Essential Knowledge

Energy

- **ENE-1.H.1** All living systems require constant input of energy.
- **ENE-1.H.2** Life requires a highly ordered system and does not violate the second law of thermodynamics—
  1. Energy input must exceed energy loss to maintain order and to power cellular processes.
  2. Cellular processes that release energy may be coupled with cellular processes that require energy.
  3. Loss of order or energy flow results in death.
- **ENE-1.H.3** Energy-related pathways in biological systems are sequential to allow for a more controlled and efficient transfer of energy. A product of a reaction in a metabolic pathway is generally the reactant for the subsequent step in the pathway.

Photosynthesis

- **ENE-1.I.1** Organisms capture and store energy for use in biological processes—
  1. Photosynthesis captures energy from the sun and produces sugars.
     a. Photosynthesis first evolved in prokaryotic organisms.
     b. Scientific evidence supports the claim that prokaryotic (cyanobacterial) photosynthesis was responsible for the production of an oxygenated atmosphere.
     c. Prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.
- **ENE-1.I.2** The light-dependent reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways that capture energy present in light to yield ATP and NADPH, which power the production of organic molecules.
- **ENE-1.J.1** During photosynthesis, chlorophylls absorb energy from light, boosting electrons to a higher energy level in photosystems I and II.
- **ENE-1.J.2** Photosystems I and II are embedded in the internal membranes of chloroplasts and are connected by the transfer of higher energy electrons through an electron transport chain (ETC).
- **ENE-1.J.3** When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) is established across the internal membrane.
- **ENE-1.J.4** The formation of the proton gradient is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase.
- **ENE-1.J.5** The energy captured in the light reactions and transferred to ATP and NADPH powers the production of carbohydrates from carbon dioxide in the Calvin cycle, which occurs in the stroma of the chloroplast.
- **ENE-1.K.1** Fermentation and cellular respiration use energy from biological macromolecules to produce ATP. Respiration and fermentation are characteristic of all forms of life.

Cellular Respiration

- **ENE-1.K.2** Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that capture energy from biological macromolecules.
- **ENE-1.K.3** The electron transport chain transfers energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes—
  1. Electron transport chain reactions occur in chloroplasts, mitochondria, and prokaryotic plasma membranes.
  2. In cellular respiration, electrons delivered by NADH and FADH2 are passed to a series of