CHAPTER 6—PHOTOSYNTHESIS

MULTIPLE CHOICE

1. Energy is required for a variety of life processes including
   a. growth and reproduction.
   b. movement.
   c. transport of certain materials across cell membranes.
   d. All of the above

   ANS: D DIF: 1 OBJ: 6-1.1

2. Heterotrophs are organisms that can
   a. produce food from inorganic molecules and sunlight.
   b. survive without energy.
   c. consume other organisms for energy.
   d. carry out either photosynthesis or chemosynthesis.

   ANS: C DIF: 1 OBJ: 6-1.1

3. Based on the cycle of photosynthesis and cellular respiration, one can say that the ultimate original source of energy for all living things on Earth is
   a. glucose.
   b. water.
   c. the sun.
   d. carbon dioxide.

   ANS: C DIF: 1 OBJ: 6-1.1

4. The process whereby plants capture energy and make complex molecules is known as
   a. homeostasis.
   b. evolution.
   c. photosynthesis.
   d. development.

   ANS: C DIF: 1 OBJ: 6-1.1

5. Suspended in the fluid stroma of chloroplasts are
   a. organelles called eukaryotes.
   b. numerous mitochondrial membranes.
   c. small coins that provide energy.
   d. stacks of thylakoids called grana.

   ANS: D DIF: 2 OBJ: 6-1.3

6. photosynthesis : oxygen ::
   a. respiration : darkness
   b. light reactions : dark reactions
   c. respiration : carbon dioxide
   d. oxygen : carbon dioxide

   ANS: C DIF: 2 OBJ: 6-1.1

7. biochemical pathway : reaction ::
   a. barrier : wall
   b. match : burn
   c. theater : drama
   d. assembly line : workers

   ANS: D DIF: 2 OBJ: 6-1.1

8. light reactions : thylakoids ::
   a. grana : thylakoids
   b. grana : ATP
   c. Calvin cycle : stroma
   d. stroma : grana of chloroplast

   ANS: C DIF: 2 OBJ: 6-2.4

9. The sun is considered the ultimate source of energy for life on Earth because
   a. all organisms carry out photosynthesis.
   b. all organisms carry out cellular respiration.
   c. either photosynthetic organisms or organisms that have eaten them provide energy for all other organisms on Earth.
   d. the sun heats Earth's atmosphere.

   ANS: C DIF: 1 OBJ: 6-1.1

10. The energy from the sun is converted into chemical energy in the form of organic compounds in a series of linked chemical reactions called a
   a. photosynthetic reactant.
   b. ATP generator.
   c. chemical equation.
   d. biochemical pathway.

   ANS: D DIF: 1 OBJ: 6-2.4

11. The role of chlorophyll in photosynthesis is to
   a. absorb light energy.
   b. pass electrons to carotenoids.
   c. split water molecules.
   d. All of the above

   ANS: A DIF: 1 OBJ: 6-1.2

12. When light strikes an object, the light may be
   a. reflected.
   b. absorbed.
   c. transmitted.
   d. All of the above

   ANS: D DIF: 1 OBJ: 6-1.2

13. Chlorophyll is green because
    a. it absorbs green wavelengths of light.
    b. it absorbs blue and yellow wavelengths, which make green.
    c. it reflects green wavelengths of light.
    d. it transmits light and causes an optical illusion.

    ANS: C DIF: 1 OBJ: 6-1.2

14. What happens when a chlorophyll molecule absorbs light?
    a. Some of its electrons are raised to a higher energy level.
    b. It disintegrates, giving off huge amounts of heat.
    c. It glows, radiating green light and giving the plant a green appearance.
    d. It attracts electrons from other molecules.

    ANS: A DIF: 1 OBJ: 6-1.3

15. chloroplast : grana ::
    a. photosystem : pigment molecules
    b. chlorophyll : pigments
    c. thylakoids : photosynthesis
    d. chlorophyll : green

    ANS: A DIF: 2 OBJ: 6-1.3

16. When electrons of a chlorophyll molecule are raised to a higher energy level,
    a. they become a particle of light.
    b. they form a glucose bond.
    c. they enter an electron transport chain.
    d. they enter the Calvin cycle.

    ANS: C DIF: 1 OBJ: 6-1.3

17. $NADP^+$ is important in photosynthesis because it
    a. becomes oxidized to form NADP.
    b. is needed to form chlorophyll.
    c. provides additional oxygen atoms.
    d. provides protons and electrons for some reactions.

    ANS: D DIF: 2 OBJ: 6-1.3

18. The electrons of photosystem I
    a. are eventually replaced by electrons from photosystem II.
    b. attach to water molecules during the light reaction.
    c. are at the end of the electron transport chain.
    d. are absorbed by oxygen molecules to form water.

    ANS: A DIF: 1 OBJ: 6-1.3

19. The source of oxygen produced during photosynthesis is
    a. carbon dioxide.
    b. water.
    c. chlorophyll.
    d. glucose.

    ANS: B DIF: 1 OBJ: 6-1.3

20. The major atmospheric byproduct of photosynthesis is
    a. nitrogen.
    b. carbon dioxide.
    c. water.
    d. oxygen.

    ANS: D DIF: 1 OBJ: 6-1.3

21. During the Calvin cycle, carbon-containing molecules are produced from
    a. carbon atoms from ATP.
    b. carbon atoms, hydrogen atoms, and oxygen atoms from glucose.
    c. carbon atoms from carbon dioxide in the air and hydrogen atoms from water.
    d. carbon atoms from carbon dioxide in the air and hydrogen atoms from NADPH.

    ANS: D DIF: 1 OBJ: 6-2.1

22. Which of the following processes occurs in the thylakoid membrane and converts captured light energy into chemical energy?
    a. the Calvin cycle
    b. ATP synthase
    c. light absorption
    d. chemiosmosis

    ANS: D DIF: 2 OBJ: 6-1.4

23. Chemiosmosis in the thylakoid membrane is directly responsible for
    a. adding protons to $NADP^+$.
    b. providing the energy to produce ATP molecules.
    c. producing ATP-synthetase.
    d. generating glucose molecules.

    ANS: B DIF: 2 OBJ: 6-1.4

24. At the thylakoid membrane,
    a. electrons return to their original energy levels.
    b. electrons are pushed out of the thylakoid.
    c. energy from electrons is used to make glucose.
    d. the thylakoid bursts, releasing energy.

    ANS: A DIF: 1 OBJ: 6-1.4

25. Products of the light reactions of photosynthesis that provide energy for the Calvin cycle are
    a. oxygen and ATP.
    b. water and oxygen.
    c. ATP and NADPH.
    d. oxygen and NADPH.

    ANS: C DIF: 1 OBJ: 6-2.4

26. The Calvin cycle of photosynthesis
    a. requires ATP and NADPH.
    b. can occur in both light and dark conditions.
    c. generates glucose.
    d. All of the above

    ANS: D DIF: 1 OBJ: 6-2.1

27. The energy used in the Calvin cycle for the production of carbohydrate molecules comes from
    a. ATP made during cellular respiration.
    b. the Krebs cycle.
    c. ATP made in the light reactions of photosynthesis.
    d. CO_2 absorbed during the last stage of photosynthesis.

    ANS: C DIF: 1 OBJ: 6-2.4

28. During photosynthesis, the series of reactions that create the complex carbohydrates needed for energy and growth is called
    a. the Calvin cycle.
    b. the Krebs cycle.
    c. the light reactions.
    d. the electron transport chain.

    ANS: A DIF: 1 OBJ: 6-2.2

29. All organic molecules contain carbon atoms that ultimately can be traced back in the food chain to
    a. the bodies of heterotrophs.
    b. carbon dioxide from the atmosphere.
    c. water absorbed by plants.
    d. the carbon that comes from the sun.

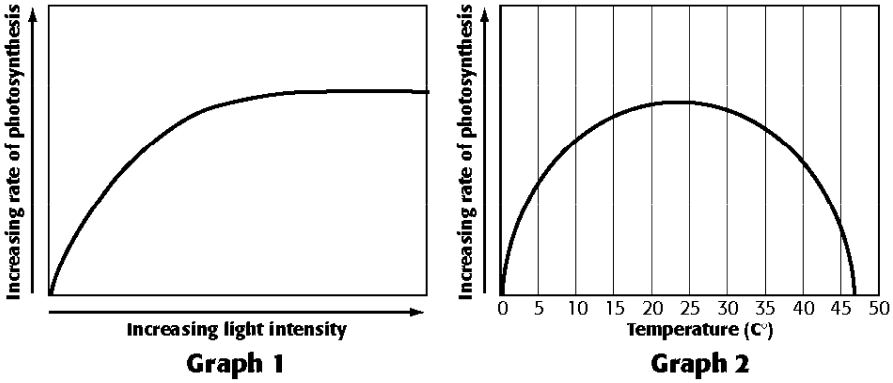
    ANS: B DIF: 1 OBJ: 6-2.2

30. Which of the following can be produced from the products of the Calvin cycle?
    a. carbohydrates
    b. lipids
    c. proteins
    d. All of the above

    ANS: D DIF: 1 OBJ: 6-2.2

31. C_3, C_4, and CAM plants differ from each other in that
    a. C_3 plants use the Calvin cycle for carbon fixation and C_4 and CAM plants use different pathways for carbon fixation.
    b. C_3 plants have their stomata open during the day and C_4 and CAM plants have their stomata open only at night.
    c. C_3 and C_4 plants have their stomata open during the day and CAM plants have their stomata open only at night.
    d. C_3 plants use CO_2 to form organic compounds and C_4 and CAM plants use other sources of carbon.

    ANS: C DIF: 2 OBJ: 6-2.3



32. Refer to the illustration above. Graph 1 demonstrates that the rate of photosynthesis
    a. decreases in response to increasing light intensity.
    b. increases indefinitely in response to increasing light intensity.
    c. increases in response to increasing light intensity, but only to a certain point.
    d. is unaffected by changes in light intensity.

    ANS: C DIF: 2 OBJ: 6-2.5

33. Refer to the illustration above. Taken together, these graphs demonstrate that
    a. photosynthesis is independent of environmental influences.
    b. increases in light intensity cause increases in temperature.
    c. as the rate of photosynthesis increases, the temperature of the plant eventually decreases.
    d. the rate of photosynthesis is affected by changes in the plant's environment.

    ANS: D DIF: 1 OBJ: 6-2.5

COMPLETION

1. Stacks of thylakoids, called _____, are suspended in the stroma of chloroplasts.

   ANS: grana

   DIF: 1 OBJ: 6-1.1

2. A photosynthetic pigment that absorbs primarily red and blue wavelengths of light and appears green is called _____, while pigments that absorb other wavelengths and appear yellow and orange are called _____.

   ANS: chlorophyll, carotenoids

   DIF: 2 OBJ: 6-1.2

3. Organisms that harvest energy from either sunlight or chemicals in order to make food molecules are called _____.

   ANS: autotrophs

   DIF: 1 OBJ: 6-1.1

4. The main pigment associated with the two photosystems is _____.

   ANS: chlorophyll

   DIF: 1 OBJ: 6-1.2

5. The abundance of oxygen in Earth's atmosphere is a result of millions of years of _____.

   ANS: photosynthesis

   DIF: 1 OBJ: 6-1.1

6. Chemiosmosis in the thylakoid membrane results in the synthesis of _____.

   ANS: ATP

   DIF: 1 OBJ: 6-1.4

7. The second stage of photosynthesis, in which glucose is manufactured, is called the _____.

   ANS: Calvin cycle

   DIF: 1 OBJ: 6-2.1

8. _____ plants have an enzyme that can fix CO_2 into four-carbon compounds.

   ANS: C_4

   DIF: 1 OBJ: 6-2.3

PROBLEM

1. Scientists have been able to induce chloroplasts to produce ATP in the dark. First, they remove intact chloroplasts from plants. Next, they soak the chloroplasts in a solution with a low pH (about 4) and keep them in the dark. After a period of time, the chloroplasts are removed from the low pH solution and placed in a higher pH solution (about 8), again in the dark. ATP is soon found to be present in the higher pH solution. Write your answers to the following in the spaces below.
   a. Evaluate the results of this experiment. Include an explanation of what apparently happened to the chloroplasts while they were in the low pH solution and how this enabled them to produce ATP when they were placed in the higher pH solution.
   b. What was simulated in this experiment that normally occurs in chloroplasts exposed to light?

   ANS:
   a. In the low pH solution, the chloroplasts apparently take up protons (hydrogen ions) from the solution. The protons move inside the thylakoid compartments of the chloroplasts and accumulate there. When the chloroplasts are placed in the higher pH solution, a pH gradient exists between the inside of the thylakoid compartments and the stroma of the chloroplasts. This drives the movement of protons from the thylakoid compartments to the stroma. As the protons move into the stroma they pass through the protein ATP synthetase. This enzyme is thereby induced to produce ATP from ADP.
   b. Chloroplasts exposed to light will have electrons passed along an electron transport chain. As they pass along this chain, they give off energy. Some of this energy is used to pump protons into the thylakoid compartments. The resulting pH gradient between the thylakoid compartments and the stroma drives the movement of protons from the thylakoid compartments to the stroma. As the protons move into the stroma they pass through the protein ATP synthetase. This enzyme is thereby induced to produce ATP from ADP.

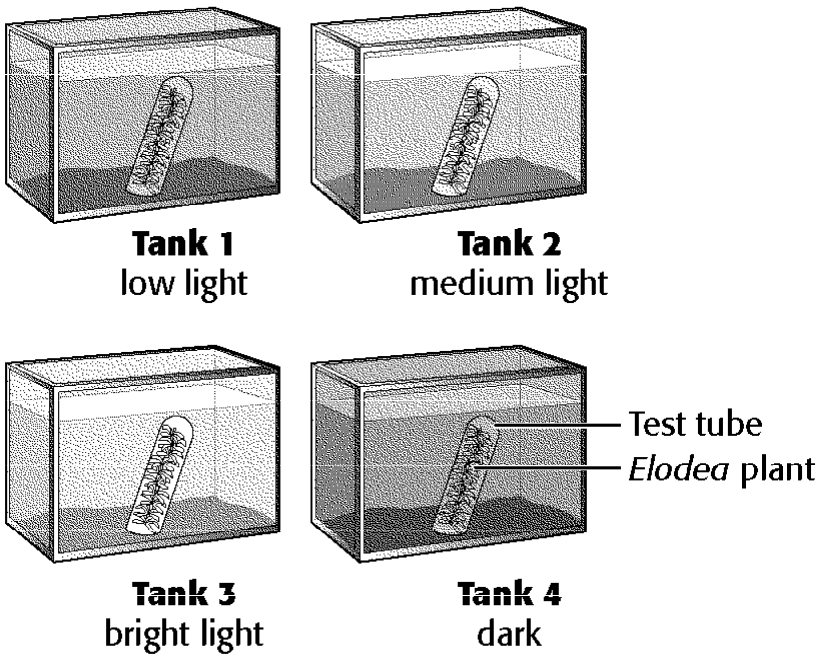
   DIF: 3 OBJ: 6-1.4

2. All of the major components of the light reactions, including the pigment molecules clustered in photosystems I and II, are located in the thylakoid membrane. What is the advantage of having these components confined to the same membrane rather than dissolved in the stroma or the cytosol?

   ANS:
   This placement makes it easier for energy and electrons to pass from one component to the next.

   DIF: 2 OBJ: 6-1.3

3.



Refer to the illustration above. Amy wants to test the hypothesis that the rate of photosynthesis is directly related to the light level to which plants are exposed. She has chosen the aquatic plant *Elodea* as her study organism. In her experimental design, she has four different tanks in which she will place *Elodea* plants. Each *Elodea* plant will be placed inside an inverted test tube. She plans to estimate the relative rate of photosynthesis by measuring the amount of oxygen produced by plants placed under different light levels. She plans to compare the amount of oxygen gas that collects in the top of each of the test tubes.

Amy plans to place tank 3 next to a window in the classroom. She plans to place tank 2 ten feet away from the window. She plans to place tank 1 twenty feet away from the window. She plans to place tank 4 in the classroom's refrigerator, because it is the only place she can find that is dark. Write your answers to the following in the spaces below.

a. What is wrong with the design of Amy's experiment?
b. What could Amy change in her experimental design to make it a better experiment?

ANS:

a. By placing tank 4 in the refrigerator, Amy would be introducing a second variable, temperature, into her experiment. A true controlled experiment tests only one variable.

b. Amy should find some location for tank 4 that is as close as possible to the same temperature as the locations where tanks 1, 2, and 3 are to be placed. It would be better to have tank 4 shielded from light and kept within the same room.

DIF: 2 OBJ: 6-2.5

ESSAY

1. Why do the cells of plant roots generally lack chloroplasts? Write your answer in the space below.

   ANS:
   Chloroplasts contain chlorophyll, the pigment that absorbs sunlight. Since most roots are underground, where light will not reach their cells, they have no need for chlorophyll or chloroplasts.

   DIF: 2 OBJ: 6-1.2

2. Define the terms *autotroph* and *heterotroph*. What types of organisms belong in each of these categories? Write your answer in the space below.

   ANS:
   Organisms that acquire energy by making their own food are called autotrophs. Plants and certain unicellular organisms are autotrophs. Organisms that gain energy by eating other organisms are called heterotrophs. Some unicellular organisms, as well as all animals and fungi, are heterotrophs.

   DIF: 2 OBJ: 6-1.1

3. Explain why the leaves of plants appear green to the human eye. Write your answer in the space below.

   ANS:
   When visible light strikes the leaves of a plant, red and blue wavelengths are absorbed by chlorophyll. Green wavelengths, however, are reflected. These reflected wavelengths enter the eyes of the observer. The observer perceives the leaves as being green.

   DIF: 2 OBJ: 6-1.2

4. Summarize how the light reactions and the Calvin cycle work together to create the continuous cycle of photosynthesis.

   ANS:
   In the light reactions, energy is absorbed from sunlight and converted into chemical energy, which is stored in ATP and NADPH. In the Calvin cycle, carbon dioxide and the chemical energy that was stored by the light reactions are used to form organic compounds. Other products of the Calvin cycle are used in turn by the light reactions, creating a continuous cycle.

   DIF: 3 OBJ: 6-2.4