openstax™

Biology 2e.

Student Solution Manual

Chapter 1

1 Figure 1.6 1: C; 2: F; 3: A; 4: B; 5: D; 6: E. The original hypothesis is incorrect, as the coffeemaker works when plugged into the outlet. Alternative hypotheses include that the toaster might be broken or that the toaster wasn't turned on. **3** Figure 1.16 Communities exist within populations which exist within ecosystems. **4** B **6** D **8** C **10** C **12** B **14** D **16** Answers will vary, but should apply the steps of the scientific method. One possibility could be a car which 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. **18** 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. **20** Answers will vary. Layers of sedimentary rock have order but are not alive. Technology is capable of regulation but is not, of itself, alive. **22** 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 Figure 2.3 Carbon-12 has six neutrons. Carbon-13 has seven neutrons. **3** Figure 2.24 C **4** A **6** C **8** D **10** C **12** D **14** 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. **16** 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. **18** 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 Figure 3.5 Glucose and galactose are aldoses. Fructose is a ketose. **3** Figure 3.33 Adenine is larger than cytosine and will not be able to base pair properly with the guanine on the opposing strand. This will cause the DNA to bulge. DNA repair enzymes may recognize the bulge and replace the incorrect nucleotide. **4** C **6** A **8** D **10** B **12** D **14** C **16** B **18** C **20** C **21** Biological macromolecules are organic because they contain carbon. **23** Amino acids can be linked into long chains through condensation reactions. One of the hydrogen atoms bonded to the nitrogen atom of an amino acid reacts with the –OH group attached to the terminal carbon on another amino acid. Since both ends of the molecule can participate in condensation reactions, peptide bonds can be made in both directions to create a long amino acid chain. **25** The β 1-4 glycosidic linkage in cellulose cannot be broken down by human digestive enzymes. Herbivores such as cows, koalas, and buffalos are able to digest grass that is rich in cellulose and use it as a food source because bacteria and protists in their digestive systems, especially in the rumen, secrete the enzyme cellulase. Cellulases can break down cellulose into glucose monomers that can be used as an energy source by the animal. **27** Fat serves as a valuable way for animals to store energy. It can also provide insulation. Waxes can protect plant leaves and mammalian fur from getting wet. Phospholipids and steroids are important components of animal cell membranes, as well as plant, fungal, and bacterial membranes. **29** Fats have a higher energy density than carbohydrates (averaging 9kcal/gram versus 4.3kcal/gram respectively). Thus, on a per gram basis, more energy can be stored in fats than can be stored in carbohydrates. Additionally, fats are packaged into spherical globules to minimize interactions with the water-based plasma membrane, while glycogen is a large branched carbohydrate that cannot be compacted for storage. **31** A change in gene sequence can lead to a different amino acid being added to a polypeptide chain instead of the normal one. This causes a change in protein structure and function. For example, in sickle cell anemia, the hemoglobin β chain has a single amino acid substitution—the amino acid glutamic acid in position six is substituted by valine. Because of this change, hemoglobin molecules form aggregates, and the disc-shaped red blood cells assume a crescent shape, which results in serious health problems. **33** The protein must form a channel in the plasma membrane that allows water into the cell since water cannot cross the plasma membrane by itself. Since aquaporins are embedded in the plasma membrane and connect with both the intracellular and extracellular spaces, it must be amphipathic like the plasma membrane. The top and bottom of the protein must contain charged or polar amino acids (hydrophilic) to interact with the aqueous environments. The exterior transmembrane region must contain non-polar amino acids (hydrophobic) that can interact with the phospholipid tails.

However, the inside of this channel must contain hydrophilic amino acids since they will interact with the traveling water molecules. **35** The four types of RNA are messenger RNA, ribosomal RNA, transfer RNA, and microRNA. Messenger RNA carries the information from the DNA that controls all cellular activities. The mRNA binds to the ribosomes that are constructed of proteins and rRNA, and tRNA transfers the correct amino acid to the site of protein synthesis. microRNA regulates the availability of mRNA for translation.

Chapter 4

1 **Figure 4.7** Substances can diffuse more quickly through small cells. Small cells have no need for organelles and therefore do not need to expend energy getting substances across organelle membranes. Large cells have organelles that can separate cellular processes, enabling them to build molecules that are more complex. **3** **Figure 4.18** It would end up on the outside. After the vesicle passes through the Golgi apparatus and fuses with the plasma membrane, it turns inside out. **4** C **6** D **8** D **10** B **12** D **14** A **16** C **18** D **20** D **22** C **24** D **25** A light microscope would be ideal when viewing a small living organism, especially when the cell has been stained to reveal details. **27** 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. **29** 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, which 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. **31** 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. **33** 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. **35** "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. **37** 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. **39** 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. **41** 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. **43** *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 5

1 **Figure 5.12** No, it must have been hypotonic as a hypotonic solution would cause water to enter the cells, thereby making them burst. **3** **Figure 5.19** A decrease in pH means an increase in positively charged H^+ ions, and an increase in the electrical gradient across the membrane. The transport of amino acids into the cell will increase. **4** A **6** A **8** C **10** A **12** D **14** D **16** B **18** C **20** B **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.

Chapter 6

1 **Figure 6.8** A compost pile decomposing is an exergonic process; enthalpy increases (energy is released) and entropy increases (large molecules are broken down into smaller ones). A baby developing from a fertilized egg is an endergonic process; enthalpy decreases (energy is absorbed) and entropy decreases. Sand art being destroyed is an exergonic process; there is no change in enthalpy, but entropy increases. A ball rolling downhill is an exergonic process; enthalpy decreases (energy is released), but there is no change in entropy. **3** **Figure 6.14** Three sodium ions could be moved by the hydrolysis of one ATP molecule. The ΔG of the coupled reaction must be negative. Movement of three sodium ions across the membrane will take 6.3 kcal of energy (2.1 kcal × 3 Na^+ ions = 6.3 kcal). Hydrolysis of ATP provides 7.3 kcal of energy, more than enough to power this reaction. Movement of four sodium ions across the membrane, however, would require 8.4 kcal of energy, more than one ATP molecule can provide. **4** C **6** C **8** B **10** A **12** A **14** C **16** 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. **18** 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. **20** 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. **22** 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. **24** Feedback inhibition allows cells to control the amounts of metabolic products produced. If there is too much of a particular product relative to the cell's needs, feedback inhibition effectively causes the cell to decrease production of that particular product. In general, this reduces the production of superfluous products and conserves energy, maximizing energy efficiency.

Chapter 7

1 **Figure 7.11** After DNP poisoning, the electron transport chain can no longer form a proton gradient, and ATP synthase can no longer make ATP. DNP is an effective diet drug because it uncouples ATP synthesis; in other words, after taking it, a person obtains less energy out of the food he or she eats. Interestingly, one of the worst side effects of this drug is hyperthermia, or overheating of the body. Since ATP cannot be formed, the energy from electron transport is lost as heat. **3** **Figure 7.14** The illness is caused by lactate accumulation. Lactate levels rise after exercise, making the symptoms worse. Milk sickness is rare today but was common in the midwestern United States in the early 1800s. **4** A **6** C **8** B **10** C **12** C **14** A **16** A **18** 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 as a consistent amount. Harvesting energy from the bonds of several different compounds would result in energy deliveries of different quantities. **20** 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. **22** 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. **24** 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; it also uses a different final electron acceptor instead of oxygen gas. **26** Citrate can inhibit phosphofructokinase by feedback regulation.

Chapter 8

1 **Figure 8.6** Levels of carbon dioxide (a necessary photosynthetic substrate) will immediately fall. As a result, the rate of photosynthesis will be inhibited. **3** **Figure 8.18** D **4** A **6** B **8** B **10** A **12** C **14** A **16** D **18** C **20** C **21** The outcome of light reactions in photosynthesis is the conversion of solar energy into chemical energy that the chloroplasts can use to do work (mostly anabolic production of carbohydrates from carbon dioxide). **23** The energy carriers that move from the light-dependent reaction to the light-independent one are "full" because they bring energy. After the energy is released, the "empty" energy carriers return to the light-dependent reaction to obtain more energy. There is not much actual movement involved. Both ATP and NADPH are produced in the stroma where they are also used and reconverted into ADP, Pi, and $NADP^+$. **25** The stomata regulate the exchange of gases and water vapor between a leaf and its surrounding environment. When the stomata are closed, the water molecules cannot escape the leaf,

but the leaf also cannot acquire new carbon dioxide molecules from the environment. This limits the light-independent reactions to only continuing until the carbon dioxide stores in the leaf are depleted. **27** Both of these molecules carry energy; in the case of NADPH, it has reducing power that is used to fuel the process of making carbohydrate molecules in light-independent reactions. **29** Because RuBP, the molecule needed at the start of the cycle, is regenerated from G3P. **31** Because G3P has three carbon atoms, and each turn of the cycle takes in one carbon atom in the form of carbon dioxide. **33** In the defined ecosystem, energy would radiate from the Sun, and be absorbed by the chlorophyll in the leaves of the tree. Photosynthesis would occur in the leaves, transforming the light energy into stored chemical energy in the covalent bonds of carbon molecules. The giraffe would eat the leaves of the tree, and digest the carbon molecules to release energy. In the same ecosystem, nutrients would cycle between the tree and the giraffe. The giraffe would consume oxygen and release carbon dioxide as its cells perform aerobic respiration to create chemical energy. The tree will consume the released carbon dioxide during photosynthesis to create its own stored chemical energy, and release oxygen as a by-product.

Chapter 9

1 **Figure 9.8** C. The downstream cellular response would be inhibited. **3** **Figure 9.17** C. **5** B **7** B **9** C **11** C **13** B **15** B **17** C **19** D **21** D **23** Intracellular signaling occurs within a cell, and intercellular signaling occurs between cells. **25** 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. **27** 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, non-polar molecules so they can cross the plasma membrane. However, since insulin does not have to cross into the cell it could be large or polar (it is a small, polar molecule). **29** The binding of the ligand to the extracellular domain would activate the pathway normally activated by the receptor donating the intracellular domain. **31** 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. **33** Possible explanations:

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. **35** 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 **Figure 10.6** D. The kinetochore becomes attached to the mitotic spindle. Sister chromatids line up at the metaphase plate. Cohesin proteins break down and the sister chromatids separate. The nucleus reforms and the cell divides. **3** **Figure 10.14** D. E6 binding marks p53 for degradation. **4** C **6** D **8** B **10** B **12** D **14** A **16** A **18** D **20** C **22** C **24** D **26** C **28** 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. **30** 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. **32** 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. **34** 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. **36** 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. **38** Cdk must bind to a cyclin, and it must be phosphorylated in the correct position to become fully active. **40** If one of the genes that produces regulator proteins becomes mutated, it produces a malformed, possibly non-functional, cell-cycle regulator, increasing the chance that more mutations will be left unrepaired in the cell. Each subsequent generation of cells sustains more damage. The cell cycle can speed up as a result of the loss of functional checkpoint proteins. The cells can lose the ability to self-destruct and eventually become "immortalized." **42** Regulatory mechanisms that might be lost include monitoring of the quality

of the genomic DNA, recruiting of repair enzymes, and the triggering of apoptosis. **44** 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 **Figure 11.9** Yes, it will be able to reproduce asexually. **2** C **4** D **6** A **8** C **10** B **12** D **14** D **16** A **18** C **19** During the meiotic interphase, each chromosome is duplicated. The sister chromatids that are formed during synthesis are held together at the centromere region by cohesin proteins. All chromosomes are attached to the nuclear envelope by their tips. As the cell enters prophase I, the nuclear envelope begins to fragment and the proteins holding homologous chromosomes locate each other. The four sister chromatids align lengthwise, and a protein lattice called the synaptonemal complex is formed between them to bind them together. The synaptonemal complex facilitates crossover between nonsister chromatids, which is observed as chiasmata along the length of the chromosome. As prophase I progresses, the synaptonemal complex breaks down and the sister chromatids become free, except where they are attached by chiasmata. At this stage, the four chromatids are visible in each homologous pairing and are called a tetrad. **21** In metaphase I, the homologous chromosomes line up at the metaphase plate. In anaphase I, the homologous chromosomes are pulled apart and move to opposite poles. Sister chromatids are not separated until meiosis II. The fused kinetochore formed during meiosis I ensures that each spindle microtubule that binds to the tetrad will attach to both sister chromatids. **23** The chromosomes of the individual cannot cross over during meiosis if the individual cannot make recombination nodules. This limits the genetic diversity of the individual's gametes to what occurs during independent assortment, with all daughter cells receiving complete maternal or paternal chromatids. An individual who cannot produce diverse offspring is considered less fit than individuals who do produce diverse offspring. **25** a. Crossover occurs in prophase I between nonsister homologous chromosomes. Segments of DNA are exchanged between maternally derived and paternally derived chromosomes, and new gene combinations are formed. b. Random alignment during metaphase I leads to gametes that have a mixture of maternal and paternal chromosomes. c. Fertilization is random, in that any two gametes can fuse. **27** Sexual reproduction increases the genetic variation within the population, because new individuals are made by randomly combining genetic material from two parents. Because only fit individuals reach sexual maturity and reproduce, the overall population tends toward increasing fitness in its environment. However, there is always a possibility that the random combination creating the offspring's genome will actually produce an organism less fit for the environment than its parents were. **29** Haploid-dominant organisms undergo sexual reproduction by making a diploid zygote. The cells that make the gametes are derived from haploid cells, but the + and – mating types that produce the zygote are randomly combined. The zygote also undergoes meiosis to return to the haploid stage, so multiple steps add genetic diversity to haploid-dominant organisms.

Chapter 12

1 **Figure 12.5** You cannot be sure if the plant is homozygous or heterozygous as the data set is too small: by random chance, all three plants might have acquired only the dominant gene even if the recessive one is present. If the round pea parent is heterozygous, there is a one-eighth probability that a random sample of three progeny peas will all be round. **3** **Figure 12.12** Half of the female offspring would be heterozygous (X^WX^w) with red eyes, and half would be homozygous recessive (X^wX^w) with white eyes. Half of the male offspring would be hemizygous dominant (X^WY) withe red yes, and half would be hemizygous recessive (X^wY) with white eyes. **5** A **7** B **9** C **11** C **13** D **15** D **17** A **19** D **21** D **22** The garden pea is sessile and has flowers that close tightly during self-pollination. These features help to prevent accidental or unintentional fertilizations that could have diminished the accuracy of Mendel's data. **24** Since we are calculating the probability of two independent events occurring simultaneously, we use the product rule. F_1 generation: Since green seed color is recessive, there is a 0% probability that any plants in the F_1 generation will have green, round seeds. F_2 generation: The probability of growing an F_2 generation plant with green seeds is ¼, while the probability of growing an F_2 generation plant with round seeds is ¾. We can use the product rule to then calculate the probability of a plant with green, round seeds: $1/4 \times 3/4 = 3/16$ **26** Because axial is dominant, the gene(12.3) would be designated as *A*. F_1 would be all heterozygous *Aa* with axial phenotype. F_2 would have possible genotypes of *AA*, *Aa*, and *aa*; these would correspond to axial, axial, and terminal phenotypes, respectively. **28** No, males can only express color blindness. They cannot carry it because an individual needs two X chromosomes to be a carrier. **30** Considering each gene separately, the cross at *A* will produce offspring of which half are *AA* and half are *Aa*; *B* will produce all *Bb*; *C* will produce half *Cc* and half *cc*. Proportions then are (1/2) × (1) × (1/2), or 1/4 *AABbCc*; continuing for the other possibilities yields 1/4 *AABbcc*, 1/4 *AaBbCc*, and 1/4 *AaBbcc*. The proportions therefore are 1:1:1:1. **32** The cross can be represented as a 4 × 4 Punnett square, with the following gametes for each parent: *WY*, *Wy*, *wY*, and *wy*. For all 12 of the offspring that express a dominant *W* gene, the offspring will be white. The three offspring that are homozygous recessive for *w* but express a dominant *Y* gene will be yellow. The remaining *wwyy* offspring will be green. **34** Mendelian inheritance would predict that all three genes are inherited independently. There are therefore 8 different gamete genotype possibilities: VYR, VYr, VyR, Vyr, vYR, vYr, vyR, vyr. If all three genes are found on the

same chromosome arm, independent assortment is unlikely to occur because the genes are close together (linked).

Chapter 13

1 **Figure 13.3** No. The predicted frequency of recombinant offspring ranges from 0% (for linked traits) to 50% (for unlinked traits). **3** **Figure 13.6** B. **4** A **6** C **8** B **10** C **12** D **14** 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 **Figure 14.10** Compartmentalization enables a eukaryotic cell to divide processes into discrete steps so it can build more complex protein and RNA products. But there is an advantage to having a single compartment as well: RNA and protein synthesis occurs much more quickly in a prokaryotic cell. **3** **Figure 14.21** If three nucleotides are added, one additional amino acid will be incorporated into the protein chain, but the reading frame wont shift. **4** C **6** D **8** D **10** C **12** D **14** A **16** D **18** C **20** B **21** Live R cells acquired genetic information from the heat-killed S cells that "transformed" the R cells into S cells. **23** If the tetranucleotide hypothesis were true, then DNA would have to contain equal amounts of all four nucleotides (A=T=G=C). However, Chargaff demonstrated that A=T and G=C, but that the four nucleotides are not present in equal amounts. **25** DNA has two strands in anti-parallel orientation. The sugar-phosphate linkages form a backbone on the outside, and the bases are paired on the inside: A with T, and G with C, like rungs on a spiral ladder. **27** Meselson's experiments with *E. coli* grown in ^{15}N deduced this finding. **29** At an origin of replication, two replication forks are formed that are extended in two directions. On the lagging strand, Okazaki fragments are formed in a discontinuous manner. **31** 1333 seconds or 22.2 minutes. **33** Primer provides a 3'-OH group for DNA pol to start adding nucleotides. There would be no reaction in the tube without a primer, and no bands would be visible on the electrophoresis. **35** Telomerase has an inbuilt RNA template that extends the 3' end, so primer is synthesized and extended. Thus, the ends are protected. **37** This is a frameshift mutation with a deletion of an "A" in the 12^{th} position of the coding region. Patient: ATGGGGATATGGCATNormal: ATGGGGATATGAGCAT

Chapter 15

1 **Figure 15.11** No. Prokaryotes use different promoters than eukaryotes. **3** **Figure 15.16** Tetracycline: a; Chloramphenicol: c. **4** D **6** C **8** B **10** B **12** B **14** A **16** C **18** A **19** For 200 commonly occurring amino acids, codons consisting of four types of nucleotides would have to be at least four nucleotides long, because $4^4 = 256$. There would be much less degeneracy in this case. **21** Met Cys Arg Asn Ser Arg The first step to writing the amino acid sequence is to find the start codon AUG. Then, the nucleotide sequence is separated into triplets: CU AUG UGU CGU AAC AGC CGA UGA. We stop the translation at UGA because that triplet encodes a stop codon. When we convert these codons to amino acids, the sequence becomes Met Cys Arg Asn Ser Arg. **23** Rho-dependent termination is controlled by the rho protein, which tracks along behind the polymerase on the growing mRNA chain. Near the end of the gene, the polymerase stalls at a run of G nucleotides on the DNA template. The rho protein collides with the polymerase and releases mRNA from the transcription bubble. Rho-independent termination is controlled by specific sequences in the DNA template strand. As the polymerase nears the end of the gene being transcribed, it encounters a region rich in C–G nucleotides. This creates an mRNA hairpin that causes the polymerase to stall right as it begins to transcribe a region rich in A–T nucleotides. Because A–U bonds are less thermostable, the core enzyme falls away. **25** To determine that a RNA polymerase I mutation or deficiency is causing the defect in protein production, the scientist would need to make observations that provide evidence that RNA polymerases II and III are working in the cell. The observations eliminating RNA polymerase II as the defect could include: Transcription of mRNAs in the nucleus;Presence of processed mRNAs in the cytoplasm The observations eliminating RNA polymerase III could include: Isolation of small nuclear RNAs from the cell;Isolation of microRNAs from the cell;Transcription of 5S rRNA in the nucleus;Presence of tRNAs in the cytoplasm The observations implicating RNA polymerase I could include: A lack of functional ribosomes in the cytoplasm (RNA polymerase I or III);A lack of RNA polymerase I protein;RNA polymerase I protein is non-functional **27** The mRNA would be: 5'-AUGGCCGGUUAUUAAGCA-3'. The protein would be: MAGY. Even though there are six codons, the fifth codon corresponds to a stop, so the sixth codon would not be translated. **29** Original mRNA: 5' –UGCC AUG GUA AUA ACA CAU GAG GCC UGA AC– 3'; Translation: Met – Val – Ile – Thr – His – Glu – Ala; Mutated mRNA: 5' –UGCC AUG G**U**U AAU AAC ACA UGA GGCCUGAAC– 3'; Translation: Met – Val – Asn – Asn – Thr; Insertion mutations can have dramatic effects on proteins because they shift the reading frame for the codons. This changes the amino acids encoded by the mRNA, and can introduce premature start or stop sites.

Chapter 16

1 **Figure 16.5** Tryptophan is an amino acid essential for making proteins, so the cell always needs to have some on hand. However, if plenty of tryptophan is present, it is wasteful to make more, and the expression of the *trp*

receptor is repressed. Lactose, a sugar found in milk, is not always available. It makes no sense to make the enzymes necessary to digest an energy source that is not available, so the *lac* operon is only turned on when lactose is present. **3** Figure 16.13 Protein synthesis would be inhibited. **4** D **6** D **8** D **10** A **12** C **14** B **16** D **18** C **20** B **22** C **23** Eukaryotic cells have a nucleus, whereas prokaryotic cells do not. In eukaryotic cells, DNA is confined within the nuclear region. Because of this, transcription and translation are physically separated. This creates a more complex mechanism for the control of gene expression that benefits multicellular organisms because it compartmentalizes gene regulation. Gene expression occurs at many stages in eukaryotic cells, whereas in prokaryotic cells, control of gene expression only occurs at the transcriptional level. This allows for greater control of gene expression in eukaryotes and more complex systems to be developed. Because of this, different cell types can arise in an individual organism. **25** Environmental stimuli can increase or induce transcription in prokaryotic cells. In this example, lactose in the environment will induce the transcription of the *lac* operon, but only if glucose is not available in the environment. **27** You can create medications that reverse the epigenetic processes (to add histone acetylation marks or to remove DNA methylation) and create an open chromosomal configuration. **29** Histone acetylation reduces the positive charge of histone proteins, loosening the DNA wrapped around the histones. This looser DNA can then interact with transcription factors to express genes found in that region. Normally, once the gene is no longer needed, histone deacetylase enzymes remove the acetyl groups from histones so that the DNA becomes tightly wound and inaccessible again. However, when there is a defect in HDAC9, the deacetylation may not occur. In an immune cell, this would mean that inflammatory genes that were made accessible during an infection are not tightly rewound around the histones. **31** If too much of an activating transcription factor were present, then transcription would be increased in the cell. This could lead to dramatic alterations in cell function. **33** RNA binding proteins (RBP) bind to the RNA and can either increase or decrease the stability of the RNA. If they increase the stability of the RNA molecule, the RNA will remain intact in the cell for a longer period of time than normal. Since both RBPs and miRNAs bind to the RNA molecule, RBP can potentially bind first to the RNA and prevent the binding of the miRNA that will degrade it. **35** Because proteins are involved in every stage of gene regulation, phosphorylation of a protein (depending on the protein that is modified) can alter accessibility to the chromosome, can alter translation (by altering the transcription factor binding or function), can change nuclear shuttling (by influencing modifications to the nuclear pore complex), can alter RNA stability (by binding or not binding to the RNA to regulate its stability), can modify translation (increase or decrease), or can change post-translational modifications (add or remove phosphates or other chemical modifications). **37** Environmental stimuli, like ultraviolet light exposure, can alter the modifications to the histone proteins or DNA. Such stimuli may change an actively transcribed gene into a silenced gene by removing acetyl groups from histone proteins or by adding methyl groups to DNA. **39** These drugs will keep the histone proteins and the DNA methylation patterns in the open chromosomal configuration so that transcription is feasible. If a gene is silenced, these drugs could reverse the epigenetic configuration to re-express the gene.

Chapter 17

1 Figure 17.7 B. The experiment would result in blue colonies only. **3** Figure 17.15 There are no right or wrong answers to these questions. While it is true that prostate cancer treatment itself can be harmful, many men would rather be aware that they have cancer so they can monitor the disease and begin treatment if it progresses. And while genetic screening may be useful, it is expensive and may cause needless worry. People with certain risk factors may never develop the disease, and preventative treatments may do more harm than good. **4** B **6** B **8** D **10** B **12** A **14** A **16** D **18** D **20** B **22** 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. **24** 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. **26** Genome mapping has many different applications and provides comprehensive information that can be used for predictive purposes. **28** 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. **30** 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 Figure 18.14 Loss of genetic material is almost always lethal, so offspring with 2*n*+1 chromosomes are more likely to survive. **3** Figure 18.23 Answer B **4** B **6** D **8** A **10** B **12** C **14** D **16** C **17** The plants that can best use the resources of the area, including competing with other individuals for those resources will produce more seeds themselves and those traits that allowed them to better use the resources will increase in the population of the next generation. **19** In science, a theory is a thoroughly tested and verified set of explanations for a body of observations of nature. It is the strongest form of knowledge in science. In contrast, a theory in common vernacular can mean a guess

or speculation about something, meaning that the knowledge implied by the theory is very weak. **21** Organisms of one species can arrive to an island together and then disperse throughout the chain, each settling into different niches and exploiting different food resources to reduce competition. **23** The formation of gametes with new *n* numbers can occur in one generation. After a couple of generations, enough of these new hybrids can form to reproduce together as a new species. **25** If the hybrid offspring are as fit or more fit than the parents, reproduction would likely continue between both species and the hybrids, eventually bringing all organisms under the umbrella of one species.

Chapter 19

1 **Figure 19.2** The expected distribution is 320 VV, 160Vv, and 20 vv plants. Plants with VV or Vv genotypes would have violet flowers, and plants with the vv genotype would have white flowers, so a total of 480 plants would be expected to have violet flowers, and 20 plants would have white flowers. **3** **Figure 19.8** Moths have shifted to a lighter color. **4** C **6** D **8** C **10** A **12** D **14** A **16** p = (8*2 + 4)/48 = .42; q = (12*2 + 4)/48 = .58; p^2 = .17; 2pq = .48; q^2 = .34 **18** Red is recessive so q2 = 200/800 = 0.25; q = 0.5; p = 1 - q = 0.5; p2 = 0.25; 2pq = 0.5. You would expect 200 homozygous blue flowers, 400 heterozygous blue flowers, and 200 red flowers. **20** 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. **22** 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 greater reproductive success.

Chapter 20

1 **Figure 20.6** Cats and dogs are part of the same group at five levels: both are in the domain Eukarya, the kingdom Animalia, the phylum Chordata, the class Mammalia, and the order Carnivora. **3** **Figure 20.11** The largest clade encompasses the entire tree. **4** C **6** D **8** C **10** B **12** C **14** A **16** 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. **18** domain, kingdom, phylum, class, order, family, genus, species **20** 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. **22** 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 **Figure 21.5** D **3** **Figure 21.10** C **4** B **6** D **8** A **10** B **12** D **14** D **16** A **18** D **20** C **22** Viruses pass through filters that eliminated all bacteria which 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. **24** 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 which 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. However, genome structure classification does not distinguish between the two viruses. This leaves out important information regarding virus function and survival. **26** 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. **28** Plant viruses infect crops, causing crop damage and failure, and considerable economic losses. **30** Rabies vaccine works after a bite because it takes a week 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, because 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. **32** This prion-based disease is transmitted through human consumption of infected meat. **34** 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 Figure 22.8 The extracellular matrix and outer layer of cells protects the inner bacteria. The close proximity of cells also facilitates lateral gene transfer, a process by which genes such as antibiotic-resistance genes are transferred from one bacterium to another. And even if lateral gene transfer does not occur, one bacterium that produces an exo-enzyme that destroys antibiotic may save neighboring bacteria. **3** Figure 22.19 D **4** A **6** A **8** C **10** D **12** B **14** C **16** B **18** A **20** A **22** D **24** D **26** D **28** B **30** As the organisms are non-culturable, the presence could be detected through molecular techniques, such as PCR. **32** Possible answers include: PsychrophileHypolith – survival in low humidity/water environment **34** 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. **36** Responses 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 chemolitotrophs. The temperatures are very high in the hydrothermal vent, so the prokaryotes would be thermophilic. **38** 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. **40** *E. coli* colonizes the surface of the leaf, forming a biofilm that is more difficult to remove than free (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. **42** Soap indiscriminately kills bacteria on skin. This kills harmful bacteria, but can also eliminate “good” bacteria from the skin. When the non-pathogenic bacteria are eliminated, pathogenic bacteria can colonize the empty surface.

Chapter 23

1 Figure 23.5 All eukaryotic cells have mitochondria, but not all eukaryotic cells have chloroplasts. **3** Figure 23.28 C **4** D **6** C **8** C **10** D **12** B **14** A **16** C **18** D **20** A **22** B **23** Eukaryotic cells arose through endosymbiotic events that gave rise to the energy-producing organelles within the eukaryotic cells such as mitochondria and chloroplasts. The nuclear genome of eukaryotes is related most closely to the Archaea, so it may have been an early archaean that engulfed a bacterial cell that evolved into a mitochondrion. Mitochondria appear to have originated from an alpha-proteobacterium, whereas chloroplasts originated as a cyanobacterium. There is also evidence of secondary endosymbiotic events. Other cell components may also have resulted from endosymbiotic events. **25** The ability to perform sexual reproduction allows protists to recombine their genes and produce new variations of progeny that may be better suited to the new environment. In contrast, asexual reproduction generates progeny that are clones of the parent. **27** Protists are defined as any eukaryotes that do not fall into the Plantae, Fungi, or Animal Kingdoms. Since the unifying characteristics describe what they are NOT, rather than what they are, Protista can include almost any cellular/organism organization. Possible examples of structure variety: Barrier to exterior world: cell wall, plasma membrane, pellicleLocomotion: flagella, cilia, pseudopodia **29** By definition, an obligate saprobe lacks the ability to perform photosynthesis, so it cannot directly obtain nutrition by searching for light. Instead, a chemotactic mechanism that senses the odors released during decay might be a more effective sensing organ for a saprobe. **31** Possible answers include: Two nuclei (a macronucleus and a micronucleus) instead of one nucleusAmitotic division/binary fission during asexual reproduction instead of mitotic cell divisionMitosis of the micronucleus after meiosis instead of direct meiotic production of gametes for sexual reproduction **33** The trypanosomes that cause this disease are capable of expressing a glycoprotein coat with a different molecular structure with each generation. Because the immune system must respond to specific antigens to raise a meaningful defense, the changing nature of trypanosome antigens prevents the immune system from ever clearing this infection. Massive trypanosome infection eventually leads to host organ failure and death.

Chapter 24

1 Figure 24.14 A **3** Figure 24.21 Without mycorrhiza, plants cannot absorb adequate nutrients, which stunts their growth. Addition of fungal spores to sterile soil can alleviate this problem. **4** C **6** D **8** C **10** B **12** B **14** C **16** C **18** C **20** B **22** A **23** Asexual reproduction is fast and best under favorable conditions. Sexual reproduction allows the recombination of genetic traits and increases the odds of developing new adaptations better suited to a changed environment. **25** Fungi break down decaying matter in their environment to serve as their food source. Since the digestion occurs externally, the large mycelium can secrete exoenzymes over a large area. The fungi must be able to absorb the small molecules released by digestion, so having a large surface area increases the amount of digested molecules that are captured by the fungi. **27** Chytridiomycota (Chytrids) may have a unicellular or multicellular body

structure; some are aquatic with motile spores with flagella; an example is the *Allomyces*. Zygomycota (conjugated fungi) have a multicellular body structure; features include zygospores and presence in soil; examples are bread and fruit molds. Ascomycota (sac fungi) may have unicellular or multicellular body structure; a feature is sexual spores in sacs (asci); examples include the yeasts used in bread, wine, and beer production. Basidiomycota (club fungi) have multicellular bodies; features includes sexual spores in the basidiocarp (mushroom) and that they are mostly decomposers; mushroom-producing fungi are an example. **29** The bark beetles and the fungus have a mutualistic relationship since each partner benefits from interacting with the other. The beetle can provide food for its offspring, while the fungus can spread to new trees. **31** Dermatophytes that colonize skin break down the keratinized layer of dead cells that protects tissues from bacterial invasion. Once the integrity of the skin is breached, bacteria can enter the deeper layers of tissues and cause infections. **33** 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 **Figure 25.6** B. **3** **Figure 25.24** D. **4** A **6** C **8** C **10** C **12** D **14** A **16** B **18** D **20** D **22** D **24** 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. **26** 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). **28** It allows for survival through periodic droughts and colonization of environments where the supply of water fluctuates. **30** The bryophytes are divided into three phyla: the liverworts or Hepaticophyta, the hornworts or Anthocerotophyta, and the mosses or true Bryophyta. **32** 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. **34** 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 **Figure 26.8** B. The diploid zygote forms after the pollen tube has finished forming, so that the male generative nuclei can fuse with the female gametophyte. **3** D **5** C **7** A **9** B **11** C **13** B **15** C **17** D **19** Both pollination and herbivory contributed to diversity, with plants needing to attract some insects and repel others. **21** The trees are adapted to arid weather, and do not lose as much water due to transpiration as non-conifers. **23** 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. **25** 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 **Figure 27.5** The animal might develop two heads and no tail. **3** **Figure 27.9** D **4** B **6** D **8** B **10** C **12** D **14** B **16** C **18** D **19** The development of specialized tissues affords more complex animal anatomy and physiology because differentiated tissue types can perform unique functions and work together in tandem to allow the animal to perform more functions. For example, specialized muscle tissue allows directed and efficient movement, and specialized nervous tissue allows for multiple sensory modalities as well as the ability to respond to various sensory information; these functions are not necessarily available to other nonanimal organisms. **21** Altered expression of homeotic genes can lead to major changes in the morphology of the individual. *Hox* genes can affect the spatial arrangements of organs and body parts. If a *Hox* gene was mutated or duplicated, it could affect where a leg might be on a fruit fly or how far apart a person's fingers are. **23** The evolution of bilateral symmetry led to designated head and tail body regions, and promoted more efficient mobility for animals. This improved mobility allowed for more skillful seeking of resources and prey escaping from predators. The appearance of the coelom in coelomates provides many internal organs with shock absorption, making them less prone to physical damage from bodily assault. A coelom also gives the body greater flexibility, which promotes more efficient movement. The relatively loose placement of organs within the coelom allows them to develop and grow with some spatial freedom, which promoted the evolution of optimal organ arrangement. The coelom also provides space for a circulatory system, which is an advantageous way to distribute body fluids and gases. **25** In many cases, morphological similarities between animals may be only superficial similarities and may not indicate a true evolutionary relationship. One of the reasons for this is that certain morphological traits can evolve along very different evolutionary branches of animals for similar ecological reasons. **27** It is true that multiple mass extinction events have taken place since the Cambrian period, when most currently existing animal phyla appeared, and the majority of animal species were commonly wiped out during these events. However, a small number of animal species representing each phylum were usually able to survive each extinction event, allowing the phylum to continue to evolve rather than become altogether extinct.

Chapter 28

1 Figure 28.3 B **3** Figure 28.45 C **4** B **6** B **8** C **10** A **12** B **14** D **16** C **18** B **20** D **22** A **24** Pinacocytes are epithelial-like cells, form the outermost layer of sponges, and enclose a jelly-like 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. **26** Nematocysts are "stinging cells" designed to paralyze prey. The nematocysts contain a neurotoxin that renders prey immobile. **28** 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. **30** 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 secrete 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. **32** 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. **34** There are nematodes with separate sexes and hermaphrodites in addition to species that reproduce parthenogentically. The nematode *Caenorhabditis elegans* has a self-fertilizing hermaphrodite sex and a pure male sex. **36** 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. **38** Insects are the predominant members of the subphylum Hexapoda. Advantages: Pollination;Eliminate pests;Cheap food source;Produce food products (ex. honey) Disadvantages: Damage to food crops;Transmit disease to agricultural workers;Contaminate/spoil food;Destroy buildings storing food crops

Chapter 29

1 Figure 29.3 A **3** Figure 29.24 The ancestor of modern Testudines may at one time have had a second opening in the skull, but over time this might have been lost. **4** B **6** A **8** B **10** D **12** C **14** D **16** D **18** D **20** A **22** B **23** The characteristic features of the phylum Chordata are a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail. **25** Comparison of hagfishes with lampreys shows that the cranium evolved first in early vertebrates, as it is seen in hagfishes, which evolved earlier than lampreys. This was followed by evolution of the vertebral column, a primitive form of which is seen in lampreys and not in hagfishes. **27** A moist environment is required, as frog eggs lack a shell and dehydrate quickly in dry environments. **29** Frogs (Anura) begin their lives as tadpoles, organisms restricted to an aquatic environment that use gills to breathe. After metamorphosis, most frogs develop lungs and lose their gills, although they will also continue to perform gas exchange through their skin. The lungs of an adult frog allow the animal to move out of the water, and become terrestrial. This limits competition between adults and tadpoles by opening new living space and food sources to the adult. **31** Lizards differ from snakes by having eyelids, external ears, and less kinematic skulls. **33** This is suggested by similarities observed between theropod fossils and birds, specifically in the design of the hip and wrist bones, as well as the presence of a furcula, or wishbone, formed by the fusing of the clavicles. **35** Ostriches and penguins are flightless birds, but ostriches are entirely terrestrial, while penguins dive and swim in the ocean to find food. Therefore, penguins and flight birds like terns have similar chest structures with a keel sternum and relatively large pectoral muscles (penguins use their wings to "fly" through water). Conversely, since ostriches move by running, they do not have a keel to their sternum. They also have smaller pectoral muscles than would be predicted for a flying bird their size, but have larger thigh muscles. **37** In some mammals, the cerebral cortex is highly folded, allowing for greater surface area than a smooth cortex. The optic lobes are divided into two parts in mammals. Eutherian mammals also possess a specialized structure that links the two cerebral hemispheres, called the corpus callosum. **39** Archaic *Homo sapiens* differed from modern humans by having a thick skull and a prominent brow ridge, and lacking a prominent chin.

Chapter 30

1 Figure 30.7 A and B. The cortex, pith, and epidermis are made of parenchyma cells. **3** Figure 30.34 B. **4** C **6** C **8** A **10** B **12** A **14** B **16** C **18** B **20** D **22** C **24** C **26** C **27** Lawn grasses and other monocots have an intercalary meristem, which is a region of meristematic tissue at the base of the leaf blade. This is beneficial to the plant because it can continue to grow even when the tip of the plant is removed by grazing or mowing. **29** Stomata allow gases to enter and exit the plant. Guard cells regulate the opening and closing of stomata. If these cells did not function

correctly, a plant could not get the carbon dioxide needed for photosynthesis, nor could it release the oxygen produced by photosynthesis. **31** In woody plants, the cork cambium is the outermost lateral meristem; it produces new cells towards the interior, which enables the plant to increase in girth. The cork cambium also produces cork cells towards the exterior, which protect the plant from physical damage while reducing water loss. **33** Annual rings can also indicate the climate conditions that prevailed during each growing season. **35** A tap root system has a single main root that grows down. A fibrous root system forms a dense network of roots that is closer to the soil surface. An example of a tap root system is a carrot. Grasses such as wheat, rice, and corn are examples of fibrous root systems. Fibrous root systems are found in monocots; tap root systems are found in dicots. **37** Monocots have leaves with parallel venation, and dicots have leaves with reticulate, net-like venation. **39** The process of bulk flow moves water up the xylem and moves photosynthates (solutes) up and down the phloem. **41** Gravitropism will allow roots to dig deep into the soil to find water and minerals, whereas the seedling will grow towards light to enable photosynthesis. **43** To prevent further entry of pathogens, stomata close, even if they restrict entry of CO_2. Some pathogens secrete virulence factors that inhibit the closing of stomata. Abscisic acid is the stress hormone responsible for inducing closing of stomata.

Chapter 31

1 Figure 31.6 The air content of the soil decreases. **3** Figure 31.10 Soybeans are able to fix nitrogen in their roots, which are not harvested at the end of the growing season. The belowground nitrogen can be used in the next season by the corn. **4** C **6** A **8** D **10** B **12** B **14** A **16** Deficiencies in these nutrients could result in stunted growth, slow growth, and chlorosis. **18** Answers may vary. Essential macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Essential micronutrients include iron, manganese, boron, molybdenum, copper, zinc, chlorine, nickel, cobalt, sodium, and silicon. **20** Parent material, climate, topography, biological factors, and time affect soil formation. Parent material is the material in which soils form. Climate describes how temperature, moisture, and wind cause different patterns of weathering, influencing the characteristics of the soil. Topography affects the characteristics and fertility of a soil. Biological factors include the presence of living organisms that greatly affect soil formation. Processes such as freezing and thawing may produce cracks in rocks; plant roots can penetrate these crevices and produce more fragmentation. Time affects soil because soil develops over long periods. **22** Because it is natural and does not require use of a nonrenewable resource, such as natural gas. **24** A nodule results from the symbiosis between a plant and bacterium. Within nodules, the process of nitrogen fixation allows the plant to obtain nitrogen from the air.

Chapter 32

1 Figure 32.3 Pollen (or sperm); carpellate; staminate. **3** Figure 32.20 B **4** B **6** A **8** B **10** D **12** A **14** D **16** 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. **18** 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. **20** 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. **22** 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. **24** 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 Figure 33.11 A **3** Figure 33.23 Pyrogens increase body temperature by causing the blood vessels to constrict, inducing shivering, and stopping sweat glands from secreting fluid. **4** A **6** C **8** D **10** D **12** C **14** D **16** D **18** A **20** B **22** C **24** A **26** B **28** A **29** Diffusion is effective over a very short distance. If a cell exceeds this distance in its size, the center of the cell cannot get adequate nutrients nor can it expel enough waste to survive. To compensate for this, cells can loosely adhere to each other in a liquid medium, or develop into multi-celled organisms that use circulatory and respiratory systems to deliver nutrients and remove wastes. **31** In an open circulatory system, the heart(s) pump

blood into an open cavity, bathing the tissues. As the blood diffuses through the tissue space, it delivers nutrients in exchange for receiving metabolic wastes. The blood then diffuses back to the heart to be pumped again. However, since this system relies on diffusion, the size of animals that use an open circulatory system is limited to fairly small volumes so that the blood can diffuse rapidly enough to efficiently exchange molecules with the tissues. **33** Squamous epithelia can be either simple or stratified. As a single layer of cells, it presents a very thin epithelia that minimally inhibits diffusion. As a stratified epithelia, the surface cells can be sloughed off and the cells in deeper layers protect the underlying tissues from damage. **35** In multiple sclerosis, the immune system attacks the oligodendrocytes. The death of oligodendrocytes results in the loss of the insulating sheath around the axon of the neurons. When the sheath is gone, the electrical impulses travel much more slowly down the length of the axon. **37** An adjustment to a change in the internal or external environment requires a change in the direction of the stimulus. A negative feedback loop accomplishes this, while a positive feedback loop would continue the stimulus and result in harm to the animal. **39** Diabetes is often associated with a lack in production of insulin. Without insulin, blood glucose levels go up after a meal, but never go back down to normal levels.

Chapter 34

1 Figure 34.11 B **3** Figure 34.19 C **4** D **6** C **8** B **10** D **12** C **14** A **16** B **18** B **20** Animals with a polygastric digestive system have a multi-chambered stomach. The four compartments of the stomach are called the rumen, reticulum, omasum, and abomasum. These chambers contain many microbes that breakdown 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. **22** 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. **24** 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. **26** 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. **28** 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. **30** 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. **32** 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. **34** 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. **36** Somatostatin is the hormone that inhibits the release of HCl into the stomach lumen after the chyme has moved to the intestine. If the receptor for somatostatin is nonfunctional, somatostatin cannot signal to the stomach parietal cells to stop acid secretion. Thus, acid secretion will continue when there is no food present, and can cause damage to the stomach tissue. However, as long as the stomach remains intact the mutation should not slow digestion since acid will always be present in the stomach to digest any new boluses of food.

Chapter 35

1 Figure 35.3 B **3** Figure 35.26 D **4** C **6** B **8** B **10** C **12** D **14** B **16** C **18** A **20** C **22** D **24** 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. **26** 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. **28** 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 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. **30** 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 disable or remove the area in an animal model. fMRI can be used to correlate specific functions with increased blood flow to brain regions. **32** Potential answers: Frontal lobe. Alzheimer's patients experience changes in personality, judgment, and behavior.;Parietal lobe. Alzheimer's patients experience difficulties with recalling and using language as disease progresses.;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. **34** 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. **36** 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. **38** 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 36

1 Figure 36.5 D **3** Figure 36.18 A **4** B **6** A **8** B **10** B **12** A **14** B **16** D **18** B **20** B **22** D **24** 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. **26** 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. **28** 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. **30** 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. **32** The sound would slow down, because it is transmitted through the particles (gas) and there are fewer particles (lower density) at higher altitudes. **34** 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. **36** The photoreceptors tonically inhibit the bipolar cells, and stimulation of the receptors turns this inhibition off, activating the bipolar cells.

Chapter 37

1 Figure 37.5 Proteins unfold, or denature, at higher temperatures. **3** Figure 37.14 Patient A has symptoms associated with decreased metabolism, and may be suffering from hypothyroidism. Patient B has symptoms associated with increased metabolism, and may be suffering from hyperthyroidism. **4** C **6** D **8** D **10** A **12** C **14** A **16** B **18** C **20** C **21** Although there are many different hormones in the human body, they can be divided into three classes based on their chemical structure: lipid-derived, amino acid-derived, and peptide hormones. One of the key distinguishing features of the lipid-derived hormones is that they can diffuse across plasma membranes whereas the amino acid-derived and peptide hormones cannot. **23** Glucagon acts in opposition to insulin, the peptide hormone that stimulates cells to take up glucose from the bloodstream, to maintain blood glucose within healthy levels. When glucagon is released into the blood in response to falling blood sugar levels, the liver catabolizes its glycogen stores to release glucose. If glucagon does not function properly, the blood sugar will drop too low from insulin signaling driving cellular uptake from the blood. **25** Depending on the location of the protein receptor on the target cell and the chemical structure of the hormone, hormones can mediate changes directly by binding to intracellular receptors and modulating gene transcription, or indirectly by binding to cell surface receptors and stimulating signaling pathways. **27** In addition to producing FSH and LH, the anterior pituitary also produces the hormone prolactin (PRL) in females. Prolactin stimulates the production of milk by the mammary glands following childbirth. Prolactin levels are regulated by the hypothalamic hormones prolactin-releasing hormone (PRH) and prolactin-inhibiting hormone (PIH) which is now known to be dopamine. PRH stimulates the release of prolactin and PIH inhibits it. The posterior pituitary releases the hormone oxytocin, which stimulates contractions during childbirth. The uterine smooth muscles are not very sensitive to oxytocin until late in pregnancy when the number of oxytocin receptors in the uterus peaks. Stretching of tissues in the uterus and vagina stimulates oxytocin release in childbirth. Contractions increase in intensity as blood levels of oxytocin rise until the birth is complete. **29** The stressed patients that catch a cold must be chronically (long-term) stressed. Long-term stress results in the production of glucocorticoids, such as cortisol. These hormones inhibit the function of the immune system, which makes people more susceptible to infectious diseases. **31** The term humoral is derived from the term humor, which refers to bodily fluids such as blood. Humoral stimuli refer to the control of hormone release in response to changes in extracellular fluids such as blood or the ion concentration in the blood. For example, a rise in blood glucose levels triggers the pancreatic release of insulin. Insulin causes blood glucose levels to drop, which signals the pancreas to stop producing insulin in a negative feedback loop. Hormonal stimuli refer to the release

of a hormone in response to another hormone. A number of endocrine glands release hormones when stimulated by hormones released by other endocrine organs. For example, the hypothalamus produces hormones that stimulate the anterior pituitary. The anterior pituitary in turn releases hormones that regulate hormone production by other endocrine glands. For example, the anterior pituitary releases thyroid-stimulating hormone, which stimulates the thyroid gland to produce the hormones T_3 and T_4. As blood concentrations of T_3 and T_4 rise they inhibit both the pituitary and the hypothalamus in a negative feedback loop. **33** The main mineralocorticoid is aldosterone, which regulates the concentration of ions in urine, sweat, and saliva. Aldosterone release from the adrenal cortex is stimulated by a decrease in blood concentrations of sodium ions, blood volume, or blood pressure, or an increase in blood potassium levels. **35** Damage to the posterior pituitary gland would prevent the release of ADH and oxytocin into the body. However, the hypothalamus's ability to produce ADH would not be affected. The hypothalamus would also still be able to produce and release inhibiting hormones to regulate the anterior pituitary.

Chapter 38

1 Figure 38.19 B **3** Figure 38.38 In the presence of Sarin, acetycholine is not removed from the synapse, resulting in continuous stimulation of the muscle plasma membrane. At first, muscle activity is intense and uncontrolled, but the ion gradients dissipate, so electrical signals in the T-tubules are no longer possible. The result is paralysis, leading to death by asphyxiation. **4** A **6** D **8** D **10** C **12** C **14** D **16** D **18** A **20** D **22** D **24** D **25** The female pelvis is tilted forward and is wider, lighter, and shallower than the male pelvis. It also has a pubic angle that is broader than the male pelvis. **27** Hydrostatic skeletons protect internal organs from harm by cushioning them from external shock. However, these skeletons do not provide protection from external trauma. Exoskeletons are hard structures that protect the organs from damage caused by their environment. However, since they are rigid, they provide little shock absorption, so the animal will need to have other ways of cushioning its internal organs. **29** Compact bone tissue forms the hard external layer of all bones and consists of osteons. Compact bone tissue is prominent in areas of bone at which stresses are applied in only a few directions. Spongy bone tissue forms the inner layer of all bones and consists of trabeculae. Spongy bone is prominent in areas of bones that are not heavily stressed or at which stresses arrive from many directions. **31** Thalidomide effected the development of the long bones of the arms, disrupting endochondral ossification. The bones would have been able to develop into a template made of the calcified cartilage matrix, but new blood vessels could not be created. Since no vessels invade the template, the structure is not converted into trabecular bone. **33** Elevation is the movement of a bone upward, such as when the shoulders are shrugged, lifting the scapulae. Depression is the downward movement of a bone, such as after the shoulders are shrugged and the scapulae return to their normal position from an elevated position. **35** Because ATP is required for myosin to release from actin, muscles would remain rigidly contracted until more ATP was available for the myosin cross-bridge release. This is why dead vertebrates undergo rigor mortis. **37** Neurons will not be able to release neurotransmitter without calcium. Skeletal muscles have calcium stored and don't need any from the outside.

Chapter 39

1 Figure 39.7 B **3** Figure 39.20 The blood pH will drop and hemoglobin affinity for oxygen will decrease. **4** A **6** B **8** D **10** B **12** D **14** C **16** 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. **18** 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. **20** 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. **22** 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. **24** 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. **26** 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 percent oxygen is an effective therapy because at that concentration, oxygen will displace the carbon monoxide from the hemoglobin.

Chapter 40

1 Figure 40.10 C **3** Figure 40.17 Blood in the legs is farthest away from the heart and has to flow up to reach it. **4**

A **6** C **8** C **10** C **12** A **14** A **16** 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. **18** 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–). **20** 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. **22** 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 41

1 **Figure 41.5** C **3** **Figure 41.8** Loop diuretics decrease the excretion of salt into the renal medulla, thereby reducing its osmolality. As a result, less water is excreted into the medulla by the descending limb, and more water is excreted as urine. **4** B **6** A **8** B **10** C **12** D **14** C **16** C **18** 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. **20** 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. **22** The removal of wastes, which could otherwise be toxic to an organism, is extremely important for survival. Having organs that specialize in this process and that operate separately from other organs provides a measure of safety for the organism. **24** 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. **26** 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, anti-diuretic hormone, and atrial natriuretic peptide help regulate the needs of the body as well as the communication between the different organ systems.

Chapter 42

1 **Figure 42.11** C **3** **Figure 42.16** If the blood of the mother and fetus mixes, memory cells that recognize the Rh antigen can form late in the first pregnancy. During subsequent pregnancies, these memory cells launch an immune attack on the fetal blood cells. Injection of anti-Rh antibody during the first pregnancy prevents the immune response from occurring. **4** D **6** A **8** D **10** B **12** D **14** C **16** C **18** D **20** C **22** If 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” and produce perforin and granzymes to induce the donor cells to undergo apoptosis, which would destroy the transplanted organ. **24** 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. **26** 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. **28** 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. **30** 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 43

1 **Figure 43.8** D **3** **Figure 43.17** B **4** A **6** D **8** A **10** A **12** C **14** A **16** A **18** C **20** D **22** A **24** B **26** B **28** D **30** D **31** Sexual reproduction produces a new combination of genes in the offspring that may better enable them to survive changes in the environment and assist in the survival of the species. **33** External fertilization can create large numbers of offspring without requiring specialized delivery or reproductive support organs. Offspring develop and mature quickly compared to internally fertilizing species. A disadvantage is that the offspring are out in the environment and predation can account for large loss of offspring. The embryos are susceptible to changes in the environment, which further depletes their numbers. Internally fertilizing species control their environment and protect their offspring from predators but must have specialized organs to complete these tasks and usually produce fewer embryos. **35** In phase one (excitement), vasodilation leads to vasocongestion and enlargement of erectile tissues. Vaginal secretions are released to lubricate the vagina during intercourse. In phase two (plateau), stimulation continues, the outer third

of the vaginal wall enlarges with blood, and breathing and heart rate increase. In phase three (orgasm), rhythmic, involuntary contractions of muscles occur. In the male, reproductive accessory glands and tubules constrict, depositing semen in the urethra; then, the urethra contracts, expelling the semen through the penis. In women, the uterus and vaginal muscles contract in waves that may last slightly less than a second each. In phase four (resolution), the processes listed in the first three phases reverse themselves and return to their normal state. Men experience a refractory period in which they cannot maintain an erection or ejaculate for a period of time ranging from minutes to hours. Women do not experience a refractory period. **37** Negative feedback in the male system is supplied through two hormones: inhibin and testosterone. Inhibin is produced by Sertoli cells when the sperm count exceeds set limits. The hormone inhibits GnRH and FSH, decreasing the activity of the Sertoli cells. Increased levels of testosterone affect the release of both GnRH and LH, decreasing the activity of the Leydig cells, resulting in decreased testosterone and sperm production. **39** The first trimester lays down the basic structures of the body, including the limb buds, heart, eyes, and the liver. The second trimester continues the development of all of the organs and systems established during the first trimester. The placenta takes over the production of estrogen and high levels of progesterone and handles the nutrient and waste requirements of the fetus. The third trimester exhibits the greatest growth of the fetus, culminating in labor and delivery. **41** Multiple sperm can fuse with the egg, resulting in polyspermy. The resulting embryo is not genetically viable and dies within a few days. **43** Organs form from the germ layers through the process of differentiation. During differentiation, the embryonic stem cells express a specific set of genes that will determine their ultimate fate as a cell type. For example, some cells in the ectoderm will express the genes specific to skin cells. As a result, these cells will differentiate into epidermal cells. The process of differentiation is regulated by cellular signaling cascades.

Chapter 44

1 **Figure 44.10** Tropical lakes don't freeze, so they don't undergo spring turnover in the same way temperate lakes do. However, stratification does occur, as well as seasonal turnover. **3** **Figure 44.21** B. the photic zone, the intertidal zone, the neritic zone, and the oceanic zone **4** B **6** D **8** D **10** D **12** C **14** 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. **16** Ocean upwelling is a continual process that occurs year-round. Spring and fall turnover in freshwater lakes and ponds, however, is a seasonal process that occurs due to temperature changes in the water that take place during springtime warming and autumn cooling. Both ocean upwelling and spring and fall turnover enable nutrients in the organic materials at the bottom of the body of water to be recycled and reused by living things. **18** 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. **20** Bogs are low in oxygen and high in organic acids. The low oxygen content and the low pH both slow the rate of decomposition. **22** 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 **Figure 45.2** Smaller animals require less food and other resources, so the environment can support more of them. **3** **Figure 45.16** Stage 4 represents a population that is decreasing. **4** C **6** A **8** A **10** D **12** C **14** A **16** D **18** A **20** B **22** D **24** C **26** D **28** B **30** The researcher would mark a certain number of penguins with a tag, release them back into the population, and, at a later time, 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. **32** Parental care is not feasible for organisms having many offspring because they do not have the energy available to take care of 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. **34** 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. **36** 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. **38** 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 (e.g., 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. **40** 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. **42** Animals that use aural or pheromone

signals to communicate with potential mates are able to 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 **Figure 46.8** According to the first law of thermodynamics, energy can neither be created nor destroyed. Eventually, all energy consumed by living systems is lost as heat or used for respiration, and the total energy output of the system must equal the energy that went into it. **3** **Figure 46.17** C: Nitrification by bacteria converts nitrates (NO_3^-) to nitrites (NO_2^-). **4** D **6** B **8** A **10** D **12** D **14** D **16** B **18** C **20** D **22** B **24** B **26** 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. **28** 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. **30** 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. **32** NPE measures the rate at which one trophic level can use and make biomass from what it attained in the previous level, taking into account 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 and more often. **34** 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. **36** 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. **38** 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 **Figure 47.6** A. An abundance of fern spores from several species was found below the K-Pg boundary, but none was found above. **3** B **5** C **7** C **9** B **11** D **13** C **15** D **17** 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. **19** 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. **21** 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. **23** 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.