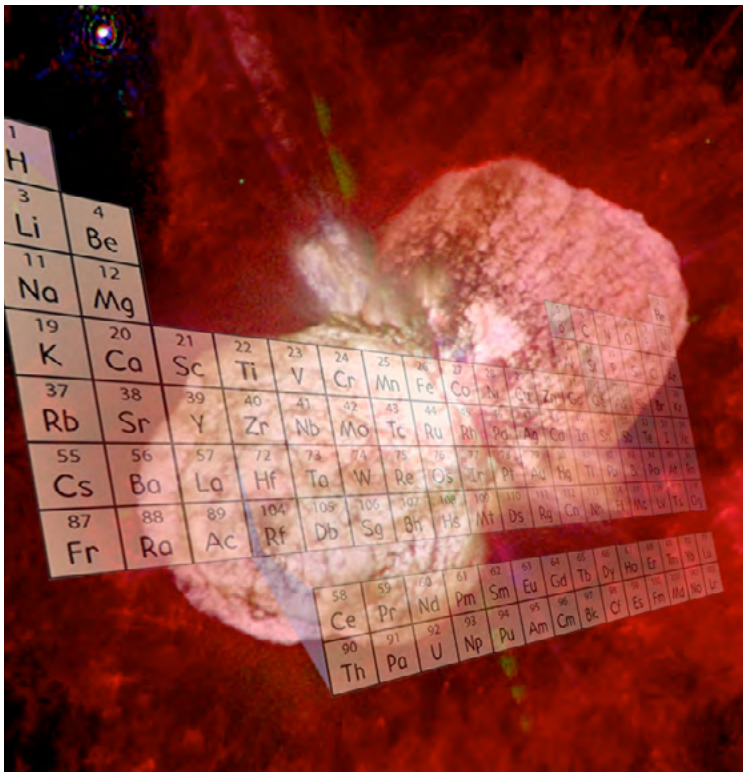

Chapter 2

Particles of Matter

THE MAIN IDEA

Matter is made of particles called atoms

2.5 Energy Moves Matter

Matter is substance, and **energy** is that which can move a substance. The concept of energy is abstract and therefore not as easy to define as the concepts of mass and volume. One definition of energy is the capacity to do work. If something has energy, it can do work on something else—it can exert a force and move that something else. Accordingly, energy is not something we observe directly. Rather, we only witness its effects.

An object may store energy by virtue of its position. This stored energy is called potential energy because it has the "potential" for doing work. As shown in **Figure 2.16**, a boulder perched on the edge of a cliff has potential energy due to the force of gravity, just as the poised arrow has potential energy due to the tension of the bow. The **potential energy** of an object increases as the distance over which the force is able to act increases. The higher a boulder is positioned above level ground, the more potential energy it has to do work as it falls downward under the pull of gravity. Similarly, an arrow in a fully drawn bow has more potential energy than does one in a half-drawn bow.

READING CHECK

How did Aristotle classify motion?

(a)

(b)

Figure 2.16 >

(a) An elevated boulder's potential energy becomes apparent when the boulder is perched in a position where it might easily fall downhill. When it does fall, this potential energy is converted to kinetic energy. (b) Much of the potential energy in Tenny's drawn bow will be converted to the kinetic energy of the arrow upon its release.

Figure 2.17 >

A firecracker is a mixture of solids that possess chemical potential energy. When a firecracker explodes, the solids react to form gases that fly outward and so possess a great deal of kinetic energy. Light and heat (both of which are forms of energy) are also formed.

Kinetic energy is the energy of motion. Both a falling boulder and a flying arrow have kinetic energy. The faster a body moves, the more kinetic energy it has and therefore the more work it can do. For example, the faster an arrow flies, the more work it can do to a target, as evidenced by its deeper penetration.

Substances possess what is known as *chemical potential energy*, which is the energy that is stored within atoms and molecules. For example, any material that can burn has chemical potential energy. The firecracker in **Figure 2.17** , for instance, has chemical potential energy. This energy gets released when the firecracker is ignited. During the explosion, some of the chemical potential energy is transformed to the kinetic energy of flying particles. Much of the chemical potential energy is also transformed to light and heat. We explore the relationship between energy and chemical reactions in Chapter 9.

∧ Figure 2.18

The energy content of this candy bar, 150 Calories per serving (150,000 calories), when released through burning, is enough to heat up 150,000 grams (about 330 pounds) of water by 1 degree Celsius.

The SI unit of energy is the joule, which is roughly the amount of energy released from a candle burning for only a moment. In the United States, a common unit of energy is the calorie. One calorie is by definition the amount of energy required to raise the temperature of 1 gram of water by 1 degree Celsius. One calorie is 4.184 times larger than 1 joule. Put differently, 4.184 joules of energy is equivalent to 1 calorie (4.184 joules = 1 calorie). So, a joule is about one-fourth of a calorie.

In the United States, the energy content of food is measured by the Calorie (note the capital C). One Calorie equals 1 kilocalorie, which is 1000 calories (note the small c). The candy bar in **Figure 2.18** offers 150 Calories (150 kilocalories), providing a total of 150,000 calories to the consumer in one serving. How many joules is this? Multiply by the appropriate conversion factor, which would be 4.184 joules/1 calorie.

CONCEPT **CHECK**

How does a flying arrow have potential energy as well as kinetic energy?

CHECK YOUR ANSWER It has gravitational potential energy as long as it remains above the ground.