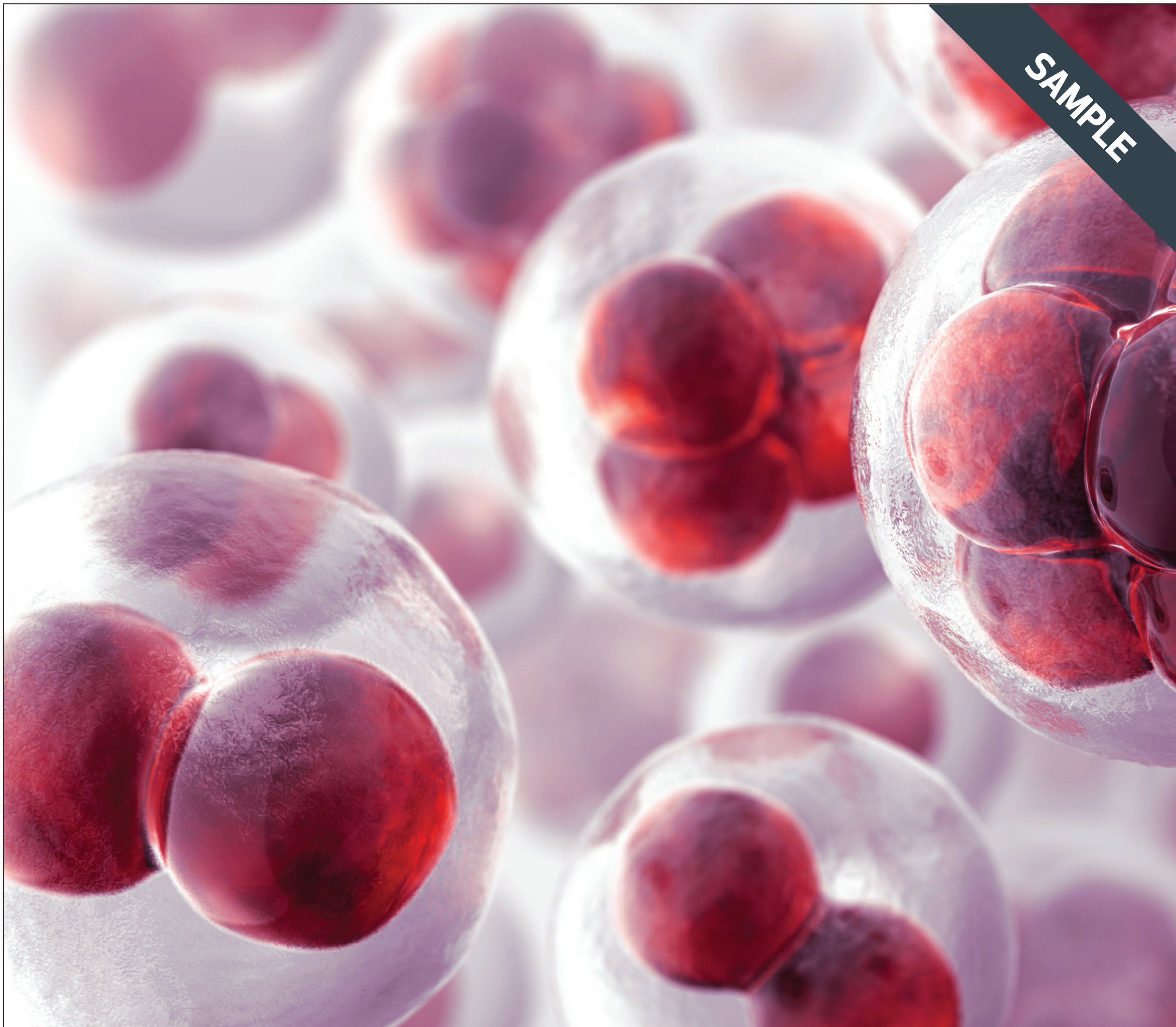

SAMPLE

COMMON CORE BASICS

Building Essential Test Readiness Skills
for High School Equivalency Exams

McGraw Hill Education

SCIENCE

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Contents

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To the Student

Common Core Basics: Building Essential Test Readiness Skills, Science will help you learn or strengthen the skills and concepts you need when you take any Common Core State Standards-aligned science test. The book's instructional content is based on the National Science Education Standards of the National Academy of Sciences.

In this book, you will focus on important concepts in three broad areas of science—Life Science, Physical Science, and Earth and Space Science.

Before beginning the lessons in this book, take the Pretest. This test will help you identify which skill areas you need to concentrate on most. Use the chart at the end of the **Pretest** to identify the types of questions you have answered incorrectly and to determine which concepts or skills you need to study further. You may decide to concentrate on specific areas of study or to work through the entire book. The latter decision is recommended, as it will help you to build a strong foundation in the core areas in which you will be tested.

Common Core Basics: Building Essential Test Readiness Skills, Science is divided into three units.

Unit 1: Life Science covers the fundamentals of biology:

- **Chapter 1: Human Body and Health** teaches you about human body systems and how those systems interact. It also teaches about health and disease.
- **Chapter 2: Life Functions and Energy Intake** describes flowering plants and the energy-producing processes of cellular respiration and fermentation.
- **Chapter 3: Ecosystems** explains ecosystem structure, limitations within ecosystems, relationships among living organisms, and the impact of environmental disturbances.
- **Chapter 4: Foundations of Life** teaches you about plant and animal cells, simple organisms, invertebrates, and vertebrates.
- **Chapter 5: Heredity** explains the genetic code and teaches you about inherited traits.
- **Chapter 6: Evolution** explains the process of natural selection and how life changes over time.

Unit 2: Physical Science covers the fundamentals of physics and chemistry:

- **Chapter 7: Energy** describes energy, waves, electricity, sources of energy, and endothermic and exothermic reactions.
- **Chapter 8: Work, Motion, and Forces** explains Newton's laws of motion, forces, and simple machines.
- **Chapter 9: Chemical Properties** teaches you about matter, atoms, compounds and molecules, chemical reactions, solutions, organic chemistry, and chemical equations.

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Unit 3: Earth and Space Science covers the fundamentals of Earth and space sciences:

- **Chapter 10: Earth and Living Things** describes the cycles of matter and the formation of fossil fuels.
- **Chapter 11: Earth** provides an overview of geology, oceanography, and meteorology.
- **Chapter 12: The Cosmos** teaches you about the origins of the universe, the Milky Way, the solar system, and Earth and the Moon.

In addition, *Common Core Basics: Building Essential Test Readiness Skills, Science* also includes a number of special features to guide your progress:

- The **Chapter Opener** provides an overview of the chapter content and a goal-setting activity.
- **Lesson Objectives** state what you will be able to accomplish after completing a lesson.
- **Skills** list the Core Skills and Reading Skills that are applied to lesson content. The Core Skills align to the Common Core State Standards.
- **Vocabulary** terms essential for understanding are listed on the opening page of a lesson. Bold words in the text are listed in the Glossary.
- The **Key Concept** summarizes the lesson's content focus.
- Instruction and practice are provided for **Core Skills** and **Reading Skills** in the context of lessons. Special features, including **21st Century Skills,** help you apply higher-order thinking skills to real-world examples.
- **Think About Science** questions check your understanding of content throughout a lesson.
- **Write to Learn** activities give you a purpose for writing.
- An end-of-lesson **Vocabulary Review** checks your understanding of important lesson vocabulary, whereas **Skill Review** and **Skill Practice** help you assess your learning of content and fundamental skills.
- The **Chapter Review** tests your understanding of the chapter content.
- **Check Your Understanding** charts link items to corresponding review pages.
- The **Answer Key** explains the answers for questions in the book.
- The **Glossary** and **Index** contain key terms found throughout the book and make it easy to review important skills and concepts.

After you have completed the book, take the **Posttest** to see how well you have learned the concepts and skills the book presents.

Keep in mind that learning the fundamentals of science will help you understand practical aspects of daily life and provide the framework for more advanced studies in science. Good luck with your studies!

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LESSON 3.4

Disruption

Lesson Objectives

You will be able to

- Identify laws of ecology
- Give examples of environmental disruptions
- Explain the consequences of disruptions

Skills

- **Reading Skill:** Determine Meaning
- **Core Skill:** Cite Textual Evidence

Vocabulary

abiotic
biodiversity
biotic
degradation
destruction
endangered
fragmentation
invasive species
threatened

KEY CONCEPT: **A disruption is a change that greatly alters an environment. Disruptions transform environments. In some cases, one ecosystem can temporarily or permanently replace another. In other cases, an ecosystem can become degraded, making it unfit for living things. Still other ecosystems are destroyed altogether.**

Take a walk outside and look around. No matter where you live, no matter where you are, the organisms that surround you make up an ecosystem. You may see plants, animals, rocks, soil, and water. An ecosystem also includes microorganisms that you don't see. Within an ecosystem, organisms interact with one another and with their physical and chemical environment. Although no ecosystem remains static, or unchanging, a healthy ecosystem maintains equilibrium, meaning it keeps balance among its species. These species depend on the stable functions of each other and the water, gases, and essential chemicals that cycle through every ecosystem.

The Laws of Ecology

An ecosystem is composed of biotic and abiotic factors. **Biotic** factors include all living organisms, from single-celled microbes to huge land and water mammals. **Abiotic** factors are the nonliving components of an ecosystem, including water, gases in the air, and minerals in rocks and soil. **Ecologists** are scientists who study the interactions between the biotic and abiotic factors within an ecosystem.

Decades ago, ecologist Barry Commoner described four basic laws of ecology that apply to all ecosystems.

1. Everything is connected to everything else. What happens to one organism within an ecosystem affects all organisms in some way.
2. Everything goes somewhere. Nature doesn't create waste, and it doesn't throw things away. What exists remains in existence in one form or another.
3. Nature knows more than humankind. Things are always changing within nature. When humans cause those changes, however, the changes are likely to be harmful to the system.
4. Everything has limits. That is, there is only so much nature that humans can exploit, or take advantage of. When humans use natural resources, those resources eventually change from useful to useless forms.

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Responding to Change

As Commoner's third law of ecology tells us, nature is always changing. And as his first law says, all living and nonliving elements within an ecosystem are connected. What happens to one affects all.

Within an ecosystem, organisms live in equilibrium, or balance, responding to the natural changes that are constantly occurring within any system. Some changes, however, are larger than others. All ecosystems respond to **disruptions**, which are breaks or interruptions in normal events. Nature causes some of these disruptions. Humans cause others.

Fire and Floods as Disruptions

Raymond Gehman/Corbis

Fire, both natural and caused by human behavior, is a common disruption. Natural fires can both harm and help a forest ecosystem. For example, after a wildfire, soils absorb nutrients from the charcoal and ash left after vegetation burns. The soil is warmer, too, encouraging microbial activity. However, intense heat can also cause soil particles to repel, or shed, water instead of allowing the water to soak in. After a fire, the water-resistant soil causes soil **erosion**, as rainwater carries soil away.

Some animals are affected more than others during a fire. Small animals, insects, and sick or old organisms may die. Larger animals are normally able to flee to safety. The fires, which destroy food resources, make it impossible for these animals to return immediately after the fire. This, however, gives other organisms opportunities for survival. **Scavengers**, or organisms that feed on dead plant and animal matter, take advantage of new food resources. Also, areas once thick with trees are laid bare, making it easier for predators to find prey.

Reading Skill
Determine Meaning

Every area of study has its own collection of vocabulary terms. Professionals within those areas of study rely on those terms to communicate their work in writing, to ask questions, and to exchange ideas.

Science is rich with specialized vocabulary. Many of its terms have Greek or Latin origins. With an understanding of these origins, it is often possible to define unfamiliar terms. For example, the prefix *eco-* comes from a Greek word that means "home." The Greek word *logos* means "knowledge," leading to the suffix *-ology*, which means "the study of." Literally, then, the word *ecology* means "the study of home."

Read the common prefixes and suffixes in the chart. As your read the lesson, circle or highlight words that use these word parts to help you understand their meaning.

Affix	Origin	Meaning
bio–	from the Greek *bio*	life
a–	from the Greek *a* or *an*	not, without
inter–	from the Latin *inter*	between
–brium	from the Latin *libra*	balance, scale
dorm–	from the Latin *dormir*	to sleep

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New plants begin to grow, and increased quantities of seeds on the forest floor encourage birds to feed. The burning of trees and other plants make more nutrients, light, and water available to survivors. With such resources suddenly available, new and surviving plants grow more quickly. Among the benefits of fire is the destruction of harmful plant parasites, like mistletoe, that rob trees of essential nutrients. Another benefit is seed production, as some plants require the heat of wildfires to open their seeds.

Like fire, flooding can cause both harmful and beneficial consequences. Those consequences depend on where floods occur, how long they last, how deep and swift the waters are, and how sensitive the environment is to such disruption.

Floods can lead to the loss of plant and animal life, as well as loss of soils. They can also lead to new life. Some plant seeds remain **dormant**, or inactive, until heavy rains occur. Then these seeds sprout, leading to new growth. Some insects and reptiles that remain inactive during periods of hot or dry weather emerge from their resting state.

THINK ABOUT SCIENCE

Directions: Think about the effects of fire and floods on habitats. List some of the advantages and disadvantages of such disturbances.

Advantages	Disadvantages
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

Introduced Species as a Disruption

Since the 1700s, about 40 percent of the species on Earth have become **extinct**, meaning they have died out completely. Scientists think that the human introduction of foreign species into environments that are not natural to these species has probably contributed to the massive extinction over recent centuries.

An **invasive species** is an organism that humans move from its natural environment to a new, foreign environment in which it causes harm. Sometimes, the introduction of an invasive species is accidental. At other times, it is done for a purpose.

An example of an accidental introduction comes from shortly after World War II, when military troops shipped cargo from Papua New Guinea to the

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Pacific island of Guam. Until then, Guam had no snakes other than a kind of blind, worm-like snake that fed on termites and ants. However, it is likely that a brown tree snake hitched a ride with the cargo. By the early 1960s, tree snakes inhabited more than half of the island. After only a few more years, they had colonized the entire island. As the tree snake population grew, native bird populations shrank. By the time the US Fish and Wildlife Service began listing species as endangered or threatened in 1984, most of the native forest bird species were extinct.

In the late 1800s, a group of Americans organized a club for the purpose of bringing birds mentioned in the plays of William Shakespeare to the United States. In 1890 and 1891, the club's members released about 100 starlings into Central Park. The species flourished. Today, their population exceeds 200 million, and the birds live across the country. Scientists continue to study their effect on native species.

Clémente Philippe/Arterra Picture Library/Alamy

In the 1930s, the US Department of Agriculture imported a Japanese plant called kudzu, and they paid southern farmers to plant it as a means of controlling soil erosion. At first, the plant's rapid growth was considered a success story. However, today some people call kudzu "the plant that ate the South." Able to grow as much as two feet per day, kudzu blankets other vegetation, blocking sunlight. The plants beneath the kudzu die, eliminating potential food and shelter for native animals. Kudzu roots also penetrate the soil, where they affect water levels throughout ecosystems. Kudzu is such a successful invasive species that it has been labeled as one of the 100 worst invasive species on Earth.

THINK ABOUT SCIENCE

Directions: Answer the question below.

What makes human beings an example of an invasive species?

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Habitat Loss as a Disruptive Force

Some scientists identify the disruptive effect of human activity on natural habitats as the greatest threat to Earth's **biodiversity**. *Diversity* means "variety," so biodiversity refers to various forms of life, including the variety of species and genes. Agriculture, forestry, mining, urban growth, and the pollution that comes with these human efforts have led to massive habitat loss. The International Union for Conservation reports that human interference has caused the rate of species extinction to increase 1,000 times its natural rate.

21st Century Skill
Media Literacy

Scientists began associating starlings with the decline of native bird species as early as 1921. They blamed starlings for the decline of the Eastern bluebird that builds nests in tree cavities. Research has continued, but it hasn't all come to the same conclusion.

For example, in one report, scientists state that the starling actually has had little effect on native bird species, including the Eastern bluebird. The only declining bird population, they say, that can be attributed to the presence of starlings is that of the sapsucker.

Among the skills linked to media literacy is the ability to analyze and evaluate media. With the wealth of available media growing daily, it is critical that readers accept that not all information is reliable. Some information, as in the example in the first paragraph, may be based on incomplete or outdated research. Only further research and analysis can lead to conclusions that are more likely to be accurate.

What are some media sources you could use to gather more information about the effects of European starlings on native bird species?

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Core Skill
Cite Textual Evidence

The International Union for Conservation of Nature and Natural Resources (IUCN) has produced the Red List of Threatened Species™. A **threatened** species remains abundant but is likely to become **endangered**, or on the verge of extinction, if not protected. Currently, the IUCN identifies habitat loss as the main threat to 85 percent of threatened and endangered species on the list.

Cite the textual evidence from this lesson that most strongly supports their conclusion. To do this, first reread the lesson text, and then look for page numbers and paragraphs where information on threatened and endangered species can be found. Then, when you find the information, highlight it, put a star next to it, or circle it.

Habitat loss includes habitat **degradation**, or the loss of habitat due to pollution or the introduction of invasive species. In habitat **fragmentation**, remaining wildlife areas are separated and divided into sections by roads, dams, and other structures. The remaining sections are often too small or they restrict access to larger areas where species can find food and mates. Fragmentation also makes it less likely that migratory animals will have the places they need to rest and feed along their routes.

In habitat **destruction**, habitats are destroyed. People use machines to cut or knock down trees, to fill wetlands with soil in preparation for building, and to scoop sediments and soils from river bottoms for the purpose of building waterways and dams and reclaiming land. Some powerful examples of habitat destruction are found in the United States. According to the US Fish and Wildlife Service, more than 85 percent of forest habitats have been permanently destroyed or logged. More than 75 percent of forests growing along waterways such as streams have been destroyed. In Michigan, 99 percent of mature oak and beech-maple forests are gone. In Oregon, nearly all of the state's temperate rain forest has been destroyed. Across the country's prairies, 95 percent of grasslands have been planted with crops or destroyed. In the Southwest, where desert conditions exist, cattle have overgrazed more than 90 percent of sagebrush habitats.

Leading causes of habitat destruction include agriculture, the conversion of land to building sites and parking lots, and water-development projects, such as dams. They also include pollution, particularly of freshwater resources. In some places, untreated sewage and other human waste enter water resources. So do metals and acids from mines and fertilizers and pesticides from farms.

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Vocabulary Review

Directions: Fill in the blanks with the word that best fits the sentence.

abiotic biodiversity biotic degradation destruction endangered fragmentation invasive species threatened

1. A species that is presently abundant in its native habitat but is likely to become extinct without protection is classified as ______________.
2. Rocks, minerals, soil, and water are examples of ______________ factors in an ecosystem.
3. An ______________ is accidentally or deliberately introduced to a non-native ecosystem.
4. Species may be unsuccessful in finding enough space and food, as well as finding mates in a habitat that has undergone ______________.
5. Rodents, mammals, and bushes are examples of ______________ factors in an ecosystem.
6. Paving land to make parking lots is an example of habitat ______________.
7. ______________ describes the variety of all forms of life on the planet.
8. When human waste enters freshwater, it can cause habitat ______________, making it unfit for living things.
9. A species with so few members that an ecological disturbance could cause it to disappear entirely is ______________.

WRITE TO LEARN

The IUCN produces Biodiversity Indicators, or mathematical measures of biodiversity. People can use these measures to understand factors that affect biological and genetic diversity. Explain how such information could be helpful to decision makers in government.

Skill Review

Directions: Read the passage. Then answer the questions that follow.

In 1859, Thomas Austin released about one dozen European rabbits from his property in Australia. Today, the descendants of these rabbits live throughout the continent, from coastal plains to deserts. The rabbits compete with native species for food and other resources, perhaps causing the extinction of several ground-dwelling mammals. They also damage vegetation, stripping bark from trees and eating seeds and seedlings, preventing regrowth. In some places, rabbits have eliminated all vegetation, leaving only bare rock behind.

1. Use the example of wild European rabbits in Australia to explain the term invasive species to someone unfamiliar with the concept.

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Skill Review (continued)

2. Describe the relationship between wild European rabbits and habitat loss.

3. Officials have undertaken a number of steps to control the populations of wild European rabbits, including the use of poisons. Use Commoner's second law of ecology to write an argument opposing the use of poisons.

4. Write two questions you might ask officials in charge of controlling the movement of species in and out of Australia today.

Skill Practice

Directions: Read the passage. Then answer the questions that follow.

The glassy-winged sharpshooter is a successful invasive species. This leaf-hopping insect, a native to the southeastern United States, may have accompanied a delivery of ornamental or agricultural plants to California. In its new, non-native home, the sharpshooter threatens the health of a number of plants, including grapes. That is because the insect carries disease-causing bacteria that it injects into plant fluids as it's feeding. Another sharpshooter feeds from the same plant and ingests the bacteria, which multiply in its mouthparts. When the second insect feeds on a new leaf, it spreads the bacteria, and the process continues. It takes very few insects to spread the disease, and at present, there is no cure for the disease or effective way of controlling the insect population.

1. Imagine you are speaking to a group of wine producers, who grow grapes for making wine. Explain the problem to them in terms they will understand.

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Skill Practice (continued)

2. Given that there is no cure for the disease spread by the glassy-winged sharpshooter, what solution would you propose to a wine producer who found a few insects on grape leaves?

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3. How has a global economy led to problems such as the glassy-winged sharpshooter?

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Directions: Think about what you learned about the kinds of habitat loss.

4. Use the following table to identify, define, and give one example of each kind of habitat loss.

Kind of Loss	Definition	Example

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LESSON 7.5

Endothermic and Exothermic Reactions

Lesson Objectives

You will be able to

- Recognize endothermic and exothermic reactions
- Relate changes in energy to endothermic and exothermic reactions

Skills

- **Core Skill:** Make Predictions
- **Core Skill:** Follow a Multistep Procedure

Vocabulary

activation energy
catalyst
chemical reaction
compounds
endothermic
exothermic
potential energy
product
reactant

KEY CONCEPT: **Chemical reactions change one substance into another and change their potential energy. When energy is released, the chemical reaction is called exothermic. When energy is absorbed, it is called endothermic.**

When you get a haircut you change the length of your hair, one of your hair's physical properties. Physical properties also include characteristics such as mass, volume, density, color, texture, and shape.

Like all matter, your hair has chemical properties, too. It has cells filled with pigments that give hair its color. But even after a haircut, chemical properties remain unchanged.

The chemical properties of matter describe how the matter reacts in the presence of other chemicals. For example, many science students build models of active volcanoes. They pour baking soda, or sodium bicarbonate ($NaCHO_3$), into the cone. Then, they add vinegar, CH_3COOH. The substances undergo two rapid chemical reactions. Carbonic acid forms but immediately changes into carbon dioxide and water. The carbon dioxide gas enters the air, and the liquid that is left is a solution of sodium acetate and water. In other words, the original matter is transformed into new matter.

Chemical Reactions

All matter is made of chemical elements. A drop of water, a plant leaf, a skin cell, and a soap bubble all are examples of matter, and so they are also made of chemicals.

Some chemicals are pure, meaning they are made of one kind of atom. Other chemicals are **compounds**, meaning they are made of more than one kind of atom.

The smallest unit of a chemical that has all of the properties of that chemical is a **molecule**. A molecule of the chemical known as water is always made of two atoms of hydrogen bonded to one atom of oxygen. You may recognize its chemical abbreviation, H_2O.

A molecule of the chemical called table salt is always made of one atom of sodium bonded to one atom of chlorine. The abbreviation for a molecule of salt is NaCl.

Some chemicals react when they meet. Their atoms interact to make a new molecule of a different kind of matter with properties different from the properties of the original chemicals. This interaction and the production of a new chemical is called a **chemical reaction**.

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A Familiar Example

Examine the following chemical reaction. It is probably familiar to you.

$6CO_2 + 6H_2O$ in the presence of sunlight $\Rightarrow C_6H_{12}O_6 + 6O_2$

Put into words, this statement says that in the presence of sunlight, 6 molecules of carbon dioxide interact with 6 molecules of water to produce new matter, one molecule of glucose and 6 molecules of diatomic (meaning "two atoms") oxygen.

Have you determined what this chemical reaction describes? It is the process of photosynthesis. Sunlight provides the energy necessary for carbon dioxide and oxygen to interact and produce sugar, or food for a plant. The process also produces oxygen, which leaves the plant as waste and enters the atmosphere.

Kinds of Energy

This is a good opportunity to recall the meanings of several words. The first is *work*. **Work** is when a force acts upon an object in the direction of its motion.

Two other words that are good to recall describe two kinds of energy, kinetic and potential. Remember that kinetic energy is the energy of motion. When you run, dance, and tie your shoes, the energy you have because of your movement is called kinetic energy. Kinetic energy exists at the molecular level, too, as atoms vibrate.

While kinetic energy is the energy of motion, potential energy is stored energy. It is the potential energy a substance has for doing work because of its position or its structure. Suppose, for example, that you hold a basketball above your head. Its position above the ground gives it **gravitational potential energy**. If you drop the ball, the force of gravity works upon the ball in a downward direction. The potential energy changes into kinetic energy.

Consider another example of potential energy. Imagine a rubber band. It has **elastic potential energy**. If you apply a force, such as pulling, the rubber band's potential energy is converted into kinetic energy.

Now consider a third kind of potential energy. The structure of a molecule gives it **chemical potential energy**. An attractive force exists between the atoms in a molecule, meaning they are attracted or drawn to each other. This force represents a kind of potential energy that changes to kinetic energy during a chemical reaction.

21st Century Skill
Creativity and Innovation

Science is a creative process. When experiments don't work as expected, scientists don't give up. Instead, they **innovate**, or try new things. They revise their procedures, try new tools. and ask more questions. An **innovation** is a new product or method that is formed as a result.

Consider this example: Dr. Michael Skinner predicted that exposing pregnant rats to a fungicide, or fungus killer, would change the sex of rat embryos. It didn't. However, the fungicide did cause disease in the mother rats. Not only that, it caused disease in their children and grandchildren. This was an unexpected result. So, Dr. Skinner continued investigating and found that it was possible for a substance from the environment, like the fungicide, to cause disease in future generations of rats. But the fungicide didn't change a parent rat's DNA. Instead, it changed the material that surrounds and regulates how the DNA works. Future generations inherited these changes.

How is Dr. Skinner's work an example of innovation?

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Exothermic Reactions

The prefix *exo–* means "outside," and the Greek base word *thermo* means "heat or hot."

The word *exothermic* means "outside heat," or releasing heat to the outside. When a force acts upon atoms and molecules, resulting in the release of heat, the process is called **exothermic**.

The chemicals that begin a chemical reaction are called the **reactants**. The chemicals that the chemical reaction produces are called the **products**. In an exothermic reaction, energy breaks the chemical bonds of reactants. The reactants rearrange themselves, forming new chemical bonds and releasing energy. An exothermic reaction feels warm to the touch. Some exothermic reactions release so much heat that it is dangerous to touch containers holding the products. Highly exothermic reactions can even explode.

Exactly how much heat is released during an exothermic reaction depends on the reactants, but all exothermic reactions release more heat than they absorb. You can use symbols to summarize an exothermic reaction.

Reactants		Products
A + B	$\longrightarrow$	C + D + heat

The burning of coal is an example of an exothermic reaction. Coal is a rock made of decayed plant material, or carbon. The purest coal, anthracite, is made almost entirely of carbon. Other kinds of coal are also made of carbon, but they contain other elements as well.

When coal is ignited, a chemical reaction occurs. Coal combines with oxygen to produce carbon dioxide. The reaction gives off heat, making it an exothermic process.

An exothermic reaction, such as burning coal, gives off heat.

McGraw-Hill Companies/Bob Coyle, photographer

THINK ABOUT SCIENCE

The National Aeronautics and Space Administration, or NASA, uses liquid hydrogen as rocket fuel. When combined with liquid oxygen and ignited, the fuel propels rockets into space. How do you know this reaction is exothermic?

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Core Skill
Make Predictions

A **prediction** is an educated guess based on available evidence. Scientists predict what they expect to happen during an investigation based on what they already know. You can make predictions, too. To make the most accurate prediction possible, it is helpful to organize your evidence in a chart that you can extend to any size.

Prediction: *The chemical reaction is exothermic, resulting in an increase in temperature of the products.*
What I Know About Chemical Reactions

What kinds of evidence regarding exothermic chemical reactions could you add to a chart like this?

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Endothermic Reactions

Some chemical reactions are **endothermic**, meaning these reactions will not occur unless work is done. The prefix *endo*– means "within." Combined with *thermo*, meaning "heat," the word *endothermic* means "heat within." Endothermic reactions absorb heat from their surroundings.

Although endothermic reactions absorb heat at first, they cool as the reaction continues. In the end, the reactions absorb more heat than they release. Look at this summary of an exothermic reaction.

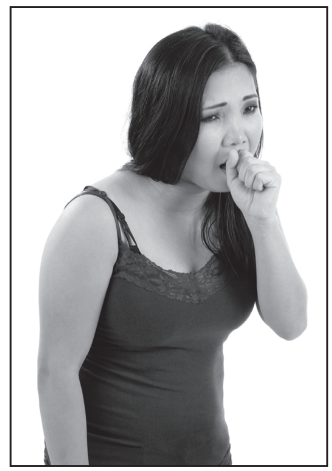
Reactants		Products
A + B + heat	$\longrightarrow$	C + D

Consider photosynthesis once more, a common example of an endothermic reaction. Photosynthesis doesn't occur without an input of energy, which comes from sunlight. The energy in the light breaks the chemical bonds of the reactants CO_2 and water. The bonds rearrange themselves to form a molecule of sugar. Heat is stored in the bonds of the new product.

Another example of an endothermic reaction involves ammonium chloride (NH_4Cl) and water (H_2O). Ammonium chloride dissolves readily in water, and it is used to make a variety of products, including firecrackers, fertilizers, cough medicine, some kinds of licorice, and shampoo. The chemical reaction, written below, absorbs heat but cools as the reaction progresses.

$$NH_4Cl_{(s)} + H_2O_{(l)} + \text{heat} \longrightarrow NH_4Cl_{(aq)}$$

solid ($_{(s)}$) — liquid ($_{(l)}$) — aqueous, or dissolved in water ($_{(aq)}$)



Dissolved in cough medicine, ammonium hydroxide changes secretions in the lungs and makes them easier to cough up.

Steven Frame/Alamy

THINK ABOUT SCIENCE

Melting ice is not a chemical reaction. It represents a phase change, from a solid to a liquid. How is this phase change similar to an endothermic reaction?

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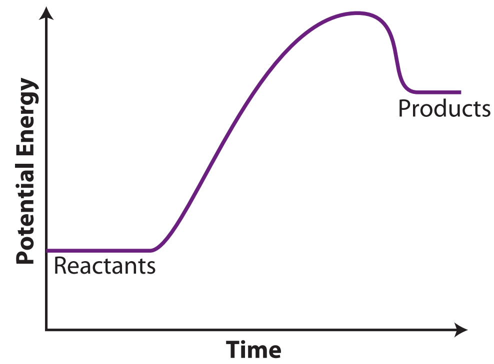
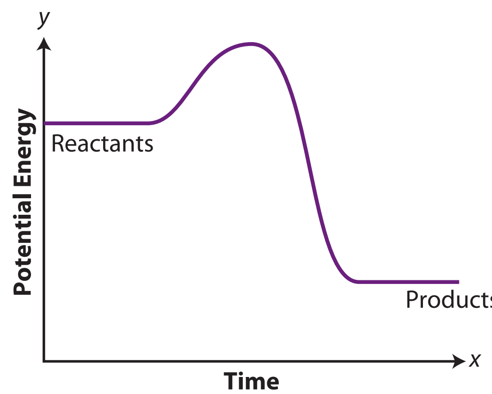
Potential Energy in Chemical Reactions

Reactants and products have different amounts of potential energy stored in the bonds that join their atoms. You can graph the change in potential energy that occurs in an endothermic reaction.



An endothermic reaction absorbs energy, so the products have more potential energy than the reactants do.

You can also graph the change in potential energy that occurs in an exothermic reaction.



An exothermic chemical reaction usually releases light, sound, or heat. So, the overall potential energy of the product is less than the potential energy of the reactants.

Notice the bump in each graph. These bumps represent a kind of barrier that must be overcome if a reaction is going to occur.

Recall that potential energy is stored in the bonds of atoms and molecules. Those bonds must be broken and made into new bonds for new products to form.

So what is required to break and possibly make new bonds? The answer is energy. It is called **activation energy**, and the amount of activation energy each kind of reaction requires is different.

THINK ABOUT SCIENCE

Directions: Review the graphs. Notice the difference in time required to overcome the energy barrier in each kind of reaction. What does this difference suggest to you?

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Core Skills
Follow a Multistep Procedure

Have you ever used technical directions to assemble a model or to conduct a chemistry experiment? Technical directions often rely on visual clues as much as they rely on text clues. Directions usually begin with labeled pictures of all of the materials required to complete the task.

Directions are usually chunked, or arranged in small blocks of text. They may be combined with diagrams that support or help explain the words. Blocks of text are numbered to help you complete each step in its proper order. There may be small text boxes, too, that provide helpful hints, reminders, or safety warnings.

Research instructions for creating a chemical reaction. For example, look for a project for making "hot ice," which results in an exothermic reaction. Follow the directions carefully in order to complete the process. Whether writers are explaining how to assemble a model or how to add a catalyst to reactants, they think carefully about every word and every diagram they choose. Why do you think it is important to follow directions precisely?

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Catalysts

The activation energy required for some chemical reactions can be very high. A **catalyst** lowers that activation energy by providing an alternative pathway for the reaction to follow. Compare the process to a train ride.

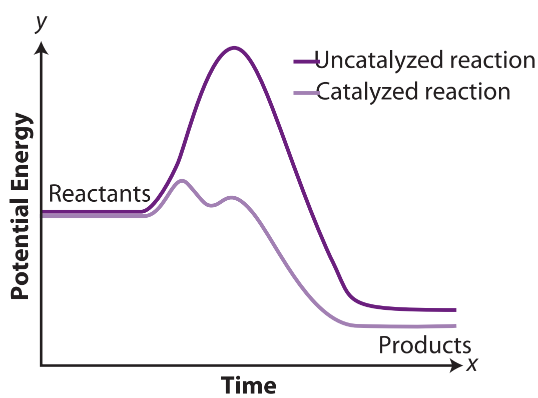
Suppose a mountain range separates two points, A and B. Builders can lay train tracks up, over, and down each mountain between the points, or they can blast tunnels through the mountains and lay tracks inside. Trains traveling through the tunnels will reach point B far sooner than trains that cross over the mountains. The tunnels provide an alternative path, just as catalysts do.

In addition to speeding up a chemical reaction, a catalyst remains intact during the process, meaning it is not used up in the reaction. So, a small quantity of catalyst can be used to speed large quantities of reactants.

There are different ways a catalyst can speed up a reaction.

1. Positive and negative electrical charges attract one another. A catalyst can give a molecule a charge that will attract other reactants.
2. A catalyst can change the concentration of reactants, increasing the likelihood that reactants will collide.
3. A catalyst can change the shape of a reactant to make it easier for another reactant to react with it.

Although a catalyst decreases amounts of activation energy, it does not affect the potential energy stored in the products, as you can see in the following graph.



WRITE TO LEARN

Think about the kinds of chemical reactions that regularly occur in your kitchen. Give two examples of chemical reactions and explain why they represent either exothermic or endothermic reactions.

THINK ABOUT SCIENCE

Directions: Fill in the blanks to describe a catalyzed reaction.

Reactant 1 + Reactant 2 + ______ ⇒ ______ + Product 2

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Vocabulary Review

Directions: Use the terms to complete the sentences.

activation energy **product** **chemical reactions** **compounds** **reactant** **endothermic** **exothermic** **potential energy** **catalyst**

1. During ______________, reactants change into products.
2. Chemicals made from more than one kind of atom form ______________.
3. A roller coaster train at the top of a train track has ______________.
4. A ______________ modifies and increases the rate of a reaction without being consumed in the process.
5. For a chemical reaction to occur, ______________ is required.
6. ______________ chemical reactions release more heat than they absorb.
7. A ______________ is a chemical that begins a chemical reaction.
8. ______________ chemical reactions absorb more heat than they release.
9. A ______________ is the chemical that the chemical reaction produces.

Skill Review

Directions: Examine the chemical sentences. Then complete the activities.

Reactants		Products	Reactants		Products
A + B	→	C + D + heat	A + B + heat	→	C + D

1. Explain how the processes are alike.

____

2. Explain how the processes are different.

____

Directions: Read the text and complete the activity.

3. In your car, a mixture of oxygen and gasoline is ignited, and a chemical reaction begins. What kind of reaction occurs? How do you know?

____

4. Sodium (Na) is a poisonous element. So is chlorine (Cl). In a chemical reaction, the elements form NaCl, or table salt. How can you explain this change?

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Skill Review (continued)

5. Ammonia forms when the gases nitrogen (N_2) and hydrogen (H_2) combine under pressure. N_2 is very unreactive. What must manufacturers do to produce ammonia?

6. Enzymes are proteins with specific jobs to do, and they are part of biochemical reactions. For example, an enzyme in your saliva begins breaking down food as you chew. How is an enzyme in a biochemical reaction like a catalyst in a chemical reaction?

Skill Practice

Directions: Examine the chemical sentence. Then answer questions 1–3.

$$6CO_2 + 6H_2O + \text{energy in sunlight} \Rightarrow C_6H_{12}O_6 + 6O_2$$

1. What name is commonly given to this process?

2. What kind of chemical reaction does the sentence represent? Explain your answer.

3. What happens to the energy that was absorbed by the reactants?

Directions: Use the chart to describe three kinds of potential energy.

4.

Gravitational Potential Energy	
Elastic Potential Energy	
Chemical Potential Energy	

5. Why do different industries use catalysts in the production of their products?

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