5.10 Cells transform energy as they perform work

- Cells are small units, a chemical factory, housing thousands of chemical reactions
  - The result of reactions is maintenance of the cell, manufacture of cellular parts, and replication

5.10 Cells transform energy as they perform work

- **Energy** is the capacity to do work and cause change
  - Work is accomplished when an object is moved against an opposing force, such as friction
  - There are two kinds of energy
    - **Kinetic energy** is the energy of motion
    - **Potential energy** is energy that an object possesses as a result of its location
5.10 Cells transform energy as they perform work

- Kinetic energy performs work by transferring motion to other matter
  - For example, water moving through a turbine generates electricity
  - Heat, or thermal energy, is kinetic energy associated with the random movement of atoms

5.10 Cells transform energy as they perform work

- An example of potential energy is water behind a dam
  - Chemical energy is potential energy because of its energy available for release in a chemical reaction

5.11 Two laws govern energy transformations

- It is important to understand two laws that govern energy transformations in organisms
  - The first law of thermodynamics—energy in the universe is constant
  - The second law of thermodynamics—energy conversions increase the disorder of the universe
    - Entropy is the measure of disorder, or randomness
5.12 Chemical reactions either release or store energy

- An exergonic reaction is a chemical reaction that releases energy
  - This reaction releases the energy in covalent bonds of the reactants
  - Burning wood releases the energy in glucose, producing heat, light, carbon dioxide, and water
  - Cellular respiration also releases energy and heat and produces products but is able to use the released energy to perform work

- An endergonic reaction requires an input of energy and yields products rich in potential energy
  - The reactants contain little energy in the beginning, but energy is absorbed from the surroundings and stored in covalent bonds of the products
  - Photosynthesis makes energy-rich sugar molecules using energy in sunlight
5.12 Chemical reactions either release or store energy

- A living organism produces thousands of endergonic and exergonic chemical reactions
  - All of these combined is called **metabolism**
  - A **metabolic pathway** is a series of chemical reactions that either break down a complex molecule or build up a complex molecule

- A cell does three main types of cellular work
  - Chemical work—driving endergonic reactions
  - Transport work—pumping substances across membranes
  - Mechanical work—beating of cilia

- To accomplish work, a cell must manage its energy resources, and it does so by **energy coupling**—the use of exergonic processes to drive an endergonic one

5.13 ATP shuttles chemical energy and drives cellular work

- ATP, adenosine triphosphate, is the energy currency of cells.
  - ATP is the immediate source of energy that powers most forms of cellular work.
  - It is composed of adenine (a nitrogenous base), ribose (a five-carbon sugar), and three phosphate groups.

- Hydrolysis of ATP releases energy by transferring its third phosphate from ATP to some other molecule
  - The transfer is called phosphorylation
  - In the process, ATP energizes molecules
5.13 ATP shuttles chemical energy and drives cellular work

- ATP is a renewable source of energy for the cell
  - When energy is released in an exergonic reaction, such as breakdown of glucose, the energy is used in an endergonic reaction to generate ATP
5.14 Enzymes speed up the cell’s chemical reactions by lowering energy barriers

- Although there is a lot of potential energy in biological molecules, such as carbohydrates and others, it is not released spontaneously
  - Energy must be available to break bonds and form new ones
  - This energy is called **energy of activation** \( (E_A) \)

- The cell uses catalysis to drive (speed up) biological reactions
  - Catalysis is accomplished by **enzymes**, which are proteins that function as biological catalysts
  - Enzymes speed up the rate of the reaction by lowering the \( E_A \), and they are not used up in the process
  - Each enzyme has a particular target molecule called the **substrate**
5.15 A specific enzyme catalyzes each cellular reaction

- Enzymes have unique three-dimensional shapes
  - The shape is critical to their role as biological catalysts
  - As a result of its shape, the enzyme has an active site where the enzyme interacts with the enzyme’s substrate
  - Consequently, the substrate’s chemistry is altered to form the product of the enzyme reaction

For optimum activity, enzymes require certain environmental conditions
- Temperature is very important, and optimally, human enzymes function best at 37ºC, or body temperature
  - High temperature will denature human enzymes
- Enzymes also require a pH around neutrality for best results

Some enzymes require nonprotein helpers
- Cofactors are inorganic, such as zinc, iron, or copper
- Coenzymes are organic molecules and are often vitamins
5.16 Enzyme inhibitors block enzyme action and can regulate enzyme activity in a cell

- Inhibitors are chemicals that inhibit an enzyme’s activity
  - One group inhibits because they compete for the enzyme’s active site and thus block substrates from entering the active site
  - These are called competitive inhibitors

- Other inhibitors do not act directly with the active site
  - These bind somewhere else and change the shape of the enzyme so that the substrate will no longer fit the active site
  - These are called noncompetitive inhibitors

Enzyme inhibitors are important in regulating cell metabolism

- Often the product of a metabolic pathway can serve as an inhibitor of one enzyme in the pathway, a mechanism called feedback inhibition
  - The more product formed, the greater the inhibition, and in this way, regulation of the pathway is accomplished