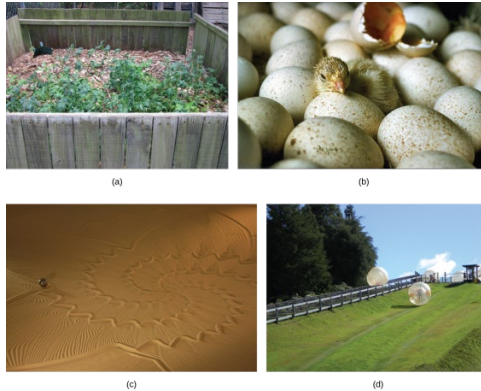


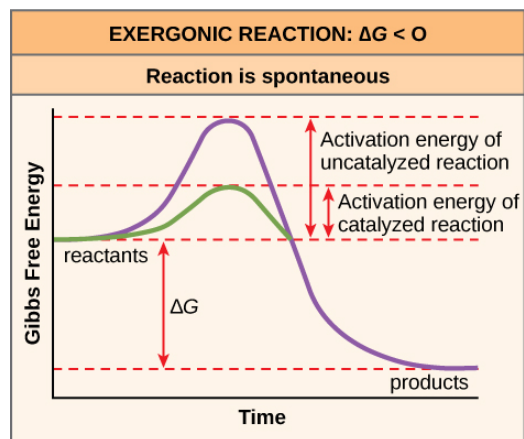
**Biology 2e**Unit 2: **The Cell**Chapter 6: **Metabolism****Visual Connection Questions**

1. Look at each of the processes, and decide if it is endergonic or exergonic. In each case, does enthalpy increase or decrease, and does entropy increase or decrease?



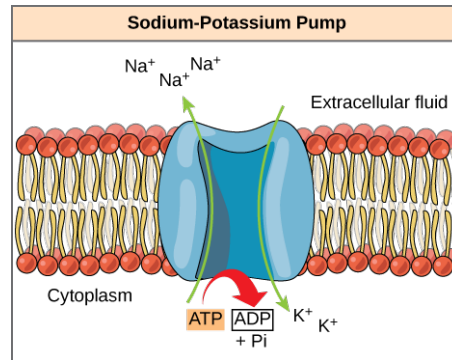
A compost pile decomposing is an exergonic process; enthalpy decreases (energy is released) and entropy increases (large molecules are broken down into smaller ones). A baby developing from a fertilized egg is an endergonic process; enthalpy increases (energy is absorbed) and entropy decreases. Sand art being destroyed is an exergonic process; there is no change in enthalpy, but entropy increases. A ball rolling downhill is an exergonic process; enthalpy decreases (energy is released), but there is no change in entropy.

2. If no activation energy were required to break down sucrose (table sugar), would you be able to store it in a sugar bowl?



No. We can store chemical energy because of the need to overcome the barrier to its breakdown.

3. One ATP molecule's hydrolysis releases 7.3 kcal/mol of energy ( $\Delta G = -7.3$  kcal/mol of energy). If it takes 2.1 kcal/mol of energy to move one  $\text{Na}^+$  across the membrane ( $\Delta G = +2.1$  kcal/mol of energy), how many sodium ions could one ATP molecule's hydrolysis move?



Three sodium ions could be moved by the hydrolysis of one ATP molecule. The  $\Delta G$  of the coupled reaction must be negative. Movement of three sodium ions across the membrane will take 6.3 kcal of energy ( $2.1 \text{ kcal} \times 3 \text{ Na}^+ \text{ ions} = 6.3 \text{ kcal}$ ). Hydrolysis of ATP provides 7.3 kcal of energy, more than enough to power this reaction. Movement of four sodium ions across the membrane, however, would require 8.4 kcal of energy, more than one ATP molecule can provide.

### Review Questions

4. Energy is stored long-term in the bonds of \_\_\_\_\_ and used short-term to perform work from a(n) \_\_\_\_\_ molecule.

c. glucose : ATP

5. DNA replication involves unwinding two strands of parent DNA, copying each strand to synthesize complementary strands, and releasing the parent and daughter DNA. Which of the following accurately describes this process?

a. This is an anabolic process

6. Consider a pendulum swinging. Which type(s) of energy is/are associated with the pendulum in the following instances: i. the moment at which it completes one cycle, just before it begins to fall back towards the other end, ii. the moment that it is in the middle between the two ends, and iii. just before it reaches the end of one cycle (just before instant i.).

c. i. potential, ii. kinetic, iii. potential and kinetic

7. Which of the following comparisons or contrasts between endergonic and exergonic reactions is false?

d. Endergonic reactions take place slowly and exergonic reactions take place quickly

**8.** Which of the following is the best way to judge the relative activation energies between two given chemical reactions?

b. Compare their reaction rates

**9.** Which of the following is not an example of an energy transformation?

a. Turning on a light switch

**10.** In each of the three systems, determine the state of entropy (low or high) when comparing the first and second: i. the instant that a perfume bottle is sprayed compared with 30 seconds later, ii. an old 1950s car compared with a brand new car, and iii. a living cell compared with a dead cell.

a. i. low, ii. high, iii. low

**11.** The energy released by the hydrolysis of ATP is \_\_\_\_.

d. providing energy to coupled reactions

**12.** Which of the following molecules is likely to have the most potential energy?

a. sucrose

**13.** Which of the following is not true about enzymes:

a. They increase  $\Delta G$  of reactions

**14.** An allosteric inhibitor does which of the following?

c. Binds to an enzyme away from the active site and changes the conformation of the active site, decreasing its affinity for the substrate

**15.** Which of the following analogies best describe the induced-fit model of enzyme-substrate binding?

a. a key fitting into a lock

### Critical Thinking Questions

**16.** Does physical exercise involve anabolic and/ or catabolic processes? Give evidence for your answer.

Physical exercise involves both anabolic and catabolic processes. Body cells break down sugars to provide ATP to do the work necessary for exercise, such as muscle contractions. This is catabolism. Muscle cells also must repair muscle tissue damaged by exercise by building new muscle. This is anabolism.

**17.** Name two different cellular functions that require energy that parallel human energy-requiring functions.

Energy is required for cellular motion, through beating of cilia or flagella, as well as human motion, produced by muscle contraction. Cells also need energy to perform digestion, as humans require energy to digest food.

**18.** Explain in your own words the difference between a spontaneous reaction and one that occurs instantaneously, and what causes this difference.

A spontaneous reaction is one that has a negative  $\Delta G$  and thus releases energy. However, a spontaneous reaction need not occur quickly or suddenly like an instantaneous reaction. It may occur over long periods due to a large energy of activation, which prevents the reaction from occurring quickly.

**19.** Describe the position of the transition state on a vertical energy scale, from low to high, relative to the position of the reactants and products, for both endergonic and exergonic reactions.

The transition state is always higher in energy than the reactants and the products of a reaction (therefore, above), regardless of whether the reaction is endergonic or exergonic.

**20.** Imagine an elaborate ant farm with tunnels and passageways through the sand where ants live in a large community. Now imagine that an earthquake shook the ground and demolished the ant farm. In which of these two scenarios, before or after the earthquake, was the ant farm system in a state of higher or lower entropy?

The ant farm had lower entropy before the earthquake because it was a highly ordered system. After the earthquake, the system became much more disordered and had higher entropy.

**21.** Energy transfers take place constantly in everyday activities. Think of two scenarios: cooking on a stove and driving. Explain how the second law of thermodynamics applies to these two scenarios.

While cooking, food is heating up on the stove, but not all of the heat goes to cooking the food, some of it is lost as heat energy to the surrounding air, increasing entropy. While driving, cars burn gasoline to run the engine and move the car. This reaction is not completely efficient, as some energy during this process is lost as heat energy, which is why the hood and the components underneath it heat up while the engine is turned on. The tires also heat up because of friction with the pavement, which is additional energy loss. This energy transfer, like all others, also increases entropy.

**22.** Do you think that the  $E_A$  for ATP hydrolysis is relatively low or high? Explain your reasoning.

The activation energy for hydrolysis is very low. Not only is ATP hydrolysis an exergonic process with a large  $-\Delta G$ , but ATP is also a very unstable molecule that rapidly breaks down into ADP + Pi if not utilized quickly. This suggests a very low EA since it hydrolyzes so quickly.

**23.** With regard to enzymes, why are vitamins necessary for good health? Give examples.

Most vitamins and minerals act as coenzymes and cofactors for enzyme action. Many enzymes require the binding of certain cofactors or coenzymes to be able to catalyze their reactions. Since enzymes catalyze many important reactions, it is critical to obtain sufficient vitamins and minerals from the diet and from supplements. Vitamin C (ascorbic acid) is a coenzyme necessary for the action of enzymes that build collagen, an important protein component of connective tissue throughout the body. Magnesium ion ( $Mg^{++}$ ) is an important cofactor that is necessary for the enzyme pyruvate dehydrogenase to catalyze part of the pathway that breaks

down sugar to produce energy. Vitamins cannot be produced in the human body and therefore must be obtained in the diet.

**24.** Explain in your own words how enzyme feedback inhibition benefits a cell.

Feedback inhibition allows cells to control the amounts of metabolic products produced. If there is too much of a particular product relative to what the cell's needs, feedback inhibition effectively causes the cell to decrease production of that particular product. In general, this reduces the production of superfluous products and conserves energy, maximizing energy efficiency.