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General Rubric

NJ SCORING GUIDE FOR BIOLOGY OPEN-ENDED QUESTIONS

The zero-to-three-point generic scoring rubric below was created to help readers score open-ended responses consistently. In scoring, a reader should accept the use of appropriate labeled diagrams, charts, formulas, and/or symbols that are part of the correct answer even when the question does not specifically request their use.

3-Point Response
The student response is reasonably correct, clear, and satisfactory.

2-Point Response
The student response has minor omissions and/or some incorrect or irrelevant information.

1-Point Response
The student response includes some correct information, but most information included in the response is either incorrect or irrelevant.

0-Point Response
The student attempts the task, but the response is incorrect, irrelevant, or inappropriate.

The above generic rubric is used as a guide to develop specific scoring guides or rubrics for each of the open-ended (OE) questions that appear on the New Jersey statewide assessments in Biology. These scoring rubrics provide the criteria for evaluating and scoring student performance and are developed by a committee of scientists and teachers. Rubrics ensure that there is consistency, fairness, and accuracy in scoring open-ended questions.
### Diagnostic Test (pp. 1–9)

#### Part 1

1. A  
2. A  
3. D  
4. B  
5. C  
6. C  
7. A  
8. C  
9. B  
10. D  
11. D  
12. A  
13. B  
14. D  
15. C  

#### Part 2

16. A  
17. C  
18. A  
19. C  
20. A  
21. D  
22. B  
23. C  
24. D  
25. C  
26. A  
27. C  
28. D  
29. A  
30. A  

#### Part 3

31. B  
32. C  
33. C  
34. B  
35. B  
36. D  
37. D  
38. C  
39. C  
40. B  
41. D  
42. B  
43. C  
44. A  
45. D  

46. • The process described by the equation is photosynthesis and the two vital products are glucose and oxygen. • Cellular respiration is basically the opposite of this process because it uses oxygen to break down glucose in the cell. • The waste products of cellular (aerobic) respiration are carbon dioxide and water.

### Scoring Guide for the Open-Ended Item

#### 3-Point Response

The student response is reasonably correct, clear, and satisfactory. It demonstrates a thorough understanding that the process described is photosynthesis; that cellular respiration is basically the opposite of this; and states the products of both processes.

#### 2-Point Response

The student response has minor omissions and/or some incorrect or irrelevant information about the processes and products of photosynthesis and cellular respiration; student states that they are basically the opposite process of each other.

#### 1-Point Response

The student response includes some correct information, but most information included in the response is either incorrect or irrelevant; student does not state that they are opposite processes and/or student does not state all the correct products of the processes.

#### 0-Point Response

The student attempts the task, but the response is incorrect, irrelevant, or inappropriate. Student does not correctly identify the processes of photosynthesis and respiration and does not identify any products of the processes.
Chapter 1 Review

Multiple Choice  (pp. 19–21)

1. A  11. C
2. D  12. C
5. C  15. C
6. C  16. D
7. D  17. B
8. C  18. D

Analysis and Open Ended  (pp. 21–22)

21. Steps of the scientific method:
   • State the problem (in question form).
   • Collect information about the problem.
   • Form a hypothesis (a possible answer).
   • Design and conduct an experiment (use an experimental group with a variable; use a control group without the variable).
   • Record observations and data.
   • Check results; redo experiment (if necessary).
   • Draw your conclusions (accept or reject your hypothesis).
   • Communicate your results.

22. A hypothesis is a possible answer to a problem that has been described. The hypothesis will be used to design an experiment to investigate the problem. A theory is a general statement supported by a great deal of evidence that gives an explanation to a scientific question.

23. To conduct a scientific experiment, a research design must be created that has the necessary variable and controlled conditions to allow for conclusions to be drawn from the results. Also the steps of the experiment need to be carefully planned so that the experiment can be repeated by others.

24. The hypothesis must be clear so that the design of the experiment is directly related to what is being tested.

25. Data can be collected in written, descriptive form and in numerical, quantitative form. It can be organized in tables, charts, and graphs.

26. For a general statement or explanation to be accepted as a theory, a great deal of experimentation by many scientists must be done. The evidence must be accepted by the majority of researchers in the scientific community before it is agreed that a theory has been established.

27. B

28. The control group could use distilled water; the experimental groups could use a range of salt concentrations such as 1%, 3%, and 5%; conditions to be kept constant could be temperature and pH; data to be collected could be time required for hatching and number of eggs hatched. Sample results:

<table>
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<th>3</th>
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</tr>
</tbody>
</table>

29. D

30. C

31. The experimental design:
   • slightly acidic soil results in red petals in the plant species
   • the experimental group will have soil with a slightly acidic pH; the control group will have soil with the basic pH that produces the white petal flowers
   • amount of light and amount of moisture
   • production of red petals in plants growing in the acidic soil

32. The experimental results may be valid for corn seedlings, but that does not mean they can be considered valid for any other plant species.

33. It is important to include all the steps used so that other scientists who read about it can repeat the experiment and be sure that the results obtained are valid.
Reading Comprehension (p. 23)

34. A scientist will revise his/her hypothesis when new observations, or published results or facts, contradict his/her current hypothesis.

35. Darwin kept a journal to record all his observations, particularly those that ideas or facts that contradicted his hypothesis.

36. Steps of the scientific method Darwin used re: seeds and salt water.
   Problem: Can seeds that were in seawater still grow?
   Collect information: How to make salt water; lengths of time in the water; types of seeds available.
   Hypothesis: That seeds in seawater for a given amount of time would germinate.
   Perform experiment: Exposure to salt water, planting seeds in soil.
   Observations: Did the seeds grow? Conclusion: Hypothesis is confirmed or contradicted.

Chapter 2 Review

Multiple Choice (pp. 34–35)

1. C 11. D
2. B 12. D
4. D 14. A
5. B 15. C
7. C 17. A
8. D 18. A
9. C 19. D

Analysis and Open Ended (pp. 35–37)

21. C 23. A
22. C 24. D

25. A 10-ml graduated cylinder would be used. To be most accurate, the measurement should be read at the bottom, or meniscus, of the curved surface of the liquid.

26. Measurements taken during scientific experimentation establish the data that will be used to determine if the hypothesis being tested is supported or not by the evidence.

27. The range of the measurements that can be made during experiments using the human senses by themselves is quite limited. Taking measurements using the appropriate tools and instruments allows scientists to greatly increase the accuracy of their observations.

28. After placing the specimen in a drop of water on a clean slide with a medicine dropper, gently lower a coverslip at an angle over the drop to avoid trapping air bubbles.

29. Both the transmission and scanning electron microscopes use beams of electrons rather than light to magnify and view images. With the transmission electron microscope, the beam of electrons passes through the specimen. With the scanning electron microscope, the beam of electrons passes over the specimen to study the surface features.

30. Metric units used in science: length—meters and centimeters; volume of liquid—liters and milliliters; temperature—degrees Celsius; mass—grams and kilograms.

31. A laboratory safety poster would include the rules and procedures outlined on pages 30-31 of this chapter.

32. To test for the presence of fat, the food sample should be gently rubbed on a piece of brown paper bag. A translucent grease spot shows that fat is present.

Reading Comprehension (p. 37)

33. By learning to use a beam of electrons aimed at the object to be viewed, in place of a beam of light, scientists have developed electron microscopes that are at least 1000 times more powerful than light microscopes.

34. Both light and electron microscopes magnify the image of an object being viewed. They are tools developed by people to see objects too small to be seen with the (unaided) human eye. Objects being viewed are usually stained to make them more visible for both types of microscopes. The light microscope aims a beam of light at the object; the transmission electron microscope aims a beam of electrons. For both of these, the beams must pass through the object for viewing. With the scanning electron microscope, a beam of electrons must pass over the object. For both types of electron microscopes, the objects being viewed must be in a vacuum. This is not necessary for a light microscope. Therefore, live cells and tissue can be viewed only with a light microscope.

35. A new microscope that combined the best features of both types of microscopes would be as powerful as the electron microscope and be able to view cells while they are still alive, as is possible with the light microscope.
Chapter 3 Review

Multiple Choice  (pp. 47–48)
1. B 12. D
2. D 13. A
4. A 15. B
5. D 16. D
7. C 18. A
10. A 21. B
11. A

Analysis and Open Ended  (pp. 48–49)
22. Living things require energy to maintain the high level of organization they need to keep alive. Plants do so by using the energy of sunlight to produce glucose; animals and other organisms use this energy to survive.
23. Carbon is important for the existence of life on Earth because all organic compounds contain this element, usually as a “skeleton” of carbon atoms bonded to each other.
24. Four important functions of organic compounds in living things include: capturing and transforming energy; building new structures; storing materials; repairing structures; keeping all chemical activities functioning.
25. Athletes need to consume lots of complex carbohydrates during training because the energy that is stored as polysaccharides in their muscles is used up and must be replaced
26. C [An organic compound]
27. B [Polysaccharide]
28. Hemoglobin and hair are both proteins, but they can have different structures because every protein has its own specific amino acid sequence that determines its shape. In turn, each protein’s shape determines its biological function.
29. C [Simple sugars join to form a larger sugar molecule.]
30. Three important characteristics of proteins would include the following:
   - Proteins are large polymers that are made up of subunits called amino acids.
   - Their main functions are to build materials, transport substances, control chemical and metabolic activities, send signals, and provide defense.
   - Structure and function are determined by the order in which the amino acid subunits are linked; the specific shape of a protein actually determines its function.
31. The particular proteins in our bodies depend on our DNA because it is our DNA sequences that are copied into RNA and used to build specific proteins at the ribosomes.
32. A tissue is a group of similar cells that works together to perform a function, e.g., nervous tissue in the brain is made up of nerve cells that transmit messages. An organ is the next level of organization; it is a group of tissues that works together to perform a function; e.g., the brain is made up of nervous, blood, and connective tissue.
33. The main levels of organization in living things are (from smallest to largest): atoms—molecules (compounds)—cells—tissues—organs—organ systems—organism.

Reading Comprehension  (pp. 49–50)
34. Through evolution, characteristics that an individual may have by chance are more likely to be passed on to future generations if these traits have a selective advantage. For example, any characteristic that would make an individual more likely to survive a period when food is scarce would make that individual more likely to survive and pass on that trait. Therefore, the characteristic of reacting to a shortage of food (“dieting”) by slowing down body systems in order to burn fewer calories is a result of evolution. It is this effect of dieting that makes it so hard to lose weight.
35. Through exercising, more calories (from fat) are burned, and more muscle tissue is created, resulting in long-term reductions in body weight rather than constant, unhealthy weight fluctuations.

36. Anorexia nervosa—abnormal fear of being overweight, refusal to eat, unhealthy appearance, can be fatal; bulimia—may appear healthy, overeating and then ridding oneself of ingested food, can be dangerous to body organs.

Chapter 4 Review

Multiple Choice  (pp. 58–60)

1. B  13. A
2. B  14. C
3. A  15. A
5. A  17. A
8. A  20. C
10. A  22. A
12. D

Analysis and Open Ended  (pp. 60–61)

24. Three important cell organelles and their functions can include the following responses: the cell membrane allows oxygen, carbon dioxide, water, and other substances to enter and leave a cell; a chloroplast uses water, carbon dioxide, and the sun’s energy to make glucose; mitochondria use food and oxygen to release energy.

25. (a) The cell membrane is said to be selectively permeable because it determines which substances (molecules) can pass through it, and whether they can enter or exit the cell. (b) This is important because the cell membrane prevents unnecessary substances from entering the cell, while keeping important chemicals within it and allowing the exchange of vital molecules. It also determines how quickly or slowly the substances move into and out of the cell.

26. Arrow A represents active transport. Active transport is different from diffusion because: (1) active transport requires the use of energy and diffusion does not; and (2) in active transport, molecules move from a region of lower concentration to a region of higher concentration, and in diffusion the reverse occurs.

27. Receptor (protein) molecules in structure B (cell membrane) bind to specific signal molecules such as hormones and neurotransmitters for cell-to-cell communication.

28. Both “integration” and “control” are important for maintaining homeostasis because an organism needs a way to make all its body parts work (integrate) together and a means for functioning in an organized and efficient manner (control). In humans, the nervous and endocrine systems work together to coordinate the body’s functions.

29. Cells communicate with each other chemically, that is, by having chemicals move between, into, and out of them.

30. The three main functions of every nerve cell are to receive, conduct, and transmit impulses.

31. How a nerve impulse travels along the length of a neuron: (a) A nerve impulse, which is an electrochemical message, is actually the rapid movement of positive ions that cause voltage changes along the length of nerve cells. (b) The role of a nerve cell’s membrane is to conduct the nerve impulse along its length; voltage changes that occur at one place on the membrane trigger the same kind of (electrochemical) changes at the next spot on the membrane. This is the impulse.

32. When a nerve impulse reaches the end of a nerve cell, chemicals are released that transmit the nerve impulse across a gap to the next nerve cell.

33. Concept map: cell membrane

[regulates the cell’s internal environment via:]

active transport  diffusion and osmosis
[work is done by cell]  [passive transport: uses energy  no work is done]  does not use energy

34. During chemical reactions (when covalent bonds are formed or broken), the energy stored in the chemical bonds is either transferred to other newly formed bonds or is released as heat and/or light. Cells use this energy (released from the bonds in glucose) to carry out vital chemical reactions.

35. If its mitochondria were removed, a cell would die because these are the organelles at which the cell’s energy is released. Without energy, a cell cannot carry out vital chemical reactions.

Reading Comprehension  (pp. 61–62)

36. The removal of the spleen was necessary for Mr. Moore in order to cure the leukemia, a type of cancer of the blood, from which he was suffering.
37. The cells in Mr. Moore’s spleen tissue were found to be producing an interesting blood protein, from which the drug company planned to develop a new and profitable medicine.

38. When Mr. Moore learned that it was likely that large profits were going to be made using the cells from his spleen, he sued the physicians for the rights to his cells and to the profits. Both the Supreme Court of California and the United States ruled in favor of the physicians, stating they had the right to use the removed cells for research and that once they were removed the patient had no expectation to get them back.

Chapter 5 Review

Multiple Choice  (pp. 70–73)

1. C  18. A
2. C  19. D
3. A  20. C
5. D  22. D
6. C  23. C
7. C  24. B
9. D  26. A
10. C  27. A
12. C  29. C
13. B  30. D
15. B  32. C
16. B  33. B
17. D  34. A

Analysis and Open Ended  (pp. 73–74)

35. Being multicellular increases an organism’s ability to maintain homeostasis by providing its body with many types of structures and systems that protect its individual cells and that protect the organism against changes in the environment.

36. Students’ essays will vary, but should explain that the ameba (a single-celled organism) would have greater difficulty maintaining homeostasis than their body cell would. The body cell probably would survive longer than the ameba would because a multicellular body has systems that protect its cells from changes in the environment.

37. Intercellular fluid (ICF) surrounds all body cells and enables the exchange of materials between the bloodstream (capillaries) and the body’s tissue cells. Thus, ICF is important to homeostasis because it helps to maintain stable conditions inside each of the cells.

38. (B) [40°C and 0.5% water/salt balance = someone who is not maintaining homeostasis]

39. The three main parts of a feedback mechanism: (a) sensor—something that can detect a change in the system; (b) control unit—something that knows what the correct level of a substance should be; and (c) effector—something that can take instructions from the control unit and make the necessary changes (to maintain correct levels).

40. Feedback mechanisms maintain homeostasis when a change occurs that produces another change, which in turn reverses the first change to reach acceptable levels in a system. For example, when blood sugar (glucose) levels rise, the pancreas secretes insulin, which decreases the blood sugar level, a condition that then triggers the release of glucagon, which raises the blood sugar back to an acceptable level.

41. How the body adjusts breathing rates to maintain homeostasis: When CO₂ levels are too high, the brain tells the chest muscles to increase their activity in order to increase the breathing rate, which decreases CO₂ levels, and increases O₂ levels, in the bloodstream.

42. D [The skin temperature increases, then levels off at about 36°C.]

43. The rising external temperature does not have much of an effect on the student’s internal temperature (which rises about 1°C), because the body has systems that work to keep internal conditions stable. The student’s skin temperature increases more dramatically before it levels off (probably through perspiration), because skin is directly exposed to changes in the external environment.

44. This behavior helps maintain a relatively cooler body temperature. Staying in the shade keeps the body temperature low enough so that dehydration will not occur, or so that enzyme action (body chemistry) is not affected.

45. How and why plants maintain their water balance:
   • Water balance is important to plants because, like animals, plants need water for the cytoplasm in their cells and to carry out cellular (chemical) activities.
   • Plants have openings on the surface of each leaf that are adapted to control water loss.
   • The two “guard cells” that surround each opening allow water to diffuse through their cell membranes, which either widens or closes the opening, depending on abundance or scarcity of water in the environment. This maintains the plant’s water balance.
46. The functions of an ameba’s contractile vacuoles and a plant’s guard cells are similar in that both structures are responsible for maintaining the organism’s water balance by either reducing or increasing water loss (to the environment).

47. The four main organ systems that are involved in maintaining homeostasis are as follows: (a) the excretory system, which regulates the chemistry of body fluids and removes wastes; (b) the nervous system, which uses electrochemical impulses to regulate body functions; (c) endocrine system, which produces hormones that regulate functions and behavior of the body; and (d) the immune system, which protects the body from dangerous substances and microorganisms that could harm its structures and functions.

48. Molecule D. It is the only (substrate) molecule that fits the shape of the enzyme.

49. The rate of reaction would most likely increase.

50. The reason a high body temperature can result in death would be that the greater heat changes the shapes of enzymes; the distorted enzyme shapes no longer match the substrates; the enzymes no longer function; so the chemical reactions necessary for life do not take place fast enough to maintain life.

51. Enzymes, which are protein molecules, must maintain their shape to work properly; slight changes in pH quickly affect an enzyme’s shape and its ability to function. Most enzymes work best at a neutral pH of about 7, so our cells must maintain that pH to survive.

Reading Comprehension (pp. 74–75)

52. It is a weightless environment, with no ceilings or floors; individual living spaces are small; and crews sleep standing up or attached to the wall.

53. How the body reacts to weightlessness teaches researchers about the body’s ability to adapt in general. It also teaches us much about the normal responses of the body to gravity that researchers did not previously understand.

54. In order to maintain an internal set of constant conditions, the body must respond to outside forces, including gravity. When the force of gravity is absent, the body has to respond appropriately in order to maintain the same homeostasis.

55. Adaptations that the body has to the force of gravity involve two important sense organs—the eyes and the fluid-filled tubes of the ears. The body also is adapted to maintain an even distribution of fluid in the blood vessels and to sense the pressure on the body due to gravity through receptors on the bottom of the feet.

Chapter 6 Review

Multiple Choice (pp. 82–84)

1. B 11. A
2. B 12. B
5. B 15. B
6. C 16. A
7. D 17. B
8. D 18. C
10. C 20. D

Analysis and Open Ended (pp. 84–85)

21. Plants are autotrophs because they make their own food (using the energy from sunlight and inorganic substances); animals are heterotrophs because they cannot make their own food, but have to eat other organisms to get their food (and energy).

22. Photosynthesis is like a “bridge” between the living and nonliving parts of the world because plants use the energy of sunlight to change inorganic compounds (H2O and CO2) into organic compounds (e.g., glucose), upon which other life-forms depend.

23. In terms of the following factors, the structures of a leaf that enable photosynthesis to occur are: (a) light: the chlorophyll-containing chloroplasts are arranged within the leaf cells such that they get maximum exposure to sunlight; (b) water: the leaf has openings through which it controls the amount of water that is lost to the air; and (c) gases: these openings also regulate the passage of CO2 and O2 into and out of the leaf.

24. The chemical equation describes the life process of photosynthesis. The two vital products of this reaction are glucose (a simple sugar) and oxygen (O2).

25. Cellular respiration is “basically the opposite” of photosynthesis in that O2 is used to help release the stored energy of glucose, and CO2 and water are released as waste products.


27. Possible answers: an increase in the level of water vapor; an increase in the carbon dioxide level; a decrease in the oxygen level.

28. Possible answers: an increase in oxygen level and a decrease in the carbon dioxide level.

29. The Euglena carries out cellular respiration, which can be summarized by the following chemical equation:
30. Cellular respiration is important for *Euglena* because it releases energy for its life processes; photosynthesis produces the food (glucose) that can supply this energy.

31. Photosynthesis produces food (and oxygen); respiration provides energy for cells.

32. For photosynthesis: (a) the source of energy is the sun; and (b) the energy ends up in glucose molecules. For respiration: (a) the source of energy is glucose molecules; and the energy ends up stored as ATP molecules.

33. Breathing is the physical process of pumping air into and out of the body, something that multicellular animals do. Respiration is the process by which gases are exchanged with the environment, and it involves the diffusion of O₂ and CO₂ gases across cell membranes.

34. The process of breathing (in mammals) is as follows: During inhalation, rib muscles move the rib cage upward and outward, and the rib cage expands; the diaphragm contracts and moves down, and the volume of the chest cavity increases; air pressure in the lungs decreases, and then air rushes into the lungs from the bronchi. During exhalation, the rib muscles relax, and the rib cage moves back down and in; the diaphragm relaxes and moves back up, and the volume of the chest cavity decreases; air pressure in the lungs increases and then air moves out of the lungs.

35. The four main characteristics of an animal’s respiratory surface are that it must: (a) stay moist at all times so that gases can diffuse across the cell membranes; (b) be very thin so that gases are able to pass through it; (c) be closely connected to the transport system that delivers gases to and from cells; and (d) have a source of oxygen, either in the air or dissolved in water.

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**Reading Comprehension (pp. 85–86)**

36. Just like the grass in fields or pastures, the drifting cells in the ocean capture the energy of sunlight and use it to convert CO₂ and water into food, which is then eaten by other organisms.

37. Drifting cells in the ocean are similar to land plants because both groups of organisms: (1) capture sunlight and use the energy to convert CO₂ and water into organic molecules; (2) serve as important sources of food for other organisms; and (3) increase in large numbers, called blooms, at particular times of the year.

38. Orbiting satellites in space have been able to take photographs of the seasonal “blooms” of these tiny drifting cells, when they reproduce in vast numbers.

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**Chapter 7 Review**

**Multiple Choice (pp. 95–97)**

1. A 16. A  
2. D 17. B  
3. C 18. D  
5. B 20. B  
6. B 21. A  
7. B 22. B  
8. D 23. C  
11. C 26. D  
12. B 27. A  
13. C 28. A  
15. B 30. C

**Analysis and Open Ended (pp. 97–100)**

31. The two main components of any ecosystem are living (biotic) factors such as plants, animals, and fungi, and nonliving (abiotic) factors, such as soil, air, and water.

32. Producers (plants and algae) differ from consumers (animals and fungi) in that they use the process of photosynthesis to make their own food (with water, carbon dioxide, and sunlight), while consumers cannot make their own food and have to feed on living things.

33. A food web is a more accurate description than a food chain of the interactions in a community because, in nature, many food chains actually interconnect in a complex pattern (i.e., a food web) in which energy is passed between many different organisms.
34. A pyramid can be used to describe the amount of energy in trophic levels because its wide base represents the largest amount of usable energy, i.e. the producers at the first trophic level, while each higher level represents the decreasing usable energy of the consumers.

35. C [Energy is lost to the environment at each level, so less mass can be supported at each higher level.]

36. D [feeds on second-level consumers]

37. B [a food web]

38. B [consumers and prey]

39. C [trees and shrubs]

40. C [community]

41. D [There is only one group of producers, so they must be numerous enough to supply the energy needed to support the food web.]

42. When a long-lasting pollutant enters an ecosystem, it may get passed from one trophic level to the next, increasing in concentration as it moves up the food chain, e.g., from a small fish to a larger fish to a fish-eating bird. It becomes most harmful at higher levels.

43. B [(Available energy is) 10 percent of what it was before]

44. An energy pyramid:

```
   fish
  /   \
/     \   
insect
  \   / \\
   algae
```

45. (a) The statement about “organisms [that] can change solar energy into chemical energy” refers to producers, i.e., plants and algae; (b) the type of nutrition they carry out is autotrophic; and (c) the process used is photosynthesis (with chloroplasts as the organelles that are directly involved in changing solar energy into chemical energy).

46. Possible answers include: Different populations of prey in an ecosystem are controlled by different kinds of predators; and more biodiversity in an ecosystem provides more stability.

47. D [grasshopper]

48. A [top carnivore]

49. B [The snake population will decrease.]

50. C [energy from sunlight]

51. Possible answers: Predator — Prey

   snake — mouse
   hawk — snake
   hawk — mouse
   owl — mouse
   owl — frog
   frog — cricket


53. Whereas the amount of energy on Earth is continually replenished by incoming sunlight, the amount of matter available is limited and cannot be replenished. All living things need certain chemical elements to survive, so these elements (e.g., C, O, H, and N) are naturally recycled during respiration, photosynthesis, ingestion (in food), and decomposition.

54. During photosynthesis, plants use carbon dioxide (along with water and light energy) to produce glucose; oxygen is given off as a waste product. During cellular respiration, plants and animals use oxygen to release the energy in glucose; carbon dioxide is given off as a waste product. In this way, carbon dioxide and oxygen are cycled between living things.

55. Ecologists are concerned about the number of species in an ecosystem because it is thought that the number of species in a community may be critical to its stability, i.e., the more species, the greater the stability. Thus, a forest ecosystem has a greater biodiversity than a cornfield because the forest has many plant species, and therefore animal species; the cornfield has primarily only one plant species, and consequently fewer animal species.

56. The main way that humans are responsible for the current decrease in biodiversity is by engaging in activities that cause habitat destruction, such as deforestation, erosion, mining, building dams, and draining wetlands. In addition, overfishing, overhunting, and the release of pollutants into the environment also contribute to the loss of species.

Reading Comprehension (pp. 100–101)

57. The Everglades is a marsh. This is a wet area that contains various types of grasses. In the Everglades, the main plant is saw grass. Water flows slowly through the Everglades from north to south, which is why it is called a “river of grass.”

58. Construction projects changed much of the Everglades in order to control floods and provide a supply of water. The projects included canals, pumping stations, and water-control structures. These projects have harmed the Everglades by disrupting the natural flow of water through the ecosystem.

59. Steps that are being undertaken to restore the Everglades include the following:
   • ending the production of sugarcane on over 100,000 acres of farmland;
   • leaving large areas of land unused in order to let them work as natural filters to remove contaminants such as pesticides and fertilizers from the water;
and changing and removing construction projects in order to improve the flow of water from north to south.

60. This vast marsh was once seen as wasted land that could be better used if it was changed and controlled by humans. It is now understood that if the natural processes in this huge ecosystem are disrupted, the results will be bad for the human population in the area. So the idea now is that the best thing to do, for humans and for wildlife, is to try to protect as much of the marsh as possible.

Chapter 8 Review

Multiple Choice  (pp. 113–115)

1. D  16. A
2. B  17. B
3. B  18. A
4. D  19. A
5. C  20. B
7. B  22. A
8. D  23. B
11. D  26. B
12. C  27. B
15. C  30. C

Analysis and Open Ended  (pp. 115–116)

31. A child can inherit a disease that neither parent appears to have if each parent carries a single copy of the gene for that disease. The combination of the two flawed genes will cause the child to suffer from the disease.

32. A pathogen is a microscopic organism that causes disease. Information about pathogens includes the following:
   • The four types of disease-causing pathogens are viruses, bacteria, fungi, and protozoa.
   • Diseases that pass from one person to another are infectious diseases.
   • Three common ways that pathogens can enter the body are through the respiratory, digestive, and excretory systems. (They can also enter through cuts in the skin.)

33. An inherited disease is passed on from parents to offspring, i.e., through reproduction. An infectious disease can be passed from one person to any other person who is exposed to it.

34. When an organ, such as the heart, liver, or kidney, malfunctions (e.g., due to some kind of damage to it), a disease of that organ may develop, causing serious effects on the body.

35. A harmful lifestyle can lead to a disease when it causes damage to an organ or organ system. For example, eating foods that are high in cholesterol may cause fatty deposits to form in one’s arteries, leading to cardiovascular disease. By exercising and eating a low-fat diet, it may be possible to prevent such a condition. Other examples can include cigarette smoking and respiratory diseases, and excessive alcohol drinking and liver disease.

36. The “first line of defense” against infection functions as follows: (a) it consists of physical barriers; (b) the skin is the main physical barrier of the body; and (c) its unbroken surface keeps harmful microorganisms out of the body by (physically) blocking their entry.

37. B [inflammation]
38. C
39. C

40. Flowchart describing the immune system’s reaction to microscopic invaders (from top to bottom): [molecules detected by immune system] antigens → [molecules produced in response] antibodies → [antibodies bind to antigens] microbes are destroyed by body → [what happens to immune system] body develops immunity.

41. The immune system helps to maintain homeostasis by working to keep internal conditions stable (i.e., to maintain a dynamic equilibrium). It does so by fighting the disease-causing agents that could harm the body’s cells and organs and disrupt body functions.

42. The term immunity refers to the body’s ability to resist or prevent an infection or disease caused by pathogens. Vaccinations are injections, e.g., of weakened microbes that prepare the immune system to fight off invasions by that same pathogen in the future.

43. A [volunteers A and D only]
44. B [vaccination]
45. C [developing a method to stimulate the production of interferon in cells]

46. B cells and T cells are both special kinds of white blood cells. B cells respond to specific antigens by producing antibodies (proteins) that bind to them and prevent their doing harm to the body. The memory B cells remain in one’s body for life. T cells recognize cells that have been infected by microbes. The killer T cells destroy body cells that have been infected. The helper T cells assist both B cells and killer T cells in fighting pathogens.

47. HIV affects the immune system as follows: “HIV” stands for human immunodeficiency virus. This virus weakens a person’s immune system by preventing his
or her white blood cells from doing their job; thus they have an *immunodeficiency* because they cannot fight off infections. HIV destroys helper T cells, which prevents them from helping the B cells and killer T cells in fighting various infections. That is how a person develops AIDS.

48. Allergic reactions and autoimmune diseases are *similar* in that they are both caused by an over-activity of the immune system. They are *different* in that an allergic reaction is the body’s strong response to a common external substance, e.g., pollen, dust, or certain foods, which causes the release of histamines; but an autoimmune disease is an inappropriate response to, and attack on, the body’s own normal tissues, e.g., rheumatoid arthritis.

**Reading Comprehension (pp. 116–117)**

49. A vaccine is a dead or weakened bacteria or portion of a pathogen or virus.

50. Vaccination promotes immunity to various diseases by stimulating the development of memory B cells and the production of the necessary antibodies.

51. Antibiotics are substances that destroy bacterial cells that may be causing an infection. One disadvantage to the use of antibiotics to fight bacterial diseases is that they do not provide protection against future attacks. The antibiotic must be given each time a bacterial infection develops. Also bacteria may become resistant to the antibiotics; there are allergies to antibiotics; and the antibiotics may target beneficial bacteria. A vaccine creates the capacity in a person to be immune to the bacterial infection for a long time through the production of the necessary antibodies after exposure. One advantage to the use of vaccinations to fight bacterial diseases is that usually you will not get the disease.
UNIT III

Diversity and Biological Evolution

Chapter 9 Review

Multiple Choice  (p. 131)
1. B  8. B
2. D  9. C
4. C  11. D
5. C  12. C
6. D  13. A
7. D

Analysis and Open Ended  (pp. 131–133)
15. C  17. B
18. The two main differences between prokaryotic and eukaryotic cells are that (a) the cells of prokaryotes lack a nucleus and other membrane-bound organelles, so they are less complex than eukaryotic cells; and (b) many functions of a prokaryotic cell are carried out by its cell membrane. The cells of eukaryotes contain a nucleus and other membrane-bound organelles; these special structures carry out many cell functions.
19. C [Cladogram]
20. Student answers will vary; an example could be: The lizard in the cladogram has dry skin, unlike the moist-skinned frog placed on the cladogram before it. Dry skin enables the reptile to adapt to habitats that amphibians cannot survive in; that is an evolutionary change and that is part of why reptiles are classified in another group. However, it does not have hair or fur, like the leopard which is placed after it on the cladogram. Being a mammal, the leopard has other adaptations that the lizard lacks.
21. A dichotomous key is composed of a list of observable, alternative characteristics that leads, step-by-step, to the correct identification of an unknown organism. There are always two choices to pick from, and at every step of the key, one of the two descriptions is eliminated. For example, at some step in a key for identifying an animal, there could be a choice between the types of structures used for locomotion, such as fins versus feet.

Reading Comprehension  (p. 133)
22. The process of simultaneous reproduction is similar in both plants and animals when it occurs. In both cases, all the individuals of a species (in a particular area) release their gametes into the environment at the same time. Fertilization of female gametes by male gametes then occurs in the external environment—either in the air (for some plants) or in the water (for some plants and animals, such as corals and some fish).
23. Cross-fertilization increases the genetic variation among the offspring.
24. Mass spawning increases the chances of fertilization because so many gametes are released at once; it increases the chances of cross-fertilization between different populations; and it reduces the loss of gametes to predation because there are so many in the water at the same time (i.e., safety in numbers).

Chapter 10 Review

Multiple Choice  (pp. 139–141)
1. D  13. C
3. D  15. D
4. C  16. A
5. C  17. A
7. B  19. D
8. C  20. D
10. C  22. B
12. A  24. D

Analysis and Open Ended  (pp. 141–142)
25. As populations of species adapt to changing environments, and to the conditions in geographically isolated areas, variations that aid survival are selected for and, over time, the populations change, leading to the evolution of diverse species.
26. The “struggle for existence” is important to evolution because only a limited number of offspring in a population can survive. Those that are best suited to their environment live to reproduce and pass on their traits; e.g., the various populations of finches that evolved into different species in the Galápagos Islands.

27. The variations among individuals are more important than the similarities in a population, because it is these variations that may give an organism an advantage over others, making it more “fit” to survive in its particular environment.

28. Two possible causes of genetic mutations would be exposure to radiation and to certain chemicals. These mutations would have to occur in the sex cells in order to be passed along to offspring via sexual reproduction.

29. Organisms in the same population compete for food, mates, and living spaces. This struggle is affected by natural selection because individuals that are better adapted (i.e., more fit) to get those resources would be more likely to survive and reproduce.

30. D [Evolution by natural selection]

31. Sexual reproduction allows for the exchange and recombination of genes from two parents, thus producing greater variation among offspring. This is important for evolution, because it produces a population that can be more adaptable to changing environments (i.e., greater variability for natural selection to work upon).

32. Mutations are important to evolutionary change because such change results, over time, from the accumulation of genetic mutations in a population. Mutations lead to the genetic variations upon which natural selection acts.

33. B [Characteristics of Mutations]

34. The concept of natural selection includes the other three concepts as follows: In a natural population, there is a competition for resources and thus a struggle for existence. As a result of variation among offspring, some organisms are more “fit” to survive in their habitat and better able to adapt to environmental change. Natural selection acts on these variations, such that the more fit organisms survive to reproduce and pass along their characteristics.

35. Natural selection can lead to the development of a new species because environmental conditions determine which organisms within a population survive to reproduce and pass on their traits. Those traits that are most “fit” will be passed on in greater frequency over time, leading to an overall change in the population’s characteristics, i.e., a new species.

36. The patient became sick again because she took the antibiotic only long enough to kill off most but not all of the bacteria (i.e., the most susceptible ones). When she stopped taking the antibiotic, the bacteria that still survived (i.e., that were resistant to the drug) were able to reproduce in even greater numbers.

37. B [more rabbits would have white fur than brown fur]

38. Students’ answers will vary, but could include the following:
   - An adaptation is a characteristic that makes an organism well suited to survive in a particular environment, e.g., the thick, white fur of a polar bear in the arctic region.
   - The white fur aids survival because it keeps the bear warm and helps camouflage it (in the snow and ice) from potential prey animals.
   - The adaptation becomes more widespread as those bears that have the trait survive to reproduce and pass on their genes.

39. Some pesticides are no longer as effective in getting rid of insect pests because the insects that were naturally resistant to the chemicals survived the initial doses, reproduced, and passed their resistant genes to more offspring (whereas the other insects were eliminated by the pesticide).

Reading Comprehension (pp. 142–143)

40. Antibiotic use has allowed many serious diseases to be brought under control and even eliminated. However, the bad news is that disease-causing strains of bacteria have evolved that are resistant to some antibiotics. These medicines are no longer effective in treating people who are infected with the resistant strains of bacteria.

41. Heavy use of antibiotics in farm animals is resulting in super-resistant strains of bacteria in these animals. The concern is that these bacteria may also infect humans.

42. The evolution of antibiotic-resistant bacteria is a result of natural selection, with the overuse of antibiotics being the selective agent. Knowledge of natural selection helps one understand how resistant strains develop and, therefore, why it is important to try to limit the overuse of antibiotics.

Chapter 11 Review

Multiple Choice (pp. 149–150)

1. D
2. A
3. A
4. C
5. C

6. C
7. A
8. D
9. C

Analysis and Open Ended (pp. 150–152)

10. A [More closely related to mammoth than manatees]
11. A family tree shows evolutionary relationships among organisms by having species that are more closely related branching off most recently (in terms of geologic time) from their common ancestor on the diagram. Distantly related species are placed farther apart on the tree, showing that they last shared a common ancestor a much longer time ago.

12. Two ways fossils form (and what parts fossilize):
   - When an organism dies and is buried in sediments, its hard tissues (bones, shells, or teeth) are slowly replaced by minerals that are dissolved in underground water. The minerals eventually harden, forming a copy of the original organism.
   - Imprints, molds, and casts are formed when an organism’s body leaves an impression in soft mud or clay, which later hardens, showing just the external shape of the body.

13. Similarities in the biochemistry of proteins can help define evolutionary relationships because all living things have a similar chemistry and a similar way of storing their genetic information in DNA molecules. A small number of differences in the same protein in two different species means they are closely related; a large number of differences means they are more distantly related.

14. B [Have adaptations for different environments]

15. An “evolutionary bush” is more accurate than a linear diagram because, within a group of related organisms, many species may evolve at the same time and branch off, with some becoming extinct, while others develop into new species over time (i.e., it is not direct).

16. C [Once shared a common ancestor]

17. A structure with no current function can be evidence of an organism’s evolutionary relationship to a similar organism if that one has a similar structure that is still functioning. For example, lizards are reptiles that have legs; snakes are reptiles that do not have legs. Yet, some snakes have vestigial leg bones, adding proof to the idea that they are related to lizards.

18. D [Fifth layer from the top]

19. The changes in moth populations are due to natural selection. In a cleaner environment, the light moths are better hidden from predators when on the light tree trunks, so more of them survive to reproduce. In a more polluted environment, the dark moths are better hidden on the darkened tree trunks, so more of them survive to reproduce.

20. C [Structures]

21. Evolution leads to “new adaptive features” that can result in new species when natural selection favors those organisms that have the new features. Those individuals live to have greater reproductive success than others and, over time, come to be the dominant type within their population. This is how speciation occurs. For example, if some rams in a wild goat species develop much larger horns (e.g., through a chance mutation) and, as a result, they fight better, feed better, and acquire more mates, they will have greater reproductive success. Over time, more rams will have the larger horns, and that population may change enough to be considered a new species of large-horned wild goats.

22. B [Biochemistry]

23. B [Evidence for evolution]

24. DNA nucleotide sequencing is important because, by matching a DNA base sequence from one organism to a DNA base sequence from another organism, scientists can determine if the sequences belong to organisms of closely related or distantly related species. The greater the similarity is, the closer the species are; i.e., the more similar their DNA sequences, the more recently the two organisms evolved from a common ancestor. For example, in the diagram, the horse and the donkey are seen to be more closely related than are the horse and the pig.

**Reading Comprehension (p. 152)**

25. We inherit the ordinary DNA found in our cell nuclei from both of our parents. However, the mitochondrial DNA in our cells comes only from one’s mother.

26. The scientists used the mitochondrial DNA to study the evolution of our own species, just as fossils are used to learn about other species that lived long ago.

27. The Mitochondrial Eve research provided the answer that all humans alive today evolved from one female who lived in Africa 200,000 years ago. This conclusion has raised many new questions about whether the original research was done correctly and about whether the conclusion that was reached was the right one. The evidence from Australia on “Mungo Man” seems to contradict the Mitochondrial Eve research.

**Chapter 12 Review**

**Multiple Choice (pp. 157–158)**

1. A 
2. B 
3. C 
4. A 
5. B 
6. B 
7. D 
8. D 
9. C 
10. B 
11. D 
12. D 
13. C 
14. A
15. The evolution of living things is an ongoing process because environments on Earth are always changing and populations change over time as they adapt to those changes (or die out).

16. B

17. The “adaptive value” of a trait in a population is determined by the specific conditions of the environment in which an organism lives and, thus, how well the trait helps the organism survive; e.g., the large ears of an African elephant help it get rid of excess heat in the hot savanna environment.

18. An example of one type of behavioral adaptation would be how an animal such as a squirrel will hide extra acorns when they are abundant so that it will have food during the winter when otherwise it would be scarce. This may behavior change over time if for some reason the environment changes and it would no longer be adaptive. Other behaviors in the population may be more adaptive and then they will be selected.

19. Natural selection affects development of behaviors by selecting for those that aid survival (i.e., are adaptive), so that organisms having them live to reproduce and pass on their genes. The behavior of an organism is related to the evolutionary process as follows: The adaptive behaviors are passed along (inherited) and reinforced.

20. A

21. C

22. C

23. C

24. A

25. B

26. Variations within a population will enable some organisms to survive changing conditions when those changes are not too severe or sudden. For example, if a climate cools slowly over time, those members of a population that are better insulated against the cold (e.g., extra fat or fur) will be able to survive and reproduce. However, in a mass extinction, the environmental changes are more dramatic. For example, the event that caused the extinction of dinosaur species was drastic, possibly due to the impact of an asteroid, which led to severe, global climate changes. The dinosaur populations could not adapt.

Reading Comprehension (p. 161)

33. Prairie dogs which are preyed on by black-footed ferrets are disliked by farmers and ranchers because the prairie dog tunnels interfere with crops and can cause injury to cattle.

34. Only 18 individuals remained and scientists wanted to protect and breed these to prevent extinction.

35. Prairie dogs are the main food source for black-footed ferrets.
Chapter 13 Review

Multiple Choice (pp. 170–171)

1. B 11. A
2. D 12. A
4. C 14. D
5. C 15. A
7. C 17. C
8. B 18. A

Analysis and Open Ended (pp. 171–173)

21. To do its job, the genetic material must be able to:
   (a) store enough information to make an organism;
   (b) make a copy of itself in order to pass along the
   information; (c) be strong and stable enough so that it
   does not easily fall apart; and (d) change slightly over
time, so that the species produces variations on which
natural selection can act.

22. The four DNA nucleotide bases are adenine (A),
thymine (T), guanine (G), and cytosine (C). They pair
as follows: A with T, and G with C.

23. The basic structure of DNA (as described by Watson
and Crick) is a double helix; i.e., it looks like a twisted
ladder with “rungs” that are composed of paired
nucleotide bases.

24. Scientists once thought DNA was too simple to con-
tain the genetic information because there are only
four nucleotide bases. They were wrong because it is
not simply the four bases but the linear sequences they
line up in that create the genetic messages.

25. C [A portion of molecule 2 may be formed differently.]

26. D [DNA from a dead organism can become active in
another organism.]

27. The genetic information within a DNA molecule is
arranged in a long, linear sequence of nucleotide sub-
units, or bases.

28. B (Their percentage of having the same proteins is high.)

29. C [DNA]

30. C [Nucleotide bases]


32. B [Proteins]

33. Students’ answer will vary but should include the fact
that DNA is the molecule that encodes all the genetic
information for all living things on Earth. This genetic
material is responsible for building bodies, determin-
ing traits, keeping organisms functioning by directing
synthesis of all proteins, and passing along these
instructions to each generation.

34. The nucleotides allow DNA to replicate by having the
ability to separate (bonds break via enzyme action), let
the two strands unwind, and then join up with free sub-
units floating in the cell to form two new, complete
double-stranded DNA molecules.

35. DNA replication occurs as follows: Through the action
of an enzyme, which breaks the bonds between the
base pairs, the DNA double helix separates and
unwinds; each strand serves as a template for the pro-
duction of a new, matching strand; many free subunits
float in the cell, and they are matched (according to
the sequence of subunits on each original strand) to
each of the subunits by the action of specific enzymes;
two DNA molecules result.

36. The molecule represented by Box A is DNA. Possible
explanations for how it serves as a template include:
The template serves as a pattern; the sequence of bases
in a DNA molecule serves as a pattern for the replica-
tion of that DNA molecule; the molecule in Box A
(DNA) serves as a pattern for the production of other
DNA molecules; the template serves as a pattern for
the eventual production of proteins; and the template
serves as a pattern for the formation of RNA.

37. B [Proteins]

38. Mutations are a change in the linear sequence of a
DNA molecule. Since the base sequence determines
the synthesis of proteins, mutations are usually harm-
ful and threaten survival. However, some mutations
do not produce harmful effects and may, in fact, be a
source of genetic variations that make an organism
better able to adjust to environmental changes.
39. Scientists formerly thought of repetitive DNA as “junk” because they did not understand its function (in terms of determining an organism’s larger size, etc.).
40. C [Large pumpkins contain a lot of repetitive DNA.]

**Reading Comprehension (pp. 173–174)**

41. The end section, or telomere, of a chromosome becomes a little shorter each time the cell divides. It has been suggested that the length of a telomere is related to the age of the cell it is in.
42. When a telomere becomes shortened to a certain point, it appears to tell the cell that it is too old to continue dividing any further.
43. The enzyme telomerase adds DNA to the ends of chromosomes, thereby preventing cell aging. When the enzyme becomes inactive, cells age and stop dividing. When the enzyme remains active, the cells continue dividing indefinitely.
44. The enzyme telomerase remains active in cells that continue dividing, such as cells that give rise to gametes and cancer cells (which result from uncontrolled cell division). By controlling the action of telomerase, scientists may be able to stop the uncontrolled growth of cancer cells.
45. The absence of telomerase may play an important role in the aging of cells. Thus, researchers are interested in the possible use of this enzyme to stop cell aging—if it can be done without causing uncontrolled (cancerous) cell growth.

**Chapter 14 Review**

**Multiple Choice (pp. 180–181)**


**Analysis and Open Ended (pp. 181–183)**

21. The order, or sequence, of bases in DNA determines the sequence of amino acids; and the order in which the amino acids are joined determines the proteins for which they code.
22. A [Proteins A and B have different functions and different amino acid chains.]
23. Possible answers: The change in amino acid sequence would reduce the ability of the hemoglobin molecule to combine with oxygen. The change in amino acid sequence would change the shape of the hemoglobin molecule, reducing its ability to carry oxygen.
24. The structures of DNA and proteins are similar in that they are both composed of subunits (nucleotide bases and amino acids, respectively) arranged in a linear sequence.
25. DNA is located within a cell’s nucleus, but protein synthesis must take place at the ribosomes out in the cytoplasm. RNA solves this problem by moving (a copy of) the genetic information out through pores in the nucleus to ribosomes in the cytoplasm.
26. Going from largest structure to smallest structure, the correct sequence is: nucleus → chromosome → DNA molecule → gene.
27. The process of copying DNA into RNA is similar to DNA replication in that, through the action of an enzyme, the double helix must unwind so that the bases are unpaired and the sequence can act as a template. The helix opens up where a specific gene, or base sequence, is located; then special enzymes match up the RNA subunits with the DNA subunits.
28. The bases must be grouped in triplets to represent amino acids because every living cell understands the same triplet code. Each different combination of three bases makes up a specific “word” or codon that stands for one of the 20 amino acids. A sequence of these amino acid triplet codes then contains the genetic information to make a particular protein.
29. Ribosomes, which are small organelles in the cytoplasm, help in the process of translation by being the site at which the nucleotide base sequence in the RNA is translated into the amino acid sequence that forms a protein.
30. The sequence of amino acids (read from left to right) would be: methionine—cysteine—valine—cysteine—proline
31. Possible answers: methionine—tryptophan—valine—cysteine—proline. So, the first cysteine would be replaced by tryptophan.
32. Possible answers: GGG and GGT both code for proline. So, the last three bases still code for proline; the same amino acid sequence is produced; and the same protein molecule will be produced.
33. Chart (from top to bottom): [This takes place first in nucleus:] DNA double helix opens up → [leads to enzymes carry this out within nucleus:] RNA subunits match up with DNA subunits → [followed by this at nuclear membrane:] new RNA molecule moves out
34. C [How Proteins Are Made]

35. RNA allows for translation from genetic base sequences to amino acid sequences by first changing the DNA code into the messenger RNA code, then bringing that sequence out to the ribosomes, where it can be translated into a sequence of amino acids, based on the triplet codes (codons).

36. The genetic code is called “universal” because all organisms on Earth use the same amino acid triplet codes to construct their proteins; i.e., the same codons (triplets) represent the same amino acids in every organism. This fact provides evidence for the common ancestry of all living things on Earth.

37. The order of bases in DNA determines the amino acid sequence of a protein. A mutation in a DNA molecule can translate into a different amino acid (i.e., a different triplet code), and this would result in a different sequence and thus a different protein being formed.

38. Given that the two different cell types (bone tissue and connective tissue) are from the same body: (a) It shows that gene expression is related to cell differentiation because different genes would have to have been expressed to produce each particular cell; (b) the different cell types would thus have different proteins, depending on their needs; and (c) all the cells have the same genetic information (DNA) since they are in the same body, but different genes are being expressed in each type of cell.

Reading Comprehension (pp. 183–184)

39. Scientists were surprised to find that humans may have only 30,000 genes, not 100,000 as had been expected.

40. There is much rearrangement of the domains in proteins, thus creating many more different proteins.

41. Genes themselves have segments that can be reshuffled in many ways to make new proteins.

Chapter 15 Review

Multiple Choice (pp. 191–192)

2. C  10. B
3. A  11. D
4. D  12. C
5. A  13. B
7. A  15. A
19. C

Analysis and Open Ended (pp. 192–193)

22. The survival of a species depends more on populations than on the individual organisms within them because all individuals will die, but reproduction within populations keeps the species alive.

23. The genetic material in a cell is the “blueprint” for how the cell is to be built and how it will function.


26. The chromosome number of any particular species is usually different from that of any other species because chromosome number is specific for each type of organism.

27. Duplication of chromosomes is necessary for cell division because each daughter cell must receive a complete set of chromosomes, i.e., the correct number for that species.

28. Cell division is important for living things as follows:
   • For one-celled organisms, it is the means by which they reproduce, i.e., asexually by replication and then division of their chromosomes, cytoplasm, and the organelles within.
   • For multicelled organisms, it is the means by which they grow in size, make new tissues, repair existing tissues, and, for some, reproduce asexually by cloning or budding.
   • A unicellular organism that relies on cell division for asexual reproduction would be the ameba (also the yeast cell, by budding). A multicellular organism that relies on cell division for asexual reproduction would be a strawberry plant (forms clones), a sea star (regenerates), or a hydra (budding). Humans are multicellular animals that rely on cell division to grow in size and to maintain vital structures and functions.

29. During cell division, the genetic material has to be equally divided first; this is the process called mitosis. Then, following mitosis, the cytoplasm of the parent cell is divided in two.

30. B [Asexual reproduction only]

31. Reproduction in the ameba is similar to reproduction in the yeast in that both reproduce asexually (via mitosis) by splitting into two cells. It is different in that the ameba parent cell divides into two equally sized...
daughter cells. Both receive the same amount of cytoplasm as well as the same genetic material and there no longer is a parent cell in existence. The yeast cell reproduces by budding. The bud receives the same genetic material as the parent cell, which it grows out of (and which still exists), but it receives less cytoplasm and is much smaller than the parent cell.

32. B. Diagram 2 represents asexual reproduction (by mitosis) because the parent cell (the large 2n cell) has replicated and divided its genetic material and cytoplasm evenly, producing two equal daughter cells (small 2n cells).

33. Yes, the rate of cell division does differ from one tissue type to another within multicellular organisms because the various cell types have different functions and life spans. This aids homeostasis in that cells are replaced at the appropriate rate; e.g., the millions of red blood cells have a short life span, so red blood cells divide more quickly than some other cells do.

34. Exposure to radiation and certain chemicals can cause uncontrolled cell division because they damage the cell’s genetic material, which controls cell functions such as replication and division. Uncontrolled cell division leads to development of the disease called cancer.

Reading Comprehension (p. 194)

35. The lymph system collects intercellular fluid from throughout the body and returns it through lymph vessels back to the bloodstream. The circulatory system transports blood throughout the body.

36. Anti-cancer drugs attack cancer cells by attacking DNA, by shutting down protein synthesis, or by stimulating the immune system.

37. Targeted drugs search out cancer cells and deliver a cancer-fighting drug directly to those cells.

Chapter 16 Review

Multiple Choice (pp. 201–203)

1. A 12. A
2. B 13. D
5. D 16. A
6. C 17. C
8. B 19. D
9. C 20. C
11. D 22. B

Analysis and Open Ended (pp. 203–204)

23. Chromosomes contain the genetic material (DNA), which determines the characteristics of an organism.
24. Sexual reproduction is “all about the chromosomes” in that the sorting, recombining, and joining of genes on the chromosomes of two individuals lead to great genetic variation in the offspring.
25. During the process of fertilization (in sexual reproduction), the nuclei of two sex cells, or gametes, join to form the fertilized egg cell, or zygote.
26. Gametes are essential to sexual reproduction because they contain half the normal chromosome number for their species. When their nuclei join, the resulting zygote contains the correct chromosome number, i.e., the double set of chromosomes.
27. Process 2 restores the normal species number of chromosomes. Fertilization is necessary to produce offspring.
28. Possible answers: Cells resulting from Process 1 have half the number of chromosomes as cells produced by Process 3. Cells produced by Process 1 are sex cells and those produced by Process 3 are body cells.
29. Mutations in gametes may be passed on to offspring. Mutations occurring in body cells are not passed on to offspring.
30. This simple form of sexual reproduction has an advantage because it allows for the introduction of new genes into the population; the recombination of genes from two parents gives more genetic variability to the offspring.
31. In mitosis, the resulting chromosome number in each daughter cell is 2n, the same as the parent cell. In meiosis, the resulting chromosome number of each sex cell is 1n (half the normal body cell number).
32. C [fertilization]
33. C [A and B]
34. C [C only]
35. C [Diagram 3 represents meiosis]
36. Offspring of parents that reproduce sexually are not identical to their parents because of crossing-over during meiosis and the combination of genes from two parents.
37. Asexual reproduction results in offspring that are usually genetically identical to the parents. This is because the offspring receive all their genetic information from one parent. Sexual reproduction involves meiosis (with crossing-over) and the joining of genes from two parents, so the offspring vary; asexual reproduction does not.
38. During meiosis, (A) the double set of chromosomes lines up and parts of them overlap; (B) pieces of each chromosome (i.e., genes) cross-over and get exchanged;
(C) the double set of chromosomes separates after the exchange of genes has occurred. The chromosomes in step A are still like those of the parent; the chromosomes in step C have a new combination of genetic material, since some genes have been exchanged between them.

39. This process of crossing-over is significant because it produces greater variability among the offspring.

40. In flowering plants, sexual reproduction takes place within the flower, where the sex organs are located. Sperm cells (pollen) from the male part (anther) travel down the female part (style) to fertilize egg cells within the flower’s ovary.

41. C [Fertilization within the body of a female parent]

42. C [Materials are exchanged between fetal and maternal blood]

43. Possible answers for why some species lay hundreds of eggs: Many eggs do not get fertilized. Many eggs are eaten by predators. The death rate for the developing young is very high. The eggs are exposed to hazards of the environment.

44. Possible answers for why fertilization in reptiles and birds must be internal: The egg is surrounded by a shell (to protect it during external development) that the sperm could not penetrate outside the body of the female. Thus, the sperm must fertilize the egg before the shell is formed, i.e., inside the female.

Reading Comprehension (pp. 204–205)

45. Joseph’s doctor ordered hormone and chromosome tests for him because he was 16 years old but showed no signs of sexual maturity.

46. The genetic explanation was that, while males normally have one X and one Y chromosome, Joseph (due to an error that occurred during meiosis) had two X chromosomes along with the one Y chromosome. Each of his cells had 47, rather than the normal 46, chromosomes.

47. Genetics counseling informed Joseph (and his family) about the cause of his symptoms.

Chapter 17 Review

Multiple Choice (pp. 216–218)

1. D 8. C
2. B 9. A
3. A 10. C
4. C 11. D
5. B 12. C

16. A 22. A
17. C 23. B
18. D 24. C
19. A 25. D

Analysis and Open Ended (pp. 218–219)

27. Mendel can be called the founder of the science of genetics because he was the first person to conduct hundreds of experiments on heredity, to apply mathematical analysis to his work, and to propose several ideas, or laws, about inheritance based on his results.

28. Mendel noticed that the “factors” that went from parents to offspring among pea plants were passed in individual units and in specific and predictable patterns of inheritance.

29. C [A pair of matching chromosomes]

30. D [The gene for a trait is at same place on matching chromosomes.]

31. A [A single trait can be determined by more than one gene.]

32. Fur color in Siamese cats demonstrates that the expression of genes is often influenced by environmental factors. The gene that codes for the enzyme that produces dark fur depends on temperature; i.e., it is only expressed on those parts of the cat’s body that have a lower temperature. This is adaptive in that the dark fur on the extremities would absorb more heat, thus helping to keep these parts of the cat warm.

33. C [Allowed the gene for dark fur to be expressed]

34. Hemophilia is a sex-linked trait and the gene for it is recessive. The disorder occurs more frequently in males than females because for a female to have it, she must have the recessive gene (allele) on both X chromosomes; but if a male inherits just one recessive gene (i.e., on the X chromosome), he will have the disorder. (The Punnett square in Figure 17-9, on page 212, shows this kind of inheritance pattern, the same as in color blindness.)

35. Humans have altered the characteristics of plants or animals by doing genetic crosses of preferred traits in, e.g., the following: disease-resistant crops; higher-productivity crops; sheep with thicker wool; chickens that lay bigger eggs; and cows that produce more milk.

36. When people carry out specific genetic crosses, they are working with organisms that reproduce sexually, since they are combining the best of those traits from both parents.
Reading Comprehension (pp. 219–220)

37. Chart of researchers who helped develop better breeds of corn:

<table>
<thead>
<tr>
<th>Genetic (Corn) Researcher</th>
<th>Contribution to Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Lorain (in 1812)</td>
<td>Did experiments to show that a hybrid corn produced a greater yield than either parent plant produced.</td>
</tr>
<tr>
<td>George H. Shull (by 1910)</td>
<td>Developed corn hybrids that increased yields 25 to 50 percent.</td>
</tr>
<tr>
<td>Edward M. East and Donald F. Jones (in 1917)</td>
<td>Crossed two hybrid corn varieties to produce the first highly productive corn to be grown commercially.</td>
</tr>
</tbody>
</table>

38. This new breed of corn is resistant to pests. It has now been found growing wild in Mexico where it could begin to spread quickly and compete with native corn species.

39. The study of genetics gave researchers the information needed to develop totally new corn varieties that could be grown commercially, thus producing more and better quality food for millions of people throughout the world.

Chapter 18 Review

Multiple Choice (pp. 228–229)


Analysis and Open Ended (pp. 229–230)

13. Recombinant DNA is different from the traditional practice of selective breeding of plants and animals because now new genes (i.e., genes from different species) can be put into organisms to change their genetic makeup.

14. Three examples of how recombinant DNA technology is being used today include:
   - genes that make crops disease-resistant are added to agricultural plants;
   - genes from one type of animal are added to another type to make it grow faster;
   - bacteria are engineered to use a human gene to produce insulin (for diabetes).

15. Embryonic stem cells have not yet become specialized. They have the ability to become almost any tissue in the body.

16. Tissues grown from stem cells may help cure diseases such as diabetes, Alzheimer’s, and Parkinson’s, as well as spinal-cord injuries.

17. Possible reasons why Human Genome Project is important for human health: scientists hope to cure (diagnose) diseases; scientists can replace defective genes with normal ones (gene therapy); gene replacement may improve the health of humans.

18. Possible reasons why scientists must use only certain enzymes when moving genes: different enzymes will cut DNA at different locations; they must be careful to use the enzyme that will splice out only the target gene; the wrong enzyme may cut out a normal gene.

19. The discovery of restriction enzymes in the 1970s advanced genetic engineering by enabling scientists to cut DNA at only the target gene. The restriction enzymes, which recognize and cut specific base-pair sequences, are used to cut a piece of DNA from one organism and then insert it into the DNA of another one, where it can replicate.

20. Vectors are the special molecules that scientists have developed to move pieces of cut DNA from one organism to another; e.g., to move a human gene (via a vector) into a bacterial cell.

21. Possible substances that can be produced by this biotechnology procedure include: insulin, which is used in the treatment of diabetes; human growth hormone, which can increase bone density in the elderly; hormones that may reduce the cost and side effects of replacing missing body chemicals.

22. Recombinant DNA process (per diagrams) is as follows: (a) restriction enzyme makes cut in bacterial (vector) DNA; (b) free ends of bacterial DNA are exposed; (c) DNA fragment with useful genes is chosen; and (d) DNA fragment has been inserted into bacterial DNA.

23. Possible answers re: how biotechnology can be used to diagnose a genetic disorder: sickle cell anemia, microscopic examination of blood, low oxygen supply to the cells; Down syndrome, karyotype analysis, mental retardation; PKU, urine analysis, mental retardation.

24. Biotechnology can be used to detect a disease even before its symptoms appear because the gene that causes the disease can be identified in a person’s DNA, sometimes even in utero.

25. Genetic engineering process (per diagrams) is as follows: (a) the desired gene (in this case, for insulin) is located on the human chromosome; (b) the gene is
inserted into the vector (circular bacterial DNA) molecule; (c) bacteria receive the vector, which contains the gene for producing insulin; and (d) the insulin is collected for use by people who have diabetes.

26. (3) [Genetic Engineering and Medicine Production]

27. Students’ answers will vary, but probably should mention that this safety precaution (to have genetically modified bacteria survive only in the laboratory) is most likely intended to protect the public from any possible contact with bacteria that otherwise might escape and possibly have a different effect, or mutate, in outside environment.

28. Sickle-cell anemia is a disorder that is caused by a single-gene defect, which causes one amino acid to be substituted for another in the hemoglobin. Hemoglobin is a complex protein molecule; with the normal amino acid sequence, it can carry oxygen to all body cells. The mutation reduces the ability of red blood cells to carry oxygen.

29. The genetic disorder phenylketonuria prevents a newborn from producing the enzyme that breaks down the amino acid phenylalanine. (As a result, phenylalanine builds up in the baby’s blood and causes mental retardation.) Routine tests for this disease are now done on newborns. With such early detection, the baby’s diet can be changed to prevent the disease’s effects from developing, and the child can lead a normal life.

30. Prenatal diagnosis can help a couple with a history of a genetic disorder make informed decisions about the children they may have; alert them to the need for in utero treatments; and/or lead to early detection and treatments for their newborn.

**Reading Comprehension (pp. 230–231)**

31. Physical evidence, i.e., the pattern of tooth marks, was used for the conviction in 1991; but DNA testing on saliva was used to release Mr. Krone from prison in 2001.

32. A national computerized database of DNA profiles of convicted offenders has been created to help solve crimes.

33. The technology is being miniaturized and made portable so DNA samples can be tested and analyzed quickly at the crime scenes.
UNIT V

Environmental Systems and Interactions

Chapter 19 Review

Multiple Choice (pp. 246–248)

1. B 17. C
2. D 18. A
3. B 19. A
4. C 20. C
5. D 21. A
6. C 22. C
7. D 23. B
8. A 24. D
9. B 25. A
10. A 26. C
11. C 27. C
12. D 28. A
13. A 29. D
15. A 31. D
16. A

Analysis and Open Ended (pp. 248–250)

32. In an environment, all the living things are biotic factors and all the nonliving things are abiotic factors. For example, in a pond environment, a frog and a lily pad are both biotic factors; the water and the sunlight reaching it are both abiotic factors.

33. Possible answers for an abiotic factor that would affect survival of organism A (the fish) include oxygen level and water temperature.

34. Every organism is adapted to live in a particular type of habitat. How the organism acts to survive in that habitat, e.g., how it avoids predators and what it eats, makes up its niche. Thus, the organism’s niche determines its habitat because it needs the particular factors provided by that habitat for its survival. For example, river otters have to live in streams and rivers because they are adapted for a life of swimming and catching fish.

35. A limiting factor, such as moisture, determines the kinds of organisms that can live in an area. For example, in very warm areas with abundant rainfall, there are tropical forests; in warm areas with limited rainfall, there are grasslands (since there is not enough moisture to support tree growth). In turn, different kinds of animals are found in these areas; this depends on whether they are adapted to live in a forest or grasslands environment.

36. The three main limiting factors in the ocean are temperature, salinity, and sunlight. The temperature and saltiness of ocean water vary from place to place, and both of these factors affect water density (the colder and saltier, the more dense it is). Organisms have different tolerances for these variations in temperature, salinity, and density. In addition, sunlight penetrates only about 200 meters below the water surface; this restricts the growth of algae and aquatic plants to that area, which in turn limits the survival of some aquatic animals to that upper zone.

37. Population growth is more rapid when density is low because there is usually sufficient food and space for the organisms, so the birth rate increases while the death rate drops.

38. C [The population grows while it is below carrying capacity.]
39. C [Is neither growing nor shrinking]
40. The size of the paramecium population levels off (to stay the same size) as it approaches carrying capacity.
41. Competition for food and space is usually greatest among members of the same species because they occupy the same niche, i.e., they need the same resources to survive. This competition results in natural selection because individuals with variations that help them obtain these limited resources will be more likely to survive and pass on their genes.

42. B [Mice and chickens compete for grain.]
43. B [Reducing competition for mice because the birds occupy separate niches]
44. Students’ answers will vary, but could include something like the following: leopards are carnivores that sometimes compete with lions and hyenas for access to prey, such as warthogs and antelopes; they may compete for safe areas (in trees and in the grass) in...
which to eat prey, rest, and raise their young, and possibly for safe access to waterholes. Squirrels in urban areas may compete with songbirds such as sparrows for access to seeds in bird feeders, water in birdbaths or fountains, and nest sites in trees or in buildings.

45. Predation and parasitism compare as follows:

- **Predation** is a basic relationship between organisms in which one type of organism, the predator, feeds on another living organism, the prey.
- **Parasitism** is a type of relationship between organisms in which one type of organism, the parasite, uses another organism, the host, as its source of food and, sometimes, shelter.
- Predation and parasitism are similar in that, in both interactions, one organism is helped while the other organism is harmed.
- They are different in that, in predation, the prey is usually killed right away (and consumed) while, in parasitism, the host usually continues to live for quite a while, but it is harmed.

46. C [One party benefits and the other is apparently unaffected]

47. D [Abrupt environmental upsets can cause long-term changes in an ecosystem.]

48. B [Species are replaced until a stable land ecosystem is established.]

49. B [fish]

50. Answer will vary; factors that might disrupt the final stage could include: natural disasters (such as fire, flood, and so on); human activity; disease; introduction of a new species; abrupt climatic change.

**Reading Comprehension (pp. 250–251)**

51. The baby elephant was very charming to watch and no other elephant had been born in New York in the last 10,000 years.

52. The baby elephants in both zoos were Asian elephants and both of them died within just two years after being born.

53. The fact that the herpes virus infects and affects both types of elephants shows that the two species are closely related. However, the fact that the effects are relatively minor in African elephants but potentially deadly in Asian elephants shows that there are also important physiological differences between the two elephant species.

54. If the symptom of the herpes infection (which is now known for baby elephants) is noticed early on, a new drug that has been developed to fight viral infections in humans (famciclovir) can be used successfully now to treat infected elephants.

**Chapter 20 Review**

**Multiple Choice (pp. 259–260)**

1. B
2. B
3. A
4. C
5. A
6. B
7. B
8. C
9. C
10. B
11. C
12. D
13. B
14. C
15. C
16. B
17. B
18. D
19. B
20. A
21. A
22. A
23. B
24. C
25. B
26. C

**Analysis and Open Ended (pp. 260–264)**

27. Humans change the land through agriculture by cutting down forests to create farmland. The nutrient-rich topsoil (which takes hundreds of years to form) is depleted of minerals by intensive farming, and the loss of forest cover leaves the soil vulnerable to erosion by wind and water. This leads to a diminished habitat for wildlife, which may lose sources of food, access to breeding grounds, and also may encounter pollutants in their environment.

28. Industrialization has changed the types of wastes produced by humans such that—in addition to there being greater quantities of sewage and garbage produced—many wastes now contain harmful chemicals and do not decompose readily, thus posing health risks.

29. A landfill built near an aquatic ecosystem may cause harm to it if some toxic chemicals dumped in the landfill are leached out and carried to the nearby body of water.

30. Nitrate pollution in the brook increased after flowing through deforested area.

31. Possible answers: Trees absorb nitrates and when trees are removed, fewer nitrates are absorbed; nitrates from topsoil are washed into the brook; nitrogen cycles are disrupted in deforested areas; debris from deforestation entered the brook and decomposed; deforestation increases nitrate runoff into the brook.

32. Toxic waste dumps are most harmful to the environment because they contain chemical and radioactive substances, which do not decompose (within any animal’s life span) and which can leach into the environment and enter food chains, concentrating at each level.
33. Good topsoil is considered valuable because it contains the nutrients necessary for healthy growth of crops and for the support of ecosystems on land. In addition, it takes hundreds of years for natural processes to form just a few inches of topsoil (which is an accumulation of organic and inorganic matter). Three human activities that cause soil loss are livestock overgrazing and poor farming practices; contamination of the soil by toxic chemicals; and cutting down of trees and other plants, which leads to soil erosion.

34. D [A decrease in dissolved oxygen and a decrease in most fish populations]

35. B [Carp, because it can live in poorly oxygenated water]

36. The power plant will increase the temperature of the river water. The dissolved oxygen content of the river water will decrease, causing a negative effect on most fish species. Some fish species may increase in number while others may decrease. The population of trout (and/or bass) may decrease; the carp population may increase. If the oxygen level decreases below 2 ppm, no fish will survive.

37. Sewage treatment is important to people and to wildlife because both need clean fresh water to drink (and bathe in), and aquatic animals in particular, such as fish and frogs, need clean, well-oxygenated water in which to live and breed.

38. The burning of fossil fuels, to power cars and run factories, results in the release of car exhaust and factory emissions to the air. These emissions contain gases and tiny particles of harmful chemicals such as sulfur dioxide and nitrogen oxide, which (when combined with water droplets in the air) produce acid rain. To reduce the emission of these chemicals, car engines and factory smokestacks now have built-in pollution control devices.

39. B [The air pollution in Baltimore is increased by pollution from other areas.]

40. The illustration shows how acid rain is an air pollutant and a water pollutant in that factory emissions containing sulfur and nitrogen are spewed into the air in the form of gases and particles that disperse on the wind. When they combine with water droplets in the air, they form acid rain, which falls to the ground as a form of water pollution.

41. These factory emissions disperse as gas and dust particulates high in the atmosphere and far from the factories that spewed them. When they are blown east with the prevailing winds, these chemicals may form acid rain; this falls on forest and aquatic ecosystems, changing the pH of the local water and causing harm to plants and animals.

42. The hypothesis may be: as the pH decreases, the bean plants will grow faster; bean plants will grow faster in normal rain than in acid rain. The independent variable is the pH level. And two factors that should be kept constant may include the type of soil, growing conditions, amount of liquid, type of bean plant, and the temperature.

43. A proper data table for organizing results must include separate labeled columns for the independent and dependent variables.

44. B [Steadily increasing]

45. B [As the amount of CO₂ in the air increases, the average temperature increases]

46. Global warming is an increase in average temperature of the atmosphere. Human activities that contribute to global warming and explanation of how include: burning fossil fuels adds CO₂ to atmosphere; factories and cars add CO₂ to the atmosphere; deforestation reduces photosynthesis and reduces CO₂ removal from the atmosphere. One negative effect of global warming if it continues for many years includes: the melting of polar icecaps and major flooding; becomes too hot for people to live; an increase in disease. (Note: Stating only that Earth is getting hotter is not acceptable without further information illustrating the negative effect.)

47. One negative effect the holes in the ozone layer can have on humans is that more UV rays (radiation) reach Earth, causing an increased incidence of sunburn and increased incidence of skin cancers (from DNA mutations) and/or cataracts. (Note: Reference to global warming or greenhouse effect is not acceptable.)

48. Chlorofluorocarbons (CFCs) are thought to be causing the depletion of the ozone layer. Many countries signed an agreement in 1987 to limit or ban the use of these chemicals.

49. Chart of some ecological problems:

<table>
<thead>
<tr>
<th>Ecological Problem</th>
<th>Cause (by humans)</th>
<th>Negative Effect</th>
<th>Positive Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming</td>
<td>Cars and factories burning fossil fuels</td>
<td>Changes in weather patterns; loss of icecaps; increase in floods and storms</td>
<td>Alternative energy sources; scrubbers in factories; public transportation</td>
</tr>
<tr>
<td>Destruction of ozone layer</td>
<td>Use of CFCs in aerosols</td>
<td>Increased exposure to UV rays; cancer and cataracts</td>
<td>Reduce use of CFCs in aerosols</td>
</tr>
<tr>
<td>Acid rain</td>
<td>Industry producing air pollution (sulfides, nitrates, etc.)</td>
<td>Lowers pH of some lakes, which kills aquatic animals; also harms trees</td>
<td>Remove chemicals from the exhaust before it leaves the factory</td>
</tr>
<tr>
<td>Fertilizer runoff</td>
<td>Increased amounts of nitrogen and phosphorus in lakes</td>
<td>Rapid aging of lakes</td>
<td>Use less fertilizer</td>
</tr>
<tr>
<td>Loss of biodiversity</td>
<td>Destruction of habitat; cutting down of forests</td>
<td>Loss of sources of medicine; loss of many species</td>
<td>Set up protected areas; restrict logging; restore wetlands</td>
</tr>
</tbody>
</table>
50. Possible answers for methods to reduce chemical pollution: Pollution controls on cars have reduced the amount of pollutants in the air; the use of biological controls has reduced the amount of pesticides being put in the environment; methods of organic farming have reduced the amount of fertilizer and thus reduced chemicals added to the environment.

51. Possible answers for how humans have made the environment less stable: Changing the chemical composition of air, soil, and water (e.g., releasing more waste products of combustion to pollute the atmosphere); reducing the biodiversity of an area (e.g., large areas of the rain forest in Brazil have been cut down); introducing advanced technologies (e.g., returning cooling water from nuclear power plants to bodies of water has raised their temperature, making them less fit for certain species).

52. A [Global warming]

53. Possible answers for how decline in amphibians can disrupt ecosystems: It reduces the biodiversity in these areas; their prey populations may increase; food chains are disrupted; their predators are denied food.

54. D [Two times the size it was in 1960]

Reading Comprehension (p. 264)

55. The melting of Antarctic Ice would raise sea levels worldwide, flooding many coastlines where people live.

56. If the ice shelves melt, then the land ice will melt more quickly, causing sea levels to rise.

57. A satellite in orbit around Earth is precisely measuring changes in the Antarctic ice sheets.

Chapter 21 Review

Multiple Choice (pp. 272–273)

1. D 10. B
2. A 11. C
4. D 13. C
5. C 14. C
6. B 15. D
7. D 16. A
8. A 17. A
9. B

Analysis and Open Ended (pp. 273–274)

18. While it is important to “think globally” and care about the health of the entire biosphere, it is probably most useful to “act locally” by becoming involved in local environmental issues and doing your part to recycle, conserve resources, reduce pollution, and so on.

19. The “3Rs” of environmentalism are to reduce, reuse, and recycle natural resources. For example, you can reduce consumption of certain products (e.g., paper plates), reuse plastic containers, and recycle aluminum soda cans to conserve limited resources.

20. It is important for industries to be involved in recycling programs because they make the products that come from our limited natural resources; so they can provide an important example of conservation by reusing some materials in other products.

21. Comparison of renewable and nonrenewable resources:
   • A renewable resource is one that can be replaced by natural processes within a generation. A nonrenewable resource is one that cannot be replaced within our lifetime; its supply is limited and it takes a very long time to form by natural processes.
   • Examples of renewable resources are trees (if replanted) and animals (if not overhunted).
   • Examples of renewable energy sources include solar, wind, geothermal, and falling water.
   • Two examples of nonrenewable resources are coal and natural gas (also oil and metals).

22. Possible answers: Trees are a renewable resource; they can be replanted if they are being depleted. Gasohol can be made from corn; when the source is depleted you can grow more corn.

23. Concept map on natural resources (from top to bottom):
   [Renewable resource used for products comes from] trees (lumber); [Renewable resources used for energy come from] flowing water, geothermal energy, sunlight, wind power, wood (charcoal); [Nonrenewable resources used for products come from] (Metals:) copper, gold, silver; (Nonmetals:) limestone, gravel, sand; [Nonrenewable resources used for energy come from] oil, coal, natural gas.

24. The term sustainable development refers to a plan for improving the way we live without harming the environment (or doing as little harm as possible to it). An example would be to cut trees for lumber by doing selective logging rather than clear-cutting and by planting seedlings to replenish the forest and protect wildlife habitat at the same time.

25. The teenagers in the photograph (Figure 21-2) are recycling newspapers, an activity that helps to conserve a resource that comes from wood. In that way, fewer trees may have to be cut, which is one way to help conserve forests and protect wildlife in them.

26. Protection of habitats helps to enforce the Endangered Species Act by conserving those wilderness areas in which many endangered or threatened species of plants and animals live; protecting an area of rain forest also protects rare birds and monkeys living in it.
27. The method of clear-cutting shown in Figure 21-6 damages habitats on land by destroying the territory of wild animals and by causing the erosion of topsoil (which prevents further plant growth). It destroys habitats in the water when runoff from rain carries the soil into nearby streams, polluting the water and disturbing life functions of aquatic life-forms.

28. People in developing nations live closer to (and depend more directly on) the kinds of habitats and wildlife that people in developed nations often want to protect. For example, a tropical forest that is set aside as part of a conservation program may once have been the source of food, fuel, and building materials for the local people.

29. The “parks for people” program can help local people and the environment at the same time by giving such people the opportunity to earn a living from their environment (e.g., as tourist guides or park rangers) without doing harm to the habitat or wildlife.

30. Students’ answers will vary, but could mention that all nations should be involved in the efforts to protect the biosphere because all ecosystems are interconnected. The impacts of air and water pollution, loss of forests and wildlife, and changes in weather patterns are not restricted by national boundaries; they have a global effect.

31. Students’ answers will vary, but could mention such changes as recycling paper goods, such as newspapers; recycling aluminum soda cans; recycling plastic containers; turning off the lights and other electrical appliances when you leave a room; taking baths instead of showers to conserve water (or just using less water whenever possible); eating lower on the food chain, e.g., less meat, more grains (for conserving more forests and generating less livestock-sewage runoff).

32. Students’ answers will vary, but could mention such community actions as setting up regulations for recycling; building a recycling center; providing a lane for bicyclists and/or providing adequate bus service (to reduce car pollution); enforcing clean air regulations; providing a sewage system that leads to a treatment center (rather than raw sewage runoff into waterways); and conserving parks and ponds that provide habitat for local wildlife.

Reading Comprehension  (pp. 274–275)

33. C [Solving a pollution problem by speeding up natural processes]

34. An ecological problem associated with the dig-and-dump method would include: That method is messy; it only moves the contaminated soil from one place to another; and it adds wastes to landfills that are already overloaded.

35. A [Carbon dioxide and water]

36. Possible answers for why the cleanup of the site took only four months: Air, water, and fertilizer were piped into the biocell, which sped up the natural process; an increase in the number of bacteria decreased the time necessary for the breakdown of the contaminants; and the bacteria were stimulated to reproduce more rapidly.

37. D [Heavy metals such as lead]
Practice Test 1 (pp. 277–282)

Part 1

1. C 9. A
2. D 10. C
3. D 11. B
4. D 12. C
5. D 13. D
7. B 15. B
8. D

Part 2

16. C 24. D
17. D 25. C
18. D 26. D
20. A 28. C
22. B 30. D
23. A

Part 3

31. B 39. D
32. A 40. C
33. C 41. D
34. C 42. B
35. A 43. D
36. D 44. C
37. D 45. D
38. D

46. • The role of enzymes in humans includes: they catalyze chemical reactions; affect the rate of reactions; help synthesize proteins; and speed up digestion.
• The effect of a high body temperature includes: the activity of enzymes will slow down; enzymes will not catalyze reactions as quickly; and the enzyme molecules may change shape and be unable to function.
• A high body temperature can result in death because: the enzymes do not work; chemical reactions necessary for life do not take place fast enough to maintain life; and the distorted shape of the enzyme no longer matches the substrate.

Scoring Guide for the Open-Ended Item

3-Point Response
The student response is reasonably correct, clear, and satisfactory. It demonstrates an understanding of the role of enzymes in the human body; the effect of high temperature on enzyme function; and of the reasons why this can result in death in humans.

2-Point Response
The student response has minor omissions and/or some incorrect or irrelevant information about the role of enzymes in the human body; the effect of high temperature on enzyme function; and/or of the reasons why this can result in death in humans.

1-Point Response
The student response includes some correct information, but most information included in the response is either incorrect or irrelevant; student does not state the role of enzymes in the human body; the effect of high temperature on enzyme function; and/or the reasons why this can result in death in humans.

0-Point Response
The student attempts the task, but the response is incorrect, irrelevant, or inappropriate. Student does not correctly identify the role of enzymes; the effect of high temperature on their functions; and the effect this can have on human health.

Practice Test 2 (pp. 283–290)

Part 1

1. D 9. A
2. C 10. A
5. C 13. C
7. D 15. C
8. C
46. • Possible answers describing the functions of two organelles could include: the cell membrane allows oxygen, carbon dioxide, and water to enter a cell; a chloroplast uses water and carbon dioxide to make glucose; the mitochondria use food (glucose) and oxygen to release energy. • An explanation of how the two organelles work together could include: the cell membrane allows carbon dioxide to enter a plant cell to be used by chloroplasts in photosynthesis. • An organelle and a body system with similar functions could include: the food vacuole and digestive system; cell membrane and respiratory system; nucleus and nervous system.

Scoring Guide for the Open-Ended Item

3-Point Response
The student response is reasonably correct, clear, and satisfactory. It demonstrates a good understanding of the functions of two organelles; clearly explains how these two organelles work together in the cell; and identifies a body system with similar functions to that of a particular cell organelle.

2-Point Response
The student response has minor omissions and/or some incorrect or irrelevant information; student identifies the functions of only one organelle; provides incomplete information about how two organelles work together in the cell; and shows a limited understanding of how a body system resembles an organelle.

1-Point Response
The student response includes some correct information, but most information included in the response is either incorrect or irrelevant; student does not correctly describe the functions of two organelles; about how they work together in the cell; and/or identify a body system with similar functions.

0-Point Response
The student attempts the task, but the response is incorrect, irrelevant, or inappropriate. Student does not correctly identify two organelles; provides no information about how any organelles work together in a cell; and does not identify a body system with similar functions.
UNIT I
Scientific and Laboratory Procedures (5.1, 5.2, 5.3, 5.4)

Sample Prompt: How Do We Learn?

OVERVIEW
Learning is a complex process in all organisms. We can begin to understand the process of learning by identifying some of the methods by which humans learn. We learn by:

- repetition—observing and copying the actions of others
- trial and error—repeating the efforts until a solution is found
- memorization—a way to increase our body of knowledge
- reasoning—drawing conclusions based on past experiences

In this investigation, you and your classmates will complete various tasks in order to study these methods of learning.

MATERIALS
Letter “L” puzzle pieces in an envelope; word lists A, B, and C on separate pieces of paper

YOUR TASK
Part A—The Letter “L” Puzzle

1. Work in pairs. Each pair should take an envelope that contains the pieces of the letter L puzzle.

2. One member of the pair will act as a timekeeper. That person should time how long it takes for the other person to solve the puzzle. The other person should be ready to begin to arrange the puzzle pieces into the letter L when the timer says “go.” The timer looks away from the person solving the puzzle.

3. For the second trial, the members of the pair should reverse roles and repeat step 2.

4. Repeat this process until each person has solved the puzzle three times.

5. Prepare a bar graph that shows the elapsed time of each trial on the vertical axis and the trial number on the horizontal axis.
### Part B—Word Lists

1. Work by yourself. Carefully read through list A three times. Put this list away. On a blank piece of paper, write down all the items on the list that you can remember. Try to write the words in the same order as they appeared on the list.

2. Repeat step 1 with list B.

3. Repeat step 1 with list C.

4. Determine your score for each list. Count one point for each item in the list you remembered. For the purposes of calculating your score, the order of the items recalled does not count.

### INTERPRETIVE QUESTIONS

1. What evidence was there that learning occurred in this activity? What were the primary methods by which learning occurred?

2. Discuss how the learning activity in this investigation is related to the skills and habits needed to become a successful learner.

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**Letter L Puzzle**

<table>
<thead>
<tr>
<th>List A</th>
<th>List B</th>
<th>List C</th>
</tr>
</thead>
<tbody>
<tr>
<td>vip</td>
<td>shoe</td>
<td>away</td>
</tr>
<tr>
<td>lor</td>
<td>book</td>
<td>with</td>
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<tr>
<td>zub</td>
<td>grass</td>
<td>recipes</td>
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<td>maf</td>
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<td>baz</td>
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<td>of</td>
</tr>
<tr>
<td>caj</td>
<td>fruit</td>
<td>cooks</td>
</tr>
</tbody>
</table>

Adapted from *Human Biology*, Board of Education of the City of New York, Brooklyn, N.Y., 1983.
UNIT II
Matter, Energy, and Organization of Living Things (5.5.12 A)

Sample Prompt: How Does Exercise Affect Our Heart and Respiratory Rates?

OVERVIEW

Exercise increases the demand by the cells of your body for oxygen, resulting in an increase in the rates of respiration and circulation. This can be measured by comparing the output of carbon dioxide with the pulse rate before and after exercise. In this investigation, you will participate in a study to determine the effects of jogging on your respiratory and circulatory systems.

MATERIALS

Test tube rack with three test tubes, phenolphthalein solution (pink), drinking straws, watch or clock with a second hand

Note: Caution should be used when handling chemicals such as phenolphthalein. Protective eyewear should be worn while performing the CO₂ test.

YOUR TASK

1. Prepare a Data Table to show the heart-rate data and carbon dioxide (CO₂) test data (1) at rest, (2) after 1 minute of jogging, and (3) after 5 minutes of jogging, for four trials (one per student) and for the average of the four trials for each of the three test conditions.

2. For this laboratory investigation, you will work in groups of four. Each member of the group will take turns being the jogger. While one person is jogging, the other three group members will keep time, take the pulse of the jogger, and record the results.

3. For Trial 1, select one member of the group as the jogger. Pour an equal amount of pink phenolphthalein (about 2.5 centimeters) into each of three test tubes. Be sure that the level in all three tubes is the same. The rate of respiration is determined by the CO₂ test, which measures the amount of carbon dioxide released. Due to CO₂ in your breath, blowing gently through a straw into phenolphthalein in a test tube causes the pink color to disappear and the solution to become clear. The time required (in seconds) to change the color of a measured amount of phenolphthalein by exhaling into it is the CO₂ test result, and it can be used as an indicator of respiratory rate. Have the jogger at rest perform the CO₂ test. Take his/her pulse rate to measure heart rate. Record your results on the Data Table.

4. The jogger now jogs in place for 1 minute. As soon as the exercising is done, repeat the measurements in step 3 for the CO₂ test using the second test tube and the heart rate. Record your results in the Data Table.

5. The jogger now jogs in place for 5 minutes. As soon as the exercising is done, repeat the measurements in step 3 for the CO₂ test, using the third test tube and the heart rate. Record your results in the Data Table.
6. Rinse out the test tubes and refill with pink phenolphthalein, again about 2.5 centimeters per tube. Select another group member as the jogger. Repeat steps 3 through 5 with the second jogger for Trial 2. Record your results in the Data Table.

7. For Trials 3 and 4, repeat as above with the other two members of the group as the joggers.

8. Compute the averages for the CO₂ test and the heart-rate data for the four trials of the three test conditions: at rest; after 1 minute of jogging; and after 5 minutes of jogging.

9. Using the averages of the results, prepare three graphs as follows: Graph 1—Heart Rate vs. Minutes of Exercise; Graph 2—CO₂ Test/Color Change (in seconds) vs. Minutes of Exercise; and Graph 3—Heart Rate vs. CO₂ Test/Color Change (in seconds).

INTERPRETIVE QUESTIONS

1. Explain why carbon dioxide exhalation can be used as a measure of respiratory rate in humans.

2. How might the concentration of carbon dioxide in the blood act as a signal for an increase in heart rate?

3. Explain the correlation between the heart rate and the respiratory rate shown in Graph 3.
UNIT III
Diversity and Biological Evolution (5.5.12 B)

Sample Prompt: How Have Animals Evolved Over Time?

OVERVIEW
Much evidence to support the theory of evolution is found in Earth’s fossil record. In this investigation, you will make a model that shows how a series of imaginary fossil organisms may have evolved.

The drawings represent a series of imaginary animals that have been found in an area rich in fossils. Look at the organisms. What unique characteristics does each organism have? How are the organisms similar? How do they differ? The goal is to organize these drawings in a way that shows the evolution of shared characteristics over time.

MATERIALS
“Creature Sheet,” scissors, glue or tape, unlined paper

YOUR TASK
1. Cut out each imaginary creature from the sheet your teacher gave you.

2. Select one creature that seems to represent the oldest fossil, that is, the ancestor of all the others. (Hint: Its form will be simpler than the others.)

3. Determine which creature appears to have evolved next. Continue arranging the drawings to show a pattern of evolution from one form to the next. There are several correct ways to arrange them. You may arrange your creatures in a straight line or in a set of branched lines that is similar to the branches of a tree. The pattern can branch into two or more directions. You should be able to support the order you place the organisms in with some logical reasons.

4. Glue or tape the creatures to the unlined paper in the order in which you have arranged them. Draw arrows that show the direction of evolutionary change.

INTERPRETIVE QUESTIONS
1. Did you choose a linear or branching diagram, or a combination of the two types? Explain your choice.

2. What shared characteristics did you use to determine the main sequences or branches of your pattern?

3. Imagine what kind of environment the organisms at the end of each branch or sequence of the pattern would live in. How might they move? What might they eat?
UNIT IV
Reproduction and Heredity (5.5.12 C)

Sample Prompt: How Do Molecules of DNA Replicate?

OVERVIEW
In 1953, Francis Crick and James Watson discovered the structure of the DNA molecule. This discovery enabled other researchers to begin to determine how molecules of DNA function. Like many other polymers, a strand of DNA is made of many individual connected subunits. A molecule of DNA consists of two parallel strands. The subunits on one strand are also connected to the subunits on the other strand. It is the connections between the two strands, which can be broken and reformed, that enable DNA to make a copy, or replicate, itself. In this laboratory investigation, you will use paper “models” of DNA subunits and portions of DNA strands to learn how this remarkable chemical is constructed and can be copied.

MATERIALS
Nucleotide and DNA diagrams for steps 1–4, scissors, blank paper, tape

YOUR TASK
1. Cut out the six nucleotides in the handout. Assemble them into a double strand of DNA that consists of three pairs of nucleotides that are joined together. (Hint: The phosphates that are attached to the sugars point up on one strand and point down on the opposite strand. Biochemists say the two strands are “anti-parallel.”) Tape the pieces into place on a sheet of paper.

2. Cut out the four nucleotides from the second handout. Match them up correctly according to the rules for nitrogenous base pairing. Remember that the hydrogen bonds (dotted lines) coming from one nitrogenous base must match up with the hydrogen bonds in its partner base. Tape the pieces into place on a sheet of paper.

3. Refer to the diagram for this step. Use the rules that govern the pairing of bases. Write the complementary base on the unlettered strand that will bond with the base shown on the lettered strand.

4. Refer to the diagram for this step. Show the replication of the 14-base-pair DNA molecule. Write in the nitrogenous base pairs after the strands have separated. Then show all the base pairs for molecules A and B. Compare these two molecules to the original.

INTERPRETIVE QUESTIONS
1. From the results in step 2, determine the two reasons why each nitrogenous base can pair with only one of the three other types of nitrogenous bases.

2. From the results of all four steps, write a paragraph that describes how DNA is a well-organized molecule. Explain why this organization makes it possible for DNA to be the genetic material for all organisms.
Step 3

The double-stranded DNA molecule automatically becomes twisted into the double helix.

Step 4

The original molecule replicates into two new molecules, 'A' and 'B'.
Answer to Step 1

Answer to Step 2

Sample Performance Assessment Prompts
Answer to Step 3

The double-stranded DNA molecule automatically becomes twisted into the double helix.

Answer to Step 4

Original Molecule  Molecule replicates  New Molecule ‘A’  New Molecule ‘B’
UNIT V
Environmental Systems and Interactions (5.10.12 A/B)

Sample Prompt: How Do Human Activities Affect Natural Ecosystems?

OVERVIEW

In this investigation, you will study how the ecosystem of a hypothetical island, Key Mangrove, has been changed by people over a 30-year period. You will probably guess from its name that the most important characteristic of this island is its mangrove swamps—a kind of wetland ecosystem found in the tropics. Mangrove trees are one of the few trees that grow in brackish water. These trees are able to absorb minerals and salt from the ocean. Mangrove trees provide food and shelter for many species of animals that breed and grow along warm ocean coasts.

People are attracted to beautiful natural environments. However, they often make alterations to these environments without being aware of the consequences of such changes. The effect of human development on Key Mangrove is the subject of this activity.

MATERIALS

Maps of Key Mangrove that cover a period of more than 30 years

YOUR TASK

1. Examine the first map of Key Mangrove. About what percent of this island was originally covered by mangrove swamps?

2. The other three maps were made at 10-year intervals. Prepare a chart to describe the changes that have occurred during each 10-year period. Keep the following questions in mind as you examine the different maps.

   • How has transportation to and around the island changed?
   • What industries have been added?
   • How have these industries changed over time?
   • How has residential use changed over time?
   • What recreational facilities have been added?
   • What municipal services have been added to meet the needs of increased residential and manufacturing developments?

3. Compare Map 1 with Map 4. What percentage of the mangrove swamps in Map 1 remains on Map 4? Approximately what percentage of mangrove swamps was lost during each 10-year time period?

4. What kind of development was built first? How did this development change the pattern of later development?

5. In what ways could people use the native mangrove swamps for recreation?
6. In what ways has the recreational use of the mangrove swamps been altered by increased development?

7. How has the recreational use of the island changed over time?

**INTERPRETIVE QUESTIONS**

1. Describe some benefits that mangrove swamps provide for coastal areas.

2. What did the mangrove swamps provide to the first human settlers of Key Mangrove?

3. Only one large area of mangrove swamp remains on Key Mangrove after 30 years of human settlements. What interests could the following people be expected to have in this area? Prepare a short statement of each person’s intentions for this area: Vacation home owner; member of the local Chamber of Commerce; National Wildlife Federation member; shrimp-packing plant owner; member of the shrimp-packer’s union; permanent homeowner; oil refinery manager; bank president.
UNIT I
How Do We Learn?

1. Evidence that learning occurred in Parts A and B would include the following observations: after repeated trials, the tasks were completed more quickly; and after repeated trials, the tasks were completed with fewer errors. The primary methods used for learning included repetition, trial and error, and memorization. Reasoning also may have been used to some degree.

2. In solving the puzzle and doing academic study, one needs to visualize possible solutions. Using reasoning is ultimately more successful than repeated trial and error. The word lists show how seeing meaning in details helps in the learning of those details.

UNIT II
How Does Exercise Affect Our Heart and Respiratory Rates?

1. Respiration uses oxygen and gives off carbon dioxide. Therefore the amount of carbon dioxide exhaled indicates the rate of respiration that is occurring.

2. The carbon dioxide level in the blood could be detected as the blood passes through the brain. This could then result in signals being sent in the brain to the area that controls heart rate.

3. Graph 3 indicates that a high heart rate correlates with a high respiratory rate, and that a low heart rate correlates with a low respiratory rate.

UNIT III
How Have Animals Evolved Over Time?

1. A linear diagram would mean that each earlier form of the creature is an ancestor of the next more recent form. A branching diagram would mean that at one or more times in the past, one form would be the ancestor of two more recent forms, perhaps populations that had become geographically isolated.

2. Shared characteristics may include the overall body form, or the presence or absence of a tail and appendages such as legs or fins attached to the body.

3. Possible environments may be aquatic, terrestrial, or wetland (a combination of water and land). Movement may be by swimming or crawling. Foods could be small plants or animals.
UNIT IV
How Do Molecules of DNA Replicate?

1. Base-pairing specificity is determined by the number of possible hydrogen bonds and the size of the nitrogenous base. To fit in the double helix structure, one small base must pair up with one large base. A base that allows for two hydrogen bonds will only pair with another that has two hydrogen bond sites. Similarly, three bond sites will pair only with three bond sites. For these reasons, A (adenine) bonds with T (thymine), and G (guanine) bonds with C (cytosine). (See answers on “Solutions for Teachers” pages.)

2. DNA is well organized from one side of the molecule to the other side by the base-pairing rule. It is also well organized lengthwise, with a specific linear sequence that matches the sequence along the other side. Finally, the molecule naturally forms a helical structure. This high level of organization allows the molecule to contain and accurately replicate genetic information and pass it on from parents to offspring.

UNIT V
How Do Human Activities Affect Natural Ecosystems?

1. Mangrove swamps stabilize coastlines. Severe storms such as hurricanes cause much less soil erosion when the root systems of trees in swamps protect the land. Mangrove swamps also provide spawning grounds for many marine organisms, such as crustaceans (shrimp) and fish. These organisms begin their lives in the shallow swamps and then live in the open ocean as adults.

2. The mangrove swamps provided protection for the island and also a livelihood for its people by supporting the shrimp and fishing industry.

3. The position taken by each person will depend upon that person’s priorities: recreation, commercialization, wildlife management, and so on.