section 1

Physical Properties and Changes

as you read

What You'll Learn

- **Identify** physical properties of matter.
- **Explain** why materials with different masses have different densities.
- **Observe** water displacement to determine volume.
- **Describe** the states of matter.
- **Determine** how temperature changes affect substances.
- **Classify** matter using physical properties.

Why It's Important

Observing physical properties will help you interpret the world around you.

Review Vocabulary

mass: amount of matter in an object

New Vocabulary

- physical property
- matter
- physical change
- density
- states of matter
- melting point
- boiling point

Using Your Senses

As you look in your empty wallet and realize that your allowance isn't coming anytime soon, you decide to get an after-school job. You've been hired at the new grocery store that will open next month. They are getting everything ready for the grand opening, and you will be helping make decisions about where things will go and how they will be arranged.

When you come into a new situation or have to make any kind of decision, what do you usually do first? Most people would make some observations. Observing involves seeing, hearing, tasting, touching, and smelling.

Whether in a new job or in the laboratory, you use your senses to observe materials. Any characteristic of a material that can be observed or measured without changing the identity of the material is a physical property. However, it is important to never taste, touch, or smell any of the materials being used in the lab without guidance, as noted in **Figure 1.** For safety reasons you will rely mostly on other observations.

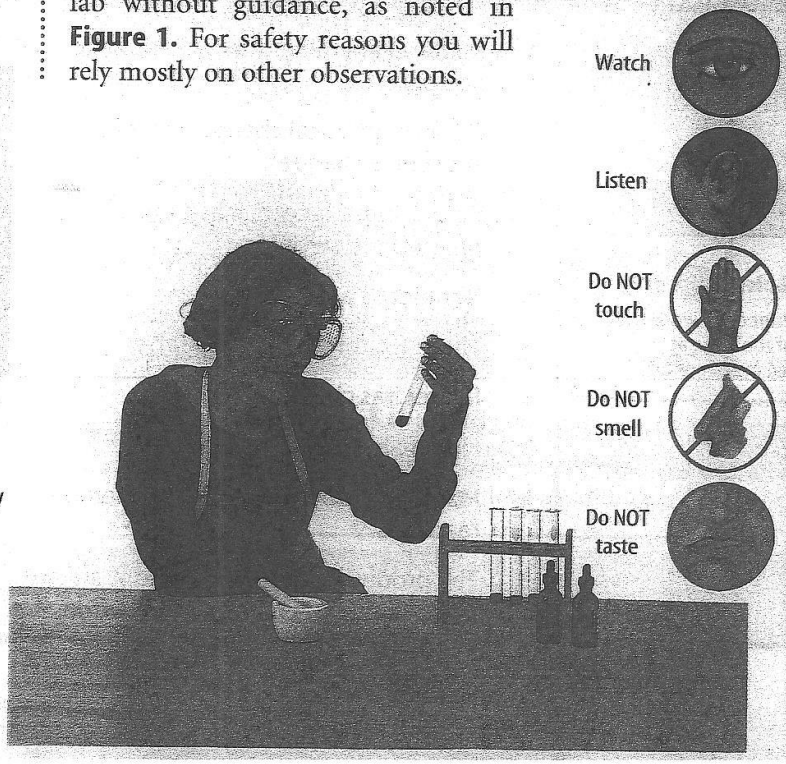


Figure 1 For safety reasons, in the laboratory you usually use only two of your senses—sight and hearing. Many chemicals can be dangerous to touch, taste, and smell.

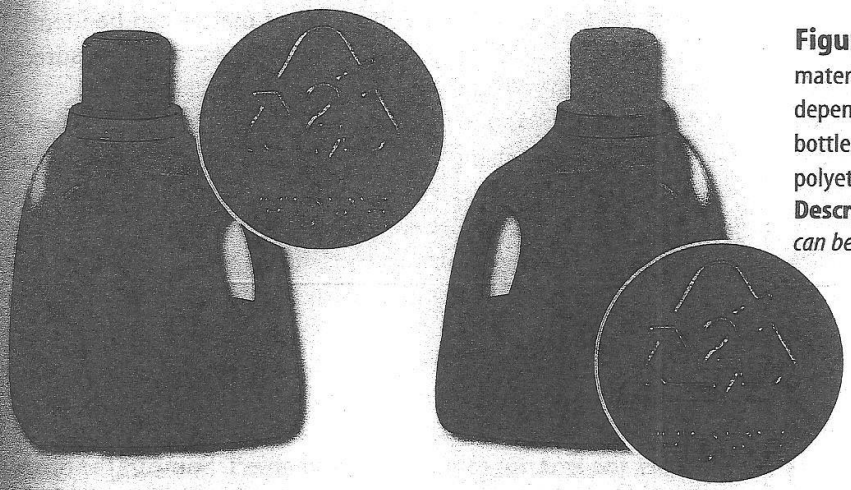


Figure 2 The identity of the material does not necessarily depend on its color. Each of these bottles is made of high-density polyethylene (HDPE).
Describe *a physical change that can be applied to the bottles.*

Physical Properties

On the first day of your new job, the boss gives you an inventory list and a drawing of the store layout. She explains that every employee is going to give his or her input as to how the merchandise should be arranged. Where will you begin?

You decide that the first thing you'll do is make some observations about the items on the list. One of the key senses used in observing physical properties is sight, so you go shopping to look at what you will be arranging.

Color and Shape Everything that you can see, touch, smell, or taste is matter. **Matter** is anything that has mass and takes up space. What things do you observe about the matter on your inventory list? The list already is organized by similarity of products, so you go to an aisle and look.

Color is the first thing you notice. The laundry detergent bottles you are looking at come in every color. Maybe you will organize them in the colors of the rainbow. You make a note and look more closely. Each bottle or box has a different shape. Some are square, some rectangular, and some are a free-form shape. You could arrange the packages by their shape.

When the plastic used to make the packaging is molded, it changes shape. However, the material is still plastic. This type of change is called a physical change. It is important to realize that in a **physical change**, the physical properties of a substance change, but the identity of the substance does not change. Notice **Figure 2.** The detergent bottles are made of high-density polyethylene regardless of the differences in the physical properties of color or shape.

Reading Check ***What is matter?***

Science Online

Topic: Physical Properties
Visit red.msscience.com for Web links to information about classifying matter by its physical properties.

Activity Choose three objects in the room around you. Try to describe them using as many different physical properties as you can. Pass your description to another classmate and see if they are able to identify the object.

Length and Mass Some properties of matter can be identified by using your senses, and other properties can be measured. How much is there? How much space does it take up?

One useful and measurable physical property is length. Length is measured using a ruler, meterstick, or tape measure, as shown in **Figure 3.** Objects can be classified by their length. For example, you could choose to organize the French bread in the bakery section of your store by the length of the loaf. But, even though the dough has been shaped in different lengths, it is still French bread.

Back in the laundry aisle, you notice a child struggling to lift one of the boxes of detergent. That raises a question. How much detergent is in each box? Mass is a physical property that describes the amount of material in an object. Some of the boxes are heavy, but, the formula of the detergent hasn't changed from the small box to the large box. Organizing the boxes by mass is another option.

Volume and Density Mass isn't the only physical property that describes how much of something you have. Another measurement is volume. Volume measures the amount of space an object takes up. Liquids usually are measured by volume. The juice bottles on your list could be organized by volume.

Another measurable physical property related to mass and volume is **density**—the amount of mass a material has in a given volume. You notice this property when you try to lift two things of equal volume that have different masses. Density is found by dividing the mass of an object by its volume.

$$\text{density} = \text{mass/volume, or } D = m/V$$

ScienceOnline

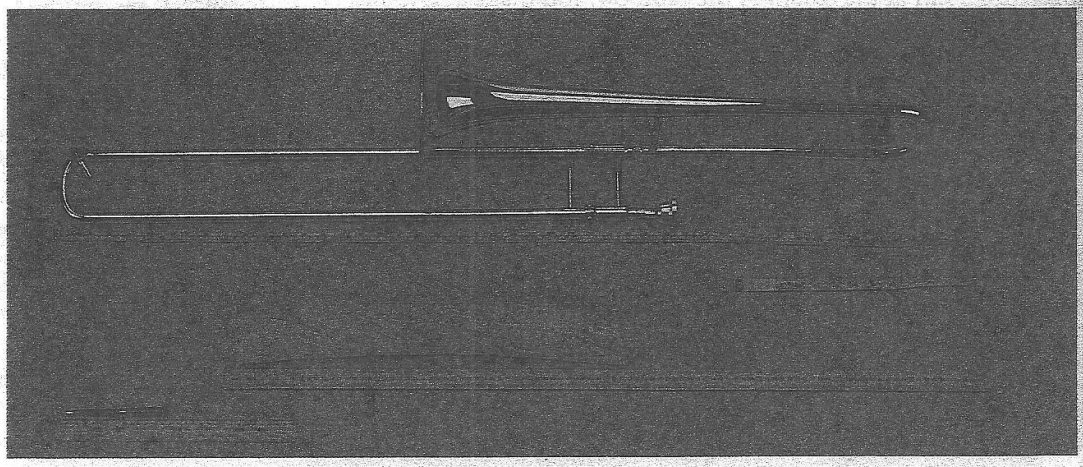
Topic: Density

Visit red.msscience.com for Web links to information about density.

Activity Find three objects in the room that are about the same size. This might be a pencil eraser, a necklace pendant, and a small rock sample. Determine the density of each object. Is density dependent on size?

Figure 3 The length of any object can be measured with the appropriate tool.

Describe *how you would measure the length of your school building.*



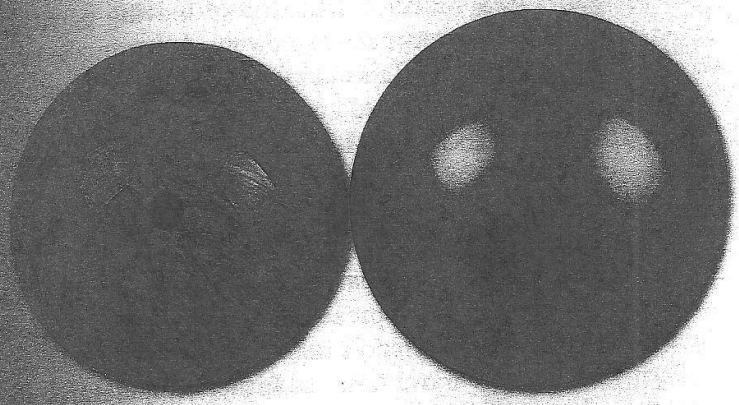


Figure 4 These balls take up about the same space, but the bowling ball on the left has more mass than the kickball on the right. Therefore, the bowling ball is more dense.

Same Volume, Different Mass **Figure 4** shows two balls that are the same size but not the same mass. The bowling ball is more dense than the kickball. The customers of your grocery store will notice the density of their bags of groceries if the baggers load all of the canned goods in one bag and put all of the cereal and napkins in the other.

The density of a material stays the same as long as pressure and temperature stay the same. Water at room temperature has a density of 1.00 g/cm^3. However, when you do change the temperature or pressure, the density of a material can change. Water kept in the freezer at 0°C is in the form of ice. The density of that ice is 0.9168 g/cm^3. Has the identity of water changed? No, but something has changed.

Reading Check ***What two properties are related in the measurement of density?***

States of Matter

How does water change when it goes from 20°C to 0°C? It changes from a liquid to a solid. The four **states of matter** are solid, liquid, gas, and plasma (PLAZ muh). The state of matter of a substance depends on its temperature and pressure. Three of these states of matter are things you talk about or experience every day, but the term *plasma* might be unfamiliar. The plasma state occurs at very high temperatures and is found in fluorescent (floo RE sunt) lightbulbs, the atmosphere, and in lightning strikes.

As you look at the products to shelve in your grocery store, you might make choices of classification based on the state of matter. The state of matter of a material is another physical property. The liquid juices all will be in one place, and the solid, frozen juice concentrates will be in another.

Mini LAB

Determining Volume

Procedure

1. **Find three objects of the same size.** For example: a marble, a rubber ball, and a wood sphere.
2. **Fill a 100-mL graduated cylinder with 50 mL of water.**
3. **Submerge one object into the graduated cylinder and record the new water level. Empty the graduated cylinder.**
4. **Repeat steps 2 and 3 for the remaining two objects.**

Analysis

1. **Which of the three items displaced the most water? Which displaced the least?**
2. **What does this tell you about the volume of the objects?**
3. **What other quantities would you measure to determine the density of each object?**

Moving Particles Matter is made up of moving particles. The state of matter is determined by how much energy the particles have. The particles of a solid vibrate in a fixed position. They remain close together and give the solid a definite shape and volume. The particles of a liquid are moving much faster and have enough energy to slide past one another. This allows a liquid to take the shape of its container. The particles of a gas are moving so quickly that they have enough energy to move freely away from other particles. The particles of a gas take up as much space as possible and will spread out to fill any container. **Figure 5** illustrates the differences in the states of water.

Particles of matter move faster as higher temperatures are applied. To demonstrate this, fill one beaker with cold water and another with very hot water. Add ten drops of food coloring. Observe in which beaker the color becomes uniform first.

Changes of State You witness a change of state when you place ice cubes in a cup and they melt. You still have water but in another form. The opposite physical change happens when you put liquid water in ice-cube trays and pop them in your freezer. The water doesn't change identity—only the state it is in.

For your job, you will need to make some decisions based on the ability of materials to change state. You don't want all the frozen items thawing out and becoming slushy liquid. You also don't want some of the liquids to get so cold that they freeze.

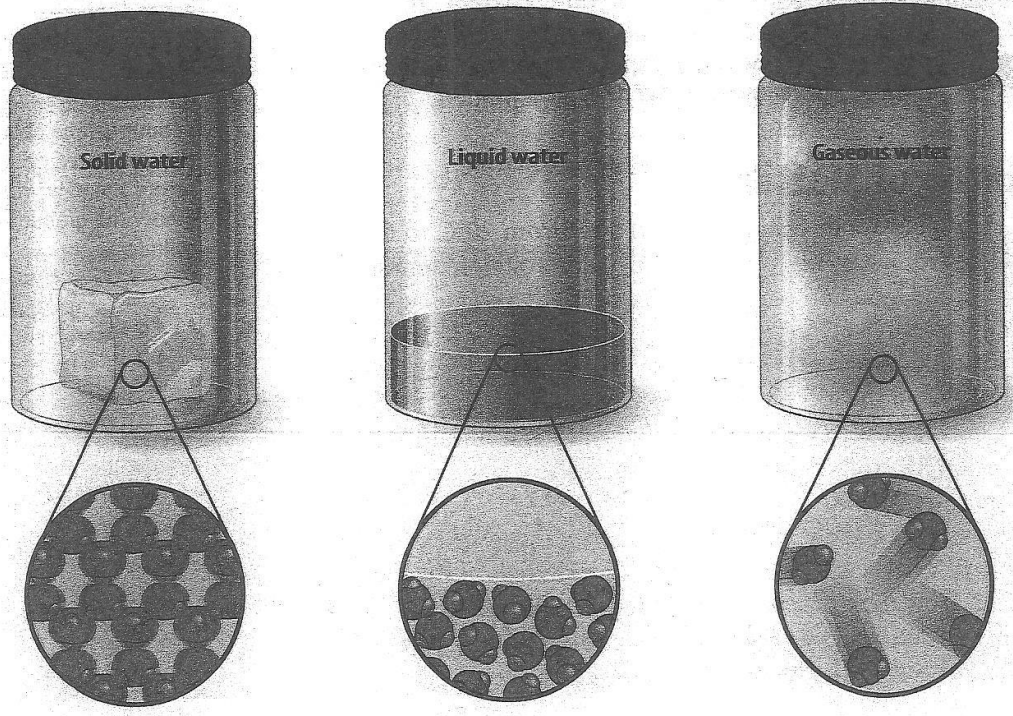


Figure 5 Water can be in three different states: solid, liquid, and gas. The molecules in ice are tightly packed and vibrate in place, but in liquid water they can slip past each other because they have more energy to move. In water vapor, they move freely all around the container with even more energy.

Melting and Boiling Points At what temperature will water in the form of ice change into a liquid? The temperature at which a solid becomes a liquid is its **melting point.** The melting point of a pure substance does not change with the amount of the substance. This means that a small sliver of ice and a block of ice the size of a house both will melt at 0°C. Lead always melts at 327.5°C. When a substance melts, it changes from a solid to a liquid. This is a physical change, and the melting point is a physical property.

At what temperature will liquid water change to a gas? The **boiling point** is the temperature at which a substance in the liquid state becomes a gas. Each pure substance has a unique boiling point at atmospheric pressure. The boiling point of water is 100°C at atmospheric pressure. The boiling point of nitrogen is −195.8°C, so it changes to a gas when it warms after being spilled into the open air, as shown in **Figure 6.** The boiling point, like the melting point, does not depend on the amount of the substance.

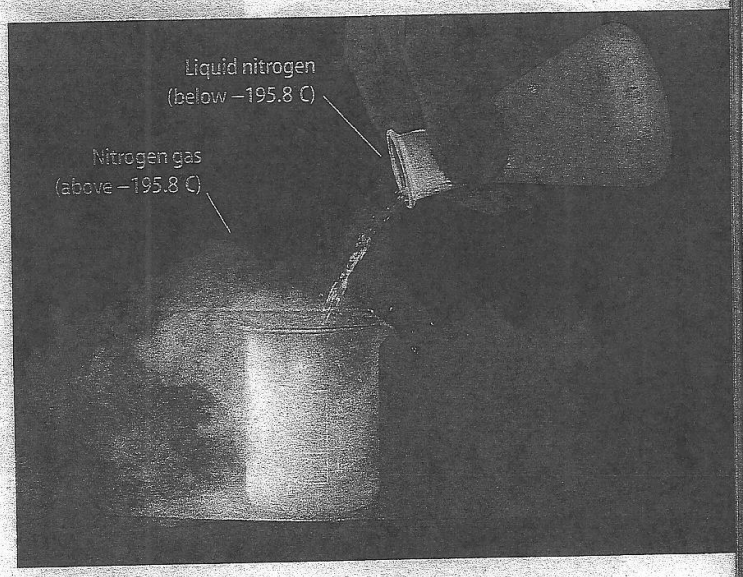


Figure 6 When liquid nitrogen is poured from a flask, you see an instant change to gas because nitrogen's boiling point is −195.8°C, which is much lower than room temperature.

Reading Check ***What physical change takes place at the boiling point?***

However, the boiling point and melting point can help to identify a substance. If you observe a clear liquid that boils at 56.1°C at atmospheric pressure, it is not water. Water boils at 100°C. If you know the boiling points and melting points of substances, you can classify substances based on those properties.

Metallic Properties

Other physical properties allow you to classify substances as metals. You already have seen how you can classify things as solids, liquids, or gases or according to color, shape, length, mass, volume, or density. What properties do metals have?

How do metals look? Often the first thing you notice about something that is a metal is its shiny appearance. This is due to the way light is reflected from the surface of the metal. This shine is called luster. New handlebars on a bike have a metallic luster. Words to describe the appearance of nonmetallic objects are *pearly, milky,* or *dull.*

INTEGRATE Language Arts

Rock Descriptions When geologists describe rocks, they use specific terms that have meaning to all other scientists who read their descriptions. To describe the appearance of a rock or mineral, they use the following terms: *metallic, adamantine, vitreous, resinous, pearly, silky,* and *greasy.* Research these terms and write a definition and example of each in your Science Journal.

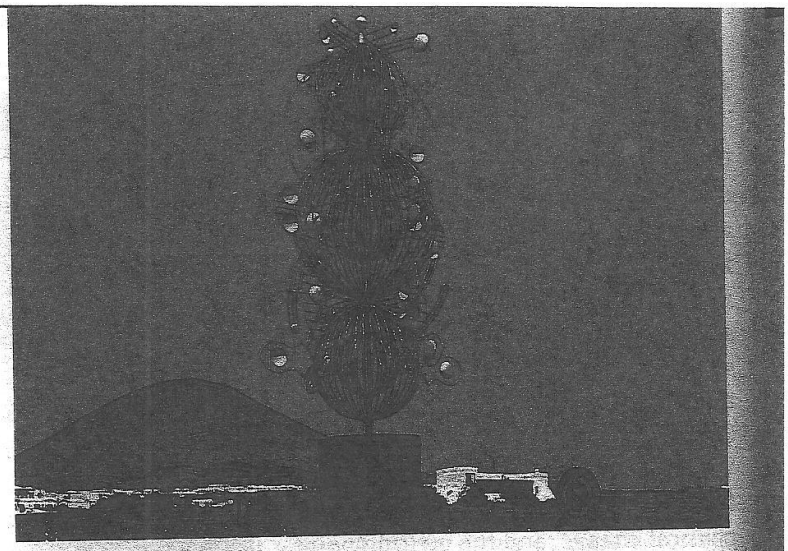
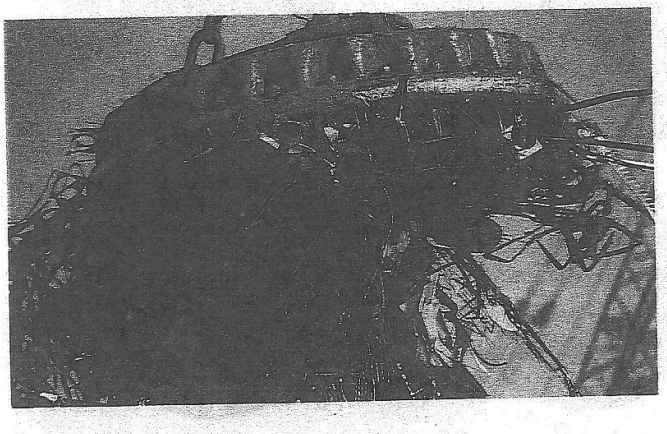


Figure 7 This artist has taken advantage of the ductility of metal by choosing wire as the medium for this sculpture.

Uses of Metals Metals can be used in unique ways because of some of the physical properties they have. For example, many metals can be hammered, pressed, or rolled into thin sheets. This property of metals is called malleability (mal lee uh BIH luh tee). The malleability of copper makes it an ideal choice for artwork such as the Statue of Liberty. Many metals can be drawn into wires as shown in **Figure 7.** This property is called ductility (duk TIH luh tee). The wires in buildings and most electrical equipment and household appliances are made from copper. Silver and platinum are also ductile.

You probably observe another physical property of some metals every day when you go to the refrigerator to get milk or juice for breakfast. Your refrigerator door is made of metal. Some metals respond to magnets. Most people make use of that property and put reminder notes, artwork, and photos on their refrigerators. Some metals have groups of atoms that can be affected by the force of a magnet, and they are attracted to the magnet because of that force. The magnet in **Figure 8** is being used to select metallic objects.

Figure 8 This junkyard magnet pulls scrap metal that can be salvaged from the rest of the debris. It is sorting by a physical property.



At the grocery store, your employer might think about these properties of metals as she looks at grocery carts and thinks about shelving. Malleable carts can be dented. How could the shelf's attraction of magnets be used to post advertisements or weekly specials? Perhaps the prices could be fixed to the shelves with magnetic numbers. After you observe the physical properties of an object, you can make use of those properties.

Using Physical Properties

In the previous pages, many physical properties were discussed. These physical properties—such as appearance, state, shape, length, mass, volume, ability to attract a magnet, density, melting point, boiling point, malleability, and ductility—can be used to help you identify, separate, and classify substances.

For example, salt can be described as a white solid. Each salt crystal, if you look at it under a microscope, could be described as having a three-dimensional cubic structure. You can measure the mass, volume, and density of a sample of salt or find out if it would attract a magnet. These are examples of how physical properties can be used to identify a substance.

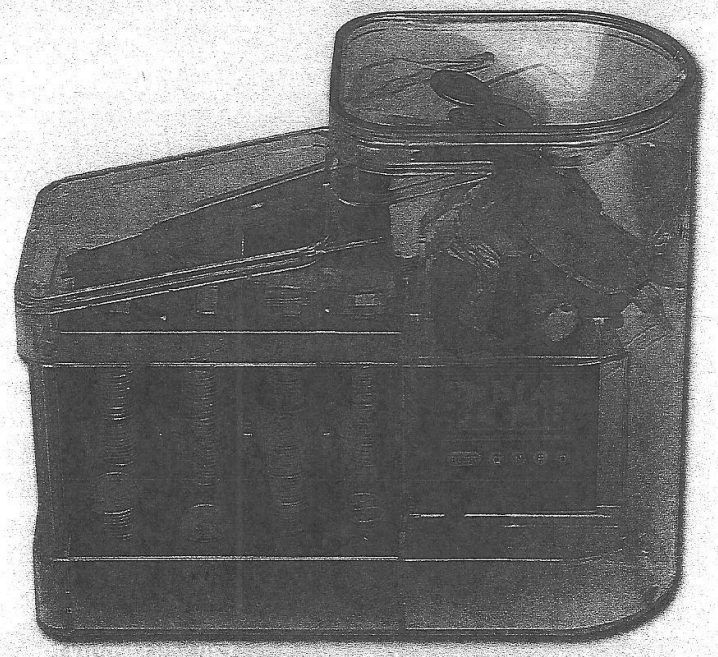


Figure 9 Coins can be sorted by their physical properties. Sorting by size is used here.
Identify *three other properties that can be used to sort coins.*

Sorting and Separating When you do laundry, you sort according to physical properties. Perhaps you sort by color. When you select a heat setting on an iron, you classify the clothes by the type of fabric. When miners during the Gold Rush panned for gold, they separated the dirt and rocks by the density of the particles. **Figure 9** shows a coin sorter that separates the coins based on their size. Iron filings can be separated from sand by using a magnet.

INTEGRATE Life Science

Scientists who work with animals use physical properties or characteristics to determine the identity of a specimen. They do this by using a tool called a dichotomous (di KAH tuh mus) key. The term *dichotomous* refers to two parts or divisions. Part of a dichotomous key for identifying hard-shelled crabs is shown on the next page in **Figure 10.** To begin the identification of your unknown animal, you are given two choices. Your animal will match only one of the choices. In the key in **Figure 10,** you are to determine whether or not your crab lives in a borrowed shell. Based on your answer, you are either directed to another set of choices or given the name of the crab you are identifying.