FOCUS ON SCIENCE

Conservation of Matter and Energy

Advanced Level

Physical Science
Interactions Between Matter and Energy

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Scientific Inquiry

Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Develop, present, and defend formal research proposals for testing their own explanations of common phenomena, including ways of obtaining needed observations and ways of conducting simple controlled experiments.

Include appropriate safety procedures.

Design scientific investigations (e.g., observing, describing, and comparing; collecting samples; seeking more information, conducting a controlled experiment; discovering new objects or phenomena; making models).

Physical Science

Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Interactions among atoms and/or molecules result in chemical reactions.

In chemical reactions, energy is transferred into or out of a system. Light, electricity, or mechanical motion may be involved in such transfers in addition to heat.

Energy cannot be created or destroyed, but only changed from one form into another.

Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others.

English Language Arts

The following is a selective listing of the competencies and indicators addressed in this book.

Word Recognition

- Use word recognition skills and strategies quickly,accurately, and automatically when decoding unfamiliar words

Background Knowledge and Vocabulary Development

- Use self-monitoring strategies to identify specific vocabulary difficulties that disrupt comprehension,and employ an efficient course of action, such asusing a known word base or a resource such as aglossary to resolve the difficulty

Comprehension Strategies

- Use a variety of strategies (e.g., summarizing,forming questions, visualizing, and making connections) to support understanding of texts read

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How to Help Your Students Make the Best Use of This Book

Encourage students to develop nonfiction literacy skills by completing the Active Reader activities. Also encourage them to . . .

- Underline main ideas in paragraphs.
- Circle details that support the main ideas.
- Write down questions as they read.
- Circle key words as well as unfamiliar words.

Printing Instructions

Student Book: print pages 5–28

Assessments: print pages 29–32

Answer Key: print pages 33–35

FOCUS ON SCIENCE

Conservation of Matter and Energy

How do the properties and interactions of matter and energy explain physical and chemical change?

Everything in the universe is made of matter. The properties of matter can change: liquid turns to gas and back to liquid again, rust forms on metal, leaves change from green to orange to brown. All these changes require energy, which itself can change form.

Most of the energy on Earth comes from the sun. Energy can be stored in batteries or used as electricity running through the wires. It can be converted to provide light from the bulbs in lamps in your home.

What else can energy do? Read on to learn more.

Conservation of Matter and Energy

Table of Contents

Starting Points

Chapter 1 Matter

Chapter 2 Energy

Starting Points

Build Background

Predict

Below are some statements about matter, the stuff that makes up every object in the universe including you, this book, and the air. Circle your response, true or false, to the statement in the first column, then provide an explanation or example to support your response. After you have read the book, come back and respond to each statement again. Do you think your answers will change?

Statement 1: Matter can be created.

Before Reading T F Explanation or example: ______________________________

After Reading T F Explanation or example: ______________________________

Statement 2: Matter can be destroyed.

Before Reading T F Explanation or example: ______________________________

After Reading T F Explanation or example: ______________________________

Statement 3: Not all matter has mass.

Before Reading T F Explanation or example: ______________________________

After Reading T F Explanation or example: ______________________________

Statement 4: All matter takes up space.

Before Reading T F Explanation or example: ______________________________

After Reading T F Explanation or example: ______________________________

Brainstorm

Everything is made of matter. In this book, you will be reading about how matter can change form. We observe matter changing form all the time. We see ice melt into liquid water. When you drop a slice of white bread into the toaster, it pops up brown and crunchy. Try to think of matter changes you have observed, and list as many as you can.

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Starting Points

Key Vocabulary

Rate Your Knowledge

The words listed below have to do with matter and energy. Each word is important, but some of them may be new to you. Rate your knowledge of each one by checking the appropriate column. Give the definition, if you know the word. After completing this book, come back to this page and write the definitions of words you did not know.

	I don't know it.	**I've seen it, but I'm not sure what it means.**	**I know it well, it means...**
matter			
volume			
weight			
mass			
atom			
conservation			
system			
environment			
physical			
chemical			
energy			

Starting Points

Key Vocabulary

Context Clues

Below are several sentences that use some of the words listed on page 9. Read each sentence. Each contains clues about what the underlined word means. Write a definition for the word using the clues.

1. **If I multiply length times height times depth, I can <u>calculate</u> the volume of an object.**

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2. **The astronaut had a <u>weight</u> of 165 pounds on Earth, but in space she floated because the effect of gravity was close to zero.**

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3. **He was raising money for the <u>conservation</u> of national forest land, which he wanted to preserve in its original condition.**

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4. **Earth's close neighbors in the solar <u>system</u> form a group of related planets and other space objects that are all affected by similar forces.**

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5. **Colton was able to describe the <u>physical</u> characteristics of the material after observing and measuring it.**

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Starting Points

Key Concepts

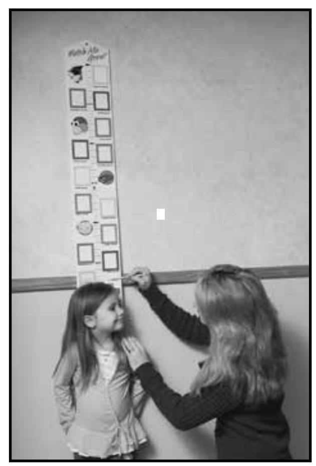
Energy and Our Changing World

Have you ever watched a plant grow? Probably. Slowly, a pale green stem sprouts from a seed, each day growing a little longer. Green leaves unfurl from the stem, and maybe colored flowers bloom. Have you ever wondered where that new plant material comes from? If you were to weigh that growing plant each day, it will grow heavier and heavier with each passing day, and not all the new weight can be explained by the plant taking up water. So, where does the added material come from?

In the spring, plants grow quickly. You can often see changes from day to day.

Come to think of it, you are growing, too. Your bones and your muscles and your fingernails and your hair are all growing, and that extra weight has to be coming from somewhere. You probably have an idea that eating helps you gain weight, which is correct.

Anything that grows or changes needs energy. Food is a form of energy that your body uses to grow. By studying the way energy changes the world around us and how energy itself can be changed, we can understand how plants and our growing bodies seem to make something out of nothing.



Some people don't reach their full height until they are in their twenties.

ACTIVE READER

1 Connect *You probably have some experience growing plants and learning about how they work. List the resources plants use to grow and explain where their added material comes from.*

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Chapter 1 Matter

FOCUS

In this section you will be reading about the properties that define matter. When you think you've come across one of these properties, underline it so it will be easy to scan for later.

What's the Matter?

Everything in the universe is made of matter. You are made of matter, the air is made of matter, any object or thing you can think of is made of matter.

So, what is matter? Sometimes we think of matter as something that takes up space; that is part of what makes matter. Another way to say it is that matter has **volume**: it takes up three-dimensional space. But that can't be the only definition that we use. Think about picking up a handful of nice, fresh snow, and packing it into a compact snowball. Though the snow in your hand now takes up less "space," there isn't less snow there, right? Another example would be a balloon; when you take an uninflated balloon, it sits, shriveled, in your hand. But when you blow it up, it takes up more space. But intuitively you understand that there is not more balloon there (where would the extra rubber come from?) and it only appears bigger.

Okay, so matter takes up space, but there's more to it. When we talk about how much matter something has, we often talk about one of the properties of matter, such as **weight**. If you put an object on a scale and find that it has weight, then it is matter, right?

Well, almost. Weight is actually a measurement of gravity's pull on an object, and that can change. Earth's gravitational force decreases as you move away from the center of the Earth. Gravity on the moon' surface is less than gravity on Earth's surface because the moon is smaller than Earth. In fact, when Neil Armstrong walked on the moon, he weighed about a sixth of what he did on Earth (which is why people on the moon seem to float a bit as they walk.)

Astronauts in outer space weigh nothing, but they still have the same mass they have on Earth, or anywhere.

ACTIVE READER

1 Extend *List other examples of matter changing volume without changing mass.*

For that matter, astronauts in outer space don't weigh anything, since they are outside gravity's pull. But that doesn't mean that Neil Armstrong and other astronauts lose matter when they travel away from Earth; they all return fully intact. This is because an astronaut's **mass**, or the amount of matter he or she contains, stays the same. Mass is a property of matter similar to weight but independent of gravity, so a person's mass is the same on Earth, in space, or on the moon. An object's mass does not depend on location. Because we know how much the force of gravity is on Earth, we know the relationship between mass and weight on Earth. Therefore, we can use weight to tell how much matter an object contains.

FOCUS QUESTIONS

1. What are two properties used to describe matter?

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2. Is your reflection in a mirror made of matter? Explain why or why not.

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ACTIVE READER

1 Infer *Do you think that you would weigh less if you were standing at the summit of Mt. Everest, the tallest mountain on Earth, than you would if you were standing at the ocean's shore? Explain your answer.*

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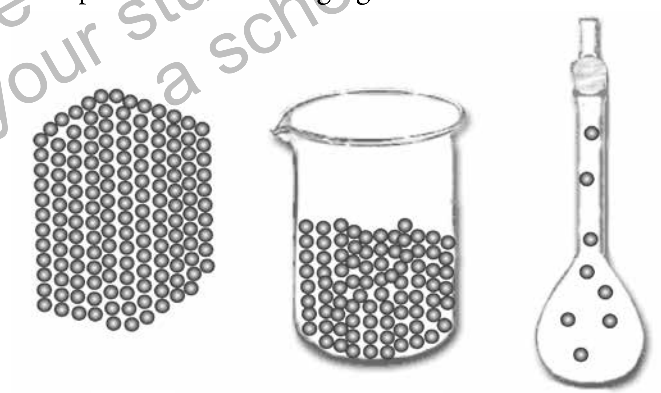
FOCUS The underlined sentence on this page describes what often happens when matter changes form. Read this section to find out more about what really happens when matter changes form.

Matter Changes

What is it in matter that takes up space and has mass? At the smallest level, all matter is made up of tiny particles called atoms. Atoms take up space and have mass. Some things are made up of a single kind of atom. Pure gold, for example, is made up of billions of identical gold atoms. Other things are made up of more than one kind of atom. You may know that water is made of two kinds of atoms, hydrogen and oxygen. Your body contains lots of water, so it has hydrogen and oxygen atoms in it, as well as other kinds of atoms, such as carbon atoms.

The atoms of an object can be spaced far apart (like in a gas) or they can be closely packed together (like in a solid). Atoms cannot, however, simply be created or destroyed. So while the volume of an object can change, the total amount of mass does not change. This principle is called the conservation of mass.

<u>Matter can change form in ways that make it seem as if matter has appeared or disappeared.</u> In a fire, wood seems to disappear as it burns into smoke and ashes. Red rust seems to form out of nothing on old metal. These, however, are examples of matter changing form.



Atoms in a solid are packed tightly in a regular arrangement. In a liquid, atoms move freely around each other, and in a gas they are the most spaced out of all.

ACTIVE READER

1 Connect *If atoms in a gas are the most spaced out and atoms in a solid are the most tightly packed, which phase of matter will tend to take up the most volume? Explain.*

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Chemical and Physical Changes

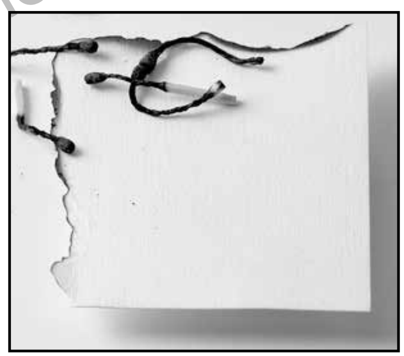
There are two main ways that matter can change. The first type of change is physical change. When matter changes physically, the particles making up the substance don't change into new types of particles, they just move around. If you take a piece of paper and crinkle it up, it has changed shape, but it is still paper. Phase changes are another kind of physical change: steam, liquid water, and ice are all water, but in different phases (gas, liquid, and solid). When you boil water and it becomes steam, the particles are still water, and when you condense the steam, it returns back to liquid water. Most physical changes are reversible.

Matter can also change chemically. In a **chemical change**, the atoms of matter are rearranged into different combinations. This kind of change is usually difficult to reverse, and tends to form what looks like a different kind of matter.

There's often a color change when a chemical change occurs. Bubbles may form, showing that gas has been created. There can also be a temperature change, and you'll notice the matter you're studying getting cooler or hotter.

Rust is an example of chemical change. A burning match is another; wood is changed irreversibly to ash and gas (carbon dioxide) and smoke. Every time you cook something, you chemically change the food you eat; think of the nice dark crust that forms when you toast your bread, and think about how the texture of a hamburger changes from raw meat to cooked.

Crumpled paper



Burned paper

Crumpling paper is a physical change; you could un-crumple it and have basically the same piece of paper. Burning the paper is a chemical change; once burned, the paper is now something different—a pile of ashes.

ACTIVE READER

1 Summarize *Explain the main differences between a physical and a chemical change.*

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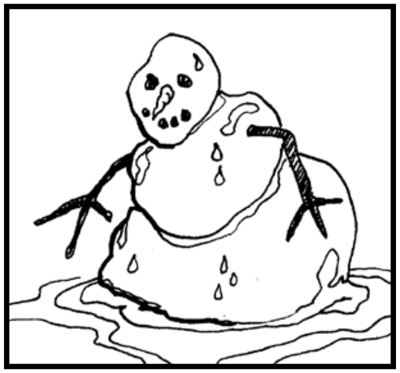
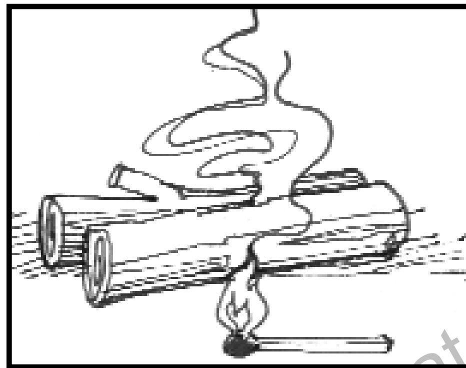
What changes do these images represent?





Good to Know

Something you have in common with every other living thing on Earth (even bacteria) is that carbon atoms are a major building block in your body. In science, the word "organic" means carbon-based. So if something is living or was once living, its body contains carbon atoms. Some rocks, like those containing fossils, are considered organic because they are made from the bodies of things that were once alive.

FOCUS QUESTIONS

1. When you drop an egg into a hot pan, the clear part of the egg turns hard and white. Is this an example or a physical or chemical change? Explain.

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2. If you leave a glass of water out over night, there will be less water in the glass in the morning. Has matter been destroyed? Give a reason why or why not.

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Think Like A Scientist

Physical or Chemical Change?

You've read about the two ways that matter can change: it can go through a physical change or a chemical change. Below are several everyday changes you might observe. Based on what you know about the differences between physical and chemical changes, determine what kind of change is occurring and provide a scientific reason for your choice.

	Physical or Chemical Change?	Explanation
1. A hamburger turns from red to brown as it is cooked.		
2. Ice in your glass melts to form a liquid.		
3. Baking soda and vinegar react together; bubbles form and heat is given off.		
4. A glass is dropped and breaks into many pieces.		
5. A metal bicycle stored outside begins to turn orange from rust.		

FOCUS The underlined sentences below explain how open and closed systems are different. Read this section to understand more about what we have learned from studying systems.

Systems

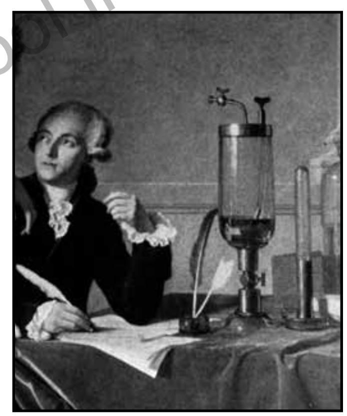
Things that are related form a **system**. For example, a burning log and the air that fuels the fire can be considered a system. During burning, wood is combined with oxygen from the air to produce heat, light, a gas (carbon dioxide), and ash. A system is simply the set of related matter we are interested in looking at; all the matter outside the boundaries of the system is called the **environment**.

So if we're interested in studying a burning log, we may consider the log and the air as our system. But what about the smoke? And the air a few feet away?

Systems can get confusing quickly, so we distinguish between two types of systems. In an **open system**, matter can freely cross the boundaries of the system. The smoke from the burning log is actually tiny bits of ash that float through the air and may land a few feet or a few miles away.

A glass of water is another example of an open system, since water can evaporate out of the top of the glass. In a **closed system**, however, matter cannot pass across the boundaries of the system. If you put a top on the same glass of water just mentioned, it would become a closed system, because even if water evaporated, it would be trapped within the system.

Antoine Lavoisier was a French scientist in the late 1700s who studied open and closed systems. He discovered that mass is conserved. In other words, even though matter changes form, as in the burning of a log, the mass of the matter left after the change is the same as the mass of the matter before the change.



Antoine Lavoisier used careful observations and precise measurements to prove that rust was not the creation of new matter, but a combination of metal and air particles, and that mass was conserved.

ACTIVE READER

1 Explain *What is the difference between open and closed systems? Explain.*

Since matter can freely pass out of an open system, matter can seem to disappear. When water evaporates out of a glass, it seems to disappear, but it simply moves into the air (the environment). It takes a closed system to observe the conservation of mass. The universe is basically a giant closed system, which is why the conservation of mass principle always holds true.

Antoine Lavoisier used his knowledge and intuition about systems to prove that rust was not truly the creation of new matter, but that it formed from particles in the air combining with particles of metal. He placed iron in a sealed jar and weighed the whole system to get the mass. In a few days, the iron had rusted. When he weighed the system again; it weighed the same! Since matter couldn't enter or leave the sealed jar, this simple experiment proved that the rust had formed from the metal reacting with the air in the jar. Overall, mass was conserved.

Good to Know

Unfortunately, Lavoisier, who was wealthy, was a victim of he French Revolution and was beheaded. In France at the time, certain wealthy people were allowed to collect taxes for the government. Lavoisier was a tax collector. The judge who sentenced him reportedly said that "the Republic needs neither scientists nor chemists," before sentencing Lavoisier to death. Lavoisier's work has far outlived him and he is often regarded as the founding father of chemistry, showing just how wrong the judge was.

FOCUS QUESTIONS

1. Which property of matter can change, and which property can't change?

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2. Was Lavoisier's experimental setup of iron inside a sealed jar an open or a closed system? Explain how you know.

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Stop and Think

This page will help you summarize what you have read so far.

Base your answers to questions 1 and 2 on the information below and on your knowledge of science.

You place half a cup of water in a glass and seal the top with plastic wrap. You weigh this closed system and it weighs 150 g. You leave it overnight. In the morning, you observe that there is less water in the glass, and there is condensation on the inside under the plastic wrap.

1. Will the system now weigh more, less, or the same?

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2. Why does this closed system weigh what it does in the morning?

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Base your answer to question 3 on the information below and on your knowledge of science.

You have two mystery chemicals labeled A and B. You have 25 g of A, which is a powder, and 25 g of B, which is a liquid. When you combine chemicals A and B in an open beaker, bubbles are formed and heat is given off. When you weigh them after the reaction has finished, your chemical mixture weighs 45 g.

3. Which of the following statements must be true?

I. A physical change has occurred.
II. A chemical change has occurred.
III. Mass has been destroyed.
IV. A solid and/or liquid combine to form a gas.

(1) I only
(2) II and III
(3) II only
(4) II and IV

Dear Ms. Understanding,

I'm confused. Is matter the same as mass? I know that all matter has to have mass. And since mass is always conserved, is matter always conserved?

Befuddled in Bedford

Dear Befuddled,

Mass is not the same as matter, but I can see how you are confused. All matter has mass, but you should remember that mass isn't the only property of matter; all matter also has volume. And while mass is always conserved (it can't be created or destroyed,) volume is not always conserved. You can blow up a balloon to take up more volume, but the mass has stayed the same. However, since all matter has mass, which is conserved, matter is always conserved, too.

Ms. Understanding

Hands On Science

Something from Nothing The scientist credited with proving that mass is always conserved was a French scientist named Antoine Lavoisier, who worked during the late 1700s. In order to test his theory, he set up a system much like the one you will set up in this experiment.

Background

In this experiment you will be watching matter undergo a change. Since everything is made of matter, we need to define what set of matter we are observing. The set of matter we choose to observe is called a system. You will be setting up two systems: both will contain a jar, a piece of steel wool, water, and air. One system will have a tightly fitting lid on it. It is important to understand that air is an important part of a system: air is made up of atoms, and definitely counts as matter. You will be observing your systems for several days, and trying to determine whether matter is conserved.

Predict

What do you think you will observe in the jars over the next several days? Do you think you will observe any differences between the open and the closed jars? ______________________________

Materials

- **two jars, one with a tight-fitting lid**
- **steel wool pad**
- **water**
- **electronic balance**

Procedure

1. **Cut the steel wool pad in half with a strong pair of scissors.**
2. **Place one half of the steel wool pad in one jar, and the other half in the other jar.**
3. **Measure out enough water to partially cover the steel wool pad, and add it to one jar.**
4. **Add the same amount of water to the other jar.**
5. **Tightly seal one of the jars.**
6. **Weigh each jar on an electric scale and record the weight in your data table.**
7. **Make observations on the two jars in the data table on the next page.**
8. **For two more days, continue to weigh and observe your jars.**

Hands On Science

	Day	Weight	Observations
Open Jar	1		
	2		
	3		
Sealed Jar	1		
	2		
	3		

Analysis

1. **What are the important differences you noticed in the two systems from Day 1 to Day 3?**

2. **Did a new substance appear? What was it?**

3. **Did the weight stay the same in the open jar? Use scientific reasoning to explain why it did or did not.**

4. **Did the weight stay the same in the closed jar? Use scientific reasoning to explain why it did or did not.**

5. **Lavoisier's model was similar to your sealed jar, and he found that the weight stayed the same, even with the formation of different-looking matter. He proposed that matter had been conserved: where did the "new" looking matter in your sealed jar have to come from?**

6. **In physics, the sealed jar would be called a closed system and the unsealed jar would be called an open system. What do you think is the difference between a closed and an open system?**

Chapter 2 Energy

FOCUS In this section you will be reading about energy and how it relates to matter. As you read, think about how energy is similar to matter, and how it is different.

Energy and Matter

In the previous chapter, you read about different ways that matter can change its form. It can change physically, such as when ice melts into water, or when water is frozen back to ice. It can also change chemically, like when the sticky cookie dough you put in the oven changes to the crispy, golden cookies you pull out!

Whether matter is going through a physical change or a chemical change, **energy** is always required to make it happen. But what is energy? Energy makes you able to do a lot of things: run fast, laugh hard, or stay up late. Basically, that's what energy is—the ability to do work. Work is any kind of action by one thing on another that causes movement. Wind does work on wind turbines, turning the blades. A bowling ball does work on bowling pins when it knocks them over. Gravity does work on any falling object, pulling it towards Earth.

Conservation of Energy

Just as matter is always conserved, energy is always conserved. Energy is never created or destroyed, it simply changes form. When you eat a bowl of cereal for breakfast, the cereal may seem to be "destroyed." But the energy you get from that cereal has simply been converted to the movement of your beating heart and blinking eyes, stored for later energy in your liver and in your fat cells, changed to heat that keeps your body warm.

Energy stored in the food you eat (potential energy) gets converted into the energy of movement (kinetic energy).

ACTIVE READER

1 Illustrate *Draw a symbol that represents energy.*

2 Outline *Create an outline that contains the important ideas about energy.*

To understand how energy changes forms, it helps to understand what forms of energy exist. There are two main types of energy: **kinetic energy** and **potential energy**. Kinetic energy is the energy of movement. Anything that is in motion has kinetic energy. Kinetic energy can do work directly on an object. Think back to the bowling ball hitting the pins; the moving ball has kinetic energy, and can do the work of knocking over the pins.

Potential energy is stored energy. Because the energy is stored, it cannot do work directly on an object. In order to do work, it has to be converted to kinetic energy first. Potential energy can be stored in the patterns of atoms that make up an object. A good example is a match; chemicals in the head of a match store energy, but they alone can't do the work of burning. When you strike a match, the potential energy stored in the head is converted to kinetic energy, and the match can burn (a kind of work.)

Energy can also be stored in an object's position. If you hold any object away from the ground, you are storing potential energy in that object. If you drop it, the potential energy will be converted to kinetic energy and gravity can then do work on the object, pulling it to the ground. Again, potential energy must always be converted to kinetic energy to do work.

FOCUS QUESTIONS

1. What property does energy share with mass?

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2. Does a baseball flying through the air have potential energy, kinetic energy, or both? Explain.

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Web Quest

Fuels, like gasoline and coal, are a form of potential energy that we rely on for our cars, our factories, and the power in our homes. These fuels are becoming scarcer, and they have some negative impacts on our environment. People are increasingly looking for alternative energy sources for the future, sources that may be cleaner and easier to produce. Research one of these "alternative energy" or "renewable energy" sources. What are the benefits? What are some possible problems?

FOCUS In this section you will read about other kinds of energy. As you read, focus on a key word or two to help you remember one form from another.

Other Forms of Energy

Energy can always be classified as potential or kinetic energy, but we further divide energy up into useful categories, or forms, that we recognize. Some of these forms are types of kinetic energy, some are types of potential energy, and some can be both.

Electrical energy is what you use when you use electricity or batteries. Tiny negatively charged particles move through wires to produce what's called a current, powering a computer or cell phone.

Thermal energy is created by the movement of atoms. Thermal energy depends on temperature, so when you measure temperature you are actually measuring the movement of atoms. The hotter something is, the more energy it has and the faster the atoms move. When matter is converted from one form to another, there is often a temperature change, which means thermal energy is involved.

Chemical energy is a form of potential (stored) energy. Energy is stored in the connections between the atoms that make up a substance. Food contains chemical energy that our bodies can use. Like the head of a match, food contains stored chemical energy and can be "burned" by our bodies to do work like thinking, reading, or riding a bike. Gasoline also contains stored chemical energy.

Electromagnetic, or **radiant energy**, is light energy. This is how plants seem to "create" mass; they are using the sun's radiant energy to store carbon from the air as chemical energy in their leaves. When you turn on the lights in your house, radiant light is converted from electrical energy. This energy conversion also generates thermal energy, as you'll know if you've ever felt how warm the light bulb gets after it has been on for a while.

Energy and Systems

In the last chapter you learned about closed and open systems, and how mass can move in or out of an open system, but is contained within the boundaries of a closed system. Similarly, energy changes can be traced through different systems. Unlike mass, energy can always move in or out of open and closed systems. If you think about heating a sealed beaker of water, the water will turn to water vapor, and condense into liquid water again, but the mass will all be contained in the sealed beaker. Once the heat is turned off, however, the thermal energy of the hot water will eventually be lost to the environment.

ACTIVE READER

1 Recall *What are the signs that a chemical change is occurring?*

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2 Infer *What kinds of energy does the sun produce?*

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You can still trace energy transformations through a closed system, realizing that some energy will be lost to the environment. We could define our closed system as the lighting system of a house. The kinetic energy of turning the switch allows electrical energy to travel through the wires to the bulb. At the light bulb, electrical energy is converted into radiant energy, giving you light, and thermal energy, making the bulb warm. Anything that uses a battery stores electricity as chemical energy, which can then be converted to electrical energy.

Putting It All Together

So, now that you are an expert on matter, mass and energy, you are ready for big-time physics. You may have seen the equation, $E = mc^2$, which is the mass-energy equation developed by Albert Einstein. What the equation says is that mass (m) and energy (E) are directly related. The c variable is the speed of light. The equation basically says that mass is a form of energy (or energy is a form of mass), so it should make sense that both mass and energy are always conserved.

FOCUS QUESTIONS

1. **A computer converts electricity to the bright display of the monitor. Describe the energy transformation occurring.**

2. **Humans rely on the chemical energy in food. Name at least two energy conversions that the human body performs.**

Good to Know

Batteries store chemical energy using toxic chemicals such as lead and sulfuric acid. Eventually batteries wear out, and are no longer able to store energy; we call these "dead" batteries. Though they no longer work, these batteries contain toxic chemicals that can leak into the ground and pollute the soil and groundwater. Never throw away old batteries in the trash; call your local garbage center to find out how to dispose of this hazardous material.

Web Quest

Earth can be considered both an open and a closed system. Do some research on the Internet to decide which you think is a better fit: is Earth more like a closed system or an open system? You will need to find out what kind of matter passes between Earth and its environment (outer space). Determine what kind of energy enters and leaves the system.

Stop and Think

This page will help you summarize what you have read so far.

1. When you turn on a lamp, it draws electricity from the wall to produce both light and heat. Which sentence describes what happens to the energy?

(1) Electrical energy is used up.

(2) Radiant energy is used up.

(3) Electrical energy is converted to thermal and kinetic energy.

(4) Electrical energy is converted to thermal and radiant energy.

Base your answers to questions 2 and 3 on the information below and on your knowledge of science.

A thermometer sits in a steaming cup of coffee, measuring the temperature. As time passes, the temperature of the coffee decreases.

2. Is energy being lost as the temperature decreases? ______________________________

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3. What is happening to the cup of coffee "system" as it cools? ____________________

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Dear Ms. Understanding,

I'm having trouble understanding what energy is. I know it's always conserved, just like mass. So does energy have mass and volume, like matter? Is energy a form of matter?

Confused in Camillus

Dear Confused,

You've hit on a very difficult question. Generally, we don't consider energy to have mass or volume; you can't feel it, pick it up, weigh it. So we don't consider energy to be a form of matter. However, Einstein's theory of relativity states that energy and mass are related. According to the theory, energy and mass are basically the same thing. These are some of the most advanced concepts in the world of physics; you could read up a bit on Einstein's theory if you want to learn more. For now, it's easiest to think of energy and matter as different.

Ms. Understanding

Glossary

atoms – the tiny particles that make up matter

chemical change – a change where atoms are rearranged permanently; usually comes with color change, bubbles, or a temperature change.

closed system – a set of matter with boundaries that mass can't cross

conservation – the saving of something

energy – the ability to do work

environment – all the matter outside a system

kinetic energy – the energy of movement, can do work directly on an object

mass – a measurement, independent of gravity, of how much substance an object has

matter – something that takes up space and has mass; makes up everything in the universe

open system – a set of matter where mass can come and go from the environment

physical change – a change that doesn't change the type of particles that make up a substance

potential energy – stored energy that must be converted to do work

system – the set of matter we're observing

volume – the amount of space an object takes up

weight – a measurement of gravity's pull on an object

FOCUS ON SCIENCE

Conservation of Matter and Energy

Assessments

Check Understanding

In the Answer Document on this page, mark your answer in the row of circles by filling in the circle that has the same number as the answer you have chosen. For question 2, write your answer on the lines provided.

Base your answers to questions 1 and 2 on the information below and on your knowledge of science.

A cup of hot chocolate is placed on a scale and a thermometer is placed into the liquid. Over time, the temperature of the liquid decreases, and the weight decreases slightly as well.

1. Which of the following is true about the hot chocolate system over time?

   (1) Thermal energy was lost from the surrounding air and the system.

   (2) Thermal energy was gained by the system and the surrounding air.

   (3) Thermal energy was transferred from the surrounding air to the system.

   (4) Thermal energy was transferred from the system to the surrounding air.

Answer Document

1. ① ② ③ ④

2. The reading of the scale shows that mass has been lost from the mug of coffee. What happened to cause the missing mass?

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Check Understanding

In the Answer Document on this page, mark your answer in the row of circles by filling in the circle that has the same number as the answer you have chosen. For questions 5 and 6, write your answer on the lines provided.

3. A piece of metal is left in water and exposed to air for several days. Each day, more rust appears on the metal.

   What is this an example of?

   (1) a physical change
   (2) a chemical change
   (3) matter being created
   (4) matter being destroyed

4. Anything made of matter has which of the following properties?

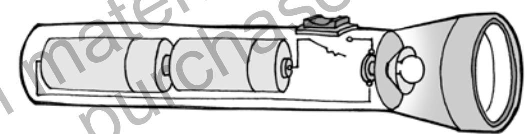
   I. It takes up space.
   II. It has mass.
   III. It's made of atoms.

   (1) I only
   (2) II only
   (3) I and II
   (4) I, II, and III

Answer Document

3. ① ② ③ ④ 4. ① ② ③ ④

The diagram below shows the inside of a flashlight. When the switch is on, energy from batteries travels across wires to the bulb, which then lights up.



5. What are two energy conversions that take place when a flashlight is lit?

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6. Is a flashlight an open or a closed system? Why?

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FOCUS ON SCIENCE

Conservation of Matter and Energy

Answer Key

Answer Key

Page 8: Build Background:
Predict: Before reading, answers will vary. After reading, 1. F; 2. F; 3. F; 4.T
Brainstorm: Answers will vary.

Page 9: Key Vocabulary
Rate Your Knowledge: Student answers will vary.

Page 10: Key Vocabulary
Context Clues: Answers will vary but should reflect the context of the sentences.

Page 11: Key Concepts
Active Reader: Plants use resources such as sunlight, water, air, and soil to grow. They make their own food through photosynthesis for growth.

Page 12: Chapter 1
Active Reader: Answers will vary; examples might include compacting trash, expansion of water as it freezes, and turning a piece of lumber into sawdust.

Page 13: Chapter 1
Active Reader: You would weigh less at the top of Mt. Everest because you would be farther from Earth's center.
Focus Questions: 1. mass and volume; 2. No. A reflection has no mass and doesn't take up three-dimensional space.

Page 14: Chapter 1
Active Reader: Gas takes up the most volume because the atoms are farthest apart.

Page 15: Chapter 1
Active Reader: In a physical change, the composition of matter doesn't change. In a chemical change, the composition of the matter changes. Chemical changes are usually accompanied by a color change, temperature change, and/or gas formation. Physical changes are often easier to reverse than chemical changes.

Page 16: Chapter 1
Focus Questions: 1. Chemical change; it's irreversible and there is a color change.; 2. Matter is never destroyed; water evaporated (it turned into a gas) and was lost to the environment (the surrounding air).

Page 17: Think Like a Scientist:

	Physical or Chemical Change?	Explanation
1. A hamburger turns from red to brown as it is cooked.	Chemical	Irreversible, color change
2. Ice in your glass melts to form a liquid.	Physical	Reversible; matter is still water (this is simply a phase change)
3. Baking soda and vinegar react together; bubbles form and heat is given off.	Chemical	Bubbles show a gas is forming, temperature change
4. A glass is dropped and breaks into many pieces.	Physical	Glass is still glass, the composition of matter hasn't changed
5. A metal bicycle stored outside begins to turn orange from rust.	Chemical	Irreversible, color change

Answer Key

Page 18: Chapter 1
Active Reader: Open systems have boundaries that allow matter to cross; closed systems have boundaries that do not allow matter to cross into the environment.

Page 19: Chapter 1
Focus Questions: 1. An object's volume can change, its mass cannot.; 2. Closed: the jar was sealed, so matter could not pass in or out.

Page 20: Chapter 1
Stop and Think: 1. The system will weigh the same because it is closed. 2. Mass cannot enter or leave. Liquid water has turned to gas, which accounts for the missing liquid and the appearance of condensation on the sides.; 3. (4)

Page 21: Chapter 1
Hands-on Science:
Predict: Answers will vary

Page 22: Think Like a Scientist:
Analysis: 1. Rust should appear on the metal in both jars, condensation should appear on the sides of the sealed jar.; 2. Rust; 3. The open jar should lose some weight from water evaporating.; 4. The closed jar should remain the same weight; mass should be conserved if the system is truly closed.; 5. The rust must come from the metal, the water and the air. (Air is important, which is why more rust may have formed on the metal in the open jar.); 6. Answers will vary, but students should explain the difference between an open and a closed system.

Page 23: Chapter 2
Active Reader: 1. Students' symbols will be different.; 2. Responses will vary but should include such ideas as: Energy exists as kinetic or potential energy., Energy is required for change to occur to matter., Energy can change form but is always conserved.

Page 24: Chapter 2
Focus Questions: 1. Both mass and energy can be transformed, but neither created nor destroyed.; 2. It has both. It has kinetic energy because it is in motion and potential energy because it is above the ground and can continue moving.

Page 25: Chapter 2
Active Reader: 1. change in temperature, change in color, the formation of bubbles; 2. electromagnetic (light), thermal (heat)

Page 25: Chapter 2
Focus Questions: 1. Electrical energy is converted to electromagnetic, or light energy. Some thermal energy is also produced.; 2. In our bodies, chemical energy is converted to thermal energy to maintain body temperature. Chemical energy is converted to electrical energy in our nervous system. Chemical energy in food is converted to the kinetic energy of the pumping heart, moving legs and arms, etc.

Page 27: Chapter 2
Stop and Think: 1. (4); 2. Energy is conserved, not lost. 3. However, energy is lost to the cup of coffee "system" as thermal energy moves into the surrounding environment.

Page 31: Check Understanding
1. (4); 2. The missing mass was liquid water. It became a gas and was transferred to the surrounding air.

Page 32: Check Understanding
3. (2); 4. (4); 5. When a flashlight switch is turned on, chemical energy in the battery is converted to electrical energy in the wires and then electrical energy is converted to electromagnetic (light) energy and thermal (heat) energy as the bulb lights up.; 6. The flashlight is an open system because heat and light are transferred into the environment.