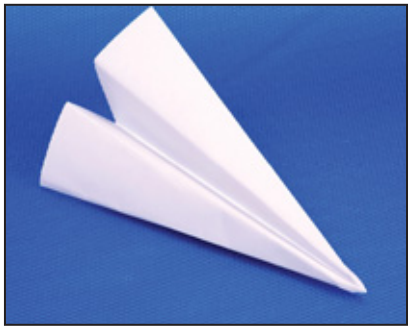
FORMATION OF A NEW SUBSTANCE

reflect

Imagine that you took a full sheet of notebook paper and made a paper airplane. What would happen if you cut the notebook paper in half before making the airplane? You would have a smaller piece of paper, but you would still have paper.



Now, suppose you threw the paper airplane into a fire. What would happen to the paper? How would it change? How are changes caused by burning different from changes caused by cutting or folding?

Physical and chemical properties can identify a substance. Different types of matter, including **elements** and **compounds**, have different properties. We can use these properties to identify specific types of matter. For example, when you hear the word *lemon*, what thoughts come to mind? You might think of the color yellow or a sour taste. These are all properties that describe lemons.

element: matter made of a single type of atom

compound: matter made of two or more types of atoms

A substance can be identified from both its physical and chemical properties. What properties help you identify a lemon?

Properties of matter are either physical or chemical. A *physical property* is one that you can observe without changing the matter itself. Some examples of physical properties of matter include color, density, and melting and boiling points. Other physical properties include whether a substance is magnetic and whether a substance conducts electricity.

A *chemical property* is one that you can observe only when the matter changes as a result of a chemical reaction. An example of a chemical property is *flammability*, or how easily a substance catches fire. Another chemical property is how a substance reacts when exposed to different chemicals. For example, if you add lemon juice to a glass of milk, the milk *curdles*, or forms large chunks. Curdling results from a chemical reaction between lemon juice and milk that changes each substance.

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The picture on the left shows flowers. The picture on the right shows a fireworks display. What physical and chemical properties can you observe in each picture?

Matter can change.
Matter can undergo two types of changes: physical and chemical changes. *Physical changes* involve changes to a substance's physical properties only. Some common physical changes are freezing, melting, evaporating, and dissolving. Making a paper airplane by folding the paper is a physical change. The paper does not undergo a chemical reaction—its chemical properties do not change. Like with the paper airplane, you can undo a physical change fairly easily. To turn the paper airplane back into a sheet of paper, simply unfold the paper. To turn an ice cube back into liquid water, simply melt the ice cube.

Liquid water freezing to form ice cubes is a physical change. Ice cubes melting to form liquid water is also a physical change.

Burning wood is also a chemical change. Like burned paper, the wood changes to ash.

Chemical changes involve changes to the physical and chemical properties of a substance. During a chemical change, a new substance forms. Burning a piece of notebook paper changes the paper's physical and chemical properties. Initially, notebook paper is white; you can crumple and rip it but it maintains its original color and composition. When the paper burns, however, it changes to black, flaky ashes. The ashes are a new type of substance that does not resemble the notebook paper. Unlike physical changes, a chemical change cannot be reversed. You cannot "unburn" the ashes to get back the original paper.

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Everyday Life: Rust is an example of a chemical change. When a piece of iron or steel is exposed to water and oxygen over a long period of time, a chemical change occurs. You may be familiar with the **product** in this chemical change: rust. Objects made of iron—such as chains, automobiles, and bicycles—have certain physical properties in common. For example, iron objects are typically hard with shiny, metallic surfaces. When an iron object rusts, the object's properties change. Rust is a flaky, red substance that crumbles easily. You cannot change rust back to iron.

product: the result of a chemical change

The nails below have rusted. The nails above have not. How does rusting change the properties of nails?

There are ways to prevent rust. In many places when it snows, people put salt on the roads to keep ice from forming. However, salt also speeds up the process of rusting. Cars driving on salt-covered roads are more likely to rust. Washing salt off cars helps to slow this chemical change. In addition, people use special chemicals to coat boats and other metals that are exposed to salt water. These chemicals create a barrier that protects the metal from the salt. Painting an object made of iron or steel can also provide a barrier to water and oxygen in the air. (The most common place for rust to form on an automobile is where the paint has chipped off the surface.)

We can identify evidence of chemical changes. There are several indicators that provide evidence of a chemical change. One chemical change may not show all of these signs; yet, one or more of these is strong evidence that a chemical change has occurred. The only way to know for sure that a chemical change has occurred is to determine if a new substance with new properties has formed.

Let's take a closer look at what you might see when a chemical change happens.

- **Production of a gas:** When a gas is produced in a reaction involving a liquid, bubbles form. If you mix two common household items, baking soda and vinegar, a chemical change occurs. During the process, the bubbles that you see are molecules of carbon dioxide gas being produced. Carbon dioxide is not present initially—it forms due to chemical changes in baking soda and vinegar.

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- **Change in temperature:** Chemical changes can either give off heat or absorb heat. When a log burns, a large amount of heat is given off. You feel this as warmth if you are near the flames. This temperature change is evidence of a chemical change. Other chemical changes absorb heat. For example, some "ice" packs contain chemicals that become colder when they react. When you bend the pack, you cause the chemicals to contact each other and react. As a result, the pack becomes cold like ice.
- **Formation of a precipitate:** A *precipitate* is a solid substance that forms and separates from a solution. A precipitate often settles to the bottom of a liquid reaction. When milk and lemon juice combine, a chemical change called curdling occurs and a precipitate forms. This is a chunky, solid substance. This precipitate is evidence of a chemical change.
- **Change in color:** A sliced apple that is left out on the table turns brown over time. This is because of a chemical reaction that occurs between the apple and oxygen in the air. The change in color, from white to brown, provides evidence that a chemical reaction has happened.

Several signs can indicate that a chemical change has occurred. Is there evidence of a chemical change in the flask?

look out!

Some physical changes may at first seem like chemical changes. For example, when you boil water, the liquid water turns into the gaseous form of water, water vapor. You may think that a chemical change has happened because a liquid has become a gas. However, a new substance has not formed—water vapor (H_2O) is still water (H_2O).

The change from liquid water to water vapor is an example of a *phase change*. A phase change (also called a change in state) is reversible—you can turn water vapor back into liquid water by cooling it. This process is called *condensation*. Because a phase change is reversible, it is a physical change, not a chemical change.

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What do you know?
Matter can change, and these changes can be physical or chemical. Study the list of changes in the box below. Decide if each change is a physical change or a chemical change. Write your answers in the table below. If the change is chemical, provide possible evidence that you could observe; write this evidence in the column to the right.

Type of Change	
• Boiling water • Exploding fireworks • Dissolving sugar in water • Cutting a circle out of a piece of paper • Baking a cake	• Green leaves turning red and yellow during autumn • Mixing oil and vinegar • Dew forming on grass in the morning • A banana ripening • Mixing lemon juice with milk

Physical Change	Chemical Change	
Type of Change	Type of Change	Evidence of a Chemical Change

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connecting with your child

Cooking with Physical and Chemical Changes

To help your child learn more about physical and chemical changes, work in the kitchen to prepare a meal or food item together. Try to prepare a dish that will allow you to demonstrate both physical changes (cutting, mixing, dissolving, boiling, melting) and chemical changes (baking, frying, burning).

For example, to demonstrate physical changes, you and your child can work together to prepare a salad. You must cut each ingredient in the salad into many small pieces; after you have put all the pieces into a bowl, you must mix them together by tossing the salad. Additionally, you could prepare a salad dressing, which includes mixing oil and vinegar. The processes of cutting and mixing are examples of physical changes.

Baking and frying are common ways to illustrate chemical changes. Baking a cake or cookies produces several examples of evidence of chemical changes: the dough changes color and increases in temperature as it cooks, and gases are produced in the form of air bubbles. Frying an egg produces similar evidence of chemical changes. If you happen to overcook an item and it burns, point out that burning is also a chemical change.

Here are some questions to discuss with your child:

- Which of the actions that you performed resulted in physical changes? Explain in terms of physical and chemical properties.
- Which of the actions that you performed resulted in chemical changes? Explain in terms of physical and chemical properties.
- What other physical and chemical changes happen during cooking?