ANSWER KEY

Chapter 1

1. b. microorganisms

3. d. computer science

5. c. peer review

7. c. cell

9. b. eukaryotic cells

11. d. biosphere → ecosystem → community → population → organism

13. Answers will vary but should apply the steps of the scientific method. One possibility could be a car that doesn't start. The hypothesis could be that the car doesn't start because the battery is dead. The experiment would be to change the battery or to charge the battery and then check whether the car starts or not. If it starts, the problem was due to the battery, and the hypothesis is accepted.

15. Answers will vary. Topics that fall inside the area of biological study include how diseases affect human bodies, how pollution impacts a species' habitat, and how plants respond to their environments. Topics that fall outside of biology (the "study of life") include how metamorphic rock is formed and how planetary orbits function.

17. Answers will vary. Layers of sedimentary rock have order but are not alive. Technology is capable of regulation but is not, of itself, alive.

19. During your walk, you may begin to perspire, which cools your body and helps your body to maintain a constant internal temperature. You might also become thirsty and pause long enough for a cool drink, which will help to restore the water lost during perspiration.

Chapter 2

1. a. 54

3. c. Shells 1, 2, and 3 are full, and shell 4 has one electron.

5. d. Water is the most abundant molecule in the Earth's atmosphere.

7. c. base

9. d. four

11. Ionic bonds are created between ions. The electrons are not shared between the atoms but rather are associated more with one ion than the other. Ionic bonds are strong bonds but are weaker than covalent bonds, meaning it takes less energy to break an ionic bond compared with a covalent one.

13. Buffers absorb the free hydrogen ions and hydroxide ions that result from chemical reactions. Because they can bond these ions, they prevent increases or decreases in pH. An example of a buffer system is the bicarbonate system in the human body. This system is able to absorb hydrogen and hydroxide ions to prevent changes in pH and keep cells functioning properly.

15. Carbon is unique and found in all living things because it can form up to four covalent bonds between atoms or molecules. These can be nonpolar or polar covalent bonds, and they allow for the formation of long chains of carbon molecules that combine to form proteins and DNA.

Chapter 3

1. c. water and polymers

3. a. condensation

5. d. polysaccharides

7. b. glycosidic; galactose

9. d. they tend to dissolve in water easily

11. c. within the tail bilayer

13. b. secondary

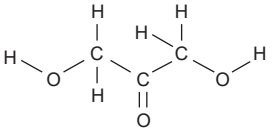
15. c. deoxyribose, thymine, and a phosphate group

17. c. Complementary base pairing creates a very stable structure.

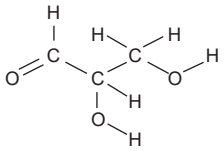
19. In a dehydration synthesis reaction, the hydrogen of one monomer combines with the hydroxyl group of another monomer, releasing a molecule of water. This creates an opening in the outer shells of atoms in the monomers, which can share electrons and form covalent bonds.

21. Glycogen and starch are polysaccharides. They are the storage form of glucose. Glycogen is stored in animals in the liver and in muscle cells, whereas starch is stored in the roots, seeds, and leaves of plants. Starch has two different forms, one unbranched (amylose) and one branched (amylopectin), whereas glycogen is a single type of a highly branched molecule.

23. The human body switches carbohydrates between their aldose and ketose forms using a family of enzymes called isomerases. The ketose triose is called dihydroxyacetone and has the oxygen double-bonded to the center carbon.



The aldose is called glyceraldehyde and can have the oxygen double-bonded to the first or third carbon of the molecule.



25. *Trans* fats are created artificially when hydrogen gas is bubbled through oils to solidify them. The double bonds of the *cis* conformation in the hydrocarbon chain may be converted to double bonds in the *trans* configuration. Some restaurants are banning *trans* fats because they cause higher levels of LDL, or "bad" cholesterol.

27. Cortisol is a small, generally hydrophobic molecule, while the phospholipids that create plasma membranes have a hydrophilic head and hydrophobic tails. Since cortisol is hydrophobic, it can interact with the sequestered tails of the phospholipids in the center of the plasma membrane. This, along with its small size, allows cortisol to move through the plasma membrane to the inside of the cell.

29. The sequence and number of amino acids in a polypeptide chain is its primary structure. The local folding of the polypeptide in some regions is the secondary structure of the protein. The three-dimensional structure of a polypeptide is known as its tertiary structure, created in part by chemical interactions, such as hydrogen bonds between polar side chains, van der Waals interactions, disulfide linkages, and hydrophobic interactions. Some proteins are formed from multiple polypeptides, also known as subunits, and the interaction of these subunits forms the quaternary structure.

31. DNA has a double-helix structure. The sugar and the phosphate are on the outside of the helix, and the nitrogenous bases are in the interior. The monomers of DNA are nucleotides containing deoxyribose, one of the four nitrogenous bases (A, T, G, and C), and a phosphate group. RNA is usually single-stranded and is made of ribonucleotides that are linked by phosphodiester linkages. A ribonucleotide contains ribose (the pentose sugar), one of the four nitrogenous bases (A, U, G, and C), and the phosphate group.

Chapter 4

1. c. special stains

3. d. diffusion

5. d. *E. coli*

7. b. produced during their oxidation reactions

9. d. ribosomes

11. a. mitochondrion

13. c. a cell that makes steroid hormones

15. d. Golgi apparatus

17. d. only intermediate filaments

19. A light microscope would be ideal when viewing a small living organism, especially when the cell has been stained to reveal details.

21. A transmission electron microscope would be ideal for viewing the cell's internal structures because many of the internal structures have membranes that are not visible by the light microscope.

23. The cell theory states:

- All living things are made of cells.
- Cells are the most basic unit of life.
- New cells arise from existing cells.

All humans are multicellular organisms whose smallest building blocks are cells. Adult humans begin with the fusion of a male gamete cell with a female gamete cell to form a fertilized egg (single cell). That cell then divides into two cells, then each divides into two more cells, and so forth until all the cells of a human embryo are made. As the embryo passes through all the developmental stages to make an adult human, the cells that are added arise from division of existing cells.

25. Some microbes are beneficial. For instance, *E. coli* bacteria populate the human gut and help break down fiber in the diet. Some foods, such as yogurt, are formed by bacteria.

27. Both are similar in that they are enveloped in a double membrane, both have an intermembrane space, and both make ATP. Both mitochondria and chloroplasts have DNA, and mitochondria have inner folds called cristae and a matrix, while chloroplasts have chlorophyll and accessory pigments in the thylakoids that form stacks (grana) and a stroma.

29. "Form follows function" refers to the idea that the function of a body part dictates the form of that body part. As an example, compare your arm to a bat's wing. While the bones of the two correspond, the parts serve different functions in each organism and their forms have adapted to follow that function.

31. Centrioles and flagella are alike in that they are made up of microtubules. In centrioles, two rings of nine microtubule "triplets" are arranged at right angles to one another. This arrangement does not occur in flagella.

33. A macrophage engulfs a pathogen by rearranging its actin microfilaments to bend the plasma membrane around the pathogen. Once the pathogen is sealed in an endosome inside the macrophage, the vesicle is walked along microtubules until it combines with a lysosome to digest the pathogen.

Chapter 5

1. a. protein

3. a. identification of the cell

5. c. from an area with a high concentration of water to one of lower concentration

7. a. Their bodies tend to take in too much water.

9. d. diffusion is constantly moving solutes in opposite directions

11. d. electrochemical gradient

13. b. phagocytosis

15. c. The virus only enters its target host cell type.

17. b. The plasma membrane would increase in size over time.

19. c. intermediate filaments

21. The fluid characteristic of the cell membrane allows greater flexibility to the cell than it would if the membrane were rigid. It also allows the motion of membrane components, required for some types of membrane transport.

23. Peripheral proteins can bind to other molecules in the extracellular space. However, they cannot directly transmit a signal to the inside of the cell since they do not have a transmembrane domain (region that goes through the plasma membrane to the inside of the cell). They must associate with integral membrane proteins in order to pass the signal to the inside of the cell.

25. Water moves through a membrane in osmosis because there is a concentration gradient across the membrane of solute and solvent. The solute cannot effectively move to balance the concentration on both sides of the membrane, so water moves to achieve this balance.

27. Decreasing temperature will decrease the kinetic energy in the system. A lower temperature means less energy in the molecules, so they will move at a slower speed. Lowering temperature also decreases the kinetic energy of the molecules in the plasma membrane, compressing them together. This increases the density of the plasma membrane, which slows diffusion into the cell.

29. The cell harvests energy from ATP produced by its own metabolism to power active transport processes, such as the activity of pumps.

31. Intestinal epithelial cells use active transport to fulfill their specific role as the cells that transfer glucose from the digested food to the bloodstream. Intestinal cells are exposed to an environment with fluctuating glucose levels. Immediately after eating, glucose in the gut lumen will be high and could accumulate in intestinal cells by diffusion. However, when the gut lumen is empty, glucose levels are higher in the intestinal cells. If glucose moved by facilitated diffusion, this would cause glucose to flow back out of the intestinal cells and into the gut. Active transport proteins ensure that glucose moves into the intestinal cells and cannot move back into the gut. It also ensures that glucose transport continues to occur even if high levels of glucose are already present in the intestinal cells. This maximizes the amount of energy the body can harvest from food.

33. The proteins allow a cell to select what compound will be transported, meeting the needs of the cell and not bringing in anything else.

35. They differ because plant cell walls are rigid. Plasmodesmata, which a plant cell needs for transportation and communication, are able to allow movement of really large molecules. Gap junctions are necessary in animal cells for transportation and communication.

37. *E. coli* infections generally cause food poisoning, meaning that the invading bacteria cross from the lumen of the gut into the rest of the body. Tight junctions hold the epithelial layer that lines the digestive tract together so that the material that crosses into the body is tightly regulated. One way *E. coli* can avoid this regulation is to destroy the tight junctions so that it can enter the body between the epithelial cells, rather than having to go through the cells.

Chapter 6

1. c. glucose; ATP

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

5. b. Compare their reaction rates.

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

9. a. sucrose

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

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

15. A spontaneous reaction is one that has a negative ΔG and, thus, releases energy. However, a spontaneous reaction need not occur quickly or suddenly like an instantaneous reaction. It may occur over long periods due to a large energy of activation, which

prevents the reaction from occurring quickly.

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

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

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

Chapter 7

1. a. ATP

3. c. ATP is made.

5. b. They go to another pathway for ATP production.

7. c. three

9. c. the movement of hydrogen ions across a mitochondrial membrane

11. a. glucose-6-phosphate

13. a. increase the activity of specific enzymes

15. ATP provides the cell with a way to handle energy in an efficient manner. The molecule can be charged, stored, and used as needed. Moreover, the energy from hydrolyzing ATP is delivered in a consistent amount. Harvesting energy from the bonds of several different compounds would result in energy deliveries of different quantities.

17. All cells must consume energy to carry out basic functions, such as pumping ions across membranes. A red blood cell would lose its membrane potential if glycolysis were blocked, and it would eventually die.

19. Q and cytochrome c are transport molecules. Their function does not result directly in ATP synthesis in that they are not pumps. Moreover, Q is the only component of the electron transport chain that is not a protein. Ubiquinone and cytochrome c are small, mobile, electron carriers , whereas the other components of the electron transport chain are large complexes anchored in the inner mitochondrial membrane.

21. Fermentation uses glycolysis only. Anaerobic respiration uses all three parts of cellular respiration, including the parts in the mitochondria like the citric acid cycle and electron transport chain; it also uses a different final electron acceptor instead of oxygen gas.

23. Citrate can inhibit phosphofructokinase by feedback regulation.

Chapter 8

1. a. chloroplasts

3. b. stroma

5. b. ATP and NADPH accumulation

7. a. ATP synthase

9. c. photosystem II

11. a. fails to grow because chlorophyll *a* and *b* reflect green light.

13. d. CO_2

15. c. chloroplast stroma

17. c. 8 G3P made, 1 G3P exported

19. Because lions eat animals that eat plants.

21. The grey wolves are apex predators in their food web, meaning they consume smaller prey animals and are not the prey of any other animal. Blocking sunlight would prevent the plants at the bottom of the food web from performing photosynthesis. This would kill many of the plants, reducing the food sources available to smaller animals in Yellowstone. A smaller prey animal population means that fewer wolves can survive in the area, and the population of grey wolves will decrease.

23. A photon of light hits an antenna molecule in photosystem II, and the energy released by it travels through other antenna molecules to the reaction center. The energy causes an electron to leave a molecule of chlorophyll *a* to a primary electron acceptor protein. The electron travels through the electron transport chain and is accepted by a pigment molecule in photosystem I.

25. Knocking out photosystem II would eliminate the production of oxygen and ATP during photosynthesis. Photosystem II splits water into oxygen atoms, hydrogen protons that remain in the thylakoid lumen, and hydrogen-derived electrons that move from the reaction center into the electron transport chain. The transfer of an electron through the electron transport chain provides the energy to pump more protons into the thylakoid lumen to maintain a higher concentration of protons there. Moving protons across the thylakoid membrane back to the stroma provides the energy for ATP synthase to produce ATP. Without this proton gradient, ATP will not be synthesized.

27. None of the cycle could take place because RuBisCO is essential in fixing carbon dioxide. Specifically,

RuBisCO catalyzes the reaction between carbon dioxide and RuBP at the start of the cycle.

29. An energy cycle between a plant and a beetle would be as follows:

1. The plant consumes carbon dioxide and releases oxygen as a byproduct of photosynthesis.
2. The beetle consumes oxygen and releases carbon dioxide to create chemical energy during aerobic respiration.
3. The plant takes up carbon dioxide from the air.
4. The cycle repeats.

The plant would also provide a carbon-based food source for the beetle.

The beetle is a heterotroph and would not survive without the plant because it would deplete all the oxygen within the terrarium. The plant is an autotroph and could survive without the beetle, but it would be unlikely to grow. Through photosynthesis, the plant can make and store its own energy in carbon-based molecules and produce oxygen. The oxygen can then be used to power aerobic respiration in the plant, which releases carbon dioxide. However, since the plant essentially continues to reuse its own resources cycling between carbon- and oxygen-consuming pathways, its growth would be limited.

Chapter 9

1. a. The molecules bind to the extracellular domain.

3. b. Ions are charged particles and cannot diffuse through the hydrophobic interior of the membrane.

5. c. enzyme-linked

7. c. They contain a hydroxyl group.

9. b. EGF signaling cascades would be active for a shorter period of time in the cell.

11. b. Phosphorylation of the inhibitor Iκ-B dissociates the complex between it and NF-κB and allows NF-κB to enter the nucleus and stimulate transcription.

13. c. The enzyme is inactivated.

15. d. all of these

17. d. a sufficient number of bacteria are present

19. Intracellular signaling occurs within a cell, and intercellular signaling occurs between cells.

21. Internal receptors are located inside the cell, and their ligands enter the cell to bind the receptor. The complex formed by the internal receptor and the ligand then enters the nucleus and directly affects protein production by binding to the chromosomal DNA and initiating the making of mRNA that codes for proteins. Cell surface receptors, however, are embedded in the plasma membrane, and their ligands do not enter the cell. Binding of the ligand to the cell-surface receptor initiates a cell signaling cascade and does not directly influence the making of proteins; however, it may involve the activation of intracellular proteins.

23. Insulin's receptor is an enzyme-linked transmembrane receptor, as can be determined from the "tyrosine kinase" in its name. This receptor is embedded in the plasma membrane, and insulin binds to its extracellular (outer) surface to initiate intracellular signaling cascades.

Normally, steroid hormones cross the plasma membrane to bind with intracellular receptors. These intracellular hormone-receptor complexes then interact directly with DNA to regulate transcription. This limits steroid hormones to be small, nonpolar molecules so that they can cross the plasma membrane. However, since insulin does not have to cross into the cell, it could be large or polar, but it is a small, polar molecule.

25. The binding of the ligand to the extracellular domain would activate the pathway normally activated by the receptor donating the intracellular domain.

27. If a kinase is mutated so that it is always activated, it will continuously signal through the pathway and lead to uncontrolled growth and possibly cancer. If a kinase is mutated so that it cannot function, the cell will not respond to ligand binding.

29. There are several possible explanations:

- The EGFR dimer cannot separate.
- An upstream mutation (in Ras, Raf, MEK) constitutively activates the signaling cascade.
- ERK has a mutation that prevents it from binding to its phosphatase.
- The cell has a mutation preventing the expression or function of the ERK-specific phosphatase.

31. Multicellular organisms must coordinate many different events in different cell types that may be very distant from each other. Single-celled organisms are only concerned with their immediate environment and the presence of other cells in the area.

Chapter 10

1. c. twice

3. d. histone

5. b. S phase

7. b. centrosome

9. d. telophase

11. a. prophase

13. a. G_1 checkpoint

15. d. anaphase

17. c. cancer cells

19. c. mitosis

21. Human somatic cells have 46 chromosomes: 22 pairs and 2 sex chromosomes that may or may not form a pair. This is the 2*n*, or diploid condition. Human gametes have 23 chromosomes, one each of 23 unique chromosomes, one of which is a sex chromosome. This is the *n,* or haploid, condition.

23. The DNA double helix is wrapped around histone proteins to form structures called nucleosomes. Nucleosomes and the linker DNA in between them are coiled into a 30 nm fiber. During cell division, chromatin is further condensed by packing proteins.

25. The mitotic spindle is formed of microtubules. Microtubules are polymers of the protein tubulin; therefore, it is the mitotic spindle that is disrupted by these drugs. Without a functional mitotic spindle, the chromosomes will not be sorted or separated during mitosis. The cell will arrest in mitosis and die.

27. Many cells temporarily enter G_0 until they reach maturity. Some cells are only triggered to enter G_1 when the organism needs to increase that particular cell type. Some cells only reproduce following an injury to the tissue. Some cells never divide once they reach maturity.

29. The G_1 checkpoint monitors adequate cell growth, the state of the genomic DNA, adequate stores of energy, and materials for S phase. At the G_2 checkpoint, DNA is checked to ensure that all chromosomes were duplicated and that there are no mistakes in newly synthesized DNA. Additionally, cell size and energy reserves are evaluated. The M checkpoint confirms the correct attachment of the mitotic spindle fibers to the kinetochores.

31. Cdk must bind to a cyclin, and it must be phosphorylated in the correct position to become fully active.

33. The common components of eukaryotic cell division and binary fission are DNA duplication, segregation of duplicated chromosomes, and division of the cytoplasmic contents.

Chapter 11

1. c. four haploid

3. d. anaphase II

5. a. Spindle microtubules guide the transfer of DNA across the synaptonemal complex.

7. c. meiosis II

9. b. haploid with two copies of each gene

11. d. Chromosomes can remain condensed at the end of telophase I but decondense after telophase II.

13. d. alternation of generations

15. a. sporophyte

17. c. Larger portions of the plant populations are susceptible to the same diseases.

19. Random alignment leads to new combinations of traits. The chromosomes that were originally inherited by the gamete-producing individual came equally from the egg and the sperm. In metaphase I, the duplicated copies of these maternal and paternal homologous chromosomes line up across the center of the cell. The orientation of each tetrad is random. There is an equal chance that the maternally derived chromosomes will be facing either pole. The same is true of the paternally derived chromosomes. The alignment should occur differently in almost every meiosis. As the homologous chromosomes are pulled apart in anaphase I, any combination of maternal and paternal chromosomes will move toward each pole. The gametes formed from these two groups of chromosomes will have a mixture of traits from the individual's parents. Each gamete is unique.

21. All of the stages of meiosis I, except possibly telophase I, are unique because homologous chromosomes are separated, not sister chromatids. In some species, the chromosomes do not decondense, and the nuclear envelopes do not form in telophase I. All of the stages of meiosis II have the same events as the stages of mitosis, with the possible exception of prophase II. In some species, the chromosomes are still condensed, and there is no nuclear envelope. Other than this, all processes are the same.

23. Crossing over does not occur during prophase II; it only occurs during prophase I. In prophase II, there are still two copies of each gene, but they are on sister chromatids within a single chromosome (rather than homologous chromosomes as in prophase I). Therefore, any crossing over event would still produce two identical chromatids. Since it is advantageous to avoid wasting energy on events that will not increase genetic diversity, crossing over does not occur.

25. Nearly all animals employ a diploid-dominant life-cycle strategy; only the gametes are haploid. Once the haploid gametes are formed, they lose the ability to divide again. There is no multicellular haploid life stage. Plants, in contrast, have a blend

of the haploid-dominant and diploid-dominant cycles; they have both haploid and diploid multicellular organisms as part of their life cycle. The diploid plant is called a sporophyte because it produces haploid spores by meiosis. The spores develop into multicellular, haploid plants that are called gametophytes because they produce gametes.

27. Organisms with a diploid-dominant life cycle make haploid gametes by meiosis, while all their somatic cells are diploid. Organisms with an alternation of generations life cycle make gametes during their haploid life stage, so the chromosome number does not need to be reduced and meiosis is not involved.

Chapter 12

1. a. anther

3. b. 100% yellow seeds

5. c. 75% violet flowers; 75% axial flowers

7. c. homozygous

9. d. multiple alleles and codominance

11. d. The polydactyl allele is very rare in the human population.

13. a. 1:1:1:1

15. d. 27 genotypes; 8 phenotypes

17. d. Men are more likely to experience hemophilia than women.

19. Two sets of P_0 parents would be used. In the first cross, pollen would be transferred from a true-breeding tall plant to the stigma of a true-breeding dwarf plant. In the second cross, pollen would be transferred from a true-breeding dwarf plant to the stigma of a true-breeding tall plant. For each cross, F_1 and F_2 offspring would be analyzed to determine if offspring traits were affected according to which parent donated each trait.

21. Heart suit or face card: This calculation requires the sum rule since there are multiple pathways to successfully pulling a desired card.

$13/52 + 12/52 = 25/52$

$= 48\%$

The probability of selecting a heart suit or a face card is significantly more likely than the probability of selecting a heart suit face card (3/52 = 5.8%).

23. The Punnett square would be 2 × 2 and would have *t* and *t* along the top, and *T* and *t* along the left side. Clockwise from the top left, the genotypes listed within the boxes will be *Tt*, *Tt*, *tt*, and *tt*. The phenotypic ratio will be 1 tall:1 dwarf.

25. Using a homozygous recessive donor is more efficient because the genotype of the unknown parent can be determined in a single generation. If a homozygous dominant donor was used, the unknown genotype could still be determined. Instead of knowing the unknown genotype through the F_1 phenotype, the F_1 offspring would have to be self-crossed (as Mendel allowed his pea plants to self-pollinate), and the F_2 generation phenotypes would be used to determine the unknown P_0 genotype.

27. Epistasis describes an antagonistic interaction between genes wherein one gene masks, or interferes, with the expression of another. The gene that is interfering is referred to as epistatic, as if it is "standing upon" the other (hypostatic) gene to block its expression.

29. In any trisomy disorder, a person inherits three copies of a chromosome instead of the normal pair. This violates the law of segregation and usually occurs when the chromosomes fail to separate during the first round of meiosis.

Chapter 13

1. a. in more males than females

3. c. 0.50

5. b. 13q12

7. c. loop

9. d. X inactivation

11. The Chromosomal Theory of Inheritance proposed that genes reside on chromosomes. The understanding that chromosomes are linear arrays of genes explained linkage, and crossing over explained recombination.

Chapter 14

1. c. 23%

3. d. all of these

5. d. histones

7. c. 3′-TTACGATG-5′

9. d. ligase

11. a. 5′-3′

13. d. telomerase

15. c. DNA pol

17. b. nonsense

19. Sulfur is an element found in proteins, and phosphorus is a component of nucleic acids.

21. The template DNA strand is mixed with a DNA polymerase, a primer, the four deoxynucleotides, and a limiting concentration of four dideoxynucleotides. DNA polymerase synthesizes a strand complementary to the template. Incorporation of ddNTPs at different locations results in DNA fragments that have terminated at every possible base in the template. These fragments are separated by gel electrophoresis and visualized by a laser detector to determine the sequence of bases.

23. Advantage: The linear arrangement of the eukaryotic chromosome allows more DNA to be packed by tightly winding it around histones. More genetic material means that the organism can encode more information into a

single cell. This eventually allowed some eukaryotes to develop into multicellular organisms with cell specialization.

Disadvantage: Maintaining more genetic material requires more energy and introduces the possibility for more errors (more complexity).

25. Following two rounds of conservative replication, two bands would be detected after ultracentrifugation. A lower (heavier) band would be at the ^{15}N density and would comprise 25% of the total DNA. A second, higher (lighter) band would be at the ^{14}N density and would contain 75% of the total DNA.

27. Short DNA fragments are formed on the lagging strand synthesized in a direction away from the replication fork. These are synthesized by DNA pol.

29. At the replication fork, the events taking place are helicase action, binding of single-strand binding proteins, primer synthesis, and synthesis of new strands. If there is a mutated helicase gene, the replication fork will not be extended.

31. Bacteria treated with quinolones will no longer be able to replicate their DNA. Topoisomerase relieves the excess DNA supercoiling that occurs ahead of the replication fork as DNA is unwound for replication. If topoisomerase is inhibited, DNA helicase will only be able to unwind the DNA for a short stretch before the supercoiling becomes too overwound for replication to continue.

33. Mutations are not repaired, as in the case of xeroderma pigmentosa. Gene function may be affected, or it may not be expressed.

Chapter 15

1. d. degeneracy

3. c. Scientists use reverse transcriptase enzymes to make DNA from RNA.

5. b. they are similar in all bacterial species

7. b. TATA box

9. b. Enhancers increase the efficiency of gene expression but are not essential for transcription. Promoter recognition is essential to transcription initiation.

11. a. methylation

13. c. nucleolus

15. a. Translation stalls after the initiation AUG codon is identified.

17. Codons that specify the same amino acid typically only differ by one nucleotide. In addition, amino acids with chemically similar side chains are encoded by similar codons. This nuance of the genetic code ensures that a single nucleotide substitution mutation might either specify the same amino acid and have no effect, or may specify a similar amino acid, preventing the protein from being rendered completely nonfunctional.

19. DNA is different from RNA in that T nucleotides in DNA are replaced with U nucleotides in RNA. Therefore, they could never be identical in base sequence.

21. AUCUUCGUGAGAUG
By examining the DNA sequence, we can see that there is a −10 consensus sequence near the 3′ end of the fragment. If we then count downstream, the +1 initiation site is the T immediately following the sequence AAT. This means the DNA fragment that will serve as the template for transcription has the sequence TGATA GAAGCACTCTAC.

The mRNA made from this template will have complementary base pairing with uracil (U) instead of thymine (T). This gives us ACUAUCUUCGUG AGAUG as the transcribed mRNA sequence.

23. Nonsense spliceosome mutations would eliminate the splicing step of mRNA processing, so the mature mRNAs would retain their introns and be perfectly complementary to the entire DNA template sequence. However, the mRNAs would still undergo addition of the 5′ cap and poly-A tail, and therefore, each has the potential to be exported to the cytoplasm for translation.

25. Nucleotide changes in the third position of codons may not change the amino acid and would have no effect on the protein. Other nucleotide changes that change important amino acids or create or delete start or stop codons would have severe effects on the amino acid sequence of the protein.

Chapter 16

1. d. epigenetic, transcriptional, post-transcriptional, translational, and post-translational levels

3. d. Both a. and b.

5. d. both b. and c.

7. a. the addition of reversible changes to histone proteins and DNA

9. c. RNA polymerase

11. b. Transcription of Gene A involves fewer transcription factors.

13. d. either increase or decrease

15. c. Alternative splicing creates shorter mRNA transcripts.

17. b. The large ribosomal subunit would not be able to interact with mRNA transcripts.

19. c. patients with a lot of the estrogen receptor expressed in their tumor

21. The cell controls which proteins are expressed and

to what level each protein is expressed in the cell. Prokaryotic cells alter the transcription rate to turn genes on or off. This method will increase or decrease protein levels in response to what is needed by the cell. Eukaryotic cells change the accessibility (epigenetic), transcription, or translation of a gene. This will alter the amount of RNA and the life span of the RNA to alter the amount of protein that exists. Eukaryotic cells also control protein translation to increase or decrease the overall levels. Eukaryotic organisms are much more complex and can manipulate protein levels by changing many stages in the process.

23. A repressible operon uses a protein bound to the promoter region of a gene to keep the gene repressed, or silent. This repressor must be actively removed in order to transcribe the gene. An inducible operon is either activated or repressed depending on the needs of the cell and what is available in the local environment.

25. Swapping the pups at birth indicates that the genes inherited from the attentive or inattentive mothers do not explain the rats' stress-responses later in life. Instead, researchers found that the attentive mothering caused the methylation of genes that control the expression of stress receptors in the brain. Thus, rats that received attentive maternal care exhibited epigenetic changes that limited the expression of stress-response genes, and the effect was durable over their life spans.

27. A mutation in the promoter region can change the binding site for a transcription factor that normally binds to increase transcription. The mutation could either decrease the ability of the transcription factor to bind, thereby decreasing transcription, or it can increase the ability of the transcription factor to bind, thus increasing transcription.

29. The easiest way to test his hypothesis would be to mutate the site in a cell and monitor levels of the mRNA transcript made from the gene. If the levels of transcript increase in the mutated cell, then the site was repressing transcription.

31. External stimuli can modify RNA-binding proteins (i.e., through phosphorylation of proteins) to alter their activity.

33. If the RNA degraded, then less of the protein that the RNA encodes would be translated. This could have dramatic implications for the cell.

35. Degrading the eIF4F complex prevents the pre-initiation complex (eIF-2-GTP, $tRNA_i$-Met, and 40S ribosomal subunit) from being recruited to the 5′ cap of mature mRNAs in the cell. This allows the virus to hijack the translation machinery of the human cell to translate its own (uncapped) mRNA transcripts instead.

37. Understanding which genes are expressed in a cancer cell can help diagnose the specific form of cancer. It can also help identify treatment options for that patient. For example, if a breast cancer tumor expresses the EGFR in high numbers, it might respond to specific anti-EGFR therapy. If that receptor is not expressed, it would not respond to that therapy.

Chapter 17

1. b. introducing recombinant DNA into an organism by any means

3. b. is a recombinant protein

5. d. all of these

7. b. is based on the natural recombination process

9. a. genetically similar

11. a. uses labeled ddNTPs

13. d. all of these

15. d. all of these

17. b. a protein that is uniquely produced in a diseased state

19. Southern blotting is the transfer of DNA that has been enzymatically cut into fragments and run on an agarose gel onto a nylon membrane. The DNA fragments that are on the nylon membrane can be denatured to make them single-stranded, and then probed with small DNA fragments that are radioactively or fluorescently labeled, to detect the presence of specific sequences. An example of the use of Southern blotting would be in analyzing the presence, absence, or variation of a disease gene in genomic DNA from a group of patients.

21. By identifying an herbicide resistance gene and cloning it into a plant expression vector system, like the Ti plasmid system from *Agrobacterium tumefaciens*. The scientist would then introduce it into the plant cells by transformation and select cells that have taken up and integrated the herbicide-resistance gene into the genome.

23. Genome mapping has many different applications and provides comprehensive information that can be used for predictive purposes.

25. Metagenomics is revolutionary because it replaced the practice of using pure cultures. Pure cultures were used to study individual species in the laboratory but did not accurately represent what happens in the environment. Metagenomics studies the genomes of bacterial

populations in their environmental niche.

27. Proteomics has provided a way to detect biomarkers and protein signatures, which have been used to screen for the early detection of cancer.

Chapter 18

1. b. natural selection

3. a. A certain duck has a blue beak.

5. a. Flood causes the formation of a new lake.

7. b. longer distance between divided groups

9. c. when members of closely related species reproduce

11. d. Two species of insects produce infertile offspring.

13. c. ongoing gene flow among all individuals

15. Vestigial structures are considered evidence for evolution because most structures do not exist in an organism without serving some function either presently or in the past. A vestigial structure indicates a past form or function that has since changed, but the structure remains present because it had a function in the ancestor.

17. The statement implies that there is a goal to evolution and that the monkey represents greater progress to that goal than the mouse. Both species are likely to be well adapted to their particular environments, which is the outcome of natural selection.

19. It is likely the two species would start to reproduce with each other. Depending on the viability of their offspring, they may fuse back into one species.

21. Both models continue to conform to the rules of natural selection and the influences of gene flow, genetic drift, and mutation.

Chapter 19

1. c. Microevolution describes the evolution of organisms in populations, while macroevolution describes the evolution of species over long periods of time.

3. d. a population undergoing natural selection

5. c. gene flow

7. a. when individuals mate with those who are similar to themselves

9. d. gradual geographic variation across an ecological gradient

11. a. sexual dimorphism

13. $p = (8 \times 2 + 4)/48 = .42$; $q = (12 \times 2 + 4)/48 = .58$; $p^2 = .17$; $2pq = .48$; $q^2 = .34$

15. Red is recessive, so $q^2 = 200/800 = 0.25$; $q = 0.5$; $p = 1-q = 0.5$; $p^2 = 0.25$; $2pq = 0.5$. You would expect 200 homozygous blue flowers, 400 heterozygous blue flowers, and 200 red flowers.

17. The theory of natural selection stems from the observation that some individuals in a population survive longer and have more offspring than others; thus, more of their genes are passed to the next generation. For example, a big, powerful male gorilla is much more likely than a smaller, weaker one to become the population's silverback: the pack's leader who mates far more than the other males of the group. Therefore, the pack leader will father more offspring who share half of his genes and are likely to grow bigger and stronger like their father. Over time, the genes for bigger size will increase in frequency in the population, and the average body size, as a result, will grow larger on average.

19. The peacock's tail is a good example of the handicap principle. The tail, which makes the males more visible to predators and less able to escape, is clearly a disadvantage to the bird's survival. But because it is a disadvantage, only the most fit males should be able to survive with it. Thus, the tail serves as an honest signal of quality to the females of the population; therefore, the male will earn more matings and have greater reproductive success.

Chapter 20

1. c. evolutionary history

3. d. Subspecies are the most specific category of classification.

5. c. They are derived by similar environmental constraints.

7. b. They evolved from a shared ancestor.

9. c. horizontal gene transfer

11. a. single common ancestor

13. The phylogenetic tree shows the order in which evolutionary events took place and in what order certain characteristics and organisms evolved in relation to others. It does not relate to time.

15. domain, kingdom, phylum, class, order, family, genus, species

17. Phylogenetic trees are based on evolutionary connections. If an analogous similarity were used on a tree, this would be erroneous and, furthermore, would cause the subsequent branches to be inaccurate.

19. Some hypotheses propose that mitochondria were acquired first, followed by the development of the nucleus. Others propose that the nucleus evolved first and that this new eukaryotic cell later acquired the mitochondria. Still others hypothesize that prokaryotes descended from eukaryotes by the loss of genes and complexity.

Chapter 21

1. b. Viruses are acellular.

3. d. vary in shape

5. a. rabies virus

7. b. During attachment, the virus attaches at specific sites on the cell surface.

9. d. either RNA or DNA

11. d. bacteria

13. a. The apple trees were infected by horizontal transmission.

15. d. stimulate an immune response

17. c. DNA

19. Viruses pass through filters that eliminated all bacteria that were visible in the light microscopes at the time. As the bacteria-free filtrate could still cause infections when given to a healthy organism, this observation demonstrated the existence of very small infectious agents. These agents were later shown to be unrelated to bacteria and were classified as viruses.

21. Rabies virus is a (-) strand RNA virus that transcribes mRNAs from its genome (Group V).

HIV-1 is a single-stranded RNA retrovirus that uses reverse transcriptase to create a double-stranded DNA copy of its genome that is integrated into the host human's genome prior to making mRNAs (Group VI).

The genome structure system classifies both viruses as single-stranded RNA viruses with linear genomes.

Baltimore classification sorts rabies virus and HIV-1 into two different groups, indicating that the two viruses have very different life cycles. On the other hand, genome structure classification does not distinguish between the two viruses. This leaves out important information regarding virus function and survival.

23. Reverse transcriptase is needed to make more HIV-1 viruses, so targeting the reverse transcriptase enzyme may be a way to inhibit the replication of the virus. Importantly, by targeting reverse transcriptase, we do little harm to the host cell since host cells do not make reverse transcriptase. Thus, we can specifically attack the virus and not the host cell when we use reverse transcriptase inhibitors.

25. Plant viruses infect crops, causing crop damage and failure as well as and considerable economic losses.

27. The rabies vaccine works after a bite because it takes weeks for the virus to travel from the site of the bite to the central nervous system, where the most severe symptoms of the disease occur. Adults are not routinely vaccinated for rabies for two reasons. First, the routine vaccination of domestic animals makes it unlikely that humans will contract rabies from an animal bite. Second, if one is bitten by a wild animal or a domestic animal that one cannot confirm has been immunized, there is still time to give the vaccine and avoid the often fatal consequences of the disease.

29. This prion-based disease is transmitted through human consumption of infected meat.

31. The botanist would need to isolate any foreign nucleic acids from infected plant cells and confirm that an RNA molecule is the etiological agent of disease. The botanist would then need to demonstrate that the RNA can infect plant cells without a capsid and that the RNA replicates but is not translated to produce proteins.

Chapter 22

1. b. prokaryotes

3. a. cyanobacteria

5. c. Most of the necessary culture conditions could be inferred for pathogenic prokaryotes.

7. d. bacteria and archaea

9. d. archaea

11. c. archaean prokaryotic cells

13. b. calcium

15. a. ammonia is released during the decomposition of nitrogen-containing organic compounds

17. a. photolithotrophs

19. d. All statements are correct.

21. d. *Yersinia pestis*

23. d. All of these occur.

25. b. the use of prokaryotes to clean up pollutants

27. As the organisms are non-culturable, the presence could be detected through molecular techniques, such as PCR.

29. Possible answers include:

- Psychrophile
- Hypolith—survival in low humidity/water environment

31. Both bacteria and archaea have cell membranes, and they both contain a hydrophobic portion. In the case of bacteria, it is a fatty acid; in the case of archaea, it is a hydrocarbon (phytanyl). Both bacteria and archaea have a cell wall that protects them. In the case of bacteria, it is composed of peptidoglycan, whereas in the case of archaea, it is pseudopeptidoglycan, polysaccharides, glycoproteins, or pure protein. Bacterial and archaeal flagella also differ in their chemical structure.

33. Answers will vary. In a deep-sea hydrothermal vent, there is no light, so prokaryotes would be chemotrophs instead of phototrophs. The source of carbon would be carbon dioxide dissolved in the ocean, so they would be autotrophs. There is not a lot of organic material in the

ocean, so prokaryotes would probably use inorganic sources; thus, they would be chemolithotrophs. The temperatures are very high in the hydrothermal vent, so the prokaryotes would be thermophilic.

35. Losing the bacteria that serve as decomposers in the ecosystem would disrupt the carbon cycle but not stop it completely since fungi can also serve as decomposers. Without bacterial decomposers functioning, organic waste would accumulate in the area, and less carbon dioxide would be released back into the atmosphere.

37. *E. coli* colonizes the surface of the leaf, forming a biofilm that is more difficult to remove than free-living (planktonic) cells. Additionally, bacteria can be taken up in the water that plants are grown in, thereby entering the plant tissues rather than simply residing on the leaf surface.

39. Soap indiscriminately kills bacteria on skin. This kills harmful bacteria but can also eliminate "good" bacteria from the skin. When the nonpathogenic bacteria are eliminated, pathogenic bacteria can colonize the empty surface.

Chapter 23

1. d. oxygenation of the atmosphere

3. c. endosymbiosis

5. c. eukaryote

7. d. proteins

9. b. a cilium

11. a. anaerobic heterotroph

13. c. 8

15. d. *Caulerpa*

17. a. photosynthesis

19. b. They occupy the apex producer niche.

21. The endosymbiotic theory proposes that one organism engulfed another, and the two coevolved together until they could not exist independently. If a bacterium engulfed an archaean, or vice versa, and the two developed an obligate symbiotic relationship, the resulting eukaryote thousands of years later would retain features from both original cells.

23. As an intestinal parasite, *Giardia* cysts would be exposed to low pH in the stomach acids of its host. To survive this environment and reach the intestine, the cysts would have to be resistant to acidic conditions.

25. Unlike *Ulva*, protists in the genus *Caulerpa* actually are large, multinucleate, single cells. Because these organisms undergo mitosis without cytokinesis and lack cytoplasmic divisions, they cannot be considered truly multicellular.

27. The key feature of Opisthokonts is the flagellum on the posterior end of cells. Example organisms:

- Choanoflagellates use the flagellum for filter feeding.
- Sponges (animals) use the flagellum for filter feeding.
- Male gametes (animals) use the flagellum for locomotion.
- Fungi spores use the flagellum for locomotion.

29. *Plasmodium* parasites infect humans and cause malaria. However, they must complete part of their life cycle within *Anopheles* mosquitoes, and they can only infect humans via the bite wound of a mosquito. If the mosquito population is decreased, then fewer *Plasmodium* would be able to develop and infect humans, thereby reducing the incidence of human infections with this parasite.

31. Ocean stresses, such as rising temperatures or increasing levels of pollution, cause corals to expel their zooxanthellae symbionts. This leads to coral bleaching and death if no new zooxanthellae colonize the corals. The dying corals will decrease the food source available to parrotfish, so the parrotfish population will decline. With fewer prey animals available, the shark population in the area will also decline.

Chapter 24

1. c. chitin

3. d. septum

5. c. haploid-dominant green algae

7. b. Basidiomycota

9. b. Deuteromycota

11. c. a mycorrhiza

13. c. Nitrogen intake would decrease.

15. c. superficial mycosis

17. b. the atmosphere does not contain oxygen

19. a. Human consumption of fungal insecticides would not make a person sick, but ingestion of chemical pesticides can be harmful to humans.

21. Animals have no cell walls; fungi have cell walls containing chitin; plants have cell walls containing cellulose. Chloroplasts are absent in both animals and fungi but are present in plants. Animal plasma membranes are stabilized with cholesterol, while fungi plasma membranes are stabilized with ergosterol, and plant plasma membranes are stabilized with phytosterols. Animals obtain nitrogen and carbon from food sources via internal digestion. Fungi obtain nitrogen and carbon from food sources via external digestion. Plants obtain organic nitrogen from the environment or through symbiotic nitrogen-fixing

bacteria; they obtain carbon from photosynthesis. Animals and fungi store polysaccharides as glycogen, while plants store them as starch.

23. By ingesting spores and disseminating them in the environment as waste, animals act as agents of dispersal. The benefit to the fungus outweighs the cost of producing fleshy fruiting bodies.

25. Protection from excess light that may bleach photosynthetic pigments allows the photosynthetic partner to survive in environments unfavorable to plants.

27. Plants with arbuscular mycorrhizae are colonized by fungi that penetrate root cells and exchange metabolites with the plant. The network of fungal hyphae extends from the root cells out into the environment, covering a larger area than the plant's root system alone. This allows the plant to draw water from a larger area, increasing the likelihood that it can meet its daily needs.

29. The dough is often contaminated by toxic spores that float in the air. It was one of Louis Pasteur's achievements to purify reliable strains of baker's yeast to produce bread consistently.

Chapter 25

1. a. green algae

3. c. tracheids

5. c. sporopollenin

7. c. The *Chara* genome is more similar to the tomato plant genome than the red algae genome.

9. d. root

11. a. 1*n*

13. b. gametophyte

15. d. horsetail

17. d. sporophyte

19. b. Mosses harbor cyanobacteria that fix nitrogen.

21. Sunlight is not filtered by water or other algae on land; therefore, there is no need to collect light at additional wavelengths made available by other pigment coloration.

23. Possible challenges include:

- Climate: Deserts are more arid than swamps, so there is less humidity in the air and less water in the soil.
- Reproduction: Cactuses are often not densely populated, whereas cattails occur in groups.
- Temperature: During the day, deserts are usually hot, which increases the risk of desiccation. The desert climate will also have broader temperature ranges (extremes).

25. It allows for survival through periodic droughts and colonization of environments where the supply of water fluctuates.

27. The bryophytes are divided into three phyla: the liverworts or Marchantiophyta, the hornworts or Anthocerotophyta, and the mosses or true Bryophyta.

29. Similarities include:

- Sexual reproduction is dependent upon water in which the male gamete swims.
- The haploid organism is the dominant part of the life cycle.

Differences include:

- Bryophyte gametotangia protect the gametes and the growing embryo.
- Bryophytes make sporangium to produce spores.

31. Ferns are considered the most advanced seedless vascular plants because they display characteristics commonly observed in seed plants; they form large leaves and branching roots.

Chapter 26

1. d. all heterosporous

3. c. Triassic

5. a. The plants carry exposed seeds on modified leaves.

7. b. 1*n*, 2*n*, 1*n*, 2*n*

9. c. the sepal

11. b. the polar nuclei of the center cell

13. c. nectar

15. d. wind

17. Both pollination and herbivory contributed to diversity, with plants needing to attract some insects and repel others.

19. The trees are adapted to arid weather and do not lose as much water due to transpiration as non-conifers.

21. The resemblance between cycads and palm trees is only superficial. Cycads are gymnosperms and do not bear flowers or fruit. Cycads produce cones: large, female cones that produce naked seeds, and smaller male cones on separate plants. Palms do not.

23. Using animal pollinators promotes cross-pollination and increases genetic diversity. The odds that the pollen will reach another flower are greatly increased compared with the randomness of wind pollination.

Chapter 27

1. b. asexual reproduction

3. d. two fewer appendages than normal

5. b. diploblastic eucoelomate

7. c. Parazoa

9. d. morphological; molecular

11. b. fossil data

13. c. small and soft-bodied

15. d. more than 5

17. Humans are multicellular organisms. They also contain differentiated tissues, such as epithelial, muscle, and nervous tissue, as well as specialized organs and organ systems. As heterotrophs, humans cannot produce their own nutrients and must obtain them by ingesting other organisms, such as plants, fungi, and animals. Humans undergo sexual reproduction, as well as the same embryonic developmental stages as other animals, which eventually lead to a fixed and motile body plan controlled in large part by *Hox* genes.

19. Humans have body plans that are bilaterally symmetrical and are characterized by the development of three germ layers, making them triploblasts. Humans have true coeloms and are, thus, eucoelomates. As deuterostomes, humans are characterized by radial and indeterminate cleavage.

21. Two new clades that comprise the two major groups of protostomes are called the lophotrochozoans and the ecdysozoans. The formation of these two clades came about through molecular research from DNA and protein data. Also, the novel phylum of worm, called Acoelomorpha, was determined due to molecular data that distinguished them from other flatworms.

23. One theory states that environmental factors led to the Cambrian explosion. For example, the rise in atmospheric oxygen and oceanic calcium levels helped to provide the right environmental conditions to allow such a rapid evolution of new animal phyla. Another theory states that ecological factors, such as competitive pressures and predator-prey relationships, reached a threshold that supported the rapid animal evolution that took place during the Cambrian Period.

Chapter 28

1. b. a collagen-like gel and suspended cells for various functions

3. b. The reliance on osmosis/diffusion requires a design that maximizes the surface-area-to-volume ratio of the sponge.

5. b. medusoids

7. a. monogeneans

9. b. true coelom

11. d. Muscle contractions can be localized to specific regions of the body to coordinate movement.

13. c. chitin

15. b. hexapods

17. d. pentaradial symmetry

19. a. Human embryos undergo indeterminate cleavage.

21. Pinacocytes are epithelial-like cells, form the outermost layer of sponges, and enclose a jellylike substance called mesohyl. In some sponges, porocytes form ostia, single tube-shaped cells that act as valves to regulate the flow of water into the spongocoel. Choanocytes ("collar cells") are present at various locations, depending on the type of sponge, but they always line some space through which water flows and are used in feeding.

23. Nematocysts are "stinging cells" designed to paralyze prey. The nematocysts contain a neurotoxin that renders prey immobile.

25. There are two key differences between Porifera (sponges) and Cubozoans (box jellyfish)—gamete production and fertilization strategy. Box jellyfish have separate sexes, while a single sponge can produce both types of gametes. Box jellyfish also undergo internal fertilization, while sponges reproduce by external fertilization. Internal fertilization allows box jellyfish to control which sperm is used for fertilization and increases the likelihood of ova and spermatozoa meeting.

27. Mollusks have a large muscular foot that may be modified in various ways, such as into tentacles, but it functions in locomotion. They have a mantle, a structure of tissue that covers and encloses the dorsal portion of the animal and secretes the shell when it is present. The mantle encloses the mantle cavity, which houses the gills (when present), excretory pores, anus, and gonadopores. The coelom of mollusks is restricted to the region around the systemic heart. The main body cavity is a hemocoel. Many mollusks have a radula near the mouth that is used for scraping food.

29. Cephalopods have a closed circulatory system, while other members of the Mollusca phylum have open circulatory systems. Having a closed system allows blood to be moved more efficiently and rapidly through the animal since the circulation is not limited by diffusion. For example, this allows the octopus to have a much more complex body plan with branching tentacles, compared to a snail. In many cases, a closed circulatory system also allows the development of larger organisms.

31. There are nematodes with separate sexes and hermaphrodites in addition to species that reproduce parthenogenetically. The nematode *Caenorhabditis elegans* has a self-fertilizing hermaphrodite sex and a pure male sex.

33. The Arthropoda include the Hexapoda, which are mandibulates with six legs; the Myriapoda, which

are mandibulates with many legs and include the centipedes and millipedes; the Crustacea, which are mostly marine mandibulates; and the Chelicerata, which include the spiders and scorpions and their kin.

35. Advantages:
- Pollination
- Eliminate pests
- Cheap food source
- Produce food products (e.g., honey)

Disadvantages:
- Damage to food crops
- Transmit disease to agricultural workers
- Contaminate/spoil food
- Destroy buildings storing food crops

Chapter 29

1. b. Echinodermata

3. a. craniates

5. b. a bony skeleton

7. d. It laid shelled eggs.

9. c. lepidosaurs and archosaurs

11. d. Archosaurs

13. d. contour feathers

15. d. platypuses

17. a. lemurs

19. b. detection and processing of three-color vision

21. The notochord is a flexible structure that provides support for the embryo's body and formation of the neural tube. In the adults, the notochord has been replaced by the bony, rigid vertebral column. This loss of flexibility restricts the movement of adult humans and would make it unlikely that the embryo would fit within the small space it is allotted inside the uterus.

23. Evolution of the jaw and paired fins permitted gnathostomes to diversify from the sedentary suspension feeding of agnathans to a mobile predatory lifestyle. The ability of gnathostomes to utilize new nutrient sources may be one reason why the gnathostomes replaced most agnathans.

25. The larval stage of frogs is the tadpole, which is usually a filter-feeding herbivore. Tadpoles usually have gills, a lateral line system, long-finned tails, and lack limbs. In the adult form, the gills and lateral line system disappear, and four limbs develop. The jaws grow larger, suitable for carnivorous feeding, and the digestive system transforms into the typical short gut of a predator. An eardrum and air-breathing lungs also develop.

27. The chorion facilitates the exchange of oxygen and carbon dioxide gases between the embryo and the surrounding air. The amnion protects the embryo from mechanical shock and prevents dehydration. The allantois stores nitrogenous wastes produced by the embryo and facilitates respiration. The yolk sac contains blood vessels that transport yolk nutrients to the circulatory system of the embryo.

29. Reptiles are ectotherms, dependent on external sources to regulate their body temperature (i.e., their environment). The highest density of reptiles will, therefore, be in regions of the world with moderate temperatures rather than areas that experience temperature extremes.

31. The sternum of birds is larger than that of other vertebrates, which accommodates the force required for flapping. Another skeletal modification is the fusion of the clavicles, forming the furcula, or wishbone. The furcula is flexible enough to bend during flapping and provides support to the shoulder girdle during flapping. Birds also have pneumatic bones that are hollow rather than filled with tissue.

33. The lower jaw of mammals consists of only one bone: the dentary. The dentary bone joins the skull at the squamosal bone. Mammals have three bones of the middle ear. The adductor muscle that closes the jaw is composed of two muscles in mammals. Most mammals have heterodont teeth.

35. The muscles that close the jaw in mammals evolved to allow chewing to occur. Chewing meant mammals could now grind food with their teeth (molars), allowing them to eat a more diverse diet. This would have protected them in the event of a mass extinction (since they would still have food sources available) and allow them to colonize new environments (and consume new food sources). Chewing also allowed mammals to break down food into smaller pieces to speed digestion, reducing the time between consumption and energy extraction.

37. The immediate ancestors of humans were *Australopithecus*. All people past and present, along with the australopithecines, are hominins. We share the adaptation of being habitually bipedal. The earliest australopithecines very likely did not evolve until five million years ago. The primate fossil record for this crucial transitional period leading to australopithecines is still sketchy and somewhat confusing. By about 2.5 MYA, there were at least two evolutionary lines of hominins descended from early australopithecines.

Chapter 30

1. c. meristematic tissue

3. c. nodes

5. a. vascular tissue

7. b. increase in thickness or girth

9. a. epiphytic roots

11. b. zone of maturation

13. c. compound

15. b. spines instead of leaves

17. d. sieve-tube elements, companion cells

19. c. mediates morphological changes in response to red and far-red light

21. c. ethylene

23. c. thigmotropism

25. Vascular tissue transports water, minerals, and sugars throughout the plant. Vascular tissue is made up of xylem tissue and phloem tissue. Xylem tissue transports water and nutrients from the roots upward. Phloem tissue carries sugars from the sites of photosynthesis to the rest of the plant.

27. Xylem is made up tracheids and vessel elements, which are cells that transport water and dissolved minerals and are dead at maturity. Phloem is made up of sieve-tube cells and companion cells, which transport carbohydrates and are alive at maturity.

29. In woody stems, lenticels allow internal cells to exchange gases with the outside atmosphere.

31. Answers will vary. Rhizomes, stolons, and runners can give rise to new plants. Corms, tubers, and bulbs can also produce new plants and can store food. Tendrils help a plant to climb, while thorns discourage herbivores.

33. The root would not be able to produce lateral roots.

35. Conifers, such as spruce, fir, and pine, have needle-shaped leaves with sunken stomata, which help to reduce water loss.

37. A long-day plant needs a higher proportion of the Pfr form to Pr form of phytochrome. The plant requires long periods of illumination with light enriched in the red range of the spectrum.

39. Refrigeration slows chemical reactions, including fruit maturation. Ventilation removes the ethylene gas that speeds up fruit ripening.

Chapter 31

1. c. The element is inorganic.

3. a. micronutrients

5. d. all of these

7. b. horizons; soil profile

9. b. nitrogen fixation

11. a. parasite

13. Deficiencies in these nutrients could result in stunted growth, slow growth, and chlorosis.

15. A mineral soil forms from the weathering of rocks; it is inorganic material. An organic soil is formed from sedimentation; it mostly consists of humus.

17. Topography affects water runoff, which strips away parent material and affects plant growth. Steep soils are more prone to erosion and may be thinner than soils that are on level surfaces.

19. Photosynthesis harvests and stores energy, whereas biological nitrogen fixation requires energy.

Chapter 32

1. b. microsporangium

3. a. sepals

5. b. an endosperm

7. d. accessory fruit

9. a. grafting

11. d. monocarpic

13. Inside the flower are the reproductive organs of the plant. The stamen is the male reproductive organ. Pollen is produced in the stamen. The carpel is the female reproductive organ. The ovary is the swollen base of the carpel where ovules are found. Not all flowers have every one of the four parts.

15. A typical flower has four main parts, or whorls: the calyx, corolla, androecium, and gynoecium. The outermost whorl of the flower has green, leafy structures known as sepals, which are collectively called the calyx. It helps to protect the unopened bud. The second whorl is made up of brightly colored petals that are known collectively as the corolla. The third whorl is the male reproductive structure known as the androecium. The androecium has stamens, which have anthers on a stalk or filament. Pollen grains are borne on the anthers. The gynoecium is the female reproductive structure. The carpel is the individual structure of the gynoecium and has a stigma, the stalk or style, and the ovary.

17. Many seeds enter a period of inactivity or extremely low metabolic activity, a process known as dormancy. Dormancy allows seeds to tide over unfavorable conditions and germinate on return to favorable conditions. Favorable conditions could be as diverse as moisture, light, cold, fire, or chemical treatments. After heavy rains, many new seedlings emerge. Forest fires also lead to the emergence of new seedlings.

19. Asexual reproduction does not require the expenditure of the plant's resources and energy that would be involved in producing a flower, attracting pollinators, or dispersing seeds. Asexual reproduction results in plants that are genetically identical to the parent plant, since there is no mixing of male and female gametes, resulting in better survival. The cuttings or buds taken from an adult plant produce progeny that mature faster

and are sturdier than a seedling grown from a seed.

21. Plant species that complete their life cycle in one season are known as annuals. Biennials complete their life cycle in two seasons. In the first season, the plant has a vegetative phase, whereas in the next season, it completes its reproductive phase. Perennials, such as the magnolia, complete their life cycle in two years or more.

Chapter 33

1. a. endotherm

3. c. estivation

5. d. transverse

7. d. Ectotherms will be able to expand into new habitats.

9. a. squamous

11. d. transitional

13. d. bone

15. a. osteoblast

17. b. skeletal muscle

19. c. The discs ensure that all the cardiac muscle cells beat as a single unit.

21. a. lowering of blood glucose after a meal

23. b. hypothalamus

25. a. sweating for evaporative cooling

27. Basal metabolic rate is an expression of the metabolic processes that occur to maintain an individual's functioning and body temperature. Smaller bodied animals have a relatively large surface area compared to a much larger animal. The small animal's large surface area leads to increased heat loss that the animal must compensate for, resulting in a higher BMR. A large animal, having less relative surface area, does not lose as much heat and has a correspondingly lower BMR.

29. Endotherms are constrained by the availability of food sources in the environment, while the temperature range in a geographic area limits ectotherms. The difference in how the two groups maintain their body temperature determines the key constraint for each group.

31. Both contain cells other than the traditional fibroblast. Both have cells that lodge in spaces within the tissue called lacunae. Both collagen and elastic fibers are found in bone and cartilage. Both tissues participate in vertebrate skeletal development and formation.

33. Skeletal muscles are involved in voluntary motion, so the person has to make the choice to work those muscles through exercise or movement. Smooth muscles are involved in involuntary activities of the body (e.g., blood vessel expansion and contraction, intestinal peristalsis), so they are active even when a person is sedentary.

35. Mammalian enzymes increase activity to the point of denaturation, increasing the chemical activity of the cells involved. Bacterial enzymes have a specific temperature for their most efficient activity and are inhibited at either higher or lower temperatures. Fever results in an increase in the destruction of the invading bacteria by increasing the effectiveness of body defenses and an inhibiting bacterial metabolism.

37. Animals are capable of thermal uncoupling when they need to generate heat to maintain their body temperatures. In this process, an uncoupling protein provides a channel in the inner mitochondrial membrane that allows protons to leave the lumen without moving through the ATP synthase. This generates heat rather than chemical energy as the final product of cellular respiration.

Chapter 34

1. d. horse

3. c. bicarbonates

5. b. snowshoe hare

7. d. vitamin C

9. c. glycogen

11. a. stomach

13. b. dehydration

15. b. somatostatin

17. Animals with a polygastric digestive system have a multichambered stomach. The four compartments of the stomach are called the rumen, reticulum, omasum, and abomasum. These chambers contain many microbes that break down the cellulose and ferment the ingested food. The abomasum is the "true" stomach and is the equivalent of a monogastric stomach chamber where gastric juices are secreted. The four-compartment gastric chamber provides larger space and the microbial support necessary for ruminants to digest plant material.

19. Accessory organs play an important role in producing and delivering digestive juices to the intestine during digestion and absorption. Specifically, the salivary glands, liver, pancreas, and gallbladder play important roles. Malfunction of any of these organs can lead to disease states.

21. The stomach and the teeth both perform mechanical digestion, which is physically (as opposed to chemically) breaking the food into smaller components. This exposes a larger surface area for chemical digestion and release of nutrients. The teeth are vital to mastication, which breaks large bites of food down into smaller pieces that are easily swallowed. The stomach's muscle contractions churn the food to expose all particles to the acid and digestive enzymes.

23. Minerals—such as potassium, sodium, and calcium—are required for the functioning of many cellular processes, including muscle contraction and nerve conduction. While minerals are required in trace amounts, not having minerals in the diet can be potentially harmful.

25. Malnutrition, often in the form of not getting enough calories or not enough of the essential nutrients, can have severe consequences. Many malnourished children have vision and dental problems, and over the years may develop many serious health problems.

27. Fats are an essential component of a healthy diet and needed by the body to function. Fats are essential for many processes, including the absorption of fat-soluble vitamins and production of some hormones. Fats also send a satiation signal to the brain that regulates hunger. Without fats in their diets, many people may have actually consumed more calories, which would have resulted in weight gain.

29. The gut microbiome includes all the bacteria that aid in chemical digestion in the intestines. Changing its composition can change the way that food is digested since not all bacteria have the same macromolecule-digesting enzymes. Additionally, changes in gut microbiome can lead to the establishment of pathogenic bacteria populations that cause inflammation in the gut or other disease.

31. Hormones control the different digestive enzymes that are secreted in the stomach and the intestine during the process of digestion and absorption. For example, the hormone gastrin stimulates stomach acid secretion in response to food intake. The hormone somatostatin stops the release of stomach acid.

Chapter 35

1. a. They use less metabolic energy.

3. c. pulmonary circulation

5. c. when platelets are attracted to a site of blood vessel damage

7. c. they have nuclei

9. a. contracting

11. a. Arteries have thicker smooth muscle layers to accommodate the changes in pressure from the heart.

13. A closed circulatory system is a closed-loop system in which blood is not free in a cavity. Blood is separate from the bodily interstitial fluid and contained within blood vessels. In this type of system, blood circulates unidirectionally from the heart around the systemic circulatory route and then returns to the heart.

15. Red blood cells are coated with proteins called antigens made of glycolipids and glycoproteins. When type A and type B blood are mixed, the blood agglutinates because of antibodies in the plasma that bind with the opposing antigen. Type O blood has no antigens. The Rh blood group has either the Rh antigen (Rh+) or no Rh antigen (Rh-).

17. Lymph capillaries take fluid from the blood to the lymph nodes. The lymph nodes filter the lymph by percolation through connective tissue filled with white blood cells. The white blood cells remove infectious agents, such as bacteria and viruses, to clean the lymph before it returns to the bloodstream.

19. The capillaries basically exchange materials with their surroundings. Their walls are very thin and are made of one or two layers of cells, where gases, nutrients, and waste are diffused. They are distributed as beds, complex networks that link arteries as well as veins.

Chapter 36

1. a. provides body tissues with oxygen

3. b. nasal cavity, larynx, trachea, bronchi, bronchioles, alveoli

5. d. Lungs exert a pressure on the air to reduce the oxygen pressure.

7. b. It would prevent inhalation because the intrapleural pressure would not change.

9. d. both a. and c.

11. c. conversion to bicarbonate

13. The main bronchus is the conduit in the lung that funnels air to the airways where gas exchange occurs. The main bronchus attaches the lungs to the very end of the trachea where it bifurcates. The trachea is the cartilaginous structure that extends from the pharynx to the primary bronchi. It serves to funnel air to the lungs. The alveoli are the sites of gas exchange; they are located at the terminal regions of the lung and are attached to the respiratory bronchioles. The acinus is the structure in the lung where gas exchange occurs.

15. FEV1/FVC measures the forced expiratory volume in one second in relation to the total forced vital capacity (the total amount of air that is exhaled from the lung from a maximal inhalation). This ratio changes with alterations in lung function that arise from diseases such as fibrosis, asthma, and COPD.

17. Oxygen moves from the lung to the bloodstream to the tissues, according to the pressure gradient. This is measured as the partial pressure of oxygen. If the amount of oxygen drops in the inspired air, there would be reduced partial pressure. This would decrease the

driving force that moves the oxygen into the blood and into the tissues. P_{O_2} is also reduced at high elevations; P_{O_2} at high elevations is lower than at sea level because the total atmospheric pressure is less than atmospheric pressure at sea level.

19. Increased airway resistance increases the volume and pressure in the lung; therefore, the intrapleural pressure would be less negative, and breathing would be more difficult.

21. The lung is particularly susceptible to changes in the magnitude and direction of gravitational forces. When someone is standing or sitting upright, the pleural pressure gradient leads to increased ventilation further down in the lung.

23. Carbon monoxide has a higher affinity for hemoglobin than oxygen. This means that carbon monoxide will preferentially bind to hemoglobin over oxygen. Administration of 100% oxygen is an effective therapy because at that concentration, oxygen will displace the carbon monoxide from the hemoglobin.

Chapter 37

1. d. desiccation

3. a. lysosome

5. d. macrophage

7. b. missing self

9. d. plasma cell

11. d. immediate hypersensitivity

13. c. systemic lupus erythematosus

15. c. BCR

17. c. IgG

19. When the MHC I molecules expressed on donor cells differ from the MHC I molecules expressed on recipient cells, NK cells may identify the donor cells as "non-self." As a result, the NK cells will produce perforin and granzymes to induce the donor cells to undergo apoptosis, which destroys the transplanted organ.

21. An antigen is a molecule that reacts with some component of the immune response (antibody, B cell receptor, T cell receptor). An epitope is the region on the antigen through which binding with the immune component actually occurs.

23. The T_H1 response involves the secretion of cytokines to stimulate macrophages and CTLs and improve their destruction of intracellular pathogens and tumor cells. It is associated with inflammation. The T_H2 response is involved in the stimulation of B cells into plasma cells that synthesize and secrete antibodies.

25. T cells bind antigens that have been digested and embedded in MHC molecules by APCs. In contrast, B cells function themselves as APCs to bind intact, unprocessed antigens.

27. Cross-reactivity of antibodies can be beneficial when it allows an individual's immune system to respond to an array of similar pathogens after being exposed to just one of them. A potential cost of cross-reactivity is an antibody response to parts of the body (self) in addition to the appropriate antigen.

Chapter 38

1. b. saline at a concentration that is isotonic with respect to body fluids

3. a. shrink due to water loss

5. b. 300 mOsm

7. c. both a. and b.

9. d. flatworms

11. c. urea

13. c. lose salts and water

15. Excretion allows an organism to rid itself of waste molecules that could be toxic if allowed to accumulate. It also allows the organism to keep the amount of water and dissolved solutes in balance.

17. The loop of Henle is part of the renal tubule that loops into the renal medulla. In the loop of Henle, the filtrate exchanges solutes and water with the renal medulla and the vasa recta (the peritubular capillary network). The vasa recta acts as the countercurrent exchanger. The kidneys maintain the osmolality of the rest of the body at a constant 300 mOsm by concentrating the filtrate as it passes through the loop of Henle.

19. The removal of wastes, which could otherwise be toxic to an organism, is extremely important for survival. Having organs specialize in this process that operate separately from other organs provides a measure of safety for the organism.

21. It is believed that the urea cycle evolved to adapt to a changing environment when terrestrial life forms evolved. Arid conditions probably led to the evolution of the uric acid pathway as a means of conserving water.

23. Hormones are small molecules that act as messengers within the body. Different regions of the nephron bear specialized cells, which have receptors to respond to chemical messengers and hormones. The hormones carry messages to the kidney. These hormonal cues help the kidneys synchronize the osmotic needs of the body. Hormones like epinephrine, norepinephrine, renin-angiotensin, aldosterone, antidiuretic hormone, and atrial natriuretic peptide help regulate the needs of the body as well as the communication between the different organ systems.

Chapter 39

1. c. peptide hormone

3. d. They are nonpolar molecules.

5. d. It will prevent activation of protein kinases.

7. a. inhibits ADH release

9. c. insulin

11. a. Patients would appear phenotypically female.

13. b. hormonal and neural stimuli

15. c. adrenal glands

17. c. pineal

19. Secreted peptides, such as insulin, are stored within vesicles in the cells that synthesize them. They are then released in response to stimuli, such as high blood glucose levels in the case of insulin.

21. The number of receptors that respond to a hormone can change, resulting in increased or decreased cell sensitivity. The number of receptors can increase in response to rising hormone levels, called up-regulation, making the cell more sensitive to the hormone and allowing for more cellular activity. The number of receptors can also decrease in response to rising hormone levels, called down-regulation, leading to reduced cellular activity.

23. In steroid hormone signaling, the steroid interacts directly with its intracellular receptor rather than signaling through a second messenger like cAMP. The steroid-receptor complex then moves into the nucleus and directly regulates the transcription of DNA. This will cause the cell to produce multiple copies of the target gene, amplifying the signal from the hormone at the transcriptional level rather than the second messenger level.

25. Hormonal regulation is required for the growth and replication of most cells in the body. Growth hormone (GH), produced by the anterior pituitary, accelerates the rate of protein synthesis, particularly in skeletal muscles and bones. Growth hormone has direct and indirect mechanisms of action. The direct actions of GH include: 1) stimulation of fat breakdown (lipolysis) and release into the blood by adipocytes. This results in a switch by most tissues from utilizing glucose as an energy source to utilizing fatty acids. This process is called a glucose-sparing effect. 2) In the liver, GH stimulates glycogen breakdown, which is then released into the blood as glucose. Blood glucose levels increase as most tissues are utilizing fatty acids instead of glucose for their energy needs. The GH-mediated increase in blood glucose levels is called a diabetogenic effect because it is similar to the high blood glucose levels seen in diabetes mellitus.

27. Hormone production and release are primarily controlled by negative feedback. In negative feedback systems, a stimulus causes the release of a substance whose effects then inhibit further release. In this way, the concentration of hormones in blood is maintained within a narrow range. For example, the anterior pituitary signals the thyroid to release thyroid hormones. Increasing levels of these hormones in the blood then feed back to the hypothalamus and anterior pituitary to inhibit further signaling to the thyroid gland.

29. Progestins, including progesterone, are hormones that help to control the fertility cycle in women. When progesterone is released, it inhibits the production of GnRH in the hypothalamus. Without GnRH, FSH and LH are not produced in the pituitary gland, so the ovaries are not signaled to mature and release an ovum. If progesterone is delivered to the body every day, it will continuously inhibit this cycle.

31. The adrenal medulla contains two types of secretory cells, one that produces epinephrine (adrenaline) and another that produces norepinephrine (noradrenaline). Epinephrine is the primary adrenal medulla hormone accounting for 75–80% of its secretions. Epinephrine and norepinephrine increase heart rate, breathing rate, cardiac muscle contractions, and blood glucose levels. They also accelerate the breakdown of glucose in skeletal muscles and stored fats in adipose tissue. The release of epinephrine and norepinephrine is stimulated by neural impulses from the sympathetic nervous system. These neural impulses originate from the hypothalamus in response to stress to prepare the body for the fight-or-flight response.

Chapter 40

1. a. asexual

3. d. hermaphroditism

5. a. aquatic

7. a. oviparity

9. c. seminiferous tubules

11. a. clitoris

13. a. one

15. c. GnRH

17. d. progesterone

19. a. placenta

21. b. hormonal

23. b. first trimester

25. d. does not change significantly

27. d. somites

29. The presence of the W chromosome in birds determines femaleness, and the presence of the Y chromosome in mammals determines

maleness. The absence of those chromosomes and the homogeneity of the offspring (ZZ or XX) leads to the development of the other sex.

31. Paired external fertilization allows the female to select the male for mating. It also has a greater chance of fertilization taking place, whereas spawning just puts many sperm and eggs together and random interactions result in the fertilization.

33. Stem cells are laid down in the male during gestation and lie dormant until adolescence. Stem cells in the female increase to one to two million, enter the first meiotic division, and are arrested in prophase. At adolescence, spermatogenesis begins and continues until death, producing the maximum number of sperm with each meiotic division. Oogenesis continues again at adolescence in batches of oogonia with each menstrual cycle. These oogonia finish the first meiotic division, producing a primary oocyte with most of the cytoplasm and its contents and a second cell called a polar body containing 23 chromosomes. The second meiotic division results in a secondary oocyte and a second oocyte. At ovulation, a mature haploid egg is released. If this egg is fertilized, it finishes the second meiotic division, including the chromosomes donated by the sperm in the finished cell. This is a diploid, fertilized egg.

35. Low levels of progesterone allow the hypothalamus to send GnRH to the anterior pituitary and cause the release of FSH and LH. FSH stimulates follicles on the ovary to grow and prepare the eggs for ovulation. As the follicles increase in size, they begin to release estrogen and a low level of progesterone into the blood. The level of estrogen rises to a peak, causing a spike in the concentration of LH. This causes the most mature follicle to rupture, and ovulation occurs.

37. Stage one of labor results in the thinning of the cervix and the dilation of the cervical opening. Stage two delivers the baby, and stage three delivers the placenta.

39. Mammalian eggs do not need a lot of yolk because the developing fetus obtains nutrients from the female. Other species, such as birds, in which the fetus develops outside of the female's body, require a lot of yolk in the egg to nourish the embryo during development.

41. Animal bodies have lateral-medial (left-right), dorsal-ventral (back-belly), and anterior-posterior (head-feet) axes. The dorsal cells are genetically programmed to form the notochord and define the axis. There are many genes responsible for axis formation. Mutations in these genes lead to the loss of symmetry required for organism development.

Chapter 41

1. b. cerebral cortex

3. a. electrical

5. b. Merkel's disks; glabrous

7. b. Meissner's corpuscles

9. a. one

11. b. olfaction; thalamus

13. d. hertz (Hz); decibels (dB)

15. b. hair cells

17. b. Their lens no longer focuses correctly.

19. d. superior colliculus

21. Transmission of sensory information from the receptor to the central nervous system will be impaired, and thus, perception of stimuli, which occurs in the brain, will be halted.

23. General sensory receptors are located throughout the body in the skin and internal organs. Conversely, special senses are all located in the head region and require specialized organs.

25. Pain is a subjective sensation that relies on the brain interpreting the nociception signals received by the sensory receptors (perception). Therefore, even though two people experience identical stimuli, their brains can perceive them as very different sensory experiences.

27. The animal might not be able to recognize the differences in food sources and, thus, might not be able to discriminate between spoiled food and safe food or between foods that contain necessary nutrients, such as proteins, and foods that do not.

29. The sound would slow down because it is transmitted through the particles (gas), and there are fewer particles (lower density) at higher altitudes.

31. The first step in processing a sound in humans is the collection of sound by the pinna. When a person encounters a sound, the pinna on both sides of the head will collect the vibrations. Since the waves originate from a single site, the two pinnae will not collect the sound at the exact same time. When the sound is processed by the auditory system, the brain is able to use this slight difference in timing to determine the location of the sound.

33. The photoreceptors tonically inhibit the bipolar cells, and stimulation of the receptors turns this inhibition off, activating the bipolar cells.

Chapter 42

1. c. dendrites

3. b. oligodendrocytes

5. b. the threshold of excitation

7. c. gap junction protein

9. d. occipital

11. b. spinal cord

13. c. an increased heart rate

15. a. acetylcholine

17. c. stimulant

19. d. all of these

21. Neurons contain organelles common to all cells, such as a nucleus and mitochondria. They are unique because they contain dendrites, which can receive signals from other neurons, and axons that can send these signals to other cells.

23. A single axon means that a neuron can only send one signal at a time (one electrical impulse down the length of the axon). However, since the axon has multiple terminals, it can send the signal to several other cells at once. This ensures that the signal is rapidly propagated to the rest of the body.

25. An action potential travels along an axon until it depolarizes the membrane at an axon terminal. Depolarization of the membrane causes voltage-gated Ca^{2+} channels to open and Ca^{2+} to enter the cell. The intracellular calcium influx causes synaptic vesicles containing a neurotransmitter to fuse with the presynaptic membrane. The neurotransmitter diffuses across the synaptic cleft and binds to receptors on the postsynaptic membrane. Depending on the specific neurotransmitter and postsynaptic receptor, this action can cause positive (excitatory postsynaptic potential) or negative (inhibitory postsynaptic potential) ions to enter the cell.

27. To determine the function of a specific brain area, scientists can look at patients who have damage in that brain area and see what symptoms they exhibit. Researchers can disable the brain structure temporarily using transcranial magnetic stimulation. They can also disable or remove the area in an animal model. fMRI can be used to correlate specific functions with increased blood flow to brain regions.

29. Potential answers:

1. Frontal lobe. Alzheimer's patients experience changes in personality, judgment, and behavior.

2. Parietal lobe. Alzheimer's patients experience difficulties with recalling and using language as disease progresses.

3. Temporal lobe. The hippocampus is one of the main areas of the brain affected in Alzheimer's disease. Patients lose the ability to make new memories and access memories.

31. The sensory-somatic nervous system transmits sensory information from the skin, muscles, and sensory organs to the CNS. It also sends motor commands from the CNS to the muscles, causing them to contract.

33. Many events in modern human life are not physical dangers; instead, they are events we think of as "stress." Finding the money to pay your student loans or being nervous before a test still activate the sympathetic nervous system, but these situations do not require the fight-or-flight response to survive.

35. Possible treatments for patients with major depression include psychotherapy and prescription medications. MAO inhibitor drugs inhibit the breakdown of certain neurotransmitters (including dopamine, serotonin, norepinephrine) in the synaptic cleft. SSRI medications inhibit the reuptake of serotonin into the presynaptic neuron.

Chapter 43

1. a. radius and ulna

3. d. pelvic

5. d. Exoskeletons provide less mechanical leverage.

7. c. is responsible for the lengthwise growth of long bones

9. c. osteons

11. d. flat bone

13. d. abduction

15. a. hinge

17. d. tropomyosin

19. d. acetylcholinesterase

21. d. Botox decreases the release of acetylcholine from motor neurons.

23. The pelvic girdle is securely attached to the body by strong ligaments, unlike the pectoral girdle, which is sparingly attached to the rib cage. The sockets of the pelvic girdle are deep, allowing the femur to be more stable than the pectoral girdle, which has shallow sockets for the scapula. Most tetrapods have 75% of their weight on the front legs because the head and neck are so heavy. The advantages of the shoulder joint include increased degrees of freedom in movement.

25. Normal vertebral columns are stacked in a vertical line. If the spine were to curve to the side instead, this would disrupt the support and cushioning functions of the vertebrae. When the spine is out of alignment, it cannot absorb shock as well, so normal activities can become painful and cause back problems later in life. The curvature also disrupts posture and structure, even disrupting lung expansion in severe cases due to changes to rib location.

27. Osteocytes function in the exchange of nutrients and wastes with the blood. They also maintain normal bone structure by recycling the mineral salts in the bony matrix. Osteoclasts remove

bone tissue by releasing lysosomal enzymes and acids that dissolve the bony matrix. Osteoblasts are bone cells that are responsible for bone formation.

29. The hip joint is flexed, and the knees are extended.

31. Taking a step would require bending the knee (modified hinge joint) and moving the leg in the hip (ball-and-socket joint) since the motion of the foot is excluded. As the foot comes off the ground in the step, the hip joint is going to move the femur in a protracted motion, and the knee will flex the shin toward the thigh. As the foot lands, the knee extends the leg, and the hip retracts the femur.

33. The cross-sectional area, the length of the muscle fiber at rest, and the frequency of neural stimulation contribute to the amount of tension produced in an individual muscle fiber.

35. Muscles are able to drive locomotion (and other task involving opposing motions) because they are paired. When walking, the hamstring muscle contracts first, causing the leg to flex around the knee joint. The quadriceps muscle then contracts (while the hamstring relaxes and extends) to straighten the leg as the foot returns to the ground.

Chapter 44

1. b. disease-causing microbe

3. d. sunlight

5. d. tropical wet forests

7. d. intertidal zone

9. c. A windstorm blew down trees in the Boundary Waters Canoe Area in Minnesota on July 4, 1999.

11. Ecologists working in organismal or population ecology might ask similar questions about how the biotic and abiotic conditions affect particular organisms and, thus, might find collaboration to be mutually beneficial. Levels of ecology such as community ecology or ecosystem ecology might pose greater challenges for collaboration because these areas are very broad and may include many different environmental components.

13. Ocean upwelling is a continual process that occurs year-round. Spring-and-fall turnovers in freshwater lakes and ponds, however, are seasonal processes that occur due to temperature changes in the water that take place during springtime warming and autumn cooling. Both ocean upwelling and spring-and-fall turnovers enable nutrients in the organic materials at the bottom of the body of water to be recycled and reused by living things.

15. Fire is less common in desert biomes than in temperate grasslands because deserts have low net primary productivity and, thus, very little plant biomass to fuel a fire.

17. Bogs are low in oxygen and high in organic acids. The low oxygen content and the low pH both slow the rate of decomposition.

19. Natural processes such as the Milankovitch cycles, variation in solar intensity, and volcanic eruptions can cause periodic, intermittent changes in global climate. Human activity, in the form of emissions from the burning of fossil fuels, has caused a progressive rise in the levels of atmospheric carbon dioxide.

Chapter 45

1. c. quadrat

3. a. Type I

5. a. few offspring

7. d. fecundity

9. c. biotic potential

11. a. *r*-selected

13. d. *K*-selected species

15. a. snow in winter

17. b. economically underdeveloped

19. d. pioneer species

21. c. mutualism

23. d. cognitive learning

25. b. kin selection

27. The researcher would mark a certain number of penguins with a tag, release them back into the population and, later, recapture penguins to see what percentage of the recaptured penguins was tagged. This percentage would allow an estimation of the size of the penguin population.

29. Parental care is not feasible for organisms having many offspring because they do not have the energy available to take care of that many offspring. Most of their energy budget is used in the formation of seeds or offspring, so there is little left for parental care. Also, the sheer number of offspring would make individual parental care impossible.

31. In the first part of the curve, when few individuals of the species are present and resources are plentiful, growth is exponential, similar to a J-shaped curve. Later, growth slows due to the species using up resources. Finally, the population levels off at the carrying capacity of the environment, and it is relatively stable over time.

33. If a natural disaster, such as a fire, happened in the winter, when populations are low, it would have a greater effect on the overall population and its recovery than if the same disaster occurred during the summer, when population levels are high.

35. Continued exponential human population growth results in the human population requiring more resources to sustain itself. These resources are usually

taken at the expense of the environment and the organisms that rely on the resources in that environment (through habitat destruction for human development, water rerouting for irrigation, etc.). The continued use of fossil fuels to generate power for human activities also contributes to climate change, changing climates in some areas so that certain species can no longer survive there.

37. Jaguars are an apex predator in the Amazon, eating a variety of prey animals and not serving as prey to any other predators. Through predation, they control the population sizes of the smaller herbivores and omnivores. If jaguars were to disappear from the ecosystem, the smaller herbivore populations would dramatically increase and could overconsume the plant populations.

39. Animals that use aural or pheromone signals to communicate with potential mates can signal over longer distances. Sound waves and chemicals can diffuse out into an environment while visual cues require a direct line of sight between the sender and receiver. Animals that use aural cues to acquire mates probably exhibit a lower population density than animals that use visual cues.

Chapter 46

1. d. resilience

3. b. detrital

5. a. analytical modeling

7. d. all of these

9. d. biomass

11. d. chemoautotrophs

13. b. the second law of thermodynamics

15. c. biogeochemical

17. d. salt water

19. b. eutrophication

21. b. plant more environmentally suitable plants

23. Food webs show interacting groups of different species and their many interconnections with each other and the environment. Food chains are linear aspects of food webs that describe the succession of organisms consuming one another at defined trophic levels. Food webs are a more accurate representation of the structure and dynamics of an ecosystem. Food chains are easier to model and use for experimental studies.

25. Grazing food webs have a primary producer at their base, which is either a plant for terrestrial ecosystems or a phytoplankton for aquatic ecosystems. The producers pass their energy to the various trophic levels of consumers. At the base of detrital food webs are the decomposers, which pass this energy to a variety of other consumers. Detrital food webs are important for the health of many grazing food webs because they eliminate dead and decaying organic material, thus, clearing space for new organisms and removing potential causes of disease. By breaking down dead organic matter, decomposers also make mineral nutrients available to primary producers; this process is a vital link in nutrient cycling.

27. Conceptual models allow ecologists to see the "big picture" of how different components of the ecosystem interact with each other, energy sources, and resources. However, this approach is more descriptive than quantitative, so it is difficult to make conclusions about the resistance or resilience of a system. Analytical modeling creates a model that can predict how the ecosystem's relationships will change in response to disturbances but does not convey the complexity of the relationships seen with conceptual modeling.

29. NPE measures the rate at which one trophic level can use and make biomass from what it attained in the previous level, considering respiration, defecation, and heat loss. Endotherms have high metabolism and generate a lot of body heat. Although this gives them advantages in their activity level in colder temperatures, these organisms are 10 times less efficient at harnessing the energy from the food they eat compared with cold-blooded animals and, thus, have to eat more often.

31. In this ecological model, the oak trees (producers) would be at the bottom, the blue jays would be in the middle level (primary consumer of acorns), and the parasites would be at the top level (secondary consumer). However, the pyramid would be inverted since each bird could support several parasites, and each tree could support several birds. This pyramid would appear to be the opposite of the energy flow pyramid.

33. Many factors can kill life in a lake or ocean, such as eutrophication by nutrient-rich surface runoff, oil spills, toxic waste spills, changes in climate, and the dumping of garbage into the ocean. Eutrophication is a result of nutrient-rich runoff from land using artificial fertilizers high in nitrogen and phosphorus. These nutrients cause the rapid and excessive growth of microorganisms, which deplete local dissolved oxygen and kill many fish and other aquatic organisms.

35. Human activity has greatly increased the amount of carbon dioxide gas in the Earth's atmosphere. The

oceanic and atmospheric levels of carbon dioxide are linked so that when atmospheric carbon dioxide levels increase, the amount of dissolved carbon dioxide in the ocean also increases (partial pressure of oxygen). When carbon dioxide dissolves in water it produces the weak acid bicarbonate. Since the Industrial Revolution, the pH of the ocean has dropped 0.1 pH units, a 30% increase in acidity.

Chapter 47

1. c. 100,000

3. c. 1.5 million

5. b. a new drug

7. d. predators of pests

9. c. islands

11. d. Kyoto Protocol

13. The hypothesized cause of the K–Pg extinction event is an asteroid impact. The first piece of evidence of the impact is a spike in iridium (an element that is rare on Earth but common in meteors) in the geological layers that mark the K–Pg transition. The second piece of evidence is an impact crater off the Yucatán Peninsula that is the right size and age to have caused the extinction event.

15. Crop plants are derived from wild plants, and genes from wild relatives are frequently brought into crop varieties by plant breeders to add valued characteristics to the crops. If the wild species are lost, then this genetic variation would no longer be available.

17. Human population growth leads to unsustainable resource use, which causes habitat destruction to build new human settlements, create agricultural fields, and so on. Larger human populations have also led to unsustainable fishing and hunting of wild animal populations. Excessive use of fossil fuels also leads to global warming.

19. Larger preserves will contain more species. Preserves should have a buffer around them to protect species from edge effects. Preserves that are round or square are better than preserves with many thin arms.