Science

Science

Physical Science

Changes in Matter

by Marcia K. Miller

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Draw Conclusions	• Labels • Diagrams • Timeline • Glossary	Changes in Matter

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Vocabulary

chemical change

chemical equation

combustion

physical change

polymer

product

reactant

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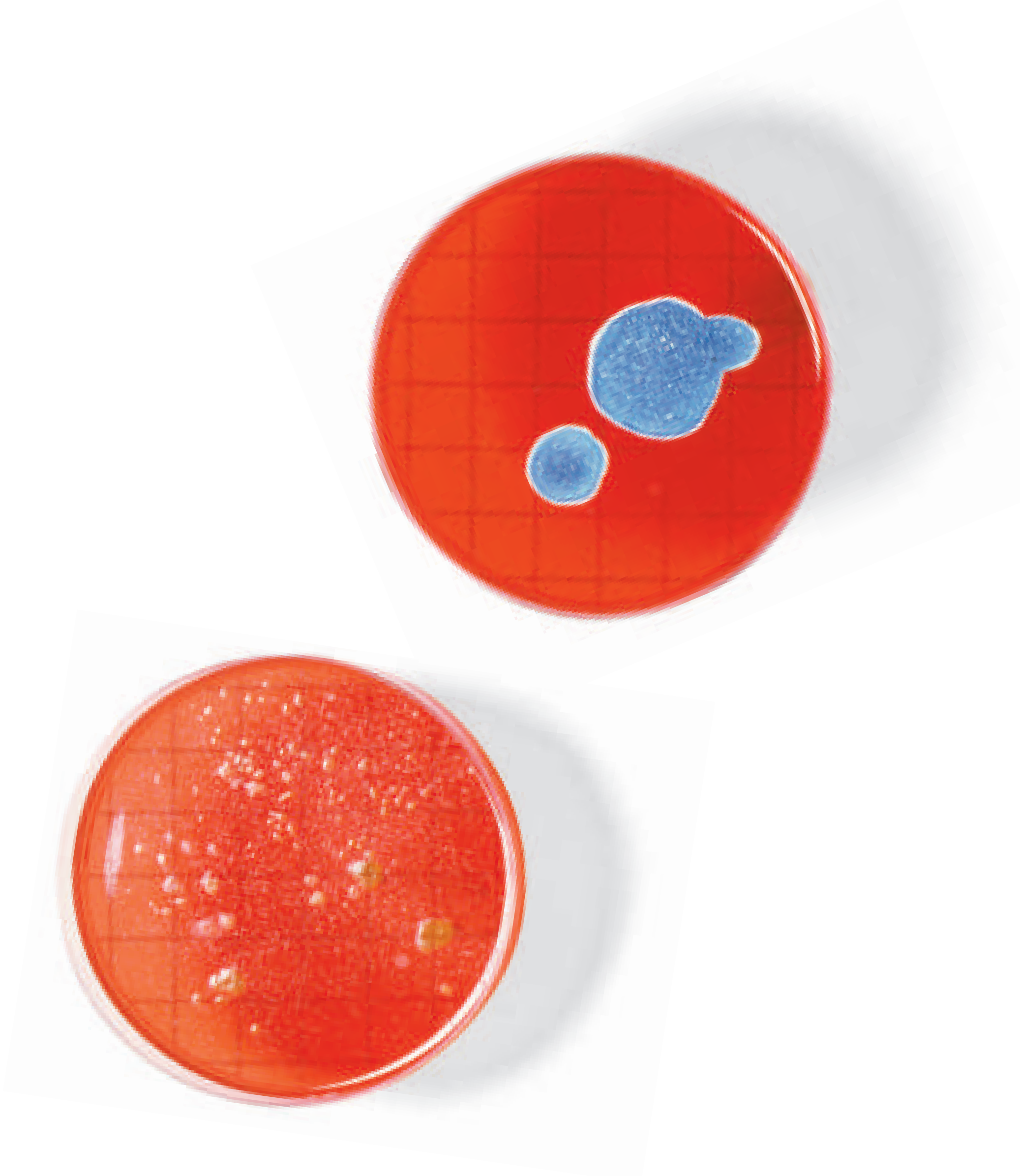

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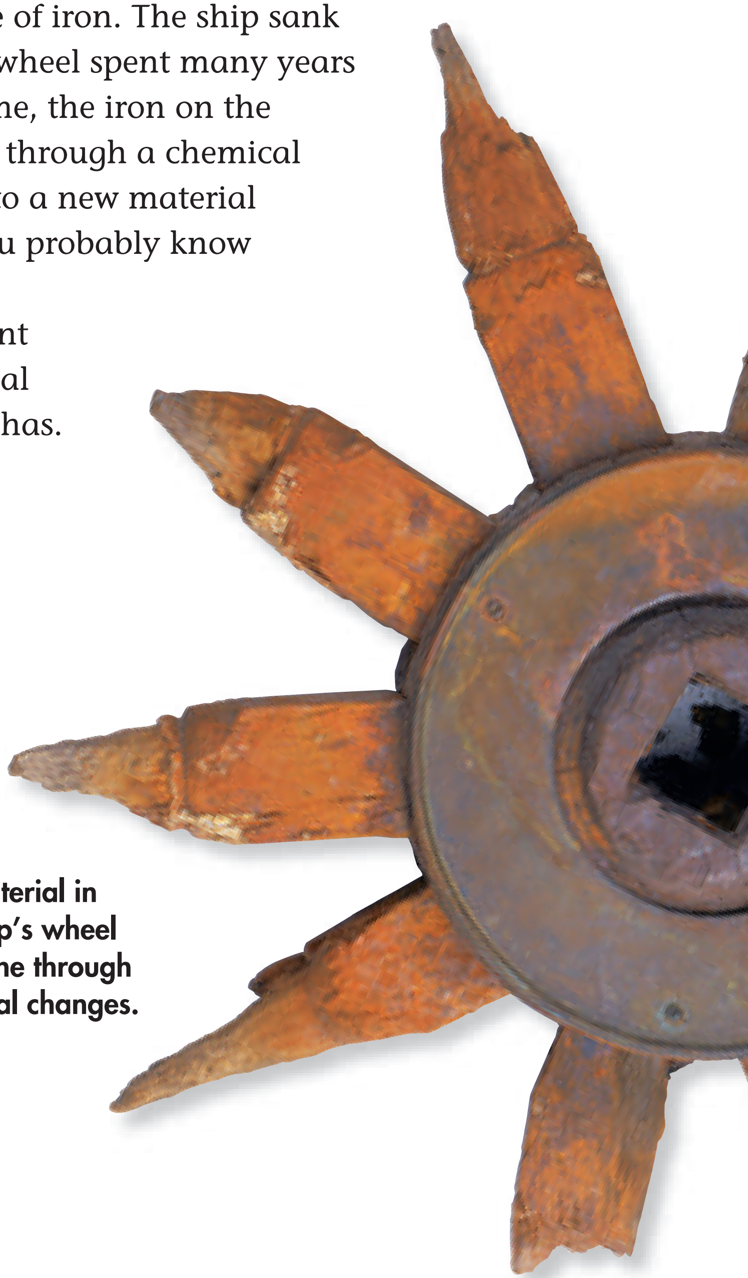
What are chemical changes?

Physical and Chemical Changes

Matter is changing all the time. It can go through two different kinds of changes. A material that goes through a **physical change** will still be the same material. Physical changes can be changes in size, shape, volume, and position. They can also be changes in the phase of matter. For example, falling raindrops can freeze into sleet. This can change their size, shape, volume, and phase. But both rain and sleet are still the same material. Both are forms of water.

Material that goes through a **chemical change** becomes a different type of matter. It is not the same as it was before. The changed matter has different properties.

Look at the picture of the old ship's wheel. The wheel was made of iron. The ship sank at sea, and the iron wheel spent many years underwater. Over time, the iron on the wheel's surface went through a chemical change. It turned into a new material called iron oxide. You probably know this compound as rust. Rust has different chemical and physical properties than iron has.



The material in this ship's wheel has gone through chemical changes.

Evidence of Chemical Change

In a chemical change, atoms are re-arranged to form different kinds of matter. It is not always easy to tell when there has been a chemical change. One sign of a chemical change may be a simple change in color. Other signs may be the forming of a solid or gas.

Iron undergoes a chemical change to turn into rust. You know this because you can see a change in color. The gray metal turns brownish-red.

Drop an antacid tablet in a glass of water. You will see a chemical change. You will see the tablet fizz in the water. It gives off many tiny bubbles. These bubbles are carbon dioxide gas. A solid antacid tablet does not contain gas. The gas forms when the material in the tablet undergoes a chemical change.

This "tree" is made of copper wires.

The copper tree is put into a solution that has chemicals in it.

Chemical Changes and Energy Changes

Chemical changes affect the bonds between atoms or molecules. Some types of chemical changes break the bonds apart. Others form new bonds. There is an exchange of energy anytime a chemical bond forms or is broken. Some materials take in energy as they change. Other materials give off energy when they change.

Sometimes we can notice energy changes as they take place. Have you ever seen a log burning in a fireplace or in a wood stove? The burning log goes through a chemical process that is called **combustion.** The log gives off energy as it burns. We can feel the heat energy. We can see the light of the fire. Other reactions may give off energy in the form of electricity.

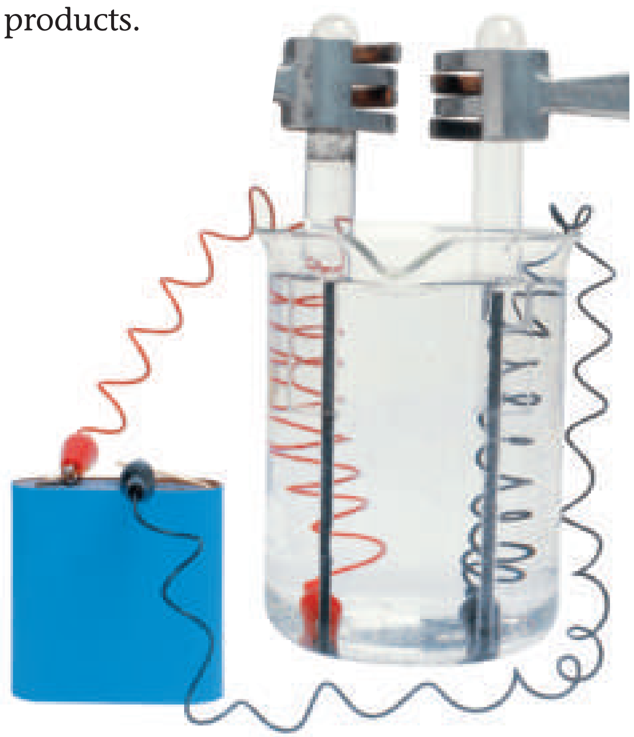
A chemical change causes solid crystals to form. Look at the top of the tree. Why hasn't it changed?

What are some kinds of chemical reactions?

Chemical Equations

One or more substances change when a chemical reaction takes place. The new substances have different chemical and physical properties. A **reactant** is a substance that is used in a reaction. A new substance that forms in the reaction is called a **product.** The reactants go through a chemical change. Their atoms are re-arranged to form the products.

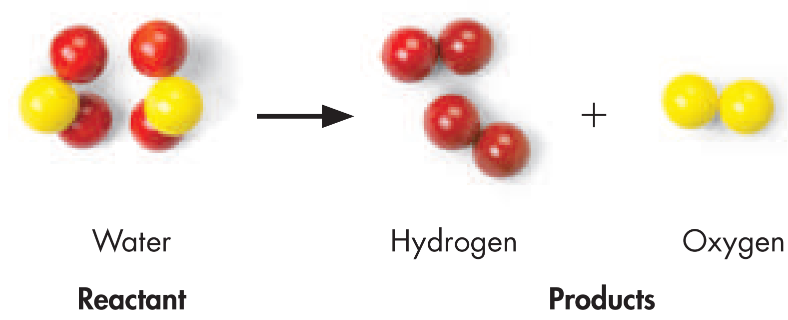
Look at the picture. Electricity moves from the battery. It flows through the curly wires to the water in the jar. The flowing electricity starts a chemical reaction. It makes the atoms in the water molecules rearrange themselves. The water separates into hydrogen and oxygen gases. You can see the gas bubbles as they rise. Water is the reactant here. Hydrogen and oxygen gases are the products.



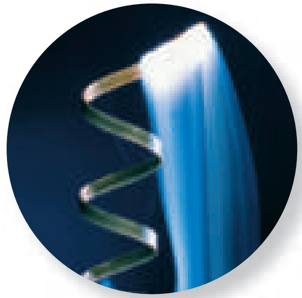
A battery provides the energy for the reaction.

A **chemical equation** is a short way to write what goes on in a chemical reaction. A chemical equation has two sides, just as a math equation does. The reactants are shown on the left side. The products are given on the right side. An arrow points from the reactants to the products. When you read the equation aloud, you say the word "makes" in place of the arrow. The chemical equation for two water molecules becoming two hydrogen and two oxygen molecules looks like this:

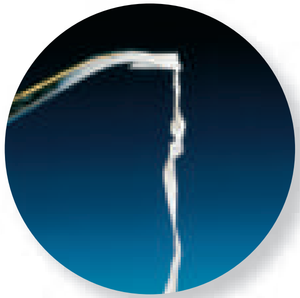
$$2\,H_2O \longrightarrow 2\,H_2 + O_2$$



Magnesium metal is gray. Oxygen is a colorless gas.



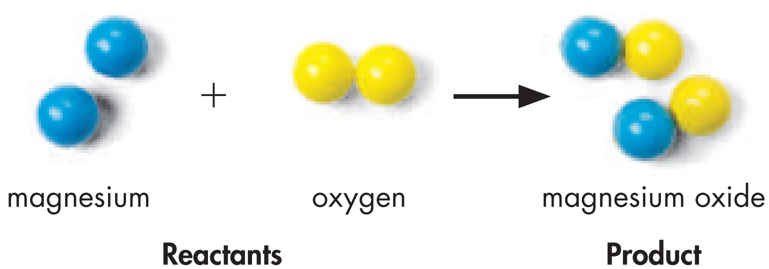
Magnesium can combine with oxygen. They are reactants. Bright light and heat are signs that a reaction is happening.



The product is magnesium oxide. Its properties are different than those of the reactants.

Magnesium is a gray metal. It is used to make fireworks. At high temperatures, magnesium reacts with oxygen in the air. It burns with a very bright white glow. A white powder forms as a result of the chemical reaction. The powder is called magnesium oxide. It is the product of the reaction between magnesium and oxygen. Here is the chemical equation that shows this reaction:

$$2\,Mg + O_2 \longrightarrow 2\,MgO_2$$



Matter Is Always Conserved

Matter is not destroyed in a chemical reaction. It is not made either. It just changes form. This idea is known as the Law of Conservation of Mass. It means that the total mass of the reactants is equal to the total mass of the products.

Suppose you make a cake. You mix all the ingredients. You bake it in a hot oven. The mass of the ingredients is equal to the mass of the cake plus the mass of the water vapor, carbon dioxide, and traces of other gases that leave the cake as it bakes. These gases are what you smell when you open the oven door.

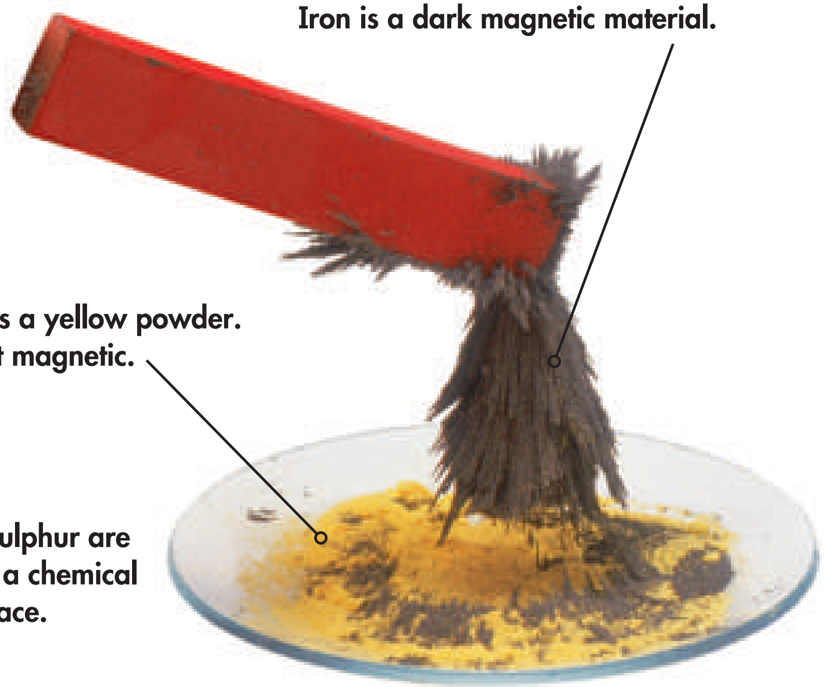
Matter is conserved when you bake a cake.

Types of Chemical Reactions

A model can help you to better understand a chemical reaction. Let's use trucks and trailers as models of atoms.

In decomposition reactions, compounds split apart. When they do, they can form smaller compounds. They also can form basic elements. Picture a trailer getting unhooked from a truck. They are split apart. Remember how the electricity made the water break apart? The water decomposed into two separate gases.

In combination reactions, elements or compounds come together. They form new compounds when they do. Think of a truck connecting to a trailer. This is the kind of reaction that happens when iron and sulfur come together. They form a new compound called iron sulfide. Follow the pictures on these pages to see this kind of reaction.



When iron and sulphur are heated together, a chemical reaction takes place.

In a replacement reaction, one or more compounds split apart. When they do, the parts can then switch places. Think of two trucks switching trailers.

A burning candle is an example of a replacement reaction. A candle is made of wax. Some candle waxes are made up of long molecules of carbon and hydrogen atoms. When the wax burns, the long molecules and oxygen molecules break apart. They rejoin to form new compounds, such as carbon dioxide and water.

reaction	model
decomposition	
combination	
replacement	

The iron and sulfur were heated together. The reaction made a new compound. This product is not magnetic.

How are chemical properties used?

Separating Mixtures

You can use physical methods to separate substances in some mixtures. It is easy to separate a mixture of salt and pepper. This is because salt and pepper have different physical properties. Many substances also have different chemical properties. You can use those differences to separate some mixtures.

The fossils do not react with vinegar. But the limestone around the fossils does.

Fossils are often found in layers of limestone. In order to study fossils, scientists need to remove them from the rock. It is hard to chip the rock away without breaking the fossil. Fossils and limestone have different chemical properties. Vinegar reacts with limestone, but not with fossils. Putting vinegar on the limestone causes it to dissolve, gently freeing the fossil. The vinegar does not affect the fossil. In this way, scientists use chemical properties to separate mixtures.

Separating Metals from Ores

Ores are rocks that have metals in them. The metals are often mixed with other substances. Chemical properties are used to release the metals from their ores.

Iron ore contains iron oxide. A chemical reaction takes place when you heat iron ore and solid carbon together in a very hot furnace. Two products result. One is pure iron. The other is carbon dioxide. This happens because oxygen bonds more strongly to carbon than it does to iron.

Scientists can use chemical properties to separate elements from solutions. For example, they can take lead out of a solution of water and other materials. How do they do it? They pour the solution with the lead into a container. That container already holds a solution made with iodine. Both solutions are clear at first. Then the lead reacts with the iodine as the two solutions mix. A new compound forms. It is a yellow solid called lead iodide. Now it is easy to filter the lead iodide from the liquid.

Iron is chemically separated from iron ore in a blast furnace.

Identifying Substances

Scientists can use chemical properties to decide what a substance is. The pictures below show one way to do this.

Acids and bases are two common types of substances. Lemon juice and vinegar contain acids. Some household cleaners contain bases. Strong acids or bases will react more easily with materials than weak ones will.

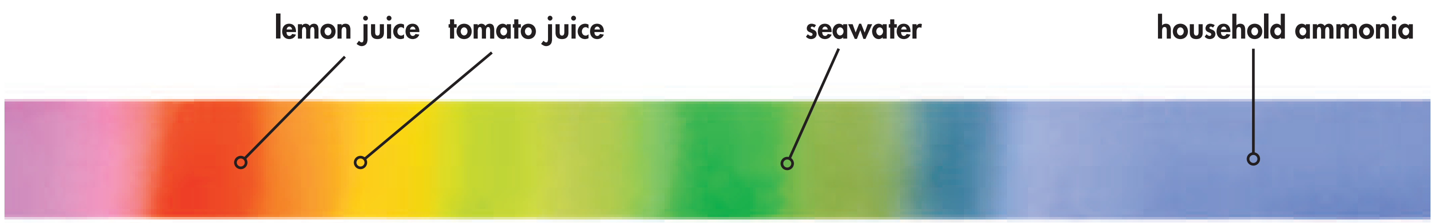
Acids and bases can be identified by their chemical properties. Both react with chemicals in a type of paper called universal indicator paper. The reactions make the paper change its color. Strong acids will turn the paper red. Strong bases will turn it purple. Weaker acids or bases will produce other colors.

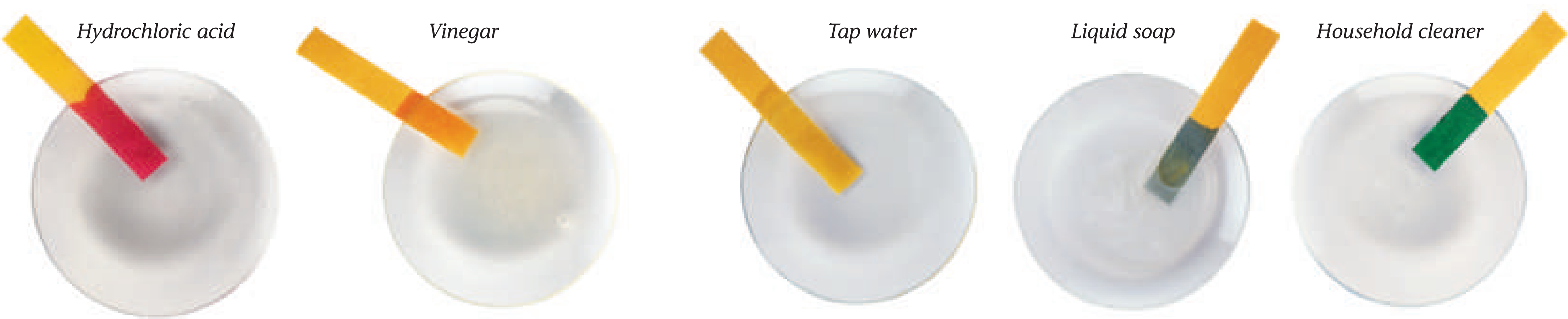
Tools such as universal indicator paper are useful. But they may not give all the details you need. Many kinds of acids will turn the paper red. Many kinds of bases will turn it purple. Using special paper is a good start, but other tests are needed too.

Scientists can use a flame test to identify some substances. They heat a material in an open flame. They see certain colors in the flame. That is because different substances burn in different colors. Scientists can use lab tools to study the flames.

Fruits such as oranges and lemons contain acid.

Soaps may contain bases.



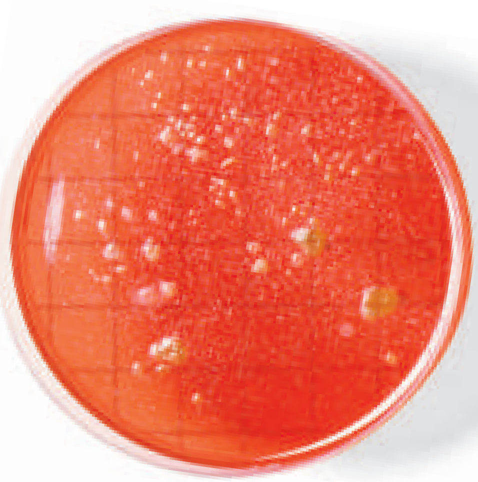


How is chemical technology used in our lives?

Chemistry and Health

Did you know that long ago people would die from simple cuts? Tiny bacteria could enter the body through a cut. An infection would form. The infection could then spread to the blood. There was no way to stop it.

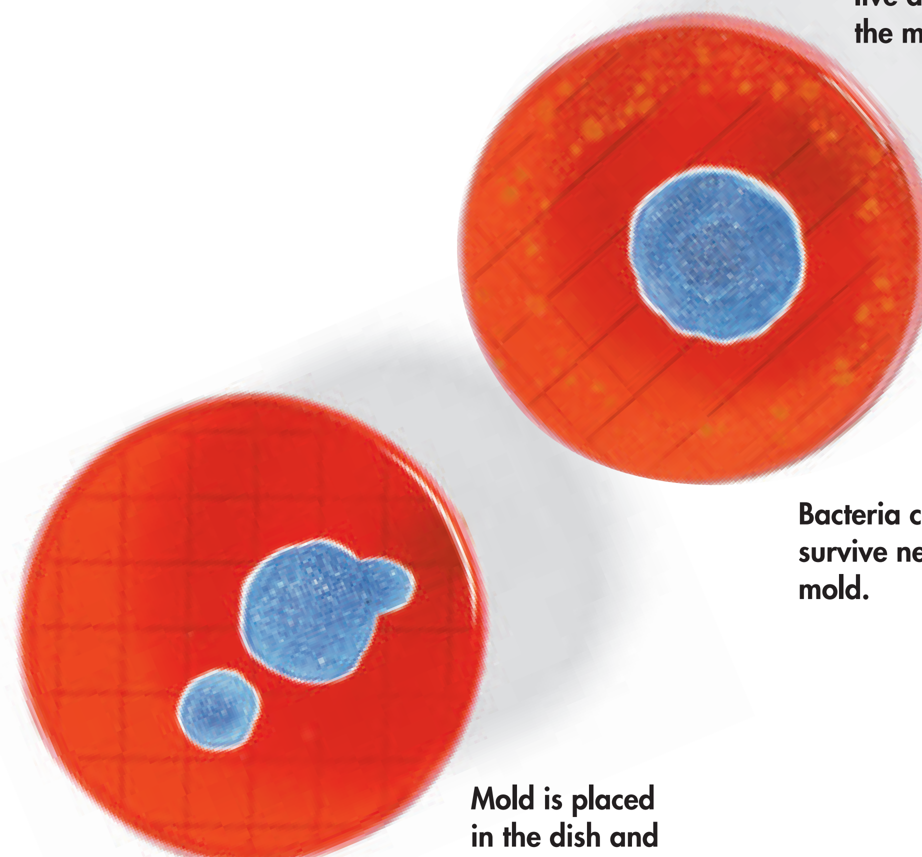
Things changed in 1928 when British scientist Alexander Fleming made an accidental discovery. He was growing bacteria in dishes to study it. Mold got into one of his dishes. Fleming saw that the bacteria near the mold died. He found that the mold produced something that killed the bacteria. Fleming named this substance *penicillin,* because that was the name of the mold. Scientists learned how to separate out the penicillin. They also found ways to make lots of it. Medicines that kill bacteria are called *antibiotics*.



This lab dish has bacteria growing in it.

Chemists have improved our lives in another way. Years ago, many people got sick from diseases that are rare today. Some of these diseases caused serious health problems or even death. Today, hardly anyone suffers from these diseases. Why is this?

Chemists found that such diseases could be stopped if people ate certain foods. They were able to identify the substances in the foods that cured the diseases. They named these chemicals *vitamins*. Many foods we now eat have vitamins added to them. Today it is rare for people in the United States to get sick from a lack of vitamins.



Bacteria can live away from the mold.

Bacteria cannot survive near the mold.

Mold is placed in the dish and it also grows.

Chemistry and New Materials

Many substances you use every day come from nature. The cotton in jeans comes from a plant. Wool is the hair of sheep. But not all materials come from nature. Scientists have invented some!

Silk is a strong, soft, and smooth fiber. But it is costly to make. The thread comes from silkworm cocoons. These cocoons must be unraveled to get the silk thread. It is a very slow job. Early attempts at human-made silk thread were not successful.

In the mid-1930s, an American chemist had success making a fiber like silk. He called it nylon. Soon nylon was used to make rope, nets, fishing line, and clothing.

Nylon is a polymer. A polymer is a large molecule of many identical units linked in long chains. A **polymer** may have thousands or even millions of units in one chain.

The solution is being drawn out to make nylon thread.

This is an artificial heart. It is made of metal and plastic.

Plastic is another type of polymer. There are many kinds of plastics. Many are made with the chemicals found in petroleum. Plastics are useful because they are lightweight. They last for a long time and can resist decay. They are not costly to make.

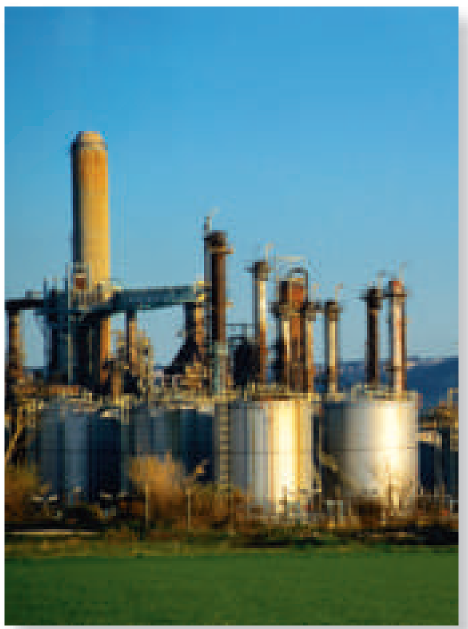
The main ingredient of concrete is cement. Cement is a human-made material. To make concrete, we mix cement with gravel, sand, and water. A chemical reaction takes place as the cement sets. The end product is as hard as rock. It lasts a long time.

Chemists have learned to make different types of concrete. They can add certain chemicals to make concrete that can harden in very cold weather. They can add other chemicals to make concrete that is very strong. Still other types of concrete have fibers added to them to prevent cracks.

Chemistry and Transportation

How did you get to school today? Did you know that chemists helped? Well, they did! Chemistry has given us a material that's very useful for transportation: rubber. Rubber is used to make tires and the soles of shoes. Natural rubber comes from plants. It bends easily and is waterproof. But when natural rubber gets cold, it becomes stiff and cracks. It melts and gets gooey in hot weather.

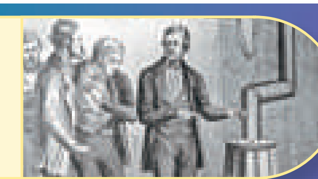
Chemists in the 1800s did research with rubber. They heated it and added sulfur to it. This process made rubber that could be used all year. Chemists in the mid-1900s took the next step. They learned how to produce human-made rubber.



Oil refineries use physical and chemical changes in petroleum to make many products.

Chemistry helps transportation in other big ways. Scientists get many products from petroleum. Petroleum is another name for crude oil. It contains many compounds you may have heard of. Some of them are gasoline, kerosene, and motor oil. Scientists have learned how to turn crude oil into all of these materials.

1839
Charles Goodyear discovers a process that makes rubber stronger.



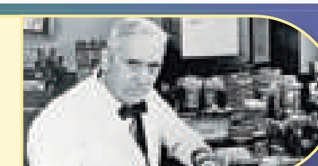
1859
The first oil well in the United States is drilled.

1889
Karl Benz develops one of the first cars that runs on gasoline.

1909
Ammonia is first made with nitrogen from the air. It would later be used as fertilizer.

1911
The word *vitamin* is first used.

1928
Alexander Fleming discovers penicillin.



1935
The first nylon fiber is made.

1820
1840
1860
1880
1900
1920
1940

Chemicals and Safety

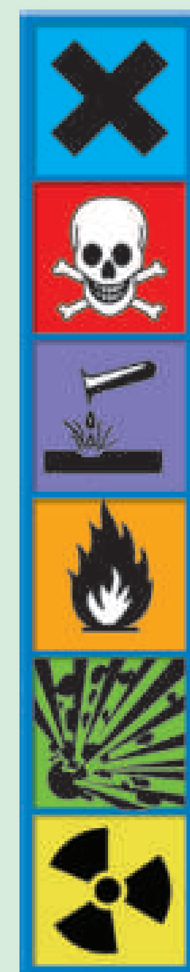
Some chemicals make life safer for us. Scientists have learned how to use them to kill germs in drinking water. In the past, many people got sick from germs in drinking water. Now chemicals such as chlorine make water much safer.

But chemicals can be harmful if they are used in the wrong way. Always read the warning labels on chemicals or on products that contain them.

Many cleaning products have warning labels.

Most cleaning supplies give directions for safe use. Be sure to read and follow them. You might have to wear gloves to protect your skin or goggles to protect your eyes. You might have to open a window to let out strong fumes. You should never mix cleaners. This could lead to very dangerous chemical reactions. These reactions could result in lung damage, burns, or explosions

Chemical Warning Labels



- *Harmful or Irritating*
- *Poisonous*
- *Corrosive*
- *Flammable*
- *Explosive*
- *Radioactive*

Glossary

chemical change a change that causes a different type of matter to form

chemical equation a short way of writing what goes on in a chemical reaction

combustion a chemical process that gives off light and heat; burning

physical change a change in the position, size, shape, volume, or phase of matter

polymer a large molecule of many identical units linked in long chains

product a new substance made during a chemical reaction

reactant a substance that is used in a chemical reaction

What did you learn?

1. What is the difference between a chemical change and a physical change?
2. Why were polymers first developed?
3. How did chemists improve natural rubber to make it more useful?
4. **Writing in Science** Discoveries made by chemists have improved people's health. On your own paper, write to explain what these discoveries were, and how they have helped us. Include details from the book to support your answer.
5. **Draw Conclusions** Cooking an egg causes it to change. Do you think a chemical change occurs? Explain why or why not.