UNIT 2

Matter

Explore Online

Unit Project: Conservation of Matter
How can you prove that matter is conserved during a change? You will conduct an investigation with your team. Ask your teacher for details.

Everything you see here is matter: the water, the sand, the air. Matter can change.

At a Glance

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Unit Review 154

Vocabulary Game: Picture It

for 3 to 4 players

Materials
- kitchen timer or online computer timer
- sketch pad

How to Play

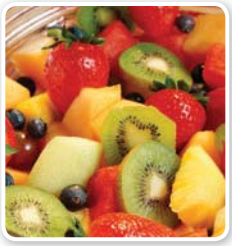
1. Take turns to play.
2. To take a turn, choose a word from the Word Box. Do not tell the word to the other players.
3. Set the timer for 1 minute.
4. Draw pictures on the sketch pad to give clues about the word. Draw only pictures and numbers. Do not use words.
5. The first player to guess the word gets 1 point. If that player can use the word in a sentence, he or she gets 1 more point. Then that player gets a turn to choose a word.
6. The first player to score 5 points wins.

Unit Vocabulary

boiling point: The point at which matter changes from a liquid to a gas.

melting point: The temperature at which matter changes from a solid to a liquid.

chemical change: Change in one or more substance, caused by a reaction, that forms new and different substances.



mixture: A combination of two or more different substances in which the substances keep their identities.

conservation of matter: A law that states that matter cannot be made or destroyed; however, matter can change into a new form.

physical change: A change in which the shape or form of the substance changes, but the substance still has the same chemical makeup.

freezing point: The temperature at which matter is changed from a liquid to a solid.

physical properties: Anything that you can observe about an object by using one or more of your senses.

matter: Anything that takes up space.

solution: A mixture that has the same composition throughout because all its parts are mixed evenly.

What Is Matter?

At an open-air market, you can see and hear many different people buying and selling things. There's fresh fruit and vegetables, freshly baked bread, spices, and drinks such as tea, coffee, and milk. Everything you see, hear, taste, touch, and smell is made of matter.

By the end of this lesson . . .
you'll be able to identify and measure matter.

Can You Explain It?

Explore Online

You see many different people running around having a good time. These people are made of matter. The matter within them is made of particles too small to be seen.

1. What kinds of matter do you see in the photo above?

EVIDENCE NOTEBOOK Look for this icon to help you gather evidence to answer the question above.

Matter Is Everything

What Matters about Matter

Where do you find things made of matter? If you can taste, smell, or touch something, it's matter. Anything that takes up space is **matter**. It can come in different forms and can behave in many different ways. Even a breeze is matter, because air takes up space. But some things that exist, such as heat and light, are not matter. Why not? They don't take up any space.

At the Fair

2. What do the sun, tents, and carnival games have in common?

Matter or Not?

3. Which of the following things are matter? Which are not? Label them as *matter* or *not matter.*

Explore Online

feelings

_____

food

_____

time

_____

4. What properties do items classified as matter have in common?

_____

_____

5. Which are examples of matter? Sort the items in the word bank into the chart below.

a candle	**a happy thought**	**light from a lamp**
air inside of a bubble	**a moving ocean wave**	**ashes from a camp fire**

Matter	Not matter

EVIDENCE NOTEBOOK There are many types of matter that can be found at the fair. There are also things that cannot be classified as matter. Which things did you see that are considered matter? Why did you select these? Write your responses in your Evidence Notebook.

What Makes Up Matter?

Matter takes up space. But what is it made of? You can break down an object into smaller parts. At first, you can see the broken pieces. Eventually, you would need to use a tool such as a microscope to see the smaller parts. At that stage, the parts can still get smaller, all the way down to their basic particles—the smallest parts of matter that exist.

You cannot see particles, but they make up all matter. The sun, whales, the air, apple juice, and the ink and paper of this page are all forms of matter made of particles.

Contents of Charcoal

6. What kinds of matter do you see here?

Explore Online

Let's explore the particles of the charcoal inside this grill.

Uh-oh. The bag of charcoal has been knocked over. Some of the briquettes have spilled out.

The individual briquette is made of particles that are stuck together.

If a briquette is broken, you can see both large and small parts that make up the whole. Notice how even the smallest particles all look the same. This is because they are made from the same type of matter, called *carbon*.

Even the tiniest speck of a charcoal briquette is made of hundreds of millions of carbon particles like this one.

The piece of charcoal is a form of matter. By zooming in, you can see that the properties of the whole are the same as the properties of the charcoal smaller pieces, from the dust to the particles of carbon.

7. Fill in the blank with the best term: *the same* or *different*.

A large piece of matter has _____ traits as the smaller pieces and the individual particles of the same matter.

HANDS-ON Apply What You Know

Is It Still There?

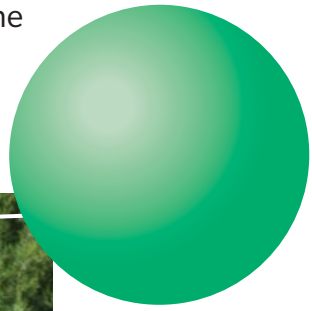
8. In this activity, you will test to see if matter can be destroyed. Your teacher will provide you with a glass of water and a sugar cube. Drop the sugar cube into your glass of water and stir it until it dissolves. Then design a method for determining what happened to it.

How can you test to see what happened to the sugar cube in the water? How can you tell if it is still present or if it disappeared?

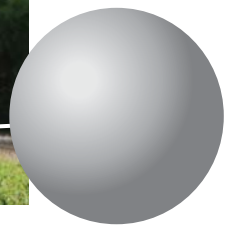
Particles, Particles, Everywhere

Remember that matter is made of tiny particles. These particles can rearrange themselves into many different shapes and sizes. But not all matter has a definite shape. Water, milk, and the air you breathe are also forms of matter. It is how these particles join together that determines what kind of matter you have.

This cyclist has all the tools he needs to win the big race. The water bottle is made of a material called aluminum, and his shoes and bike have carbon fibers in them. The water in the bottle is made of two different types of particles joined together.



Aluminum is a lightweight metal. It is often used to build things that need to move quickly, including cars. The water bottle is made of aluminum.



Carbon is a very useful material. It can be found in charcoal in your grill, the sweet tea you drank earlier, and in the soles of the cyclist's shoes.

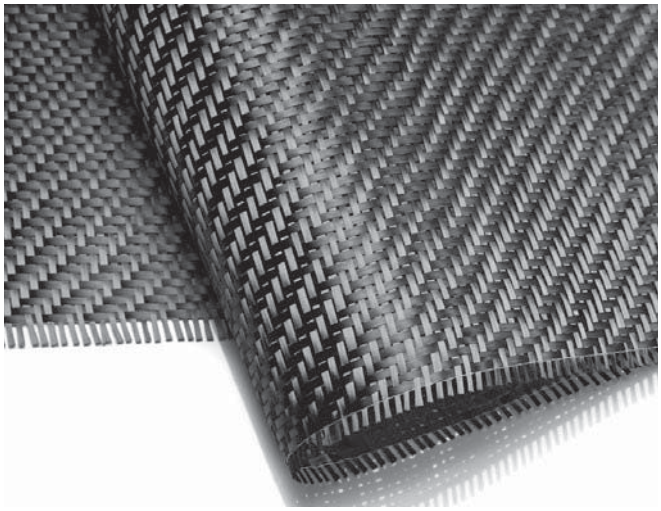
9. Name something else in the photo. Circle it on the page, and then describe it here.

10. Language SmArts You know that matter can be broken down into smaller and smaller particles. Describe how different particles join together to form other things. Provide an example.

Engineer It!

Carbon Fiber

New technologies are always being invented. Carbon fiber is an example. It consists of extremely thin "hairs" that are joined together to form different materials. Because the fibers are so thin, the materials made from them are very lightweight. This property is very useful when designing running shoes or other things that are built for speed.



Carbon fibers are hairlike strings, or sheets, of carbon that can be stuck or woven together to make different materials.

Thanks to carbon fiber, this toy plane is more lightweight, and therefore faster, than a plastic, wooden, or metal toy plane.

11. What are the benefits of using carbon fiber instead of other materials, such as metal, to build machines?

States of Matter

Matter has particular properties. One property of matter is the state in which matter exists. The term *state* refers to how the particles of the matter are behaving. Sometimes scientists call states of matter *phases*.

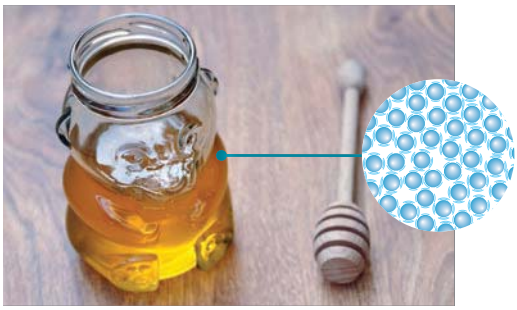
A *solid* is the state of matter that has definite shape and volume. A solid's particles are tightly packed together and only vibrate in place.

A *liquid* has no definite shape but does have a definite volume. A liquid's particles are not as tightly packed and can flow past each other.

A *gas* has neither definite shape nor definite volume. Its particles have space between them to move freely.

12. Look at the images of matter in different states, and then write down your observations. Focus on shapes and volumes. Do they change?

The shoe consists mainly of different solid materials.



At room temperature, honey is a liquid.

The gas-filled bouncy house can be inflated and deflated by fans.

13. Place the words in the box into the appropriate category, according to the state of matter they're normally found in.

Solid	Liquid	Gas

banana
sailboat
hot cocoa
penny
air
maple syrup
oxygen

HANDS-ON Apply What You Know

Air Is Matter

14. How can you test to see if air has the properties of the state you assigned it to above? Your teacher will give you a glass bowl of water, a plastic cup, and a paper towel.

Pack the paper towel into the bottom of the plastic cup. Hold the cup upside down, with paper towel packed inside, and push it straight down into the bowl all the way to the bottom. Hold it there for a minute, and then pull the cup out the same way it went in—upside down.

What do you notice about the paper towel? Does that prove that air is matter?

Putting It Together

Matter is all around us. It can be broken down from a large size to a small size, but its identity doesn't change. If you add more of the same matter to the original amount of matter, it is still the same substance.

15. What is the difference between a single particle of water and a glass of water?

HANDS-ON ACTIVITY

How Much Matter Do You Have?

You already know that all matter has certain properties that make it special. These properties are used to determine what kind of matter you have. Some of these properties can be measured.

Materials
- 2 solid objects
- balance
- beaker
- meterstick
- metric ruler
- unit cubes

Objective

Collaborate to measure two different objects in as many ways as possible with the tools you have. You will be investigating volume, weight, and length.

What question will you investigate to meet this objective?

Procedure

STEP 1 Select two different solid objects to measure, and record what they are in the table below.

Object	Length	Weight	Volume

STEP 2 Determine how you will measure the objects. Plan to measure everything twice for accuracy.

Are there some things you are not able to measure? If so, what?

STEP 3 Use the balance to measure any weight measurements you need to make. Record your measurements in the table with the appropriate unit of measure.

STEP 4 Use a ruler to measure any length measurements you need to make. Record your measurements in the table with the appropriate unit of measure.

STEP 5 Come up with a method to make any volume measurements you need to measure. Record your results in the table with the appropriate unit of measure.

Analyze Your Results

STEP 6 Which object had the greatest volume? What tools did you use to confirm that?

STEP 7 What questions do you have about measuring volume?

Draw Conclusions

STEP 8 Make a claim based on your investigation. Use evidence to support your claim.

Measuring Matter

Making the Meter

When someone asks you how far you live from school, you probably reply with an answer in miles. In science, however, we use metric units such as kilometers, meters, and centimeters to measure length. How did we get from feet and miles to meters and kilometers?

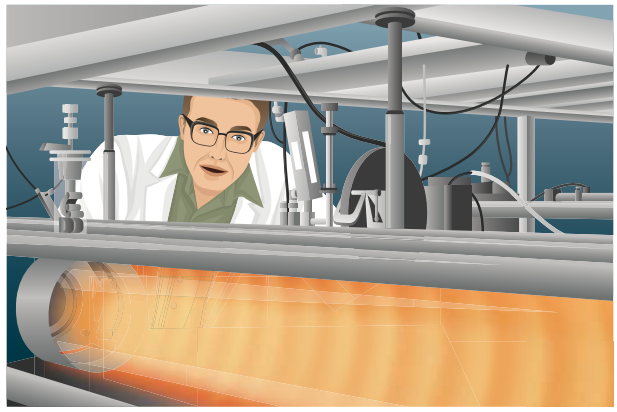
People used feet to measure because it was easy to walk heel to toe in a straight line to find a distance. But people's feet vary in size, which led to disagreements about what a "foot" really was.

A yard was equivalent to 108 barleycorns (a grain) laid end to end. Yardsticks could be cut to this length. A yard had three feet, so a yardstick could be marked to measure feet as well.

In the 1400s, a more standard unit of measure was established. Metals often served as the standards, and copies were made from wood and other less expensive materials.

The metric system originated in 18th century France. It uses a decimal-based system. A meter was equal to 1/10,000,000 of the distance from the equator to the North Pole.

In 1875, a convention was held to establish the meter as the unit of measure. A metal bar was designed that would serve as the standard and wasn't distributed around the world until 1960.



Since the 1980s, light has been used as the measure of a meter. A meter is the distance light travels in a split second ($\frac{1}{299,792,458}$ of a second) when shown in a vacuum.

As you can see, the units of measure for length have changed significantly over time, and we no longer need to argue whose feet are the right size to measure distances.

Do the Math

Measuring Length with the Metric System

16. Measure and record the length, width, and height of your desk in centimeters. Then convert your measurements into meters.

Unit of measure	Length	Width	Height
Centimeters			
Meters			

17. What pattern do you see between your measurements in centimeters and the measurements after you converted them to meters?

Wait for Weight

Another property of matter you have already investigated is weight. Suppose you are measuring how light or heavy an object is. The tools you use to do this are a balance or scale. While most Americans measure weight in pounds, the metric (SI) system uses units called *grams*. The same prefixes are used with weight as are used with length, such as *centi-*, *milli-*, and *kilo-*. With a scale, you might measure a small dog's weight as about 7.5 pounds, which is also 3.4 kg.

A balance can be used to compare the weights of two objects to one another.

You can use known weights to find the weight of an object on a balance.

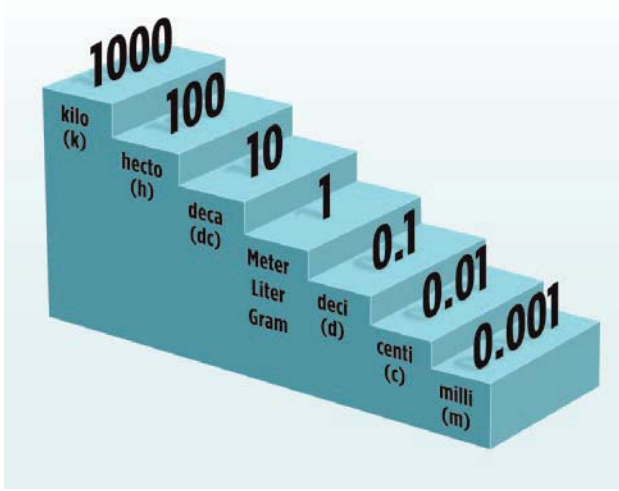
18. Find the weights of three things in or near your desk.

Item	Weight

19. How can you use the pan balance to confirm that the heaviest of your objects really was the heaviest?

Scientists and doctors use balances all the time to weigh different things. This vet is measuring the weight of this rabbit to see if it is healthy.

20. Language SmArts Research the meaning of four commonly used prefixes in the metric system. Write an explanation for what each prefix means.



21. Choose the correct words for each sentence.

graduated cylinder		**metric ruler**	**balance**
meters	**grams**	**converted**	**made**

A _____ is used to measure weight. Weight can be measured in _____. The advantage of the metric system is that measurements can be easily _____ into other units.

Measuring Volume

Another property of matter that can be measured is *volume*—the amount of space a given amount of matter takes up. All matter has volume, but sometimes it can be difficult to measure.

If it is a regular shaped object, such as a cube or a box, then you can measure it using a formula: length × width × height. If you take all of these measurements and multiply them together, you will get the volume in cubic units (usually cm^3).

If the object does not have an easy shape to measure, you'll need to use *displacement*. The volume of an object is equal to the volume of water it displaces. If you fill a graduated cylinder or beaker with a known amount of water and drop in your irregular object, you can measure how much the water rises. That displacement is the volume of the object.

Unit blocks are another way to measure the dimensions of a regular object. This shoebox has many sides of different lengths, so the student uses a different number of cubes to measure each one.

To find the volume, the student needs to find the length, width, and height of the shoebox. Using the cubes is one way of doing this.

22. Someone hands you three apples and asks you for the combined volume of all three. How would you measure this?

EVIDENCE NOTEBOOK Matter has weight and volume. There are many different methods for measuring these properties. What evidence do you have for this claim? Enter your answer in your Evidence Notebook.

Even if an object whose volume you want to measure has neat, regular sides and an even shape, it may not be practical to stack unit cubes next to or inside the object. A metric ruler may be more practical.

Measuring the length, width, and height in centimeters allows this student to then calculate the volume of the shoebox.

The formula for calculating the volume of the shoebox is length × width × height. This student used the ruler to have more precise results.

23. Find the volumes of three rectangular objects in or near your desk by using unit cubes and a metric ruler.

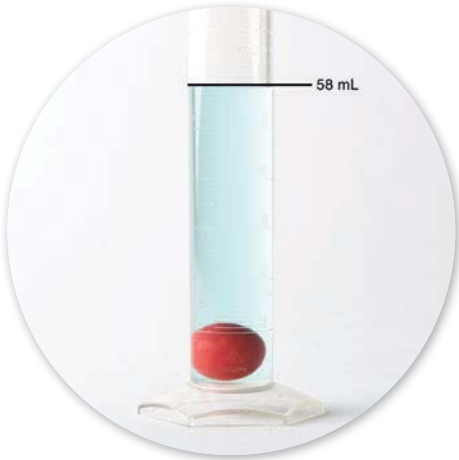
Item	Volume—unit cubes	Volume—ruler

24. Was there much difference between the volumes measured by unit cubes and the volumes measured with a ruler? Explain.

Solid in Liquid

Some objects do not have the kind of shape that can be measured with rulers. To measure the volumes of such objects, water can be used.

A graduated cylinder is filled with a specific volume of water.



Compare the new water level in the cylinder to the original water level. It shows the volume of the object using displacement.

HANDS-ON Apply What You Know

How Does Matter Fit Together?

25. Measure out 25 mL of rice using a graduated cylinder. Pour the rice into a container. Then measure out 25 mL of beans. Pour the beans into the same container as the rice. Stir the rice and beans together until they are thoroughly mixed. Then pour the combination into the graduated cylinder. Measure the volume. Why is the measurement less than 50 mL?

Putting It Together

26. What properties of matter can you measure? Cite evidence.

Discover More

Check out this path . . . or go online to choose one of these other paths.

Careers in Science & Engineering

- **Organizing Particles**
- **More States of Matter**

Materials Scientists and Engineers

Explore Online

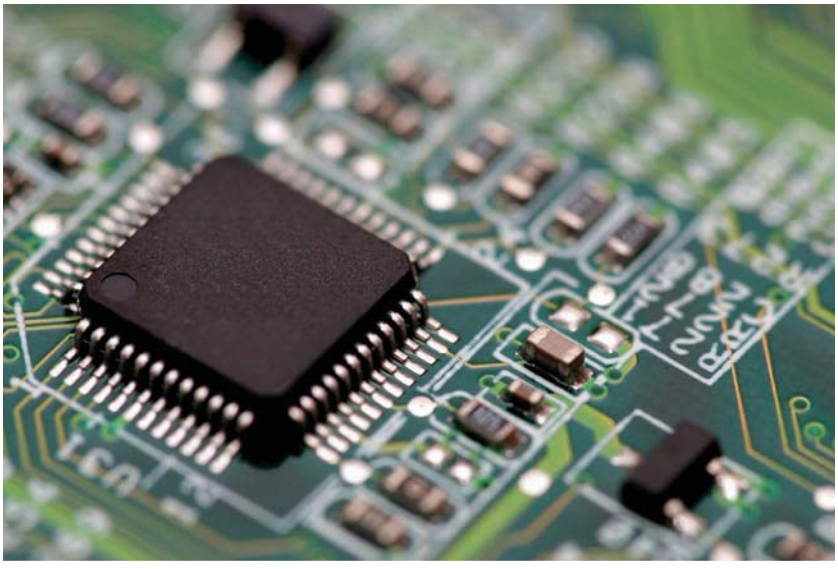
Knowing the different properties of matter has allowed for the development of many useful technologies. The scientists who make new materials or improved existing materials are called *materials scientists. Materials engineers* take these substances and design new or improved products for us to use. Some of the things materials scientists and engineers have invented include bike helmets, memory foam used in mattresses, and microprocessors used in computers.

Advancements in safety are one way materials scientists and engineers have helped people. Bike helmets are usually made of plastics and other materials that allow air to flow through.

The helmet is also very strong, so it gives a lot of protection to the head. At the same time, it is designed to be weak enough to shatter if an impact is especially strong. This helps prevent the wearer from suffering a concussion.

27. What makes foam a good choice as a material for the inside of a bike helmet?

Do you like to jump up and down on your bed? The mattress is most likely made of springs and filling. Memory foam is a new technology that greatly improves comfort for some people when sleeping. When you lay down on the foam, it curves around your body.



What would computers look like if the microprocessor had never been invented? They would still be the size of a large room and be very slow. Knowing the properties of different chemicals allowed materials scientists to invent the tiny chips that are now found in almost all electronic devices.

Think about what other things materials scientists and engineers have invented. Many things you take for granted were once brand new ideas. These things could be invented because people knew about how matter behaves and what its properties are. Maybe someday you can use your knowledge of matter to invent something amazing, too!

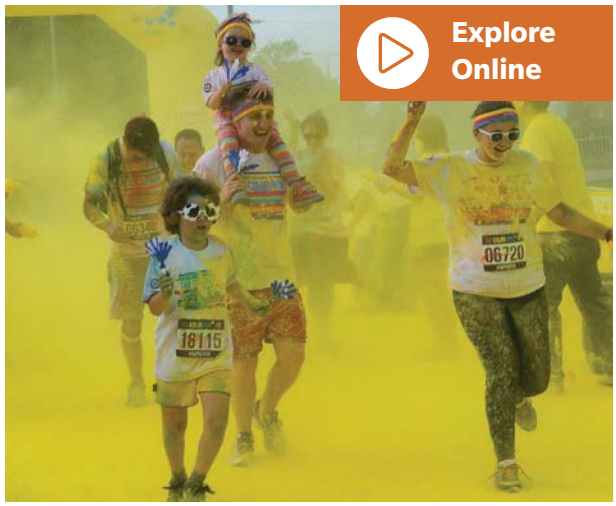
28. What properties of matter do you think materials scientists and engineers needed to know to invent memory foam?

LESSON 1

Lesson Check

Name _____

Can You Explain It?



1. Now that you've learned more about matter and its different properties, explain how the three main states of matter compare to each other. Be sure to do the following:

- Name three states of matter.
- Detail the different motion of particles in each state of matter.
- Identify ways to measure forms of matter.

EVIDENCE NOTEBOOK Use the information you've collected in your Evidence Notebook to help you cover each point above.

Checkpoints

2. Select the correct words from the word bank to complete each sentence.

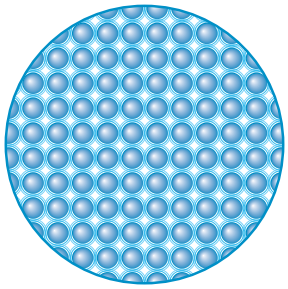
solid	**liquid**	**gas**	**fast**
slow	**low**	**high**	

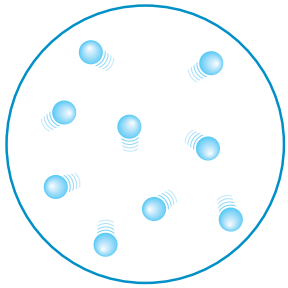
A _____ is a state of matter that has a definite shape. The speed of its particles is very _____ related to other states of matter. These particles have very _____ energy due to their speed.

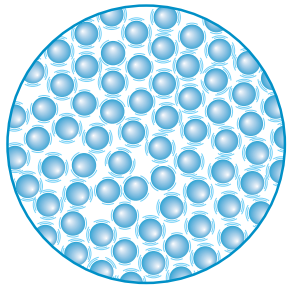
3. Draw lines to match the tools in the right-hand column with the things they measure.

volume	**balance**
length	**graduated cylinder**
weight	**metric ruler**

4. Label each illustration with the term that describes the state of matter: solid, liquid, or gas.







_____ _____ _____

5. Select the appropriate term to complete the sentence.

displacement	**length × height × weight**	**a balance**

In order to measure the volume of an irregularly shaped object, the best method to use is _____.

6. Choose the correct words from the word bank to complete each sentence.

solid	**liquid**	**gas**	**weight**
volume	**matter**	**balance**	**displacement**

The three states of _____ are _____, _____, and _____.

One way to measure the _____ of a solid is by _____ of water.

A _____ measures the _____ of a solid.

Lesson Roundup

A. Matter is anything that takes up space. Which of these are considered types of matter? Circle all that apply.

1. a feeling of happiness
2. a thought
3. a chicken laying an egg
4. a container filled with milk
5. five minutes passing by
6. bowling pins set up on an alley

B. Choose the correct words from the word bank to complete the sentence.

particles	**large**	**gases**	**small**

All matter is made of _____. Most are too _____ to see without a very strong microscope.

C. How do you calculate the volume of a solid? What is the volume of these solid objects? Complete the table.

	Length	Width	Height	Volume
Object 1	10	5	10	
Object 2	12	3	20	
Object 3	20	10	30	

D. Match the types of measuring tools with the properties they can measure.

balance	**scale**	**displacement**	**metric ruler**
ruler	**meter stick**	**length × width × height**	

Length	Weight	Volume

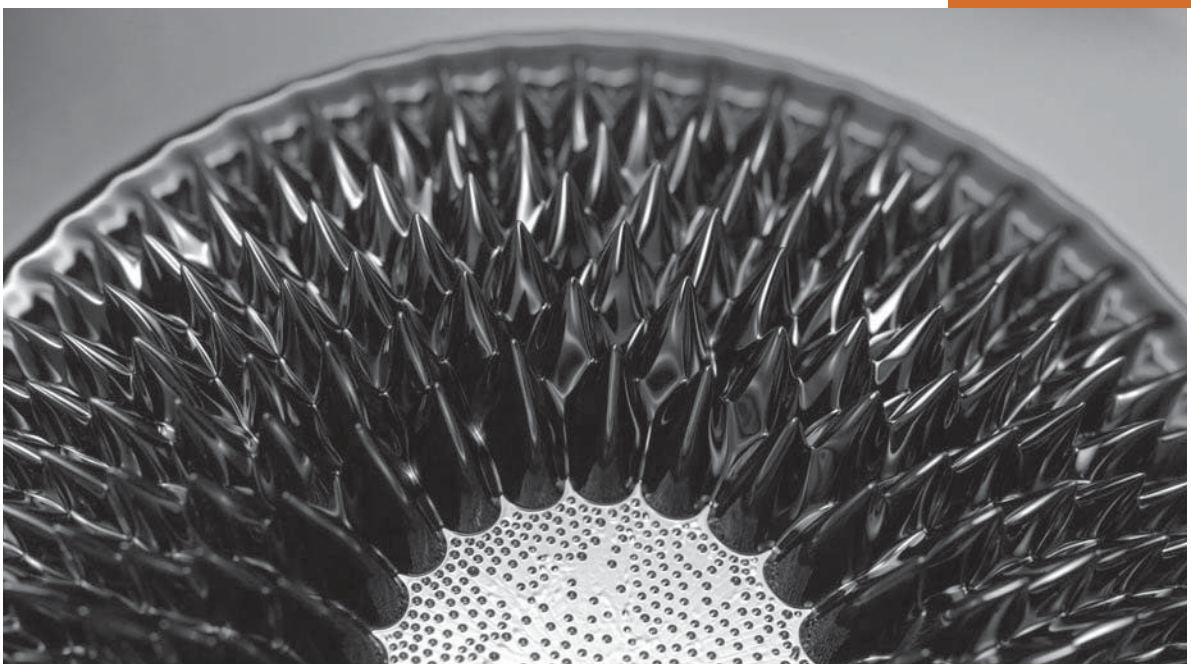
What Are Properties of Matter?

This salt water aquarium contains different types of matter, living and nonliving, in different states: solids, liquids, and gases.

By the end of this lesson . . .
you will be able to describe and recognize properties of matter and how those properties are affected by different factors.

Can You Explain It?

Explore Online



Matter does not always behave as expected. Look at this substance. Sometimes it behaves like a solid, but when a magnet is near it behaves like a liquid.

1. How would you describe this substance to a friend? What sort of properties would you say it has?

Tip

Learn more about how animals obtain and use energy and matter in How Do Matter and Energy Move Through Ecosystems?

EVIDENCE NOTEBOOK Look for this icon to help you gather evidence to answer the question above.

HANDS-ON ACTIVITY

What Affects the Rate of Dissolving?

Objective

Do all things dissolve at the same rate? Imagine you are making lemonade on a hot summer day. When you mix the sugar and water and begin to stir, the items mix together. Now, what would happen if you did this same thing on a cold winter day? Would the mixing happen at the same speed? Sometimes by changing certain things, the mixing can go faster or slower.

Collaborate to investigate three different variables. You will see how the type of salt, the temperature of the water, and the rate of stirring impact how fast salt dissolves in water. The ability to dissolve is a property of matter. Knowing how fast or slow something will dissolve helps to identify what substance you have.

Materials

- safety goggles
- lab apron
- 5 spoons for stirring
- 3 clear 100-mL containers
- measuring spoon
- measuring cups
- stopwatch
- room temperature water
- table salt
- coarse salt
- cold tap water
- warm tap water

Objective

What question will you investigate to meet this objective?

Procedure

STEP 1 For each step of the experiment, use a stopwatch to time how long it takes the salt to dissolve. Stop timing if the salt has not completely dissolved after two minutes. Be sure to empty and rinse the containers between each test. Make sure to wear goggles and an apron to protect your clothes, eyes, and skin.

STEP 2 Add 50 mL of room-temperature water to each of the three containers. Add a level tablespoon of table salt to each of the three containers. DO NOT STIR the first container. Stir the second container at a medium speed and the third container at faster speed. Record the time it takes for the salt in each cup to dissolve in the table.

Why did you not stir one of the containers? What purpose does that container serve?

Time It Takes to Dissolve	
Treatment	**Time (seconds)**
no stirring	
stirring slowly	
stirring quickly	

STEP 3 Does the particle size of salt make a difference in the amount of time it takes to dissolve? How can you test the difference between table salt and coarse salt? Make a plan and test it out!

When testing the difference in particle size, what factors did you keep the same between both samples? Why?

Time It Takes to Dissolve	
Treatment	**Time (seconds)**
coarse salt	
table salt	

STEP 4 Does the temperature of the water make a difference in the amount of time it takes salt to dissolve? How can you test the temperature difference? Make a plan and test it out!

Time It Takes to Dissolve	
Treatment	**Time (seconds)**
cold water	
warm water	

Look at your data. What would happen if the water were boiling?

Analyze Your Results

STEP 5 Which type of stirring caused the salt to dissolve the fastest?

STEP 6 Select one of the factors you tested. Graph your data on the graph.

Compare your graph with another group's graph. What does your graph say about the rate of dissolving?

STEP 7 Which type of salt dissolved at a faster rate?

STEP 8 Which temperature of water caused the salt to dissolve the fastest?

STEP 9 How did the salt in the water that was not stirred compare to the salt in the water that was stirred quickly or slowly?

STEP 10 What questions do you have about how certain substances dissolve?

Draw Conclusions

STEP 11 Why do you think that stirring the salt at a high rate of speed caused it to dissolve faster than the slower rate?

STEP 12 Why do you think the coarse salt took a different amount of time than the table salt to dissolve?

STEP 13 Make a claim based on your investigation and support it with evidence.

So Many Properties

Properties Describe Matter

All matter has properties. Some of the easiest properties to identify are the color, shape, and size of an object. These are called **physical properties**—characteristics of matter that you can observe or measure directly. No matter what terms you use, being able to describe an object using its properties is very important in science.

2. What properties describe this hat? Think about its color, size, and shape. Use words that really tell about the hat.

_____

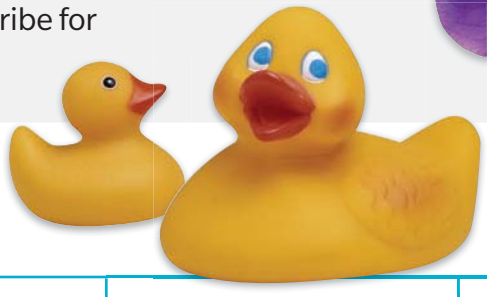
_____

_____

_____

Identifying Properties

3. Look at the pictures, and then complete the table below. Choose your own property to describe for the last column.



	Color	Shape	
Ducks			
Flower			

High-Priority Properties

Finding common properties or characteristics among objects can help scientists organize and classify them. But what happens when some properties match but others do not?

Property Categories

4. Sort the different objects according to shared properties by choosing a property, and writing the name of each object in the columns.






Color		

5. How did you sort the objects?

_____

_____

_____

Amazing Properties of Matter!

Color and shape are two basic properties of matter. Many other properties help you tell one type of matter from another.

Some properties, like reflectivity and response to magnetic forces, are important to scientists and engineers. An engineer designing a new type of magnetic device would not use wood to build it, because wood does not react to magnetic forces. Remember the substance that was discussed at the beginning of the lesson, which behaves sometimes like a solid and sometimes like a liquid? Response to magnetic forces is the property that causes that strange behavior.

Most rocks are hard. Feathers are soft. Hardness describes how easily something can be bent or dented.

Reflectivity is the ability to reflect light. Smooth objects, like this tea set, tend to be more reflective than objects that are bumpy.

6. Your teacher hands you three objects: a piece of wood, a metal nail, and a rubber band. Using the properties on these two pages, describe how you know what each of the objects is, and how it behaves.

HANDS-ON Apply What You Know

Bridge Building

7. How do physical properties affect the materials you select to build a model of a bridge? Come up with a plan to test different materials. With your teacher's permission, build your model. Which materials worked? Which did not? What physical properties describe the materials that are part of a successful bridge model?

This electromagnet attracts scrap metal for sorting. Response to magnetic forces is a physical property that is very useful at garbage dumps and recycling centers.

How can you bend a long, skinny balloon into all of those other shapes? The balloons are rubber. Rubber is flexible, so it bends easily.

8. Choose the correct words to complete each sentence.

hardness	flexible	magnets	reflectivity

Some objects that are _____ can bend without breaking. Objects that are attracted to _____ are usually made of metal. Mirrors and glass can be easily identified by the property of _____ .

_____ is a property that describes a brick wall.

EVIDENCE NOTEBOOK Think about how the properties you've learned about so far—color, size, shape, hardness, and reflectivity—would be good or not so good for identifying types of matter. Enter your answers in your Evidence Notebook.

Conductivity (Thermal and Electrical)

You have already learned about several different properties that matter can have. Another one to add the list is conductivity—the ability to transfer heat or electricity. Materials that let heat or electricity travel through them easily are conductive. Most things that are conductors are made of metal, although other materials can be conductive as well.

Materials that do not conduct heat or electricity or are called insulators. Insulation is often made of cloth, plastic, or rubber. In fact, have you ever noticed what covers the electric power cords of electric devices? The wires inside are covered with plastic to keep the electricity and heat from flowing out and starting a fire.

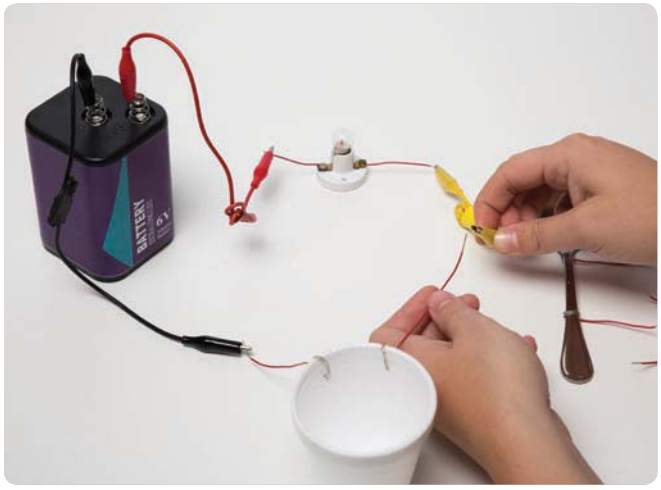
9. Why would holding up a metal umbrella during a lightning storm be a bad idea?

Using a metal spoon to stir the pot could result in a burn to your hands because metal conducts heat from boiling water.

Using a spoon with a nylon handle is a much better idea. Nylon does not conduct heat as well as metal.

10. The spoon in the left-hand pot of boiling water is made of _____. It is a good _____ of heat and electricity.

Just looking at something isn't a good way to determine its conductivity. Objects may be very polished so they look like metal but are actually made of plastic. The best way to test for conductivity is to see if the object heats up, just like the spoons in the previous photos.



Explore Online

Many things conduct electricity and heat, while others do not. Which conductors do you think will make the light go on? Most objects made of metal are good conductors. Objects made of plastic or wood are not. Objects made of other materials may or may not conduct electricity or heat.

HANDS-ON Apply What You Know

Conducting Conductors

11. You can make your own circuits to test different materials for conductivity. Your teacher will provide you with a light bulb in a holder, some copper wire, a AA battery, and a few materials to test. You will need to put on safety goggles and heat-resistant gloves.

Attach one end of a wire to the light bulb. Attach the other end of that wire to one side of the battery. Attach one end of the other wire to the light bulb. Place the material to be tested between the other end of this second wire and the other side of the battery. If the bulb lights up, what can you say about the material?

_____

Language SmArts

Researching Insulators and Conductors

12. Research conductors and insulators to compare their properties. Determine the traits of good conductors and good insulators. Describe how they differ.

_____

_____

Dissolving and Evaporating

Matter has so many different properties that it is hard to keep track. Another property of matter you should consider is solubility, which is the ability of one substance to dissolve in another. When something dissolves, it may look like one substance has disappeared, but those particles are still there! They are just too small to be seen. If you let salt water evaporate, for example, you will be left with a pile of salt.

Think back to the activity you did with the salt and the water. After you stirred the water with the salt in it, was the salt still there? You could not see it, but it was still in the water. It had dissolved.

Explore Online

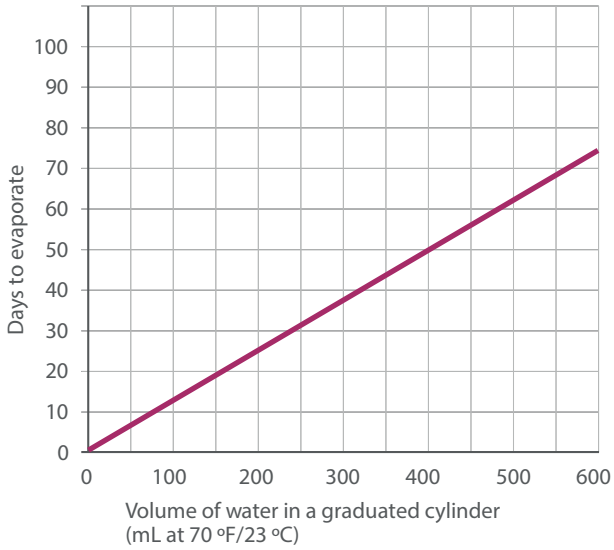
You may have seen a sodium bicarbonate tablet dropped in water to produce a bubbly antacid drink that's meant to soothe an upset stomach. The solid seems to disappear as it reacts with water and produces bubbles. This means sodium bicarbonate is soluble in water.

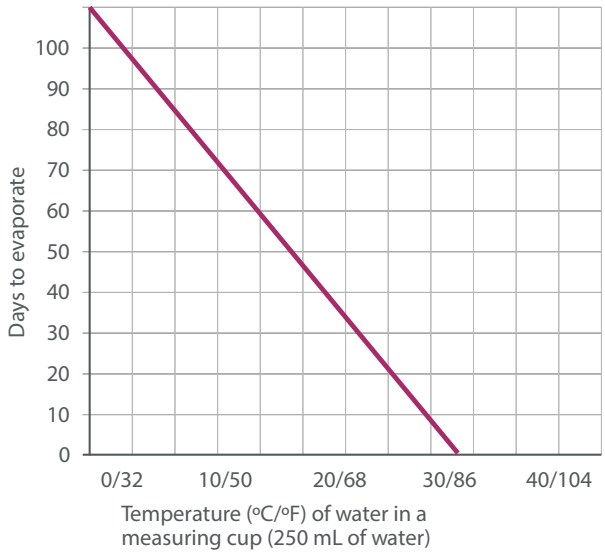
These salt deposits are the product of salt water evaporating.

Do the Math

Interpret a Graph

13. Bodhi investigated how temperature and volume affect how long it takes liquid to evaporate in class. Identify the patterns he discovered and graphed.





14. Describe how long it takes different volumes of water to evaporate.

_____

_____

15. Describe how long it takes different temperatures of water to evaporate.

_____

_____

EVIDENCE NOTEBOOK What evidence would you need to determine if something shows the properties of solubility, flexibility, and magnetism? Enter your answer in your Evidence Notebook.

Putting It Together

16. List four properties of matter that can be used to determine and describe an object.

_____

_____

Mixtures and Solutions

What Is It?

Imagine you are making a drink from a mix. You add water to a pitcher and then add a packet of flavor crystals. You take a spoon and stir everything together. Other than a tasty drink, what have you made? Adding these things together formed something called a mixture. A **mixture** is a combination of two or more different substances in which the substances keep their identities. If you sipped the drink you mixed, you would taste the flavor that was added to the water.

This salad is a great example of a mixture. Even though they are mixed together, you can still see all of the different vegetables.

Some types of orange juice are made by mixing water with a smaller volume of concentrated orange juice.

In a mixture, each part keeps its own properties. Have you ever accidentally swallowed some ocean water? If so, then you have tasted a mixture—water and salt. Mixtures can often be separated. If you leave a dish of ocean water out in the sun, the water evaporates, and a small pile of salt remains.

17. Name a mixture you may find at a meal.

Have you ever been to the beach? Take a close look at the sand under your feet. If you look closely, you can see that it has many different colors and sizes of particles. You may also be able to see tiny parts of seashells.

You have a mixture inside of you. Your blood is a mixture made of water and different types of cells. Some of these cells carry oxygen. Others fight off infections. Other parts of blood help to stop bleeding if you get a cut.

Go outside, and take a close look at a street. It is another type of mixture. Asphalt is made of many different sizes of particles. A heavy machine blends and presses these particles and a type of oil together to make a road.

18. Choose the correct words to complete each sentence.

mixture	**physical trait**	**behavior**	**properties**
separated	**shrunk**	**salad**	**bread**

When particles are blended together, they form a substance called a _____. When this happens, each particle keeps its own _____. One thing that is special here is that the particles can always be _____. A good example of a mixture is _____.

What Is a Solution?

Some mixtures are obvious, such as a salad. Other mixtures, such as ocean water, are so well blended that it's hard to know they contain more than one thing. A mixture that has the same composition throughout because its parts are mixed evenly is called a **solution**.

Think of lemonade, ocean water, or orange juice. Can you see the different parts that make up these liquids? Probably not. That is because the solids, such as the sugar in lemonade, have dissolved into the water. The particles are too small to be seen. You can taste them, but you cannot see them. How could you collect the solids? As with salt water, you could let lemonade sit out in the sun until the water evaporates. You would be left with a pile of lemony sugar.

Ocean water is a great example of a solution. What kinds of things can be found in it? Ocean water has a lot of dissolved salt in it, which is why you cannot drink it. All of the organisms living in the ocean have ways to drink or absorb water but avoid too much salt. Ocean water also has small amounts of other substances, including calcium and potassium.

Adding food coloring to water is a good way to observe how a solution is made. When the coloring is first dropped in, you can still see it distinctly. But after stirring it, the coloring is spread out evenly in the water. You cannot see where the coloring starts or the water ends.

When you think of solutions, you probably think of liquids. However, solutions can also be mixtures of gases. The solution of gases that you are probably most familiar with is air. Nitrogen, carbon dioxide, oxygen, and other gases all mix together to form the mixture you breathe.

This hang glider flies through the air. Air is a mixture of different gases.

Do you help with the dishes after dinner? The soap you use is a solution. It has several different things mixed together that help get the dishes clean.

19. Fill in the blank with the best term.

A taco is a good example of a _____ because all of its parts can be seen.

Lemonade is an example of a _____ because its parts are so well mixed that they can't be easily seen or separated.

EVIDENCE NOTEBOOK How would you know if something is a solution or just a mixture? Enter your answers in your Evidence Notebook.

Separating Mixtures

You now know that mixtures are combinations of matter where each part keeps its own properties. Think back to the salad you saw earlier. What kinds of things did you see in this mixture? Now, imagine you want to remove all of the carrots and cucumbers from the rest of the salad.

Sometimes solutions need to be separated. There are several different ways this can be done. Some of these ways involve the use of advanced equipment, while others use very simple methods.

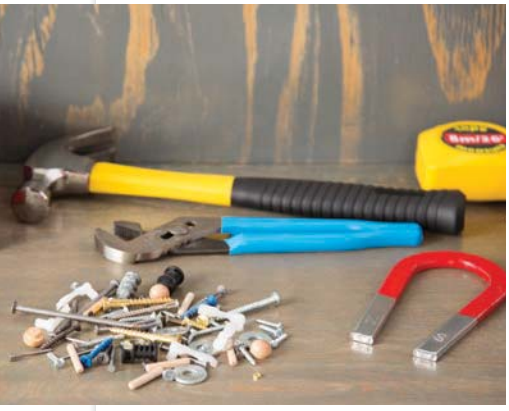
Mixed and Sorted

20. Identify how the two mixtures below were sorted.

Explore Online

The salad is made of different vegetables. How can these ingredients be separated?

The messy workbench gets sorted into metal and nonmetal piles. How?



When particles are mixed so well together that other separation methods don't work, sometimes scientists have to resort to very advanced techniques. DNA is the part of your cells that carries the code for all of your traits. Because there is so much of it inside each cell, scientists need to separate different segments to be able to "read" it. They do this by sending electricity through a gel that has segments of DNA at one end. The different-sized segments travel different lengths along the shell, creating a DNA "fingerprint." You can model this method of separating a mixture in the Hands-On Activity.

HANDS-ON Apply What You Know

Colors on the Move

21. You are now going to use your knowledge of mixtures and solutions to separate a mixture. Paper chromatography is a way scientists separate different pigments. Inks and dyes are often made from different pigments mixed together. Your job will be to separate them.

Using scissors, cut several strips of the filter paper. Using the black marker, draw a large dot about one half-inch up from the bottom. Do the same thing using the other pens on the other strips of filter paper. Tape the strip to a pencil so that it will hang down into the cup. Pour water into the cup until it barely touches the bottom of the strip. Let the strip hang until the color has traveled most of the way up the filter paper strip.

Materials

- scissors
- filter paper
- black marker and non-primary color pens
- 5 clear 100-mL beakers
- tape
- several pencils
- water
- ruler

22. How would you go about separating the materials found in an unorganized desk drawer? After you have written your response, go carry out your plan.

Engineer It!

Alloys

You might think metals are strong, but most metals are really quite weak. It is only when they are mixed with other metals that they get their strength. When metals are mixed together, they form a new material called an *alloy*. Scientists and engineers use alloys when they design and build buildings. Alloys are thought of as a solution of metals. Stainless steel, pewter, and 18-carat gold are all examples of alloys.

In order to create an alloy, the metals often have to be melted down. To do this, it takes a very hot temperature. Once the metals are in liquid form, they are mixed together. When they cool, a new, stronger metal is formed.

If the metal used in a building were not strong, the structure would topple over in the first wind storm. Steel is one of the strongest alloys used for buildings. It is a mixture of iron, carbon, and other substances.

Language SmArts

A Solution of Metals

23. The engines of airplanes are made of materials called superalloys. Do some research on superalloys and where and why they are commonly used.

Putting It Together

24. What is a mixture, and why are solutions considered the "best mixed" ones?

Discover More

Check out this path... or go online to choose one of these other paths.

People in Science & Engineering

- **Healthy Mixtures**
- **Mineral Hardness Scale**

Shirley Ann Jackson and Anthony Atala

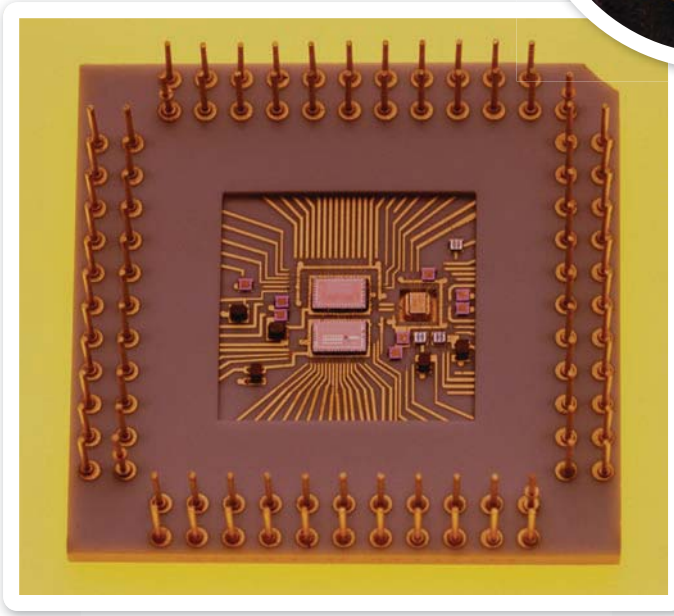
Explore Online

Two modern scientists have spent their careers studying the properties of matter. Dr. Shirley Ann Jackson is a physicist who studies how particles move to different places. She has done research on tiny devices called semiconductors, which are used in electronics.

Dr. Anthony Atala is a physician and medical researcher who is pioneering the use of 3D printers in regenerative medicine—making tissues and even organs that can be tailored to specific patients who are suffering from organ failure or have been injured.

Dr. Shirley Ann Jackson is the president of Rensselaer Polytechnic Institute in New York. She is the first African American woman to receive a doctoral degree from the Massachusetts Institute of Technology. Her interests include the properties of semiconductors and how they work in lasers, optics, and other machines.

Dr. Shirley Ann Jackson



Semiconductors are at the center of just about anything that has a computer chip. They are often made of a material called silicon. One of their properties is that they work somewhere between a conductor and an insulator. This property makes them very useful in electronic devices.

Dr. Anthony Atala

At the Wake Forest Institute for Regenerative Medicine, Dr. Atala and his team have developed a method of "printing" human tissues.

Dr. Anthony Atala was born in Peru and raised in Florida. He earned his M.D. from the University of Louisville and is now the director of the Wake Forest Institute for Regenerative Medicine. One of the projects Dr. Atala and his colleagues are working on is bioprinting, which combines the technology of 3D printing with medicine.

A 3D printer uses plastic or wax to create an object from a computer-drawn design. Dr. Atala's printers are a little different—they print living cells onto a supporting structure that can then be transplanted into a human.

Dr. Atala hopes this technology will one day eliminate the long waits that many ill patients have to endure before receiving vital organs such as kidneys and bladders. Replacement tissues and organs could also be grown and printed to treat wounded soldiers and others who have lost tissue or have damaged organs.

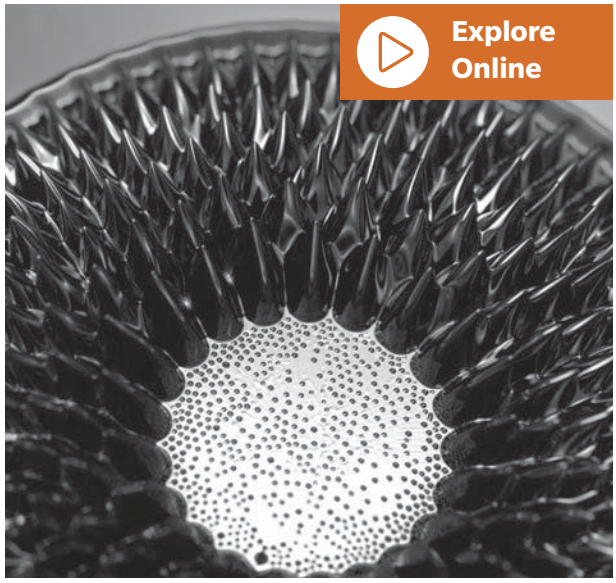
25. How can knowing the properties of matter lead to new technologies?

LESSON 2

Lesson Check

Name _____

Can You Explain It?



1. Use what you have learned about properties of matter to describe the properties of this substance and explain how it is alike and different from other matter. Be sure to do the following:
   - Describe the properties of the substance.
   - Explain if the substance is a solid or a liquid.
   - Identify how the substance has flexibility but is also solid in some ways.

EVIDENCE NOTEBOOK Use the information you've collected in your Evidence Notebook to help you cover each point.

Checkpoints

2. Why is a vegetable salad considered a mixture?

   a. The particles are very small.

   b. The vegetables can be put together easily.

   c. Each part keeps its own identity.

   d. All of the colors and flavors fit well together.

3. Suppose you were asked to identify the properties of most fire trucks. Select all the terms that you could use.

a. red
b. purple
c. large
d. round
e. long
f. slow moving
g. very speedy
h. loud
i. soft

4. Match the objects in the word bank to the property that it best demonstrates.

rubber band	**bungee cord**	**brick**
feather	**iron bar**	**metal fork**

Elasticity	hardness	conductivity

5. You have a shallow container filled with ocean water. What could you do to separate the salt from the ocean water?

a. Add additional water to the container.
b. Let it stand in the sun for a while.
c. Take some water out of the container.
d. Decrease the temperature of the water.

6. Choose the correct words to complete each sentence.

dissolve	**evaporate**	**slowly**	**quickly**
increase	**decrease**	**temperature**	**conductivity**

When trying to get salt to _____ in water, it is best to stir it _____. If you wanted to get the salt into solution faster, you could _____ the _____ of the water.

LESSON 2

Lesson Roundup

A. Suppose you were asked to design a machine that would be made of materials that will best conduct electricity. Select those that would be useful to you.

1. plastic
2. wood
3. aluminum
4. gold
5. rubber
6. silk
7. flannel

B. Choose the correct words to complete each sentence.

red	**purple**	**giraffe**	**button**	**paper clip**
grasshopper	**an ice cube**	**an ice cream cone**	**a shoebox**	

You have a ripe apple and a picture of a stop sign. Both of these objects are _____ in color, so they can be sorted this way. Two things that can be sorted by similar size are a _____ and a _____ When sorting by shape, _____ and _____ would be in the same category.

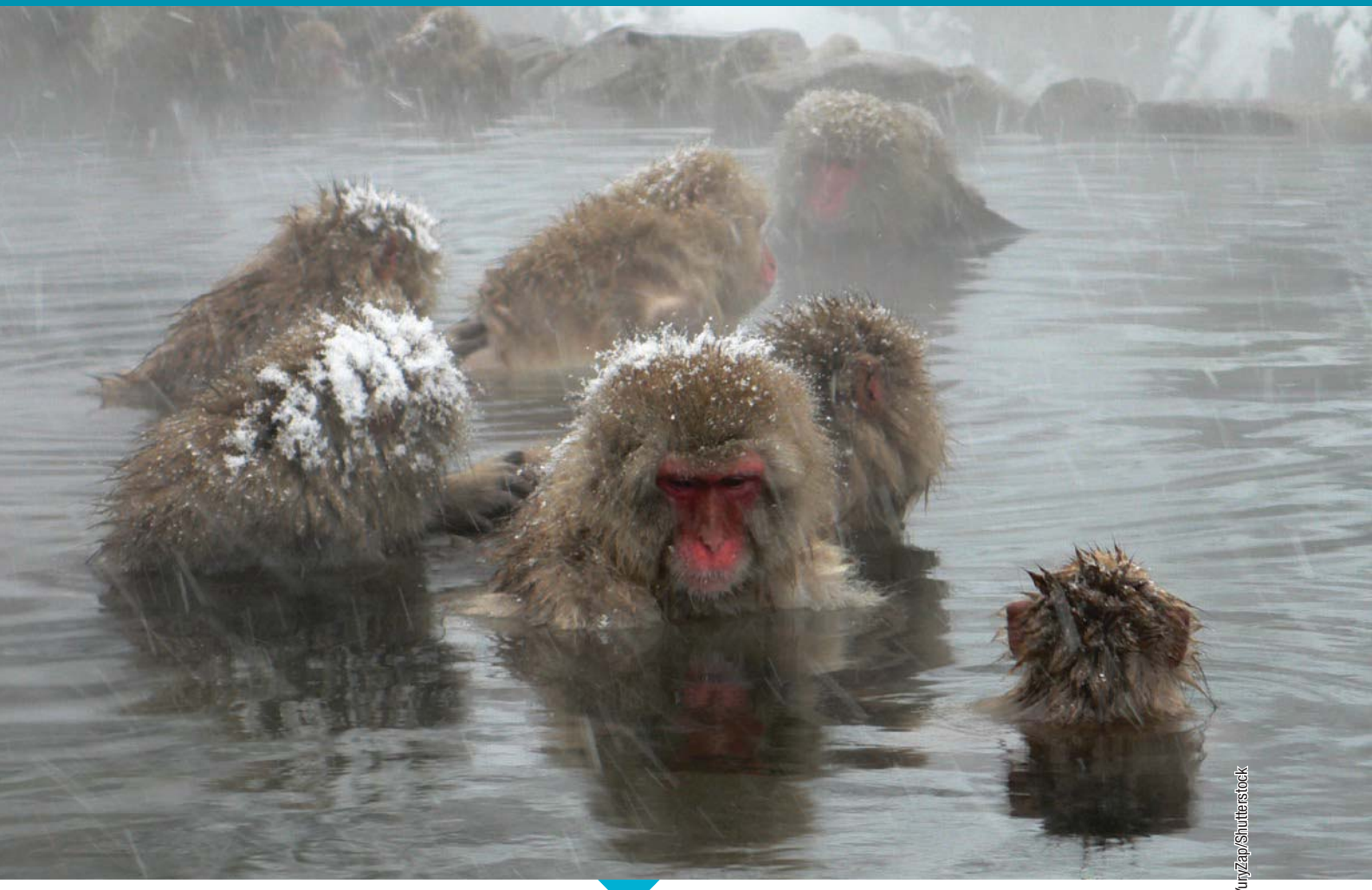
C. A scientist has a special container of ocean water. She wants to keep it so she can study it further. Her lab gets a lot of sunlight every day. What can she do to keep the ocean water from turning into just a pile of salt?

1. cover the container to prevent evaporation
2. increase the temperature of the container
3. separate the water into different containers
4. add more plain water to the container

D. A solution is a special type of mixture. An alloy is a special type of solution. Select all of the properties of an alloy.

1. can be easily separated
2. very strong
3. made of metals
4. high elasticity
5. high flexibility
6. conductivity
7. insulator

How Does Matter Change?



In this location, water exists in three different states: liquid, solid, and gas.

By the end of this lesson . . .
you'll be able to identify different changes that can happen to matter.

Can You Explain It?

Explore Online

Matter is not always what it seems. In this experiment, two liquids are added together. When they interact, they form a solid. How is this possible?

1. How could a solid result from the mixing of two liquids?

Tip

Review what it means for something to be a liquid or solid in What Are Properties of Matter?

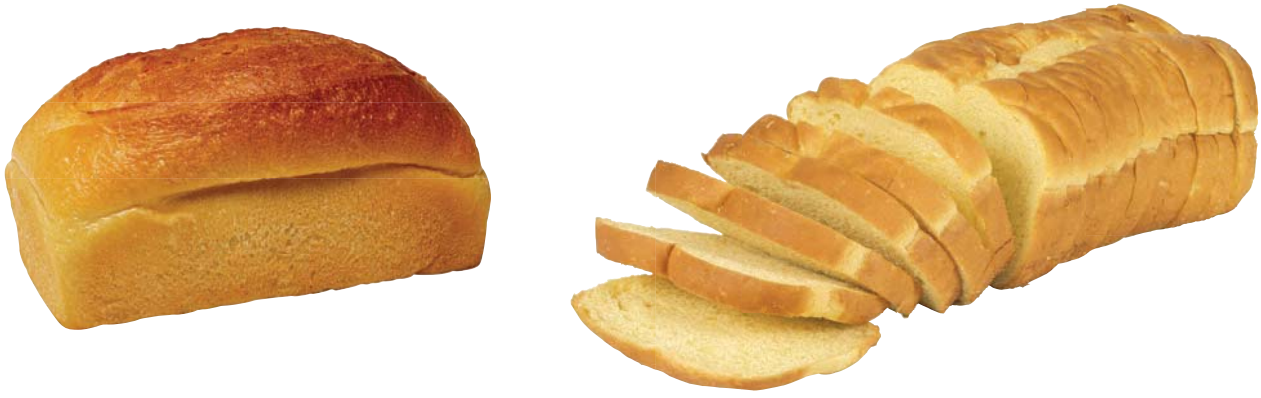
EVIDENCE NOTEBOOK Look for this icon to help you gather evidence to answer the question above.

Physical Changes

Ch, Ch, Ch, Changes

One of the ways matter can be changed is in how it looks. It can be scribbled with pencil and change color. It can be cut into many pieces. It can be bent into a different shape. The matter itself is still the same. This type of change is called a **physical change.** The key to a physical change is that nothing new is made.

There's a stack of paper. Some of it gets folded into this crane. Is it still paper? Yes! Folding it is just changing its shape. This is a great example of a physical change.



To make a sandwich, you have to cut slices from this loaf of bread. Once the slices are in the sandwich, you have made a new substance, right? Wrong! The slices of bread are made of exactly the same stuff as the unsliced bread.

Another example of a physical change happens when you mix things together. Imagine you have a bag of blue beads and a bag of red beads. Then you put them together into the same bag and shake it up. What happens? The beads mix with each other. Can you still see the different colors? Yes! This is because you have not created anything new. The physical change is just the mixing of the beads.

This can is made of steel. It is used to hold soup or vegetables. What happens to the can after it gets crushed? Is the can still made of steel? Sure! All you have done by crushing it is change its shape. It is still the same kind of matter.

2. Choose the correct words for each sentence.

color	**location**	**makeup**	**shape**	**cutting**
burning	**matter**	**temperature**	**flammability**	**size**

Physical changes happen when matter changes _____,

_____, or _____.

An example of this type of change would be _____

a piece of wood. In this type of change, no new _____

is created.

EVIDENCE NOTEBOOK What evidence have you found that a physical change has occurred? Enter your answers in your Evidence Notebook.

Physical Changes Up Close: Melting and Freezing

Remember that matter can exist in different states. Solids, liquids, and gases are the three most common states of matter on Earth. These states are also important to know when thinking about physical changes. Changing from one state to another is an example of a physical change. The thing to keep in mind when looking at these changes of state is that no new matter is made. The matter you started with is still there, just in a different form.

Have you ever put orange juice into the freezer? It becomes a solid. To make orange juice ice pops, pour orange juice into an ice cube tray. Then cover the top with plastic wrap. Punch a toothpick into each chamber and then put it in the freezer. In a couple of hours, you will have a treat! Physical changes in action!

3. How does the orange juice compare in each of its different states?

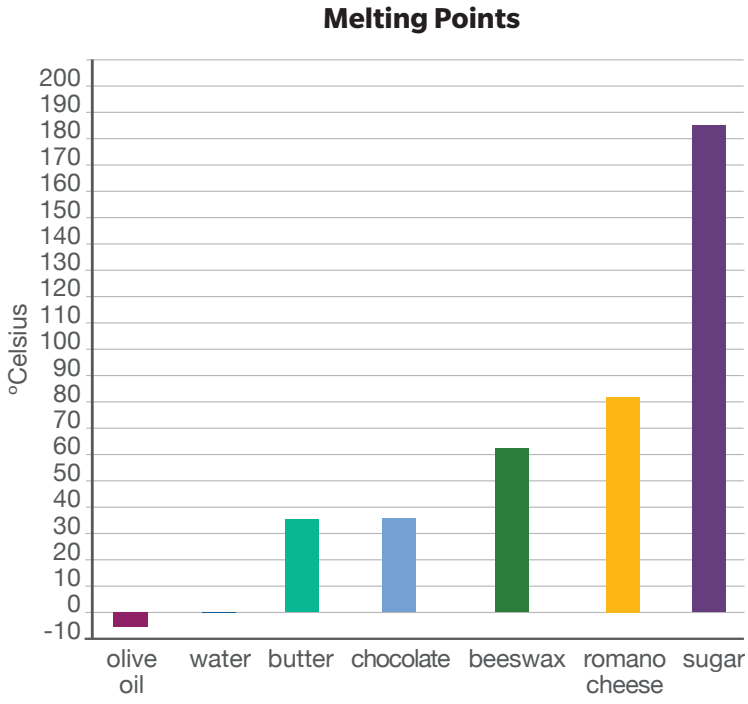
Freezing and melting are two common physical changes. When you freeze a liquid, its particles slow down because they have less energy. Remember that the particles in solids vibrate in fixed positions. Freezing a liquid changes it into a solid. When you take that solid out of the freezer and warm it up, it is called melting. When the temperature is warmer, the particles gain energy and start to move faster. When they gain enough energy, they break loose and slide past one another. This changes the solid into a liquid.

Do the Math

Explaining Patterns in Melting

4. Substances change their state at different temperatures. The substances at right all change from solids to liquids with different amounts of energy.

Which substance has the highest melting point? Which substance has the lowest melting point? Would the substance that melts at the lowest melting point also melt at the highest melting point? Explain your answer.



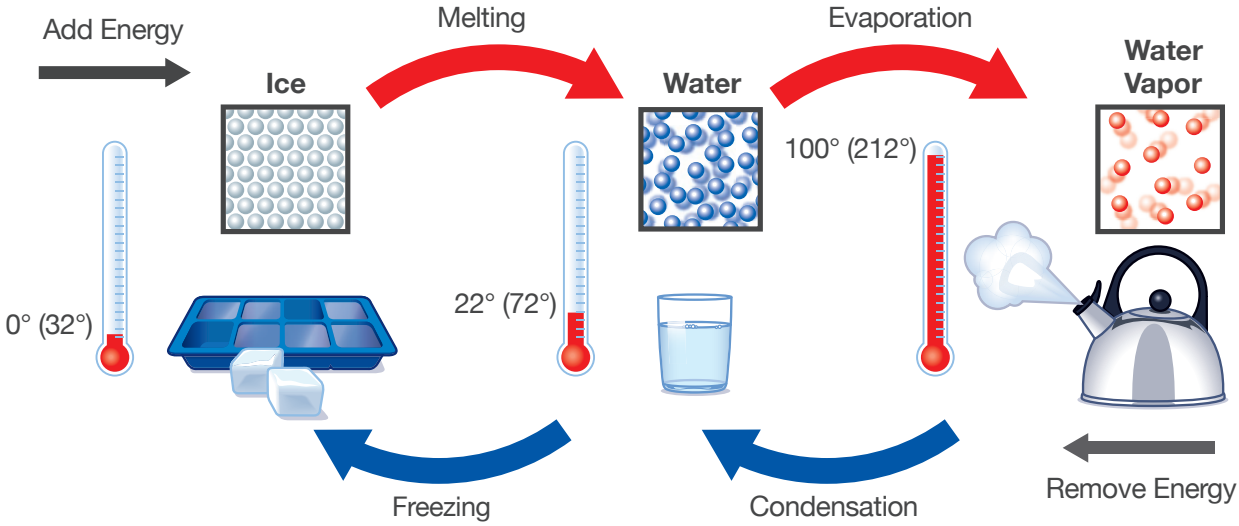
The **melting point** is the temperature at which a solid changes to a liquid. This metal, which was once a solid, is now a liquid. Different metals have different melting points. For example, tin has a lower melting point than iron.

5. Enter *freezing* or *boiling* to complete the sentence.

To turn this liquid back into a solid, it needs to be at its _____ point.

Phase In, Phase Out

Changing the state of matter is an example of a physical change. This is also called a *phase change*. It means that going from solid to liquid to gas and back again does not change the matter present.



Imagine a teakettle filled with water. The kettle is heating up. What is happening to the water inside? The water is a liquid. When it reaches its boiling point, it will turn into a gas. The **boiling point** is the temperature at which matter changes from a liquid to a gas. As the gas tries to escape from the kettle, it whistles (remember that gas particles move very fast). After the kettle is removed from the heat, it will start to cool. This changes the gas back into a liquid. If that liquid water is then placed into the freezer, it will cool more. It will then become a solid. All this time, physical changes have been happening. Nothing new has been made.

Language SmArts

Making Rice in the Kitchen

6. What changes happen to water when making rice?

Tip

The English Language Arts Handbook can provide help with understanding how to determine sequence of events.

HANDS-ON ACTIVITY

Which Will React?

Objective

Collaborate to identify substances. The ingredients in a kitchen have lost their labels. How can you tell the cornstarch, cream of tartar, and baking soda apart? Just by looking at them you can't tell. But by observing if a mystery substance undergoes a physical or chemical change you can often determine what it is.

What question will you investigate to meet this objective?

_____

_____

_____

_____

Materials

- safety goggles
- apron
- 3 droppers
- 3 plastic spoons
- 9 test tubes
- test tube holder
- dry ingredient 1
- dry ingredient 2
- dry ingredient 3
- iodine solution
- vinegar
- water
- labels and pen
- test tube brush
- soap

Procedure

STEP 1 A 5th grade student has three containers, each with white powders in them. She is confused as to what they are. She needs to figure out which is baking soda, cornstarch, and cream of tartar, but they look the same and have no labels.

STEP 2 Label three water test tubes "A," "B," and "C." Prepare test tubes the same way for the vinegar and iodine. Carefully place each test tube in the test tube holder.

STEP 3 Add a tiny spoonful of powder 1 to the first set of test tubes water "A," vinegar "A," and iodine "A."

STEP 4 Repeat Step 3 with powder 2 and powder 3, making sure that powder 2 only goes in test tubes with a *B*, and powder 3 only goes in test tubes with a *C*.

STEP 5 Using a dropper, add three drops of water to all three water test tubes. Record your results in the table.

STEP 6 Use a different dropper and add three drops of vinegar to all three vinegar test tubes. Record your results in the table.

STEP 7 Now use a third dropper to add three drops of iodine to all three iodine test tubes. Record your results in the table.

Do you think three drops is enough to see a reaction? Would you get the same result with only two drops?

DATA TABLE: Reactions			
	A (Powder 1)	**B (Powder 2)**	**C (Powder 3)**
Water			
Vinegar			
Iodine			

STEP 8 Analyze your results on the table. Using your observations, label the powder containers with the names of the liquids that reacted with each one.

Did all of the powders undergo a chemical change?

STEP 9 Once you are done recording all the reactions, keep your safety gear on and clean the test tubes using soap, water, and a test tube brush.

Analyze Your Results

STEP 10 Baking soda will react with vinegar to produce a gas. Cornstarch will mix with iodine and change color. Cream of tartar will not react with water, vinegar, or iodine. Using this information, complete the table below to identify each mystery ingredient.

Powder #1	Powder #2	Powder #3

STEP 11 What effect did the vinegar have on the baking soda? Did any of the other tests show the same effect as the baking soda and vinegar?

STEP 12 What reaction did you see with the cornstarch and iodine solution? Did any others react in the same way?

STEP 13 What was the purpose of testing the cream of tartar?

Draw Conclusions

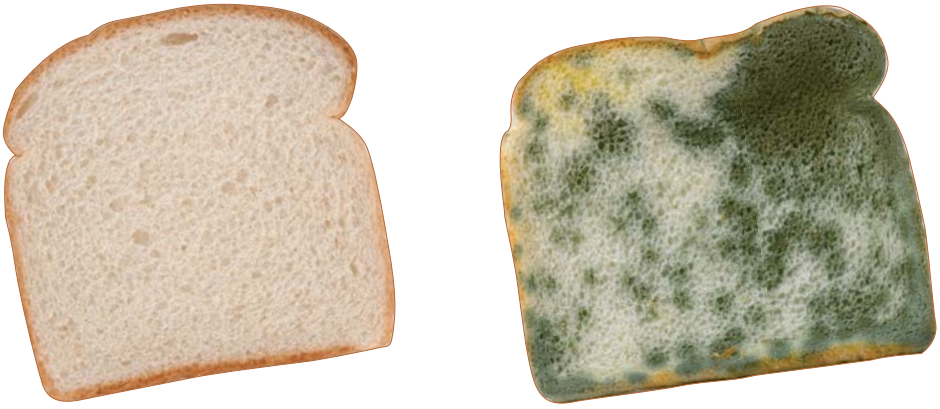
STEP 14 Make a claim about which types of changes took place in this investigation. Support your answer with evidence.

Chemical Changes

Before and After Are Different

Another type of change that can occur is a chemical change. During a **chemical change,** new matter is formed. There may be a new product (such as a *precipitate,* the solid material that forms at the bottom of a tube) or a gas. Or you may observe an increase in temperature. The key thing is that the original matter has changed for good.

Burning things is a great example of a chemical change. When something burns, energy is released in the form of heat. The burning substance changes into something new as heat is released. Think of the pile of ashes that remains after a campfire has burned out. You cannot make the ashes change back into wood.



What happens when you leave food out on the counter or in the refrigerator for a long time? It "goes bad," or rots. The chemical makeup of the food changes.

Glow sticks have chemicals inside of them. When these chemicals come together, they start to glow. Can you ever separate those chemicals? No. This is because a chemical change has happened. Once the reaction is over, the light will die out.

If you cook eggs, then you have seen the result of a chemical change. Once you crack the egg into the hot pan, the heat starts to change it. The liquid part of the egg now becomes more solid and changes color. The smell of the cooking egg is another sign that a chemical change is taking place. Once cooked, there's no way to put the egg back into its original state.

7. Categorize the following changes or products as evidence of chemical or physical change.

strong odor	**temperature change**	**precipitate**
breaking in half	**bending**	**painting**

Chemical change	Physical change

HANDS-ON Apply What You Know

Seeing Chemical Changes

8. Your teacher will provide you with Epsom salts and ammonia. Use a balance to measure out 2 g of the Epsom salts and place them into a beaker. Then use a graduated cylinder to measure out 10 mL of ammonia (safety note*—be sure to wear safety goggles, do not touch the ammonia, and do the activity in a well-ventilated area). Add the ammonia to the beaker of Epsom salts, and set a timer for 5 hours. Monitor the beaker regularly, and record your observations.

EVIDENCE NOTEBOOK What happened to the Epsom salts immediately after you added the ammonia? What happened to the Epsom salts over time? What evidence did you collect that showed a chemical change happened? How is this different from a physical change? Record your answers and evidence in your Evidence Notebook.

Chemical Changes Up Close: Rusting and Rotting

Have you ever seen a rusty metal can? Rusting is another example of a chemical change. If metals are not protected and they get wet, they may start to rust. The water causes the metal to develop a reddish-brown color. Over time, the spot where the rust forms will "eat away" at the can. This will form a hole. The rust will spread, and the entire metal can will fall apart.

Explore Online

9. Describe the appearance of the car and the environment it's in.

10. How has the scene changed?

11. How about now?

Engineer It!

Electroplating

Did you know electricity is able to cause chemical changes? Engineers use electricity to cause chemical changes in metals in a process called *electroplating*. During this process, an electric current produces chemical changes that result in one metal being coated with a thin layer of another metal. Electroplating is used to improve the durability and appearance of metal objects. The coating prevents unwanted physical and chemical changes from occurring in the metal.

Explore Online

An electric change is applied to both metals, causing them to join. The coated metal may have a different color or other new properties.

Electroplating was used to develop gold-plated visors for astronauts to protect them against the unfiltered rays of the sun.

Electroplating changes the surface of metal objects. This gives the metal different properties. Iron nails, nuts, and bolts are commonly plated with zinc to keep them from rusting. Attractive yet more affordable jewelry is made by placing silver or gold plating on a less expensive metal. Electroplating is also used to give electronic and computer parts more desirable physical properties and to make them last longer. Electroplating is even used to make coins. The pennies we use today consist of a solid zinc core covered with a thin plating of copper.

12. Why is electroplating an example of a chemical change?

Changes at Home: Cooking Science

Did you know that there are all kinds of chemical changes that happen in the kitchen? Remember that a chemical change results in something new being produced and the original materials are used up, or changed into something else. What types of things happen in the kitchen that result in new things being made? Do you like bananas? Bananas change from green to yellow as they ripen. Eventually they turn brown and get mushy. Ripening is a chemical change.

Home-Cooked Chemistry

Explore Online

This family is cooking a meal. They have washed their hands and gathered all the things they need. It also looks like they are going to make something with graham crackers and marshmallows. On the stovetop is a sauté pan with colorful vegetables in it. The father is stirring it while a loaf of bread is baking in the oven.

13. What kinds of energy are causing chemical changes as the meal is prepared?

Baking bread in the oven is a chemical change. What gets put into the dough for bread? Flour, sugar, yeast, and eggs are blended together. After the bread is baked, it has undergone a chemical change to form something new.

Stir-frying vegetables on the stovetop is another example of a chemical change. As they cook, the vegetables become sweeter and slightly brown, due to the heat.

What do you get when you take graham crackers, chocolate, and marshmallows and add a chemical change? S'mores! The roasted marshmallow and chocolate melt together and stick to the cracker. Who knew a chemical change could taste so good?

Composting is another example of a chemical change. The food scraps that go into a compost pile break down over time. The scraps will eventually turn into a nutrient-rich soil. The unpleasant smell of the compost pile is another clue that chemical changes are taking place.

14. Choose words that correctly complete the sentences.

chemical	**physical**	**mix**	**separate**	**always**	**never**

Baking bread is an example of a _____ change. The ingredients of the bread _____ to form a new substance. The original ingredients can _____ be separated.

EVIDENCE NOTEBOOK What types of things happen in the kitchen that are chemical changes? How do you know these are chemical changes? Enter your answers in your Evidence Notebook.

What Kind of Change Is It?

Did you know that the same substance can undergo both physical and chemical changes? Remember that during physical changes, the substance stays the same but changes a property. During chemical changes, new substances are formed .

This pile of wood used to be a tall tree. The person chopped it into smaller pieces. Is it still the same wood? Yes! This would be a physical change.

Now that same wood is placed into a fireplace. It starts to burn. After it is all burned up, what will be left? Will you still have the same wood? No. The wood will be changed into ash.

This loaf of bread is perfect for a sandwich. Using cookie cutters lets you make it into fun shapes. This is a physical change because the bread is just a different shape.

Putting bread in the toaster will make it warm and golden brown. What kind of change is this? Can the original bread ever come back? No. This is a chemical change.

Putting it Together

15. Describe one type of cooking that involves both physical and chemical changes.

Conservation of Matter

Physical Changes

During a physical change, the amount of matter in the object stays the same. This happens because no new matter is being formed. When you cut a piece of paper in half, you still have the same amount of paper, just in two pieces. The fact that the amount of matter stays the same is called the **conservation of matter.**

Imagine you have a pile of building blocks. You build a tower using all of the blocks. Then you are asked to take apart the tower and build another shape using the same number of blocks. The new shape looks totally different than the tower but still has the exact same number of blocks in it. This is the conservation of matter during a physical change.

An orange is being weighed on a digital scale.

The same orange has been peeled and sectioned. How does its weight compare with that of the entire orange?

These are the materials needed for an activity. The sugar and the water will be added together. What is their combined weight here?

The sugar has been added to the water. What is the weight now? Did it change from before they were added together? This is how the conservation of matter works.

Conservation in a Phase Change

The conservation of matter also applies to phase changes. Remember that changing from a solid to a liquid to a gas are all physical changes. The matter does not change, only the speed of its particles. If you were to melt solid gold to a liquid, you would see that it has the same weight as the solid.

Here is a block of ice sitting in a beaker. Notice what the scale says. This beaker will be left out at room temperature.

What does the ice look like now? Here it is partially melted and partially solid. You know this because there is some liquid water in the beaker. What does the scale say the weight is?

The thermometer shows that the ice (now liquid water) is almost near its boiling point. What does the scale say about the weight of the water?

The water is now at a full boil. Its temperature has also gone up. What does the scale say now about the weight? It says it is less than before. Why is this? Where did the rest of the water go?

HANDS-ON Apply What You Know

Pull the Wool Over Your Eyes

16. In this activity, you will investigate the conservation of matter during a chemical change.

Your teacher will provide you with the steel wool you need to complete the activity. Begin by wetting the steel wool pad and then calculating its weight. Continue to rewet the pad over several days, recording its weight every time until it starts to rust. Let the pad get rusty for a few days before it turns to dust, and then measure its weight one last time.

17. Choose the correct words. Words can be used more than once.

chemical	physical	increase	decrease	stay the same

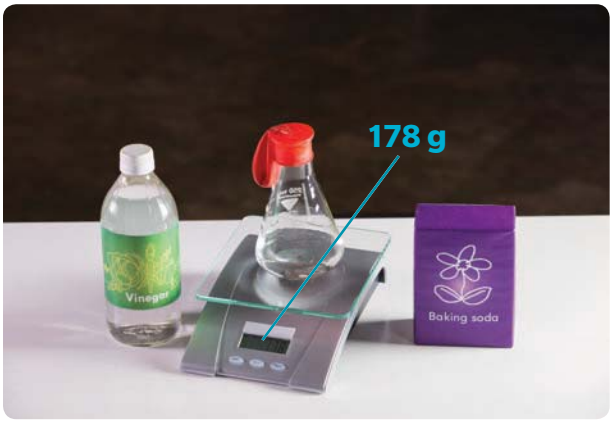
Phase changes are considered _____ changes. This means that no new matter is formed. When changing from solid to liquid form, the weight of the matter will _____. When changing from liquid to gas form, the weight will _____. This supports the conservation of matter.

EVIDENCE NOTEBOOK If two liquids combined to form a solid and liquid, how much matter do you think the new substances would have compared to the amounts of matter in the original substances? Record your answer in your Evidence Notebook.

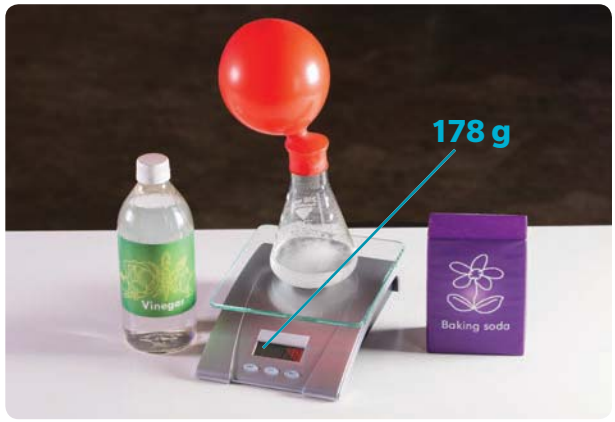
18. Why does the weight change as the water in the beaker changes state?

Conservation of Matter: Chemical Change

Chemical changes also demonstrate the conservation of matter. Remember that in a chemical change new things are formed. However, if you were to collect this new matter and weigh it, you would see that it has the same weight as the original materials. One needs to be careful here, though. Many times, during chemical changes, some of the matter is lost as gas. Therefore, the final weight of the new matter may appear to be less than the original. For example, the weight of the ashes collected after burning paper will be less than the original because some of the weight is lost as gas.



The total weight of a balloon full of baking soda and a flask of vinegar is shown. Notice the weight on the scale.



Vinegar and baking soda produce a liquid and a gas. When this reaction occurs in a flask sealed with a balloon, the gas produced by the reaction is contained. The total weight is unchanged.

19. What would happen if the reaction between baking soda and vinegar occurred in an open container with no balloon? Would it be easy to show conservation of matter?

Putting It Together

20. How does the conservation of matter relate to phase changes?

Discover More

Check out this path . . . or go online to choose one of these other paths.

People in Science & Engineering

- **Slow Down the Spoil**
- **Acids and Bases**

People in Science: Antoine Lavoisier

Conservation of matter is demonstrated during chemical changes. When new substances are formed, their weight will still be the same as the original materials. When burning something, some of the material becomes a gas, and it escapes, the weight of what remains will be slightly less. But conservation of matter still applies!

When things are heated, a chemical change is taking place. In order to get things to burn, a gas called oxygen must be present. Here, a chemical called *phosphorus* is undergoing a chemical change in the presence of oxygen.

Antoine Lavoisier was one of the first to realize that the number of things going into a reaction equals the number of things produced. He was very detail-oriented in his studies and collected a lot of data.

Antoine Lavoisier is known as the father of modern chemistry. He was a French scientist who actually started his career as a lawyer. After law school, he got a job at the Royal Gunpowder and Saltpeter Administration. It was here that he began his chemical studies. He is responsible for what we know about how things burn. He discovered oxygen and determined that it made up a percentage of the air we breathe. He also figured out that in order for things to burn, oxygen must be present.

Lavoisier became very curious about how different chemicals could mix together but still have the same weight. He studied the heating of a chemical called mercury oxide. He found that when this was heated, it lost weight. He figured out how to collect the oxygen that is released from the mercury. It turned out that the weight of the oxygen was exactly the same as the decrease in weight of the mercury oxide. This led him to other experiments that would result in him putting together the law of conservation of matter.

If you could capture or contain the tiny smoke particles and gases from a fire and add their weight to the weight of the ash, it would be equal to the weight of the wood and the oxygen it reacted with.

21. What contributions did Antoine Lavoisier make to the understanding of the conservation of matter?

LESSON 3

Lesson Check

Name _____

Can You Explain It?

1. Now that you have learned about how chemical and physical changes differ and how they relate to the conservation of matter, explain the different changes that occur. Be sure to do the following:
   - Explain the differences between chemical and physical changes.
   - Describe how you know which type of change has occurred.
   - Explain how the conservation of matter relates to chemical and physical changes

EVIDENCE NOTEBOOK Use the information you've collected in your Evidence Notebook to help you cover each point.

Checkpoints

Answer the following questions to test your knowledge.

2. Which phrase describes a physical change?
   - **a.** bread baking
   - **b.** the smell produced by rotting trash
   - **c.** crumpling paper
   - **d.** gas bubbles rising after adding chemicals together

3. Choose the correct words to complete the sentences.

phase	liquid	freezing point	melting point	boiling point	gas

When matter changes _____, it is a physical change. To do this, energy is needed. The temperature at which a solid becomes a liquid is called the _____. If the temperature keeps going up, the _____ will be reached. The liquid will then turn into a _____.

4. Decide which terms relate to chemical changes and which to physical changes.

Chemical change	Physical change

precipitate
odor
gas produced
color change
shape change
phase change

5. Select the best answer for the question. You leave a glass of ice outside on a sunny day. When the ice melts, it turns into water. What does the conservation of matter state about the weight of that water?

a. It will weigh much more than the ice.

b. It will weigh less than the ice.

c. It will weigh slightly more than the ice.

d. It will weigh the same as the ice.

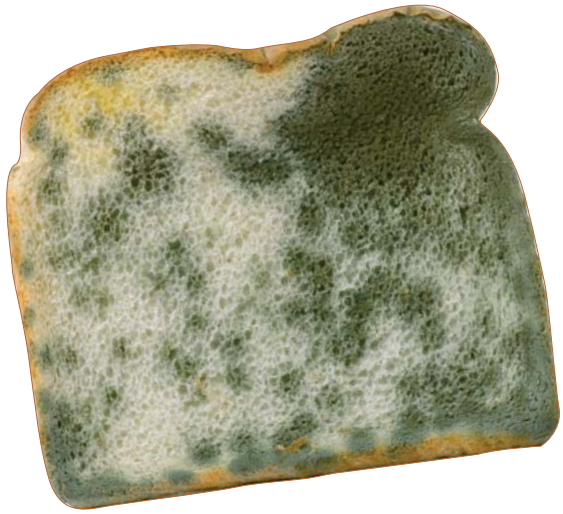
6. Choose the correct words for each sentence.

freezing	melting	energy	matter

A physical change happens when matter changes its phase. Changing from a solid to a liquid is called _____. This requires an input of _____. When a liquid changes back into a solid, _____ is removed. This is called _____.

LESSON 3

Lesson Roundup



A. Which of the following would be physical changes? Choose all that apply.

1. folding paper
2. breaking a window
3. baking bread
4. food spoiling
5. building a tower out of blocks
6. boiling water

B. Which of the following would be chemical changes? Choose all that apply.

1. bending a metal bar
2. breaking a glass
3. baking brownies
4. fruit getting moldy
5. building a wall out of bricks
6. burning wood in a fireplace

C. Choose the correct words for each sentence.

burning wood	**cutting cardboard**	**cannot**	**can**

An example of a chemical change would be _____. When this happens, new matter is formed. This matter _____ be changed back into its original form.

D. Select the correct answer for the question.

What would happen to the amount of matter in a piece of wood if it were cut it into pieces, and then burned?

1. The amount of matter would go up after burning.
2. The amount of matter would go down after cutting into pieces.
3. The amount of matter would increase then decrease when cutting.
4. There would be no change in the amount of matter.

Physical or Chemical?

You belong to a club that puts on science shows for young students. It is your turn to organize a show, and your focus is "The Two Different Ways that Matter Can Change." You are required to develop and demonstrate that topic using three or four examples.

Burning is an example of one type of change that can happen to matter.

DEFINE YOUR TASK: What do you want to accomplish with your demonstration?

Examine the checklist at the end of this activity and be sure that you follow it as you proceed.

RESEARCH: Look up the two ways that matter can change and how to tell the difference. Summarize your research here.

BRAINSTORM: Brainstorm three or four examples of matter changing. Be sure to find examples of both kinds of change.

MAKE A PLAN: Consider the form that your presentation will take.

a. What general concepts do you want to address?

b. In what order should you address those concepts?

c. What materials will you need for your demonstrations, and how will you use those materials?

Present a step-by-step plan here.

EVALUATE: Does your presentation address your topic? What could you add or take away to make it better?

COMMUNICATE: Present your science show to your group.

Checklist

Review your project, and check off each completed item.

_____ Includes definitions and descriptions of the two types of changes in matter

_____ Includes text that orders material in a clear and logical way

_____ Includes an example(s) of physical change in matter and a concise plan to demonstrate it

_____ Includes an example(s) of chemical change in matter and a concise plan to demonstrate it

_____ The science show was presented using the text and examples effectively.

Unit Review

Use this image to answer question 1.

1. Write the correct answer on the line. The matter inside these containers takes up _____ .

2. Place the words in the correct column in the table.

emotions	**clock**	**helium gas**
sunlight	**magma**	**sound**

Matter	Not matter

3. Circle the correct answer. What is all matter made of?

a. plasma

b. liquid

c. living things

d. smaller particles

4. Draw a line from each word in the first column to the state of matter that describes it in the second column.

nitrogen	solid
bus	
tea	liquid
milk	
sidewalk	gas
hydrogen	

Use this image to answer questions 5 and 6.

5. Which properties could you use to sort the items in the photo? Circle all that apply.

a. taste

b. smell

c. color

d. shape

e. luster

f. size

6. Write the correct word to complete each sentence.

color	**size**	**shape**	**luster**

The paper clips can be sorted by _____ . The building blocks can be sorted by _____ . The colored pencils can be sorted by _____ .

7. Write an *M* in front of the substances that are simple mixtures. Write an *S* in front of the solutions.

_____ sugar water

_____ concrete

_____ jelly beans

_____ salt and sugar

_____ metal alloys

_____ gases

8. Which are examples of physical changes? Circle all that apply.

a. paper burning

b. paper being torn

c. wood being chopped down

d. wood burning

e. cake being cut

f. cake baking

9. Choose the correct answer. What type of change is happening in the picture to the right?

a. metal rusting; a chemical change

b. metal rusting; a physical change

c. metal rotting; a chemical change

d. metal rotting; a physical change

10. When a chemical change occurs, what do you know about the amount of matter in the new substances? What is this known as?