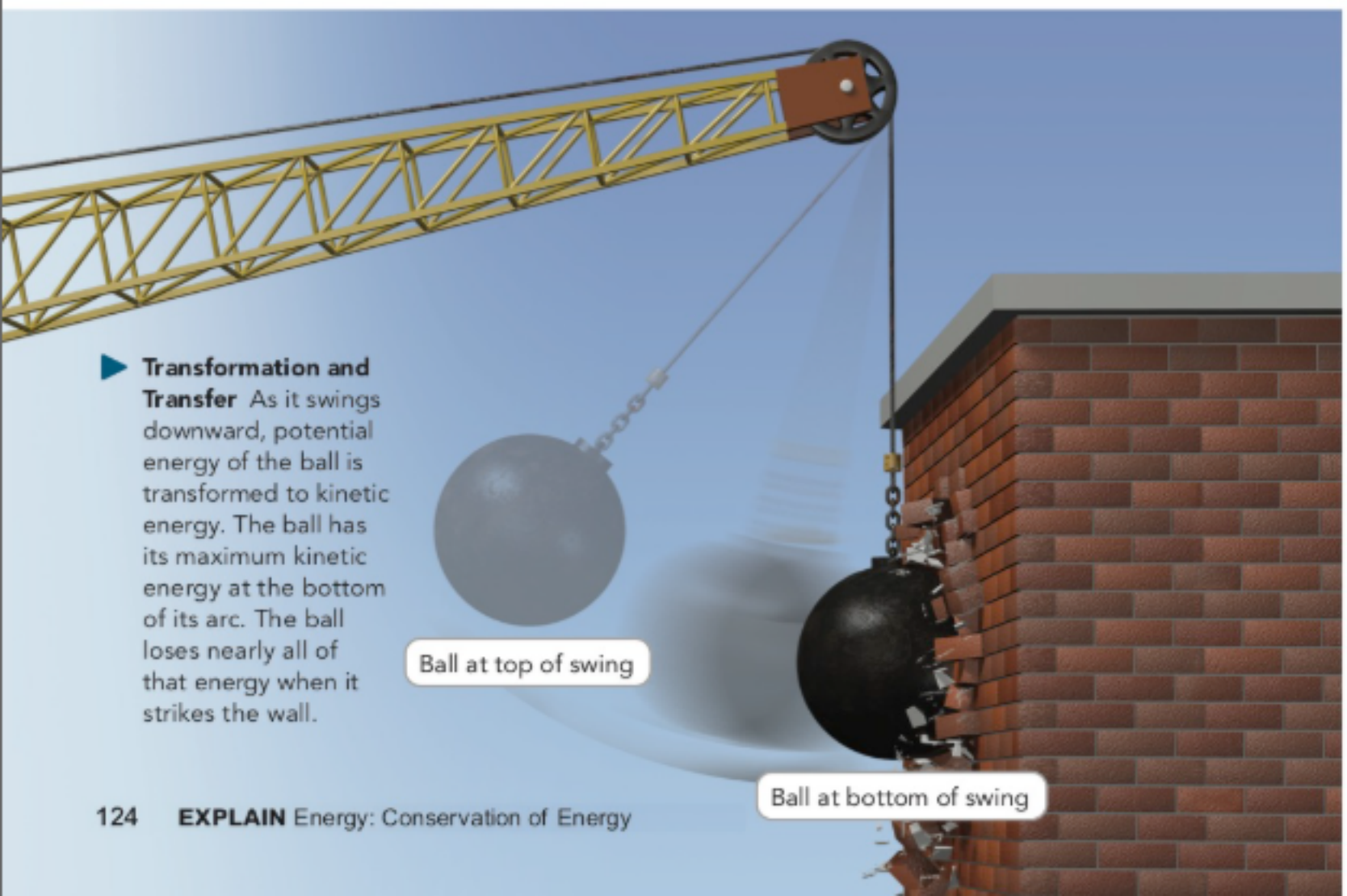
Energy Transformation and Transfer

6 Energy transformation and energy transfer are not the same thing, but they sometimes occur in the same process at the same time. The potential energy of a pendulum is transformed into kinetic energy as its weight falls due to the force of gravity. A wrecking ball is one example of a pendulum.

7 When the wrecking ball swings downward and hits the wall, some of its kinetic energy is transformed into the energy of sound. Some is transformed into thermal energy that warms the wrecking ball. However, much of the kinetic energy of the ball is transferred to the wall, causing the wall to collapse. Throwing a ball or transmitting electric power are also energy transfers. Can you think of other examples?

8 The wall falling down is not the only transfer of energy from the wrecking ball. When the ball swings, kinetic energy is transferred from the ball to the air, due to the force of friction. As the kinetic energy is transferred, it is also transformed into thermal energy of the surrounding air.

9 Whenever a moving object experiences friction, some of its mechanical energy is transformed into thermal energy. You may notice that a roller coaster's hills get smaller as the ride continues. That is because some mechanical energy is lost to friction as the wheels rub against the track during the ride, slowing the car down.



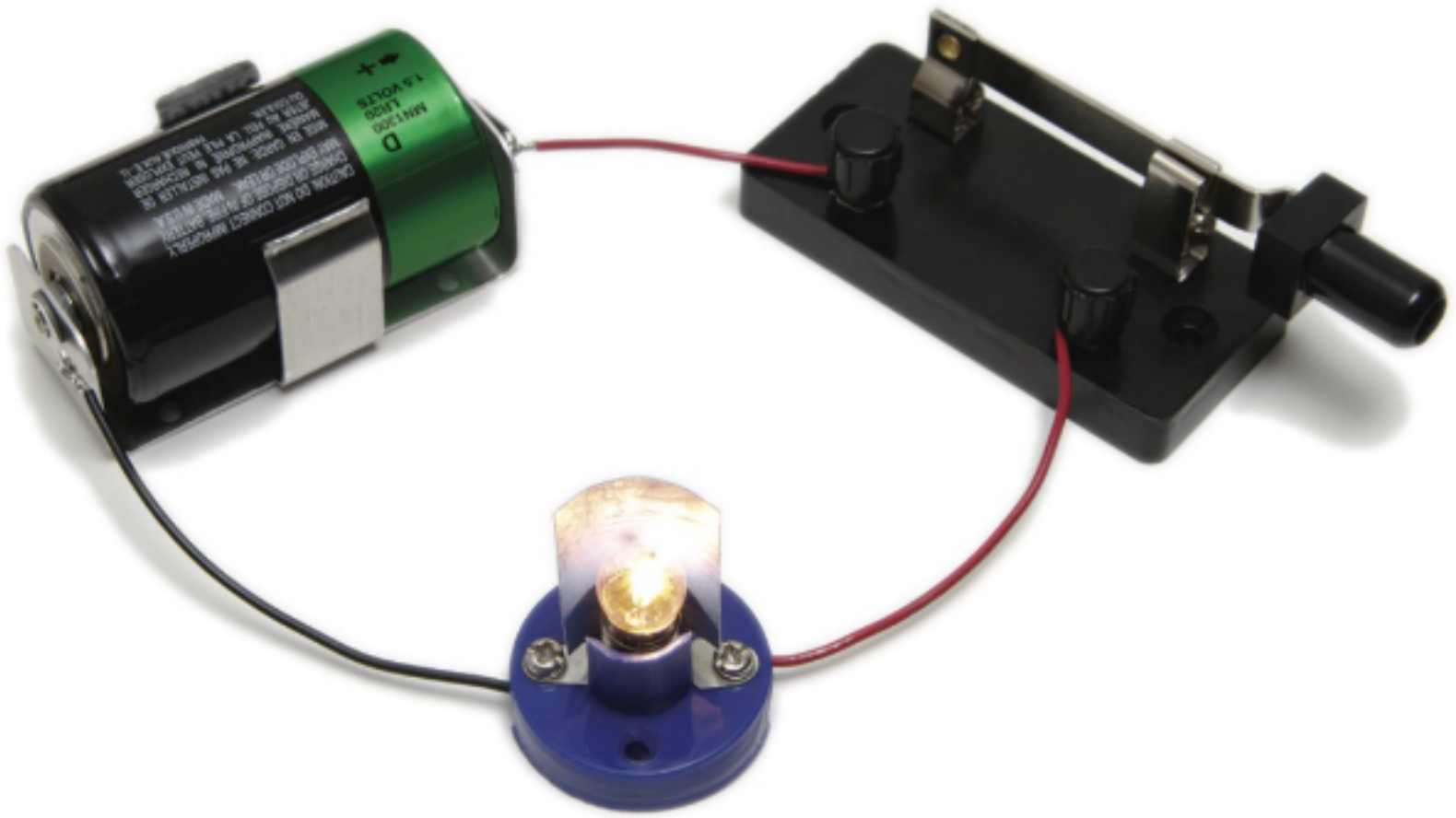
Transformation and Transfer As it swings downward, potential energy of the ball is transformed to kinetic energy. The ball has its maximum kinetic energy at the bottom of its arc. The ball loses nearly all of that energy when it strikes the wall.

10 When a batter hits a baseball, the ball flies through the air. Kinetic energy of the ball is transferred to the air and is transformed into thermal energy due to the force of friction. In Denver, at high altitude, the air is not as dense as at lower altitudes. The result is less friction, and less loss of kinetic energy, so a batted ball travels farther. Conservation of energy explains why more home runs are hit in Denver than in other cities. In every case, whether a baseball, a wrecking ball, or a roller coaster, energy is conserved because the environment absorbs the heat that friction generates.

Energy Conservation in Electric Circuits

11 Think about the electric circuit in the photo. The chemical potential energy in the battery is transformed to electrical energy, a form of kinetic energy. That energy travels through the wire and is changed into heat and electromagnetic energy (light) in the bulb. In the wire, some of the electrical energy is transformed into thermal energy. If you felt the wire or the bulb, the warmth would demonstrate the change to thermal energy. The environment absorbs the thermal energy generated by the circuit, so that the total amount of energy remains the same. Energy is conserved!

Simple Circuit Electric circuits demonstrate the law of conservation of energy. The electricity in a circuit can be transformed into many different forms, but energy is neither created nor destroyed.

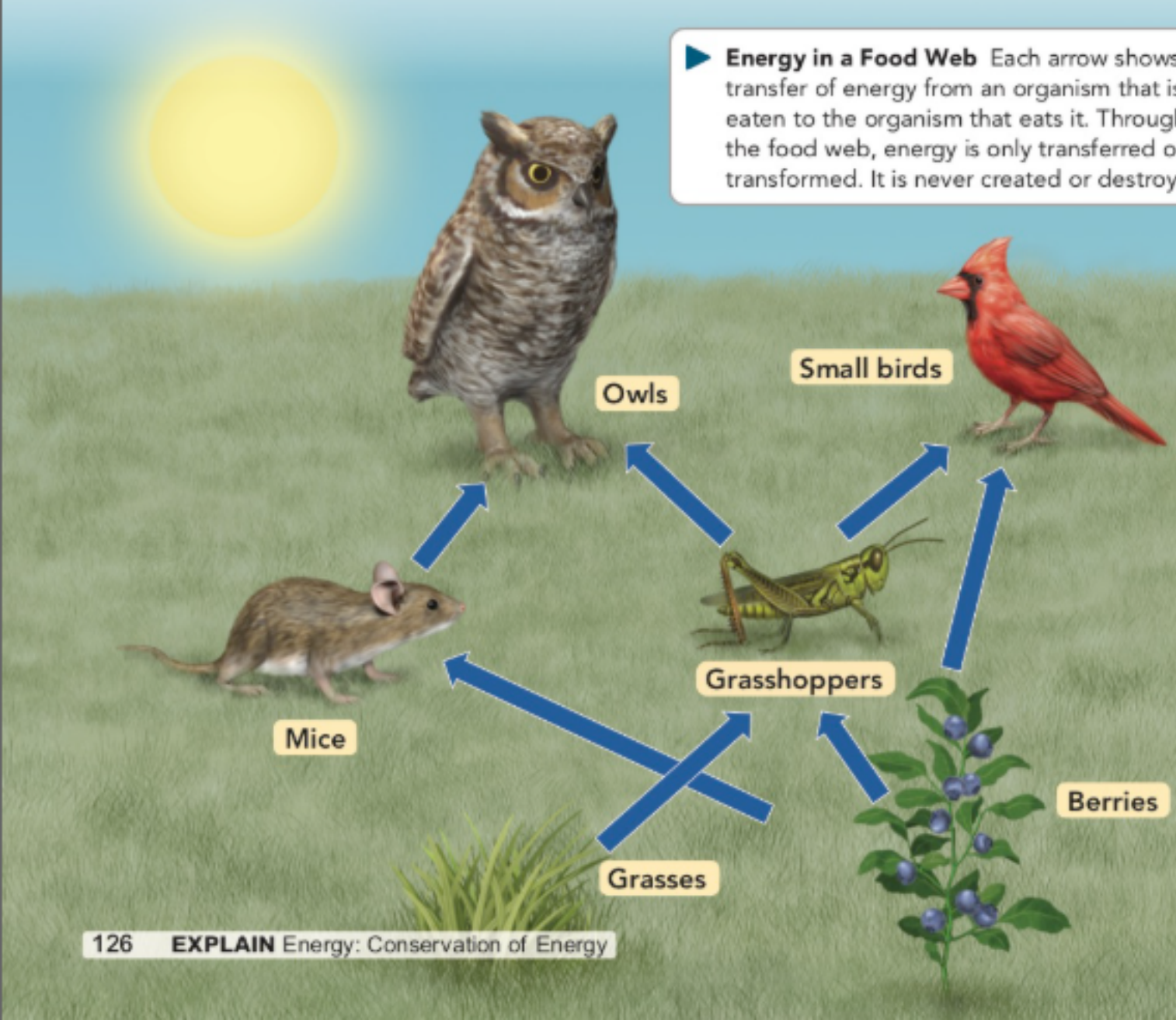


Energy Conservation in Biology

12 In some processes, energy is transformed once (a single transformation), and in others, multiple times. Think about how bread is made. Sunlight, which is electromagnetic energy, is transformed to chemical energy by wheat plants. Mechanical energy is used to grind the wheat into flour and then to mix it with yeast and water. The resulting dough is baked in an oven, which is heated by transforming electrical energy or chemical energy to thermal energy.

13 When you eat the bread, there are again multiple transformations. Your body transforms chemical energy stored in your cells into the kinetic energy of your moving jaws. Your digestive system uses mechanical and chemical energy to digest the bread. The energy that is released from the bread keeps your body warm and provides energy for movement, growth, and all your other body functions.

14 A food web shows the relationships between the plants and animals in an area. Plants use photosynthesis to transform light energy into chemical energy stored in sugar. Plants are eaten by animals, and then those animals are eaten by other animals. The energy stored in the sugar is conserved throughout the food web.



Energy in a Food Web Each arrow shows the transfer of energy from an organism that is eaten to the organism that eats it. Throughout the food web, energy is only transferred or transformed. It is never created or destroyed.

NAME _____ CLASS _____ DATE _____

Reading Check

Conservation of Energy

Answer the following questions after you have completed reading the Read About It.

1. In paragraph 2, you read about the law of conservation of energy. Which of the following describes the law of conservation of energy?

   A. Energy cannot be created or destroyed.

   B. Energy can only be released through transformation.

   C. When energy is conserved, it always changes form.

   D. Energy increases when it is transferred.

2. In paragraphs 3–5, you learned about mechanical energy. In its orbit around the sun, a comet has the least KE when it is far from the sun. It has the greatest KE when it is close to the sun. How does the difference in KE explain why a comet is only near the sun for a short time in each orbit?

3. In paragraphs 6 and 7, you learned about energy transfer and energy transformation. What type(s) of energy do you acquire when you eat a bowl of hot vegetable soup? Is energy transferred or transformed? Explain.

4. In paragraphs 6 and 7, you learned about energy transfer and energy transformation. During the summer, pavement gets hot when the sun shines on it. How can you describe the process?

   A. Energy transformed by radiation is transferred to thermal energy.

   B. Thermal energy is transformed by conduction.

   C. Electromagnetic radiation is transformed to thermal energy.

   D. Energy transferred by conduction is transformed to radiation.

5. In paragraphs 8–10, you learned about friction. A bicycle's brakes use friction to stop. When it stops, what happens to the bicycle's kinetic energy?

   A. It is destroyed.

   B. It is transformed to electrical energy.

   C. It is transformed to thermal energy.

   D. It is transformed to elastic potential energy.

6. In paragraph 11, you learned about energy in electric circuits. Which of the following is (are) true of toasting bread? Select all that apply.

   A. The toaster transforms electrical energy into light energy.

   B. The toaster transforms electrical energy into sound energy.

   C. The toaster transforms electrical energy into thermal energy.

   D. Energy is destroyed.

7. In paragraphs 12–14, you learned about energy in biological systems. Sunlight supplies the energy for ecosystems.

   Part A

   When you burn wood in a fireplace, you get light and heat. Put the following forms of energy into the order they occur in the process: chemical energy, fire light, sunlight, thermal energy.

   Part B

   Corn can be made into alcohol fuel that is burned in an automobile's engine to make it move. Put the following forms of energy into the order they occur in the process: chemical energy, kinetic energy, sunlight, thermal energy.

Process	Chemical Energy	Fire Light	Kinetic Energy	Sunlight	Thermal Energy
Part A: Firewood					
Part B: Automobile fuel					

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Conservation of Energy

1. **Model** Write an example of each type of conversion process.

Kinetic Energy to Potential Energy		Potential Energy to Kinetic Energy	
Process	**Example**	**Process**	**Example**
KE to Gravitational		Gravitational to KE	
KE to Elastic		Chemical to Electrical	
Thermal to Mechanical		Chemical to Thermal	

2. **Apply** Energy transformation processes are not perfect. What form does the "lost" energy typically take?

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Lesson Review

Conservation of Energy

The diagram below shows an arrow in a drawn bow. Use the diagram to answer questions 1 and 2.

1. A drawn bow stores elastic potential energy. What was the source of that energy, and what form was it in?

   A. elastic potential energy in the archer's blood

   B. chemical energy in the archer's muscles

   C. electrical energy from the sun

   D. thermal energy in the archer's muscles

2. When the archer releases the bowstring, the bow will transfer its potential energy. Where will the energy go, and what form will it take?

   A. It will be transferred to the arrow as elastic potential energy.

   B. It will be transferred to the bow as thermal energy.

   C. It will be transferred to the arrow as kinetic energy.

   D. It will be transferred to the arrow as thermal energy.

3. Javier connects a battery to a light bulb using wires. The light bulb turns on and shines brightly. Several hours later, the light bulb burns out. Explain how energy is conserved in this system even though the circuit no longer works.

   A. Energy continues to flow out of the battery into the wire.

   B. Energy continues to flow out of the battery into the bulb.

   C. Energy flows out of the wire into the battery.

   D. Energy stops flowing and remains in the battery

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Graphing Motion

I can…

- measure and graph distance versus time for a moving object.
- interpret the relationships among distance, time, and speed.

Vocabulary

acceleration motion reference slope speed velocity

Phenomenon How is the distance a Florida panther can travel during an attack related to its speed?

Photo Credit: US Army Photo/Alamy Stock Photo

Develop a Model Create a distance-time graph to show how a panther's speed during an attack is related to the distance it can travel in a certain amount of time. Assume the panther runs at a constant speed of 54 km/h. Show how many seconds it takes the panther to run 200 meters.

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Hands-On Lab

Distance-Time Graphs

You will…

- collect distance and time data for an object moving at a constant speed.
- use the distance and time data to construct a graph of the object's motion.

What You Need to Know

What does **speed** refer to? Speed is the distance an object moves in a given unit of time. As you may know, a panther has greater speed than a house cat. That means the panther runs faster. When you apply the brakes to a bicycle, you decrease the speed of the bicycle—it slows down.

In this investigation, you will collect data about a moving object. Then you will explore how distance, time, and speed are related by constructing a graph to represent the object's motion.

Materials

- constant-velocity car
- masking tape
- tape measure
- 3 stopwatches
- calculator

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Be careful not to trip over the car as you perform the investigation.


Avoid running the car into people.

Procedure

1. Construct a straight, level course for the car to run on. Use the tape measure to make sure that the course is 3 meters long. Use the tape to create a starting line (0 m) and a finish line (3 m). Use the tape to mark distances of 1 m and 2 m along the length of the course.

2. Test the course using the car. Let the car run down the course. If the car moves off to one side, modify the course. You may find it necessary to set up guides, such as placing books on either side of the course. Make sure your car travels in a straight path for 3 meters before you continue with the investigation.

3. When you are ready, place the car on the floor a few car lengths behind the starting line. One student will start the car.

4. A second student should be positioned at the starting line.

5. Three other students should be positioned with stopwatches at 1 m, 2 m, and the finish line.

6. A sixth student should be positioned at the finish line to catch the car after it crosses the line.

7. When everyone is in position and ready, start the car. When the car crosses the starting line, the student at the starting line should call out "start" so that the students along the course can start the stopwatches at the same time.

8. As the car crosses the 1-m mark, the student positioned there should stop their stopwatch. Repeat the process for the 2-m mark and the finish line.

9. Record the times in the data table.

10. Run 2 more trials with the car and record the data in the table. Calculate the average time for each position along the course.

Observations

Distance (m)	Time (s)		Average Time (s)
1	Trial 1		
	Trial 2		
	Trial 3		
2	Trial 1		
	Trial 2		
	Trial 3		
3	Trial 1		
	Trial 2		
	Trial 3		

Analyze and Interpret Data

1. **Graph** Construct a graph for the distance and average time data you collected.

   - Label the *x*-axis *Time (s)*. Create intervals of 5 seconds from 0 to 20 seconds on the *x*-axis.
   - Label the *y*-axis *Distance (m)*. Create intervals of 1 meter from 0 to 4 meters on the *y*-axis.
   - Plot the data from your table as points on the graph. The first point should be (0, 0) because the car has traveled 0 meters at 0 seconds.

2. **Calculate** The car's speed is a rate that tells how far it travels in a given unit of time. Speed is often measured in m/s or km/h. To find the car's speed, divide the total distance it travels by the amount of time it takes to travel that distance. What is the car's speed, in meters per second?

3. **Analyze Data** How would you describe the line created by the points on the graph? What do you think that tells you about the speed of the car?

4. **Predict** How could you use the graph to predict the distance the car travels in 24 or 48 seconds?

Graphing Motion

1 How do you decide whether something is moving? For example, if you were taking the photo of the dog below, would you say the dog is moving? Parts of it seem to be. Its eyes blink, and its ears flap in the wind. But to you, the dog appears to be staying in one position. You know, however, that the dog is in a car that is speeding down the road, so it must be moving. What determines whether the dog is moving or not?

Vocabulary Support

Reference means something consulted as an authority, or for background. A frame of reference is something to measure against.

Motion

2 To decide whether the dog is moving, you need a reference point. A **reference** point is a place or object used for comparison to determine whether something is moving. A change in the relative position of objects is called **motion**. Suppose a tree along the road in the photo is used as a reference point. The car moves past the tree, as does the dog inside the car. In relation to the tree, the dog changes position, and therefore it is in motion. However, if you are the photographer in the front seat of the car, and you are the reference point, your position relative to the dog does not change. You could say that, compared to you, the dog is not in motion. Motion is a key characteristic of all matter that can be observed, described, and measured.

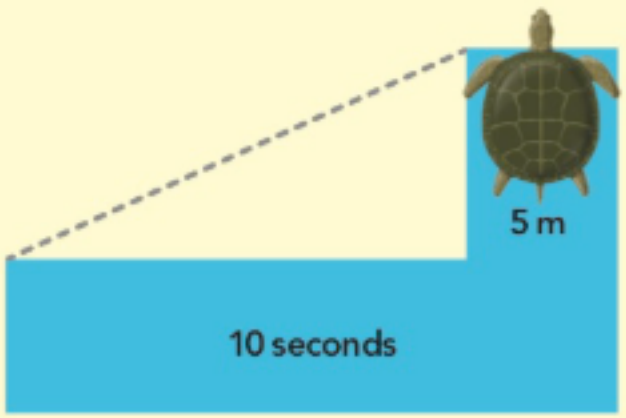
Relative Motion The dog is moving in relation to the landscape, but it is not moving in relation to the car.

Speed

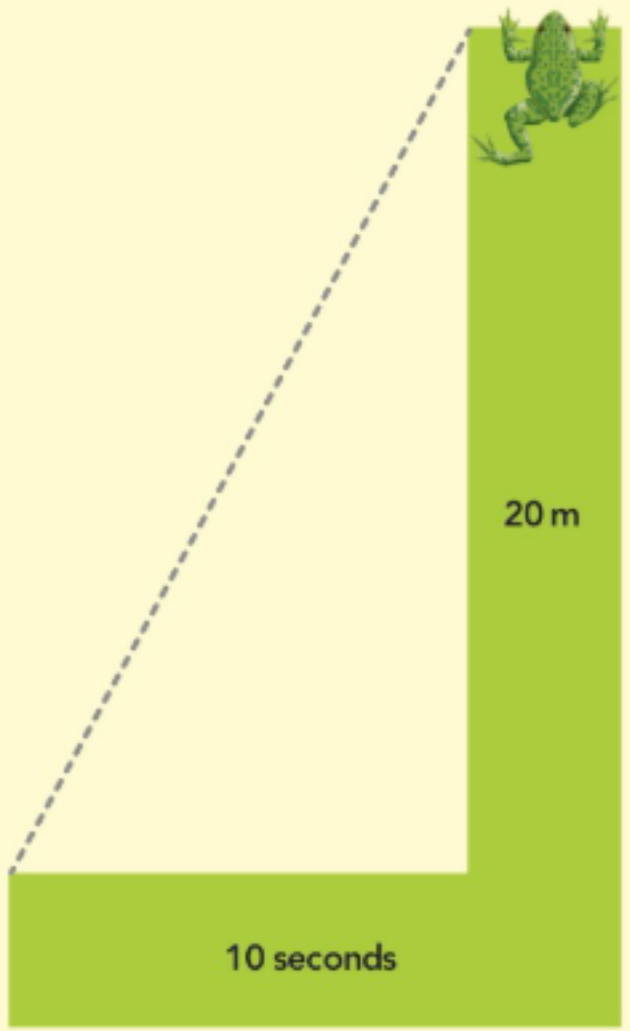
3 When you run or bicycle, you move faster than when you walk. Sometimes just fast and slow are good descriptions of movement, but scientists have a more precise definition of speed. **Speed** is the ratio of distance traveled to the amount of time taken. It can be measured in miles per hour (mph), meters per second, or kilometers per hour, depending on the situation. Since it is a ratio, it can also be written as a fraction—mi/h, m/s, or km/h.

4 Speed can be constant, but often it varies from one part to another of an object's journey. For example, a car traveling through a city may often slow down and speed up. Knowing its speed in a two-second period of time may not reveal much about the whole trip. Knowing its average speed over three miles, or over ten minutes, might be more meaningful.

▶ **Speed** The vertical bars represent distance traveled by the turtle and the frog, and the horizontal bars represent time.



The turtle moved 5 meters in 10 seconds.



The frog moved 20 meters in 10 seconds. The frog is much faster than the turtle.

Graphing Motion

5 A very useful way of representing an object's movement is to measure and graph distance versus time. A graph shows where an object is at a given time. The graph on this page is a distance-versus-time graph. Each point on the graph represents the distance a swimmer has traveled from his starting point during a given time period. The *x*-value of the point is time, and the *y*-value is distance.

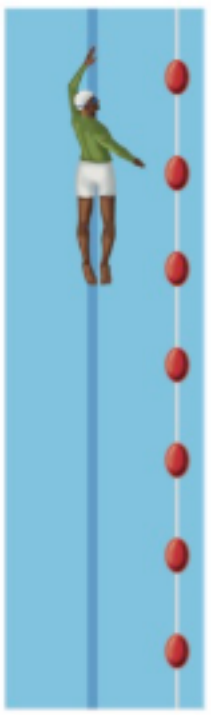
6 The tilt of a line on a graph is called **slope**. You can calculate the slope of a line by dividing the rise by the run. The rise is the vertical difference between any two points on the line. The run is the horizontal difference between the same two points. On a distance-versus-time graph, the rise is distance and the run is time.

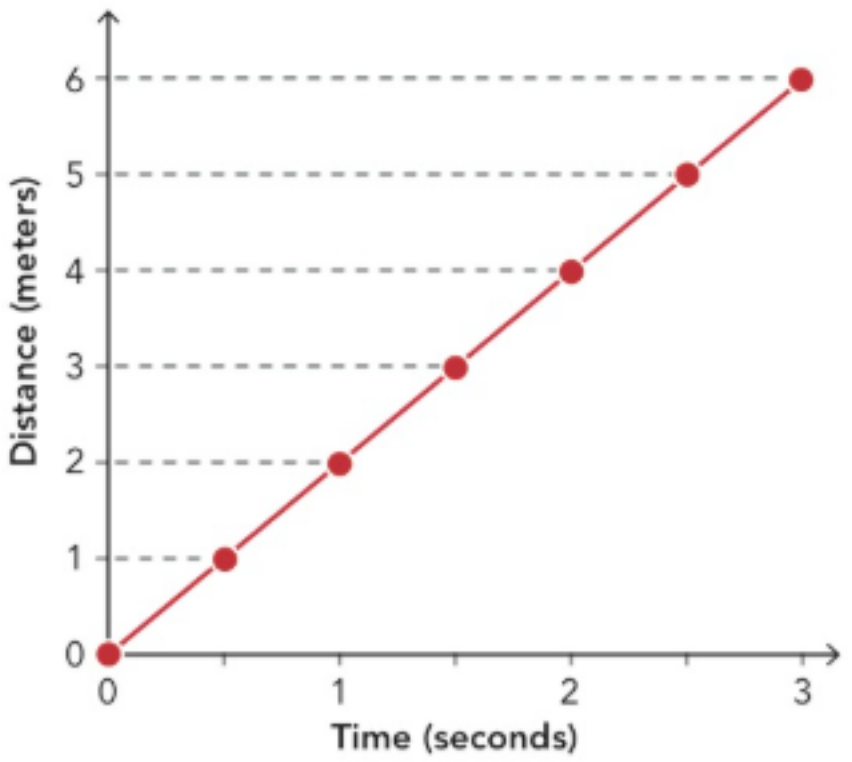
Slope = rise ÷ run = distance ÷ time.

7 Because speed is the rate that distance changes in relation to time, the slope of a distance-versus-time graph represents speed. The steeper the slope is, the greater the speed. For a graph with a constant slope, you can interpret the relationship of distance versus time as a constant speed. A level line represents zero speed.

8 Slope may be positive or negative, so when you make a graph, you want to be sure to define positive and negative distance with reference to your starting point. But whether it is positive or negative, steepness of the slope reflects speed. For an object with a constant speed, you would have only a straight line, and you might not go to the trouble of making a graph. But if the speed of the object varies, a graph is an excellent way to show the changes.

▶ **Slope** The points in the graph below show a rise of 6 meters and a run of 3 seconds. The slope is 2 meters per second.





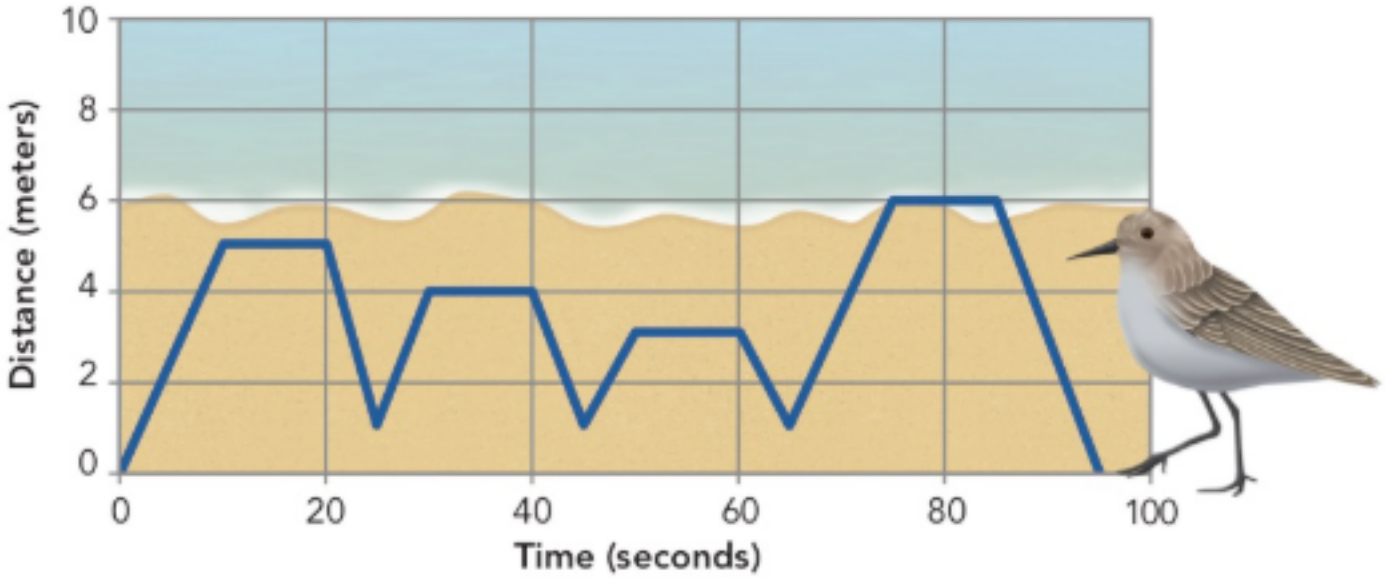
Velocity and Uniform Motion

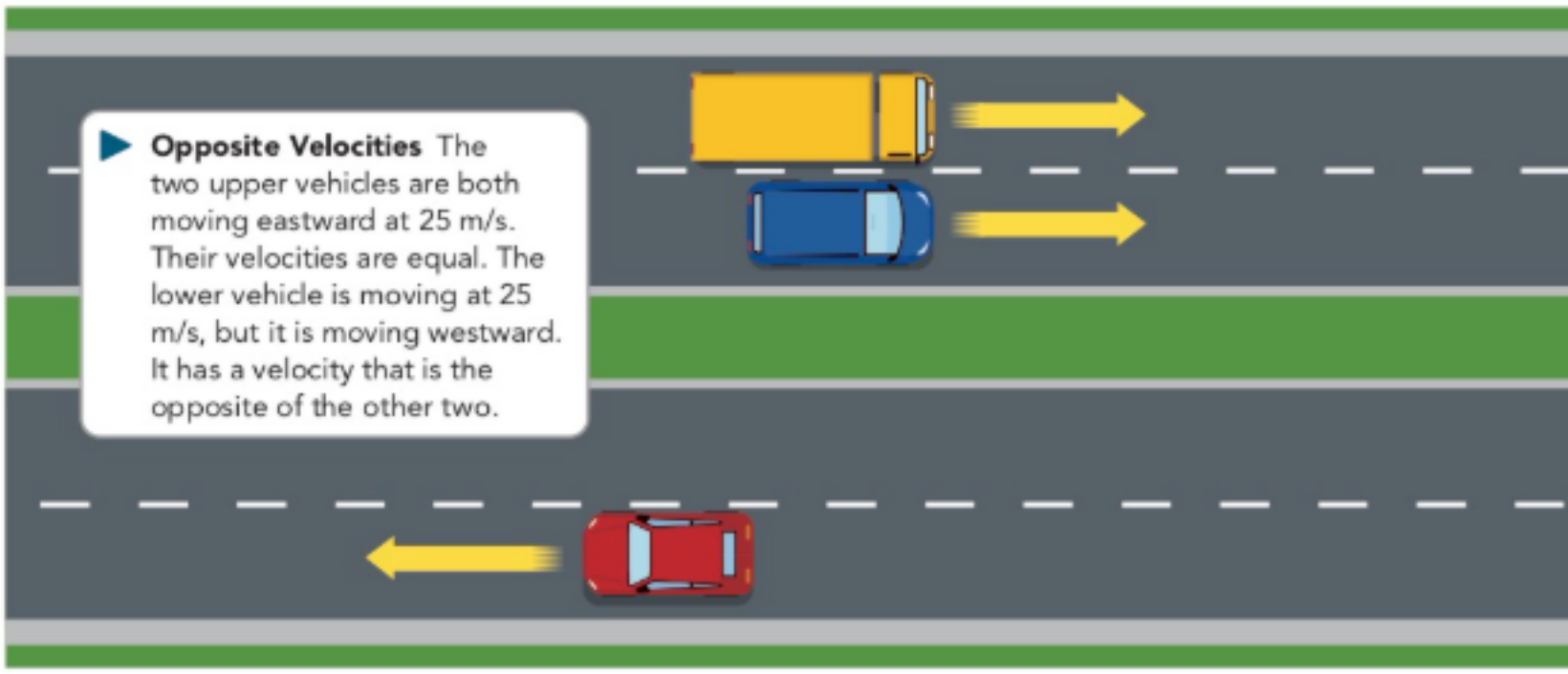
9 Speed tells you how much distance an object travels during a specific amount of time, but it does not tell you anything about direction. When a system contains more than one object in motion, it is important to know both speed and direction in order to determine what will happen. **Velocity** is speed in a specific direction. Two objects may have exactly the same speed, but if they are traveling in opposite directions, they have opposite velocities. One velocity might be described as +7 m/s, and the other as –7 m/s. An object with a velocity that does not change is said to be in uniform motion.

Literacy Support

Explain how knowing velocities of aircraft is important for air-traffic controllers to avoid collisions.

Graphing Nonuniform Motion For complicated motion, the distance-time graph can be irregular. For example, each peak of the graph shows that a sandpiper moves toward the water (positive velocity), stops for a few seconds to feed (zero velocity), and then runs away from the water as a wave comes in (negative velocity).





Opposite Velocities The two upper vehicles are both moving eastward at 25 m/s. Their velocities are equal. The lower vehicle is moving at 25 m/s, but it is moving westward. It has a velocity that is the opposite of the other two.

10 Scientists often study objects with velocities that vary. Suppose you are a passenger in a car stopped at a red light. When the light changes to green, the driver steps on the gas pedal. As a result, the car speeds up, or accelerates. But acceleration can mean more than just speeding up. Scientists define **acceleration** as any change in velocity. When an object accelerates, it increases speed, decreases speed, or changes direction.

11 The term *acceleration* means any change in speed or any change in direction. A dog that starts running to chase a squirrel is accelerating. You accelerate when you start walking faster to get to class on time. When objects slow down, they are also accelerating, or you can say they are decelerating. Even an object that is traveling at a constant speed is accelerating when it changes direction. Earth is accelerating as it moves around the sun in its elliptical orbit.

Speed and Direction Each racer accelerates as she follows the curve in the track or changes lanes to pass another racer.

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Reading Check

Graphing Motion

Answer the following questions after you have completed reading the Read About It.

1. In paragraphs 1 and 2, you learned about motion. Suppose you are riding a bicycle along a street. In relation to a street sign, which of the following is moving?

   A. you

   B. bicycle

   C. both

   D. neither

2. In paragraphs 3 and 4, you learned about speed. The following time and distance measurements are for a person walking: (0 s, 0 m), (1 s,1 m), (3 s, 7 m), and (5 s, 10 m). She starts at zero and walks 1 meter in the first second, 7 meters in the first three seconds, and so on. What is her average speed for the five seconds?

   A. 10 m/s

   B. 3 m/s

   C. 10 m/ 0 s

   D. 2 m/s

3. In paragraphs 5–8, you learned about graphing motion. Suppose a student graphed distance versus time for an object that moves 14 m every 2 s. What is the slope of the line on the graph? Explain.

_____

_____

_____

4. In paragraphs 5–8, you learned about graphing motion. Suppose you have a graph of distance versus time that shows a line connecting the following points: (0 s, 0 m), (1 s, 1 m), (2 s, 3 m), (3 s, 3 m), (4 s, 2 m). Answer the following questions about the graph. It may help to make a sketch of the graph on a piece of paper.

Part A

What is the change in slope between the interval from 1 s to 2s and the interval from 2 s to 3 s? What does that tell you about the speed?

Part B

What is the slope in the interval from 2 s to 3 s? What does that tell you about the speed?

5. You learned about velocity in paragraph 9. Suppose objects A, B, and C are all moving at the same speed. However, A and B are moving apart at 10 m/s, while A and C are not moving at all with respect to each other. Explain what is going on, and give the velocity of each object.

6. In paragraphs 10 and 11, you learned about acceleration. The table shows four stages in a race around an oval track. Fill in the appropriate description of the acceleration at each stage.

Starting Line	Straightaway	Curve	Finish Line

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Extend and Enrich Activities

Graphing Motion

1. **Model** A sparrow flies 48 m in 4 s. Assuming the sparrow flies at a constant speed, complete the table to identify the distance it flies in 1, 2, and 3 seconds.

Time (s)	Distance (m)
1	
2	
3	
4	48

2. **Apply** Construct a distance-time graph for the data in the table. What is the sparrow's speed?

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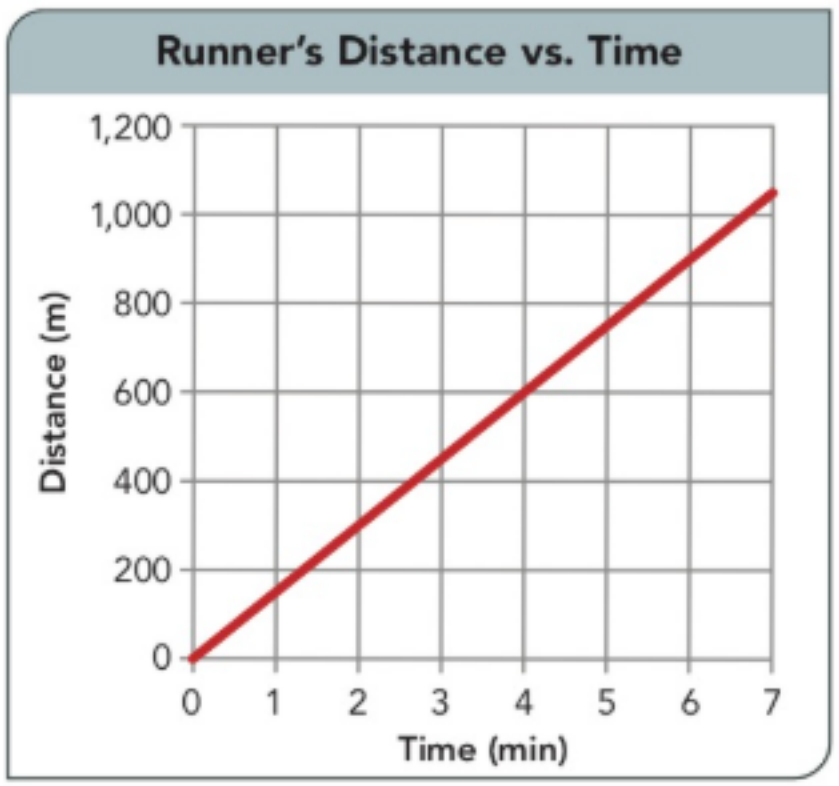
Lesson Review

Graphing Motion

The graph shows the motion of a runner. Use the graph to answer questions 1 and 2.



1. Based on the data in the graph, what is the speed of the runner, to the nearest meter per minute?

   A. 150 m/min

   B. 171 m/min

   C. 1,050 m/min

   D. 8,400 m/min

2. Why is the graph of the data a straight line that slopes upward?

   A. The runner ran in a straight line.

   B. The runner ran up a hill.

   C. The runner ran at a constant speed.

   D. The runner ran faster near the end of the race.

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Phenomenon Activity

Types of Forces

I can...

- describe the different types of forces—both contact forces and forces that act at a distance.
- explain the law of gravity.

Vocabulary

contact force electrical force factor force friction gravity
magnetism noncontact force

Phenomenon What keeps the skater from flying off into space?

Photo Credit: Steve Smith/Digital Vision/Getty Images

Make a Claim Identify and explain the force(s) that keep the skater from flying off into space during a jump.

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Hands-On Lab

Observing Forces

You will…

- conduct an investigation to observe contact forces and other forces.
- use your observations to describe what a force is.
- use real-world applications to describe different forces.

What You Need to Know

When was the last time you opened a door, bounced a ball, or rode your bicycle? You use different kinds of forces every day. But what exactly is a **force**? A force is a push or a pull. In this investigation, you will observe three different kinds of forces: **friction**, **gravity**, and **magnetism**. You will then use your observations to infer what a force is and describe the different forces in the real world.

Materials

- 4 metal washers
- pencil
- ruler or meter stick
- felt
- tape
- sandpaper
- 2 bar magnets

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Wear safety goggles.


Make sure no one gets hit by objects when you drop or slide them.


Be aware that washers may roll when they hit the floor.

Procedure

Part I: Friction

1. In Part I, you will investigate how the texture of a sliding surface affects the distance a washer travels when it is launched. The surfaces you will test are a smooth desktop, sandpaper, and felt.

2. Write a hypothesis predicting how a washer will travel across each of the three surfaces.

3. What is your independent (manipulated) variable? What is your dependent (responding) variable?

4. Tape the sandpaper and felt along the edge of the desk. You should have three different surfaces side by side: the smooth desktop, the sandpaper, and the felt.

5. Place a washer on the smooth desktop so that part of it hangs over the edge. Use a pencil to draw a line across the washer, marking the desk edge. That will allow you to set the washer in the same place for each trial.

6. Then, strike the washer with an open hand so it slides across the desktop. (If the washer flies up or doesn't slide smoothly, try again until it consistently slides smoothly.)

7. Measure the distance (cm) the washer slides across the surface. Record your data in the table.

8. Repeat Steps 6–7 two more times. Be sure to use the line drawn on the washer to position it in the same place on the edge of the desk each time.

9. Next, place the washer on the sandpaper in the same position as you did during Step 5. Repeat Steps 6–8.

10. Finally, place the washer on the felt in the same position as you did during Steps 5 and 9. Repeat Steps 6–8.

11. Determine the average distance measured in the three trials for each surface. Record the averages in the table.

Surface	Distance Washer Slides			Average of Three Trials (cm)
	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	
smooth desktop				
felt				
sandpaper				

Part II: Gravity

1. Push a single washer (Washer A) off your desk. Observe what happens. Record your observations in the table below.
2. Tape three washers together to construct Washer B.
3. Push Washer B off the edge of your desk. Record your observations.
4. Place Washers A and B on the edge of your desk. This time, push both washers over the edge at the same time.
5. Place both washers at the edge of a shelf or other surface that is higher than your desk. Repeat Step 4.
6. Record your observations in the data table.

Object(s)	Observations
Washer A only from height 1	
Washer B only from height 1	
Washers A and B from height 1	
Washers A and B from height 2	

Part III: Magnetism

1. Set a bar magnet at one end of your desk, with the end marked "N" for north pointing toward the desk's center.
2. Place the second magnet on the desk about 30 cm from the first. The end marked "S" for south should be pointing toward the north end of the first magnet.
3. Slide the second magnet slowly toward the first until the first magnet moves. Record your observations in the table.
4. Repeat Steps 1–3, changing the distance to 3 cm.
5. Repeat Steps 1–4, turning the second magnet so the north ends point toward each other.

Magnetic Ends	Starting Distance (cm)	Observations
N–S	30	
N–S	3	
N–N	30	
N–N	3	

Analyze and Interpret Data

1. **Describe** You observed different forces in action. Based on your observations, what do you think a force is?

2. **Cause and Effect** Do all forces require that objects be touching in order to have an effect? Explain your answer.

3. **Describe** Based on your observations in Part I, is the force of friction greater or less on smooth surfaces than on rough surfaces? Use your data to support your answer.

4. **Describe** Based on your observations in Part II, did Washer A have less or more mass than Washer B? Did washer B hit the floor sooner than or at the same time as Washer A? Based on your data, what can you infer about the force of gravity acting on the two washers?

5. **Describe** Based on your observations in Part III, how is magnetic force affected by the distance between the objects? Use your data to support your answer.

6. **Apply Concepts** Complete the table with your lab group by describing each of the forces you observed in this investigation. Then identify one example of each force that you have observed in your daily life.

Force	Description	Example from Daily Life
friction		
gravity		
magnetism		

Types of Forces

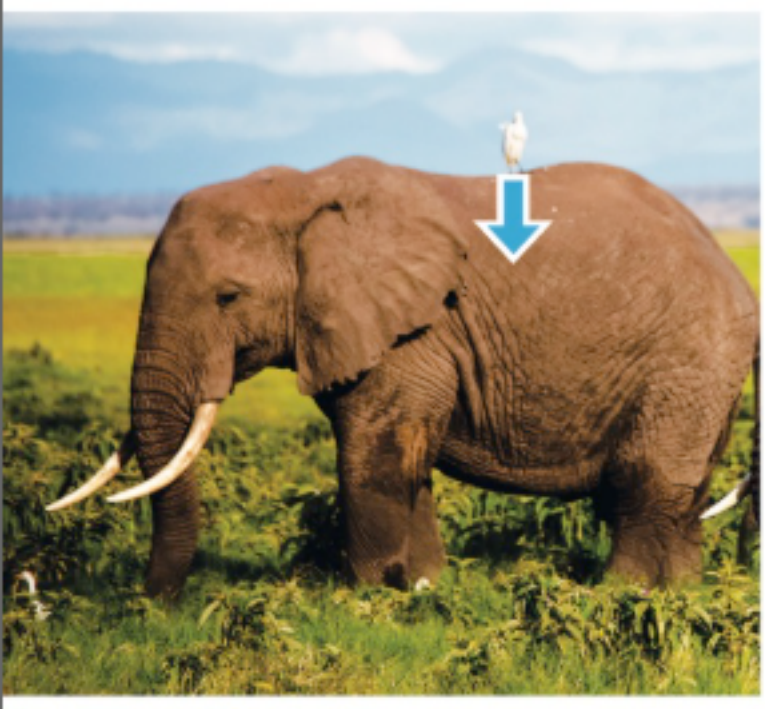
1 Oh, no! You're late for class! You rush down the hallway in such a hurry that you accidentally bump into a teacher, which knocks you back. Finally, you make it to class, sit down in your chair, and pull your book out of your backpack. Whew!

Describing Force

2 Different types of forces made it possible for you to get to class, even if you were late. A **force** is a push or pull. When you push open a door or pull a book out of your backpack, you exert forces on those objects. Forces are characterized in terms of their strength and direction. The force needed to lift a dinner plate is smaller than the force needed to push a refrigerator. Pushing a faucet handle to the left is a different force from pushing it to the right.

3 In a diagram, the direction and strength of a force acting on an object can be represented with an arrow. The arrow points in the direction of the force, as shown in the photos. The length of the arrow indicates the strength of the force—the longer the arrow, the greater is the force. Scientists use the newton (N) as the unit for measuring the strength of a force.

Forces The blue arrow shows a small downward force exerted by a bird perched on an elephant. The red arrow shows a much larger force exerted by a horse pulling a man in a cart.

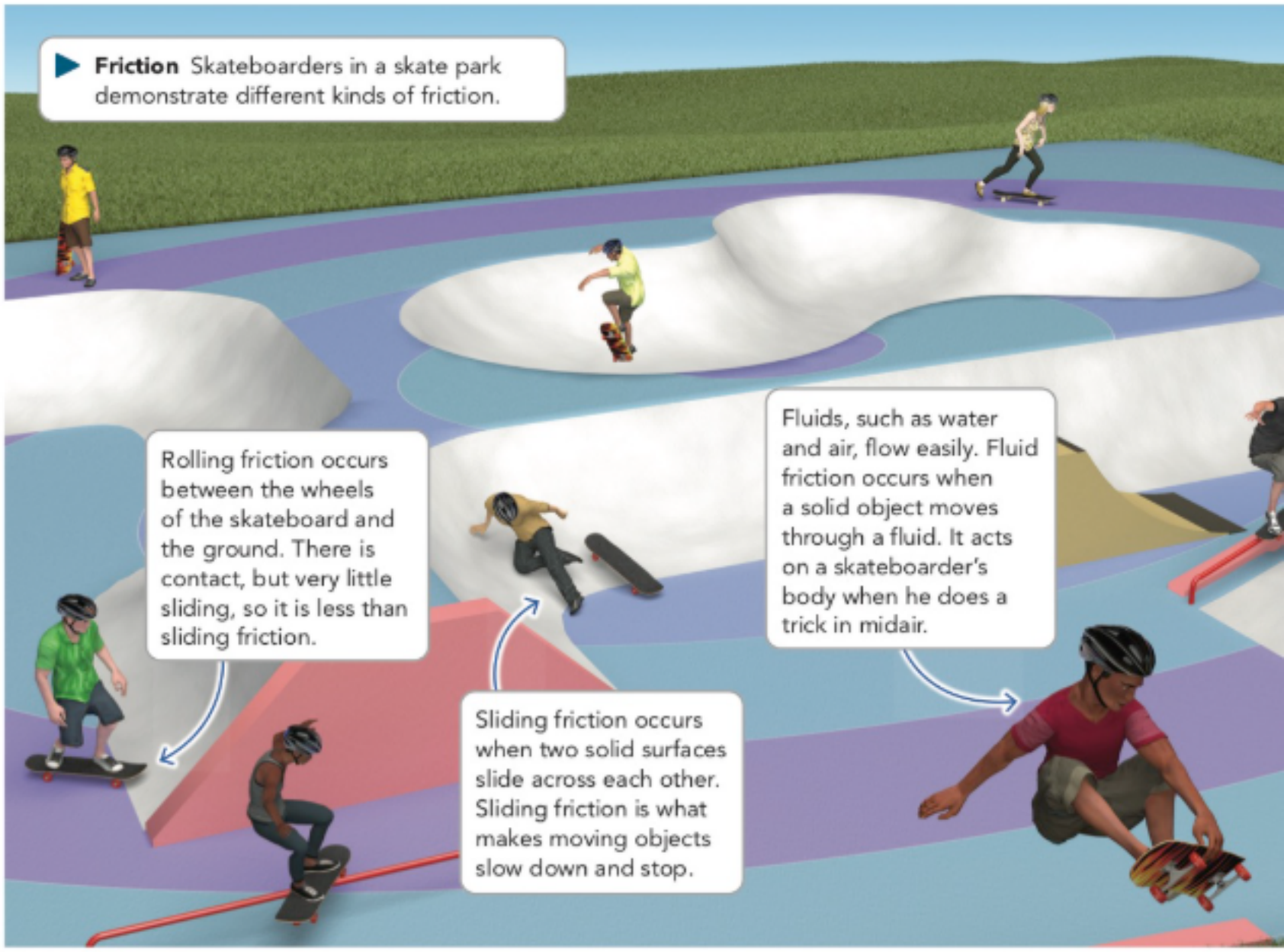


Friction

4 Some forces, known as **contact forces**, act through physical contact. They are exerted when objects are touching each other. Other forces, called **noncontact forces**, are forces that act at a distance and do not require objects to be touching. When you push a box across the floor, your push is a contact force because the force only acts while you touch the box. The box may be difficult to push because there is another contact force acting on the box in the opposite direction. It is the force of friction between the box and the floor.

5 **Friction** is a contact force that two surfaces exert on each other when they rub against each other. Sliding friction, the friction between your shoes and the floor, for example, prevents you from slipping as you rush down a school hallway. A smooth or wet floor reduces friction, which is why you might slip and fall.

6 Friction acts in a direction opposite to the direction of an object's motion. Two other types of friction are rolling friction and fluid friction, as shown in the figure.



Friction Skateboarders in a skate park demonstrate different kinds of friction.

7 Both the types of surfaces involved and how hard the surfaces are pushed together affect the friction between two surfaces. Have you ever examined the surface of a tire? The tread on the tire increases friction between the tire and the ground. In general, smoother surfaces produce less friction than rougher surfaces.

8 Friction increases as surfaces push harder against each other. For a bicycle, friction occurs not just between the tires and the ground, but also between the brake pads and the wheels. The friction slows the wheel turning. The harder the rider applies the brakes, the more quickly the bike will come to a stop.

Increasing Friction This mountain biker applies his brakes and skids to slow down.

Gravity

9 A noncontact force is a force acting between objects whether they are touching or not. One noncontact force that you experience every day is **gravity**—a force that pulls objects toward each other as a result of their masses. The force of gravity pulls your body toward the center of Earth. You are so familiar with objects falling that you may not think much about why they fall. One person who did think about it was Isaac Newton.

10 Newton was not the first who noticed that gravity made objects fall toward Earth. But he was the first who realized that not only any everyday object but even the moon was attracted by Earth's gravity. Newton recognized that Earth's gravity is what keeps the moon in its orbit around Earth, and the sun's gravity is what keeps Earth in its orbit around the sun. Gravity acts everywhere in the universe, not just on Earth. Newton's realization is now called the Law of Gravity, or the law of universal gravitation.

11 The law of universal gravitation states that every object exerts gravitational force on every other object. So, any two objects anywhere in the universe attract each other. In fact, all the objects around you are attracted to you. You can clearly see the gravitational effect of Earth on an object. However, you do not notice the attraction between objects on Earth because those forces are extremely small compared to the attraction between the objects and Earth itself.

Literacy Support

Write an argument that explains why the pencil and notebook resting on your desk are not being pulled together by the force of gravity between them.

Earth's Pull Gravity is the force that keeps objects in place on Earth.

The force of gravity exerted on the pan keeps it from floating away, which would make cooking very difficult!

Factors That Affect Gravity

12 What **factors** control the strength of the gravitational force between two objects? The force depends on how much mass the objects have and how far apart they are. The more mass an object has, the greater is the gravitational force between it and other objects. Earth's gravitational force on nearby objects is strong because the mass of Earth is so large.

13 Gravitational force also depends on the distance between the objects' centers. As distance increases, gravitational force decreases. What happens when you drop a pencil? You see your pencil fall to Earth because Earth and your pencil are close together. If your pencil were on the moon, Earth would not exert a noticeable gravitational attraction to it because Earth and the pencil would be so far apart. The pencil would be much closer to the moon, and if it fell, it would fall toward the center of the moon.

Vocabulary Support

A *factor* is something that influences or contributes to a result or outcome. As you read, consider which factors affect different kinds of forces.

Factors Affecting Gravity Gravitational force depends on the masses of objects and the distance between them.

All objects with mass exert a gravitational force on other objects.

Gravitational force increases as the masses of the objects increase.

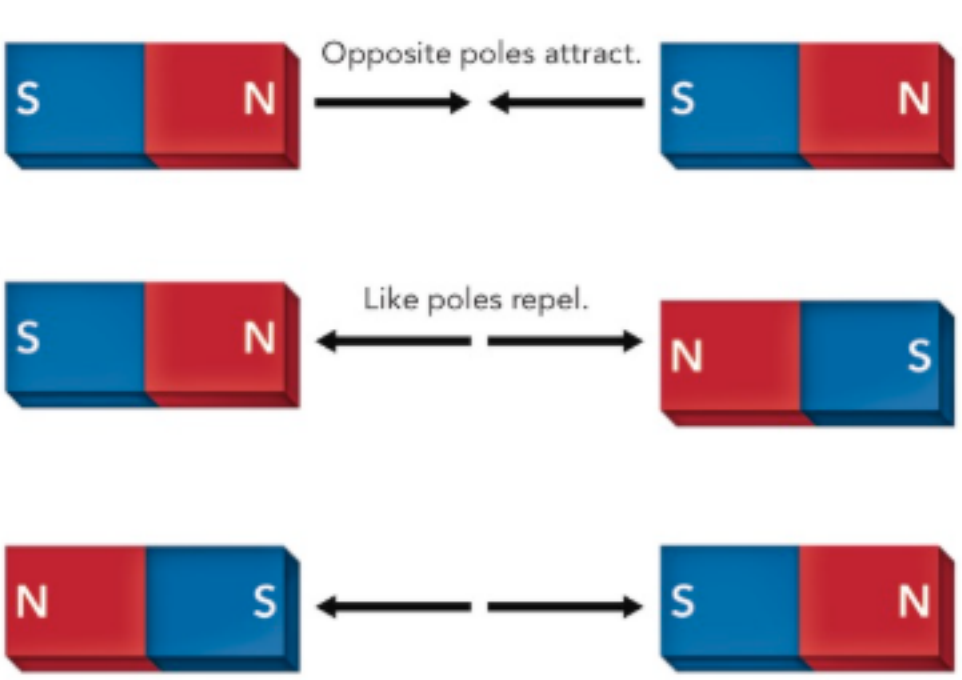
Gravitational force decreases as the distance between the objects increases.

Magnetic and Electrical Forces

14 Two other types of forces that act at a distance are the forces exerted by magnets and the forces exerted by electric charges. A magnet is a material that attracts iron and materials that contain iron. A magnet can also attract (pull) or repel (push) another magnet. **Magnetism** is the attractive or repulsive force exerted by magnetic materials. Like gravity, magnetism is a noncontact force, so it does not require objects to be touching. Unlike gravity, it can be a repelling force as well as an attracting force.

15 The strength of a magnetic force depends on the strength of the two magnets, and, like gravity, it also depends on distance. A stronger magnet exerts a greater magnetic force, but magnetic force decreases as the distance between the magnetic materials increases.

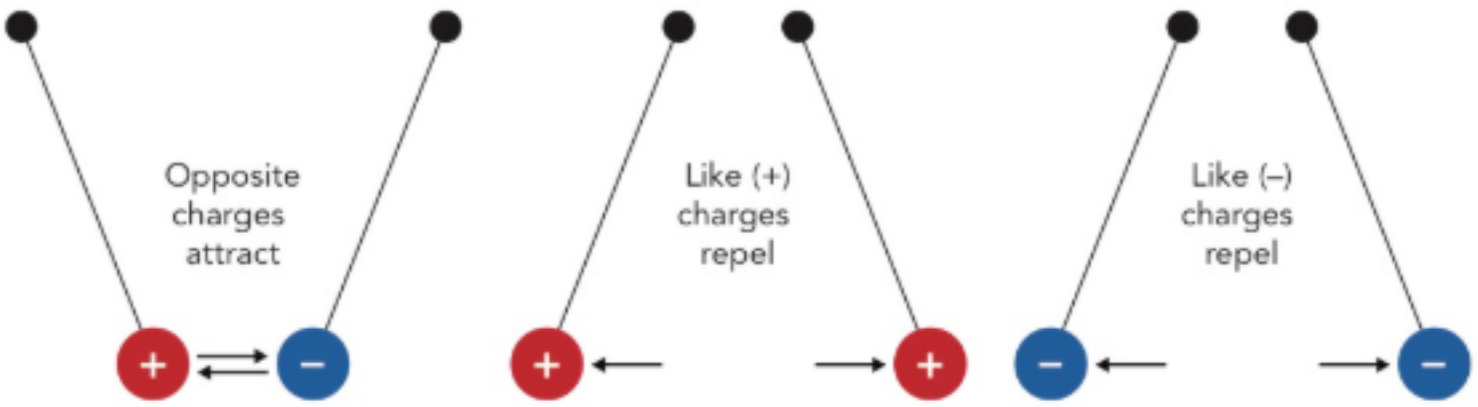
▶ **Magnetic Force** Any magnet has two ends, called poles. One pole is labeled the north pole, and the other is labeled the south pole. A magnet exerts the strongest force at its poles.



16 The **electrical force** is the attraction or repulsion between electric charges. If you have found your hair misbehaves when you brush it on a dry day, you have experienced the electrical force. Brushing your hair transfers electrons from the brush to your hair, so your hair and the brush gain opposite charges. As with magnetic poles, opposite electric charges attract each other, and like charges repel each other. Since each hair on your head has a negative charge, it repels the other charged hairs, and you have trouble getting your hair to stay in place.

17 As is the case with magnetism, the strength of the electrical force depends on the strength of the charges, and it also depends on distance. The electrical force decreases as the distance between charged materials increases.

Electrical Force Charged objects exert forces on each other. They either attract or repel.



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Reading Check

Types of Forces

Answer the following questions after you have completed reading the Read About It.

1. You read about forces in paragraphs 2 and 3. Forces are described in terms of which **two** of the following characteristics?

   A. strength

   B. position

   C. direction

   D. velocity

2. In paragraph 4, you learned about contact forces and noncontact forces. What is the difference between those two?

   _____

   _____

   _____

3. You learned about friction in paragraphs 5–8. Automobile engines have bearings in which a shaft spins inside a metal collar. Friction in the bearings is reduced by pumping oil through the bearings. How does that work?

   A. Sliding friction is replaced with rolling friction.

   B. Sliding friction is replaced with fluid friction.

   C. Rolling friction is replaced with sliding friction.

   D. Rolling friction is replaced with fluid friction.

4. You learned about friction in paragraphs 5–8. One way to transmit energy is with a drive belt looped around two metal pulleys. If the belt is too loose, it will slip and lose energy. Which would be the best way to reduce energy loss?

   A. Loosen the belt to reduce friction.

   B. Loosen the belt to increase friction.

   C. Tighten the belt to reduce friction.

   D. Tighten the belt to increase friction.

5. In paragraphs 9–17, you learned about noncontact forces. What are three examples of noncontact forces?

_____

_____

6. In paragraphs 9–13 and the diagram, you learned about gravity. Earth is attracted by the gravity of which of the following objects? Select all answers that apply.

   A. objects resting on Earth's surface

   B. objects in orbit around Earth

   C. the moon

   D. the sun

7. In paragraphs 9–13, you learned about gravity. Gravity on the surface of the moon is weaker than gravity on the surface of Earth. What property of the moon accounts for the difference?

_____

_____

_____

8. In paragraphs 14–17, you learned about magnetic and electrical forces. Both of those forces can be either attractive or repulsive. Fill in the table with the correct pairing of poles or charges to produce each sort of for force.

Magnetic Attraction	Magnetic Repulsion	Electrical Attraction	Electrical Repulsion

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Types of Forces

1. **Model** Use the graphic organizer to identify the different types of forces based on whether they require objects to be in direct contact.

Contact Forces	Noncontact Forces

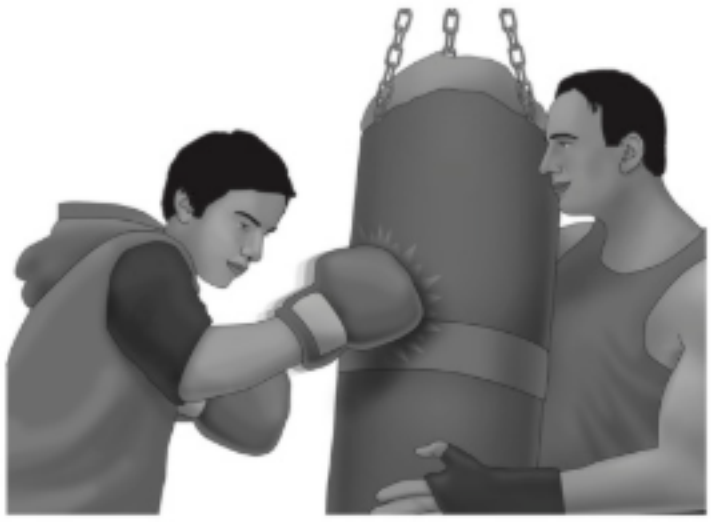
2. **Apply** Think about the force of gravity and the factors that affect its strength. If the sun is so much more massive than Earth, then why does the moon orbit Earth and not the sun?

NAME _____ CLASS _____ DATE _____

Lesson Review

Types of Forces

At boxing practice, Ian works with his coach to improve the strength of his punch. Use the picture to answer questions 1 and 2.



1. Which of the following is a contact force experienced by the punching bag?

   A. electrical

   B. frictional

   C. gravitational

   D. magnetic

2. Ian says the reason the bag is heavy is due to the force of gravity that he exerts on it. Is he correct?

   A. Yes, Ian is correct.

   B. No, it is heavy due to the gravitational force that Ian's coach exerts on it.

   C. No, it is heavy due the gravitational force that the bag exerts on Ian.

   D. No, it is heavy due to the gravitational force that Earth exerts on it.

3. Which of the following statements about friction is **not** correct?

   A. Friction depends on how hard surfaces are pressed together.

   B. Friction does not require objects to be in direct contact.

   C. Friction depends on the materials that make up the surfaces.

   D. Friction acts in a direction opposite to the direction of the object's motion.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Unbalanced Forces and Motion

I can…

- describe the effects of unbalanced forces on the motion of objects.

Vocabulary

balanced forces inertia magnitude unbalanced forces

Phenomenon Why does the curling stone keep moving for so long?

Photo Credit: Aleksandra Suzi/Shutterstock

Make a Claim Identify the forces acting on the curling stone. Explain why the motion of the stone remains unchanged for so long and why it eventually comes to a stop.

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Hands-On Lab

Net Force and Motion

You will…

- investigate balanced and unbalanced forces.
- describe the changes in motion that result from those forces.
- calculate the net force acting on an object.

What You Need to Know

An object's motion is determined by the combination of all the forces acting on it, also known as net force. A book lying still on your desk has forces acting on it, even though it is not in motion. When you lift the book off your desk, you also exert a force on it. The book's motion depends on whether the forces acting on it are **balanced** or **unbalanced**. In this activity, you will explore how different forces affect an object's motion.

Materials

- block of wood with hooks on each end and with midline marked on it
- standard spring scale
- push/pull spring scale
- paper
- tape

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Wear safety goggles.


Make sure no one gets hit by objects when you push or pull them.


Be aware that the wood block may move unexpectedly.

Procedure

Part I

1. Draw a line down the center of the paper. Then tape the paper to the center of the table.
2. Place the block so that the midline of the block aligns with the line on the paper.
3. Place a spring scale at each end of the block so that it hooks onto the block.
4. While one student holds the block still on the line, have two other students pick up the spring scales on either side of the block.
5. The student holding the block counts to 3. At 3, each student holding the scales on either end of the block pulls the block using a force of 5 N. Each student should keep the force steady at 5 N.
6. The student holding the block lets go of the block. Observe the motion of the block and record your observations.

Part II

1. Set up the block and spring scales as you did for Part I, with a spring scale attached to each side of the block.
2. While one student holds the block still on the line, have two other students pick up the spring scales on either end of the block.
3. The student holding the block counts to 3. At 3, each student pulls the block. This time, the student on the left pulls with a using a force of 5 N, and the student on the right pulls with a force of 10 N.
4. The student holding the block lets go of the block. Observe the motion of the block and record your observations.

Part III

1. Set up the block and spring scales as you did for Parts I and II, but replace the spring scale on the left side with a push/pull spring scale.
2. While one student holds the block still on the line, have two other students pick up the scales on either end of the block.
3. The student holding the block counts to 3. At 3, the student on the left with the push/pull scale pushes with a force of 5 N. The student on the right with the standard spring scale pulls with a force of 5 N.
4. The student holding the block lets go of the block. Observe the motion of the block and record your observations.

Observations

Part	Description of Forces	Observations of Block Motion
Part I		
Part II		
Part III		

Analyze and Interpret Data

1. **Describe** In Part I, would you say the forces on the block were balanced or unbalanced? Why?

2. **Describe** In Part II, would you say the forces on the block were balanced or unbalanced? Why?

3. **Describe** In Part III, would you say the forces on the block were balanced or unbalanced? Why?

4. **Patterns** What kinds of forces result in an object changing its motion? What kinds of forces result in no change to an object's motion?

5. **Calculate** When forces are applied to an object in the same direction, the strengths of the forces are added together to find the net force. When forces are applied in opposite directions, the strengths of the forces are subtracted to find the net force. Calculate the net force on the block for each part of the investigation.

Part	Net Force Calculation
Part I	
Part II	
Part III	

6. **Patterns** What is the net force on the block when the forces are balanced? What is the net force on the block when the forces are unbalanced?

7. **Apply Concepts** Based on your observations, what generalization can you make about the net force on an object and its effect on an object's motion?

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Effects of Net Force

You will…

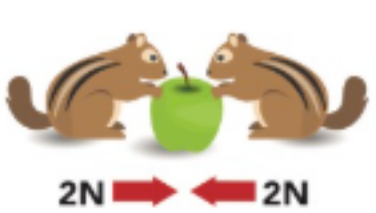
- analyze data about the forces acting on an object to determine its motion.

What You Need to Know

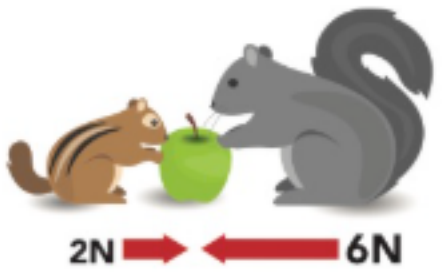
The net force on an object is the combination of all the forces acting on that object. Net force is the sum of the forces when they are acting in the same direction. When the forces act in the opposite direction, the net force is the difference of the forces.

In each diagram, two animals push on an apple. In each scenario, the forces of gravity and friction acting on the apple do not change. The forces that may cause a change come from the animals.

A. Two chipmunks push on the apple in opposite directions with forces of equal strength.



B. A chipmunk and a squirrel push on the apple in opposite directions with forces of different strengths.



C. A chipmunk and a squirrel push on the apple in the same direction with forces of different strengths.

Analyze and Interpret Data

1. **Calculate** For each scenario, determine the net force acting on the apple.

A: _____

B: _____

C: _____

2. **Analyze Data** For each scenario, identify whether the apple will move. If the apple will move, identify the direction in which it will move.

Scenario	Will apple move? (yes or no)	Direction of motion (left or right)
A		
B		
C		

3. **Patterns** Based on your answers to the previous questions, what do you think is the relationship between net force and the motion of an object?

Unbalanced Forces and Motion

1 Forces govern the motions of objects, from specks of dust floating in the air to faraway galaxies colliding in space. You deal with forces every day, without even thinking about them.

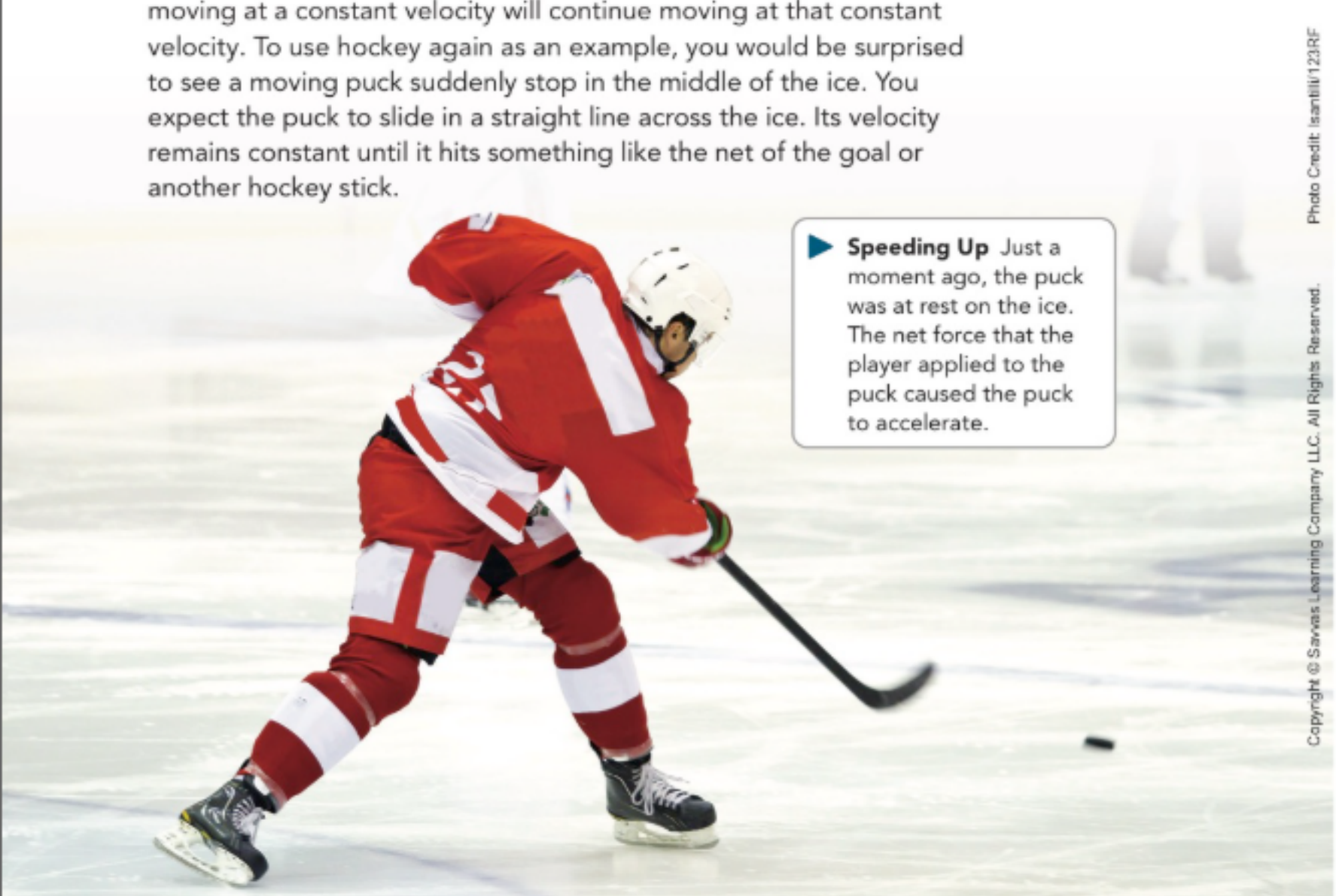
Vocabulary Support

Magnitude means size, or importance. In science, specific scales assign numbers to earthquakes and stars of different magnitudes.

Force

2 If you were watching a game of ice hockey, you would be surprised to see a puck that was sitting still suddenly start moving without being hit. Your surprise would be the result of knowing that the motion of objects can only be changed by forces. Therefore, a hockey puck that is sitting still will remain at rest unless a player hits it, applying a force.

3 A force is a push or a pull, characterized by its **magnitude** and direction. A force is required to put an object in motion, but putting an object in motion is not all that a force can do. It can also change the motion of an object already moving. In fact, changing the motion (and the energy) of an object can only be understood in terms of forces—pushes or pulls. When no force acts, an object moving at a constant velocity will continue moving at that constant velocity. To use hockey again as an example, you would be surprised to see a moving puck suddenly stop in the middle of the ice. You expect the puck to slide in a straight line across the ice. Its velocity remains constant until it hits something like the net of the goal or another hockey stick.



Speeding Up Just a moment ago, the puck was at rest on the ice. The net force that the player applied to the puck caused the puck to accelerate.

Inertia

4 The tendency of an object to remain in motion or to remain stationary is **inertia**. You can also say that inertia is resistance to any change in velocity. The law of inertia states that a body at rest will stay at rest, and a body in motion will stay in uniform motion, unless a net force acts on it. It takes energy to change the motion of objects.

5 One measure of the inertia of an object is its mass. Big, heavy objects have a great deal of inertia. Think of moving a piano across a room, and you will have a good idea of inertia. Once you get the piano moving, it will soon roll to a stop, and you might think that inertia is the reason. In fact, the force of friction with the floor is what brings the piano to a stop. A force is needed to stop the piano, because inertia alone would keep it moving.

6 If you need a large force to put an object in motion, you may also need a large force to change an object's motion. Think about the piano again. If you and some friends pushed hard and started the piano moving quickly across the room, it would have a great deal of inertia. The faster it moved, the more inertia it would have. It would tend to keep moving, and you would need a large amount of force to change its velocity. Changing its velocity means changing its speed or changing its direction, or both. You would want to be very sure you could apply enough force to steer the piano or to stop it.

Literacy Support

As you read, take note of information you can use to define the law of inertia.

A Show of Force Getting a large object in motion means overcoming friction as well as inertia.

Safe! The runner moving at high speed into second base has a large amount of inertia. She must push hard against the ground and the base itself to overcome that inertia.

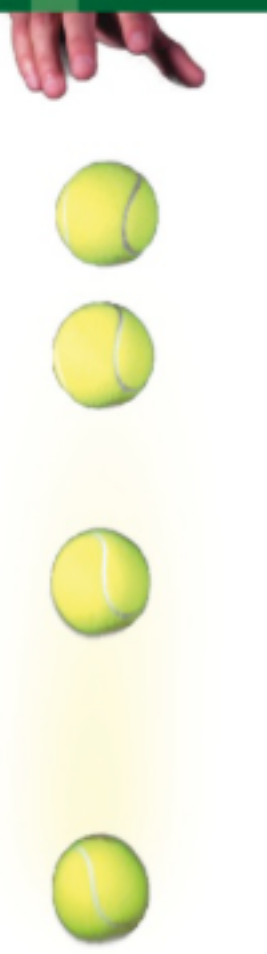
Balanced and Unbalanced Forces

7 Suppose you are holding a tennis ball in your hand. If you drop it, the ball quickly falls to the floor. In order for the ball to start moving, a force must act, and that force is gravity. The force of gravity is an example of an **unbalanced force**, or a net force, which means it is a force on an object that is not canceled by other forces. An unbalanced force is needed to change the motion of an object.

8 Instead of dropping the ball, suppose you just hold the ball in place. The ball is pulled toward the center of Earth with a force of some number of newtons. To prevent the ball from dropping, your hand applies a force on the ball with the same number of newtons in the opposite direction—a balancing force.

9 Forces of equal magnitude but in opposite directions acting on the same object are called **balanced forces**. The ball and every other object on Earth are constantly pulled down by gravity. If an object is not moving, there must be another force balancing gravity's steady pull. When you stand still, the ground supports you with an upward force that balances gravity.

10 Balanced forces acting on stationary objects are all around you. You can also find moving bodies with balanced forces acting on them. When you walk or bicycle at a steady speed, you apply a steady force to overcome friction. You know it takes effort to keep moving, but you may never have thought of it as balancing.



Force Unbalanced
When you release the ball, gravity takes control and gives the ball a downward velocity.

Forces in Balance
The boy's weight is a downward force that is balanced by an upward force from the ground. The water and smooth material of the slide reduce friction enough to let the moving boy slide across the surface for a few moments.

NAME _____ CLASS _____ DATE _____

Reading Check

Unbalanced Forces and Motion

Answer the following questions after you have completed reading the Read About It.

1. You read in paragraphs 2 and 3 that changing an object's motion requires force. In the game of curling, one player slides a heavy stone about 45 meters across ice. To lengthen its slide, other players sweep the ice ahead of the stone. How does the sweeping affect the movement of the stone?

   A. The sweeping increases friction to increase the speed of the stone.

   B. The sweeping decreases friction to increase the speed of the stone.

   C. The sweeping increases friction to decrease the stone's rate of deceleration.

   D. The sweeping decreases friction to decrease the stone's rate of deceleration.

2. As you read in paragraphs 4–5, inertia is resistance to change in motion. Suppose a bowling ball is sitting in the bed of a pickup truck. When the truck starts quickly, the ball rolls backward and hits the tailgate. Explain what happens in terms of inertia.

3. You read in paragraphs 5–6 that inertia is a property of moving bodies as well as stationary bodies. Which **two** characteristics of a body affect its inertia?

   A. mass

   B. volume

   C. speed

   D. density

4. As you read in paragraphs 7–10, forces can be balanced or unbalanced. The top row in the table below contains descriptions of four objects. In the middle row, write either "balanced" or "unbalanced" to correctly describe the forces acting on each object.

5. As you read in paragraphs 7–10, forces can be balanced or unbalanced. In the bottom row of the table below, enter the balanced forces or the unbalanced force to correctly describe the forces on each object.

Moon in orbit around Earth	Bird on branch	Coin dropped to the floor	Nail picked up by magnet

6. As you read in paragraphs 7–10, forces can be balanced or unbalanced. Suppose a skydiver takes a jump from a plane.

Part A

What forces are acting when she first jumps? Are they balanced?

Part B

After a few seconds, the skydiver reaches a maximum speed and then goes no faster. What forces are acting? Are they balanced?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Unbalanced Forces and Motion

1. **Model** Use the graphic organizer to describe how forces affect an object's motion. For each description, identify whether balanced or unbalanced forces are responsible.

Change in Speed	No Change in Speed

Change in Direction	No Change in Direction

2. **Apply** While studying for a test, you knock over a glass of water sitting on your desk. Draw a two-panel comic strip to illustrate the scenario. Include labels and captions in your comic to identify when the forces acting on the glass of water are balanced, when they are unbalanced, and how they affect the motion of the glass.

NAME _____ CLASS _____ DATE _____

Lesson Review

Unbalanced Forces and Motion

Choose the best answer to each question.

1. You push on a filing cabinet on wheels with a force of 125 N to the right. A friend pushes on the same filing cabinet with a force of 97 N to the left. What is the net force on the filing cabinet? In what direction will it move?

   A. The net force is 28 N to the right, so it will move to the right.

   B. The net force is 0 N, so it will not move.

   C. The net force is 28 N to the left, so it will move to the left.

   D. The net force is 222 N to the right, so it will move to the right.

2. Tomás and his younger sister Gwen are finishing work on a wood sculpture. A friend is helping them attach the sculpture to its base. Tomás and Gwen stand on either side of the sculpture and push on it. They hold it still until their friend finishes attaching the base. Which statement about the forces in this situation is correct?

   A. The forces exerted by Tomás and Gwen are balanced because the sculpture will fall over without a base.

   B. The forces exerted by Tomás and Gwen are balanced because the sculpture remains still.

   C. The forces exerted by Tomás and Gwen are unbalanced because the siblings are not the same age.

   D. The forces exerted by Tomás and Gwen are unbalanced because the sculpture cannot stand on its own.

3. Four friends push on the front, back, and sides of a shopping cart. The friends in the front and on the two sides push with a force of 60 N. The friend in back pushes with a force of 50 N. Which statement about the cart's motion is correct?

   A. The shopping cart will not move.

   B. The shopping cart will move backward.

   C. The shopping cart will move forward.

   D. The shopping cart will tip over on its side.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Scientific Theory of Cells

I can...

- explain the components of the scientific theory of cells.

Vocabulary

cell organism structure

Phenomenon If something grows, then is it alive?

Make a Claim In some caverns in Florida, you can observe structures growing from the cavern roof, called stalactites. Explain why these structures are not considered living things even though they grow larger.

Photo Credit: Iinak/Shutterstock

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Observing Cells

You will…

- distinguish between living and nonliving things based on the presence or absence of cells.
- provide evidence that all living things are made up of cells.

What You Need to Know

You and your classmates are invited to visit a special microscopy lab at the local museum of natural history. Your job is to help the museum design an interactive exhibit to help people distinguish between living and non-living things at the microscopic level. Before you help design the exhibit, you must first determine ways to identify the differences between living and non-living things. You will use a microscope to observe and sketch characteristics present in living things. With this information, you will help design an interactive exhibit that will help visitors distinguish between living and non-living things.

Materials

- prepared paramecium slide
- prepared nylon fibers slide
- prepared human skin slide
- prepared bacteria slide
- prepared onion root tip slide
- prepared salt slide
- microscope

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Procedure

1. Start at the designated microscope station indicated by your teacher. You will rotate with your partner among six stations.
2. **Conduct an Investigation** Record your observations and discuss them with your partner. Fill in the table. Then make sketches of your observations from stations 1, 3, and 6.

Observations

Station	Unicellular, Multicellular, or No Cells	Tissue or No Tissue	Living or Non-Living
1: Paramecium			
2: Nylon Fibers			
3: Onion Root			
4: Bacteria			
5: Human Skin			
6: Salt			

Analyze and Interpret Data

1. **Synthesize Information** Based on your observations, what characteristics distinguish living things from non-living things under the microscope? Support your statement using what you know about the scientific theory of cells. Give an example of a living and non-living specimen you examined.

2. **Support Your Explanation** Tissues are made up of groups of cells that work together to perform a specific function. Compare your sketches, and determine which one represents a tissue. Use what you know about cell theory to explain your answer.

3. **Design an Investigation** How would you build an interactive exhibit to help visitors determine the difference between living and non-living things?

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

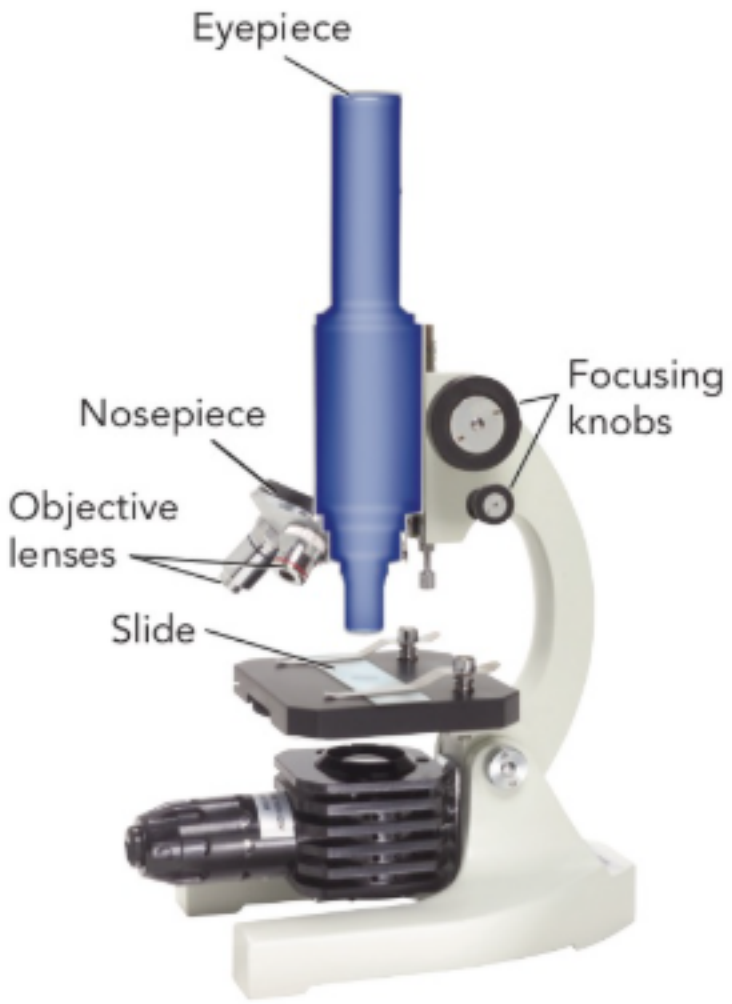
Getting the Right Magnification

You will…

- explore how a microscope magnifies the image of a specimen.
- understand how cell theory could not have been developed without microscopes.

What You Need to Know

When you examine a specimen under a microscope, the total magnification of the image equals the magnifications of the microscope's two lenses multiplied together. If the objective lens magnifies the object 10 times, and the eyepiece lens also magnifies the object 10 times, then the total magnification of the microscope is 10 × 10, or 100 times (expressed as "100X"). The image you see will be 100 times larger than the actual specimen.



This compound light microscope has a 10X lens in the eyepiece. The revolving nosepiece holds three objective lenses: 4X, 10X, and 40X.

Analyze and Interpret Data

1. **Write an Expression** Calculate the total magnification of a microscope with eyepiece lens 10X and objective lens 4X. Then complete the table.

Objective Lens	Total Magnification
4X	
10X	
40X	

2. **Explain** Which magnification would you select in the revolving nosepiece to look at a sample of pond water? Write an expression to show the total magnification of the microscope.

3. **Evaluate Scale** Suppose you used this microscope to view a sample of human hair that is 0.1 mm across, and the hair appears to be 4mm across in the image. Which objective lens did you select from the revolving nosepiece? What was the total magnification of the microscope? Use math to check your answer.

4. **Cause and Effect** How did the microscope contribute to the development of cell theory?

Scientific Theory of Cells

1 What do a whale, a rose, bacteria, a ladybug, and you have in common? You are all living things.

Cells

2 All living things share certain characteristics. For example, all living things are made of cells. A **cell** is the basic unit of all the structures and functions of living things. Cells form the parts of a living thing, or **organism**, and carry out its functions. The smallest organisms, such as the bacteria in the photo, have only one cell, while the largest organisms may have trillions of cells. All cells come from existing cells.

3 The **structure** of an object can refer to what it is made of and how its parts are put together. The structure of a living thing is determined by the amazing variety of ways its cells are put together.

4 A single cell has the same needs as an entire organism. For a cell to stay alive, it must perform biological functions. Those functions include obtaining energy, bringing in nutrients and water, and getting rid of wastes. Most organisms have bodies with many different cells that work together to help the organism to stay alive, grow, and reproduce. For example, cells in your circulatory system move blood around your body. This blood provides you with fresh oxygen and removes the waste product carbon dioxide. Cells in your heart pump blood to every part of you. Your body's cells work together to keep you alive.

Vocabulary Support

The noun *structure* can mean different things in biology. When we talk about a structure *in* a cell, we mean a part *of* the cell. When we talk about the structure *of* a cell, we mean the way it is put together.

Cells Are Everywhere If you were to swab your tongue, this is what you might see under the microscope. These cells are all bacteria with different shapes, sizes, and functions.

Development of Cell Theory

5 Scientists discovered living organisms are made of cells in the 1600s. The invention of the microscope, an instrument that makes small objects look larger, made this discovery possible. Use of the microscope led to new knowledge of how life is organized. As microscope technology improved, scientists were able to discover new information about cells and how they function. Scientists put these discoveries together to develop a theory about cells.

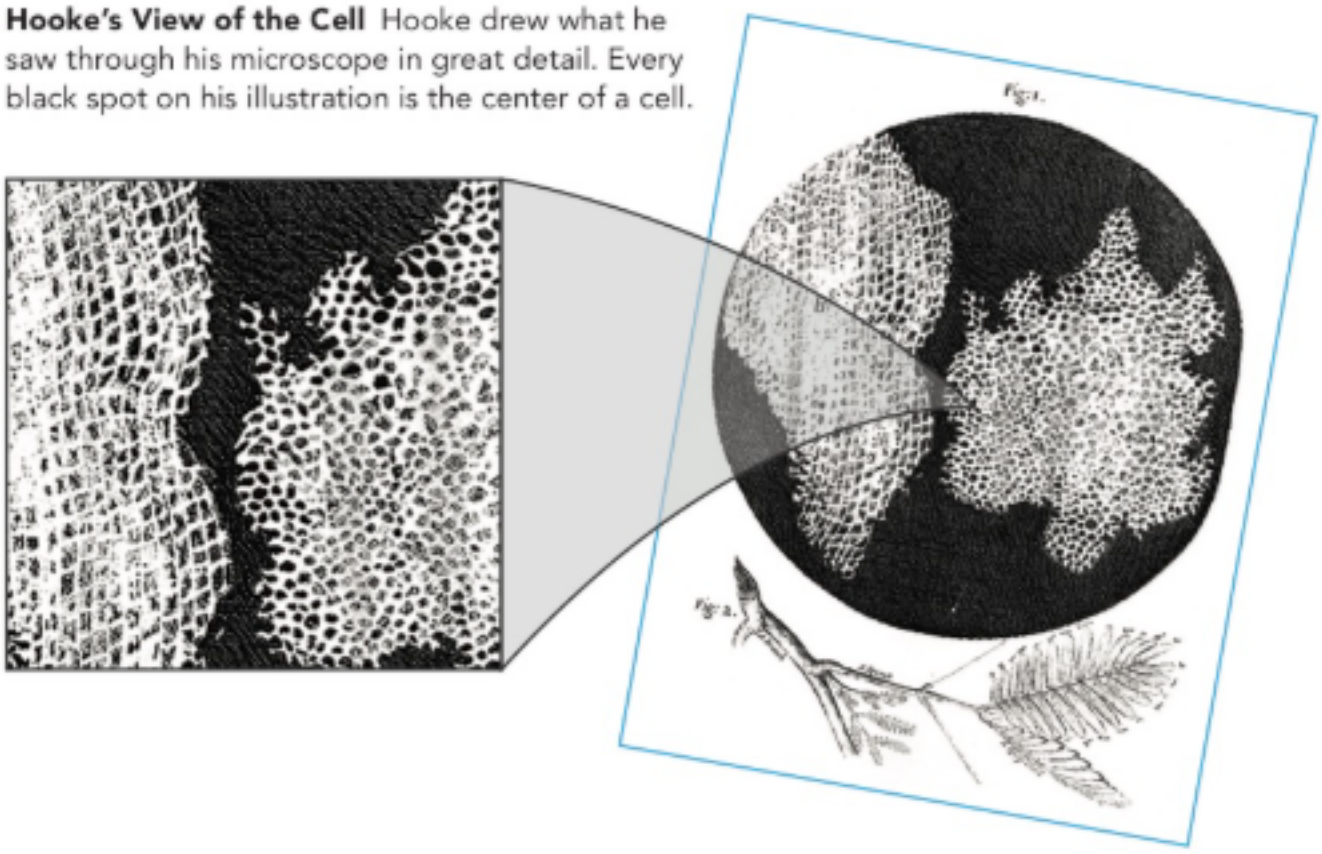
Literacy Support

How did early scientists learn about cells without performing experiments?

6 In the mid-1600s, English scientist Robert Hooke built his own microscopes to learn about nature. He made drawings of what he saw when he looked at the bark of cork oak trees (see below). Hooke thought that the empty spaces he observed in the tree bark looked like tiny rooms, so he named them "cells." Tree bark, however, contains only dead cells.

7 Continuous improvements to the microscope furthered the study of cells. Each scientist proposed a hypothesis (plural: hypotheses), a possible answer to a scientific question. Their hypotheses, supported through the observations and experiments of other scientists, led to a theory about cells and all living things. A scientific theory, such as cell theory, is a well-supported and widely accepted explanation of nature and is not simply a claim stated by an individual. Terms that describe examples of scientific knowledge, such as *hypothesis* and *theory*, have very specific meanings and functions in science.

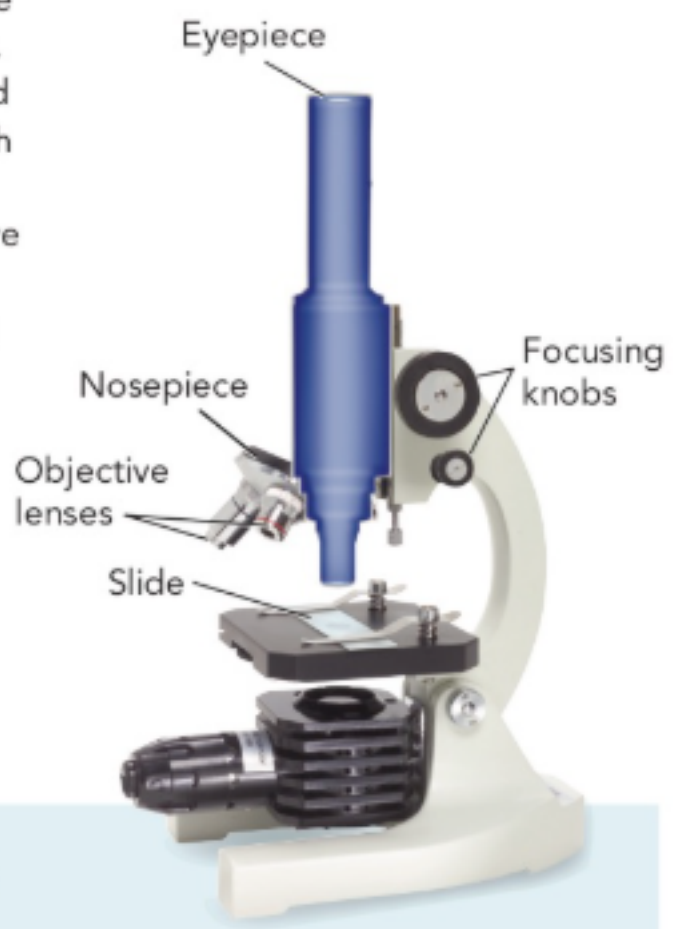
Hooke's View of the Cell Hooke drew what he saw through his microscope in great detail. Every black spot on his illustration is the center of a cell.



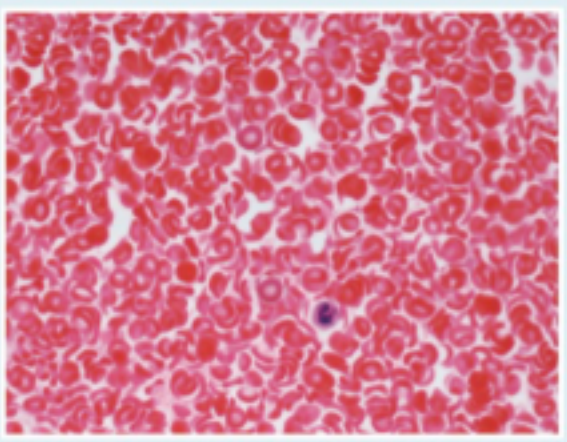
Microscopes

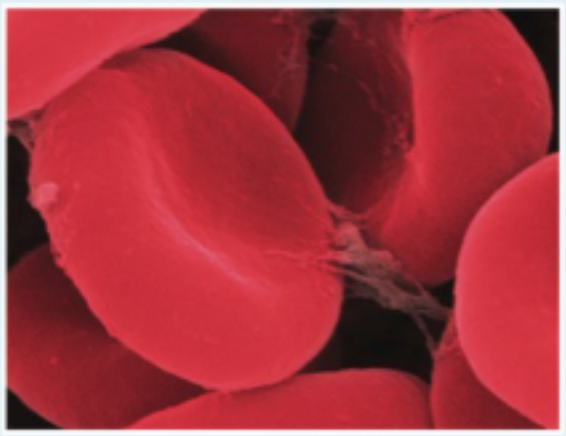
8 The cell theory could not have been developed without microscopes, as you see on the timeline on the next page. The microscopes we use today have the same basic function as the one Hooke invented—to view tiny specimens. The advanced technology in modern microscopes, however, provides far greater detail. Light microscopes focus light through lenses to produce a magnified image. Electron microscopes use beams of electrons that scan the surface of the specimen. Electron microscopes provide higher magnification and greater resolution, or sharpness, than light microscopes. Observe the different photos of the same red blood cells below.

9 A compound light microscope, like the one in the illustration, magnifies an image using two lenses. One lens is in the eyepiece. A second lens, called the objective, is on the revolving nosepiece. Each objective lens has a different magnifying power. By turning the nosepiece, you select the objective with the magnifying power you need. A glass rectangle called a slide holds the sample. A light shines up and passes through the slide and the sample. The light passes through the lenses in the nosepiece and the eyepiece. Each lens magnifies the sample. When the light reaches your eye, you see the sample in detail!



Magnification Red blood cells look very different when viewed through a light microscope (left) and an electron microscope with much higher magnification (right).





Microscopes and Cell Theory The invention of the microscope and improvements to it have led to the scientific theory of the cell.

1650

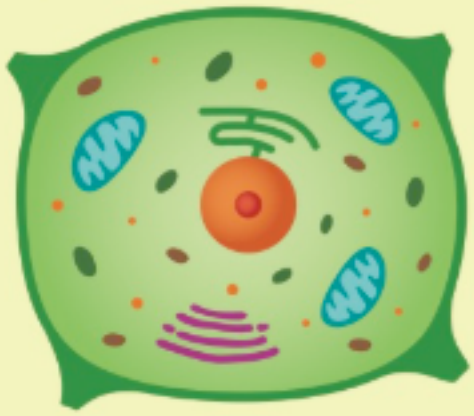
1663 — Robert Hooke studies bark and fossils with microscopes and coins the term "cells."

1674 — Anton van Leeuwenhoek observes living microorganisms under the microscope.

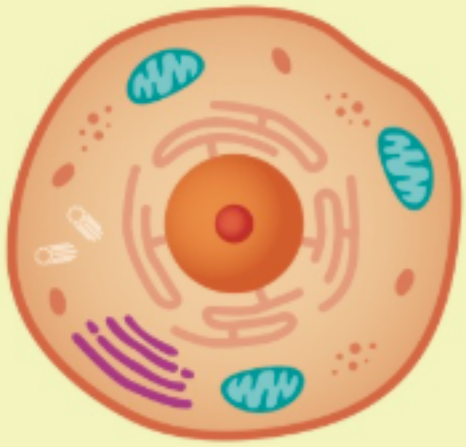
1675

1825

1838 — Matthias Schleiden concludes that all plants are made of cells.

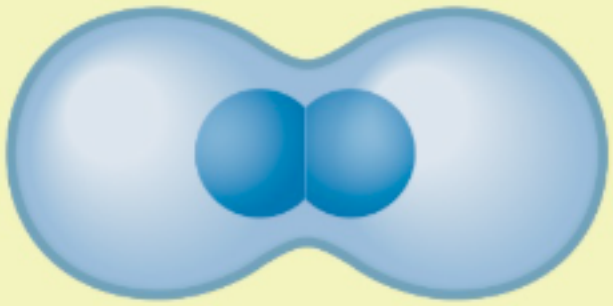


1839 — Theodor Schwann reaches the conclusion that all animals are made of cells. Schwann concludes that all organisms are made of cells, and that cells are the basic units of life.



1850

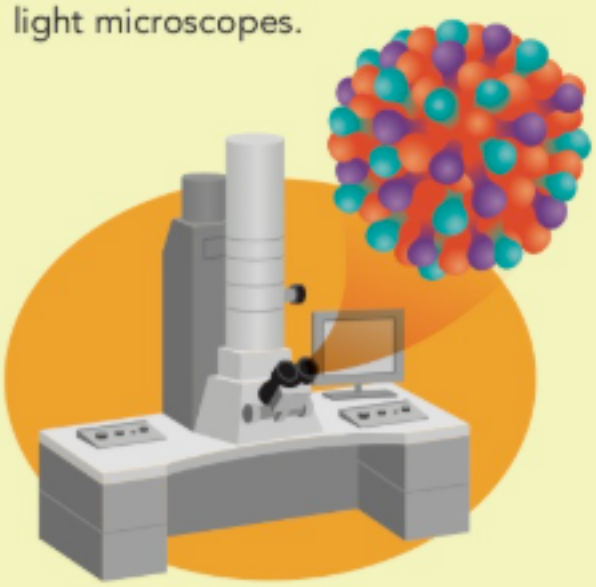
1855 — Rudolf Virchow concludes that cells only come from other cells.



1875

1925

1930s — Scientists developed several types of electron microscopes that are 5,000 times more powerful than light microscopes.



1950

Principles of Cell Theory

10 Cell theory is one of the most important ideas in biology. The scientific theory of cells is a basic organizing principle of life. According to this scientific theory:

- All living things are made of cells.
- Cells are the basic units of structure and function in living things.
- All new cells are produced from existing cells.

11 Cells are the basic unit of life. Even though living things differ greatly, they are all made of one or more cells. Most cells are tiny. But some, like those shown in the photo, can be surprisingly large. The cell theory holds true for all living things, no matter how big or how small. Organisms can be made of one cell or of many cells. We can study how single-celled organisms remove wastes to sustain life. Then we can use this information to understand how multicellular organisms carry out the same task. And, because all new cells are produced from existing cells, scientists can study cells to learn about growth and reproduction.

▶ **Cell Sizes** Many scientists consider eggs to be single cells. An ostrich egg is about 15 cm long, and a large chicken egg is about 6 cm long. A human egg is about the size of the period at the end of this sentence.

NAME _____ CLASS _____ DATE _____

Reading Check

Scientific Theory of Cells

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraphs 2 and 3, you read that cells are the basic units of all living things. What does the term *structure* mean?

_____

_____

2. In paragraph 4, you read that a single cell has the same needs as an entire organism. How is a single cell similar to an elephant? (Hint: Think of functions.)

_____

_____

_____

_____

3. In paragraph 5, you read about an invention that made the discovery of cells possible. What was it?

   A. the microscope

   B. the scientific theory of cells

   C. science

   D. living organisms

4. In paragraph 6, you read about how Robert Hooke discovered cells. What features did he observe in tree bark, and what did he name them?

   A. tiny rooms, empty spaces

   B. empty spaces, cork

   C. empty spaces, cells

   D. dead cells, empty spaces

5. In paragraph 7, you read about improvements to the microscope. How did advancements in microscope technology influence cell theory?

6. In paragraphs 8, 9, and the timeline, you read how improvements to microscope technology contributed to cell theory. Was the invention of the electron microscope essential to the development of cell theory? Explain.

7. In paragraph 10, you read how cell theory is a basic organizing principle of life. What are the three parts of cell theory?

8. In paragraph 11, you read that all new cells are produced from existing cells. Knowing this is true, what can scientists learn from studying cells?

   A. how organisms remove waste

   B. how organisms sustain life

   C. how organisms grow and reproduce

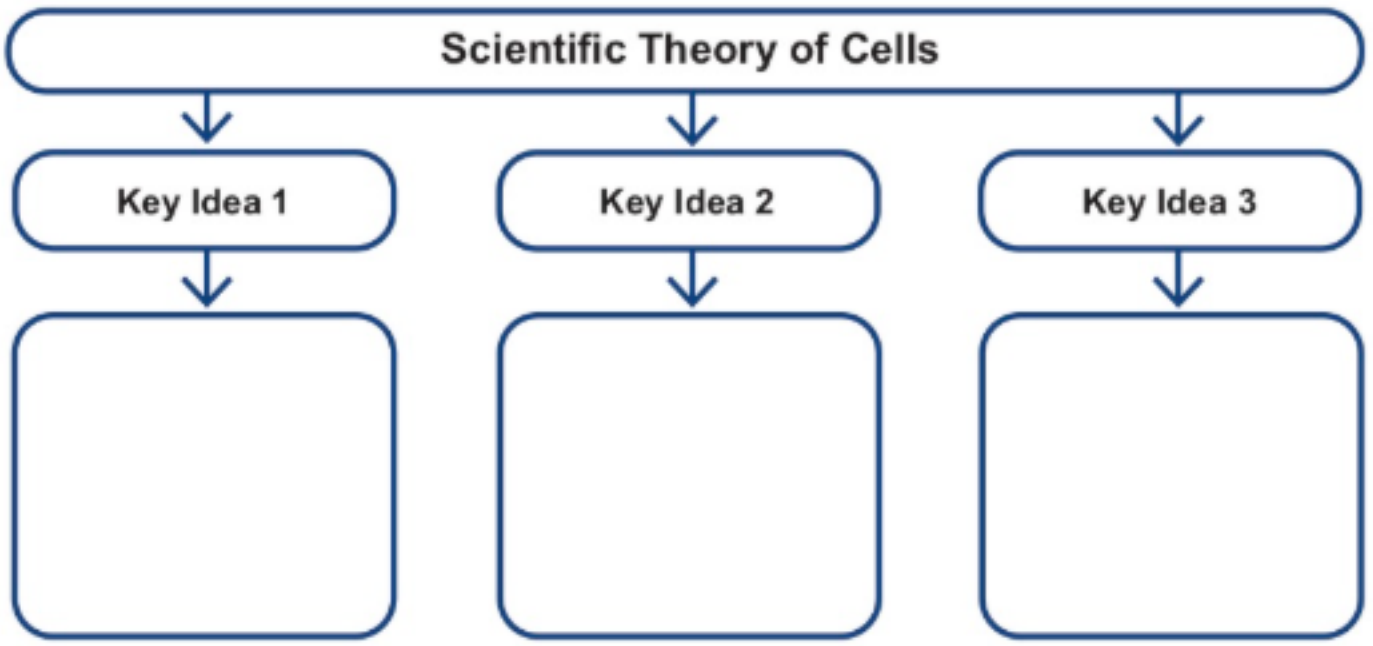
   D. how organisms become multicellular

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Scientific Theory of Cells

1. **Model** Complete the graphic organizer. Use it to explain the three key ideas of cell theory.



2. **Apply** Explain how you would investigate, or test, the key ideas supporting cell theory. Draw a two-column table with enough rows for each key idea. In column two, describe an investigation you could do to support the key idea.

NAME _____ CLASS _____ DATE _____

Lesson Review

Scientific Theory of Cells

1. Which of the following is **not** stated in the cell theory?

   A. Animal cells are more complex than plant cells.

   B. All living things are composed of cells.

   C. Cells are the basic units of structure and function in living things.

   D. All new cells are produced from other cells.

2. What would be the first step in proving that an object is a living thing?

   A. Determining whether the object is an organism.

   B. Determining the mass of the object.

   C. Determining whether the object is made up of cells.

   D. Determining the temperature of the object.

3. Which statement **best** explains why a single cell is like an entire organism?

   A. They both can be investigated using a microscope.

   B. They both perform functions that sustain life.

   C. They both share similar structures.

   D. They both reproduce.

4. Which of the following statements most accurately explains how advancements in technology influenced cell theory?

   A. After the microscope was invented, it took 150 years to develop cell theory.

   B. High-powered microscopes made more scientists interested in observing cells.

   C. As microscope technology improved, scientists could see cells more clearly.

   D. Scientists worked to improve the microscope until new discoveries led to cell theory.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Structures and Functions of Plant and Animal Organelles

I can…

- explain how the cells of all organisms undergo similar life processes.
- compare the structure and function of organelles in plant and animal cells.

Vocabulary

cell membrane cell wall chloroplast cytoplasm endoplasmic reticulum function homeostasis mitochondrion nucleus organelle vacuole

Phenomenon What makes a mangrove tree different from a pelican?

Make a Claim Explain what makes a mangrove tree different from a pelican in terms of the cells that make up each organism.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Comparing Cells

You will…

- explore how different parts of a cell help it to function.
- recognize how animal cells are different from plant cells.

What You Need to Know

The invention of the microscope allowed scientists to discover that living things are made of cells. As microscopes improved, scientists began to identify the parts of cells and to compare the structures of cells from different organisms. In this investigation, you will gather evidence to describe how plant and animal cells are the same and how they are different. This comparison helps explain the different ways that plants and animals live, grow, and function.

Materials

- prepared slide of cells, labeled "Slide A"
- microscope
- prepared slide of cells, labeled "Slide B"

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Caution: Slides and cover slips are fragile, and their edges can cause cuts. Handle them carefully.

Procedure

1. With your teacher, review the proper use of the microscope.
2. Use the microscope and the prepared slides to provide evidence that living things are made of cells. Obtain Slide A from your teacher. Examine the cells of the slide under the low-power and high-power lenses of the microscope. Decide which lens provides the better view of cell structures, and use this lens to make your observations.
3. Use one box to draw a picture of what you see. Label your drawing "Slide A."
4. Repeat Steps 2 and 3 with Slide B.

Observations

Analyze and Interpret Data

5. **Compare Data** Based on your observations, identify and describe the structure of the two types of cells. In your answer, be sure to describe how the two types of cells are alike and how they are different.

6. **Relate Structure and Function** Which slide shows animal cells, and which shows plant cells? Explain how the structures you identified allow you to classify the cells.

7. **Explain Phenomena** Why do the animal cells not have chloroplasts?

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Breathing Without Lungs

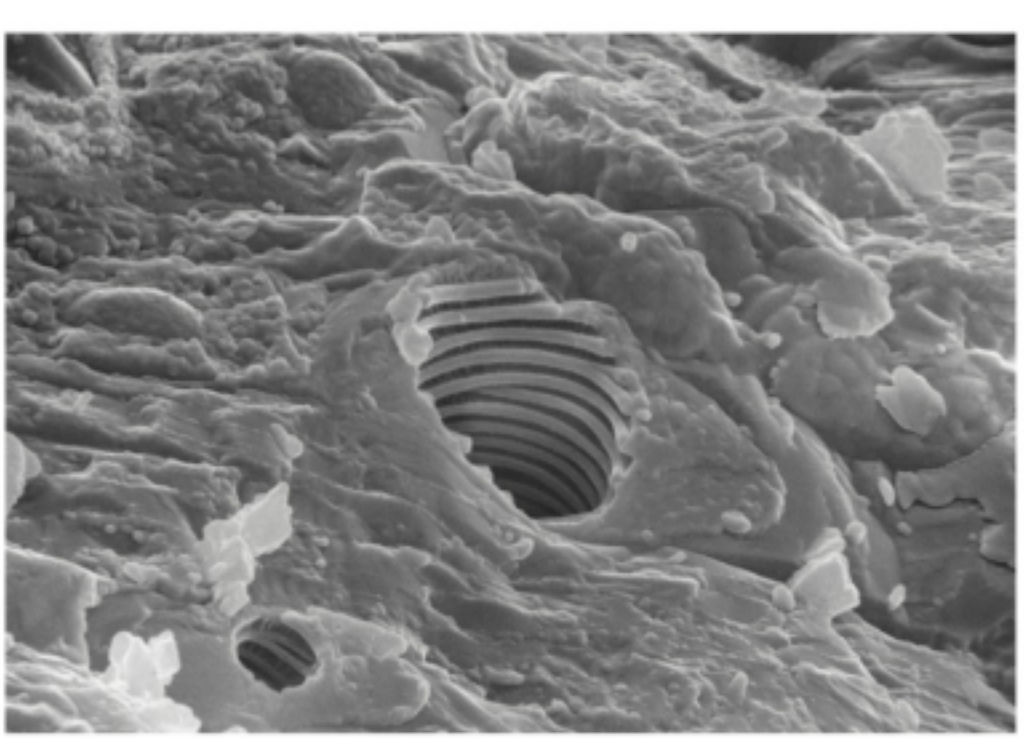
You will…

- learn how the cells of one type of animal gets oxygen.
- understand how the level of oxygen in Earth's atmosphere impacts growth.

What You Need to Know

The largest insects ever discovered were giant dragonflies that lived 300 million years ago. These dragonflies had a wingspan of 67 cm! Today the largest dragonfly has a wingspan of about 20 cm. The giant dragonflies existed at a time when the oxygen level in the atmosphere was about 35 percent, compared to 21 percent today. Use this information to answer the following questions.

The image was taken by a high-powered microscope. It shows you the details of the exoskeleton, or outer shell, of an insect. The structure that looks like a hole, or a tunnel entrance, is called a spiracle. It is an opening on the exoskeleton. Its function is to allow oxygen to enter and diffuse, or spread out, into the insect's cells. Spiracles connect to air passages that lead into all parts of an insect.



Analyze and Interpret Data

1. **Analyze Proportional Relationships** What is the percentage size difference between the giant dragonfly and the modern dragonfly?

2. **Evaluate** How did the oxygen levels in the atmosphere change between the time of the giant dragonflies and today? Did levels increase or decrease?

3. **Calculate Percent Change** First find the difference between the oxygen levels in the atmosphere at the time of the giant dragonflies and today. (*Hint: To keep it simple, remove the percent signs before you do the math.*) Then calculate the percent difference. Finally, explain what that difference means in terms of how the amount of oxygen in Earth's atmosphere changed.

4. **Make Inferences** Refer to the image of the spiracle. What do you think the relationship is between the spiracles, insect size, and air oxygen levels?

Structures and Functions of Plant and Animal Organelles

1 Animals and plants are made of many parts. If you've ever taken apart a flower, a leaf, or a nut, you've seen that it also contains smaller parts. You could keep dividing the plant up into parts until you had individual cells. As you learned in your study of the scientific cell theory, cells are the basic units of living organisms.

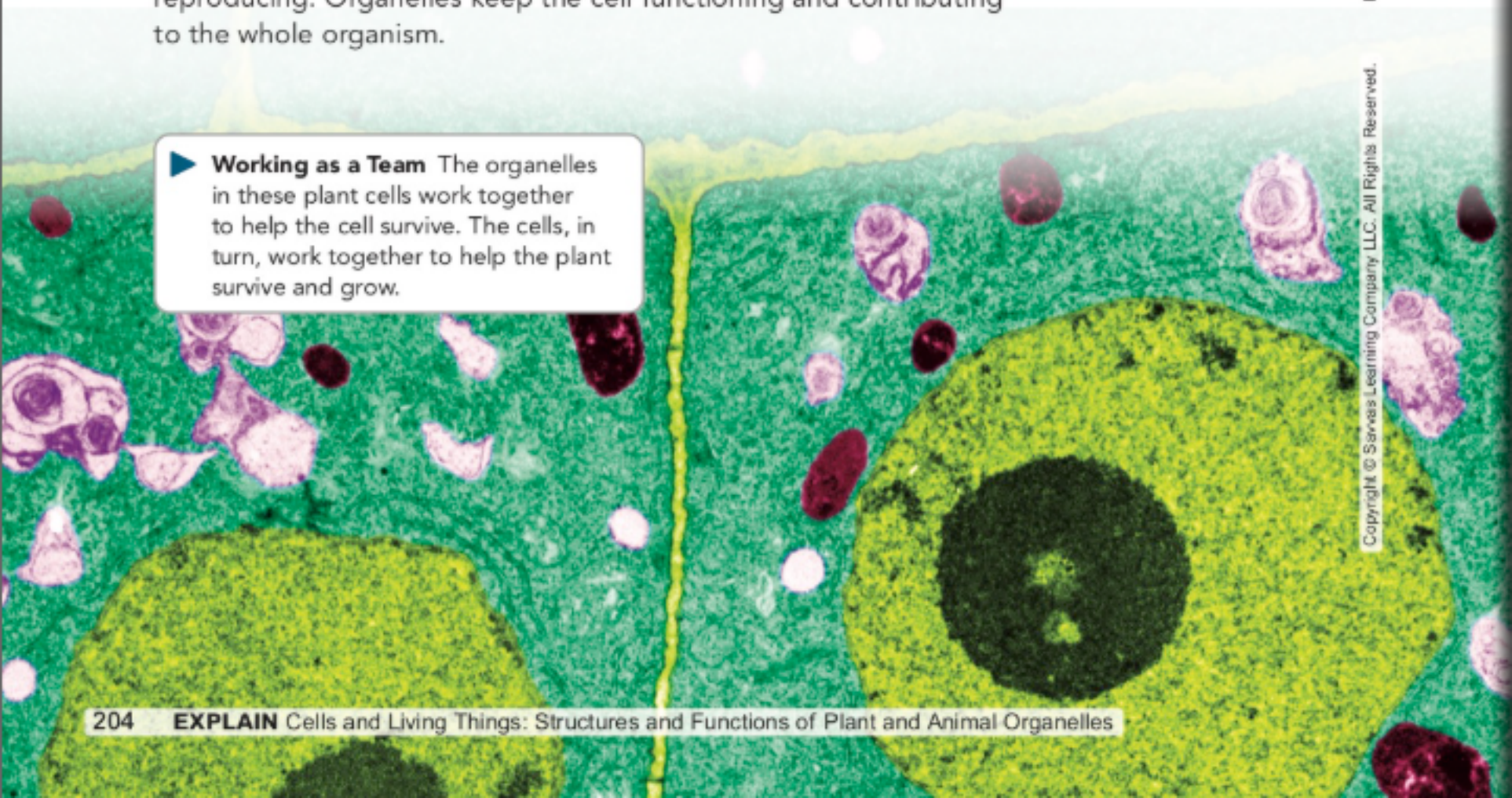
Vocabulary Support

With a partner, identify some structures in your classroom. What *function*, or role, does each structure have? The function of any object relies on its structure.

Parts of a Cell

2 Within each cell there are working structures called organelles that help the cell function, much like an entire organism has smaller parts that help it to function. An **organelle** is a cell structure that carries out a specific function within a cell.

3 Structure and function are always closely related in biology. Each organelle has a different structure because each has a different **function.** Also, some organelles are found only in the cells of certain types of organisms. Plant and animal cells have some different organelles. Bacteria are single-celled organisms that contain fewer types of organelles than plant or animal cells do. In every organism, organelles are structures that allow cells to carry out the same essential functions as organisms: maintaining stable conditions, getting energy from food, getting rid of waste, and reproducing. Organelles keep the cell functioning and contributing to the whole organism.

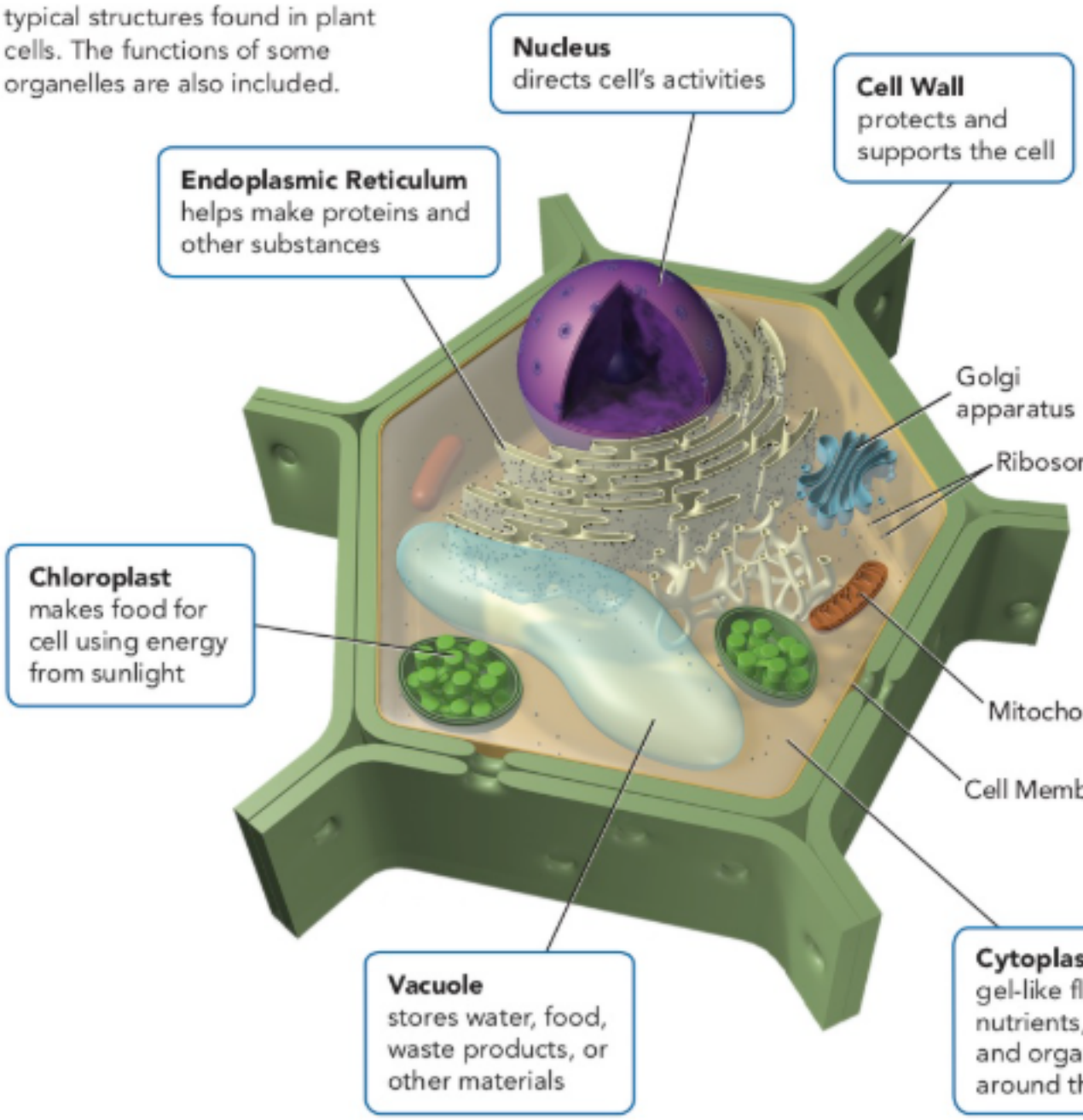


Working as a Team The organelles in these plant cells work together to help the cell survive. The cells, in turn, work together to help the plant survive and grow.

Plant and Animal Cell Organelles

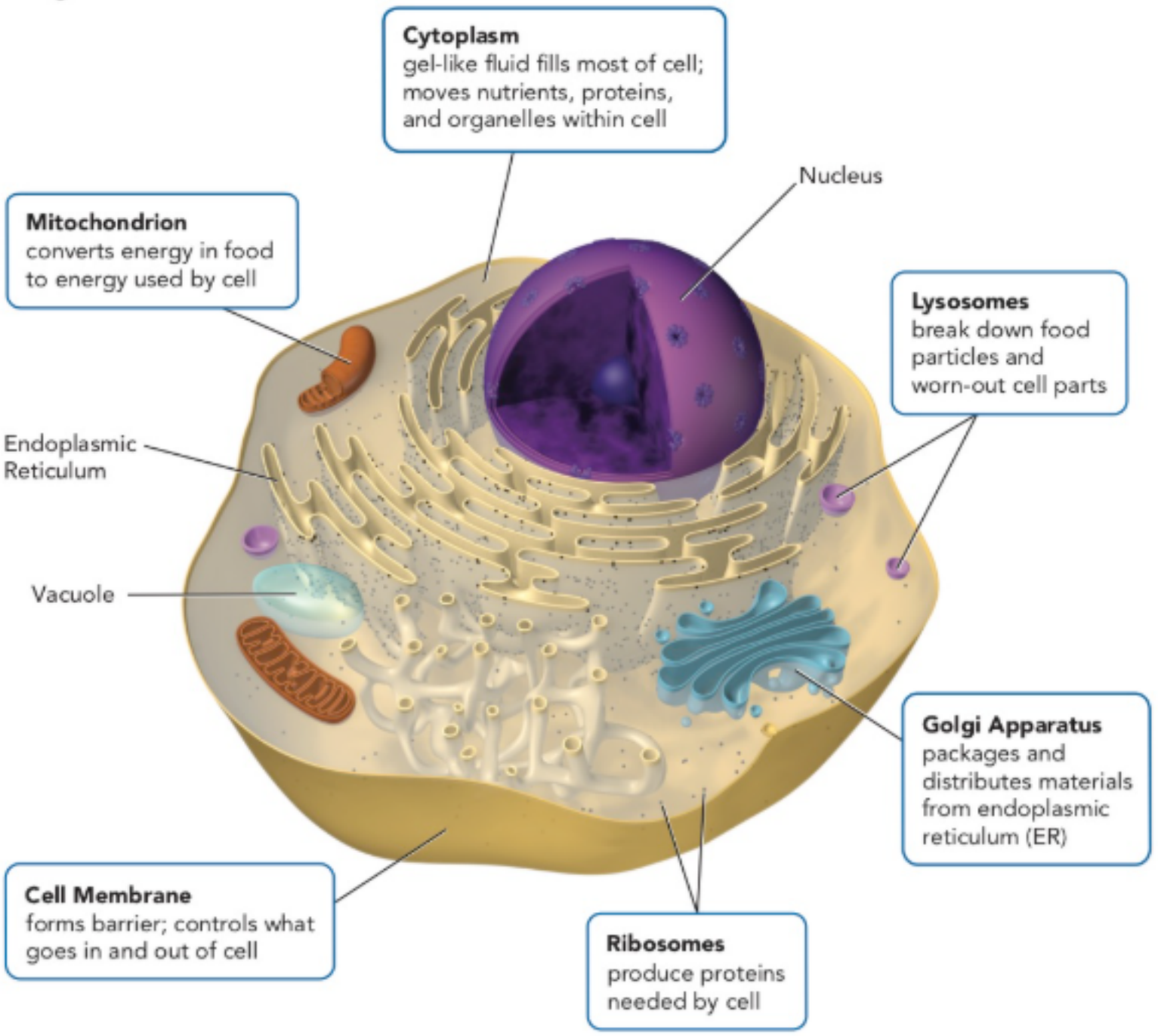
4 Some organelles are found only in plant cells, some are found only in animal cells, and some are found in both plant and animal cells. The rigid supporting layer that surrounds the cells of plants and some other organisms is the **cell wall**. While plants, protists, fungi, and bacteria have cell walls, the cells of animals do not have cell walls. One function of the cell wall is to help protect and support the cell. The cell walls of plant cells are made mostly of a strong material called cellulose. Observe in the illustration that there are small holes, or pores, in the plant cell wall. Pores allow materials such as water and oxygen to pass through the cell wall.

Plant Cells This illustration shows typical structures found in plant cells. The functions of some organelles are also included.



5 The **cell membrane** is a thin, flexible barrier that surrounds a cell and controls which substances pass into and out of a cell. All cells have a cell membrane. In plant cells, the cell membrane is a fluid-like layer between the cell and the cell wall. As you can see in the illustration, animal cells do not have a cell wall, so the cell membrane is the outermost layer. For cells without a cell wall, the cell membrane forms the border between the cell and its environment. Everything a cell needs, such as food particles, water, and oxygen, enters through the cell membrane. Waste products leave through the cell membrane. A cell membrane is selectively permeable, which means some substances can cross it, while others cannot. These movements allow a cell to maintain **homeostasis**, a stable internal environment.

Animal Cells This illustration shows typical structures found in animal cells. The functions of some organelles are also included.



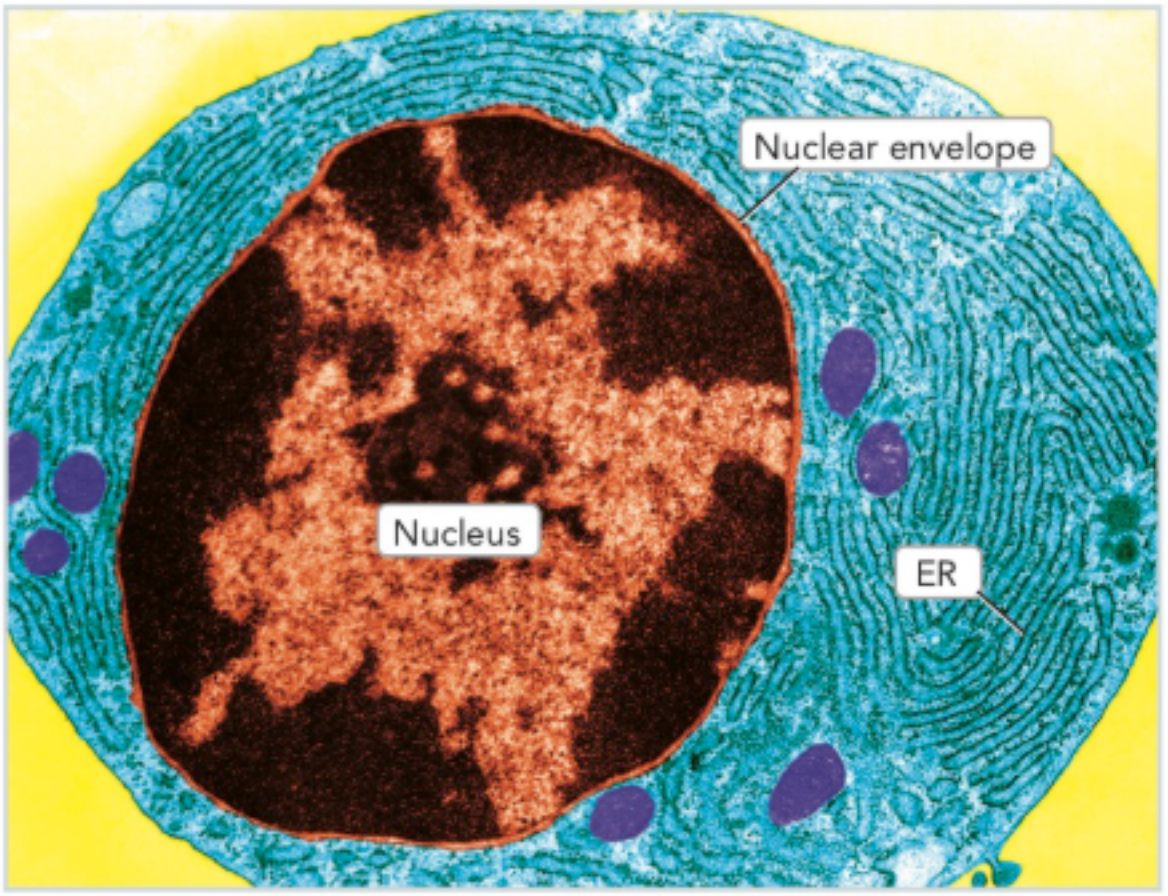
Organelles in the Cytoplasm

6 Most of a cell consists of a clear, gel-like fluid called **cytoplasm**. Cytoplasm fills the region between the cell membrane and the nucleus. The cytoplasm is made mostly of water and some salt, and it holds all the cell's organelles. The clear fluid of the cytoplasm carries nutrients, proteins, and organelles around the cell as it circulates.

7 In some cells, the **nucleus** is a large oval organelle that contains the cell's genetic material in the form of DNA and controls many of the cell's activities. The nucleus is one of the largest of the cell's organelles. Notice in the photo that the nucleus is surrounded by a membrane called the nuclear envelope. Materials pass into and out of the nucleus through pores in the nuclear envelope.

8 In the photo, you can see a structure like a maze of passageways. The **endoplasmic reticulum** (en-doh-PLAZ-mik rih-TIK-yuh-lum), or ER, is an organelle that processes many substances, including proteins and lipids, or fats. Ribosomes are organelles that make proteins. The ER and its attached ribosomes make and process proteins that the cell uses.

Nucleus The nucleus acts as the control center of the cell. Folds of the endoplasmic reticulum surround the nucleus.



9 As proteins leave the ER, they move to the Golgi apparatus, a structure that looks like flattened sacs and tubes. The Golgi apparatus can be considered the cell's warehouse. It receives proteins and other newly formed materials from the ER, and then packages and distributes them.

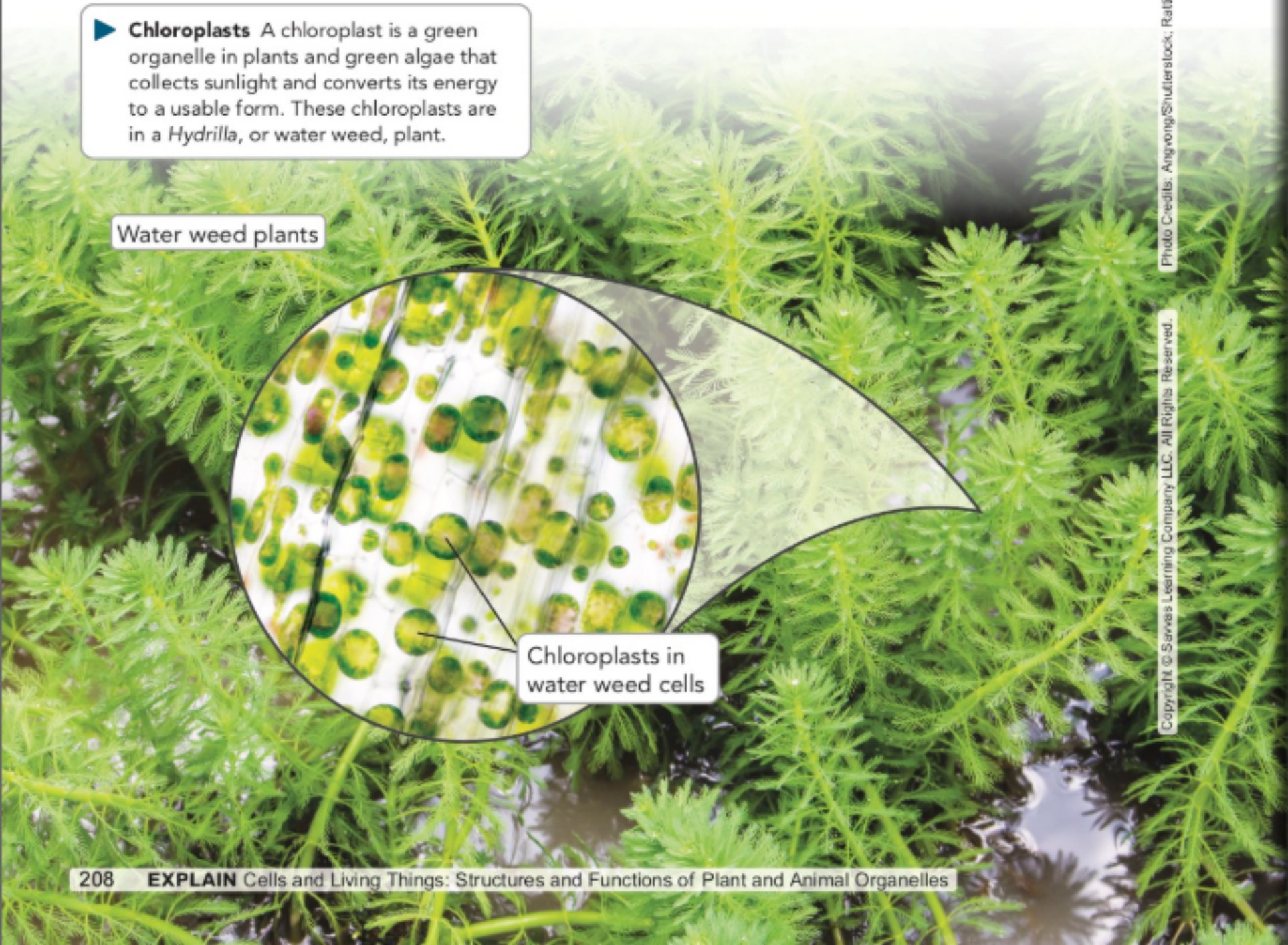
10 Floating in the cytoplasm are rod-shaped structures. Look back at the animal cell image. **Mitochondria** (myt-oh-KAHN-dree-uh; singular: mitochondrion) convert energy stored in food to energy the cell can use to live and function. They are the "powerhouses" of the cell.

11 The **chloroplast** is an organelle in the cells of plants and some other organisms that captures energy from sunlight and changes it to a form of energy that cells can use. The function of the chloroplast is to make food, in the form of sugar, for the cell. Plant cells in leaves typically contain many green chloroplasts. Animal cells do not have chloroplasts because animals eat food instead of making their own food from sunlight.

Literacy Support

Find a partner, and take turns retelling paragraph 10 in your own words. When you are both finished, discuss the differences in your retellings.

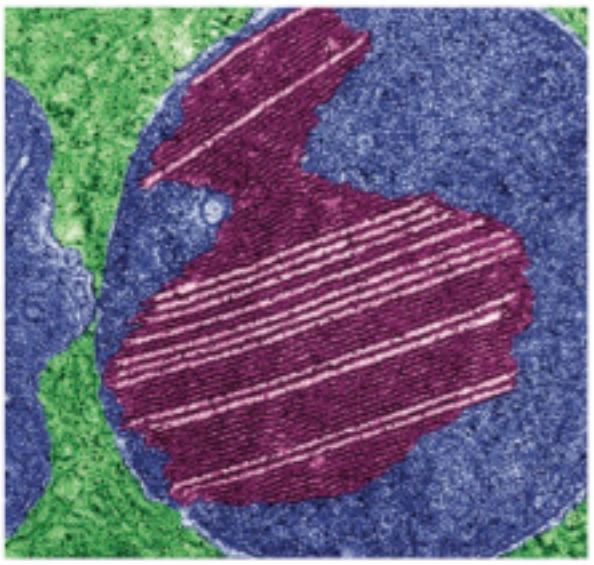
▶ **Chloroplasts** A chloroplast is a green organelle in plants and green algae that collects sunlight and converts its energy to a usable form. These chloroplasts are in a *Hydrilla*, or water weed, plant.



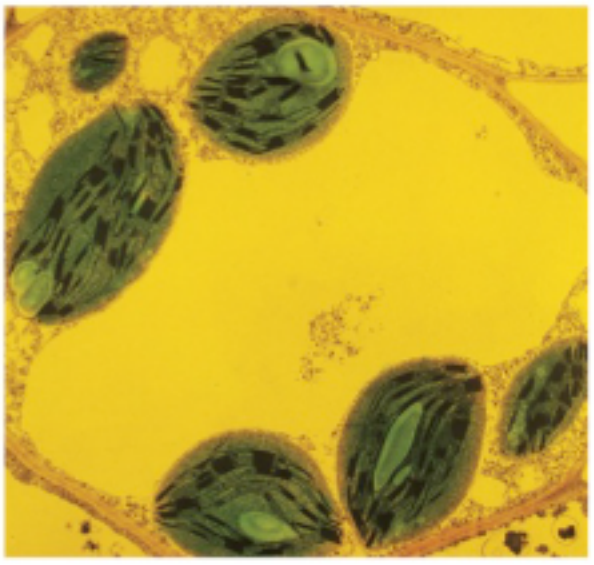
12 You can think of lysosomes (LY-suh-sohmz) as a cell's recycling centers. Look back at the animal cell figure. The small, round organelles are called lysosomes. Lysosomes contain substances that break down large food particles into smaller ones. Lysosomes also break down old cell parts and release the materials so they can be used again.

13 Plant cells often have one or more large, waterfilled sacs floating in the cytoplasm, as you observed in the plant cell figure. In some animal cells these sacs are much smaller. This structure is a **vacuole** (VAK-yoo-ohl), a sac-like organelle that stores water, food, or other materials needed by the cell. In addition, vacuoles store waste products until the wastes are removed. In some plants, vacuoles also perform the function of digestion that lysosomes perform in animal cells.

Organelle Closeups Advanced microscopes capable of very high magnification allow scientists to see organelles in fine detail. All of these images have been colorized to help you see details.

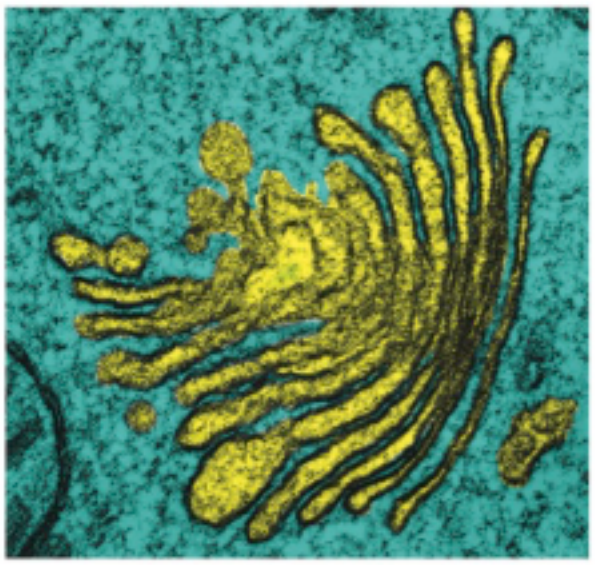


Nucleus



Chloroplast

Mitochondrion



Golgi apparatus

NAME _____ CLASS _____ DATE _____

Reading Check

Structures and Functions of Plant and Animal Organelles

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraphs 2 and 3, you read that each organelle has a different structure and a different function. What is a function?

2. In paragraphs 4 and 5, you read about the cell wall and the cell membrane. Compare and contrast their structures and functions.

3. In paragraph 6, you read about cytoplasm. Suppose there is a drought and a plant cannot get enough water. What might happen to the cytoplasm and the organelles in the cells of the plant?

4. In paragraph 7, you read about the nucleus. Why is it important?

5. In paragraphs 8 and 9, you read about the endoplasmic reticulum (ER) and Golgi apparatus. What does the Golgi apparatus receive from the ER?

   A. the cytoplasm's clear, circulating fluid

   B. proteins and other newly formed materials

   C. energy stored in rod-shaped structures

   D. materials passed through the cell membrane

6. In paragraph 10, you read about the cell's "powerhouses." What are they called?

   A. mitochondria

   B. chloroplasts

   C. lipids

   D. sugars

7. In paragraph 11, you read about chloroplasts found in plant cells. Why don't animal cells have chloroplasts?

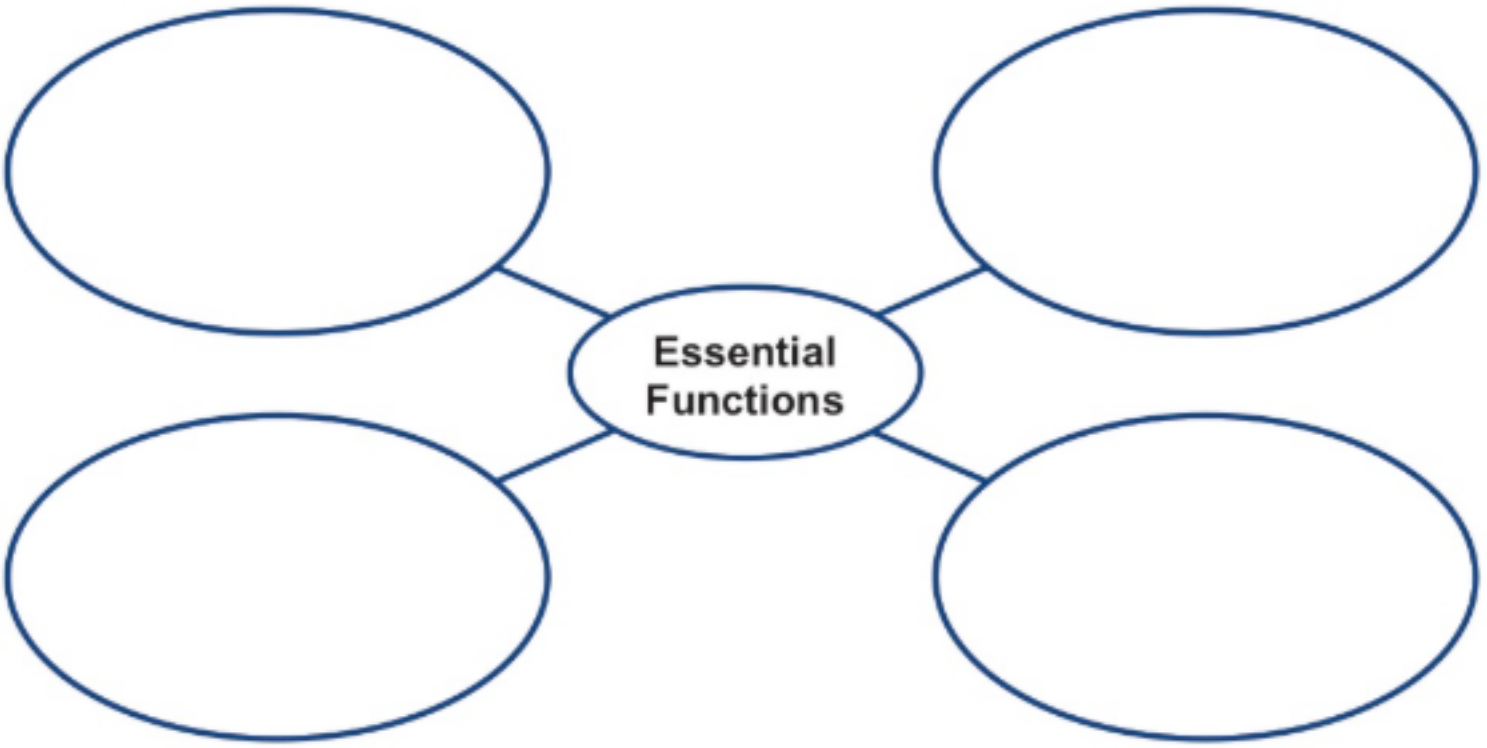
8. In paragraphs 12 and 13, you read about lysosomes and vacuoles. What is the main difference between these two organelles?

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Structures and Functions of Plant and Animal Organelles

1. **Model** Use a graphic organizer to show essential functions carried out by both cells and organisms.



2. **Apply** Create a Venn diagram to compare organelles in plants and animals.

NAME _____ CLASS _____ DATE _____

Lesson Review

Structures and Functions of Plant and Animal Organelles

1. What do plant cells have that animal cells do **not** have?

   A. endoplasmic reticulum and Golgi apparatus

   B. cell wall and chloroplasts

   C. lysosomes and ribosomes

   D. vacuoles and mitochondria

2. Which organelle is found in animal cells but **not** in plant cells?

   A. cell wall

   B. Golgi apparatus

   C. lysosomes

   D. vacuole

3. What is the function of the mitochondria?

   A. They capture energy from sunlight and use it to make food for the cell.

   B. They convert energy stored in food to release energy for the cell.

   C. They act as the cell's control center directing many of its activities.

   D. They store water, food, or other materials needed by the cell.

4. What would happen to a cell if waste products could not leave through the cell membrane?

   A. The cell would no longer be selectively permeable.

   B. The cell would no longer be able to maintain homeostasis.

   C. The cell's lysosomes would have to recycle the waste products.

   D. The cell wall would have to become less rigid to let the waste move out.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Levels of Organization

I can…

- describe the patterns of hierarchical organization in all organisms.

Vocabulary

hierarchy organ organ system tissue

Phenomenon How do the cells in a surfer's body allow them to surf?

Make a Claim Explain how all the cells in the surfer's body are able to work together when the surfer is riding a wave.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Observing Cells and Tissues

You will…

- identify patterns in the hierarchical organization of organisms.
- describe the hierarchical organization of organisms from atoms to molecules and cells to tissues to organs to organ systems to organisms.

What You Need to Know

A national organ-sharing organization has partnered with your local children's hospital to educate young patients about what organs are and how they function. Your class has been selected to make presentations about various organs that describe what they are made of and how various organ tissues function. In this lab you will look at a variety of microscopic views of different tissues for specific organs and gather evidence that demonstrates the function of various tissues. This information will be used in your hospital presentation to the children.

Materials

- microscope
- prepared bone tissue slide
- prepared cardiac muscle tissue slide
- prepared lung tissue slide
- prepared nerve tissue slide
- Handout: Tissue Structure and Function

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

Slides and cover slips are fragile, and their edges can cause cuts. Handle them carefully.

Procedure

1. Go to the station assigned by your teacher. Note that the station number is the same as the slide number. Fill in the slide number on Table 1.
2. View the first tissue sample under a microscope. Then, draw and describe your observations in the table. Using the Tissue Structure and Function handout, identify the tissue type. Move to the next station according to your teacher's directions.
3. For each remaining slide, repeat steps 1 and 2.

Observations

Table 1

Slide Number	
Drawing	
Observations	
Tissue Type	

Table 2

Slide Number	
Drawing	
Observations	
Tissue Type	

Table 3

Slide Number	
Drawing	
Observations	
Tissue Type	

Table 4

Slide Number	
Drawing	
Observations	
Tissue Type	

Analyze and Interpret Data

1. **Relate Structure and Function** How does the structure of the cells that make up nerve tissue help with completing its function?

2. **Construct Explanations** The four cells you viewed are all types of animal cells, but they are all shaped differently. What is the basic shape of a cardiac muscle cell? Why do you think cardiac muscle cells have that shape?

3. **Cite Evidence** Use evidence from your tissue observations to inform your young patients about how four organs function in the body.

4. **Describe Patterns** There are three types of muscle tissue in your body. Cardiac and skeletal muscle tissue look very similar, but smooth muscle tissue looks different. Smooth muscle tissue makes up organs such as the stomach and bladder. All three tissue types contract, but smooth muscle tissue contracts more slowly than the other two types. Draw how you think smooth muscle tissue would appear under the microscope.

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Counting Cells in the Body

You will…

- learn how difficult it is to estimate the number of cells in a human.
- understand why scientists use powers of ten, called scientific notation, to write large numbers.

What You Need to Know

Scientists and mathematicians have wondered about the number of cells in the human body for centuries. Estimates of the number of cells have ranged from 100 billion to 1 quadrillion, or a 1 followed by 15 zeros! It's easier to write one quadrillion using exponents: 1×10^{15} where the exponent 15 is the number of zeros.

A team of European scientists recently completed a new estimate of the human cells in an average person. Their estimate is about 37 trillion cells per person.

Name	Number	Written with Power of Ten Exponent (Scientific Notation)
million	1,000,000	1×10^6
billion	1,000,000,000	1×10^9
trillion	1,000,000,000,000	1×10^{12}
quadrillion	1,000,000,000,000,000	1×10^{15}

Analyze and Interpret Data

1. **Identify Equivalent Expressions** How do you write 37 trillion as a number and using a power of ten exponent (in scientific notation)?

2. **Analyze Quantitative Relationships** How does the new European estimate compare to the smallest and largest estimates of other research groups?

3. **Calculate** How many billions are in one trillion?

4. **Describe Patterns** Refer to the table. Compare each number, and how it is written in scientific notation, to the number in the row below. What pattern do you see?

5. **Make Inferences** Quintillion comes after quadrillion. There are one thousand quadrillions in a quintillion. Write one quintillion as a number and in scientific notation (using the power of ten exponent).

Levels of Organization

1 Flying an airplane is a demanding task. For a plane to fly safely to its destination, all its systems must be working well. And for a system such as navigation to be working, all the parts of the system must work well. For each part of the navigation system to work, the part's machinery or software must be working well. For machinery to work well, the material it is made from, such as steel, must be in good condition. The condition of the steel relies on the molecules and atoms that make it up.

Body Organization

2 Like an airplane, your body is a system that is made up of smaller systems. All these systems are essential to your body's overall functioning.

▶ **All Systems Go** All systems in an airplane, including the pilot and co-pilot, must function properly in order to operate the plane.

3 The smooth functioning of your body depends on its organization. The levels of organization in the human body are atoms, molecules, cells, tissues, organs, and organ systems. All cells are made of atoms and molecules. All tissues are made up of cells. Organs are made of different kinds of tissues. And your body can maintain homeostasis because different organ systems work together. This sort of ranked order is called a **hierarchy**.

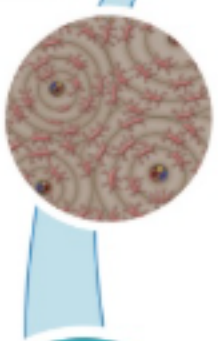
Vocabulary Support

A *hierarchy*, or ranked order, is a way to organize things. Sports standings from "first to worst" are hierarchies. With a partner, come up with other hierarchies in everyday life.

Animal Cells This illustration shows typical structures found in animal cells.

Cell Bone cells are made of molecules, which are made of atoms. Three types of bone cells help maintain homeostasis, form new bone tissue, and produce blood cells. All cells get energy from their environment, as organisms do.

Tissue The three bone cell types make up two bone tissues: a hard, dense outer layer and a light, spongy inner layer.



Organism A human is an organism. All organisms are made up of simpler parts, such as the skeletal system, that contribute to its survival.

Organ The two types of bone tissue form bones, the organs of the skeletal system.

Organ System Bones make up the skeletal system. The skeletal system gives a body shape, aids in movement, makes blood cells, and protects organs.

Cells

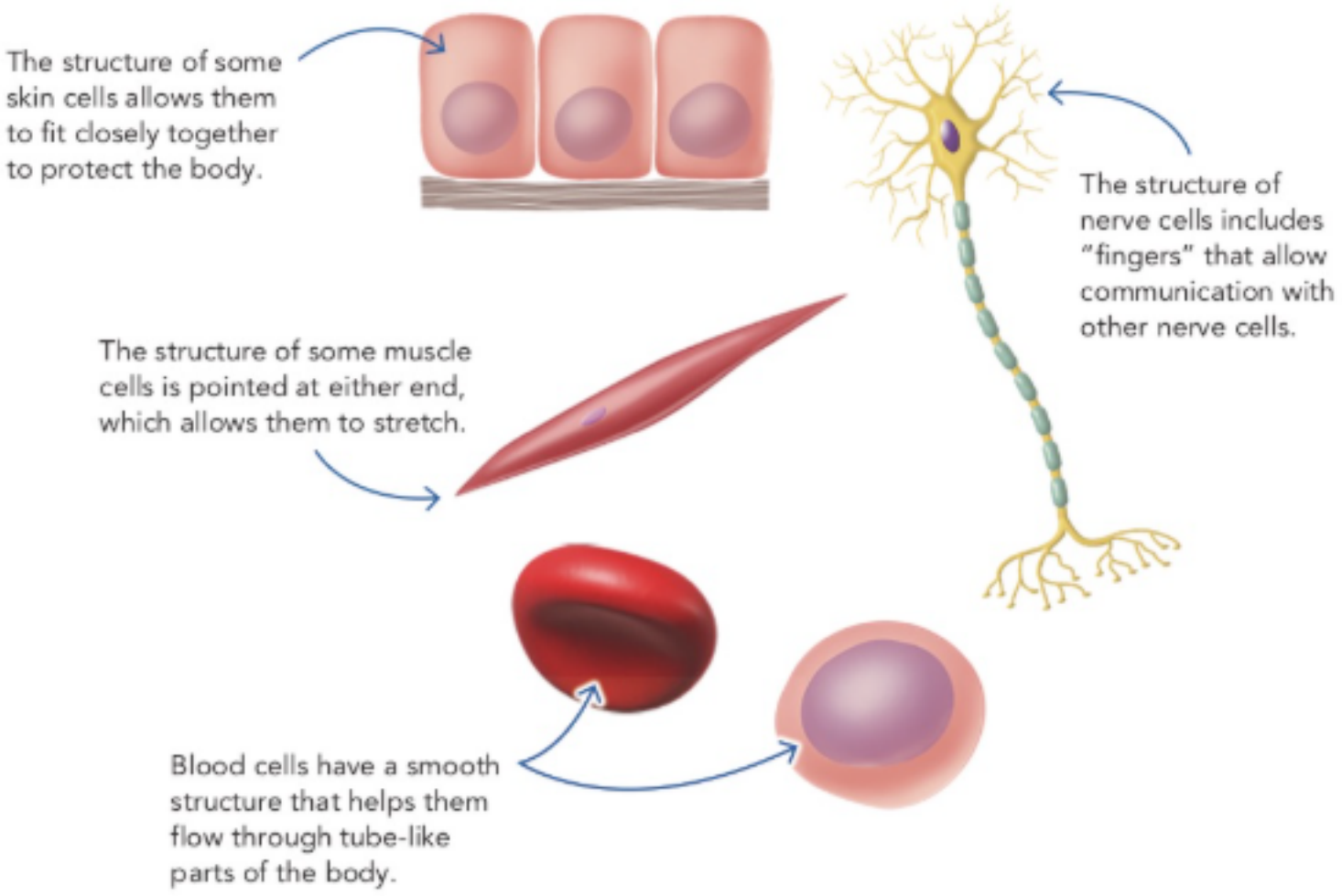
4 You are alive because specialized cells are performing their functions throughout your body. Multicellular, or many-celled, organisms, such as humans and plants, are more complex than unicellular, or one-celled organisms. Multicellular organisms are composed of different types of cells with different functions. One type of cell does one type of job, while other types of cells do other jobs. For example, red blood cells are specialized to deliver oxygen to cells throughout your body. However, they would not travel through your body without the specialized cells of the heart, which send them to cells needing oxygen.

5 Just as specialized cells differ in function, they also differ in structure. The figure shows specialized cells from animals. Each type of cell has a distinct shape. For example, a nerve cell has thin, thread-like "fingers" that seem to reach toward other cells. These structures help nerve cells transmit information from one part of your body to another. The nerve cell's shape would not help a red blood cell fulfill its function.

Literacy Support

What is the purpose of the example involving the red blood cells and the heart cells in paragraph 4? Discuss your ideas with a partner.

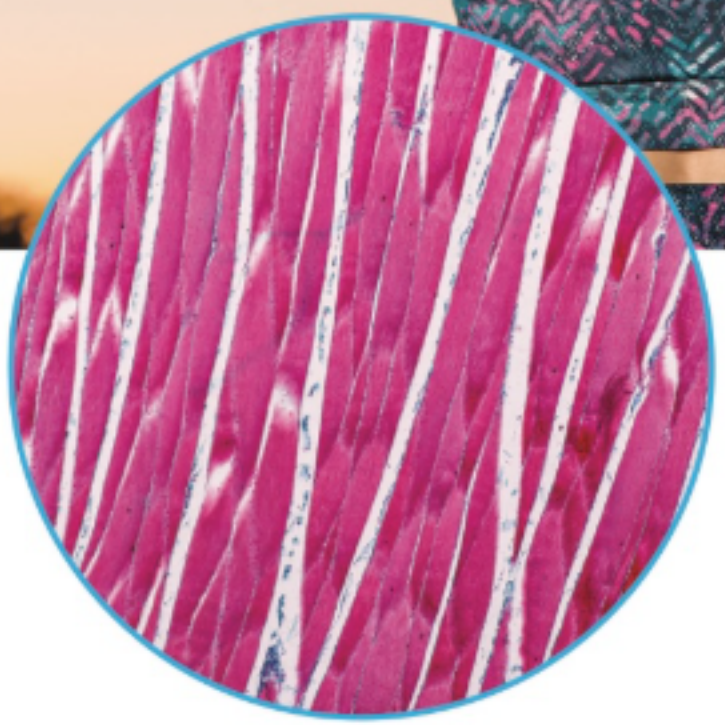
▶ **Cell Specialization** Multicellular organisms, such as humans, have specialized cells with unique structures that carry out specific functions.



Tissues

6 A **tissue** is a group of similar, specialized cells that perform the same function. Muscle tissue, for example, contracts, or shortens, to make parts of your body move. Nerve tissue carries electrical signals from the brain all over the body and back again. Connective tissue, such as bone and fat, provides support for your body and attaches its parts together. Skin, the largest organ of the human body, has epithelial (ep-uh-THEE-lee-ul) tissue that protects your insides from damage. Epithelial tissue covers the inner and outer surfaces of your body.

Muscle Tissue You can often see the shape of the muscle tissue beneath the skin tissue when a person is "making a muscle."



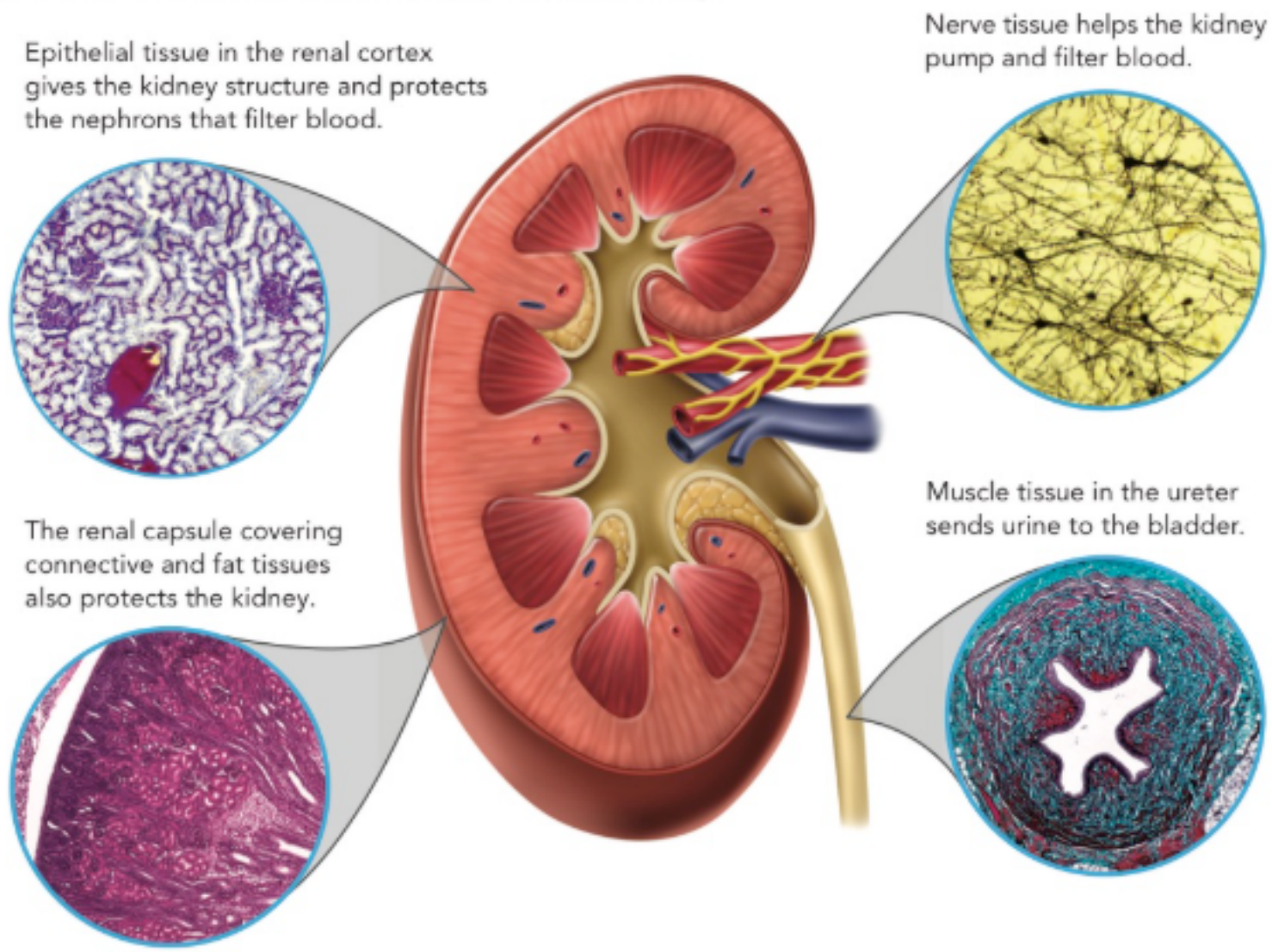
Skeletal muscle tissue sample, showing the arrangement of long cells into muscle tissue

Organs and Organ Systems

7 Your kidneys, heart, brain, and skin are all organs. An **organ** is a body structure composed of different tissues that work together. Each organ has a specific function in the body. Because the functions of organs are more complex than those of tissues, the structures of organs are more complex. For example, kidneys remove waste from your blood and produce urine. Each kidney contains muscle, connective, and epithelial tissues. In addition, nerve tissue that connects to the kidney helps to control its function. Look at the figure to see where different tissues are found in the kidney. Each tissue contributes in a different way to the kidney's function of filtering blood.

8 Every organ is part of an **organ system**, which is a group of organs that work together to perform major functions. For example, your kidneys are part of your excretory system. The excretory system also includes the skin, lungs, and liver. The major systems of the human body include the digestive, respiratory, circulatory, reproductive, excretory, immune, nervous, and musculoskeletal systems.

▶ **Tissues Make Up an Organ** Kidneys are organs whose tissues filter blood to remove waste and excess water from the body.



NAME _____ CLASS _____ DATE _____

Reading Check

Levels of Organization

Answer the following questions after you have completed reading the Read About It.

1. In paragraphs 1 and 2, you read about how some of an airplane's systems and parts work together so the airplane can fly. How is the human body similar to an airplane?

_____

_____

_____

2. **Vocabulary** In paragraph 3, you read about the ranked order of the levels of organization in the human body. What is another word for *ranked order*?

_____

_____

3. In paragraph 3 and the diagram, you read about levels of organization in the human body. Which of the following is the hierarchical organization of multicellular organisms?

   A. atoms, molecules, cells, tissues, organs, organ systems, organism

   B. cells, atoms, molecules, tissues, organs, organism, organ systems

   C. atoms, molecules, cells, organs, tissues, organism, organ systems

   D. molecules, atoms, cells, organs, tissues, organ systems, organism

4. In paragraphs 4 and 5 and the diagram, you read about specialized cells. Give one example of how the structure and function of specialized cells are related.

_____

_____

_____

_____

5. In paragraph 6, you read about tissues. What type of cells work together to make a tissue?

6. **Vocabulary** In paragraph 7 and the diagram, you read about organs. Which **two** of the following describe an organ?

   A. a body structure composed of different tissues that work together

   B. the level of organization in the human body with the most systems

   C. a body structure that is more complex than a cell

   D. the level of organization in the human body with the simplest structures

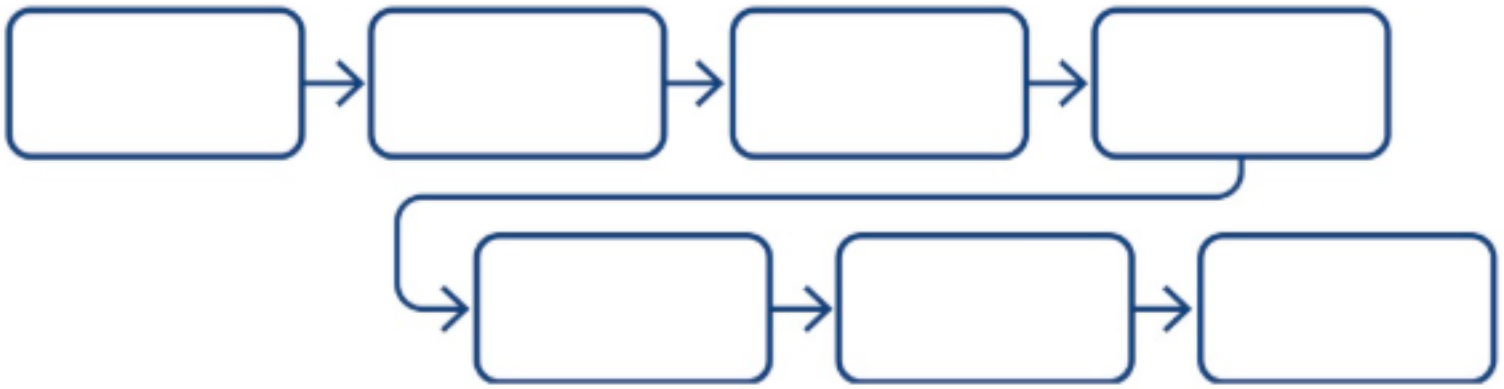
7. In paragraph 8, you read about organ systems. Give an example of an organ system, and describe an organ, type of tissue, and type of cell that are part of it.

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Levels of Organization

1. **Model** Use a graphic organizer to show the hierarchy in an organism's level of organization.



2. **Apply** Blood cells are specially adapted to transport materials from one part of the body to another and keep the body healthy. Research the five major human white blood cell types. Construct a table to identify and describe their functions. Then answer the question, *Why is blood considered a tissue in the human body?*

NAME _____ CLASS _____ DATE _____

Lesson Review

Levels of Organization

1. What does the smooth functioning of your body depend on?

   A. its number of organs

   B. its specialized cells

   C. its organization

   D. its circulatory system

2. What are all cells made of?

   A. molecules and tissue

   B. atoms and molecules

   C. other cells

   D. organ systems

3. Which option describes the hierarchical organization of the system that includes bones?

   A. muscle cells, nerve tissue, bones, integumentary system

   B. bone cells, spongy outer tissue, bone, skeletal system

   C. epithelial cells, renal capsule, bone, excretory system

   D. nerve cells, connective tissue, bones, nervous system

4. What is an example of multiple body systems performing one specific function?

   A. The circulatory system carrying blood cells with oxygen throughout the body.

   B. The circulatory and muscular systems working together to enable breathing

   C. The integumentary system having epithelial tissue like a cell membrane covering the inner and outer surfaces.

   D. The excretory system and immune system filter blood to remove waste and excess water from the body.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

Classification

I can…

- describe how and why organisms are classified according to shared characteristics.

Vocabulary

binomial nomenclature characteristic classification convergent evolution domain evolution genus natural selection species taxonomy

Phenomenon Why isn't a bat considered a bird?

Photo Credit: Beth Ruggiero-York/Shutterstock

Make a Claim Explain why a bat is not considered a bird, even though it has wings and it flies in the air.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Living Mysteries

You will…

- make observations to create a taxonomic key for classifying plants.
- analyze how living things are classified into groups.

What You Need to Know

A taxonomic key is a series of paired statements or questions about the physical characteristics of organisms. It is used to identify organisms. In this activity, you will create a taxonomic key.

Materials

- variety of plant leaves
- hand lens
- metric ruler

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.


Handle tree leaves carefully.


Wash your hands with warm water and soap when you complete the procedure.

Procedure

1. Your teacher will give you five different tree leaves.
2. Use the hand lens to examine each of the leaves. Look for characteristics like those in the table. You may make some measurements with a ruler. Make a list of five or more characteristics for each leaf in the Observations section.

Characteristics to consider:

Characteristics	Observations
Overall shape	Is the leaf needle-like and narrow, or is it flat? If it is a flat leaf, is it rounded, oblong, heart-shaped, or some other shape?
Simple vs. compound	Is the leaf a single unit, or is it made up of individual leaflets? If it is made up of leaflets, how are they arranged on the leaf stalk?
Pattern of veins	Do the leaf's veins run parallel from a central vein, or do they form a branching pattern?
Leaf edges	Are the edges of the leaf jagged or smooth?
Leaf texture	Is the leaf's surface fuzzy, shiny, or another texture?

3. Use your observations to create a taxonomic key for the leaves on a separate piece of paper. Your taxonomic key should consist of paired statements or questions such as those shown in the table.

4. Exchange your leaves and taxonomic key with another student pair. If the other pair cannot match all the leaves using your key, revise your key as necessary.

Observations

Analyze and Interpret Data

1. **Test and Evaluate** What characteristics did you choose to make a taxonomic key? How did you test and evaluate your taxonomic key? What did you change?

2. **Support Your Explanation** Why is a taxonomic key an important classification tool? Could finding a new plant species change a taxonomic key? Explain your answer.

NAME _____ CLASS _____ DATE _____

Data Analysis Activity

Aristotle and Classification

You will…

- understand how scientists use shared characteristics to classify living things.

What You Need to Know

Aristotle was a Greek scholar who lived from 384 to 322 BCE. He created the classification system shown in the table.

Animals with blood that…	Percentage of animals
fly 	22%
walk, run, or hop 	46%
Swim 	

Analyze and Interpret Data

1. **Write an Expression** Use variables to write an expression to find the percentage of animals that swim. Then complete the table.

2. **Classify** How did Aristotle organize the animals?

3. **Calculate** Suppose Aristotle based his classification system on 50 different animals. How many of those would be animals that fly? Show your work.

4. **Calculate** Suppose Aristotle based his classification system on 200 different animals. How many of those were animals that walk, run, or hop? Show your work.

5. **Analyze** Suppose Aristotle saw a snake while he was observing animals. How would he classify the snake according to his system? Explain.

Classification

1 Do you have a collection of treasures? Are they seashells, trading cards, coins? Do you organize your collection by color, name, or something else? Scientists organize Earth's estimated 8.7 million types of organisms based on similarities and differences.

Vocabulary Support

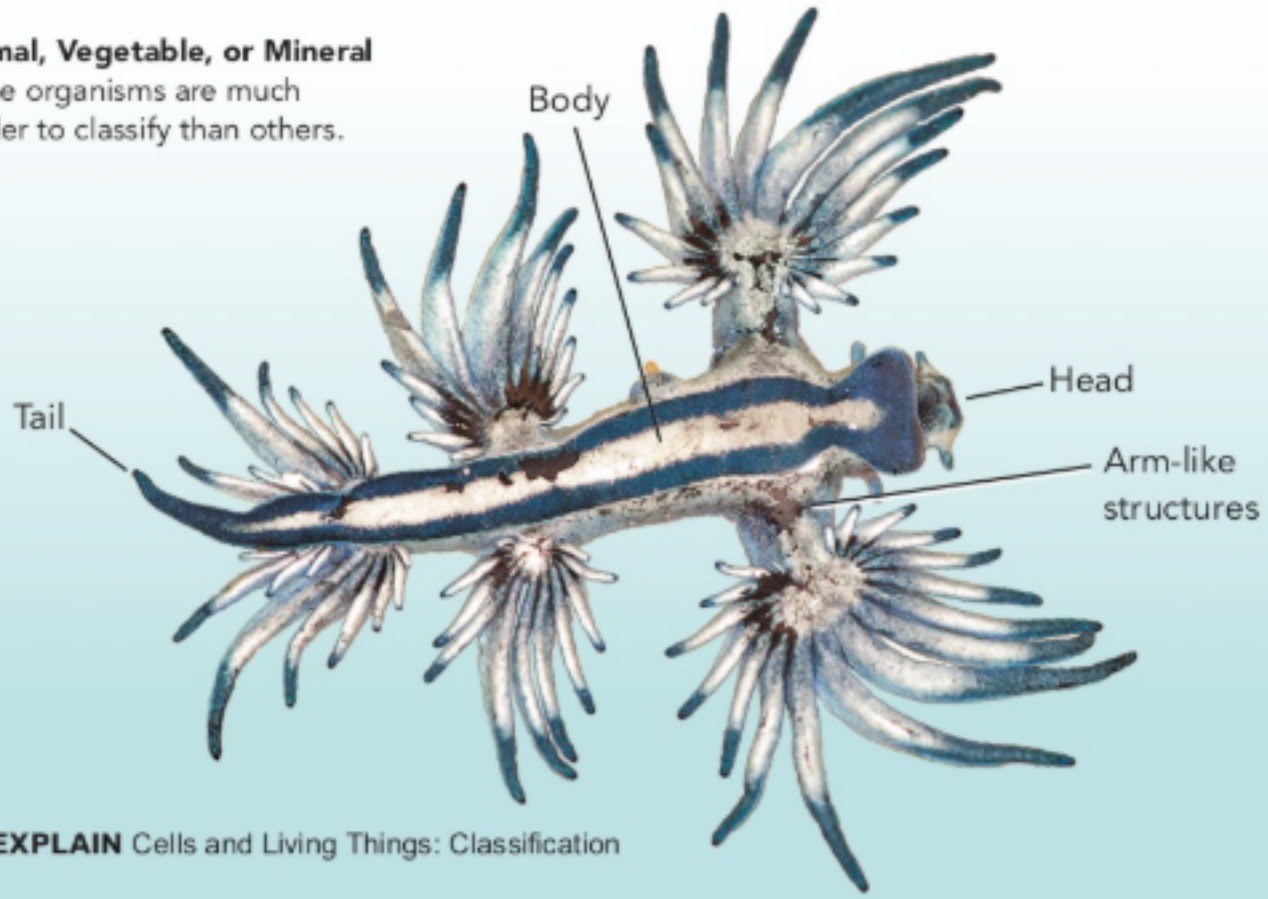
A *characteristic* is a feature of an object or organism that allows you to compare and contrast it with another. With a partner, list five observable characteristics of an animal you both know.

Organizing Organisms

2 Biologists place similar organisms into groups based on **characteristics** they have in common. **Classification** is the process of grouping things based on their similarities. To classify the organism in the figure, you'd first need to know about its characteristics. Then you could figure out which group it belonged to.

3 In the 1730s, biologist Carolus Linnaeus arranged organisms in groups based on their observable features. Then he gave each organism a two-part scientific name. The first word in the name is the organism's **genus**, which refers to a group of similar, closely related organisms. (The plural of *genus* is genera.) The second word refers to the species level and might describe where the organism lives or its appearance. This system in which each organism is given a unique, two-part scientific name that indicates its genus and species is known as **binomial nomenclature**. The scientific name itself is often referred to as a species name. A **species** is a group of similar organisms that can mate with each other and produce offspring that can also mate and reproduce. Scientists still use this naming system that classifies organisms according to their shared characteristics.

Animal, Vegetable, or Mineral
Some organisms are much harder to classify than others.



Taxonomy

4 The scientific study of classifying organisms is called **taxonomy** (tak-SAHN-uh-mee). Scientists use taxonomy to identify the name of an unknown organism or to name a newly discovered organism. For example, if you look closely at the characteristics of the organism in the photo on the previous page, you might guess it was a sea slug. It would then be simple to research sea slugs and find out that they are ocean animals related to slugs and snails. Sea slugs eat other animals by scraping away their flesh.

5 In the classification of organisms, the broadest level of organization is the **domain**. There are three domains: Eukarya, Archaea, and Bacteria. Eukarya (yoo-KA-ree-uh) includes the familiar kingdoms of Plantae, Animalia, and Fungi, and a less familiar kingdom, Protista, which has simpler organisms. Members of Domain Eukarya are called eukaryotes. Eukaryotes have nuclei containing DNA. Domain Archaea (ahr-KEE-uh) contains only the kingdom Archaebacteria. Its members are one-celled organisms with no nuclei in their cells. Members of Domain Bacteria, which contains the kingdom Eubacteria, also have only one cell and no nucleus, but bacteria have different structures and chemical processes from those of Archaea.

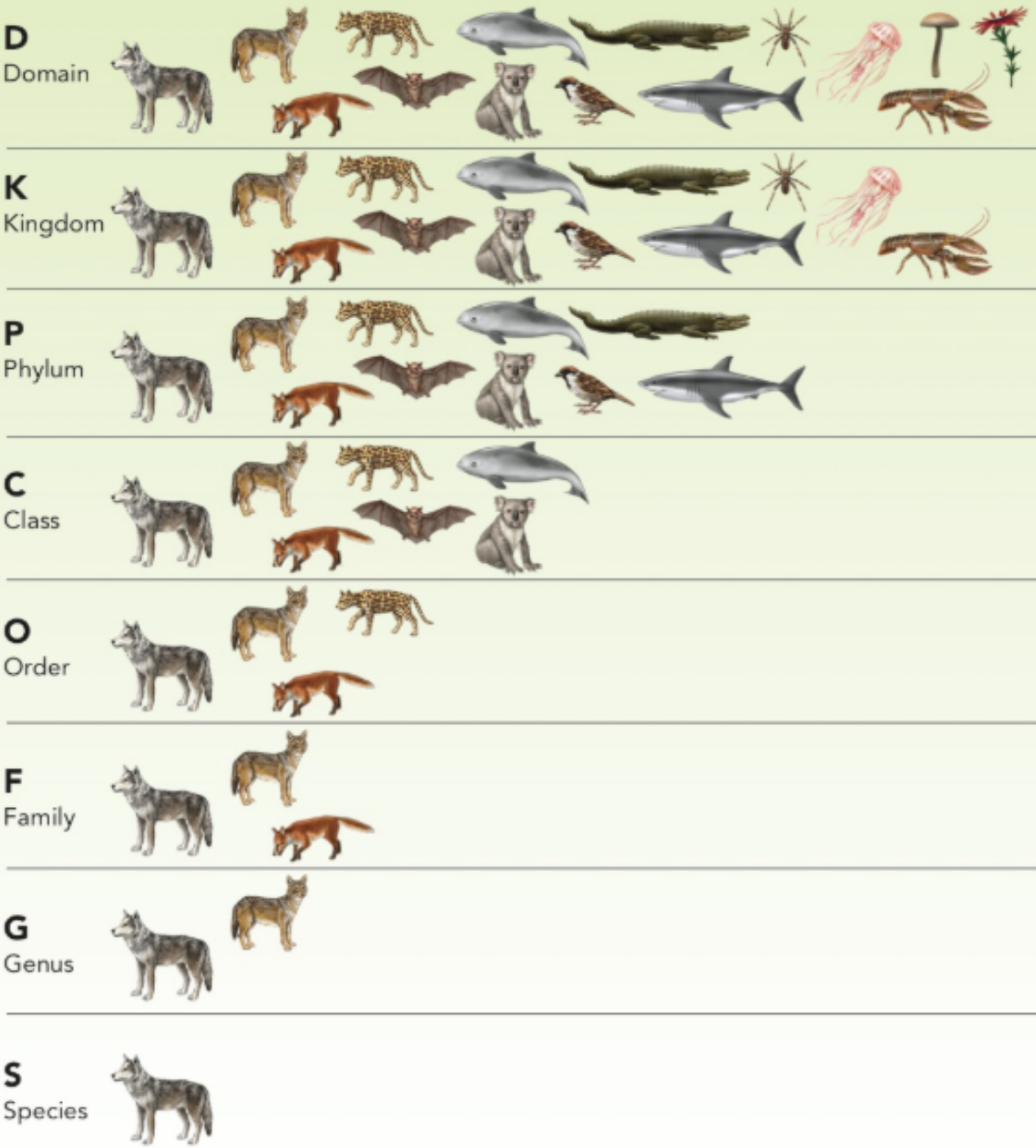
Literacy Support

Books become outdated, and the Internet is full of incorrect information. When you need an accurate answer to a scientific question, where do you look? Whom could you ask for help? Discuss your ideas with a partner.

Domains Because the gray wolf has a nucleus in its cells, it is in Domain Eukarya. Eubacteria, such as the *Lactobacillus acidophilus* in yogurt, have no nuclei and are different from Archaea, so they are in Domain Bacteria.

6 The figure below shows the Linnaean levels of classification for the gray wolf. The levels *domain, kingdom, phylum, class, order, family, genus,* and *species* indicate how similar organisms are. The fewer types of organisms in a level, the more specific their similarities are. The more organisms in a level, the more general their similarities are. For this reason, there are many more types of organisms at the Domain level than at the Genus level.

Levels of Classification This figure shows how the levels of classification apply to the gray wolf.



Scientific Names

7 As explained at the start of this lesson, the first word in an organism's scientific name is its genus, a classification level of closely related organisms. Each genus contains one or more species. The more classification levels two organisms share, the more characteristics they have in common and the more closely related they are. The photo to the right shows a giant puffball mushroom in the genus *Calvatia*. Another closely related kind of puffball is also in *Calvatia*. Other puffballs that are not as closely related are in other genera. The giant puffball's species name, *gigantea*, describes its size, but does not indicate how closely it is related to other species. Together, the two words that identify the genus and species form the scientific name.

8 A scientific name is written in italics. The first letter in the first word is capitalized. You will notice that most scientific names in binomial nomenclature are in Latin. Linnaeus used Latin in binomial nomenclature because it was the language used for European scientific research at the time. He also used it because it eliminated the confusion of different common names for the same organism in different areas.

Scientific Names vs. Common Names All of these mushrooms are commonly called puffballs.

Calvatia gigantea

Calvatia craniiformis

Lycoperdon echinatum

Confusing Common Names Is this a firefly, a lightning bug, a glowworm, or a golden sparkler? Different common names are used in different areas. Thankfully, this insect has only one scientific name, *Photinus pyralis*.

Evolution and Classification

9 When Linnaeus was alive, people thought that species never changed. Then Charles Darwin developed a new idea in the 1830s. Darwin sailed around the world for five years observing nature and collecting samples of fossils and animals. Darwin was fascinated by the relationships between modern and ancient species. He was one of the first scientists to understand **evolution**, or the process of change over time.

10 Darwin concluded that modern species evolved from earlier species over time through natural selection. **Natural selection** is the idea that some individuals are better adapted to their environment than others. Natural selection is the primary way organisms change over time. The better-adapted individuals are more likely to survive and reproduce than other members of the same species. So an increasing percentage of their species has their characteristics.

11 The scientific theory of evolution by natural selection is the organizing principle of life science. Like cell theory, the theory of evolution is a well-supported and widely accepted explanation of nature, and not simply the claim of an individual. Evidence from thousands of scientific investigations supports the theory of evolution. As understanding of evolution has increased, biologists have changed how they classify species. Scientists now understand that groups of organisms may be similar because they share a common ancestor and evolutionary history. The more similar groups are, the more recent their common ancestor is.

Evolution of Whales and Dolphins Darwin compared ancient and modern species to develop his theory of evolution by natural selection. The bones of the organisms below show their evolution into a modern dolphin.

50 million years ago (mya)

Pakicetus, land-dwelling, four-footed mammal

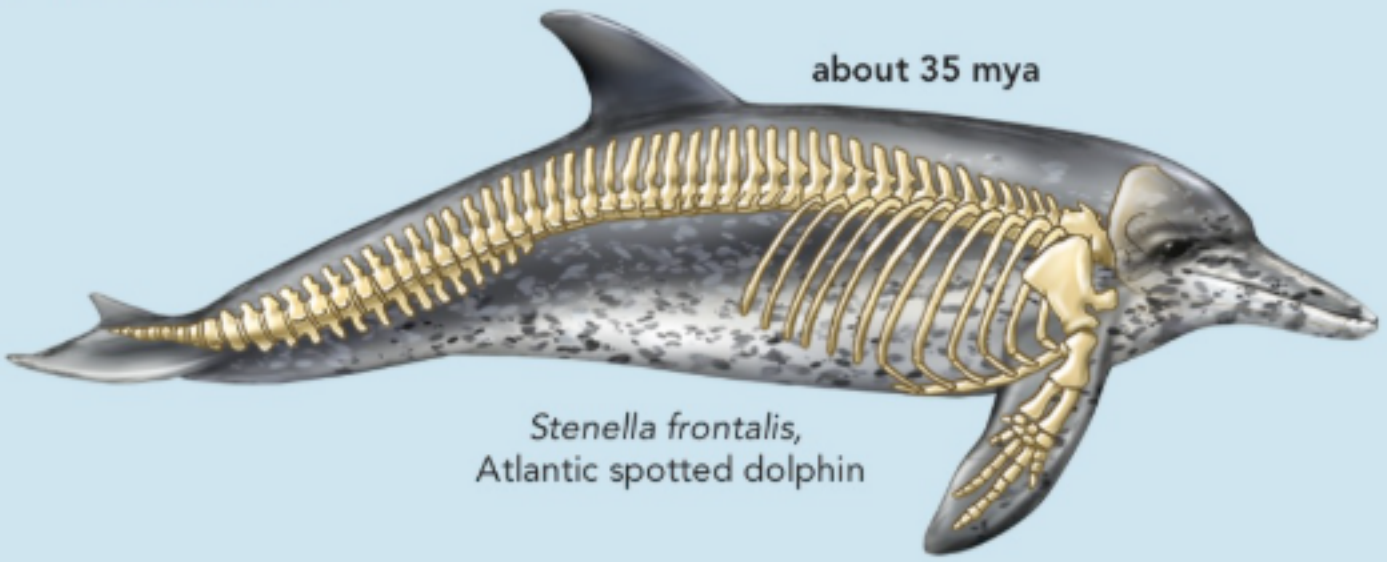
48 mya

Ambulocetus, "walking whale," mammal lived both on land and in water

34-40 mya

Dorudon, "spear tooth," water-dwelling mammal

about 35 mya



Stenella frontalis, Atlantic spotted dolphin

12 Scientists research the evolutionary history of a species by comparing several forms of evidence. They also compare the genetic information contained in the DNA of organisms' cells. Sometimes unrelated organisms that live in similar environments evolve similar characteristics, as shown in the figure below.

13 Sharing common characteristics, however, does not necessarily mean that organisms are closely related. The process by which unrelated organisms evolve similar characteristics is called **convergent evolution**. When scientists discovered convergent evolution, they had to change the placement of organisms within the classification system. Because scientific research leads to discovery and new knowledge, scientists sometimes reclassify organisms according to new evidence. Though scientific knowledge is supported by evidence, it is also open to change based on new evidence.

Convergent Evolution Over time, these three organisms evolved the characteristic of flight. But they are not closely related.

NAME _____ CLASS _____ DATE _____

Reading Check

Classification

Answer the following questions after you have completed reading the Read About It.

1. **Vocabulary** In paragraph 2, you read about biologists using shared characteristics of organisms to place them in group. What is a characteristic?

2. In paragraph 3, you read about the two-part scientific names that are part of the Linnaean system of classification. What is that two-part name called? What is the first name and what does it tell you?

3. In paragraph 4, you read about the scientific study of classifying organisms. What is it called, and what are two ways scientists use it?

4. In paragraph 5, you read about domains. List the domains and the kingdoms in each.

5. In paragraph 6 and the figure, you learned about levels of classification. Which are the most general and least general levels of classification we now use?

   A. most general: domain; least general: genus

   B. most general: species; least general: domain

   C. most general: domain; least general: species

   D. most general: genus; least general: species

6. In paragraphs 7 and 8, you read about the importance of binomial nomenclature. Why is it important for organisms to have scientific names?

7. **Vocabulary** In paragraph 9, you read about evolution. Define *evolution*.

8. In paragraphs 10 and 11, you read about evolution by natural selection. Identify **two** true statements about evolution by natural selection.

   A. Natural selection is a necessary part of evolution.

   B. Natural selection is based on how scientists classify organisms.

   C. Evolution is supported by multiple forms of evidence.

   D. Evolution shows scientists how DNA can be compared.

9. In paragraphs 12 and 13, you read about convergent evolution. Describe an example of convergent evolution.

NAME _____ CLASS _____ DATE _____

Extend and Enrich Activities

Classification

1. **Model** Use the graphic organizer to make a mnemonic for the Linnean levels of classification. Fill each box with one word. Create a sentence or a rhyming scheme you can remember.

D	K	P
C	O	F
G	S	

2. **Apply** Draw a T-chart to categorize several organisms as animal or not animal. Choose at least six organisms to categorize.

NAME _____ CLASS _____ DATE _____

Lesson Review

Classification

1. What are the three domains?

   A. Eukarya, Bacteria, and Plants

   B. Bacteria, Plants, and Protists

   C. Archaea, Bacteria, and Eukarya

   D. Animals, Fungi, and Plants

2. In the Linnaean system of classification, which levels contain more kinds of organisms than the phylum?

   A. domain and kingdom

   B. genus and species

   C. kingdom and class

   D. order and family

3. What choice shows the levels of classification from broadest to most specific?

   A. domain phylum, kingdom, class, genus, order, family, and species

   B. domain kingdom, phylum, class, order, family, genus, and species

   C. genus order, class, kingdom, family, phylum, domain, and species

   D. kingdom species, genus, family, phylum, kingdom, class, and domain

4. Which of the following statements most accurately explains how scientists classify animals?

   A. By examining an organism's physical characteristics and comparing them to those of extinct organisms.

   B. By examining an organism's physical characteristics and comparing them to those of living and extinct organisms.

   C. By examining an organism's DNA and comparing it to the DNA of living and extinct organisms.

   D. By examining an organism's physical characteristics and comparing them to those of a common ancestor's fossil.

NAME _____ CLASS _____ DATE _____

Phenomenon Activity

The Functions of Human Body Systems

I can...

- identify the general functions of the major systems of the human body.

Vocabulary

circulatory system digestive system endocrine system excretory system hormones immune system integumentary system muscular system nervous system regulate reproductive system respiratory system skeletal system

Phenomenon Why can having asthma make a person feel tired?

Photo Credit: JPC-PROD/Shutterstock

Develop a Model Draw a model with labels and captions to explain the main function of the respiratory system and how having asthma might make a person feel tired.

NAME _____ CLASS _____ DATE _____

Hands-On Lab

Gathering Information

You will…

- test your reaction time by seeing or hearing how quickly you can catch a dropped ruler or meter stick.
- test your touch sense by doing a two-point threshold with two toothpicks.
- test your vision by using two pencils to check how your eyes use sight to perceive depth.

What You Need to Know

Have you ever wondered how your body can quickly react or respond to changes in your surroundings? What allows you to move, think, and act? The sensory organs—eyes, ears, nose, tongue, and skin—communicate with the brain, spinal cord, and nerve cells (neurons). Together, the parts of the nervous system control and coordinate the body's activities. In this investigation, you will try out three sensory stations. You will explore how information is gathered and how the body uses that information.

Materials Per Group

- 30-cm ruler
- 2 toothpicks
- 2 pencils
- modeling clay
- metal nut
- a table with a hard surface

Safety Precautions

Be sure to follow all safety precautions provided by your teacher.

⚠ Be careful with the sharp ends of toothpicks.

Procedure

Station I: Measuring Your Reaction Time – Ruler-Drop Test

1. When a ball is moving towards you, there is a slight delay before you try to catch it. This delay is called your reaction time. At Station I, you will test your reaction time by seeing or hearing how quickly you can catch a dropped ruler or meter stick.
2. Write a hypothesis stating whether you think you will have a faster reaction time by performing the test using your sense of hearing (eyes closed) or sight (eyes opened).

   _____

   _____

3. Based on your hypothesis, identify one independent variable (manipulated variable) and one dependent variable (responding variable).

   _____

   _____

4. Hold a ruler vertically with one of your arms stretched out. Your fingers should be at the highest measurement of 30 cm.
5. Your lab partner should keep their thumb and index finger slightly open at the bottom of the ruler. The ruler should fit between their opened fingers so that the 0-cm mark is just above the fingers.
6. Release the ruler. Your lab partner should catch the ruler.
7. Record where your partner's fingers are on the ruler. The reading should be taken on the top side of the fingers holding the ruler.
8. Repeat Steps 3–6 for all members in your group, including yourself. Each person should have three trials and record the mean, or average, value of three trials.
9. The person with the fastest reaction time is the one who catches the ruler at the lowest measurement (cm). (The sooner the ruler was caught, the less time it had to fall.)
10. After completing the challenge with your eyes open, test your reaction time with your eyes closed (but with your ears listening). The person holding the ruler will tell the listener when the ruler is about to be dropped. Repeat Steps 3–6.

11. Record your measurements in the data table.

Senses Used	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Mean of Three Trials (cm)
sight				
hearing				

12. Create a bar graph comparing the data for the trials for each sense used.

Station II: Measuring Your Touch Sense – Two-Point Threshold

13. Different types of nerve endings found in skin receive information about touch, pressure, pain, temperature, and vibration. At Station II, you will test your sense of touch on different parts of your hand by using two toothpicks to do a two-point threshold.

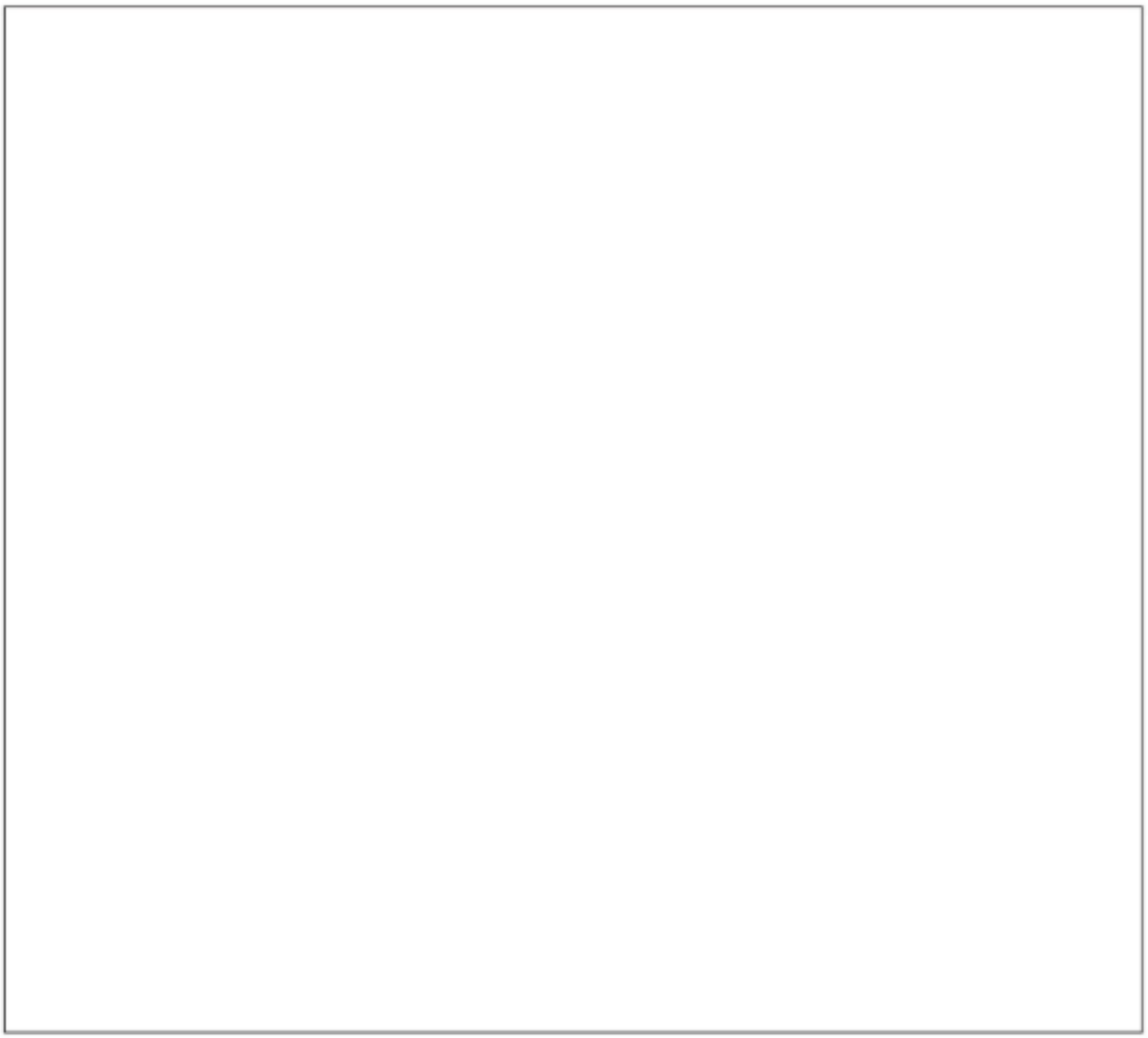
14. Close your eyes. Your partner will gently tap you with the end of one or two toothpicks. Each time they tap you, state whether you feel one point or two points. Do not guess; just state what you actually feel.

15. When using two toothpicks, begin with the tips 2 mm apart. Tap the points evenly so they touch the skin at the same time. Move the toothpick tips apart in 1-mm increments until your partner says they feel two points. Then, record the distance in the table. Perform three trials on each location and calculate the mean.

16. Repeat Steps 12 and 13 for all members in your group, including yourself. Each member should record their results in their own data table.

Two-Point Threshold (Touch Sense)				
My Results	**Trial 1 (cm)**	**Trial 2 (cm)**	**Trial 3 (cm)**	**Mean of Three Trials (cm)**
tip of the index finger				
inside of palm				
forearm				
back of hand				

17. Create a bar graph comparing the mean you calculated for each location.



Station III: Checking Your Depth Perception – Two-Point Threshold

18. Sight is an important way to learn about your surroundings. At Station III, you will use two pencils to check how your eyes use sight to perceive depth.

19. Hold a pencil horizontally in each hand with the points facing each other. Hold your arms out on each side and close one eye.

20. With one eye closed, bring your arms forward. Can you bring the pencil points together so that they touch? When one eye is closed, you see in 2D. Now try that again with both eyes open (3D).

21. Place a metal nut on top of one pencil. Use modeling clay to hold the nut in place. Repeat Step 17.

22. With one eye closed, bring your arms forward. Can you slide one pencil through the nut on the other pencil? Now try that again with both eyes open.

23. Record your observations in the data table.

Test	3D versus 2D (Depth Perception)
two pencil points touching	
sliding a pencil through a nut	

Analyze and Interpret Data

1. **Explain** How do you think your body receives information from the surrounding environment? How do you think yo ur body responds to that information? Use evidence from one of the stations to support your answer.

2. **Develop Models** Work with a partner to draw a model showing the pathway of the nervous system for receiving and responding to information. Use one of the stations you completed. Label your drawings.

3. **Cause and Effect** At Station II, for each part of your hand and arm, why do you think that you did not feel the two toothpicks until they were a certain distance apart?

4. **Draw Conclusions** At Station III, why do you think depth perception was more difficult with one eye closed?