Chapter 3

Elements of Chemistry

THE MAIN IDEA

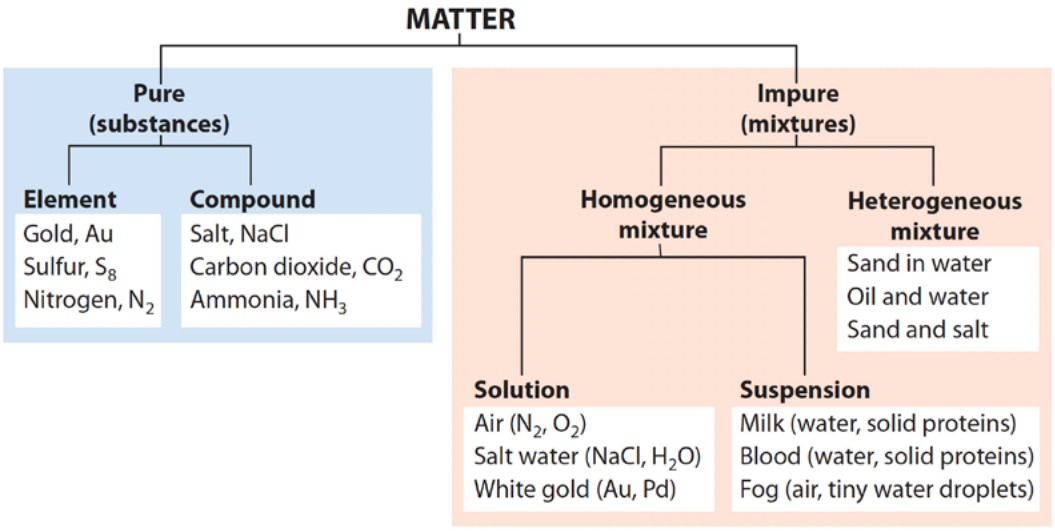
Elements combine to form compounds, which blend together to form mixtures

3.7 Matter Can Be Classified as Pure or Impure

From a chemist's point of view, if a material is **pure**, it consists of only a single element or a single compound. In pure gold, for example, there is nothing but the element gold. In pure table salt, there is nothing but the compound sodium chloride. If a material is **impure**, it is a mixture and contains two or more elements or compounds. These concepts are mapped out in the classification scheme shown in **Figure 3.29**.

READING CHECK

How does a chemist define a "pure" material?



< Figure 3.29

The chemical classification of matter.

FOR YOUR INFORMATION

White gold is a mixture of gold with smaller amounts of white metals, such as silver, palladium, or rhodium, that increase its hardness. Unlike gold, the precious metal platinum is used in jewelry in almost its pure form, about 95 percent. Platinum is a very white metal and is also very dense. A platinum ring will feel heavier than a typical yellow or white gold ring, but it will also be much more expensive.

Because atoms and molecules are so small, there is a countless number of them in even a tiny sample. If just one atom or molecule out of many were different, then this sample could not be classified as 100 percent pure. Samples can be "purified," however, by various methods, such as distillation. When we say pure, it is understood to be a relative term. Comparing the purity of two samples, the purer one contains fewer impurities. A sample of water that is 99.9 percent pure has a greater proportion of impurities than does a sample of water that is 99.9999 percent pure. The 99.9999 percent pure water would be much more expensive, because this high degree of purity is rather difficult to attain.

Sometimes naturally occurring mixtures are labeled as being pure, as in "pure orange juice." Such a statement means that nothing artificial has been added. According to a chemist's definition, however, orange juice is anything but pure, as it contains a wide variety of materials, including water, pulp, flavorings, vitamins, and sugars. Also, outside the language of chemistry, sometimes a mixture can be identified as pure. A cook, for example, might ask for pure baking powder. To a chemist, however, this doesn't make sense because baking powder is a mixture of baking soda and sodium aluminum sulfate, plus many other chemicals.

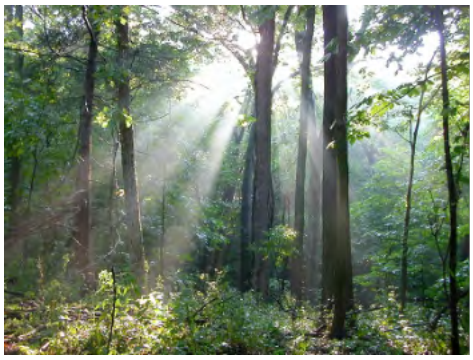
Mixtures may be heterogeneous or homogeneous. In a **heterogeneous mixture**, the different components can be seen as individual substances, such as pulp in orange juice, sand in water, or oil globules dispersed in vinegar. The different components are visible. **Homogeneous mixtures** have the same composition throughout as judged by the unaided eye. Any one region of the mixture has the same ratio of substances as does any other region. The reason for this is because the different components are mixed at a very fine level such that the components cannot be seen as individual identifiable entities. The distinction is shown in **Figure 3.30**.

Figure 3.30 >

(a) In heterogeneous mixtures, the different components can be seen with the naked eye. (b) In homogeneous mixtures, the different components are mixed at a much finer level and so are not readily distinguished.

A homogeneous mixture may be either a solution or a suspension. In a **solution**, all components are in the same phase. The atmosphere we breathe is a gaseous solution consisting of the gaseous elements nitrogen and oxygen as well as minor amounts of other gaseous materials. Salt water is a liquid solution, because both the water and the dissolved sodium chloride are found in a single liquid phase. An example of a solid solution is white gold. We will discuss solutions in more detail in Chapter 7.

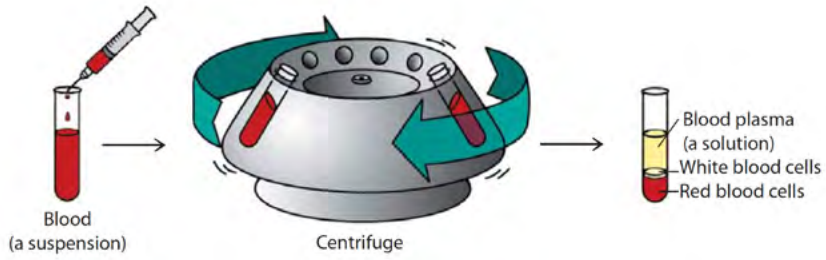
A **suspension** forms when the particles of a substance are finely mixed but not dissolved. The components of a suspension can be of different phases, such as solid particles suspended within a liquid or liquid droplets suspended within a gas. In a suspension, the mixing can be so thorough that the different phases are not readily distinguished. Milk is a suspension because it is a homogeneous mixture of proteins and fats finely dispersed in water. Blood is a suspension composed of finely dispersed blood cells in water. Another example of a suspension is clouds, which are homogeneous mixtures of tiny water droplets suspended in air. Light shining through a suspension, as is shown in **Figure 3.31**, results in a visible cone as the light is reflected by the suspended components.



Λ Figure 3.31

The path of light becomes visible when it passes through a suspension.

The easiest way to distinguish a suspension from a solution in the laboratory is to spin a sample in a centrifuge. This device, spinning at thousands of revolutions per minute, separates the components of suspensions but not those of solutions, as **Figure 3.32** shows.



Λ Figure 3.32

Blood, because it is a suspension, can be centrifuged into its components, which include the blood plasma (a yellowish solution) and white and red blood cells. The components of the plasma cannot be separated from one another because a centrifuge has no effect on solutions. Notice that blood plasma, white blood cells, and red blood cells can be isolated from blood. None of these components of blood, however, are in themselves pure materials.

CONCEPT **CHECK**

Impure water can be purified by

a. removing the impure water molecules.
b. removing everything that is not water.
c. breaking down the water to its simplest components.
d. adding some disinfectant, such as chlorine.

CHECK YOUR ANSWER

The answer is b: impure water can be purified by removing everything that isn't water. H_2O is a compound made of the elements hydrogen and oxygen in a 2-to-1 ratio. Every H_2O molecule is the same as every other, and there's no such thing as an impure H_2O molecule. Just about anything, including you, beach balls, rubber ducks, dust particles, and bacteria, can be found in water. When something other than water is found in water, we say that the water is impure. It is important to see that the impurities are in the water and not part of the water, which means that it is possible to remove them by a variety of physical means, such as filtration or distillation.