7. The difference between anabolic and catabolic pathways is the change in free energy as a result of the reaction. An anabolic pathway is a process in which complex molecules are built from simpler ones, requiring free energy. A catabolic pathway is a process in which large complex molecules are broken down into simpler ones, releasing free energy.

8. (a) When organic food waste decomposes, this is a spontaneous reaction. It is a catabolic process and results in an increase in entropy. It would occur when bacteria or fungi release digestive enzymes onto the food waste that break large molecules into smaller molecules, releasing energy for the bacteria or fungi to use.

(b) When a bacterial cell propels itself using a flagellum, this is non-spontaneous. The bacterial cell requires a source of free energy to move its flagellum. The bacteria would obtain this free energy by coupling the reactions needed to move the flagellum to exergonic chemical reactions.

(c) When a honey bee converts sucrose into glucose and fructose, this is a spontaneous reaction because it is a catabolic/exergonic reaction in which entropy increases. Bees might do this by converting sucrose they obtained from plants into honey.

(d) When an electric eel creates an electric field, this would be a non-spontaneous process since the eel would need a source of free energy. The eel would convert chemical potential energy in its food to electrical energy generated by specialized cells in its body.

9. (a) The first law of thermodynamics: energy transforms from one form to another or transfers from one object to another, but it is neither created nor destroyed. The second law of thermodynamics: in every transfer and conversion of energy, there is less energy available to do work; the total entropy of a system and its surroundings always increases.

(b) Answers may vary. Sample answer: When living things grow they become more orderly not less orderly, so it appears as if their actions reduce entropy. However, while their bodies may become more ordered, they release waste particles and waste thermal energy that results in an overall increase in entropy.

10. (a) This can be spontaneous. Answers may vary. Sample answer: An example of a spontaneous exothermic process that increases entropy in a setting with a low temperature would be the combustion of wood in the winter.

(b) Exothermic process that decreases entropy in a setting with a high temperature are not generally spontaneous.

(c) This can be spontaneous. Answers may vary. Sample answer: An example of an endothermic reaction that results in an increase in entropy in a setting with a high temperature is evaporating water on a hot day. The water releases the trapped thermal energy as a result of a phase change, which decreases the entropy of the system.

(d) There are no endothermic processes that decrease entropy at low temperatures. These reactions are nonspontaneous.

Section 3.2: ATP: Energy Currency of the Cell

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1. (a) Answers may vary. Sample answer: An example of chemical work using ATP is supplying energy for non-spontaneous, endergonic reactions, including protein synthesis and DNA replication.

(b) Answers may vary. Sample answer: An example of mechanical work using ATP energy is the beating of cilia or movement of flagella, contraction of muscle fibres, or movement of chromosomes during mitosis/meiosis.

(c) Answers may vary. Sample answer: An example of transport work using ATP energy is pumping substances such as Na^+ or K^+ ions across membranes against their concentration gradient.

2. The universality of ATP as an energy source for every type of cell in every living organism supports an argument that all species have evolved from one original organism.
3. (a) ATP can be described as a phosphorylated sugar. It has a triphosphate group attached to a ribose sugar molecule, which is attached to a molecule of adenosine.
(b) The structure of an ATP molecule allows it to contain large amounts of free energy. The unique feature that allows ATP to do this is its triphosphate tail. The triphosphate tail is the location of several high energy bonds that can be recycled using the cellular machinery.
4. ATP hydrolysis is the process by which ADP and P_i are formed and water is consumed. The process releases free energy.
5. During the hydrolysis of ATP the ADP is retained and recycled. This is in contrast to the oxidation of glucose, in which the entire molecule is catabolized. When a cell uses glucose during cellular respiration the entire molecule is oxidized and converted into water and carbon dioxide.
7. The first group (glutamic acid, NH_3 and ATP) has more free energy than the second group (glutamine, ADP, and $P_{i)}$. This because group 2 is only formed when group 1 is catabolized, therefore group 2 must have less overall free energy. This can be confirmed as follows: When the molecules in group 1 react, producing the molecules in group 2, the process is exergonic.
8. There is very little ATP in the diet and it is a relatively large and energy-rich molecule. It would be extremely wasteful and inefficient to use an "entire ATP" and discard it just to obtain the energy released by a single hydrolysis reaction.
10. The phosphorylation reaction is the addition of an inorganic phosphate group to a molecule resulting in the formation of a high-energy bond.
11. (a) Reactions ii and iii are spontaneous.
(b) Combinations of i & iii, ii & iv, and iii & iv would be spontaneous.