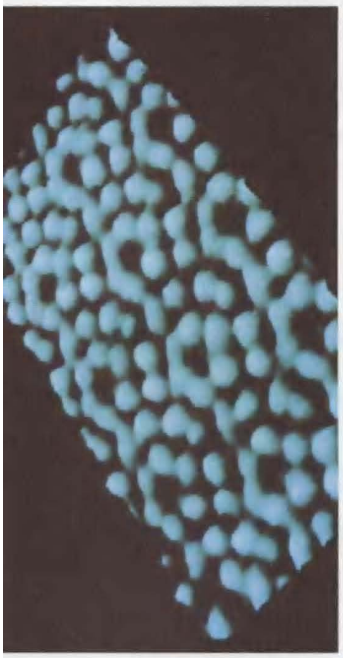
Pure Substances and Mixtures

In the previous investigation you looked at different substances. But why is each substance different from other substances? Why does each substance have its own properties?

The Particle Theory



To answer these questions we need to look at the **particle theory**. The particle theory, developed over many centuries, explains that matter is made up of tiny particles with spaces between them (**Figure 1**). Particles are always moving. The more energy they have, the faster they move. The particle theory also explains that the tiny particles in matter are attracted to each other (**Figure 2**). This theory has been useful in explaining some observations about the behaviour of matter.

Figure 1
A magnified view of a thin metal foil supports the particle theory explanation that matter consists of tiny particles with spaces between them.

Different Particles, Different Substances

According to the particle theory, there are many different kinds of particles. The differences between the particles cause the substances that contain them to have different properties.

Pure Substances

A **pure substance** contains only one kind of particle throughout. There are many pure substances, but only a few can actually be found in nature. We often think of our drinking water as being pure, but this water has chemicals in it to remove bacteria, so it is actually made up of several pure substances. In nature, pure substances tend to mix together. There are exceptions; for example, diamonds are pure. They are formed deep in the mantle of Earth's crust, but they are rarely found.

Almost all of the pure substances we encounter in our lives have been made pure by human beings. Aluminum foil is pure, and so is table sugar. To obtain these substances in a pure form, we take the **raw material** that contains them, and separate out the substance we want, as shown in **Figure 3**. All samples of pure substances have the same properties whether the sample is large or small.

Figure 2

Solid
In a solid, the particles are close together and locked into a pattern. They can move, but only back and forth a little. Attractive forces hold the particles together.

Liquid
In a liquid, the particles are slightly farther apart. Because the particles are farther apart, the attractive forces are weaker. They are able to slide past one another.

Gas
In a gas, the particles are far apart. The particles can move in any direction because the attractive forces are weakest.

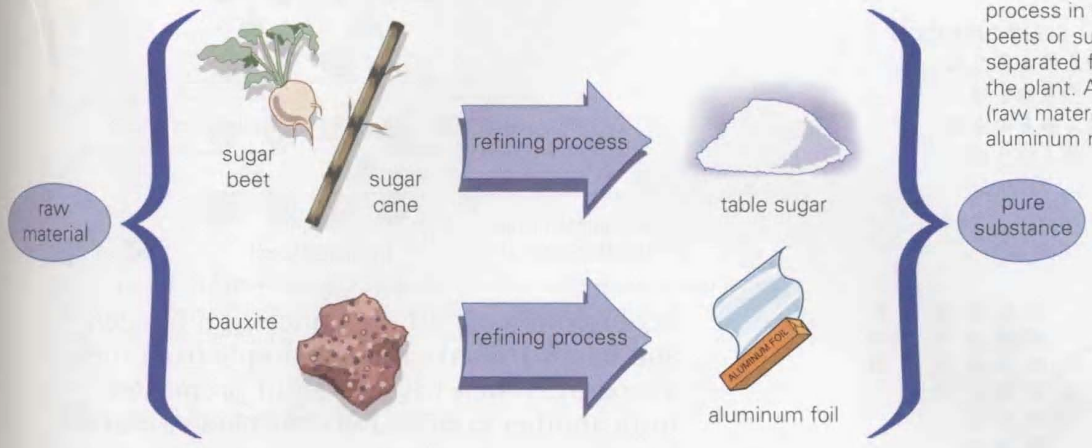
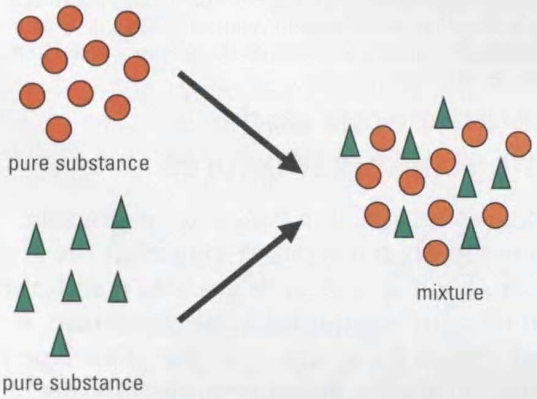


Figure 3
Table sugar is obtained by a refining process in which the sugar from sugar beets or sugar cane (raw material) is separated from the fibre and other parts of the plant. Aluminum comes from bauxite (raw material), a type of rock that contains aluminum mixed up with other minerals.

Mixtures

Almost all of the natural substances, as well as human-made and manufactured products, in the world are mixtures of pure substances. A **mixture** contains two or more pure substances, as shown in **Figure 4**. Mixtures can be any combination of solids, liquids, and gases. For example, soft drinks are a mixture that includes liquid water, solid sugar, and carbon dioxide gas. Bread is a mixture of yeast, flour, sugar, water, air, and other chemicals.

Figure 4
Most substances you will come in contact with are mixtures. Mixtures contain at least two pure substances.



Try This — Is Tap Water a Solution?

- Clean two glass containers or watch glasses, ensuring that there are no spots on them.
- Mark one container T (for tap water) and the other D (for distilled water).
- With a clean medicine dropper, add 5 drops of tap water to the container marked T, and 5 drops of distilled water to the container marked D.
- Place the containers near a sunny window or a heater, and let them stand until the water evaporates.
- Hold the containers up to the light.

1. What do you notice about each container?
2. Based on your observations, is tap water a solution? Explain.
3. How would you classify the distilled water? Explain.
4. Do you think evaporation is a reliable method for separating a dissolved solid from all liquid solutions? Why or why not?

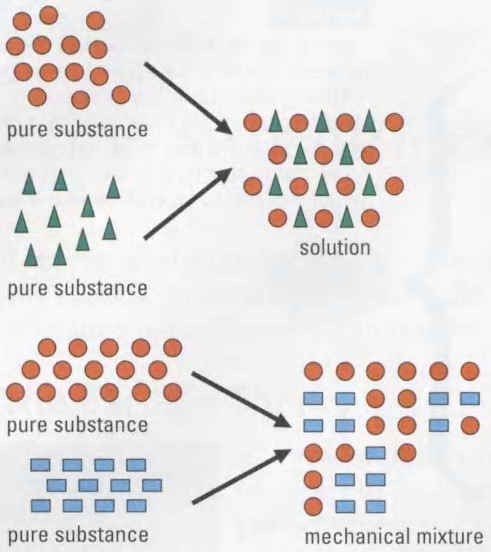


Figure 5

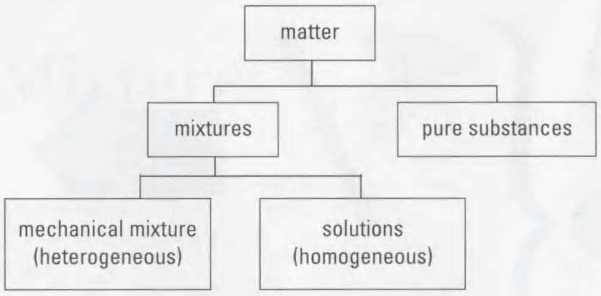
Pure substances mix to form mechanical mixtures or solutions. In a solution, the particles of the pure substances are mixed evenly so that neither original substance is visible. In a mechanical mixture, the substances do not mix evenly. Both substances are clearly visible.

Heterogeneous and Homogeneous Mixtures

In many mixtures, like concrete or granola, you can clearly see separate pieces in the mixture. Each spoonful of granola is different. If you take up a spoonful of wet concrete, it may or may not contain a pebble. This type of mixture is called a **heterogeneous mixture** (heterogeneous means "different kinds"), because two or more substances can be seen and felt. If you take a small sample from such a mixture, it may have different properties from another sample. Another name for a heterogeneous mixture is a **mechanical mixture** (see **Figure 5**).

In a **homogeneous mixture** (homogenous means "same kind"), the particles of the pure substances mix together so completely that the mixture looks and feels as though it is made of only one substance. No matter where you sample it, or how small the sample is, the properties of this mixture are always the same. Steel, composed of iron, oxygen, and carbon, is a homogeneous mixture. No matter where you cut a steel bar, it always looks the same. When you mix a small amount of salt with water you create a homogeneous mixture. Another name for a homogeneous mixture is a **solution**. We can classify matter based on its observable properties (see **Table 1**).

Table 1 **Classification of Matter**



Try This — Mechanical Mixtures and Solutions from the Refrigerator

- Make a jelly dessert in a clear glass bowl following the package directions. When the jelly has set, observe it closely.

1. Is the jelly transparent?
2. Can you see more than one type of particle?
3. How would you classify it?
4. Is the jelly a solution?

- Try shining a flashlight through the bowl, so any fine particles will become visible.

5. What do you think now? Would you change your classification? State reasons.

- Add a tablespoon of chocolate syrup to a glass of water and stir until the syrup and water are thoroughly mixed.

6. Is the mixture homogeneous (a solution) or heterogeneous (a mechanical mixture)?

- Let the mixture stand for a while, then observe it again.

7. What do you notice?
8. Make a list of other mixtures that have similar properties to chocolate syrup and water.

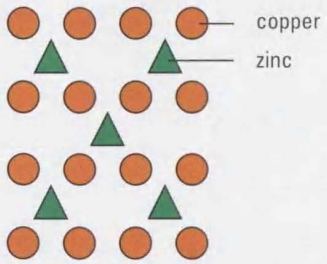


Figure 6

Brass, a decorative metal, is a solid solution in which a small amount of zinc (the solute) is dissolved in copper (the solvent) while it is molten hot. The zinc makes the brass harder than pure copper.

More About Solutions

In a solution, one substance has mixed completely, or **dissolved**, into another. Solutions can be solid, liquid, or gas. Steel, a solid solution, is made when oxygen (a gas) and carbon (a solid) dissolve into the main substance, iron. The substances that dissolve (in the case of steel, oxygen and carbon) are called the **solutes**. The substance into which they dissolve (iron) is called the **solvent**. Brass is another solid solution. The solvent in brass is copper, and the solute is zinc, as you can see in **Figure 6**.

Air, a solution of gases, consists mostly of nitrogen gas (the solvent). The gases dissolved in it include oxygen, argon, and carbon dioxide (the solutes).

Liquid solutions are formed when a solid, a liquid, or a gas dissolves in a liquid. For example, apple juice is a solution of sugar and minerals (the solutes) dissolved in water (the solvent). The oceans are a solution of many different salts dissolved in water. Another liquid solution is vinegar. Vinegar, used on French fries and salads, and for cleaning stains, is a solution that consists mostly of water (the solvent) and a small amount of liquid acetic acid (the solute).

Liquid solutions may also include dissolved gases. Pop is a sweet solution that is mostly water (the solvent), with both solid sugar and carbon dioxide gas (the solutes) dissolved in it. All solutions are homogeneous, so they look the same throughout, but liquid and gas solutions are also transparent (you can see through them). They may have a colour, however, as the solutions apple juice and tea do.

Understanding Concepts

1. **(a)** What is a pure substance? Give an example.
   (b) What is a mixture? Give an example.
2. Identify the solute and the solvent in the picture below.

3. Describe in your own words the difference between a mechanical mixture and a solution. Include the terms homogeneous and heterogeneous in your answer.
4. Which of the following is a solution, and which is a mechanical mixture? Explain the reason for your choice.
   (a) wood **(c)** tap water
   (b) orange juice **(d)** loonie coin

Making Connections

5. Give an example of each of the following types of solutions (not including those already mentioned in this section):
   (a) a liquid in a liquid
   (b) a solid in a solid
   (c) a solid in a liquid
6. Make a chart and list 10 liquids found at home. Examine the contents by reading the labels on the containers.
   (a) On your chart identify the liquids that meet the definition of a solution.
   (b) For each solution, list the solvent and the solute(s) on your chart.

Design Challenge

Are the mixtures you must separate for your Challenge mechanical mixtures or solutions?