METALS, NONMETALS, AND METALLOIDS

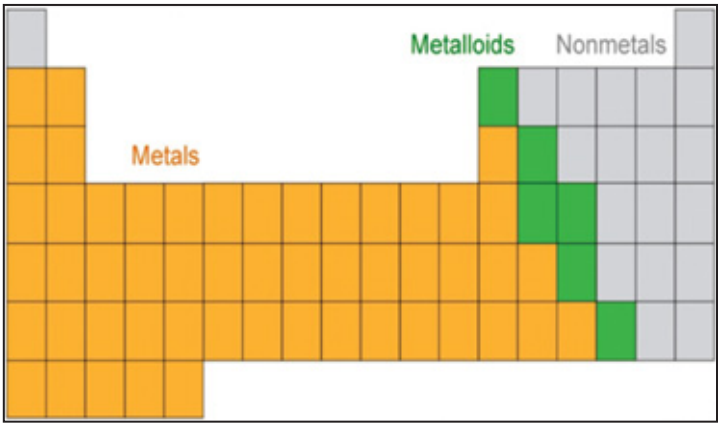
reflect

Earth contains a number of different materials that we use to meet specific needs. We breathe air, drink water, and use different rocks and stones for construction and transportation. Early humans used rocks and minerals that they took from the ground to help them hunt, travel, and provide shelter. Humans could remove materials such as copper, gold, and silver from Earth rather easily. They found these materials had properties that made them useful.

Iron found beneath Earth's surface can be removed from the ground and put to use. What physical properties does iron have?

Over time, the way that humans used these materials changed their lives. Iron, silicon, and wood are only a few of the many materials that have made building, travel, and communication much easier. How do you use these materials to make your life easier? What properties of these materials make them so useful?

Scientists use the periodic table to classify elements.



All of the materials that surround you—the objects you use, the air you breathe, the ground that you walk upon, even you—are made of elements and compounds. Compounds are all made of elements. A list of elements can be found on an organized chart called the *periodic table*. The location of each element in the periodic table is based on its properties. One of the ways the periodic table groups the elements is to separate them into *metals*, *nonmetals*, and *metalloids*.

Metals are on the left and lower side of the periodic table; they include elements such as aluminum and gold. Most of these elements are shiny; they can be molded and shaped, and they can conduct heat and electricity. All nonmetals except hydrogen are on the upper-right side of the periodic table. Nonmetals are elements such as helium, oxygen, and bromine. These materials are either gases (like helium and oxygen) or brittle solids (like carbon). They have properties that are much different than the properties of metals. For example, nonmetals are not easily molded or shaped, and they are not good conductors of heat or electricity.

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A diagonal line of elements separates the metals from the nonmetals. These are called metalloids. The metalloids—elements like boron, silicon, and antimony—have some properties of metals and other properties of nonmetals.

look out!

When you think of nonmetals, you might think of materials made of plastic or polystyrene. (*Polystyrene* is the substance used to make white, insulated coffee cups.) Like nonmetals, these materials do not conduct heat or electricity, and they may not have shiny appearances. However, they are compounds, not elements. *Compounds* are made of more than one element. In this lesson, *elements* are referred to as metals, nonmetals, or metalloids.

Metals have distinct physical properties.
Imagine that you have two different objects that are made of metal: a metal frying pan and a piece of copper wire. What properties are similar between these two objects? They are both metals and appear shiny. Yet the frying pan, the wire, and most other metals also share other properties. Let's take a closer look at the common physical properties of metals to determine how you can distinguish metals from other elements.

- **Luster:** Most objects made of metal are shiny in their appearance. Some examples are aluminum cans, silver coins, and gold jewelry.
- **Malleability:** Most metals can be molded or stretched into sheets when they are heated. They can form many different shapes. For example, the metal aluminum is very *malleable*—that is, it can be hammered into thin sheets of aluminum foil. Most metals are also *ductile*—that is, they can be pulled into thin wires.
- **Conductivity:** Heat and electricity flow easily through most metals. In other words, metals are *conductors* of heat and electricity. A frying pan is made of metal because the heat from a stove can transfer through the metal pan and cook the food. An electrical wire is often made of copper because the metal allows electrons to flow through the metal wire.

look out!

You may have touched a metal door handle and felt a brief shock. This happens because the metal door handle is a good conductor of electricity. Electrons jump from you to the door, and the shock is called *static electricity*. The door handle may also have felt very cold to the touch. This is not because the door handle attracts the cold air. It is because the metal conducts heat easily. When you touch the metal door handle, heat transfers from you to the handle, which makes it feel cold.

Nonmetals have distinct physical properties.

Nonmetals have properties that are different than those of metals. Imagine that you have two different objects containing a nonmetal element: a sign filled with neon gas (the neon is the nonmetal) and a piece of carbon. At first glance, these objects may not seem similar. However, they do share some properties. Let's take a closer look at the common physical properties of nonmetals to determine how they can be distinguished from other elements.

- **Luster:** Objects made of nonmetals are usually dull in their appearance. Some examples are solid sulfur and carbon nuggets.
- **Malleability:** Nonmetals are usually more brittle than metals—they cannot be molded or stretched like metals can. If you were to drop a nonmetal or strike it with a hammer, it would likely shatter into many smaller pieces. Many nonmetals are also gases at room temperature. For example, oxygen is a very common nonmetal that is typically found as a gas.
- **Conductivity:** Nonmetals do not allow either heat or electricity to flow through them easily. They are *insulators*. For example, heat does not pass easily through air. Air is a mixture of several nonmetal gases, such as oxygen and nitrogen. For this reason, air pockets are often built into jackets, buildings, and other objects that are intended to keep people warm. The air pockets insulate the objects.

Most nonmetals—including the carbon in this photograph—are brittle and break easily into smaller pieces.

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what do you think?

In our daily lives, we use many substances that are made of either metals or nonmetals. Identify things in the following images that are made of metal. Then, identify things made of nonmetals.

Metalloids have distinct physical properties.
Several elements lie in a diagonal line that separates the metals from the nonmetals on the periodic table. These elements—the metalloids—are boron, silicon, germanium, arsenic, antimony, and tellurium. Some scientists also include polonium and astatine as metalloids. Metalloids lie between the metals and the nonmetals. They can have properties of both metals and nonmetals. Let's investigate some common physical properties of metalloids.

- **Luster:** Metalloids can be either shiny or dull in their appearance.
- **Malleability:** Metalloids can be malleable and ductile, like metals. They also can be brittle, similar to nonmetals.
- **Conductivity:** Metalloids have intermediate heat and electrical conductivity. They do not conduct as effectively as metals, but they are not insulators like the nonmetals.

Getting Technical: Advances in Computer Technology

One of the key parts of a computer is the actual computer chip itself. These chips are made of materials called semiconductors. A semiconductor is a type of material that conducts electricity, but not as well as a metal. We can more easily control the amount of electricity that passes through a semiconductor. For this reason, they are used in many electronic devices.

Semiconductors have intermediate electrical conductivity. Because of this they are used in electronics.

In the design of computer chips, metalloids are often used to make semiconductors. Silicon is the most common element used to make semiconductors. Silicon is a metalloid that is found in sand and is used to make glass. Germanium, which is directly below silicon on the periodic table, is also used in electronic semiconductors.

Engineers who design computer chips change the amount of the metalloid that is added to computer chips. This changes the conductive properties of the chip. One of the benefits of adding small amounts of metalloids to the semiconductor is that smaller, faster computer chips have been created. These advances to the semiconductor's conductive properties have allowed rapid growth in both computer and cellular phone technology.

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What do you know?
Elements in the periodic table can be divided into three main groups: metals, nonmetals, and metalloids. The physical properties of each element determine in which group it is placed. The table below shows three different objects. Study each image and read the object's properties. Decide if the image is an example of a metal, a nonmetal, or a metalloid, and write your answers in the third column of the table.

Object	Properties	Substance
	shiny solid used to make semiconductors	
	gas (inside the balloon) heat insulator electrical insulator	
	electrical conductor malleable ductile heat conductor	

connecting with your child

Ancient Artifacts Using Metals, Nonmetals, and Metalloids

To help your child learn more about the uses of metals, nonmetals, and metalloids in ancient civilizations, visit a natural history museum or another museum that contains ancient artifacts. (If it is not possible to visit a museum, you may want to use online resources to investigate ancient civilizations with your child.) Have your child pay special attention to objects and artifacts that were made by these early civilizations. For example, many early Americans removed iron, copper, gold, or silver from Earth. They used these metals as tools, weapons, utensils, ornaments, and jewelry.

Because most of the objects the students will observe will be metals, have them pay close attention to objects made of either metalloids or nonmetals. For example, quartz is the pure form of silicon, which is a metalloid. Many Native American tribes used quartz as a valuable stone in jewelry. Ancient Egyptians used antimony, another metalloid, as a type of face paint. Compounds of bromine, a nonmetal, were used by ancient civilizations as a valuable purple dye.

Encourage your child to research how the materials were "processed" by early civilizations so that they could be used to make these objects. Have your child compare how this processing has changed today.

Here are some questions to discuss with your child:

- Were most of the artifacts made by these civilizations metals, metalloids, or nonmetals? Why do you think this was the case?
- What methods did ancient civilizations use to extract the material from Earth? How has this changed today?
- What methods did ancient civilizations use to process the material after it was extracted from Earth? How has this changed today?
- How did the civilizations use the properties of metals, nonmetals, and metalloids for different purposes?