



Elements and Compounds

Lessons 1–3

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Elements and Compounds

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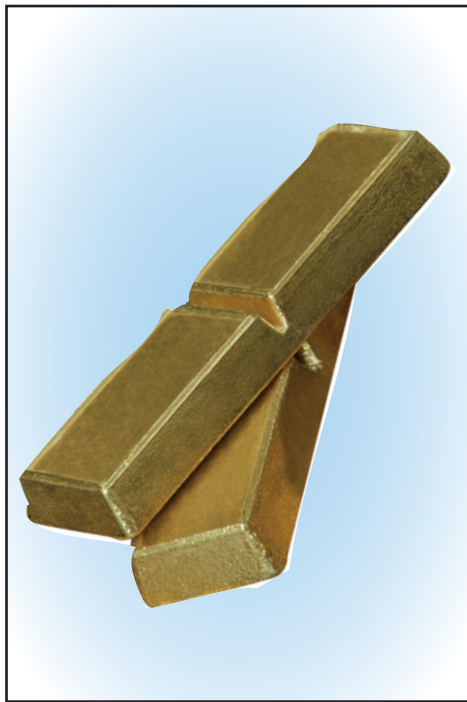
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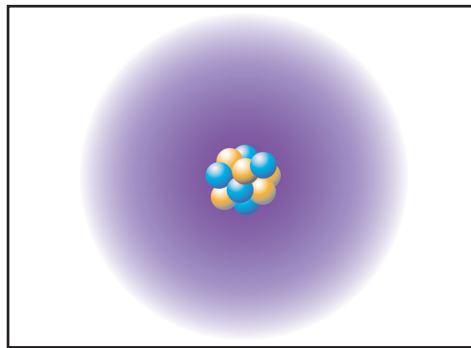
What Are Atoms and Elements?

VOCABULARY

- element
- atom
- periodic table
- compound
- molecule
- physical property
- mixture



These gold bars have only one kind of **element** in them.



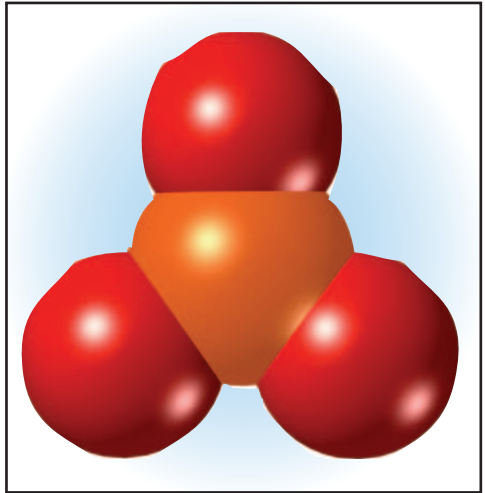
An **atom** is a very small unit of matter.

A standard periodic table of elements. The elements are arranged in rows and columns, with each element represented by a small box containing its symbol and name. The table is color-coded, with different colors for different groups of elements.

Scientists use the **periodic table**. It tells them a lot about the elements.



These **compounds** are made from different elements.



Atoms of different elements join to make a **molecule**.



The shape of this lizard is a **physical property**.



This salad is made from a **mixture** of different fruits.



READING FOCUS SKILL

MAIN IDEA AND DETAILS

The **main idea** is what the text is mostly about.

Details tell more about the main idea.

The **main idea** is that all matter is made from elements. Look for **details** about how elements are combined into mixtures and compounds.

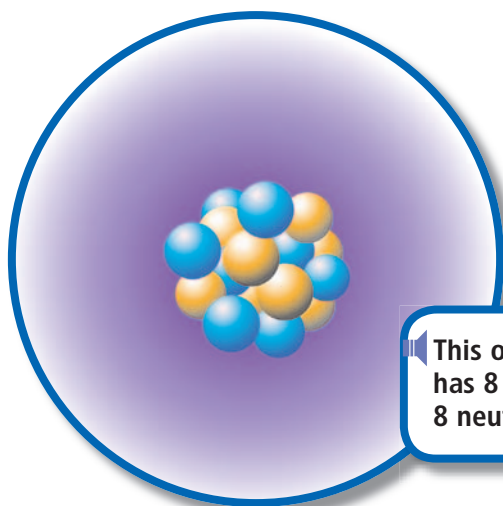


Atoms and Elements

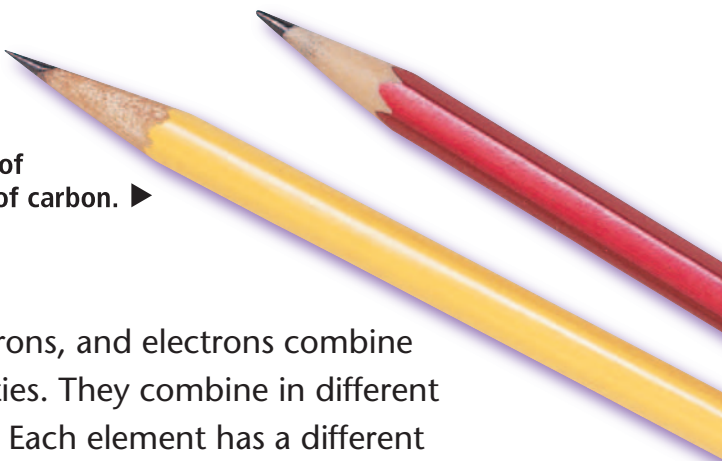
An **atom** is the smallest unit of an element. It is the smallest part that has that element's *properties*. An element is the simplest form of matter. It has only one kind of atom. Oxygen is an element. Oxygen is made only of oxygen atoms.



Atoms can be broken down into smaller parts. Atoms are made of protons, neutrons, and electrons. All protons are alike. All neutrons are alike. All electrons are alike. They do not have properties of any element.



This oxygen atom has 8 protons and 8 neutrons.



▶ The lead of a pencil is made of graphite. This is a soft form of carbon. ▶

▶ The ways protons, neutrons, and electrons combine form an element's properties. They combine in different amounts in each element. Each element has a different number of protons. The number of protons tells scientists which element it is.

▶ Atoms have the properties of the element they are part of. Carbon atoms have the properties of carbon.

▶ There are about 100 elements. But only a few are found in their pure states. Scientists give each element a short name. They use one to three letters to name each element. Carbon is C. Sodium is Na.

▶  **What makes an element different from other elements?**

▶ All living things have carbon in them. ▶



▶ A diamond is made of almost pure carbon.

The Periodic Table

Elements are the building blocks of matter. From only about 100 elements, millions of things are made. Everything on Earth is made from different groups of elements.

Atoms of each element have a certain number of protons. Each atom of hydrogen has just one proton. Each atom of iron has 26 protons. The number of protons in an atom is called its *atomic number*.

Scientists use a chart called the **periodic table**. In this chart, the atomic numbers of all elements are shown. Each element has its own box in the table. In that box is the atomic number of the element. Also in the box are the element's name and symbol.

 **How many elements are in the periodic table?**

The Periodic Table

METALS

NON-METALS

1 H Hydrogen

2 He Helium

3 Li Lithium

4 Be Beryllium

5 B Boron

6 C Carbon

7 N Nitrogen

8 O Oxygen

9 F Fluorine

10 Ne Neon

11 Na Sodium

12 Mg Magnesium

13 Al Aluminum

14 Si Silicon

15 P Phosphorus

16 S Sulfur

17 Cl Chlorine

18 Ar Argon

19 K Potassium

20 Ca Calcium

21 Sc Scandium

22 Ti Titanium

23 V Vanadium

24 Cr Chromium

25 Mn Manganese

26 Fe Iron

27 Co Cobalt

28 Ni Nickel

29 Cu Copper

30 Zn Zinc

31 Ga Gallium

32 Ge Germanium

33 As Arsenic

34 Se Selenium

35 Br Bromine

36 Kr Krypton

37 Rb Rubidium

38 Sr Strontium

39 Y Yttrium

40 Zr Zirconium

41 Nb Niobium

42 Mo Molybdenum

43 Tc Technetium

44 Ru Ruthenium

45 Rh Rhodium

46 Pd Palladium

47 Ag Silver

48 Cd Cadmium

49 In Indium

50 Sn Tin

51 Sb Antimony

52 Te Tellurium

53 I Iodine

54 Xe Xenon

55 Ba Barium

56 La Lanthanide

57 Ce Cerium

58 Pr Praseodymium

59 Nd Neodymium

60 Pm Promethium

61 Sm Samarium

62 Eu Europium

63 Gd Gadolinium

64 Tb Terbium

65 Dy Dysprosium

66 Ho Holmium

67 Er Erbium

68 Tm Thulium

69 Yb Ytterbium

70 Lu Lutetium

71 Fr Francium

72 Ra Radium

73 Ac Actinide

74 Th Thorium

75 Pa Protactinium

76 U Uranium

77 Np Neptunium

78 Pu Plutonium

79 Am Americium

80 Cm Curium

81 Bk Berkelium

82 Cf Californium

83 Es Einsteinium

84 Fm Fermium

85 Md Mendelevium

86 No Nobelium

87 Lr Lawrencium

Molecules and Compounds

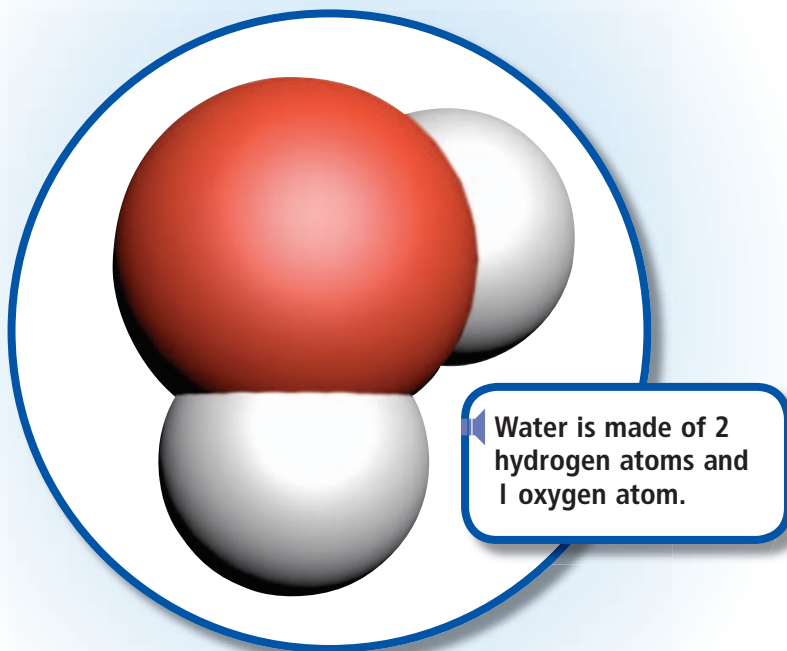
Most elements are seen as parts of compounds. A **compound** is a substance made of two or more elements. The elements have been joined chemically. A *formula* tells what is in a compound. It shows how many atoms of each element are in the compound.

 H_2O is the symbol for the compound *water*. Water is made of hydrogen and oxygen atoms. Both of these are elements.

 The smallest piece of the compound water is a water molecule. A **molecule** is the smallest unit of a compound.



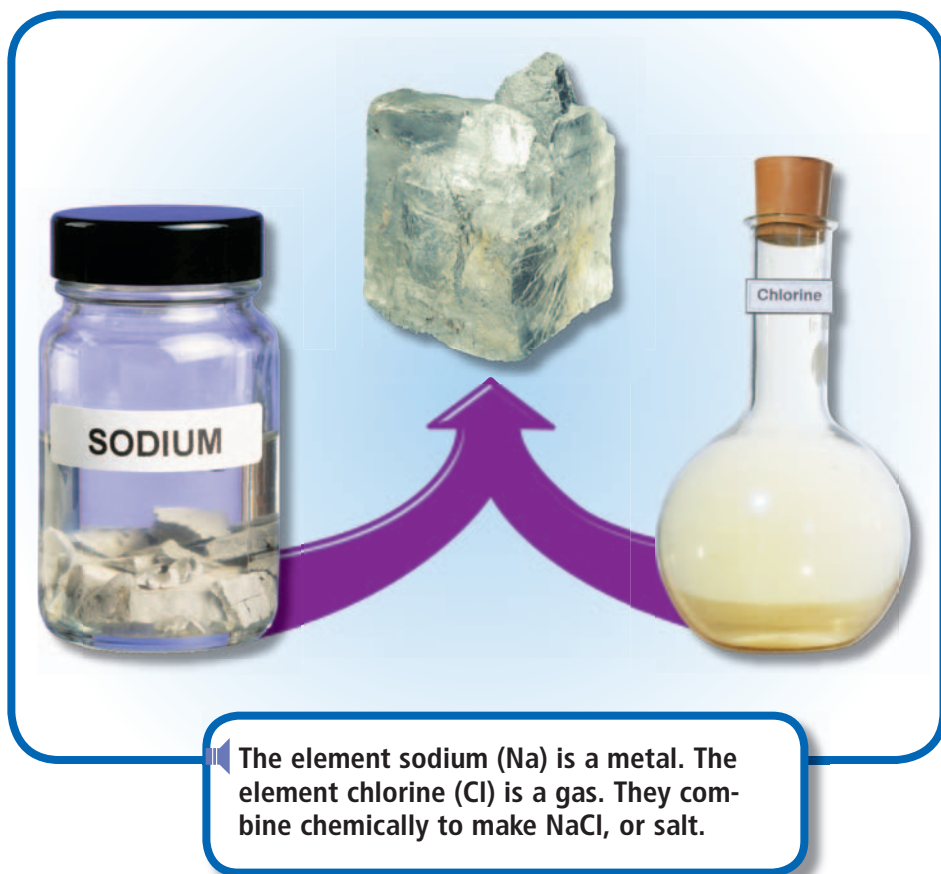
 What elements make up a water molecule?



Physical Properties

Physical properties describe a substance. They tell what a substance is like by itself. Water is wet. Wood is hard. These are physical properties.

Some physical properties cannot be seen directly. Temperature is a physical property. But you cannot see it. Mass is a physical property. But you cannot see it. Both mass and temperature have to be measured.



▶ A **mixture** is a combination of two or more substances. In a mixture, the substances themselves are not changed. Each part of the mix could be separated out again.

▶ Most materials found in nature are mixtures. Sand and air are both mixtures.

▶  In what form are most materials found in nature?



▶ Nitrogen boils at very low temperatures. That is a physical property.

▶ **Review**



Complete this **main idea** statement.

▶ 1. _____ are the building blocks of matter.

▶ Complete these **detail** statements.

▶ 2. Scientists use the _____ to learn about elements.

▶ 3. A _____ is the smallest unit in which an element can exist.

▶ 4. In a _____ physical, but not chemical, changes take place.

What Are Metals?

VOCABULARY

- metal
- nonmetal
- malleable
- alloy
- metalloid



▶ **Metal** is used to build things that need to last a long time.



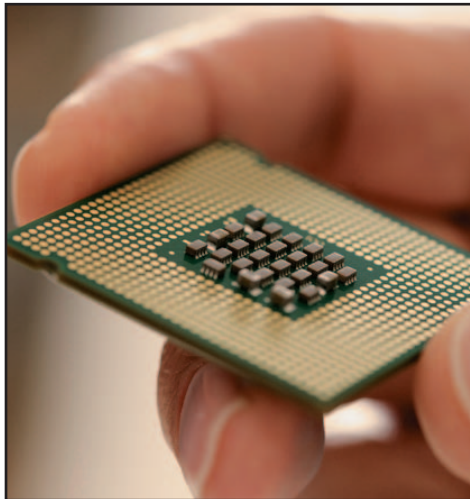
▶ This lump of coal is made of carbon, a **nonmetal**.



▶ The aluminum in this can is very **malleable**.



▶ This statue is made of bronze. Bronze is a metal **alloy**.



▶ Computer chips are made from silicon, a **metalloid**.

READING FOCUS SKILL

MAIN IDEA AND DETAILS

The **main idea** is what the text is mostly about.

Details tell more about the main idea

The **main idea** is that metals and nonmetals have different properties. Look for more **details** about the properties of metals and nonmetals.

Metals and Nonmetals

A **metal** is a substance that easily conducts heat and electricity. This means that metals heat up quickly. Electricity passes through them easily.

About 75% of all elements are metals.

Copper is a metal.



Copper is used for wires. This is because it is a good conductor of electricity. ▼



Metals are **malleable**. They can be hammered or rolled into thin sheets. They can be made into different shapes.

Carbon is a **nonmetal**. Nonmetals do not have the properties of metals. Nonmetals do not conduct electricity well. They do not conduct heat well.

 **How are metals different than nonmetals?**



Properties of Metals

Elements in columns in the periodic table are alike. For example, some metals conduct heat better than others.

Some metals are much less dense than others. Aluminum and titanium are two such metals. They are very light. They are used to make airplanes and other things that need to be light.



What are two physical properties of metals?

Iron is a good conductor of heat. It is often used to make cooking pans.



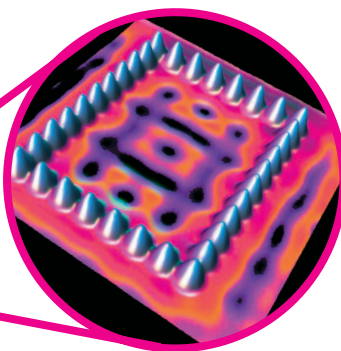
Seeing Metal Atoms

Atoms are very small! Scientists must magnify atoms in order to see them. They use special microscopes.

Most microscopes magnify things about 1,000 times. An *electron microscope* can magnify more than 50,000 times. Scientists can see very tiny objects, like cells. Another powerful microscope is called a *scanning tunneling microscope*, or STM. This microscope lets scientists look at atoms a different way. It makes images based on how electrons move. The atoms in a solids are arranged in set patterns. This is called an *array*.

Scientists can now use an STM to move single atoms to the surface of a metal. They hope someday to make new materials this way.

 **How does seeing atoms help scientists?**



 This scientist is using an electron microscope. Images are viewed on a screen.

Alloys and Metalloids

Steel is an **alloy**. An alloy is a solid solution. One way to make an alloy is to combine metals. Another way is to combine a metal and a nonmetal. An alloy has properties different from the materials in it.

 Iron is the main metal in many steel alloys. But iron is not very hard. It becomes harder when carbon is added to make steel.

 Bronze is an alloy made from mixing copper and tin. Bronze is harder and stronger than copper. Many large statues are made of bronze. They can stay outside for a long time and not *corrode*, or break down.



 ▲ This bell is made of brass. It does not corrode easily.



Metalloids are elements. They have some of the properties of metals. They have some of the properties of nonmetals. Silicon is a metalloid.

Silicon is less malleable than metal. It conducts electricity, but not as well as copper. The flow of electricity can be controlled in silicon. Metalloids like this are called *semiconductors*. Semiconductors are used in computers and CD players.



What is the main metal in many steel alloys?



The elements used in making steel alloys differ. They are changed to make an alloy better for the use it will have.



Review



Complete this **main idea** statement.

1. _____ is a substance that easily conducts electricity and heat.



Complete these **detail** statements.

2. Metals are _____. They can be hammered or rolled into shapes.
3. An _____ is made from different metals, or a metal and a nonmetal.
4. A _____ has properties of both metals and nonmetals.

VOCABULARY

- gas
- liquid
- solid

What Are the Properties of Some Common Substances?



- These balloons are filled with helium **gas**.



- Skim milk is a **liquid** that is healthful to drink.



 The sand in this sand castle is a **solid**.



READING FOCUS SKILL

MAIN IDEA AND DETAILS

The **main idea** is what the text is mostly about.

Details tell more about the main idea.

The **main idea** is that many substances have similar properties. Look for more **details** about the properties of common substances.



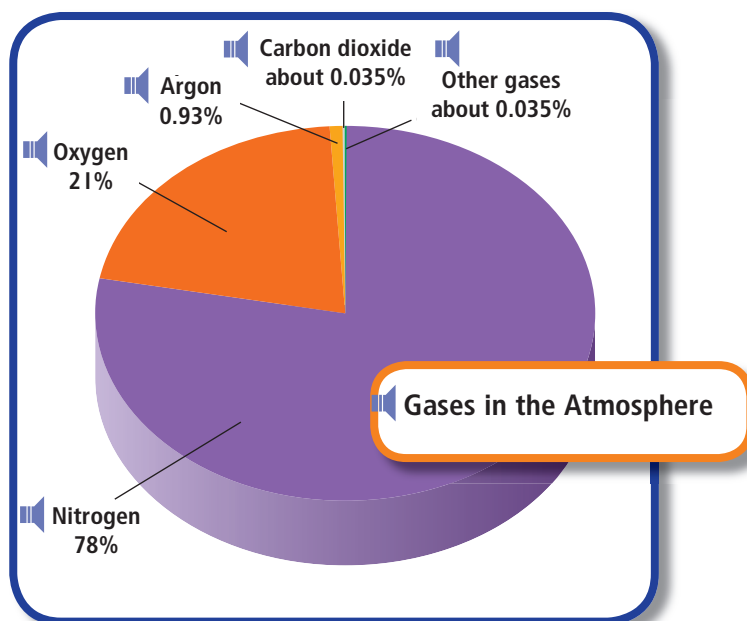
Common Gases

Air is invisible. Air is not an element or a compound. Air has no chemical formula. It is a mixture of gases.



A **gas** is a state of matter. In a gas, matter has no definite shape. It has no definite *volume*, or amount either.

Air is about 78% nitrogen (N_2). Air also has about 21% oxygen (O_2) in it. Oxygen makes it possible for other substances to burn. They burn when they mix with oxygen.



- ▶ Another form of oxygen is ozone (O_3). There is ozone in Earth's upper atmosphere. Ozone helps keep Earth at a constant temperature.
- ▶ Hydrogen is another gas. It is the most common element in the universe.
- ▶ Helium is a gas that is lighter than air. It is used in weather balloons and blimps.
- ▶ Another common gas is carbon dioxide (CO_2). When you breathe out, you *exhale* mostly carbon dioxide.

▶ **Why doesn't air have a chemical formula?**

- ▶ This balloon is filled with helium. Helium weighs less than air, so the balloon floats. ▼



Common Liquids

A **liquid** is a state of matter. In this state, matter has a definite volume. But it has no definite shape.

 Water is the most common liquid on earth. The oceans cover more than 70% of the earth. Ocean water is salt water.

 Water is the only compound on Earth that can be found in all three states. Water can be a liquid. It can be a gas (water vapor). Or it can be a solid (ice).

 These monkeys in a hot spring have ice on their heads. Water is seen in all three states here. ▼



When most liquids are cooled, their particles get closer together. They *contract*, or take up less space. Water contracts until it reaches about 4 degrees centigrade (39° F). As it cools further, it *expands*, or takes up more space.

As water molecules change into ice, they form rings. The rings take up more space. That is why ice takes up more space than water.

Mercury is the only metallic element that is liquid at normal temperatures. It was used in thermometers. But mercury is poisonous, so it is not used any more. Alcohol is used now.



What are some unusual properties of water?

Mercury was used in thermometers for many years.

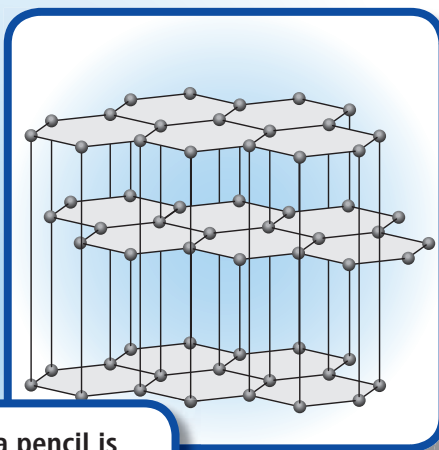


Common Solids

The element carbon is a solid. A **solid** is a state of matter. It has a definite shape and a definite volume.

 Carbon is the sixth most common element in the universe. There are millions of compounds that have carbon in them. Charcoal, the “lead” in a pencil, and diamonds are all carbon.

 Coal, petroleum, and natural gas are compounds. They are made of carbon and hydrogen. When oxygen is added to carbon and hydrogen, sugars are made. Corn syrup and table sugar are two of these sugars.



 The “lead” in a pencil is called graphite. In graphite, the carbon atoms are joined in flat layers.



The most common solid on Earth is Earth itself.

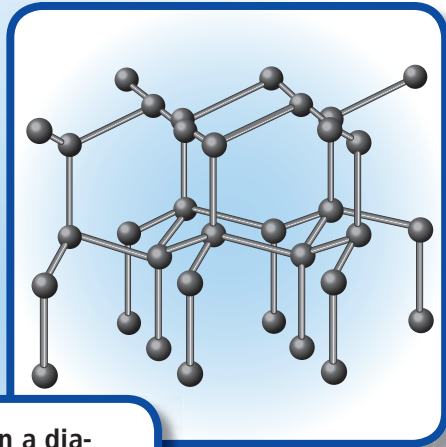
Copper and nickel come from Earth. They are used in making coins. Stones for fireplaces also come from Earth. Aluminum for cans and silicon for glasses come from Earth's crust.



Gemstones, like rubies and diamonds, are mined from under the ground. Metals for cars and ovens come from materials found in Earth's crust.



Where do most of the objects you use originally come from?



The atoms in a diamond are arranged in a way that makes it very hard.

Molecules of Life

Without carbon, Earth would be lifeless. Even tiny bacteria are 50% carbon. Carbon is the basic building block of life.

 About 98.8% of the human body is made from 6 elements. Oxygen, at 65%, makes up the largest amount. Carbon is second, at 18.5%. Hydrogen, nitrogen, calcium, and phosphorous are the other four.

 Each element is needed for good health.



 Red blood cells get their color from a molecule called hemoglobin. Each molecule has four atoms of iron. ▼

■ DNA is in every cell of the body. It makes sure that when new cells are made, they are exactly like the old ones. But it is made from just a few elements.

■ The DNA molecule looks like a twisted ladder. Each colored ball in this picture of DNA shows a different element.

■  **What element is the basic building block of the molecules of life?**



■ DNA is found in the nucleus of every cell in the body.

■ **Review**



Complete this **main idea** statement.

■ 1. All _____ comes in three states: solid, liquid, or gas.

■ Complete these **detail** statements.

■ 2. A _____ has no definite shape and no definite volume.

■ 3. A _____ has a definite shape but no definite volume.

■ 4. A _____ has a definite shape and a definite volume.

GLOSSARY

-  **alloy** (AL•oy) A solid solution in which a metal or a nonmetal dissolves in a metal.
-  **atom** (AT•um) The smallest unit of an element that has the properties of that element.
-  **compound** (KAHM•pownd) A substance made of two or more different elements.
-  **element** (EL•uh•muhnt) A substance made only of one kind of an atom.
-  **gas** (GAS) The state of matter that does not have a definite shape or volume.
-  **liquid** (LIH•kwid) The state of matter that has a definite volume but no definite shape.
-  **malleable** (MAL•ee•uh•buhl) Easy to shape or to form.
-  **metal** (MET•uhl) A substance that transfers heat and electricity well and is malleable.
-  **metalloid** (MET•uh•loyd) A substance that has some of the properties of a metal and some of the properties of a nonmetal.
-  **mixture** (MIKS•CHER) A combination of two or more different substances.
-  **molecule** (MAHL•uh•kyool) A group of two or more atoms that are joined.
-  **nonmetal** (nahn• MET•uhl) A substance that does not transfer heat and electricity well and is not malleable.
-  **periodic table** (pir•ee•AHD•ik TAY•buhl) A table that shows the elements arranged by their atomic numbers.
-  **physical property** (FIZ•ih•kuhl PRAHP•er•tee) A trait—such as color, shape or hardness—that describes a substance by itself.
-  **solid** (SAHL•id) The state of matter that has a definite shape and a definite volume.

Think About the Reading

-  **1.** What can you do to remember the difference between atoms and molecules?
-  **2.** You learned about elements, compounds, metals, nonmetals, solids, liquids and gases. Would you like to learn more about any one of these? Where can you go to find out more about them?

Hands-On Activity

You learned about solids, liquids and gases.

-  **1.** Make a list of common objects you see every day.
-  **2.** Divide your list into three parts. Place all things that are solids in one list. Place liquids in another list. Place gases in the third list.

School-Home Connection

Take your lists home. Share them with your family. Tell them about solids, liquids and gases. See if you and they can find other examples in your home. See if you and your family members can find examples of metals and nonmetals in your home.