5.6 Types of Energy

Learning objectives

By the end of this section, you will be able to:

- *Understand that there are different types of energy and be able to give examples of types of energy*
- *Explain the difference between kinetic and potential energy*
- *Describe endergonic and exergonic reactions*
- *Be able to define and explain all bolded terms*

Energy exists in different forms. You may be familiar with some types of energy, such as light and heat; however, there are other types of energy that are much less tangible. An object held above the ground has energy, as does a ball moving through the air. To understand how energy flows through biological systems, it's important to look more closely at the different types of energy that exist in the world.

Kinetic and Potential Energy

When an object is in motion, there is energy associated with that object. Think of a wrecking ball. Even a slow-moving wrecking ball can do a great deal of damage to other objects. The energy associated with objects in motion is called **kinetic energy**. A speeding bullet, a person walking, and flowing water all have kinetic energy (Figure 5.26).

Figure 5.26 Still water has potential energy; moving water, such as in a waterfall or a rapidly flowing river, has kinetic energy. (credit "dam": modification of work by "Pascal"/Flickr; credit "waterfall": modification of work by Frank Gualtieri / [Concepts of Biology OpenStax](#))

What if that same motionless wrecking ball is lifted two stories above the ground with a crane? If the suspended wrecking ball is unmoving, is there energy associated with it? The answer is yes. The energy that was required to lift the wrecking ball did not disappear but is now stored in the wrecking ball because of its position and the force of gravity acting on it. This type of energy is called **potential energy**. If the ball were to fall, the potential energy would be transformed into kinetic energy until the ball rested on the ground. Wrecking balls swing like a pendulum. As a pendulum swings, there is a constant change of potential energy to kinetic energy (Figure 5.27). Potential energy is highest when the pendulum is at the top of the swing. As the pendulum swings, potential energy is converted into kinetic energy. Other examples of potential energy include the energy of water held behind a dam (Figure 5.26) or a person about to skydive out of an airplane.

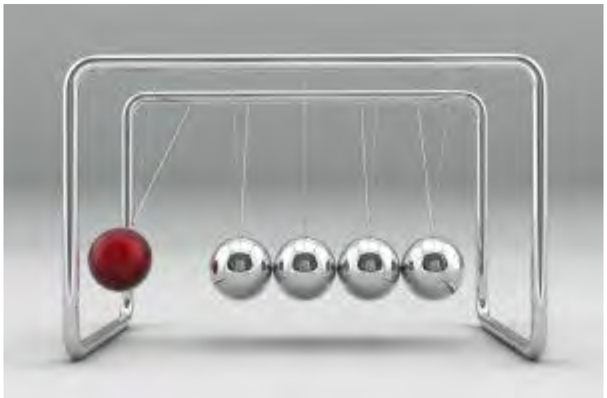

Figure 5.27 This image shows a pendulum with one spherical ball at the top of its swing. (credit: Chris Potter ccPixs.com / Flickr)

Potential energy is not only associated with the location of matter, but also with the structure of matter. A spring on the ground, if it is compressed, or a rubber band that is pulled taut both have potential energy. On a molecular level, chemical bonds that hold a molecule together also have potential energy. Remember that anabolic reactions require energy to form complex molecules. A catabolic reaction releases energy when complex molecules are broken down. The release of energy by the breakdown of individual chemical bonds implies that those bonds have stored potential energy.

All food molecules we eat have potential energy stored within their bonds. The potential energy is released when the bonds are broken. The type of potential energy that exists within chemical bonds is called **chemical energy**.

CONCEPTS IN ACTION- Visit the site and select "Pendulum" from the "Work and Energy" menu to see the shifting kinetic and potential energy of a pendulum in motion.

Free and Activation Energy

According to the second law of thermodynamics, all energy transfers involve the loss of some energy in an unusable form, such as heat. "Free energy" specifically refers to the energy associated with a chemical reaction that is available after the losses occur. In other words, **free energy** is usable energy or energy that is available to do work.

If energy is released during a chemical reaction, it means that the products of the reaction have less free energy than the reactants. This is because the reactants released some free energy during the reaction. Chemical reactions that release free energy are called **exergonic reactions** (Figure 5.28). Think: *ex*ergonic means energy is *ex*iting the system.

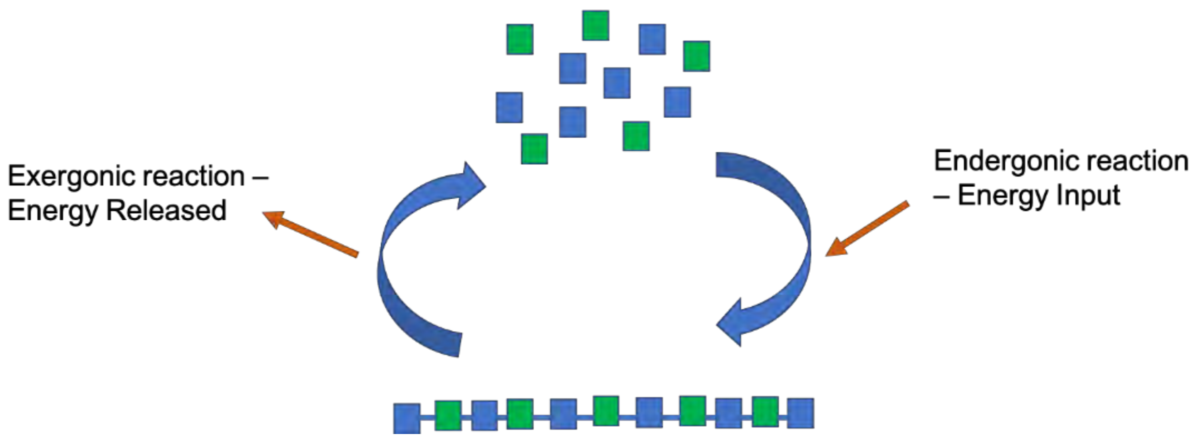

Figure 5.28 This figure shows the energy input of an endergonic reaction and the energy output of an exergonic reaction. (credit: Elizabeth O'Grady)

If a chemical reaction absorbs (requires) energy rather than releases energy, the products have more free energy than the reactants. Thus, the products of these reactions can be thought of as energy-storing molecules. These chemical reactions are called **endergonic** reactions (Figure 5.28). An endergonic reaction will not take place on its own without the addition or input of free energy.