Matter has mass and volume.

BEFORE, you learned

- Scientists study the world by asking questions and collecting data
- Scientists use tools such as microscopes, thermometers, and computers

NOW, you will learn

- What matter is
- How to measure the mass of matter
- How to measure the volume of matter

All objects are made of matter.

Suppose your class takes a field trip to a museum. During the course of the day you see mammoth bones, sparkling crystals, hot-air balloons, and an astronaut's space suit. All of these things are matter.

Matter is what makes up all of the objects and living organisms in the universe. As you will see, **matter** is anything that has mass and takes up space. Your body is matter. The air that you breathe and the water that you drink are also matter. Matter makes up the materials around you. Matter is made of particles called atoms, which are too small to see. You will learn more about atoms in the next section.

Not everything is matter. Light and sound, for example, are not matter. Light does not take up space or have mass in the same way that a table does. Although air is made of atoms, a sound traveling through air is not.

Mass is a measure of the amount of matter.

Different objects contain different amounts of matter. **Mass** is a measure of how much matter an object contains. A metal teaspoon, for example, contains more matter than a plastic teaspoon. Therefore, a metal teaspoon has a greater mass than a plastic teaspoon. An elephant has more mass than a mouse.

Measuring Mass

When you measure mass, you compare the mass of the object with a standard amount, or unit, of mass. The standard unit of mass is the kilogram (kg). A large grapefruit has a mass of about one-half kilogram. Smaller masses are often measured in grams (g). There are 1000 grams in a kilogram. A penny has a mass of between two and three grams.

How can you compare the masses of two objects? One way is to use a pan balance, as shown below. If two objects balance each other on a pan balance, then they contain the same amount of matter. If a basketball balances a metal block, for example, then the basketball and the block have the same mass. Beam balances work in a similar way, but instead of comparing the masses of two objects, you compare the mass of an object with a standard mass on the beam.

A bowling ball and a basketball are about the same size, but a bowling ball has more mass.

Volume is a measure of the space matter occupies.

Matter takes up space. A bricklayer stacks bricks on top of each other to build a wall. No two bricks can occupy the same place because the matter in each brick takes up space.

The amount of space that matter in an object occupies is called the object's **volume.** The bowling ball and the basketball shown on page 10 take up approximately the same amount of space. Therefore, the two balls have about the same volume. Although the basketball is hollow, it is not empty. Air fills up the space inside the basketball. Air and other gases take up space and have volume.

Determining Volume by Formula

There are different ways to find the volume of an object. For objects that have well-defined shapes, such as a brick or a ball, you can take a few measurements of the object and calculate the volume by substituting these values into a formula.

A rectangular box, for example, has a length, a width, and a height that can be measured. To find the volume of the box, multiply the three values.

$$\textbf{Volume} = \textbf{length} \cdot \textbf{width} \cdot \textbf{height}$$
$$V = lwh$$

If you measure the length, the width, and the height of the box in centimeters (cm), the volume has a unit of centimeters times centimeters times centimeters, or centimeters cubed (cm^3). If the measurements are meters, the unit of volume is meters cubed (m^3). All measurements must be in the same unit to calculate volume.

Other regular solids, such as spheres and cylinders, also have formulas for calculating volumes. All formulas for volume require multiplying three dimensions. Units for volume are often expressed in terms of a length unit cubed, that is, a length to the third power.