

# Anat- omy



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and

# Physi- ology

# ANSWER KEY

## Chapter 1

1 Fatty acid catabolism. 3 X-rays. 5 PET scans can indicate how patients are responding to chemotherapy. 6 C 8 A 10 D 12 C 14 C 16 C 18 C 20 D 22 D 24 D 26 C 28 An understanding of anatomy and physiology is essential for any career in the health professions. It can also help you make choices that promote your health, respond appropriately to signs of illness, make sense of health-related news, and help you in your roles as a parent, spouse, partner, friend, colleague, and caregiver. 30 Chemical, cellular, tissue, organ, organ system, organism. 32 When you are sitting at a campfire, your sense of smell adapts to the smell of smoke. Only if that smell were to suddenly and dramatically intensify would you be likely to notice and respond. In contrast, the smell of even a trace of smoke would be new and highly unusual in your residence hall, and would be perceived as danger. 34 In a sealed bottle of sparkling water, carbon dioxide gas is kept dissolved in the water under a very high pressure. When you open the bottle, the pressure of the gas above the liquid changes from artificially high to normal atmospheric pressure. The dissolved carbon dioxide gas expands, and rises in bubbles to the surface. When a bottle of sparkling water is left open, it eventually goes flat because its gases continue to move out of solution until the pressure in the water is approximately equal to atmospheric pressure. 36 The four components of a negative feedback loop are: stimulus, sensor, control center, and effector. If too great a quantity of the chemical were excreted, sensors would activate a control center, which would in turn activate an effector. In this case, the effector (the secreting cells) would be adjusted downward. 38 If the body were supine or prone, the MRI scanner would move from top to bottom to produce frontal sections, which would divide the body into anterior and posterior portions, as in “cutting” a deck of cards. Again, if the body were supine or prone, to produce sagittal sections, the scanner would move from left to right or from right to left to divide the body lengthwise into left and right portions. 40 CT scanning subjects patients to much higher levels of radiation than X-rays, and should not be performed repeatedly.

## Chapter 2

1 The mass number is the total number of protons and neutrons in the nucleus of an atom. 3 The water hydrolyses, or breaks, the glycosidic bond, forming two monosaccharides. 4 D 6 A 8 B 10 C 12 B 14 A 16 C 18 A 20 B 22 D 24 B 26 A 28 B 30 D 32 B 33 These four elements—oxygen, carbon, hydrogen, and nitrogen—together make up more than 95 percent of the mass of the human body, and the body cannot make elements, so it is helpful to have them in consumables. 35 Magnesium’s 12 electrons are distributed as follows: two in the first shell, eight in the second shell, and two in its valence shell. According to the octet rule, magnesium is unstable (reactive) because its valence shell has just two electrons. It is therefore likely to participate in chemical reactions in which it donates two electrons. 37 Water is a polar molecule. It has a region of weakly positive charge and a region of weakly negative charge. These regions are attracted to ions as well as to other polar molecules. Oils are nonpolar, and are repelled by water. 39 It is not. An exchange reaction might be  $AB + CD \rightarrow AC + BD$  or  $AB + CD \rightarrow AD + BC$ . In all chemical reactions, including exchange reactions, the components of the reactants are identical to the components of the products. A component present among the reactants cannot disappear, nor can a component not present in the reactants suddenly appear in the products. 41 Lemon juice is one hundred times more acidic than orange juice. This means that lemon juice has a one hundred-fold greater concentration of hydrogen ions. 43 Maltose contains 12 atoms of carbon, but only 22 atoms of hydrogen and 11 atoms of oxygen, because a molecule of water is removed during its formation via dehydration synthesis.

## Chapter 3

1 Higher temperatures speed up diffusion because molecules have more kinetic energy at higher temperatures. 3 an enzyme 5 the spindle 6 B 8 C 10 D 12 A 14 A 16 C 18 A 20 C 22 C 24 B 26 B 28 C 30 Only materials that are relatively small and nonpolar can easily diffuse through the lipid bilayer. Large particles cannot fit in between the individual phospholipids that are packed together, and polar molecules are repelled by the hydrophobic/nonpolar lipids that line the inside of the bilayer. 32 These four phenomena are similar in the sense that they describe the movement of substances down a particular type of gradient. Osmosis and diffusion involve the movement of water and other substances down their concentration gradients, respectively. Filtration describes the movement of particles down a pressure gradient, and the movement of ions away from like charge describes their movement down their electrical gradient. 34 Peroxisomes and lysosomes are both cellular organelles bound by lipid bilayer membranes, and they both contain many enzymes. However, peroxisomes contain enzymes that detoxify substances by transferring hydrogen atoms and producing  $H_2O_2$ , whereas the enzymes in lysosomes function to break down and digest various unwanted materials. 36 During cell division, one cell divides to produce two new cells. In order for all of the cells in your body to maintain a full genome, each cell must replicate its DNA before it divides so that a full genome can be allotted to each of its offspring cells. If DNA replication did not take place fully, or at all, the offspring cells would be missing some or all of the genome. This could be disastrous if a cell was missing genes necessary for its function and health. 38 Transcription is really a “copy” process and translation is really an “interpretation” process, because transcription involves copying the DNA message into a very similar RNA message whereas translation involves converting the RNA message into the very different amino acid message. The two processes also differ in their location: transcription occurs in the nucleus and translation in the cytoplasm. The mechanisms by

which the two processes are performed are also completely different: transcription utilizes polymerase enzymes to build mRNA whereas translation utilizes different kinds of RNA to build protein. **40** A cyclin is one of the primary classes of cell cycle control molecules, while a cyclin-dependent kinase (is one of a group of molecules that work together with cyclins to determine progression past cell checkpoints. By interacting with many additional molecules, these triggers push the cell cycle forward unless prevented from doing so by “stop” signals, if for some reason the cell is not ready. **42** Embryonic stem cells derive from human embryos, which are destroyed to obtain the cells. The destruction of human embryos is an ethical problem. And, the DNA in an embryonic stem cell would differ from the DNA of the person being treated, which could result in immune problems or rejected of tissue.

## Chapter 4

**1** Most somatic stem cells give rise to only a few cell types. **3** Click at the bottom of the quiz for the answers. **5** Dendrites, cell body, and the axon. **7** A mass of cancer cells that continue to grow and divide. **8** C **10** B **12** A **14** B **16** B **18** B **20** B **22** A **24** D **26** B **28** C **30** B **32** The four types of tissue in the body are epithelial, connective, muscle, and nervous. Epithelial tissue is made of layers of cells that cover the surfaces of the body that come into contact with the exterior world, line internal cavities, and form glands. Connective tissue binds the cells and organs of the body together and performs many functions, especially in the protection, support, and integration of the body. Muscle tissue, which responds to stimulation and contracts to provide movement, is divided into three major types: skeletal (voluntary) muscles, smooth muscles, and the cardiac muscle in the heart. Nervous tissue allows the body to receive signals and transmit information as electric impulses from one region of the body to another. **34** Synovial membranes are a type of connective tissue membrane that supports mobility in joints. The membrane lines the joint cavity and contains fibroblasts that produce hyaluronan, which leads to the production of synovial fluid, a natural lubricant that enables the bones of a joint to move freely against one another. **36** Blood is a fluid connective tissue, a variety of specialized cells that circulate in a watery fluid containing salts, nutrients, and dissolved proteins in a liquid extracellular matrix. Blood contains formed elements derived from bone marrow. Erythrocytes, or red blood cells, transport the gases oxygen and carbon dioxide. Leukocytes, or white blood cells, are responsible for the defense of the organism against potentially harmful microorganisms or molecules. Platelets are cell fragments involved in blood clotting. Some cells have the ability to cross the endothelial layer that lines vessels and enter adjacent tissues. Nutrients, salts, and waste are dissolved in the liquid matrix and transported through the body. **38** The cells in the dish are cardiomyocytes, cardiac muscle cells. They have an intrinsic ability to contract. When they link up, they form intercalating discs that allow the cells to communicate with each other and begin contracting in synchrony. **40** Neurons are well suited for the transmission of nerve impulses because short extensions, dendrites, receive impulses from other neurons, while a long tail extension, an axon, carries electrical impulses away from the cell to other neurons. **42** These symptoms would indicate that infection is present. **44** The genetic makeup and the lifestyle of each individual are factors which determine the degree of decline in cells, tissues, and organs as an individual ages.

## Chapter 5

**1** The epidermis provides protection, the dermis provides support and flexibility, and the hypodermis (fat layer) provides insulation and padding. **3** **Figure 5.6** These cells have desmosomes, which give the cells their spiny appearance. **5** D **7** C **9** C **11** D **13** B **15** A **17** C **19** C **21** C **23** B **25** The pigment melanin, produced by melanocytes, is primarily responsible for skin color. Melanin comes in different shades of brown and black. Individuals with darker skin have darker, more abundant melanin, whereas fair-skinned individuals have a lighter shade of skin and less melanin. Exposure to UV irradiation stimulates the melanocytes to produce and secrete more melanin. **27** Eccrine sweat glands are all over the body, especially the forehead and palms of the hand. They release a watery sweat, mixed with some metabolic waste and antibodies. Apocrine glands are associated with hair follicles. They are larger than eccrine sweat glands and lie deeper in the dermis, sometimes even reaching the hypodermis. They release a thicker sweat that is often decomposed by bacteria on the skin, resulting in an unpleasant odor. **29** Sweating cools the body when it becomes warm. When the body temperature rises, such as when exercising on a hot day, the dermal blood vessels dilate, and the sweat glands begin to secrete more sweat. The evaporation of the sweat from the surface of the skin cools the body by dissipating heat. **31** Acne results from a blockage of sebaceous glands by sebum. The blockage causes blackheads to form, which are susceptible to infection. The infected tissue then becomes red and inflamed. Teenagers experience this at high rates because the sebaceous glands become active during puberty. Hormones that are especially active during puberty stimulate the release of sebum, leading in many cases to blockages.

## Chapter 6

**1** B **3** C **5** B **7** B **9** A **11** C **13** B **15** C **17** C **19** A **21** D **23** D **25** B **27** B **29** D **31** C **33** A **35** A **37** D **39** B **40** It supports the body. The rigid, yet flexible skeleton acts as a framework to support the other organs of the body. It facilitates movement. The movable joints allow the skeleton to change shape and positions; that is, move. It protects internal organs. Parts of the skeleton enclose or partly enclose various organs of the body including our brain, ears, heart, and lungs. Any trauma to these organs has to be mediated through the skeletal system. It produces blood cells. The central cavity of long bones is filled with marrow. The red marrow is responsible for forming red and white blood cells. It stores and releases minerals and fat. The mineral component of bone, in addition to providing hardness to bone, provides a mineral reservoir that can be tapped as needed.

Additionally, the yellow marrow, which is found in the central cavity of long bones along with red marrow, serves as a storage site for fat. **42** Structurally, the femur is a long bone, meaning its length is greater than its width, while the patella, a sesamoid bone, is small and round. Functionally, the femur acts as a lever, while the patella protects the patellar tendon from compressive forces. **44** The densely packed concentric rings of matrix in compact bone are ideal for resisting compressive forces, which is the function of compact bone. The open spaces of the trabeculated network of spongy bone allow spongy bone to support shifts in weight distribution, which is the function of spongy bone. **46** A single primary ossification center is present, during endochondral ossification, deep in the periosteal collar. Like the primary ossification center, secondary ossification centers are present during endochondral ossification, but they form later, and there are two of them, one in each epiphysis. **48** The internal callus is produced by cells in the endosteum and is composed of a fibrocartilaginous matrix. The external callus is produced by cells in the periosteum and consists of hyaline cartilage and bone. **50** Astronauts floating in space were not exerting significant pressure on their bones; they were “weightless.” Without the force of gravity exerting pressure on the bones, bone mass was lost. To alleviate this condition, astronauts now do resistive exercise designed to apply forces to the bones and thus help keep them healthy. **52** Under “normal” conditions, receptors in the parathyroid glands bind blood calcium. When the receptors are full, the parathyroid gland stops secreting PTH. In the condition described, the parathyroid glands are not responding to the signal that there is sufficient calcium in the blood and they keep releasing PTH, which causes the bone to release more calcium into the blood. Ultimately, the bones become fragile and hypercalcemia can result.

## Chapter 7

**1** The sphenoid bone joins with most other bones of the skull. It is centrally located, where it forms portions of the rounded brain case and cranial base. **3** Osteoporosis causes thinning and weakening of the vertebral bodies. When this occurs in thoracic vertebrae, the bodies may collapse producing kyphosis, an enhanced anterior curvature of the thoracic vertebral column. **5** The anterior longitudinal ligament is thickest in the thoracic region of the vertebral column, while the supraspinous ligament is thickest in the lumbar region. **7 D 9 B 11 B 13 A 15 D 17 B 19 A 21 B 23 A 25 B 27** The axial skeleton forms the vertical axis of the body and includes the bones of the head, neck, back, and chest of the body. It consists of 80 bones that include the skull, vertebral column, and thoracic cage. The appendicular skeleton consists of 126 bones and includes all bones of the upper and lower limbs. **29** The brain case is that portion of the skull that surrounds and protects the brain. It is subdivided into the rounded top of the skull, called the calvaria, and the base of the skull. There are eight bones that form the brain case. These are the paired parietal and temporal bones, plus the unpaired frontal, occipital, sphenoid, and ethmoid bones. The facial bones support the facial structures, and form the upper and lower jaws, nasal cavity, nasal septum, and orbit. There are 14 facial bones. These are the paired maxillary, palatine, zygomatic, nasal, lacrimal, and inferior nasal conchae bones, and the unpaired vomer and mandible bones. **31** The anterior cranial fossa is the shallowest of the three cranial fossae. It extends from the frontal bone anteriorly to the lesser wing of the sphenoid bone posteriorly. It is divided at the midline by the crista galli and cribriform plates of the ethmoid bone. The middle cranial fossa is located in the central skull, and is deeper than the anterior fossa. The middle fossa extends from the lesser wing of the sphenoid bone anteriorly to the petrous ridge posteriorly. It is divided at the midline by the sella turcica. The posterior cranial fossa is the deepest fossa. It extends from the petrous ridge anteriorly to the occipital bone posteriorly. The large foramen magnum is located at the midline of the posterior fossa. **33** The adult vertebral column consists of 24 vertebrae, plus the sacrum and coccyx. The vertebrae are subdivided into cervical, thoracic, and lumbar regions. There are seven cervical vertebrae (C1–C7), 12 thoracic vertebrae (T1–T12), and five lumbar vertebrae (L1–L5). The sacrum is derived from the fusion of five sacral vertebrae and the coccyx is formed by the fusion of four small coccygeal vertebrae. **35** The sacrum is a single, triangular-shaped bone formed by the fusion of five sacral vertebrae. On the posterior sacrum, the median sacral crest is derived from the fused spinous processes, and the lateral sacral crest results from the fused transverse processes. The sacral canal contains the sacral spinal nerves, which exit via the anterior (ventral) and posterior (dorsal) sacral foramina. The sacral promontory is the anterior lip. The sacrum also forms the posterior portion of the pelvis. **37** The anterior longitudinal ligament is attached to the vertebral bodies on the anterior side of the vertebral column. The supraspinous ligament is located on the posterior side, where it interconnects the thoracic and lumbar spinous processes. In the posterior neck, this ligament expands to become the nuchal ligament, which attaches to the cervical spinous processes and the base of the skull. The posterior longitudinal ligament and ligamentum flavum are located inside the vertebral canal. The posterior longitudinal ligament unites the posterior sides of the vertebral bodies. The ligamentum flavum unites the lamina of adjacent vertebrae. **39** The sternum consists of the manubrium, body, and xiphoid process. The manubrium forms the expanded, superior end of the sternum. It has a jugular (suprasternal) notch, a pair of clavicular notches for articulation with the clavicles, and receives the costal cartilage of the first rib. The manubrium is joined to the body of the sternum at the sternal angle, which is also the site for attachment of the second rib costal cartilages. The body receives the costal cartilage attachments for ribs 3–7. The small xiphoid process forms the inferior tip of the sternum. **41** Ribs are classified based on if and how their costal cartilages attach to the sternum. True (vertebrosternal) ribs are ribs 1–7. The costal cartilage for each of these attaches directly to the sternum. False (vertebrochondral) ribs, 8–12, are attached either indirectly or not at all to the sternum. Ribs 8–10 are attached indirectly to the sternum. For these ribs, the costal cartilage of each attaches to the cartilage of the next higher rib. The last false ribs (11–12) are also called floating (vertebral) ribs, because these ribs do not attach to the sternum at all. Instead, the ribs and their small costal cartilages terminate within the muscles of the lateral abdominal wall. **43** The facial bones and base of the skull arise via the process of endochondral ossification. This process begins with the localized accumulation of mesenchyme tissue at the sites of the future bones. The mesenchyme differentiates into hyaline cartilage, which forms a cartilage model of the future bone. The cartilage allows for growth and enlargement of the model. It is gradually converted into bone over time.

## Chapter 8

**1** A fracture through the joint surface of the distal radius may make the articulating surface of the radius rough or jagged. This can then cause painful movements involving this joint and the early development of arthritis. Surgery can return the joint surface to its original smoothness, thus allowing for the return of normal function. **3** Surgery may be required if the fracture is unstable, meaning that the broken ends of the radius won't stay in place to allow for proper healing. In this case, metal plates and screws can be used to stabilize the fractured bone. **5** A hole is drilled into the greater trochanter, the bone marrow (medullary) space inside the femur is enlarged, and finally an intramedullary rod is inserted into the femur. This rod is then anchored to the bone with screws. **7** The proximal group of tarsal bones includes the calcaneus and talus bones, the navicular bone is intermediate, and the distal group consists of the cuboid bone plus the medial, intermediate, and lateral cuneiform bones. **9** (a) The upper limb bud initially appears on day 26 as the upper limb ridge. This becomes the upper limb bud by day 28. (b) The handplate and footplate appear at day 36. (c) Rotation of the upper and lower limbs begins during the seventh week (day 48). **10 B 12 D 14 C 16 A 18 D 20 B 22 B 24 A 26 C 28 C 30 D 32 A 33** The clavicle extends laterally across the anterior shoulder and can be palpated along its entire length. At its lateral end, the clavicle articulates with the acromion of the scapula, which forms the bony tip of the shoulder. The acromion is continuous with the spine of the scapula, which can be palpated medially and posteriorly along its length. Together, the clavicle, acromion, and spine of the scapula form a V-shaped line that serves as an important area for muscle attachment. **35** As you push against the car, forces will pass from the metacarpal bones of your hand into the carpal bones at the base of your hand. Forces will then pass through the midcarpal and radiocarpal joints into the radius and ulna bones of the forearm. These will pass the force through the elbow joint into the humerus of the arm, and then through the glenohumeral joint into the scapula. The force will travel through the acromioclavicular joint into the clavicle, and then through the sternoclavicular joint into the sternum, which is part of the axial skeleton. **37** The pelvis is formed by the combination of the right and left hip bones, the sacrum, and the coccyx. The auricular surfaces of each hip bone articulate with the auricular surface of the sacrum to form the sacroiliac joint. This joint is supported on either side by the strong anterior and posterior sacroiliac ligaments. The right and left hip bones converge anteriorly, where the pubic bodies articulate with each other to form the pubic symphysis joint. The sacrum is also attached to the hip bone by the sacrospinous ligament, which spans the sacrum to the ischial spine, and the sacrotuberous ligament, which runs from the sacrum to the ischial tuberosity. The coccyx is attached to the inferior end of the sacrum. **39** The lower limb is divided into three regions. The thigh is the region located between the hip and knee joints. It contains the femur and the patella. The hip joint is formed by the articulation between the acetabulum of the hip bone and the head of the femur. The leg is the region between the knee and ankle joints, and contains the tibia (medially) and the fibula (laterally). The knee joint is formed by the articulations between the medial and lateral condyles of the femur, and the medial and lateral condyles of the tibia. Also associated with the knee is the patella, which articulates with the patellar surface of the distal femur. The foot is found distal to the ankle and contains 26 bones. The ankle joint is formed by the articulations between the talus bone of the foot and the distal end of the tibia, the medial malleolus of the tibia, and the lateral malleolus of the fibula. The posterior foot contains the seven tarsal bones, which are the talus, calcaneus, navicular, cuboid, and the medial, intermediate, and lateral cuneiform bones. The anterior foot consists of the five metatarsal bones, which are numbered 1–5 starting on the medial side of the foot. The toes contain 14 phalanx bones, with the big toe (toe number 1) having a proximal and a distal phalanx, and the other toes having proximal, middle, and distal phalanges. **41** A radiograph (X-ray image) of a child's femur will show the epiphyseal plates associated with each secondary ossification center. These plates of hyaline cartilage will appear dark in comparison to the white imaging of the ossified bone. Since each epiphyseal plate appears and disappears at a different age, the presence or absence of these plates can be used to give an approximate age for the child. For example, the epiphyseal plate located at the base of the lesser trochanter of the femur appears at age 9–10 years and disappears at puberty (approximately 11 years of age). Thus, a child's radiograph that shows the presence of the lesser trochanter epiphyseal plate indicates an approximate age of 10 years.

## Chapter 9

**1** Although they are still growing, the carpal bones of the wrist area do not show an epiphyseal plate. Instead of elongating, these bones grow in diameter by adding new bone to their surfaces. **3** Gout is due to the accumulation of uric acid crystals in the body. Usually these accumulate within joints, causing joint pain. This patient also had crystals that accumulated in the space next to his spinal cord, thus compressing the spinal cord and causing muscle weakness. **5** The immune system malfunctions and attacks healthy cells in the lining of your joints. This causes inflammation and pain in the joints and surrounding tissues. **7** The first motion is rotation (hinging) of the mandible, but this only produces about 20 mm (0.78 in) of mouth opening. **9** The glenoid labrum is wedge-shaped in cross-section. This is important because it creates an elevated rim around the glenoid cavity, which creates a deeper socket for the head of the humerus to fit into. **11** The articular cartilage functions to absorb shock and to provide an extremely smooth surface that makes movement between bones easy, without damaging the bones. **13** The articular cartilage is thickest in the upper and back part of the acetabulum, the socket portion of the hip joint. These regions receive most of the force from the head of the femur during walking and running. **15** The anterior cruciate ligament prevents the tibia from sliding too far forward in relation to the femur and the posterior cruciate ligament keeps the tibia from sliding too far backward. **17** The ligaments of the lateral ankle are the anterior and posterior talofibular ligaments and the calcaneofibular ligament. These ligaments support the ankle joint and resist excess inversion of the foot. **19** An inversion ankle sprain may injure all three ligaments located on the lateral side of the ankle. The sequence of injury would be the anterior talofibular ligament first, followed by the calcaneofibular ligament second, and finally, the posterior talofibular ligament third. **20 C 22 A 24 A 26 D 28 B 30 A 32 A 34 C 36**

D 38 B 40 A 42 D 44 C 46 A 48 C 50 B 52 A 53 Functional classification of joints is based on the degree of mobility exhibited by the joint. A synarthrosis is an immobile or nearly immobile joint. An example is the manubriosternal joint or the joints between the skull bones surrounding the brain. An amphiarthrosis is a slightly moveable joint, such as the pubic symphysis or an intervertebral cartilaginous joint. A diarthrosis is a freely moveable joint. These are subdivided into three categories. A uniaxial diarthrosis allows movement within a single anatomical plane or axis of motion. The elbow joint is an example. A biaxial diarthrosis, such as the metacarpophalangeal joint, allows for movement along two planes or axes. The hip and shoulder joints are examples of a multiaxial diarthrosis. These allow movements along three planes or axes. 55 Narrow fibrous joints are found at a suture, gomphosis, or syndesmosis. A suture is the fibrous joint that joins the bones of the skull to each other (except the mandible). A gomphosis is the fibrous joint that anchors each tooth to its bony socket within the upper or lower jaw. The tooth is connected to the bony jaw by periodontal ligaments. A narrow syndesmosis is found at the distal tibiofibular joint where the bones are united by fibrous connective tissue and ligaments. A syndesmosis can also form a wide fibrous joint where the shafts of two parallel bones are connected by a broad interosseous membrane. The radius and ulna bones of the forearm and the tibia and fibula bones of the leg are united by interosseous membranes. 57 Cartilaginous joints are where the adjacent bones are joined by cartilage. At a synchondrosis, the bones are united by hyaline cartilage. The epiphyseal plate of growing long bones and the first sternocostal joint that unites the first rib to the sternum are examples of synchondroses. At a symphysis, the bones are joined by fibrocartilage, which is strong and flexible. Symphysis joints include the intervertebral symphysis between adjacent vertebrae and the pubic symphysis that joins the pubic portions of the right and left hip bones. 59 All synovial joints have a joint cavity filled with synovial fluid that is the site at which the bones of the joint articulate with each other. The articulating surfaces of the bones are covered by articular cartilage, a thin layer of hyaline cartilage. The walls of the joint cavity are formed by the connective tissue of the articular capsule. The synovial membrane lines the interior surface of the joint cavity and secretes the synovial fluid. Synovial joints are directly supported by ligaments, which span between the bones of the joint. These may be located outside of the articular capsule (extrinsic ligaments), incorporated or fused to the wall of the articular capsule (intrinsic ligaments), or found inside of the articular capsule (intracapsular ligaments). Ligaments hold the bones together and also serve to resist or prevent excessive or abnormal movements of the joint. 61 Ball-and-socket joints are multiaxial joints that allow for flexion and extension, abduction and adduction, circumduction, and medial and lateral rotation. 63 The shoulder joint allows for a large range of motion. The primary support for the shoulder joint is provided by the four rotator cuff muscles. These muscles serve as “dynamic ligaments” and thus can modulate their strengths of contraction as needed to hold the head of the humerus in position at the glenoid fossa. Additional but weaker support comes from the coracohumeral ligament, an intrinsic ligament that supports the superior aspect of the shoulder joint, and the glenohumeral ligaments, which are intrinsic ligaments that support the anterior side of the joint. 65 Mesenchyme gives rise to cartilage models of the future limb bones. An area called the joint interzone located between adjacent cartilage models will become a synovial joint. The cells at the center of the interzone die, thus producing the joint cavity. Additional mesenchyme cells at the periphery of the interzone become the articular capsule.

## Chapter 10

1 (a) Z-lines. (b) Sarcomeres. (c) This is the arrangement of the actin and myosin filaments in a sarcomere. (d) The alternating strands of actin and myosin filaments. 3 (a) The T-tubules are inward extensions of the sarcolemma that trigger the release of  $\text{Ca}^{++}$  from SR during an Action Potential. (b)  $\text{Ca}^{++}$  binds to tropomyosin, and this slides the tropomyosin rods away from the binding sites. 4 D 6 C 8 A 10 D 12 C 14 D 16 B 18 B 20 A 22 C 24 D 26 A 28 C 30 It allows muscle to return to its original length during relaxation after contraction. 32 When a muscle contracts, the force of movement is transmitted through the tendon, which pulls on the bone to produce skeletal movement. 34 The opening of voltage-gated sodium channels, followed by the influx of  $\text{Na}^+$ , transmits an Action Potential after the membrane has sufficiently depolarized. The delayed opening of potassium channels allows  $\text{K}^+$  to exit the cell, to repolarize the membrane. 36 Dark A bands and light I bands repeat along myofibrils, and the alignment of myofibrils in the cell cause the entire cell to appear striated. 38 Eyes require fine movements and a high degree of control, which is permitted by having fewer muscle fibers associated with a neuron. 40 Creatine phosphate is used because creatine phosphate and ADP are converted very quickly into ATP by creatine kinase. Glycolysis cannot generate ATP as quickly as creatine phosphate. 42 Endurance training modifies slow fibers to make them more efficient by producing more mitochondria to enable more aerobic metabolism and more ATP production. Endurance exercise can also increase the amount of myoglobin in a cell and formation of more extensive capillary networks around the fiber. 44 An action potential could reach a cardiac muscle cell before it has entered the relaxation phase, resulting in the sustained contractions of tetanus. If this happened, the heart would not beat regularly. 46 Smooth muscles can contract over a wider range of resting lengths because the actin and myosin filaments in smooth muscle are not as rigidly organized as those in skeletal and cardiac muscle. 48 If the damage exceeds what can be repaired by satellite cells, the damaged tissue is replaced by scar tissue, which cannot contract.

## Chapter 11

1 D 3 B 5 C 7 A 9 C 11 D 13 B 15 B 17 A 19 B 21 B 23 A 25 D 27 B 28 Fascicle arrangements determine what type of movement a muscle can make. For instance, circular muscles act as sphincters, closing orifices. 30 Agonists are the prime movers while antagonists oppose or resist the movements of the agonists. Synergists assist the agonists, and fixators stabilize a muscle's origin. 32 Axial muscles originate on the axial skeleton (the bones in the head, neck, and core of the body), whereas appendicular muscles originate on the bones that make up the body's limbs. 34 Most skeletal muscles create movement by actions

on the skeleton. Facial muscles are different in that they create facial movements and expressions by pulling on the skin—no bone movements are involved. **36** Both diaphragms are thin sheets of skeletal muscle that horizontally span areas of the trunk. The diaphragm separating the thoracic and abdominal cavities is the primary muscle of breathing. The pelvic diaphragm, consisting of two paired muscles, the coccygeus and the levator ani, forms the pelvic floor at the inferior end of the trunk. **38** The muscles that make up the shoulders and upper limbs include the muscles that position the pelvic girdle, the muscles that move the humerus, the muscles that move the forearm, and the muscles that move the wrists, hands, and fingers. **40** The rectus femoris, vastus medialis, vastus lateralis, and vastus intermedius form the quadriceps. The quadriceps muscles extend the leg at the knee joint.

## Chapter 12

**1** MRI uses the relative amount of water in tissue to distinguish different areas, so gray and white matter in the nervous system can be seen clearly in these images. **3** Neurons enable thought, perception, and movement. Plants do not move, so they do not need this type of tissue. Microorganisms are too small to have a nervous system. Many are single-celled, and therefore have organelles for perception and movement. **5** Sodium is moving into the cell because of the immense concentration gradient, whereas potassium is moving out because of the depolarization that sodium causes. However, they both move down their respective gradients, toward equilibrium. **7** A second signal from a separate presynaptic neuron can arrive slightly later, as long as it arrives before the first one dies off, or dissipates. **9** C **11** D **13** B **15** B **17** A **19** C **21** C **23** A **25** B **27** D **29** B **31** D **33** A **34** Running on a treadmill involves contraction of the skeletal muscles in the legs, increase in contraction of the cardiac muscle of the heart, and the production and secretion of sweat in the skin to stay cool. **36** The disease would target oligodendrocytes. In the CNS, oligodendrocytes provide the myelin for axons. **38** Afferent means “toward,” as in sensory information traveling from the periphery into the CNS. Efferent means “away from,” as in motor commands that travel from the brain down the spinal cord and out into the periphery. **40** The cell membrane must reach threshold before voltage-gated  $\text{Na}^+$  channels open. If threshold is not reached, those channels do not open, and the depolarizing phase of the action potential does not occur, the cell membrane will just go back to its resting state. **42** EPSP1 = +5 mV, EPSP2 = +7 mV, EPSP 3 = +10 mV, IPSP1 = -4 mV, IPSP2 = -3 mV.  $5 + 7 + 10 - 4 - 3 = +15$  mV.

## Chapter 13

**1** The three regions (forebrain, midbrain, and hindbrain) appear to be approximately equal in size when they are first established, but the midbrain in the adult is much smaller than the others—suggesting that it does not increase in size nearly as much as the forebrain or hindbrain. **3** Both cells are inhibitory. The first cell inhibits the second one. Therefore, the second cell can no longer inhibit its target. This is disinhibition of that target across two synapses. **5** There are more motor neurons in the anterior horns that are responsible for movement in the limbs. The cervical enlargement is for the arms, and the lumbar enlargement is for the legs. **7** If blood could not get to the middle cerebral artery through the posterior circulation, the blood would flow around the circle of Willis to reach that artery from an anterior vessel. Blood flow would just reverse within the circle. **9** The choroid plexuses of the ventricles make CSF. As shown, there is a little of the blue color appearing in each ventricle that is joined by the color flowing from the other ventricles. **11** **Figure 13.22** The endoneurium surrounding individual nerve fibers is comparable to the endomysium surrounding myofibrils, the perineurium bundling axons into fascicles is comparable to the perimysium bundling muscle fibers into fascicles, and the epineurium surrounding the whole nerve is comparable to the epimysium surrounding the muscle. **13** C **15** A **17** A **19** C **21** A **23** C **25** A **27** D **29** D **31** D **33** The retina, a PNS structure in the adult, grows from the diencephalon in the embryonic nervous system. The mature connections from the retina through the optic nerve/tract are to the hypothalamus and thalamus of the diencephalon, and to the midbrain, which developed directly adjacent to the diencephalon as the mesencephalon in the embryo. **35** The temporal lobe has sensory functions associated with hearing and vision, as well as being important for memory. A stroke in the temporal lobe can result in specific sensory deficits in these systems (known as agnosias) or losses in memory. **37** The structure is a circular connection of blood vessels, so that blood coming up from one of the arteries can flow in either direction around the circle and avoid any blockage or narrowing of the blood vessels. **39** The peripheral nervous tissues are out in the body, sometimes part of other organ systems. There is not a privileged blood supply like there is to the brain and spinal cord, so peripheral nervous tissues do not need the same sort of protections.

## Chapter 14

**1** Answers will vary, but a typical answer might be: I can eat most anything (except mushrooms!), so I don't think that I'm that sensitive to tastes. My whole family likes eating a variety of foods, so it seems that we all have the same level of sensitivity. **3** The small bones in the middle ear, the ossicles, amplify and transfer sound between the tympanic membrane of the external ear and the oval window of the inner ear. **5** Photoreceptors convert light energy, or photons, into an electrochemical signal. The retina contains bipolar cells and the RGCs that finally convert it into action potentials that are sent from the retina to the CNS. It is important to recognize when popular media and online sources oversimplify complex physiological processes so that misunderstandings are not generated. This video was created by a medical device manufacturer who might be trying to highlight other aspects of the visual system than retinal processing. The statement they make is not incorrect, it just bundles together several steps, which makes it sound like RGCs are the transducers, rather than photoreceptors. **7** Even if a person cannot recognize a person's face, other cues such as clothing, hairstyle, or a particular feature such as a prominent nose or facial hair, can help make an identification. **9** The



movement disorders were similar to those seen in movement disorders of the extrapyramidal system, which would mean the basal nuclei are the most likely source of haloperidol side effects. In fact, haloperidol affects dopamine activity, which is a prominent part of the chemistry of the basal nuclei. **11** While walking, the sole of the foot may be scraped or scratched by many things. If the foot still reacted as in the Babinski reflex, an adult might lose their balance while walking. **12 B 14 B 16 C 18 D 20 A 22 D 24 A 26 A 27** The stevia molecule is similar to glucose such that it will bind to the glucose receptor in sweet-sensitive taste buds. However, it is not a substrate for the ATP-generating metabolism within cells. **29** The right leg would feel painful stimuli, but not touch, because the spinothalamic tract decussates at the level of entry, which would be below the injury, whereas the dorsal column system does not decussate until reaching the brain stem, which would be above the injury and thus those fibers would be damaged. **31** The prefrontal cortex is involved in decision-making functions that lead to motor responses through connections to the more posterior motor regions. These early aspects of behavior are often associated with a person's personality, so disrupting those connections will lead to severe changes in behavior.

## Chapter 15

**1** The heart rate increases to send more blood to the muscles, and the liver releases stored glucose to fuel the muscles. **3** The effect of gravity on circulation means that it is harder to get blood up from the legs as the body takes on a vertical orientation. **5** The release of urine in extreme fear. The sympathetic system normally constricts sphincters such as that of the urethra. **7 D 9 C 11 A 13 D 15 A 17 A 19 B 21 B 23 C 25 D 27** Whereas energy is needed for running away from the threat, blood needs to be sent to the skeletal muscles for oxygen supply. The additional fuel, in the form of carbohydrates, probably wouldn't improve the ability to escape the threat as much as the diversion of oxygen-rich blood would hinder it. **29** The nerves that carry sensory information from the diaphragm enter the spinal cord in the cervical region where somatic sensory fibers from the shoulder and neck would enter. The brain superimposes this experience onto the sensory homunculus where the somatic nerves are connected. **31** Pupillary dilation and sweating, two functions lost in Horner's syndrome, are caused by the sympathetic system. A tumor in the thoracic cavity may interrupt the output of the thoracic ganglia that project to the head and face. **33** Blood vessels, and therefore blood pressure, are primarily influenced by only the sympathetic system. There is no parasympathetic influence on blood pressure, so nicotine activation of autonomic ganglia will preferentially increase blood pressure. Also, cardiac muscle tissue is only modulated by autonomic inputs, so the conflicting information from both sympathetic and parasympathetic postganglionic fibers will cause arrhythmias. Both hypertension and arrhythmias are cardiac risk factors.

## Chapter 16

**1** Coordination and gait were tested first, followed by mental status, motor, sensory, and reflexes. There were no specific tests of the cranial nerves. **3** The patient was unable to form episodic memories during the events described in the case, so the medial temporal lobe structures might have been affected by the antibodies. **5** She has just demonstrated voluntary control by closing her eyes, but when he provides the resistance that she needs to hold tight against, she has already relaxed the muscles enough for him to pull them open. She needs to squeeze them tighter to demonstrate the strength she has in the orbicular oculi. **7** The region lateral to the umbilicus is innervated by T9–T11, approximately. A lack of contraction following that stimulation would therefore suggest damage at those levels. **9 D 11 C 13 D 15 D 17 A 19 A 21 D 23 C 25 D 27 C 29 C 31 B 33 D 34** If an ischemic event has occurred, nervous tissue may be compromised, but quick intervention—possibly within a few hours—may be the critical aspect of recovery. **36** The patient has suffered a stroke to the prefrontal cortex where working memory is localized. **38** If the person already has problems focusing on far objects, and wears corrective lenses to see farther objects, then as accommodation changes, focusing on a reading surface might still be in their naturally near-sighted range. **40** Where spinal nerves innervate the skin is represented by “slices” of the body surface referred to as dermatomes. The fibers originating in each region are contained within the same spinal nerve, which relates to the perception of that localization. **42** The spinocerebellum is related to controlling the axial muscles and keeps the body balanced on the bike. The cerebrocerebellum is related to controlling the appendicular muscles and keeps the legs moving to pedal the bike. The vestibulocerebellum receives input about equilibrium to help keep everything balanced as the bike is moving forward.

## Chapter 17

**1** cAMP **3** Cortisol. **5** Insulin is overproduced. **6 C 8 B 10 C 12 C 14 B 16 B 18 C 20 B 22 A 24 D 26 B 28 D 30 D 32 B 34 C 36 A 38** The endocrine system uses chemical signals called hormones to convey information from one part of the body to a distant part of the body. Hormones are released from the endocrine cell into the extracellular environment, but then travel in the bloodstream to target tissues. This communication and response can take seconds to days. In contrast, neurons transmit electrical signals along their axons. At the axon terminal, the electrical signal prompts the release of a chemical signal called a neurotransmitter that carries the message across the synaptic cleft to elicit a response in the neighboring cell. This method of communication is nearly instantaneous, of very brief duration, and is highly specific. **40** True. Neurotransmitters can be classified as paracrines because, upon their release from a neuron's axon terminals, they travel across a microscopically small cleft to exert their effect on a nearby neuron or muscle cell. **42** An intracellular hormone receptor is located within the cell. A hydrophobic hormone diffuses through the cell membrane and binds to the intracellular hormone receptor, which may be in the cytosol or in the cell nucleus. This hormone–receptor complex binds to a segment of DNA. This initiates the transcription of a target gene, the end



result of which is protein assembly and the hormonal response. **44** The mammary glands are the target tissues for prolactin. **46** Hyperthyroidism is an abnormally elevated blood level of thyroid hormones due to an overproduction of T<sub>3</sub> and T<sub>4</sub>. An individual with hyperthyroidism is likely to lose weight because one of the primary roles of thyroid hormones is to increase the body's basal metabolic rate, increasing the breakdown of nutrients and the production of ATP. **48** A parathyroid gland tumor can prompt hypersecretion of PTH. This can raise blood calcium levels so excessively that calcium deposits begin to accumulate throughout the body, including in the kidney tubules, where they are referred to as kidney stones. **50** Damage to the innervation of the adrenal medulla would prevent the adrenal glands from responding to the hypothalamus during the fight-or-flight response. Therefore, the response would be reduced. **52** SAD is thought to occur in part because low levels and duration of sunlight allow excessive and prolonged secretion of melatonin. Light therapy—daytime exposure to very bright lighting—is one common therapy. **54** Both estrogens and progesterone are steroid hormones produced by the ovaries that help regulate the menstrual cycle. Estrogens play an important role in the development of the female reproductive tract and secondary sex characteristics. They also help maintain pregnancy. Progesterone prepares the body for pregnancy and helps maintain pregnancy. **56** The beta cells produce the hormone insulin, which is important in the regulation of blood glucose levels. All insulin-dependent cells of the body require insulin in order to take up glucose from the bloodstream. Destruction of the beta cells would result in an inability to produce and secrete insulin, leading to abnormally high blood glucose levels and the disease called type 1 diabetes mellitus. **58** The presence of food in the GI tract stimulates the release of hormones that aid in digestion. For example, gastrin is secreted in response to stomach distention and causes the release of hydrochloric acid in the stomach. Secretin is secreted when acidic chyme enters the small intestine, and stimulates the release of pancreatic bicarbonate. In the presence of fat and protein in the duodenum, CCK stimulates the release of pancreatic digestive enzymes and bile from the gallbladder. Other GI tract hormones aid in glucose metabolism and other functions. **60** Menopause occurs as the result of a progressive decline in the function of the ovaries, resulting in low estrogen and progesterone levels. Ovulation ceases, and postmenopausal woman can no longer conceive a child. In contrast, andropause is a much more gradual and subtle decline in testosterone levels and functioning. A man typically maintains fertility until very old age, although the quantity, quality, and motility of the sperm he produces may be reduced.

## Chapter 18

**1** There are values given for percent saturation, tension, and blood gas, and there are listings for different types of hemoglobin. **3** **Figure 18.13** This should appear to be a normal blood smear. **5 C 7 D 9 A 11 A 13 D 15 D 17 B 19 A 21 A 23 B 25 B 27** The patient's blood is approximately 58 percent plasma (since the buffy coat is less than 1 percent). **29** False. The buffy coat is the portion of blood that is made up of its leukocytes and platelets. **31** The adjective myelogenous suggests a condition originating from (generated by) myeloid cells. A cute myelogenous leukemia impairs the production of erythrocytes and other mature formed elements of the myeloid stem cell lineage. Lymphocytes arise from the lymphoid stem cell line. **33** Bilirubin is a breakdown product of the non-iron component of heme, which is cleaved from globin when erythrocytes are degraded. Excessive erythrocyte destruction would deposit excessive bilirubin in the blood. Bilirubin is a yellowish pigment, and high blood levels can manifest as yellowed skin. **35** Any severe stress can increase the leukocyte count, resulting in leukocytosis. A burn is especially likely to increase the proliferation of leukocytes in order to ward off infection, a significant risk when the barrier function of the skin is destroyed. **37** In a thrombotic stroke, a blood vessel to the brain has been blocked by a thrombus, an aggregation of platelets and erythrocytes within a blood vessel. A thrombolytic agent is a medication that promotes the breakup of thrombi. **39** The lab technician has not made an error. Blood type AB has both A and B surface antigens, and neither anti-A nor anti-B antibodies circulating in the plasma. When anti-A antibodies (added to the first well) contact A antigens on AB erythrocytes, they will cause agglutination. Similarly, when anti-B antibodies contact B antigens on AB erythrocytes, they will cause agglutination.

## Chapter 19

**1** The pressure gradient between the atria and the ventricles is much greater than that between the ventricles and the pulmonary trunk and aorta. Without the presence of the chordae tendineae and papillary muscles, the valves would be blown back (prolapsed) into the atria and blood would regurgitate. **2 D 4 A 6 B 8 C 10 D 12 D 14 B 16 B 18 A 20 A 22 D 24 D 26 D 27** When the ventricles contract and pressure begins to rise in the ventricles, there is an initial tendency for blood to flow back (regurgitate) to the atria. However, the papillary muscles also contract, placing tension on the chordae tendineae and holding the atrioventricular valves (tricuspid and mitral) in place to prevent the valves from prolapsing and being forced back into the atria. The semilunar valves (pulmonary and aortic) lack chordae tendineae and papillary muscles, but do not face the same pressure gradients as do the atrioventricular valves. As the ventricles relax and pressure drops within the ventricles, there is a tendency for the blood to flow backward. However, the valves, consisting of reinforced endothelium and connective tissue, fill with blood and seal off the opening preventing the return of blood. **29** It prevents additional impulses from spreading through the heart prematurely, thereby allowing the muscle sufficient time to contract and pump blood effectively. **31** Gap junctions within the intercalated disks allow impulses to spread from one cardiac muscle cell to another, allowing sodium, potassium, and calcium ions to flow between adjacent cells, propagating the action potential, and ensuring coordinated contractions. **33** The cardiac cycle comprises a complete relaxation and contraction of both the atria and ventricles, and lasts approximately 0.8 seconds. Beginning with all chambers in diastole, blood flows passively from the veins into the atria and past the atrioventricular valves into the ventricles. The atria begin to contract following depolarization of the atria and pump blood into the ventricles. The ventricles begin to contract, raising pressure within the ventricles. When ventricular pressure rises above the pressure in the two major arteries, blood pushes open the two semilunar valves and moves into the pulmonary trunk and aorta in the ventricular ejection phase.

Following ventricular repolarization, the ventricles begin to relax, and pressure within the ventricles drops. When the pressure falls below that of the atria, blood moves from the atria into the ventricles, opening the atrioventricular valves and marking one complete heart cycle. **35** Afterload represents the resistance within the arteries to the flow of blood ejected from the ventricles. If uncompensated, if afterload increases, flow will decrease. In order for the heart to maintain adequate flow to overcome increasing afterload, it must pump more forcefully. This is one of the negative consequences of high blood pressure or hypertension. **37** After fusion of the two endocardial tubes into the single primitive heart, five regions quickly become visible. From the head, these are the truncus arteriosus, bulbus cordis, primitive ventricle, primitive atrium, and sinus venosus. Contractions propel the blood from the sinus venosus to the truncus arteriosus. About day 23, the heart begins to form an S-shaped structure within the pericardium. The bulbus cordis develops into the right ventricle, whereas the primitive ventricle becomes the left ventricle. The interventricular septum separating these begins to form about day 28. The atrioventricular valves form between weeks five to eight. At this point, the heart ventricles resemble the adult structure.

## Chapter 20

**1** Water. **3 A 5 C 7 C 9 A 11 D 13 B 15 A 17 C 19 A 21 C 23 D 25 D 27 C 28** Arterioles receive blood from arteries, which are vessels with a much larger lumen. As their own lumen averages just 30 micrometers or less, arterioles are critical in slowing down—or resisting—blood flow. The arterioles can also constrict or dilate, which varies their resistance, to help distribute blood flow to the tissues. **30** This is a venule. **32** People who stand upright all day and are inactive overall have very little skeletal muscle activity in the legs. Pooling of blood in the legs and feet is common. Venous return to the heart is reduced, a condition that in turn reduces cardiac output and therefore oxygenation of tissues throughout the body. This could at least partially account for the patient's fatigue and shortness of breath, as well as her "spaced out" feeling, which commonly reflects reduced oxygen to the brain. **34** False. The plasma proteins suspended in blood cannot cross the semipermeable capillary cell membrane, and so they remain in the plasma within the vessel, where they account for the blood colloid osmotic pressure. **36** Nitric oxide is a very powerful local vasodilator that is important in the autoregulation of tissue perfusion. If it were not broken down very quickly after its release, blood flow to the region could exceed metabolic needs. **38** The gonadal veins drain the testes in males and the ovaries in females. **40** Angiogenesis inhibitors are drugs that inhibit the growth of new blood vessels. They can impede the growth of tumors by limiting their blood supply and therefore their access to gas and nutrient exchange.

## Chapter 21

**1** The three main components are the lymph vessels, the lymph nodes, and the lymph. **3** The bacterium is digested by the phagocyte's digestive enzymes (contained in its lysosomes). **5 B 7 C 9 A 11 D 13 C 15 B 17 B 19 D 21 D 23 B 25 C 27 B 29 C 31 D 33 A 35 B 37 B 39** The lymph enters through lymphatic capillaries, and then into larger lymphatic vessels. The lymph can only go in one direction due to valves in the vessels. The larger lymphatics merge to form trunks that enter into the blood via lymphatic ducts. **41** Interferons are produced in virally infected cells and cause them to secrete signals for surrounding cells to make antiviral proteins. C-reactive protein is induced to be made by the liver and will opsonize certain species of bacteria. **43** Antigen-specific clones are stimulated as their antigen receptor binds to antigen. They are then activated and proliferate, expanding their numbers. The result is a large number of antigen-specific lymphocytes. **45** IgM is an antigen receptor on naïve B cells. Upon activation, naïve B cells make IgM first. IgM is good at binding complement and thus has good antibacterial effects. IgM is replaced with other classes of antibodies later on in the primary response due to class switching. **47** Tuberculosis is caused by bacteria resistant to lysosomal enzymes in alveolar macrophages, resulting in chronic infection. The immune response to these bacteria actually causes most of the lung damage that is characteristic of this life-threatening disease. **49** Antibody response to the cell walls of  $\beta$ -*Streptococcus* cross-reacts with the heart muscle. Complement is then activated and the heart is damaged, leading to abnormal function. Tolerance is broken because heart myosin antigens are similar to antigens on the  $\beta$ -*Streptococcus* bacteria.

## Chapter 22

**1** Inflammation and the production of a thick mucus; constriction of the airway muscles, or bronchospasm; and an increased sensitivity to allergens. **3** When oxygen binds to the hemoglobin molecule, oxyhemoglobin is created, which has a red color to it. Hemoglobin that is not bound to oxygen tends to be more of a blue-purple color. Oxygenated blood traveling through the systemic arteries has large amounts of oxyhemoglobin. As blood passes through the tissues, much of the oxygen is released into systemic capillaries. The deoxygenated blood returning through the systemic veins, therefore, contains much smaller amounts of oxyhemoglobin. The more oxyhemoglobin that is present in the blood, the redder the fluid will be. As a result, oxygenated blood will be much redder in color than deoxygenated blood. **4 C 6 D 8 C 10 B 12 C 14 A 16 D 18 D 20 D 22 C 24 C 26 B 28 A 30 D 32 A 34 A 36** The pharynx has three major regions. The first region is the nasopharynx, which is connected to the posterior nasal cavity and functions as an airway. The second region is the oropharynx, which is continuous with the nasopharynx and is connected to the oral cavity at the fauces. The laryngopharynx is connected to the oropharynx and the esophagus and trachea. Both the oropharynx and laryngopharynx are passageways for air and food and drink. **38** The conducting zone of the respiratory system includes the organs and structures that are not directly involved in gas exchange, but perform other duties such as providing a passageway for air, trapping and removing debris and pathogens, and warming and humidifying incoming air. Such structures include the nasal cavity, pharynx, larynx, trachea, and most of the bronchial tree. The respiratory zone

includes all the organs and structures that are directly involved in gas exchange, including the respiratory bronchioles, alveolar ducts, and alveoli. **40** There is a cavity, called the pleural cavity, between the parietal and visceral layers of the pleura. Mesothelial cells produce and secrete pleural fluid into the pleural cavity that acts as a lubricant. Therefore, as you breathe, the pleural fluid prevents the two layers of the pleura from rubbing against each other and causing damage due to friction. **42** Quiet breathing occurs at rest and without active thought. During quiet breathing, the diaphragm and external intercostal muscles work at different extents, depending on the situation. For inspiration, the diaphragm contracts, causing the diaphragm to flatten and drop towards the abdominal cavity, helping to expand the thoracic cavity. The external intercostal muscles contract as well, causing the rib cage to expand, and the rib cage and sternum to move outward, also expanding the thoracic cavity. Expansion of the thoracic cavity also causes the lungs to expand, due to the adhesiveness of the pleural fluid. As a result, the pressure within the lungs drops below that of the atmosphere, causing air to rush into the lungs. In contrast, expiration is a passive process. As the diaphragm and intercostal muscles relax, the lungs and thoracic tissues recoil, and the volume of the lungs decreases. This causes the pressure within the lungs to increase above that of the atmosphere, causing air to leave the lungs. **44** Both Dalton's and Henry's laws describe the behavior of gases. Dalton's law states that any gas in a mixture of gases exerts force as if it were not in a mixture. Henry's law states that gas molecules dissolve in a liquid proportional to their partial pressure. **46** Both adult and fetal hemoglobin transport oxygen via iron molecules. However, fetal hemoglobin has about a 20-fold greater affinity for oxygen than does adult hemoglobin. This is due to a difference in structure; fetal hemoglobin has two subunits that have a slightly different structure than the subunits of adult hemoglobin. **48** Carbon dioxide can be transported by three mechanisms: dissolved in plasma, as bicarbonate, or as carbaminohemoglobin. Dissolved in plasma, carbon dioxide molecules simply diffuse into the blood from the tissues. Bicarbonate is created by a chemical reaction that occurs mostly in erythrocytes, joining carbon dioxide and water by carbonic anhydrase, producing carbonic acid, which breaks down into bicarbonate and hydrogen ions. Carbaminohemoglobin is the bound form of hemoglobin and carbon dioxide. **50** A major mechanism involved in acclimatization is the increased production of erythrocytes. A drop in tissue levels of oxygen stimulates the kidneys to produce the hormone erythropoietin, which signals the bone marrow to produce erythrocytes. As a result, individuals exposed to a high altitude for long periods of time have a greater number of circulating erythrocytes than do individuals at lower altitudes. **52** Fetal breathing movements occur due to the contraction of respiratory muscles, causing the fetus to inhale and exhale amniotic fluid. It is thought that these movements are a way to "practice" breathing, which results in toning the muscles in preparation for breathing after birth. In addition, fetal breathing movements may help alveoli to form and mature.

## Chapter 23

**1** Answers may vary. **3** Answers may vary. **5** Answers may vary. **7** Answers may vary. **8 A 10 D 12 B 14 A 16 B 18 D 20 A 22 B 24 B 26 A 28 C 30 B 32 B 33** The enteric nervous system helps regulate alimentary canal motility and the secretion of digestive juices, thus facilitating digestion. If a person becomes overly anxious, sympathetic innervation of the alimentary canal is stimulated, which can result in a slowing of digestive activity. **35** The majority of digestion and absorption occurs in the small intestine. By slowing the transit of chyme, segmentation and a reduced rate of peristalsis allow time for these processes to occur. **37** Parotid gland saliva is watery with little mucus but a lot of amylase, which allows it to mix freely with food during mastication and begin the digestion of carbohydrates. In contrast, sublingual gland saliva has a lot of mucus with the least amount of amylase of all the salivary glands. The high mucus content serves to lubricate the food for swallowing. **39** Usually when food is swallowed, involuntary muscle contractions cause the soft palate to rise and close off the nasopharynx. The larynx also is pulled up, and the epiglottis folds over the glottis. These actions block off the air passages. **41** Peristalsis moves the bolus down the esophagus and toward the stomach. Esophageal glands secrete mucus that lubricates the bolus and reduces friction. When the bolus nears the stomach, the lower esophageal sphincter relaxes, allowing the bolus to pass into the stomach. **43** The stomach has an additional inner oblique smooth muscle layer that helps the muscularis churn and mix food. The epithelium includes gastric glands that secrete gastric fluid. The gastric fluid consists mainly of mucous, HCl, and the enzyme pepsin released as pepsinogen. **45** If large quantities of chyme were forced into the small intestine, it would result in osmotic water loss from the blood into the intestinal lumen that could cause potentially life-threatening low blood volume and erosion of the duodenum. **47** The pancreas secretes protein-digesting enzymes in their inactive forms. If secreted in their active forms, they would self-digest the pancreas. These enzymes are activated in the duodenum. **49** Bile salts and lecithin can emulsify large lipid globules because they are amphipathic; they have a nonpolar (hydrophobic) region that attaches to the large fat molecules as well as a polar (hydrophilic) region that interacts with the watery chyme in the intestine.

## Chapter 24

**1 C 3 A 5 C 7 C 9 A 11 D 13 C 15 C 17 A 19 D 21 C 23 D 25 C 27 A 29 B 30** An increase or decrease in lean muscle mass will result in an increase or decrease in metabolism. **32** Glucose is oxidized during glycolysis, creating pyruvate, which is processed through the Krebs cycle to produce NADH, FADH<sub>2</sub>, ATP, and CO<sub>2</sub>. The FADH<sub>2</sub> and NADH yield ATP. **34** Carbohydrates are converted into pyruvate during glycolysis. This pyruvate is converted into acetyl CoA and proceeds through the Krebs cycle. When excess acetyl CoA is produced that cannot be processed through the Krebs cycle, the acetyl CoA is converted into triglycerides and fatty acids to be stored in the liver and adipose tissue. **36** Amino acids are not stored in the body. The individual amino acids are broken down into pyruvate, acetyl CoA, or intermediates of the Krebs cycle, and used for energy or for lipogenesis reactions to be stored as fats. **38** Insulin stimulates the uptake of glucose into the cells. In diabetes, the insulin does not function properly; therefore, the blood glucose is unable to be transported across the cell membrane for processing. These patients

are unable to process the glucose in their blood and therefore must rely on other sources of fuel. If the disease is not controlled properly, this inability to process the glucose can lead to starvation states even though the patient is eating. **40** When blood flows to the outer layers of the skin or to the extremities, heat is lost to the environment by the mechanisms of conduction, convection, or radiation. This will cool the blood and the body. Vasoconstriction helps increase the core body temperature by preventing the flow of blood to the outer layer of the skin and outer parts of the extremities. **42** Factors that influence weight gain are food intake (both quantity and quality), environmental factors, height, exercise level, some drugs or disease states, and genes.

## Chapter 25

**1 B 3 D 5 B 7 D 9 A 11 C 13 B 15 B 17 A 19 B 21 C 23 D 25 D 27 B 29 C 31** The presence of white blood cells found in the urine suggests urinary tract infection. **33** The longer urethra of males means bacteria must travel farther to the bladder to cause an infection. **35** Retroperitoneal anchoring, renal fat pads, and ribs provide protection to the kidney. **37** The structures found in the renal hilum are arteries, veins, ureters, lymphatics, and nerves. **39** The major structures comprising the filtration membrane are fenestrations and podocyte fenestra, fused basement membrane, and filtration slits. **41** Symptoms of kidney failure are weakness, lethargy, shortness of breath, widespread edema, anemia, metabolic acidosis or alkalosis, heart arrhythmias, uremia, loss of appetite, fatigue, excessive urination, and oliguria. **43** The approximate osmolarities are: CT = 300; deepest loop = 1200; DCT = 100; and collecting ducts = 100–1200. **45** To excrete more  $\text{Na}^+$  in the urine, increase the flow rate. **47** PTH affects absorption and reabsorption of calcium. **49** In cases of diabetes mellitus, there is more glucose present than the kidney can recover and the excess glucose is lost in the urine. It possesses osmotic character so that it attracts water to the forming urine. **51** The three electrolytes are most closely regulated by the kidney are calcium, sodium, and potassium.

## Chapter 26

**1** The interstitial fluid (IF). **3** Drinking seawater dehydrates the body as the body must pass sodium through the kidneys, and water follows. **5 A 7 C 9 D 11 B 13 A 15 B 17 B 19 B 21 B 23 D 25 B 27 C 29 C 31** There are additional negatively charged molecules in plasma besides chloride. The additional sodium balances the total negative charges. **33** ADH constricts the arterioles in the peripheral circulation, limiting blood to the extremities and increasing the blood supply to the core of the body. ADH also causes the epithelial cells lining the renal collecting tubules to move water channel proteins called aquaporins from the sides of the cells to the apical surface. This greatly increases the passage of water from the renal filtrate through the wall of the collecting tubule as well as the reabsorption of water into the bloodstream. **35** Very little of the carbon dioxide in the blood is carried dissolved in the plasma. It is transformed into carbonic acid and then into bicarbonate in order to mix in plasma for transportation to the lungs, where it reverts back to its gaseous form. **37** Bicarbonate ions are freely filtered through the glomerulus. They cannot pass freely into the renal tubular cells and must be converted into  $\text{CO}_2$  in the filtrate, which can pass through the cell membrane. Sodium ions are reabsorbed at the membrane, and hydrogen ions are expelled into the filtrate. The hydrogen ions combine with bicarbonate, forming carbonic acid, which dissociates into  $\text{CO}_2$  gas and water. The gas diffuses into the renal cells where carbonic anhydrase catalyzes its conversion back into a bicarbonate ion, which enters the blood. **39** Respiratory acidosis is present as evidenced by the decreased pH and increased  $\text{pCO}_2$ , with some compensation as shown by the increased total  $\text{HCO}_3^-$ . His asthma has compromised his respiratory functions, and excess  $\text{CO}_2$  is being retained in his blood.

## Chapter 27

**1** Sperm remain in the epididymis until they degenerate. **3** The fimbriae sweep the oocyte into the uterine tube. **5** The testes are located in the abdomen. **6 b 8 b 10 c 12 a 14 c 16 d 18 b 20** A single gamete must combine with a gamete from an individual of the opposite sex to produce a fertilized egg, which has a complete set of chromosomes and is the first cell of a new individual. **22** The three accessory glands make the following contributions to semen: the seminal vesicle contributes about 60 percent of the semen volume, with fluid that contains large amounts of fructose to power the movement of sperm; the prostate gland contributes substances critical to sperm maturation; and the bulbourethral glands contribute a thick fluid that lubricates the ends of the urethra and the vagina and helps to clean urine residues from the urethra. **24** Testosterone production by the body would be reduced if a male were taking anabolic steroids. This is because the hypothalamus responds to rising testosterone levels by reducing its secretion of GnRH, which would in turn reduce the anterior pituitary's release of LH, finally reducing the manufacture of testosterone in the testes. **26** Meiosis in the man results in four viable haploid sperm, whereas meiosis in the woman results in a secondary oocyte and, upon completion following fertilization by a sperm, one viable haploid ovum with abundant cytoplasm and up to three polar bodies with little cytoplasm that are destined to die. **28** Endometrial tissue proliferating outside of the endometrium—for example, in the uterine tubes, on the ovaries, or within the pelvic cavity—could block the passage of sperm, ovulated oocytes, or a zygote, thus reducing fertility. **30** The internal reproductive structures form from one of two rudimentary duct systems in the embryo. Testosterone secretion stimulates growth of the male tract, the Wolffian duct. Secretions of sustentacular cells trigger a degradation of the female tract, the Müllerian duct. Without these stimuli, the Müllerian duct will develop and the Wolffian duct will degrade, resulting in a female embryo.

## Chapter 28

**1** The first structure shown is the morula. The blastocoel appears at approximately 20 seconds. The movie ends with the hatching of the conceptus. **3 C 5 B 7 A 9 B 11 B 13 A 15 B 17 A 19 B 21 B 23 B 25 B 27 D 29 C 31** The process of capacitation appears to be incomplete. Capacitation increases sperm motility and makes the sperm membrane more fragile. This enables it to release its digestive enzymes during the acrosomal reaction. When capacitation is inadequate, sperm cannot reach the oocyte membrane. **33** The timing of this discomfort and bleeding suggests that it is probably caused by implantation of the blastocyst into the uterine wall. **35** Circulatory shunts bypass the fetal lungs and liver, bestowing them with just enough oxygenated blood to fulfill their metabolic requirements. Because these organs are only semifunctional in the fetus, it is more efficient to bypass them and divert oxygen and nutrients to the organs that need it more. **37** Devin is very likely experiencing Braxton Hicks contractions, also known as false labor. These are mild contractions that do not promote cervical dilation and are not associated with impending birth. They will probably dissipate with rest. **39** The first breath inflates the lungs, which drops blood pressure throughout the pulmonary system, as well as in the right atrium and ventricle. In response to this pressure change, the flow of blood temporarily reverses direction through the foramen ovale, moving from the left to the right atrium, and blocking the shunt with two flaps of tissue. The increased oxygen concentration also constricts the ductus arteriosus, ensuring that these shunts no longer prevent blood from reaching the lungs to be oxygenated. **41** Milk is secreted by lactocytes into alveoli. Suckling stimulates the contraction of myoepithelial cells that squeeze milk into lactiferous ducts. It then collects in lactiferous sinuses and is secreted through the nipple pores. **43** By using large sample sizes, Mendel minimized the effect of random variability resulting from chance. This allowed him to identify true ratios corresponding to dominant–recessive inheritance.