exercise results in increased ventilation, and chronic exposure to a high altitude results in a greater number of circulating erythrocytes. Hyperpnea, an increase in the rate and depth of ventilation, appears to be a function of three neural mechanisms that include a psychological stimulus, motor neuron activation of skeletal muscles, and the activation of proprioceptors in the muscles, joints, and tendons. As a result, hyperpnea related to exercise is initiated when exercise begins, as opposed to when tissue oxygen demand actually increases.

In contrast, acute exposure to a high altitude, particularly during times of physical exertion, does result in low blood and tissue levels of oxygen. This change is caused by a low partial pressure of oxygen in the air, because the atmospheric pressure at high altitudes is lower than the atmospheric pressure at sea level. This can lead to a condition called acute mountain sickness (AMS) with symptoms that include headaches, disorientation, fatigue, nausea, and lightheadedness. Over a long period of time, a person's body will adjust to the high altitude, a process called acclimatization. During acclimatization, the low tissue levels of oxygen will cause the kidneys to produce greater amounts of the hormone erythropoietin, which stimulates the production of erythrocytes. Increased levels of circulating erythrocytes provide an increased amount of hemoglobin that helps supply an individual with more oxygen, preventing the symptoms of AMS.

22.7 Embryonic Development of the Respiratory System

The development of the respiratory system in the fetus begins at about 4 weeks and continues into childhood. Ectodermal tissue in the anterior portion of the head region invaginates posteriorly, forming olfactory pits, which ultimately fuse with endodermal tissue of the early pharynx. At about this same time, an protrusion of endodermal tissue extends anteriorly from the foregut, producing a lung bud, which continues to elongate until it forms the laryngotracheal bud. The proximal portion of this structure will mature into the trachea, whereas the bulbous end will branch to form two bronchial buds. These buds then branch repeatedly, so that at about week 16, all major airway structures are present. Development progresses after week 16 as respiratory bronchioles and alveolar ducts form, and extensive vascularization occurs. Alveolar type I cells also begin to take shape. Type II pulmonary cells develop and begin to produce small amounts of surfactant. As the fetus grows, the respiratory system continues to expand as more alveoli develop and more surfactant is produced. Beginning at about week 36 and lasting into childhood, alveolar precursors mature to become fully functional alveoli. At birth, compression of the thoracic cavity forces much of the fluid in the lungs to be expelled. The first inhalation inflates the lungs. Fetal breathing movements begin around week 20 or 21, and occur when contractions of the respiratory muscles cause the fetus to inhale and exhale amniotic fluid. These movements continue until birth and may help to tone the muscles in preparation for breathing after birth and are a sign of good health.

INTERACTIVE LINK QUESTIONS

1. Visit this **site (http://openstaxcollege.org/l/asthma)** to learn more about what happens during an asthma attack. What are the three changes that occur inside the airways during an asthma attack?

2. Watch this **video (http://openstaxcollege.org/l/spirometers)** to learn more about lung volumes and spirometers. Explain how spirometry test results can be used to diagnose respiratory diseases or determine the effectiveness of disease treatment.

3. Watch this **video (http://openstaxcollege.org/l/oxyblood)** to see the transport of oxygen from the lungs to the tissues. Why is oxygenated blood bright red, whereas deoxygenated blood tends to be more of a purple color?

REVIEW QUESTIONS

4. Which of the following anatomical structures is *not* part of the conducting zone?

a. pharynx
b. nasal cavity
c. alveoli
d. bronchi

5. What is the function of the conchae in the nasal cavity?

a. increase surface area
b. exchange gases
c. maintain surface tension
d. maintain air pressure

6. The fauces connects which of the following structures to the oropharynx?

a. nasopharynx
b. laryngopharynx
c. nasal cavity
d. oral cavity

7. Which of the following are structural features of the trachea?

a. C-shaped cartilage
b. smooth muscle fibers
c. cilia
d. all of the above

8. Which of the following structures is *not* part of the bronchial tree?

a. alveoli
b. bronchi
c. terminal bronchioles
d. respiratory bronchioles

9. What is the role of alveolar macrophages?

a. to secrete pulmonary surfactant
b. to secrete antimicrobial proteins
c. to remove pathogens and debris
d. to facilitate gas exchange

10. Which of the following structures separates the lung into lobes?
- a. mediastinum
- b. fissure
- c. root
- d. pleura

11. A section of the lung that receives its own tertiary bronchus is called the _____.
- a. bronchopulmonary segment
- b. pulmonary lobule
- c. interpulmonary segment
- d. respiratory segment

12. The _____ circulation picks up oxygen for cellular use and drops off carbon dioxide for removal from the body.
- a. pulmonary
- b. interlobular
- c. respiratory
- d. bronchial

13. The pleura that surrounds the lungs consists of two layers, the _____.
- a. visceral and parietal pleurae.
- b. mediastinum and parietal pleurae.
- c. visceral and mediastinum pleurae.
- d. none of the above

14. Which of the following processes does atmospheric pressure play a role in?
- a. pulmonary ventilation
- b. production of pulmonary surfactant
- c. resistance
- d. surface tension

15. A decrease in volume leads to a(n) _____ pressure.
- a. decrease in
- b. equalization of
- c. increase in
- d. zero

16. The pressure difference between the intra-alveolar and intrapleural pressures is called _____.
- a. atmospheric pressure
- b. pulmonary pressure
- c. negative pressure
- d. transpulmonary pressure

17. Gas flow decreases as _____ increases.
- a. resistance
- b. pressure
- c. airway diameter
- d. friction

18. Contraction of the external intercostal muscles causes which of the following to occur?
- a. The diaphragm moves downward.
- b. The rib cage is compressed.
- c. The thoracic cavity volume decreases.
- d. The ribs and sternum move upward.

19. Which of the following prevents the alveoli from collapsing?
- a. residual volume
- b. tidal volume
- c. expiratory reserve volume
- d. inspiratory reserve volume

20. Gas moves from an area of _____ partial pressure to an area of _____ partial pressure.
- a. low; high
- b. low; low
- c. high; high
- d. high; low

21. When ventilation is not sufficient, which of the following occurs?
- a. The capillary constricts.
- b. The capillary dilates.
- c. The partial pressure of oxygen in the affected alveolus increases.
- d. The bronchioles dilate.

22. Gas exchange that occurs at the level of the tissues is called _____.
- a. external respiration
- b. interpulmonary respiration
- c. internal respiration
- d. pulmonary ventilation

23. The partial pressure of carbon dioxide is 45 mm Hg in the blood and 40 mm Hg in the alveoli. What happens to the carbon dioxide?
- a. It diffuses into the blood.
- b. It diffuses into the alveoli.
- c. The gradient is too small for carbon dioxide to diffuse.
- d. It decomposes into carbon and oxygen.

24. Oxyhemoglobin forms by a chemical reaction between which of the following?
- a. hemoglobin and carbon dioxide
- b. carbonic anhydrase and carbon dioxide
- c. hemoglobin and oxygen
- d. carbonic anhydrase and oxygen

25. Which of the following factors play a role in the oxygen–hemoglobin saturation/dissociation curve?
- a. temperature
- b. pH
- c. BPG
- d. all of the above

26. Which of the following occurs during the chloride shift?
- a. Chloride is removed from the erythrocyte.
- b. Chloride is exchanged for bicarbonate.
- c. Bicarbonate is removed from the erythrocyte.
- d. Bicarbonate is removed from the blood.

27. A low partial pressure of oxygen promotes hemoglobin binding to carbon dioxide. This is an example of the _____.
- a. Haldane effect
- b. Bohr effect
- c. Dalton’s law
- d. Henry’s law

28. Increased ventilation that results in an increase in blood pH is called _____.
- a. hyperventilation

b. hyperpnea
c. acclimatization
d. apnea

29. Exercise can trigger symptoms of AMS due to which of the following?
a. low partial pressure of oxygen
b. low atmospheric pressure
c. abnormal neural signals
d. small venous reserve of oxygen

30. Which of the following stimulates the production of erythrocytes?
a. AMS
b. high blood levels of carbon dioxide
c. low atmospheric pressure
d. erythropoietin

31. The olfactory pits form from which of the following?
a. mesoderm
b. cartilage
c. ectoderm
d. endoderm

32. A full complement of mature alveoli are present by _____.
a. early childhood, around 8 years of age
b. birth
c. 37 weeks
d. 16 weeks

33. If a baby is born prematurely before type II cells produce sufficient pulmonary surfactant, which of the following might you expect?
a. difficulty expressing fluid
b. difficulty inflating the lungs
c. difficulty with pulmonary capillary flow
d. no difficulty as type I cells can provide enough surfactant for normal breathing

34. When do fetal breathing movements begin?
a. around week 20
b. around week 37
c. around week 16
d. after birth

35. What happens to the fluid that remains in the lungs after birth?
a. It reduces the surface tension of the alveoli.
b. It is expelled shortly after birth.
c. It is absorbed shortly after birth.
d. It lubricates the pleurae.

CRITICAL THINKING QUESTIONS

36. Describe the three regions of the pharynx and their functions.

37. If a person sustains an injury to the epiglottis, what would be the physiological result?

38. Compare and contrast the conducting and respiratory zones.

39. Compare and contrast the right and left lungs.

40. Why are the pleurae not damaged during normal breathing?

41. Describe what is meant by the term “lung compliance.”

42. Outline the steps involved in quiet breathing.

43. What is respiratory rate and how is it controlled?

44. Compare and contrast Dalton’s law and Henry’s law.

45. A smoker develops damage to several alveoli that then can no longer function. How does this affect gas exchange?

46. Compare and contrast adult hemoglobin and fetal hemoglobin.

47. Describe the relationship between the partial pressure of oxygen and the binding of oxygen to hemoglobin.

48. Describe three ways in which carbon dioxide can be transported.

49. Describe the neural factors involved in increasing ventilation during exercise.

50. What is the major mechanism that results in acclimatization?

51. During what timeframe does a fetus have enough mature structures to breathe on its own if born prematurely? Describe the other structures that develop during this phase.

52. Describe fetal breathing movements and their purpose.

6. By watching this **animation (http://openstaxcollege.org/l/foodgroups)** , you will see that for the various food groups—proteins, fats, and carbohydrates—digestion begins in different parts of the digestion system, though all end in the same place. Of the three major food classes (carbohydrates, fats, and proteins), which is digested in the mouth, the stomach, and the small intestine?

7. Watch this **video (http://openstaxcollege.org/l/liver)** to see the structure of the liver and how this structure supports the functions of the liver, including the processing of nutrients, toxins, and wastes. At rest, about 1500 mL of blood per minute flow through the liver. What percentage of this blood flow comes from the hepatic portal system?

REVIEW QUESTIONS

8. Which of these organs is not considered an accessory digestive structure?
a. mouth
b. salivary glands
c. pancreas
d. liver

9. Which of the following organs is supported by a layer of adventitia rather than serosa?
a. esophagus
b. stomach
c. small intestine
d. large intestine

10. Which of the following membranes covers the stomach?
a. falciform ligament
b. mesocolon
c. parietal peritoneum
d. visceral peritoneum

11. Which of these processes occurs in the mouth?
a. ingestion
b. mechanical digestion
c. chemical digestion
d. all of the above

12. Which of these processes occurs throughout most of the alimentary canal?
a. ingestion
b. propulsion
c. segmentation
d. absorption

13. Which of the following stimuli activates sensors in the walls of digestive organs?
a. breakdown products of digestion
b. distension
c. pH of chyme
d. all of the above

14. Which of these statements about reflexes in the GI tract is false?
a. Short reflexes are provoked by nerves near the GI tract.
b. Short reflexes are mediated by the enteric nervous system.
c. Food that distends the stomach initiates long reflexes.
d. Long reflexes can be provoked by stimuli originating outside the GI tract.

15. Which of these ingredients in saliva is responsible for activating salivary amylase?
a. mucus
b. phosphate ions
c. chloride ions
d. urea

16. Which of these statements about the pharynx is true?
a. It extends from the nasal and oral cavities superiorly to the esophagus anteriorly.
b. The oropharynx is continuous superiorly with the nasopharynx.
c. The nasopharynx is involved in digestion.
d. The laryngopharynx is composed partially of cartilage.

17. Which structure is located where the esophagus penetrates the diaphragm?
a. esophageal hiatus
b. cardiac orifice
c. upper esophageal sphincter
d. lower esophageal sphincter

18. Which phase of deglutition involves contraction of the longitudinal muscle layer of the muscularis?
a. voluntary phase
b. buccal phase
c. pharyngeal phase
d. esophageal phase

19. Which of these cells secrete hormones?
a. parietal cells
b. mucous neck cells
c. enteroendocrine cells
d. chief cells

20. Where does the majority of chemical digestion in the stomach occur?
a. fundus and body
b. cardia and fundus
c. body and pylorus
d. body

21. During gastric emptying, chyme is released into the duodenum through the _____.
a. esophageal hiatus
b. pyloric antrum
c. pyloric canal
d. pyloric sphincter

22. Parietal cells secrete _____.
a. gastrin
b. hydrochloric acid
c. pepsin
d. pepsinogen

23. In which part of the alimentary canal does most digestion occur?
a. stomach
b. proximal small intestine
c. distal small intestine
d. ascending colon

24. Which of these is most associated with villi?
a. haustra
b. lacteals
c. bacterial flora
d. intestinal glands

25. What is the role of the small intestine's MALT?
a. secreting mucus
b. buffering acidic chyme
c. activating pepsin
d. preventing bacteria from entering the bloodstream

26. Which part of the large intestine attaches to the appendix?
a. cecum
b. ascending colon
c. transverse colon
d. descending colon

27. Which of these statements about bile is true?
a. About 500 mL is secreted daily.
b. Its main function is the denaturation of proteins.
c. It is synthesized in the gallbladder.
d. Bile salts are recycled.

28. Pancreatic juice _____.
a. deactivates bile.
b. is secreted by pancreatic islet cells.
c. buffers chyme.
d. is released into the cystic duct.

29. Where does the chemical digestion of starch begin?
a. mouth
b. esophagus
c. stomach
d. small intestine

30. Which of these is involved in the chemical digestion of protein?
a. pancreatic amylase
b. trypsin
c. sucrase
d. pancreatic nuclease

31. Where are most fat-digesting enzymes produced?
a. small intestine
b. gallbladder
c. liver
d. pancreas

32. Which of these nutrients is absorbed mainly in the duodenum?
a. glucose
b. iron
c. sodium
d. water

CRITICAL THINKING QUESTIONS

33. Explain how the enteric nervous system supports the digestive system. What might occur that could result in the autonomic nervous system having a negative impact on digestion?

34. What layer of the alimentary canal tissue is capable of helping to protect the body against disease, and through what mechanism?

35. Offer a theory to explain why segmentation occurs and peristalsis slows in the small intestine.

36. It has been several hours since you last ate. Walking past a bakery, you catch a whiff of freshly baked bread. What type of reflex is triggered, and what is the result?

37. The composition of saliva varies from gland to gland. Discuss how saliva produced by the parotid gland differs in action from saliva produced by the sublingual gland.

38. During a hockey game, the puck hits a player in the mouth, knocking out all eight of his most anterior teeth. Which teeth did the player lose and how does this loss affect food ingestion?

39. What prevents swallowed food from entering the airways?

40. Explain the mechanism responsible for gastroesophageal reflux.

41. Describe the three processes involved in the esophageal phase of deglutition.

42. Explain how the stomach is protected from self-digestion and why this is necessary.

43. Describe unique anatomical features that enable the stomach to perform digestive functions.

44. Explain how nutrients absorbed in the small intestine pass into the general circulation.

45. Why is it important that chyme from the stomach is delivered to the small intestine slowly and in small amounts?

46. Describe three of the differences between the walls of the large and small intestines.

47. Why does the pancreas secrete some enzymes in their inactive forms, and where are these enzymes activated?

48. Describe the location of hepatocytes in the liver and how this arrangement enhances their function.

49. Explain the role of bile salts and lecithin in the emulsification of lipids (fats).

50. How is vitamin B_{12} absorbed?

physical contact. Convection transfers heat to air or water. Radiation transfers heat via infrared radiation. Evaporation transfers heat as water changes state from a liquid to a gas.

24.7 Nutrition and Diet

Nutrition and diet affect your metabolism. More energy is required to break down fats and proteins than carbohydrates; however, all excess calories that are ingested will be stored as fat in the body. On average, a person requires 1500 to 2000 calories for normal daily activity, although routine exercise will increase that amount. If you ingest more than that, the remainder is stored for later use. Conversely, if you ingest less than that, the energy stores in your body will be depleted. Both the quantity and quality of the food you eat affect your metabolism and can affect your overall health. Eating too much or too little can result in serious medical conditions, including cardiovascular disease, cancer, and diabetes.

Vitamins and minerals are essential parts of the diet. They are needed for the proper function of metabolic pathways in the body. Vitamins are not stored in the body, so they must be obtained from the diet or synthesized from precursors available in the diet. Minerals are also obtained from the diet, but they are also stored, primarily in skeletal tissues.

REVIEW QUESTIONS

1. A monosaccharide is formed from a polysaccharide in what kind of reaction?
- a. oxidation–reduction reaction
- b. anabolic reaction
- c. catabolic reaction
- d. biosynthetic reaction

2. If anabolic reactions exceed catabolic reactions, the result will be _____.
- a. weight loss
- b. weight gain
- c. metabolic rate change
- d. development of disease

3. When NAD becomes NADH, the coenzyme has been _____.
- a. reduced
- b. oxidized
- c. metabolized
- d. hydrolyzed

4. Anabolic reactions use energy by _____.
- a. turning ADP into ATP
- b. removing a phosphate group from ATP
- c. producing heat
- d. breaking down molecules into smaller parts

5. Glycolysis results in the production of two _____ molecules from a single molecule of glucose. In the absence of _____, the end product of glycolysis is _____.
- a. acetyl CoA, pyruvate, lactate
- b. ATP, carbon, pyruvate
- c. pyruvate, oxygen, lactate
- d. pyruvate, carbon, acetyl CoA

6. The Krebs cycle converts _____ through a cycle of reactions. In the process, ATP, _____, and _____ are produced.
- a. acetyl CoA; FAD, NAD
- b. acetyl CoA; $FADH_2$; NADH
- c. pyruvate; NAD; $FADH_2$
- d. pyruvate; oxygen; oxaloacetate

7. Which pathway produces the most ATP molecules?
- a. lactic acid fermentation
- b. the Krebs cycle
- c. the electron transport chain
- d. glycolysis

8. Aerobic cellular respiration results in the production of these two products.
- a. NADH and $FADH_2$
- b. ATP and pyruvate
- c. ATP and glucose
- d. ATP and H_2O

9. When NAD^+ becomes NADH, the coenzyme has been _____.
- a. reduced
- b. oxidized
- c. metabolized
- d. hydrolyzed

10. Lipids in the diet can be _____.
- a. broken down into energy for the body
- b. stored as triglycerides for later use
- c. converted into acetyl CoA
- d. all of the above

11. The gallbladder provides _____ that aid(s) in transport of lipids across the intestinal membrane.
- a. lipases
- b. cholesterol
- c. proteins
- d. bile salts

12. Triglycerides are transported by chylomicrons because _____.
- a. they cannot move easily in the blood stream because they are fat based, while the blood is water based
- b. they are too small to move by themselves
- c. the chylomicrons contain enzymes they need for anabolism
- d. they cannot fit across the intestinal membrane

13. Which molecule produces the most ATP?
- a. carbohydrates
- b. $FADH_2$
- c. triglycerides
- d. NADH

14. Which molecules can enter the Krebs cycle?
- a. chylomicrons
- b. acetyl CoA
- c. monoglycerides

d. ketone bodies

15. Acetyl CoA can be converted to all of the following except _____.
a. ketone bodies
b. fatty acids
c. polysaccharides
d. triglycerides

16. Digestion of proteins begins in the _____ where _____ and _____ mix with food to break down protein into _____.
a. stomach; amylase; HCl; amino acids
b. mouth; pepsin; HCl; fatty acids
c. stomach; lipase; HCl; amino acids
d. stomach; pepsin; HCl; amino acids

17. Amino acids are needed to _____.
a. build new proteins
b. serve as fat stores
c. supply energy for the cell
d. create red blood cells

18. If an amino acid is not used to create new proteins, it can be _____.
a. converted to acetyl CoA
b. converted to glucose or ketones
c. converted to nitrogen
d. stored to be used later

19. During the absorptive state, glucose levels are _____, insulin levels are _____, and glucagon levels _____.
a. high; low; stay the same
b. low; low; stay the same
c. high; high; are high
d. high; high; are low

20. Starvation sets in after 3 to 4 days without food. Which hormones change in response to low glucose levels?
a. glucagon and insulin
b. ketones and glucagon
c. insulin, glucose, and glucagon
d. insulin and ketones

21. The postabsorptive state relies on stores of _____ in the _____.
a. insulin; pancreas
b. glucagon; pancreas
c. glycogen; liver
d. glucose; liver

22. The body's temperature is controlled by the _____. This temperature is always kept between _____.
a. pituitary; 36.5–37.5 °C
b. hypothalamus; 97.7–99.5 °F
c. hypothalamus; 36.5–37.5 °F
d. pituitary; 97.7–99.5 °F

23. Fever increases the body temperature and can induce chills to help cool the temperature back down. What other mechanisms are in place to regulate the body temperature?
a. shivering
b. sweating
c. erection of the hairs on the arms and legs
d. all of the above

24. The heat you feel on your chair when you stand up was transferred from your skin via _____.
a. conduction
b. convection
c. radiation
d. evaporation

25. A crowded room warms up through the mechanism of _____.
a. conduction
b. convection
c. radiation
d. evaporation

26. A deficiency in vitamin A can result in _____.
a. improper bone development
b. scurvy
c. improper eye development or sight
d. all of the above

27. Rickets results in improper bone development in children that arises from the malabsorption of calcium and a deficiency in _____.
a. vitamin D
b. vitamin C
c. vitamin B_{12}
d. niacin

28. Consuming which type of food will help the most with weight loss?
a. fats
b. vegetables
c. lean meats
d. fruits

29. Which of the following is stored in the body?
a. thiamine
b. phosphorous
c. folic acid
d. vitamin C

CRITICAL THINKING QUESTIONS

30. Describe how metabolism can be altered.

31. Describe how Addison's disease can be treated.

32. Explain how glucose is metabolized to yield ATP.

33. Insulin is released when food is ingested and stimulates the uptake of glucose into the cell. Discuss the mechanism cells employ to create a concentration gradient to ensure continual uptake of glucose from the bloodstream.

34. Discuss how carbohydrates can be stored as fat.

35. If a diabetic's breath smells like alcohol, what could this mean?

36. Amino acids are not stored in the body. Describe how excess amino acids are processed in the cell.

37. Release of trypsin and chymotrypsin in their active form can result in the digestion of the pancreas or small intestine itself. What mechanism does the body employ to prevent its self-destruction?

38. In type II diabetes, insulin is produced but is nonfunctional. These patients are described as "starving in a sea of plenty," because their blood glucose levels are high, but none of the glucose is transported into the cells. Describe how this leads to malnutrition.

39. Ketone bodies are used as an alternative source of fuel during starvation. Describe how ketones are synthesized.

40. How does vasoconstriction help increase the core temperature of the body?

41. How can the ingestion of food increase the body temperature?

42. Weight loss and weight gain are complex processes. What are some of the main factors that influence weight gain in people?

43. Some low-fat or non-fat foods contain a large amount of sugar to replace the fat content of the food. Discuss how this leads to increased fat in the body (and weight gain) even though the item is non-fat.

produces ammonia. Most ammonia is converted into less-toxic urea in the liver and excreted in the urine. Regulation of drugs is by glomerular filtration, tubular secretion, and tubular reabsorption.

25.10 The Urinary System and Homeostasis

The effects of failure of parts of the urinary system may range from inconvenient (incontinence) to fatal (loss of filtration and many others). The kidneys catalyze the final reaction in the synthesis of active vitamin D that in turn helps regulate Ca^{++}. The kidney hormone EPO stimulates erythrocyte development and promotes adequate O_2 transport. The kidneys help regulate blood pressure through Na^+ and water retention and loss. The kidneys work with the adrenal cortex, lungs, and liver in the renin–angiotensin–aldosterone system to regulate blood pressure. They regulate osmolarity of the blood by regulating both solutes and water. Three electrolytes are more closely regulated than others: Na^+, Ca^{++}, and K^+. The kidneys share pH regulation with the lungs and plasma buffers, so that proteins can preserve their three-dimensional conformation and thus their function.

REVIEW QUESTIONS

1. Diabetes insipidus or diabetes mellitus would most likely be indicated by _____.
- a. anuria
- b. polyuria
- c. oliguria
- d. none of the above

2. The color of urine is determined mainly by _____.
- a. diet
- b. filtration rate
- c. byproducts of red blood cell breakdown
- d. filtration efficiency

3. Production of less than 50 mL/day of urine is called _____.
- a. normal
- b. polyuria
- c. oliguria
- d. anuria

4. Peristaltic contractions occur in the _____.
- a. urethra
- b. bladder
- c. ureters
- d. urethra, bladder, and ureters

5. Somatic motor neurons must be _____ to relax the external urethral sphincter to allow urination.
- a. stimulated
- b. inhibited

6. Which part of the urinary system is *not* completely retroperitoneal?
- a. kidneys
- b. ureters
- c. bladder
- d. nephrons

7. The renal pyramids are separated from each other by extensions of the renal cortex called _____.
- a. renal medulla
- b. minor calyces
- c. medullary cortices
- d. renal columns

8. The primary structure found within the medulla is the _____.
- a. loop of Henle
- b. minor calyces
- c. portal system
- d. ureter

9. The right kidney is slightly lower because _____.
- a. it is displaced by the liver
- b. it is displace by the heart
- c. it is slightly smaller
- d. it needs protection of the lower ribs

10. Blood filtrate is captured in the lumen of the _____.
- a. glomerulus
- b. Bowman's capsule
- c. calyces
- d. renal papillae

11. What are the names of the capillaries following the efferent arteriole?
- a. arcuate and medullary
- b. interlobar and interlobular
- c. peritubular and vasa recta
- d. peritubular and medullary

12. The functional unit of the kidney is called _____.
- a. the renal hilus
- b. the renal corpuscle
- c. the nephron
- d. Bowman's capsule

13. _____ pressure must be greater on the capillary side of the filtration membrane to achieve filtration.
- a. Osmotic
- b. Hydrostatic

14. Production of urine to modify plasma makeup is the result of _____.
- a. filtration
- b. absorption
- c. secretion
- d. filtration, absorption, and secretion

15. Systemic blood pressure must stay above 60 so that the proper amount of filtration occurs.
- a. true
- b. false

16. Aquaporin channels are only found in the collecting duct.

a. true
b. false

17. Most absorption and secretion occurs in this part of the nephron.
a. proximal convoluted tubule
b. descending loop of Henle
c. ascending loop of Henle
d. distal convoluted tubule
e. collecting ducts

18. The fine tuning of water recovery or disposal occurs in _____.
a. the proximal convoluted tubule
b. the collecting ducts
c. the ascending loop of Henle
d. the distal convoluted tubule

19. Vasodilation of blood vessels to the kidneys is due to _____.
a. more frequent action potentials
b. less frequent action potentials

20. When blood pressure increases, blood vessels supplying the kidney will _____ to mount a steady rate of filtration.
a. contract
b. relax

21. Which of these three paracrine chemicals cause vasodilation?
a. ATP
b. adenosine
c. nitric oxide

22. What hormone directly opposes the actions of natriuretic hormones?
a. renin
b. nitric oxide
c. dopamine
d. aldosterone

23. Which of these is a vasoconstrictor?
a. nitric oxide
b. natriuretic hormone
c. bradykinin
d. angiotensin II

24. What signal causes the heart to secrete atrial natriuretic hormone?
a. increased blood pressure
b. decreased blood pressure
c. increased Na^+ levels
d. decreased Na^+ levels

25. Which of these beverages does *not* have a diuretic effect?
a. tea
b. coffee
c. alcohol
d. milk

26. Progesterone can bind to receptors for which hormone that, when released, activates water retention?
a. aldosterone
b. ADH
c. PTH
d. ANH

27. Renin is released in response to _____.
a. increased blood pressure
b. decreased blood pressure
c. ACE
d. diuretics

28. Which step in vitamin D production does the kidney perform?
a. converts cholecalciferol into calcidiol
b. converts calcidiol into calcitriol
c. stores vitamin D
d. none of these

29. Which hormone does the kidney produce that stimulates red blood cell production?
a. thrombopoeitin
b. vitamin D
c. EPO
d. renin

30. If there were no aquaporin channels in the collecting duct, _____.
a. you would develop systemic edema
b. you would retain excess Na^+
c. you would lose vitamins and electrolytes
d. you would suffer severe dehydration

CRITICAL THINKING QUESTIONS

31. What is suggested by the presence of white blood cells found in the urine?

32. Both diabetes mellitus and diabetes insipidus produce large urine volumes, but how would other characteristics of the urine differ between the two diseases?

33. Why are females more likely to contract bladder infections than males?

34. Describe how forceful urination is accomplished.

35. What anatomical structures provide protection to the kidney?

36. How does the renal portal system differ from the hypothalamo–hypophyseal and digestive portal systems?

37. Name the structures found in the renal hilum.

38. Which structures make up the renal corpuscle?

39. What are the major structures comprising the filtration membrane?

40. Give the formula for net filtration pressure.

41. Name at least five symptoms of kidney failure.

42. Which vessels and what part of the nephron are involved in countercurrent multiplication?

43. Give the approximate osmolarity of fluid in the proximal convoluted tubule, deepest part of the loop of Henle, distal convoluted tubule, and the collecting ducts.

44. Explain what happens to Na^+ concentration in the nephron when GFR increases.

45. If you want the kidney to excrete more Na^+ in the urine, what do you want the blood flow to do?

46. What organs produce which hormones or enzymes in the renin–angiotensin system?

47. PTH affects absorption and reabsorption of what?

48. Why is ADH also called vasopressin?

49. How can glucose be a diuretic?

50. How does lack of protein in the blood cause edema?

51. Which three electrolytes are most closely regulated by the kidney?

26.1 Body Fluids and Fluid Compartments

Your body is mostly water. Body fluids are aqueous solutions with differing concentrations of materials, called solutes. An appropriate balance of water and solute concentrations must be maintained to ensure cellular functions. If the cytosol becomes too concentrated due to water loss, cell functions deteriorate. If the cytosol becomes too dilute due to water intake by cells, cell membranes can be damaged, and the cell can burst. Hydrostatic pressure is the force exerted by a fluid against a wall and causes movement of fluid between compartments. Fluid can also move between compartments along an osmotic gradient. Active transport processes require ATP to move some solutes against their concentration gradients between compartments. Passive transport of a molecule or ion depends on its ability to pass easily through the membrane, as well as the existence of a high to low concentration gradient.

26.2 Water Balance

Homeostasis requires that water intake and output be balanced. Most water intake comes through the digestive tract via liquids and food, but roughly 10 percent of water available to the body is generated at the end of aerobic respiration during cellular metabolism. Urine produced by the kidneys accounts for the largest amount of water leaving the body. The kidneys can adjust the concentration of the urine to reflect the body's water needs, conserving water if the body is dehydrated or making urine more dilute to expel excess water when necessary. ADH is a hormone that helps the body to retain water by increasing water reabsorption by the kidneys.

26.3 Electrolyte Balance

Electrolytes serve various purposes, such as helping to conduct electrical impulses along cell membranes in neurons and muscles, stabilizing enzyme structures, and releasing hormones from endocrine glands. The ions in plasma also contribute to the osmotic balance that controls the movement of water between cells and their environment. Imbalances of these ions can result in various problems in the body, and their concentrations are tightly regulated. Aldosterone and angiotensin II control the exchange of sodium and potassium between the renal filtrate and the renal collecting tubule. Calcium and phosphate are regulated by PTH, calcitrol, and calcitonin.

26.4 Acid-Base Balance

A variety of buffering systems exist in the body that helps maintain the pH of the blood and other fluids within a narrow range—between pH 7.35 and 7.45. A buffer is a substance that prevents a radical change in fluid pH by absorbing excess hydrogen or hydroxyl ions. Most commonly, the substance that absorbs the ion is either a weak acid, which takes up a hydroxyl ion (OH^-), or a weak base, which takes up a hydrogen ion (H^+). Several substances serve as buffers in the body, including cell and plasma proteins, hemoglobin, phosphates, bicarbonate ions, and carbonic acid. The bicarbonate buffer is the primary buffering system of the IF surrounding the cells in tissues throughout the body. The respiratory and renal systems also play major roles in acid-base homeostasis by removing CO_2 and hydrogen ions, respectively, from the body.

26.5 Disorders of Acid-Base Balance

Acidosis and alkalosis describe conditions in which a person's blood is, respectively, too acidic (pH below 7.35) and too alkaline (pH above 7.45). Each of these conditions can be caused either by metabolic problems related to bicarbonate levels or by respiratory problems related to carbonic acid and CO_2 levels. Several compensatory mechanisms allow the body to maintain a normal pH.

INTERACTIVE LINK QUESTIONS

1. Watch this **video (http://openstaxcollege.org/l/bodyfluids)** to learn more about body fluids, fluid compartments, and electrolytes. When blood volume decreases due to sweating, from what source is water taken in by the blood?

2. Watch this **video (http://openstaxcollege.org/l/dynamicfluid)** to see an explanation of the dynamics of fluid in the body's compartments. What happens in tissues when capillary blood pressure is less than osmotic pressure?

3. Watch this **video (http://openstaxcollege.org/l/saltwater)** to see an explanation of the effect of seawater on humans. What effect does drinking seawater have on the body?

4. Watch this **video (http://openstaxcollege.org/l/altitude)** to see a demonstration of the effect altitude has on blood pH. What effect does high altitude have on blood pH, and why?

REVIEW QUESTIONS

5. Solute contributes to the movement of water between cells and the surrounding medium by _____.

a. osmotic pressure
b. hydrostatic pressure

c. Brownian movement
d. random motion

6. A cation has a(n) _____ charge.
a. neutral
b. positive
c. alternating
d. negative

7. Interstitial fluid (IF) is _____.
a. the fluid in the cytosol of the cells
b. the fluid component of blood
c. the fluid that bathes all of the body's cells except for blood cells
d. the intracellular fluids found between membranes

8. The largest amount of water comes into the body via _____.
a. metabolism
b. foods
c. liquids
d. humidified air

9. The largest amount of water leaves the body via _____.
a. the GI tract
b. the skin as sweat
c. expiration
d. urine

10. Insensible water loss is water lost via _____.
a. skin evaporation and in air from the lungs
b. urine
c. excessive sweating
d. vomiting or diarrhea

11. How soon after drinking a large glass of water will a person start increasing their urine output?
a. 5 minutes
b. 30 minutes
c. 1 hour
d. 3 hours

12. Bone serves as a mineral reserve for which two ions?
a. sodium and potassium
b. calcium and phosphate
c. chloride and bicarbonate
d. calcium and bicarbonate

13. Electrolytes are lost mostly through _____.
a. renal function
b. sweating
c. feces
d. respiration

14. The major cation in extracellular fluid is _____.
a. sodium
b. potassium
c. chloride
d. bicarbonate

15. The major cation in intracellular fluid is _____.
a. sodium
b. potassium
c. chloride
d. bicarbonate

16. The major anion in extracellular fluid is _____.
a. sodium
b. potassium
c. chloride
d. bicarbonate

17. Most of the body's calcium is found in _____.
a. teeth
b. bone
c. plasma
d. extracellular fluids

18. Abnormally increased blood levels of sodium are termed _____.
a. hyperkalemia
b. hyperchloremia
c. hypernatremia
d. hypercalcemia

19. The ion with the lowest blood level is _____.
a. sodium
b. potassium
c. chloride
d. bicarbonate

20. Which two ions are most affected by aldosterone?
a. sodium and potassium
b. chloride and bicarbonate
c. calcium and phosphate
d. sodium and phosphate

21. Which of the following is the most important buffer inside red blood cells?
a. plasma proteins
b. hemoglobin
c. phosphate buffers
d. bicarbonate: carbonic acid buffer

22. Which explanation best describes why plasma proteins can function as buffers?
a. Plasma proteins combine with bicarbonate to make a stronger buffer.
b. Plasma proteins are immune to damage from acids.
c. Proteins have both positive and negative charges on their surface.
d. Proteins are alkaline.

23. The buffer that is adjusted to control acid-base balance is _____.
a. plasma protein
b. hemoglobin
c. phosphate buffer
d. bicarbonate: carbonic acid buffer

24. Carbonic acid levels are controlled through the _____.
a. respiratory system
b. renal system

c. digestive system
d. metabolic rate of cells

25. Bicarbonate ion concentrations in the blood are controlled through the _____.

a. respiratory system
b. renal system
c. digestive system
d. metabolic rate of cells

26. Which reaction is catalyzed by carbonic anhydrase?

a. $HPO_4^{2-} + H^+ \leftrightarrow H_2PO_{4-}$
b. $CO_2 + H_2O \leftrightarrow H_2CO_3$
c. $H_2PO_{4-} + OH^- \leftrightarrow HPO_4^{2-} + H_2O$
d. $H_2CO_3 \leftrightarrow HCO_{3-} + H^+$

27. Which of the following is a cause of metabolic acidosis?

a. excessive HCl loss
b. increased aldosterone
c. diarrhea
d. prolonged use of diuretics

28. Which of the following is a cause of respiratory acidosis?

a. emphysema
b. low blood K^+
c. increased aldosterone
d. increased blood ketones

29. At a pH of 7.40, the carbonic acid ratio is _____.

a. 35:1
b. 4:1
c. 20:1
d. 3:1

30. Which of the following is characterized as metabolic alkalosis?

a. increased pH, decreased pCO_2, decreased HCO_3^-
b. increased pH, increased pCO_2, increased HCO_3^-
c. decreased pH, decreased pCO_2, decreased HCO_3^-
d. decreased pH, increased pCO_2, increased HCO_3^-

CRITICAL THINKING QUESTIONS

31. Plasma contains more sodium than chloride. How can this be if individual ions of sodium and chloride exactly balance each other out, and plasma is electrically neutral?

32. How is fluid moved from compartment to compartment?

33. Describe the effect of ADH on renal collecting tubules.

34. Why is it important for the amount of water intake to equal the amount of water output?

35. Explain how the CO_2 generated by cells and exhaled in the lungs is carried as bicarbonate in the blood.

36. How can one have an imbalance in a substance, but not actually have elevated or deficient levels of that substance in the body?

37. Describe the conservation of bicarbonate ions in the renal system.

38. Describe the control of blood carbonic acid levels through the respiratory system.

39. Case Study: Bob is a 64-year-old male admitted to the emergency room for asthma. His laboratory results are as follows: pH 7.31, pCO_2 higher than normal, and total HCO_3^- also higher than normal. Classify his acid-base balance as acidosis or alkalosis, and as metabolic or respiratory. Is there evidence of compensation? Propose the mechanism by which asthma contributed to the lab results seen.

40. Case Study: Kim is a 38-year-old women admitted to the hospital for bulimia. Her laboratory results are as follows: pH 7.48, pCO_2 in the normal range, and total HCO_3^- higher than normal. Classify her acid-base balance as acidosis or alkalosis, and as metabolic or respiratory. Is there evidence of compensation? Propose the mechanism by which bulimia contributed to the lab results seen.

reproductive organs. The initiation of spermatogenesis begins in boys, and girls begin ovulating and menstruating. Increases in sex steroid hormones also lead to the development of secondary sex characteristics such as breast development in girls and facial hair and larynx growth in boys.

INTERACTIVE LINK QUESTIONS

1. Watch this **video (http://openstaxcollege.org/l/vasectomy)** to learn about vasectomy. As described in this video, a vasectomy is a procedure in which a small section of the ductus (vas) deferens is removed from the scrotum. This interrupts the path taken by sperm through the ductus deferens. If sperm do not exit through the vas, either because the man has had a vasectomy or has not ejaculated, in what region of the testis do they remain?

2. Watch this **video (http://openstaxcollege.org/l/spermpath)** to explore the structures of the male reproductive system and the path of sperm that starts in the testes and ends as the sperm leave the penis through the urethra. Where are sperm deposited after they leave the ejaculatory duct?

3. Watch this **video (http://openstaxcollege.org/l/ovulation)** to observe ovulation and its initiation in response to the release of FSH and LH from the pituitary gland. What specialized structures help guide the oocyte from the ovary into the uterine tube?

4. Watch this series of **videos (http://openstaxcollege.org/l/oocyte)** to look at the movement of the oocyte through the ovary. The cilia in the uterine tube promote movement of the oocyte. What would likely occur if the cilia were paralyzed at the time of ovulation?

5. A baby's gender is determined at conception, and the different genitalia of male and female fetuses develop from the same tissues in the embryo. View this **animation (http://openstaxcollege.org/l/fetus)** that compares the development of structures of the female and male reproductive systems in a growing fetus. Where are the testes located for most of gestational time?

REVIEW QUESTIONS

6. What are male gametes called?
- a. ova
- b. sperm
- c. testes
- d. testosterone

7. Leydig cells _____.
- a. secrete testosterone
- b. activate the sperm flagellum
- c. support spermatogenesis
- d. secrete seminal fluid

8. Which hypothalamic hormone contributes to the regulation of the male reproductive system?
- a. luteinizing hormone
- b. gonadotropin-releasing hormone
- c. follicle-stimulating hormone
- d. androgens

9. What is the function of the epididymis?
- a. sperm maturation and storage
- b. produces the bulk of seminal fluid
- c. provides nitric oxide needed for erections
- d. spermatogenesis

10. Spermatogenesis takes place in the _____.
- a. prostate gland
- b. glans penis
- c. seminiferous tubules
- d. ejaculatory duct

11. What are the female gonads called?
- a. oocytes
- b. ova
- c. oviducts
- d. ovaries

12. When do the oogonia undergo mitosis?
- a. before birth
- b. at puberty
- c. at the beginning of each menstrual cycle
- d. during fertilization

13. From what structure does the corpus luteum originate?
- a. uterine corpus
- b. dominant follicle
- c. fallopian tube
- d. corpus albicans

14. Where does fertilization of the egg by the sperm typically occur?
- a. vagina
- b. uterus
- c. uterine tube
- d. ovary

15. Why do estrogen levels fall after menopause?
- a. The ovaries degrade.
- b. There are no follicles left to produce estrogen.
- c. The pituitary secretes a menopause-specific hormone.
- d. The cells of the endometrium degenerate.

16. The vulva includes the _____.
- a. lactiferous duct, rugae, and hymen
- b. lactiferous duct, endometrium, and bulbourethral glands
- c. mons pubis, endometrium, and hymen
- d. mons pubis, labia majora, and Bartholin's glands

17. What controls whether an embryo will develop testes or ovaries?
- a. pituitary gland
- b. hypothalamus
- c. Y chromosome
- d. presence or absence of estrogen

18. Without *SRY* expression, an embryo will develop _____.

a. male reproductive structures
b. female reproductive structures
c. no reproductive structures
d. male reproductive structures 50 percent of the time and female reproductive structures 50 percent of the time

19. The timing of puberty can be influenced by which of the following?

a. genes
b. stress
c. amount of body fat
d. all of the above

CRITICAL THINKING QUESTIONS

20. Briefly explain why mature gametes carry only one set of chromosomes.

21. What special features are evident in sperm cells but not in somatic cells, and how do these specializations function?

22. What do each of the three male accessory glands contribute to the semen?

23. Describe how penile erection occurs.

24. While anabolic steroids (synthetic testosterone) bulk up muscles, they can also affect testosterone production in the testis. Using what you know about negative feedback, describe what would happen to testosterone production in the testis if a male takes large amounts of synthetic testosterone.

25. Follow the path of ejaculated sperm from the vagina to the oocyte. Include all structures of the female reproductive tract that the sperm must swim through to reach the egg.

26. Identify some differences between meiosis in men and women.

27. Explain the hormonal regulation of the phases of the menstrual cycle.

28. Endometriosis is a disorder in which endometrial cells implant and proliferate outside of the uterus—in the uterine tubes, on the ovaries, or even in the pelvic cavity. Offer a theory as to why endometriosis increases a woman's risk of infertility.

29. Identify the changes in sensitivity that occur in the hypothalamus, pituitary, and gonads as a boy or girl approaches puberty. Explain how these changes lead to the increases of sex steroid hormone secretions that drive many pubertal changes.

30. Explain how the internal female and male reproductive structures develop from two different duct systems.

31. Explain what would occur during fetal development to an XY individual with a mutation causing a nonfunctional *SRY* gene.

changes from the beginning to the end of a feeding. Foremilk quenches the infant's thirst, whereas hindmilk satisfies the infant's appetite.

28.7 Patterns of Inheritance

There are two aspects to a person's genetic makeup. Their genotype refers to the genetic makeup of the chromosomes found in all their cells and the alleles that are passed down from their parents. Their phenotype is the expression of that genotype, based on the interaction of the paired alleles, as well as how environmental conditions affect that expression.

Working with pea plants, Mendel discovered that the factors that account for different traits in parents are discretely transmitted to offspring in pairs, one from each parent. He articulated the principles of random segregation and independent assortment to account for the inheritance patterns he observed. Mendel's factors are genes, with differing variants being referred to as alleles and those alleles being dominant or recessive in expression. Each parent passes one allele for every gene on to offspring, and offspring are equally likely to inherit any combination of allele pairs. When Mendel crossed heterozygous individuals, he repeatedly found a 3:1 dominant–recessive ratio. He correctly postulated that the expression of the recessive trait was masked in heterozygotes but would resurface in their offspring in a predictable manner.

Human genetics focuses on identifying different alleles and understanding how they express themselves. Medical researchers are especially interested in the identification of inheritance patterns for genetic disorders, which provides the means to estimate the risk that a given couple's offspring will inherit a genetic disease or disorder. Patterns of inheritance in humans include autosomal dominance and recessiveness, X-linked dominance and recessiveness, incomplete dominance, codominance, and lethality. A change in the nucleotide sequence of DNA, which may or may not manifest in a phenotype, is called a mutation.

INTERACTIVE LINK QUESTIONS

1. View this time-lapse **movie (http://openstaxcollege.org/l/conceptus)** of a conceptus starting at day 3. What is the first structure you see? At what point in the movie does the blastocoel first appear? What event occurs at the end of the movie?

2. Use this interactive **tool (http://openstaxcollege.org/l/embryogenesis)** to view the process of embryogenesis from the perspective of the conceptus (left panel), as well as fetal development viewed from a maternal cross-section (right panel). Can you identify when neurulation occurs in the embryo?

3. Visit this **site (http://openstaxcollege.org/l/pregstages)** for a summary of the stages of pregnancy, as experienced by the mother, and view the stages of development of the fetus throughout gestation. At what point in fetal development can a regular heartbeat be detected?

REVIEW QUESTIONS

4. Sperm and ova are similar in terms of _____.

a. size
b. quantity produced per year
c. chromosome number
d. flagellar motility

5. Although the male ejaculate contains hundreds of millions of sperm, _____.

a. most do not reach the oocyte
b. most are destroyed by the alkaline environment of the uterus
c. it takes millions to penetrate the outer layers of the oocyte
d. most are destroyed by capacitation

6. As sperm first reach the oocyte, they will contact the _____.

a. acrosome
b. corona radiata
c. sperm-binding receptors
d. zona pellucida

7. Fusion of pronuclei occurs during _____.

a. spermatogenesis
b. ovulation
c. fertilization
d. capacitation

8. Sperm must first complete _____ to enable the fertilization of an oocyte.

a. capacitation
b. the acrosomal reaction
c. the cortical reaction
d. the fast block

9. Cleavage produces daughter cells called _____.

a. trophoblasts
b. blastocysts
c. morulae
d. blastomeres

10. The conceptus, upon reaching the uterus, first _____.

a. implants
b. divides
c. disintegrates
d. hatches

11. The inner cell mass of the blastocyst is destined to become the _____.

a. embryo
b. trophoblast
c. chorionic villi
d. placenta

12. Which primary germ layer gave rise to the cells that eventually became the central nervous system?
- a. endoderm
- b. ectoderm
- c. acrosome
- d. mesoderm

13. What would happen if the trophoblast did not secrete hCG upon implantation of the blastocyst?
- a. The cells would not continue to divide.
- b. The corpus luteum would continue to produce progesterone and estrogen.
- c. Menses would flush the blastocyst out of the uterus.
- d. The uterine mucosa would not envelop the blastocyst.

14. During what process does the amnion envelop the embryo?
- a. embryonic folding
- b. gastrulation
- c. implantation
- d. organogenesis

15. The placenta is formed from _____.
- a. the embryo's mesenchymal cells
- b. the mother's endometrium only
- c. the mother's endometrium and the embryo's chorionic membrane
- d. the mother's endometrium and the embryo's umbilical cord

16. The foramen ovale causes the fetal circulatory system to bypass the _____.
- a. liver
- b. lungs
- c. kidneys
- d. gonads

17. What happens to the urine excreted by the fetus when the kidneys begin to function?
- a. The umbilical cord carries it to the placenta for removal.
- b. The endometrium absorbs it.
- c. It adds to the amniotic fluid.
- d. It is turned into meconium.

18. During weeks 9–12 of fetal development, _____.
- a. bone marrow begins to assume erythrocyte production
- b. meconium begins to accumulate in the intestines
- c. surfactant production begins in the fetal lungs
- d. the spinal cord begins to be myelinated

19. Progesterone secreted by the placenta suppresses _____ to prevent maturation of ovarian follicles.
- a. LH and estrogen
- b. hCG and FSH
- c. FSH and LH
- d. estrogen and hCG

20. Which of the following is a possible culprit of "morning sickness"?
- a. increased minute respiration
- b. decreased intestinal peristalsis
- c. decreased aldosterone secretion
- d. increased blood volume

21. How does the decrease in progesterone at the last weeks of pregnancy help to bring on labor?
- a. stimulating FSH production
- b. decreasing the levels of estrogens
- c. dilating the cervix
- d. decreasing the inhibition of uterine contractility

22. Which of these fetal presentations is the easiest for vaginal birth?
- a. complete breech
- b. vertex occiput anterior
- c. frank breech
- d. vertex occiput posterior

23. Which of these shunts exists between the right and left atria?
- a. foramen ovale
- b. ductus venosus
- c. ductus arteriosis
- d. foramen venosus

24. Why is brown fat important?
- a. It is the newborn's primary source of insulation.
- b. It can be broken down to generate heat for thermoregulation.
- c. It can be broken down for energy between feedings.
- d. It can be converted to white fat.

25. Constriction of umbilical blood vessels during vaginal birth _____.
- a. causes respiratory alkalosis
- b. inhibits the respiratory center in the brain
- c. elevates carbon dioxide levels in the blood
- d. both a and b

26. Alveoli are connected to the lactiferous sinuses by _____.
- a. lactocytes
- b. lactiferous ducts
- c. nipple pores
- d. lobules

27. How is colostrum most important to a newborn?
- a. It helps boost the newborn's immune system.
- b. It provides much needed fat.
- c. It satisfies the newborn's thirst.
- d. It satisfies the infant's appetite.

28. Mature breast milk _____.
- a. has more sodium than cow's milk
- b. has more calcium than cow's milk
- c. has more protein than cow's milk
- d. has more fat than cow's milk

29. Marfan syndrome is inherited in an autosomal dominant pattern. Which of the following is true?
- a. Female offspring are more likely to be carriers of the disease.
- b. Male offspring are more likely to inherit the disease.
- c. Male and female offspring have the same likelihood of inheriting the disease.

d. Female offspring are more likely to inherit the disease.

30. In addition to codominance, the ABO blood group antigens are also an example of _____.

a. incomplete dominance
b. X-linked recessive inheritance
c. multiple alleles
d. recessive lethal inheritance

31. Zoe has cystic fibrosis. Which of the following is the most likely explanation?

a. Zoe probably inherited one faulty allele from her father, who is a carrier, and one normal allele from her mother.
b. Zoe probably inherited one faulty allele from her mother, who must also have cystic fibrosis, and one normal allele from her father.
c. Zoe must have inherited faulty alleles from both parents, both of whom must also have cystic fibrosis.
d. Zoe must have inherited faulty alleles from both parents, both of whom are carriers.

CRITICAL THINKING QUESTIONS

32. Darcy and Raul are having difficulty conceiving a child. Darcy ovulates every 28 days, and Raul's sperm count is normal. If we could observe Raul's sperm about an hour after ejaculation, however, we'd see that they appear to be moving only sluggishly. When Raul's sperm eventually encounter Darcy's oocyte, they appear to be incapable of generating an adequate acrosomal reaction. Which process has probably gone wrong?

33. Sherrise is a sexually active college student. On Saturday night, she has unprotected sex with her boyfriend. On Tuesday morning, she experiences the twinge of mid-cycle pain that she typically feels when she is ovulating. This makes Sherrise extremely anxious that she might soon learn she is pregnant. Is Sherrise's concern valid? Why or why not?

34. Approximately 3 weeks after her last menstrual period, a sexually active woman experiences a brief episode of abdominopelvic cramping and minor bleeding. What might be the explanation?

35. The Food and Nutrition Board of the Institute of Medicine recommends that all women who might become pregnant consume at least 400 µg/day of folate from supplements or fortified foods. Why?

36. What is the physiological benefit of incorporating shunts into the fetal circulatory system?

37. Why would a premature infant require supplemental oxygen?

38. Devin is 35 weeks pregnant with her first child when she arrives at the birthing unit reporting that she believes she is in labor. She states that she has been experiencing diffuse, mild contractions for the past few hours. Examination reveals, however, that the plug of mucus blocking her cervix is intact and her cervix has not yet begun to dilate. She is advised to return home. Why?

39. Janine is 41 weeks pregnant with her first child when she arrives at the birthing unit reporting that she believes she has been in labor "for days" but that "it's just not going anywhere." During the clinical exam, she experiences a few mild contractions, each lasting about 15–20 seconds; however, her cervix is found to be only 2 cm dilated, and the amniotic sac is intact. Janine is admitted to the birthing unit and an IV infusion of pitocin is started. Why?

40. Describe how the newborn's first breath alters the circulatory pattern.

41. Newborns are at much higher risk for dehydration than adults. Why?

42. Describe the transit of breast milk from lactocytes to nipple pores.

43. A woman who stopped breastfeeding suddenly is experiencing breast engorgement and leakage, just like she did in the first few weeks of breastfeeding. Why?

44. Explain why it was essential that Mendel perform his crosses using a large sample size?

45. How can a female carrier of an X-linked recessive disorder have a daughter who is affected?

ANSWER KEY

Chapter 1

1 Fatty acid catabolism. **2** The kidneys. **3** X-rays. **4** The magnets induce tissue to emit radio signals that can show differences between different types of tissue. **5** PET scans can indicate how patients are responding to chemotherapy. **6** C **7** A **8** A **9** A **10** D **11** D **12** C **13** A **14** C **15** A **16** C **17** A **18** C **19** B **20** D **21** C **22** D **23** B **24** D **25** C **26** C **27** B **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. **29** A student would more readily appreciate the structures revealed in the dissection. Even though the student has not yet studied the workings of the heart and blood vessels in her class, she has experienced her heart beating every moment of her life, has probably felt her pulse, and likely has at least a basic understanding of the role of the heart in pumping blood throughout her body. This understanding of the heart's function (physiology) would support her study of the heart's form (anatomy). **30** Chemical, cellular, tissue, organ, organ system, organism. **31** The female ovaries and the male testes are parts of the reproductive system. But they also secrete hormones, as does the endocrine system, therefore ovaries and testes function within both the endocrine and reproductive systems. **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. **33** Growth can occur by increasing the number of existing cells, increasing the size of existing cells, or increasing the amount of non-cellular material around cells. **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. **35** The primary way that the body responds to high environmental heat is by sweating; however, sweating requires water, which comes from body fluids, including blood plasma. If Josh becomes dehydrated, he will be unable to sweat adequately to cool his body, and he will be at risk for heat stroke as his blood pressure drops too much from the loss of water from the blood plasma. **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. **37** Any prolonged exposure to extreme cold would activate the brain's heat-gain center. This would reduce blood flow to your skin, and shunt blood returning from your limbs away from the digits and into a network of deep veins. Your brain's heat-gain center would also increase your muscle contraction, causing you to shiver. This increases the energy consumption of skeletal muscle and generates more heat. Your body would also produce thyroid hormone and epinephrine, chemicals that promote increased metabolism and heat production. **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. **39** The bullet would enter the ventral, thoracic, and pleural cavities, and it would encounter the parietal layer of serous membrane first. **40** CT scanning subjects patients to much higher levels of radiation than X-rays, and should not be performed repeatedly. **41** Ultrasonography does not expose a mother or fetus to radiation, to radiopharmaceuticals, or to magnetic fields. At this time, there are no known medical risks of ultrasonography.

Chapter 2

1 The mass number is the total number of protons and neutrons in the nucleus of an atom. **2** The plastic sheets jump to the nail (the conductor), because the conductor takes on electrons from the electroscope, reducing the repellant force of the two sheets. **3** The water hydrolyses, or breaks, the glycosidic bond, forming two monosaccharides. **4** D **5** B **6** A **7** C **8** B **9** C **10** C **11** A **12** B **13** A **14** A **15** B **16** C **17** D **18** A **19** D **20** B **21** A **22** D **23** C **24** B **25** C **26** A **27** C **28** B **29** A **30** D **31** 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. **34** Oxygen has eight protons. In its most abundant stable form, it has eight neutrons, too, for a mass number of 16. In contrast, ^{17}O has nine neutrons, and ^{18}O has 10 neutrons. **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. **36** A carbon atom has four electrons in its valence shell. According to the octet rule, it will readily participate in chemical reactions that result in its valence shell having eight electrons. Hydrogen, with one electron, will complete its valence shell with two. Electron sharing between an atom of carbon and four atoms of hydrogen meets the requirements of all atoms. The bonds are covalent because the electrons are shared: although hydrogen often participates in ionic bonds, carbon does not because it is highly unlikely to donate or accept four 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. **38** Identical atoms have identical electronegativity and cannot form ionic bonds. Oxygen, for example, has six electrons in its valence shell. Neither donating nor accepting the valence shell electrons of the other will result in the oxygen atoms completing their valence shells. Two atoms of the same element always form covalent bonds. **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. **40** Recall that the greater the surface area of the reactants, the more quickly and easily they will interact. It takes energy to separate particles of a substance. Powder and liquid laundry detergents, with relatively more surface area per unit, can quickly dissolve into their reactive components when added to the water. **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. **42** Lemon juice, like any acid, releases hydrogen ions in solution. As excessive H^+ enters the digestive tract and is absorbed into blood, Eli's blood pH falls below 7.35. Recall that bicarbonate is a buffer, a weak base that accepts hydrogen ions. By administering bicarbonate intravenously, the emergency department physician helps raise Eli's blood pH back toward neutral. **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. **44** All lipids are hydrophobic and unable to dissolve in the watery environment of blood. They are packaged into lipoproteins, whose outer protein envelope enables them to transport fats in the bloodstream.

Chapter 3

1 Higher temperatures speed up diffusion because molecules have more kinetic energy at higher temperatures. **2** Processing, packaging, and moving materials manufactured by the cell. **3** an enzyme **4** They separate and move and are free to join translation of other segments of mRNA. **5** the spindle **6** B **7** D **8** C **9** B **10** D **11** B **12** A **13** C **14** A **15** B **16** C **17** C **18** A **19** B **20** C **21** A **22** C **23** D **24** B **25** D **26** B **27** D **28** C **29** 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. **31** Receptor-mediated endocytosis is more selective because the substances that are brought into the cell are the specific ligands that could bind to the receptors being endocytosed. Phagocytosis or pinocytosis, on the other hand, have no such receptor-ligand specificity, and bring in whatever materials happen to be close to the membrane when it is enveloped. **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. **33** The structure of the Golgi apparatus is suited to its function because it is a series of flattened membranous discs; substances are modified and packaged in sequential steps as they travel from one disc to the next. The structure of Golgi apparatus also involves a receiving face and a sending face, which organize cellular products as they enter and leave the Golgi apparatus. The ER and the mitochondria both have structural specializations that increase their surface area. In the mitochondria, the inner membrane is extensively folded, which increases surface area for ATP production. Likewise, the ER is elaborately wound throughout the cell, increasing its surface area for functions like lipid synthesis, Ca^{++} storage, and protein synthesis. **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. **35** DNA replication is said to be semiconservative because, after replication is complete, one of the two parent DNA strands makes up half of each new DNA molecule. The other half is a newly synthesized strand. Therefore, half ("semi") of each daughter DNA molecule is from the parent molecule and half is a new molecule. **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. **37** Transcription and DNA replication both involve the synthesis of nucleic acids. These processes share many common features—particularly, the similar processes of initiation, elongation, and termination. In both cases the DNA molecule must be untwisted and separated, and the coding (i.e., sense) strand will be used as a template. Also, polymerases serve to add nucleotides to the growing DNA or mRNA strand. Both processes are signaled to terminate when completed. **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. **39** One or both of the new daughter cells would accidently receive duplicate chromosomes and/or would be missing certain chromosomes. **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. **41** Transcription factors bind to DNA and either promote or inhibit the transcription of a gene. If they promote the transcription of a particular gene, then that gene will be transcribed and the mRNA subsequently translated into protein. If gene transcription is inhibited, then there will be no way of synthesizing the gene's corresponding protein. **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. **2** The inside of the mouth, esophagus, vaginal canal, and anus. **3** Click at the bottom of the quiz for the answers. **4** Skeletal muscle cells are striated. **5** Dendrites, cell body, and the axon. **6** Approximately one month. **7** A mass of cancer cells that continue to grow and divide. **8** C **9** A **10** B **11** D **12** A **13** C **14** B **15** A **16** B **17** D **18** B **19** C **20** B **21** D **22** A **23** A **24** D **25** A **26** B **27** D **28** C **29** B **30** B **31** C **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. **33** The zygote divides into many cells. As these cells become specialized, they lose their ability to differentiate into all tissues. At first they form the three primary germ layers. Following the cells of the ectodermal germ layer, they too become more restricted in what they can form. Ultimately, some of these ectodermal cells become further restricted and differentiate in to nerve cells. **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. **35** Columnar epithelia, which form the lining of the digestive tract, can be either simple or stratified. The cells are long and narrow. The nucleus is elongated and located on the basal side of the cell. Ciliated columnar epithelium is composed of simple columnar epithelial cells that display cilia on their apical surfaces. **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. **37** A layer of dense irregular connective tissue covers cartilage. No blood vessels supply cartilage tissue. Injuries to cartilage heal very slowly because cells and nutrients needed for repair diffuse slowly to the injury site. **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. **39** Under the light microscope, cells appear striated due to the arrangement of the contractile proteins actin and myosin. **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. **41** Astrocytes regulate ions and uptake and/or breakdown of some neurotransmitters and contribute to the formation of the blood-brain-barrier. **42** These symptoms would indicate that infection is present. **43** Since NSAIDs or other anti-inflammatory drugs inhibit the formation of blood clots, regular and prolonged use of these drugs may promote internal bleeding, such as bleeding in the stomach. Excessive levels of cortisol would suppress inflammation, which could slow the wound healing process. **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. **45** All cells experience changes with aging. They become larger, and many cannot divide and regenerate. Because of alterations in cell membranes, transport of oxygen and nutrients into the cell and removal of carbon dioxide and waste products are not as efficient in the elderly. Cells lose their ability to function, or they begin to function abnormally, leading to disease and cancer.

Chapter 5

1 The epidermis provides protection, the dermis provides support and flexibility, and the hypodermis (fat layer) provides insulation and padding. **2** **Figure 5.4** These cells do not have nuclei, so you can deduce that they are dead. They appear to be sloughing off. **3** **Figure 5.6** These cells have desmosomes, which give the cells their spiny appearance. **4** There are none. **5** D **6** A **7** C **8** B **9** C **10** C **11** D **12** B **13** B **14** B **15** A **16** C **17** C **18** A **19** C **20** C **21** C **22** D **23** B **24** C **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. **26** As the cells move into the stratum spinosum, they begin the synthesis of keratin and extend cell processes, desmosomes, which link the cells. As the stratum basale continues to produce new cells, the keratinocytes of the stratum spinosum are pushed into the stratum granulosum. The cells become flatter, their cell membranes thicken, and they generate large amounts of the proteins keratin and keratohyalin. The nuclei and other cell organelles disintegrate as the cells die, leaving behind the keratin, keratohyalin, and cell membranes that form the stratum lucidum and the stratum corneum. The keratinocytes in these layers are mostly dead and flattened. Cells in the stratum corneum are periodically shed. **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. **28** Nails are composed of densely packed dead keratinocytes. They protect the fingers and toes from mechanical stress. The nail body is formed on the nail bed, which is at the nail root. Nail folds, folds of skin that overlap the nail on its side, secure the nail to the body. The crescent-shaped region at the base of the nail is the lunula. **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. **30** When the core body temperature drops, the body switches to heat-conservation mode. This can include an inhibition to excessive sweating and

a decrease of blood flow to the papillary layers of the skin. This reduction of blood flow helps conserve body 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. **32** Scars are made of collagen and do not have the cellular structure of normal skin. The tissue is fibrous and does not allow for the regeneration of accessory structures, such as hair follicles, and sweat or sebaceous glands.

Chapter 6

1 B **2** D **3** C **4** A **5** B **6** B **7** B **8** D **9** A **10** A **11** C **12** C **13** B **14** A **15** C **16** D **17** C **18** C **19** A **20** C **21** D **22** B **23** D **24** A **25** B **26** C **27** B **28** B **29** D **30** B **31** C **32** A **33** A **34** C **35** A **36** D **37** D **38** A **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. **41** Structurally, a tarsal is a short bone, meaning its length, width, and thickness are about equal, while a metatarsal is a long bone whose length is greater than its width. Functionally, the tarsal provides limited motion, while the metatarsal acts as a lever. **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. **43** If the articular cartilage at the end of one of your long bones were to deteriorate, which is actually what happens in osteoarthritis, you would experience joint pain at the end of that bone and limitation of motion at that joint because there would be no cartilage to reduce friction between adjacent bones and there would be no cartilage to act as a shock absorber. **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. **45** In intramembranous ossification, bone develops directly from sheets of mesenchymal connective tissue, but in endochondral ossification, bone develops by replacing hyaline cartilage. Intramembranous ossification is complete by the end of the adolescent growth spurt, while endochondral ossification lasts into young adulthood. The flat bones of the face, most of the cranial bones, and a good deal of the clavicles (collarbones) are formed via intramembranous ossification, while bones at the base of the skull and the long bones form via endochondral ossification. **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. **47** In closed reduction, the broken ends of a fractured bone can be reset without surgery. Open reduction requires surgery to return the broken ends of the bone to their correct anatomical position. A partial fracture would likely require closed reduction. A compound fracture would require open reduction. **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. **49** Since maximum bone mass is achieved by age 30, I would want this patient to have adequate calcium and vitamin D in her diet. To do this, I would recommend ingesting milk and other dairy foods, green leafy vegetables, and intact canned sardines so she receives sufficient calcium. Intact salmon would be a good source for calcium and vitamin D. Other fatty fish would also be a good vitamin D source. **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. **51** Vitamin D is required for calcium absorption by the gut. Low vitamin D could lead to insufficient levels of calcium in the blood so the calcium is being released from the bones. The reduction of calcium from the bones can make them weak and subject to fracture. **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. **2** A basilar fracture may damage an artery entering the skull, causing bleeding in the brain. **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. **4** Lifting a heavy object can cause an intervertebral disc in the lower back to bulge and compress a spinal nerve as it exits through the intervertebral foramen, thus producing pain in those regions of the lower limb supplied by that nerve. **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. **6** Bones on the top and sides of the skull develop when fibrous membrane areas ossify (convert) into bone. The bones of the limbs, ribs, and vertebrae develop when cartilage models of the bones ossify into bone. **7** D **8** C **9** B **10** A **11** B **12** D **13** A **14** A **15** D **16** A **17** B **18** C **19** A **20** A **21** B **22** D **23** A **24** D **25** B **26** D **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. **28** The axial skeleton supports

the head, neck, back, and chest of the body and allows for movements of these body regions. It also gives bony protections for the brain, spinal cord, heart, and lungs; stores fat and minerals; and houses the blood-cell producing tissue. **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. **30** The coronal suture passes across the top of the anterior skull. It unites the frontal bone anteriorly with the right and left parietal bones. The sagittal suture runs at the midline on the top of the skull. It unites the right and left parietal bones with each other. The squamous suture is a curved suture located on the lateral side of the skull. It unites the squamous portion of the temporal bone to the parietal bone. The lambdoid suture is located on the posterior skull and has an inverted V-shape. It unites the occipital bone with the right and left parietal 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. **32** There are two bony parts of the nasal septum in the dry skull. The perpendicular plate of the ethmoid bone forms the superior part of the septum. The vomer bone forms the inferior and posterior parts of the septum. In the living skull, the septal cartilage completes the septum by filling in the anterior area between the bony components and extending outward into the nose. **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. **34** A typical vertebra consists of an anterior body and a posterior vertebral arch. The body serves for weight bearing. The vertebral arch surrounds and protects the spinal cord. The vertebral arch is formed by the pedicles, which are attached to the posterior side of the vertebral body, and the lamina, which come together to form the top of the arch. A pair of transverse processes extends laterally from the vertebral arch, at the junction between each pedicle and lamina. The spinous process extends posteriorly from the top of the arch. A pair of superior articular processes project upward and a pair of inferior articular processes project downward. Together, the notches found in the margins of the pedicles of adjacent vertebrae form an intervertebral foramen. **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. **36** An intervertebral disc fills in the space between adjacent vertebrae, where it provides padding and weight-bearing ability, and allows for movements between the vertebrae. It consists of an outer anulus fibrosus and an inner nucleus pulposus. The anulus fibrosus strongly anchors the adjacent vertebrae to each other, and the high water content of the nucleus pulposus resists compression for weight bearing and can change shape to allow for vertebral column movements. **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. **38** The thoracic cage is formed by the 12 pairs of ribs with their costal cartilages and the sternum. The ribs are attached posteriorly to the 12 thoracic vertebrae and most are anchored anteriorly either directly or indirectly to the sternum. The thoracic cage functions to protect the heart and lungs. **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. **40** A typical rib is a flattened, curved bone. The head of a rib is attached posteriorly to the costal facets of the thoracic vertebrae. The rib tubercle articulates with the transverse process of a thoracic vertebra. The angle is the area of greatest rib curvature and forms the largest portion of the thoracic cage. The body (shaft) of a rib extends anteriorly and terminates at the attachment to its costal cartilage. The shallow costal groove runs along the inferior margin of a rib and carries blood vessels and a nerve. **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. **42** The brain-case bones that form the top and sides of the skull are produced by intramembranous ossification. In this, mesenchyme from the sclerotome portion of the somites accumulates at the site of the future bone and differentiates into bone-producing cells. These generate areas of bone that are initially separated by wide regions of fibrous connective tissue called fontanelles. After birth, as the bones enlarge, the fontanelles disappear. However, the bones remain separated by the sutures, where bone and skull growth can continue until the adult size is obtained. **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. **44** The vertebrae, ribs, and sternum all develop via the process of endochondral ossification. Mesenchyme tissue from the sclerotome portion of the somites accumulates on either side of the notochord and produces hyaline cartilage models for each

vertebra. In the thorax region, a portion of this cartilage model splits off to form the ribs. Similarly, mesenchyme forms cartilage models for the right and left halves of the sternum. The ribs then become attached anteriorly to the developing sternum, and the two halves of sternum fuse together. Ossification of the cartilage model into bone occurs within these structures over time. This process continues until each is converted into bone, except for the sternal ends of the ribs, which remain as the costal cartilages.

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. **2** The hand has a proximal transverse arch, a distal transverse arch, and a longitudinal arch. These allow the hand to conform to objects being held. These arches maximize the amount of surface contact between the hand and object, which enhances stability and increases sensory input. **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. **4** The obturator foramen is located between the ischium and the pubis. The superior and inferior pubic rami contribute to the boundaries of the obturator foramen. **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. **6** Metal cutting jigs are attached to the bones to ensure that the bones are cut properly prior to the attachment of prosthetic components. **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. **8** A bunion results from the deviation of the big toe toward the second toe, which causes the distal end of the first metatarsal bone to stick out. A bunion may also be caused by prolonged pressure on the foot from pointed shoes with a narrow toe box that compresses the big toe and pushes it toward the second toe. **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 **11** C **12** D **13** A **14** C **15** D **16** A **17** C **18** D **19** B **20** B **21** A **22** B **23** C **24** A **25** B **26** C **27** D **28** C **29** C **30** D **31** C **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. **34** A blow to the shoulder or falling onto an outstretched hand passes strong forces through the scapula to the clavicle and sternum. A hard fall may thus cause a fracture of the clavicle (broken collarbone) or may injure the ligaments of the acromioclavicular joint. In a severe case, the coracoclavicular ligament may also rupture, resulting in complete dislocation of the acromioclavicular joint (a "shoulder separation"). **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. **36** The base of the hand is formed by the eight carpal bones arranged in two rows (distal and proximal) of four bones each. The proximal row contains (from lateral to medial) the scaphoid, lunate, triquetrum, and pisiform bones. The distal row contains (from medial to lateral) the hamate, capitate, trapezoid, and trapezium bones. (Use the mnemonic "So Long To Pinky, Here Comes The Thumb" to remember this sequence). The rows of the proximal and distal carpal bones articulate with each other at the midcarpal joint. The palm of the hand contains the five metacarpal bones, which are numbered 1–5 starting on the thumb side. The proximal ends of the metacarpal bones articulate with the distal row of the carpal bones. The distal ends of the metacarpal bones articulate with the proximal phalanx bones of the thumb and fingers. The thumb (digit 1) has both a proximal and distal phalanx bone. The fingers (digits 2–5) all contain proximal, middle, and distal phalanges. **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. **38** Compared to the male, the female pelvis is wider to accommodate childbirth. Thus, the female pelvis has greater distances between the anterior superior iliac spines and between the ischial tuberosities. The greater width of the female pelvis results in a larger subpubic angle. This angle, formed by the anterior convergence of the right and left ischiopubic rami, is larger in females (greater than 80 degrees) than in males (less than 70 degrees). The female sacral promontory does not project anteriorly as far as it does in males, which gives the pelvic brim (pelvic inlet) of the female a rounded or oval shape. The lesser pelvic cavity is wider and more shallow in females, and the pelvic outlet is larger than in males. Thus, the greater width of the female pelvis, with its larger pelvic inlet, lesser pelvis, and pelvic outlet, are important for childbirth because the baby must pass through the pelvis during delivery. **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. **40** The talus bone articulates superiorly with the tibia and fibula at the ankle joint, with body weight passed from the tibia to the talus. Body weight from the talus is transmitted to the ground by both ends of the medial and lateral longitudinal foot arches. Weight is passed posteriorly through both arches to the calcaneus bone, which forms the heel of the foot and is in contact with the ground. On the medial side of the foot, body weight is passed anteriorly from the talus bone to the navicular bone, and then to the medial, intermediate, and lateral cuneiform bones. The cuneiform bones pass the weight anteriorly to the first, second, and third metatarsal bones, whose heads (distal ends) are in contact with the ground. On the lateral side, body weight is passed anteriorly from the talus through the calcaneus, cuboid, and fourth and fifth metatarsal bones. The talus bone thus transmits body weight posteriorly to the calcaneus and anteriorly through the navicular, cuneiform, and cuboid bones, and metatarsals one through five. **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. **42** Unlike other bones of the appendicular skeleton, the clavicle develops by the process of intramembranous ossification. In this process, embryonic mesenchyme accumulates at the site of the future bone and then differentiates directly into bone-producing tissue. Because of this direct and early production of bone, the clavicle is the first bone of the skeleton to begin to ossify. However, the growth and enlargement of the clavicle continues throughout childhood and adolescence, and thus, it is not fully ossified until 25 years of age.

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. **2** Ball-and-socket joint. **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. **4** The most common cause of hip disability is osteoarthritis, a chronic disease in which the articular cartilage of the joint wears away, resulting in severe hip pain and stiffness. **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. **6** Dorsiflexion of the foot at the ankle decreases the angle of the ankle joint, while plantar flexion increases the angle of the ankle joint. **7** The first motion is rotation (hinging) of the mandible, but this only produces about 20 mm (0.78 in) of mouth opening. **8** The shoulder joint is a ball-and-socket joint that allows for flexion-extension, abduction-adduction, medial rotation, lateral rotation, and circumduction of the humerus. **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. **10** The structures that stabilize the elbow include the coronoid process, the radial (lateral) collateral ligament, and the anterior portion of the ulnar (medial) collateral ligament. **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. **12** An intracapsular fracture of the neck of the femur can result in disruption of the arterial blood supply to the head of the femur, which may lead to avascular necrosis of the femoral head. **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. **14** There are five ligaments associated with the knee joint. The tibial collateral ligament is located on the medial side of the knee and the fibular collateral ligament is located on the lateral side. The anterior and posterior cruciate ligaments are located inside the knee joint. **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. **16** The anterior cruciate ligament (ACL) is most commonly injured when traumatic force is applied to the knee during a twisting motion or when side standing or landing from a jump. **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. **18** Because of the square shape of the ankle joint, it has been compared to a mortise-and-tendon type of joint. **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 **21** B **22** A **23** D **24** A **25** A **26** D **27** C **28** B **29** D **30** A **31** A **32** A **33** B **34** C **35** C **36** D **37** D **38** B **39** A **40** A **41** C **42** D **43** A **44** C **45** C **46** A **47** D **48** C **49** B **50** B **51** C **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. **54** The functional needs of joints vary and thus joints differ in their degree of mobility. A synarthrosis, which is an immobile joint, serves to strongly connect bones thus protecting internal organs such as the heart or brain. A slightly moveable amphiarthrosis provides for small movements, which in the vertebral column can add together to yield a much larger overall movement. The freedom of movement provided by a diarthrosis can allow for large movements, such as is seen with most joints of the limbs. **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. **56** The teeth are anchored into their sockets within the bony jaws by the periodontal ligaments. This is a gomphosis type of fibrous joint. In scurvy, collagen production is inhibited and the periodontal ligaments become weak. This will cause the teeth to become loose or even to fall out. **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. **58** The first sternocostal joint is a synchondrosis type of cartilaginous joint in which hyaline cartilage unites the first rib to the manubrium of the sternum. This forms an immobile (synarthrosis) type of joint. The pubic symphysis is a slightly mobile (amphiarthrosis) cartilaginous joint, where the pubic portions of the right and left hip bones are united by fibrocartilage, thus forming a symphysis. **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. **60** Direct support for a synovial joint is provided by ligaments that strongly unite the bones of the joint and serve to resist excessive or abnormal movements. Some joints, such as the sternoclavicular joint, have an articular disc that is attached to both bones, where it provides direct support by holding the bones together. Indirect joint support is provided by the muscles and their tendons that act across a joint. Muscles will increase their contractile force to help support the joint by resisting forces acting on it. **61** Ball-and-socket joints are multiaxial joints that allow for flexion and extension, abduction and adduction, circumduction, and medial and lateral rotation. **62** To cross your arms, you need to use both your shoulder and elbow joints. At the shoulder, the arm would need to flex and medially rotate. At the elbow, the forearm would need to be flexed. **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. **64** A strong blow to the lateral side of the extended knee will cause the medial side of the knee joint to open, resulting in a sequence of three injuries. First will be damage to the tibial collateral ligament. Since the medial meniscus is attached to the tibial collateral ligament, the meniscus is also injured. The third structure injured would be the anterior cruciate ligament. **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. **66** Intramembranous ossification is the process by which mesenchymal cells differentiate directly into bone producing cells. This process produces the bones that form the top and sides of the skull. The remaining skull bones and the bones of the limbs are formed by endochondral ossification. In this, mesenchymal cells differentiate into hyaline cartilage cells that produce a cartilage model of the future bone. The cartilage is then gradually replaced by bone tissue over a period of many years, during which the cartilage of the epiphyseal plate can continue to grow to allow for enlargement or lengthening of the bone.

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. **2** (a) It is the number of skeletal muscle fibers supplied by a single motor neuron. (b) A large motor unit has one neuron supplying many skeletal muscle fibers for gross movements, like the Temporalis muscle, where 1000 fibers are supplied by one neuron. A small motor has one neuron supplying few skeletal muscle fibers for very fine movements, like the extraocular eye muscles, where six fibers are supplied by one neuron. (c) To avoid prolongation of muscle contraction. **3** (a) The T-tubules are inward extensions of the sarcolemma that trigger the release of Ca^{++} from SR during an Action Potential. (b) Ca^{++} binds to tropomyosin, and this slides the tropomyosin rods away from the binding sites. **4** D **5** B **6** C **7** B **8** A **9** D **10** D **11** B **12** C **13** C **14** D **15** C **16** B **17** A **18** B **19** D **20** A **21** B **22** C **23** A **24** D **25** C **26** A **27** A **28** C **29** D **30** It allows muscle to return to its original length during relaxation after contraction. **31** Muscles would lose their integrity during powerful movements, resulting in muscle damage. **32** When a muscle contracts, the force of movement is transmitted through the tendon, which pulls on the bone to produce skeletal movement. **33** Produce movement of the skeleton, maintain posture and body position, support soft tissues, encircle openings of the digestive, urinary, and other tracts, and maintain body temperature. **34** The opening of voltage-gated sodium channels, followed by the influx of Na^{+}, transmits an Action Potential after the membrane has sufficiently depolarized. The delayed opening of potassium channels allows K^{+} to exit the cell, to repolarize the membrane. **35** Without T-tubules, action potential conduction into the interior of the cell would happen much more slowly, causing delays between neural stimulation and muscle contraction, resulting in slower, weaker contractions. **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. **37** Without ATP, the myosin heads cannot detach from the actin-binding sites. All of the “stuck” cross-bridges result in muscle stiffness. In a live person, this can cause a condition like “writer’s cramps.” In a recently dead person, it results in rigor mortis. **38** Eyes require fine movements and a high degree of control, which is permitted by having fewer muscle fibers associated with a neuron. **39** The length, size and types of muscle fiber and the frequency of neural stimulation contribute to the amount of tension produced in an individual muscle fiber. **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. **41**

Aerobic respiration is much more efficient than anaerobic glycolysis, yielding 36 ATP per molecule of glucose, as opposed to two ATP produced by glycolysis. **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. **43** Resistance exercises affect muscles by causing the formation of more actin and myosin, increasing the structure of muscle fibers. **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. **45** Cardiac and skeletal muscle cells both contain ordered myofibrils and are striated. Cardiac muscle cells are branched and contain intercalated discs, which skeletal muscles do not have. **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. **47** Single-unit smooth muscle is found in the walls of hollow organs; multiunit smooth muscle is found in airways to the lungs and large arteries. Single-unit smooth muscle cells contract synchronously, they are coupled by gap junctions, and they exhibit spontaneous action potential. Multiunit smooth cells lack gap junctions, and their contractions are not synchronous. **48** If the damage exceeds what can be repaired by satellite cells, the damaged tissue is replaced by scar tissue, which cannot contract. **49** Smooth muscle tissue can regenerate from stem cells called pericytes, cells found in some small blood vessels. These allow smooth muscle cells to regenerate and repair much more readily than skeletal and cardiac muscle tissue.

Chapter 11

1 D **2** A **3** B **4** A **5** C **6** C **7** A **8** A **9** C **10** D **11** D **12** C **13** B **14** B **15** B **16** C **17** A **18** D **19** B **20** C **21** B **22** B **23** A **24** A **25** D **26** B **27** B **28** Fascicle arrangements determine what type of movement a muscle can make. For instance, circular muscles act as sphincters, closing orifices. **29** Muscles work in pairs to facilitate movement of the bones around the joints. 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. **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. **31** In anatomy and physiology, many word roots are Latin or Greek. Portions, or roots, of the word give us clues about the function, shape, action, or location of a muscle. **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. **33** The muscles of the anterior neck are arranged to facilitate swallowing and speech. They work on the hyoid bone, with the suprahyoid muscles pulling up and the infrahyoid muscles pulling down. **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. **35** Arranged into layers, the muscles of the abdominal wall are the internal and external obliques, which run on diagonals, the rectus abdominis, which runs straight down the midline of the body, and the transversus abdominis, which wraps across the trunk of the body. **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. **37** Tendons of the infraspinatus, supraspinatus, teres minor, and the subscapularis form the rotator cuff, which forms a foundation on which the arms and shoulders can be stabilized and move. **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. **39** The biceps femoris, semimembranosus, and semitendinosus form the hamstrings. The hamstrings flex the leg at the knee joint. **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. **2** They are part of the somatic nervous system, which is responsible for voluntary movements such as walking or climbing the stairs. **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. **4**Lipid membranes, such as the cell membrane and organelle membranes. **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. **6** The properties of electrophysiology are common to all animals, so using the leech is an easier, more humane approach to studying the properties of these cells. There are differences between the nervous systems of invertebrates (such as a leech) and vertebrates, but not for the sake of what these experiments study. **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. **8** The action potential depolarizes the cell membrane of the axon terminal, which contains the voltage-gated Ca^{2+} channel. That voltage change opens the channel so that Ca^{2+} can enter the axon terminal. Calcium ions make it possible for synaptic vesicles to release their contents through exocytosis. **9** C **10** A **11** D **12** D **13** B **14** A **15** B **16** D **17** A **18** C **19** C **20** D **21** C **22** C **23** A **24** B **25** B **26** A **27** D **28** D **29** B **30** C **31** D **32** 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. **35** The sensation of taste associated with eating is sensed by nerves in the periphery that are involved in sensory and somatic functions. **36** The disease would target oligodendrocytes. In the CNS, oligodendrocytes provide the myelin for axons. **37** Bipolar cells, because they have one dendrite that receives input and one axon that provides output, would be a direct relay between two other cells. **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. **39** The upper motor neuron would be affected because it is carrying the command from the brain down. **40** The cell membrane must reach threshold before voltage-gated 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. **41** Axons of pain sensing sensory neurons are thin and unmyelinated so that it takes longer for that sensation to reach the brain than other sensations. **42** EPSP1 = +5 mV, EPSP2 = +7 mV, EPSP 3 = +10 mV, IPSP1 = -4 mV, IPSP2 = -3 mV. 5 + 7 + 10 – 4 – 3 = +15 mV. **43** Different neurotransmitters have different receptors. Thus, the type of receptor in the postsynaptic cell is what determines which ion channels open. Acetylcholine binding to the nicotinic receptor causes cations to cross the membrane. GABA binding to its receptor causes the anion chloride to cross the membrane.

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. **2** This is really a matter of opinion, but there are ethical issues to consider when a teenager's behavior results in legal trouble. **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. **4** By disinhibiting the subthalamic nucleus, the indirect pathway increases excitation of the globus pallidus internal segment. That, in turn, inhibits the thalamus, which is the opposite effect of the direct pathway that disinhibits the thalamus. **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. **6** Energy is needed for the brain to develop and perform higher cognitive functions. That energy is not available for the muscle tissues to develop and function. The hypothesis suggests that humans have larger brains and less muscle mass, and chimpanzees have the smaller brains but more muscle mass. **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. **8** The spinal cord ends in the upper lumbar area of the vertebral column, so a needle inserted lower than that will not damage the nervous tissue of the CNS. **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. **10** **Figure 13.20** They derive from the neural crest. **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. **12** The optic nerve enters the CNS in its projection from the eyes in the periphery, which means that it crosses through the meninges. Meningitis will include swelling of those protective layers of the CNS, resulting in pressure on the optic nerve, which can compromise vision. **13** C **14** B **15** A **16** D **17** A **18** D **19** C **20** B **21** A **22** B **23** C **24** A **25** A **26** B **27** D **28** C **29** D **30** A **31** D **32** B **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. **34** The neural crest gives rise to PNS structures (such as ganglia) and also to cartilage and bone of the face and cranium. **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. **36** A copy of descending input from the cerebrum to the spinal cord, through the pons, and sensory feedback from the spinal cord and special senses like balance, through the medulla, both go to the cerebellum. It can therefore send output through the midbrain that will correct spinal cord control of skeletal muscle movements. **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. **38** The nerves that connect the periphery to the CNS pass through these layers of tissue and can be damaged by that inflammation, causing a loss of important neurological functions. **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. **40** The contraction of extraocular muscles is being tested, which is the function of the oculomotor, trochlear, and abducens nerves.

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. **2** **Figure 14.9** The hair cells are located in the organ of Corti, which is located on the basilar membrane. The stereocilia of those cells would normally be attached to the tectorial membrane (though they are detached in the micrograph because of processing of the tissue). **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. **4** High frequencies activate hair cells toward the base of the cochlea, and low frequencies activate hair cells toward the apex of the cochlea. **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. **6** Whereas the video shows opposite movement information in each eye for an object moving toward the face on the midline, movement past one side of the head will result in movement in the same direction on both retinae, but it will be slower in the eye on the side nearer to the object. **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. **8** The video only describes the lateral division of the corticospinal tract. The anterior division is omitted. **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. **10** The left eye also blinks. The sensory input from one eye activates the motor response of both eyes so that they both blink. **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 **13** D **14** B **15** D **16** C **17** C **18** D **19** A **20** A **21** B **22** D **23** B **24** A **25** C **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. **28** The visual field for each eye is projected onto the retina as light is focused by the lens. The visual information from the right visual field falls on the left side of the retina and vice versa. The optic disc in the right eye is on the medial side of the fovea, which would be the left side of the retina. However, the optic disc in the left eye would be on the right side of that fovea, so the right visual field falls on the side of the retina in the left field where there is no blind spot. **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. **30** As the tumor enlarges, it would press against the optic chiasm, and fibers from the medial retina would be disrupted. These fibers carry information about the lateral visual field because the visual scene is reversed as the light passes through the pupil and lens. **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. **32** Though reflexes are simple circuits within the nervous system, they are representative of the more involved circuits of the somatic nervous system and can be used to quickly assess the state of neurological function for a person.

Chapter 15

1 The heart rate increases to send more blood to the muscles, and the liver releases stored glucose to fuel the muscles. **2** The endocrine system is also responsible for responses to stress in our lives. The hypothalamus coordinates the autonomic response through projections into the spinal cord and through influence over the pituitary gland, the effective center of the endocrine system. **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. **4** The optic nerve still carries the afferent input, but the output is from the thoracic spinal cord, through the superior cervical ganglion, to the radial fibers of the iris. **5** The release of urine in extreme fear. The sympathetic system normally constricts sphincters such as that of the urethra. **6** When the visual field is completely taken up by the movie, the brain is confused by the lack of vestibular stimuli to match the visual stimuli. Sitting to the side, or so that the edges of the screen can be seen, will help by providing a stable visual cue along with the magic of the cinematic experience. **7** D **8** A **9** C **10** B **11** A **12** C **13** D **14** B **15** A **16** C **17** A **18** C **19** B **20** D **21** B **22** A **23** C **24** C **25** D **26** B **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. **28** The postganglionic sympathetic fiber releases norepinephrine, whereas the postganglionic parasympathetic fiber releases acetylcholine. Specific locations in the heart have adrenergic receptors and muscarinic receptors. Which receptors are bound is the signal that determines how the heart responds. **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. **30** Within the cardiovascular system, different aspects demonstrate variation in autonomic tone. Heart rate is under parasympathetic tone, and blood pressure is under sympathetic tone. Pharmaceuticals that treat cardiovascular disorders may be more effective if they work with the normal state of the autonomic system. Alternatively, some disorders may be exacerbated by autonomic deficits and common therapies might not be as effective. **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. **32** The heart—based on the resting heart rate—is under parasympathetic tone, and the blood vessels—based on the lack of parasympathetic input—are under sympathetic tone. The vagus nerve contributes to the lowered resting heart rate, whereas the vasomotor nerves maintain the slight constriction of systemic blood vessels. **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. **34** Drops of these substances into the eyes, as was once done cosmetically, blocks the muscarinic receptors in the smooth muscle of the iris. The concentration of this direct application is probably below the concentration that would cause poisoning if it got into the bloodstream. The possibility of that concentration being wrong and causing poisoning is too great, however, for atropine to be used as a cosmetic.

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. **2** History is the report from the patient, or others familiar with the patient, that can assist in diagnosis and formulation of treatment and care—essentially the result of an interview with the patient. **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. **4** The left hemisphere of the cerebrum controls the right side of the body through the corticospinal tract. Because language function is largely associated with the dominant hemisphere, the hand with which a person writes will most likely be the one controlled by the left hemisphere. **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. **6** The fingertips are the most sensitive skin on the hand, so the points of the caliper can be closer together and still be recognized as two separate points. On the palm, the sensitivity is less, so the points need to be farther apart. This will continue on the arm and shoulder, as sensitivity decreases, the discrimination of separate stimuli will be wider. **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. **8** A wide stance would suggest the person needs to maintain balance by broadening their base. Instead of continuous correction to posture, this can keep the body stable when the cerebellum cannot. **9** D **10** A **11** C **12** B **13** D **14** C **15** D **16** B **17** A **18** C **19** A **20** A **21** D **22** A **23** C **24** A **25** D **26** B **27** C **28** D **29** C **30** A **31** B **32** C **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. **35** The main difference between a stroke and TIA is time. If the result of a cerebrovascular accident lasts longer than 24 hours, then it is considered a stroke. Otherwise, it is considered transient and is labeled a TIA. **36** The patient has suffered a stroke to the prefrontal cortex where working memory is localized. **37** Wernicke's area is associated with the comprehension of language, so the person probably doesn't understand the question being asked and cannot respond meaningfully. This is called a receptive aphasia. **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. **39** The medulla is where the accessory nerve, which controls the sternocleidomastoid muscle, and the hypoglossal nerve, which controls the genioglossus muscle, are both located. The weakness of the left side of the neck, and the tendency of the tongue to point to that side, both show that the damage is on the left side of the brain stem. **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. **41** Paralysis means that voluntary muscle control is not possible because of the interruption of descending motor input. Spasticity refers to what could be called "hypercontractility" of the muscles in the absence of the descending input. **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. **43** Rapid alternating movements in speech relate to how the lips, tongue, and palate move to produce speech sounds. The cerebrocerebellum is required for the proper implementation of these movements.

Chapter 17

1 cAMP **2** Thyroid-stimulating hormone. **3** Cortisol. **4** Turning on the lights. **5** Insulin is overproduced. **6** C **7** B **8** B **9** B **10** C **11** B **12** C **13** A **14** B **15** D **16** B **17** C **18** C **19** D **20** B **21** C **22** A **23** B **24** D **25** B **26** B **27** C **28** D **29** A **30** D **31**B **32** B **33** D **34** C **35** A **36** A **37** B **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. **39** Endocrine glands are ductless. They release their secretion into the surrounding fluid, from which it enters the bloodstream or lymph to travel to distant cells. Moreover, the secretions of endocrine glands are hormones. Exocrine glands release their secretions through a duct that delivers the secretion to the target location. Moreover, the secretions of exocrine glands are not hormones, but compounds that have an immediate physiologic function. For example, pancreatic juice contains enzymes that help digest food. **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. **41** In both cAMP and IP_3–calcium signaling, a hormone binds to a cell membrane hormone receptor that is coupled to a G protein. The G protein becomes activated when the hormone binds. In the case of cAMP signaling, the activated G protein activates adenylyl cyclase, which causes ATP to be converted to cAMP. This second messenger can then initiate other signaling events, such as a phosphorylation cascade. In the case of IP_3–calcium signaling, the activated G protein activates phospholipase C, which cleaves a membrane phospholipid compound into DAG and IP_3. IP_3 causes the release of calcium, another second messenger, from intracellular stores. This causes further signaling events. **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. **43** The anterior lobe of the pituitary gland is connected to the hypothalamus by vasculature, which allows regulating hormones from the hypothalamus to travel to the anterior pituitary. In contrast, the posterior lobe is connected to the hypothalamus by a bridge of nerve axons called the hypothalamic–hypophyseal tract, along which the hypothalamus sends hormones produced by hypothalamic nerve cell bodies to the posterior pituitary for storage and release into the circulation. **44** The mammary glands are the target tissues for prolactin. **45** Iodine deficiency in a pregnant woman would also deprive the fetus. Iodine is required for the synthesis of thyroid hormones, which contribute to fetal growth and development, including maturation of the nervous system. Insufficient amounts would impair these functions. **46** Hyperthyroidism is an abnormally elevated blood level of thyroid hormones due to an overproduction of T_3 and T_4. 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. **47** The production and secretion of PTH is regulated by a negative feedback loop. Low blood calcium levels initiate the production and secretion of PTH. PTH increases bone resorption, calcium absorption from the intestines, and calcium reabsorption by the kidneys. As a result, blood calcium levels begin to rise. This, in turn, inhibits the further production and secretion of PTH. **48** A parathyroid gland tumor can prompt hypersecretion of PTH. This can raise blood calcium levels so excessively that calcium deposits begin to

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 **3** A **4** A **5** C **6** B **7** B **8** C **9** C **10** D **11** D **12** D **13** D **14** B **15** C **16** B **17** B **18** A **19** B **20** B **21** C **22** D **23** C **24** D **25** A **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. **28** The pulmonary circuit consists of blood flowing to and from the lungs, whereas the systemic circuit carries blood to and from the entire body. The systemic circuit is far more extensive, consisting of far more vessels and offers much greater resistance to the flow of blood, so the heart must generate a higher pressure to overcome this resistance. This can be seen in the thickness of the myocardium in the ventricles. **29** It prevents additional impulses from spreading through the heart prematurely, thereby allowing the muscle sufficient time to contract and pump blood effectively. **30** It ensures sufficient time for the atrial muscle to contract and pump blood into the ventricles prior to the impulse being conducted into the lower chambers. **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. **32** Without a true resting potential, there is a slow influx of sodium ions through slow channels that produces a prepotential that gradually reaches threshold. **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. **34** Increasing EDV increases the sarcomeres' lengths within the cardiac muscle cells, allowing more cross bridge formation between the myosin and actin and providing for a more powerful contraction. This relationship is described in the Frank-Starling mechanism. **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. **36** The human embryo is rapidly growing and has great demands for nutrients and oxygen, while producing waste products including carbon dioxide. All of these materials must be received from or delivered to the mother for processing. Without an efficient early circulatory system, this would be impossible. **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. **2** Take medications as prescribed, eat a healthy diet, exercise, and don't smoke. **3** A **4** D **5** C **6** B **7** C **8** B **9** A **10** B **11** D **12** D **13** B **14** D **15** A **16** D **17** C **18** C **19** A **20** B **21** C **22** C **23** D **24** A **25** D **26** B **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. **29** Vasoconstriction causes the lumens of blood vessels to narrow. This increases the pressure of the blood flowing within the vessel. **30** This is a venule. **31** The patient's pulse pressure is 130 – 85 = 45 mm Hg. Generally, a pulse pressure should be at least 25 percent of the systolic pressure, but not more than 100 mm Hg. Since 25 percent of 130 = 32.5, the patient's pulse pressure of 45 is normal. The patient's mean arterial pressure is 85 + 1/3 (45) = 85 + 15 = 100. Normally, the mean arterial blood pressure falls within the range of 70 – 110 mmHg, so 100 is normal. **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. **33** The patient's blood would flow more sluggishly from the arteriole into the capillary bed. Thus, the patient's capillary hydrostatic pressure would be below the normal 35 mm Hg at the arterial end. At the same time, the patient's blood colloidal osmotic pressure is normal—about 25 mm Hg. Thus, even at the arterial end of the capillary bed, the net filtration pressure would be below 10 mm Hg, and an abnormally reduced level of filtration would occur. In fact, reabsorption might begin to occur by the midpoint of the capillary bed. **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. **35** This blood pressure is insufficient to circulate blood throughout the patient's body and maintain adequate perfusion of the patient's tissues. Ischemia would prompt hypoxia, including to the brain, prompting confusion. The low blood pressure would also trigger the renin-angiotensin-aldosterone mechanism, and release of aldosterone would stimulate the thirst mechanism in the hypothalamus. **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. **37** The right ventricle of the heart pumps oxygen-depleted blood to the pulmonary arteries. **38** The gonadal veins drain the testes in males and the ovaries in females. **39** The internal carotid arteries and the vertebral arteries provide most of the brain's blood supply. **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. **41** The ductus arteriosus is a blood vessel that provides a passageway between the pulmonary trunk and the aorta during fetal life. Most blood ejected from the fetus' right ventricle and entering the pulmonary trunk is diverted through this structure into the fetal aorta, thus bypassing the fetal lungs.

Chapter 21

1 The three main components are the lymph vessels, the lymph nodes, and the lymph. **2** The dendritic cell transports the virus to a lymph node. **3** The bacterium is digested by the phagocyte's digestive enzymes (contained in its lysosomes). **4** Breastfeeding is an example of natural immunity acquired passively. **5** B **6** A **7** C **8** D **9** A **10** C **11** D **12** B **13** C **14** B **15** B **16** D **17** B **18** C **19** D **20** D **21** D **22** A **23** B **24** D **25** C **26** B **27** B **28** A **29** C **30** C **31** D **32** C **33** A **34** B **35** B **36** A **37** B **38** D **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. **40** The cell debris and damaged cells induce macrophages to begin to clean them up. Macrophages release cytokines that attract neutrophils, followed by more macrophages. Other mediators released by mast cells increase blood flow to the area and also vascular permeability, allowing the recruited cells to get from the blood to the site of infection, where they can phagocytose the dead cells and debris, preparing the site for wound repair. **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. **42** The antigen is digested by the proteasome, brought into the endoplasmic reticulum by the TAP transporter system, where it binds to class I MHC molecules. These are taken to the cell surface by transport vesicles. **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. **44** B cells activated during a primary response differentiate either into terminally differentiated plasma cells or into memory B cells. These memory B cells are what respond during a secondary or memory antibody response. **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. **46** Seroconversion is the clearance of virus in the serum due to the increase in specific serum antibody levels. Seroconversion happens in the early stages of HIV disease. Unfortunately, the antibody cannot completely clear the virus from the body and thus it most often progresses to AIDS. **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. **48** The peanuts cause high levels of mast cell degranulation in the throats of these individuals. The histamine released increases vascular permeability, causing edema and (swelling), making breathing difficult. This must be treated with epinephrine as soon as possible. **49** Antibody response to the cell walls of β-*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 β-*Streptococcus* bacteria. **50** Stress causes the release of hormones and the activation of nerves that suppress the immune response. Short-term stress has little effect on the health of an already healthy individual, whereas chronic stress does lead to increases in disease in such people.

Chapter 22

1 Inflammation and the production of a thick mucus; constriction of the airway muscles, or bronchospasm; and an increased sensitivity to allergens. **2** Patients with respiratory ailments (such as asthma, emphysema, COPD, etc.) have issues with airway resistance and/or lung compliance. Both of these factors can interfere with the patient's ability to move air effectively. A spirometry test can determine how much air the patient can move into and out of the lungs. If the air volumes are low, this can indicate that the patient has a respiratory disease or that the treatment regimen may need to be adjusted. If the numbers are normal, the patient does not have a significant respiratory disease or the treatment regimen is working as expected. **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 **5** A **6** D **7** A **8** C **9** C **10** B **11** A **12** C **13** A **14** A **15** C **16** D **17** A **18** D **19** A **20** D **21** A **22** C **23** B **24** C **25** D **26** B **27** A **28** A **29** D **30** D **31** C **32** A **33** B **34** A **35** C **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. **37** The epiglottis is a region of the larynx that is important during the swallowing of food or drink. As a person swallows, the pharynx moves upward and the epiglottis closes over the trachea, preventing food or drink from entering the trachea. If a person's epiglottis were injured, this mechanism would be impaired. As a result, the person may have problems with food or drink entering the trachea, and possibly, the lungs. Over time, this may cause infections such as pneumonia to set in. **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. **39** The right and left lungs differ in size and shape to accommodate other organs that encroach on the thoracic region. The right lung consists of three lobes and is shorter than the left lung, due to the position of the liver underneath it. The left lung consist of two lobes and is longer and narrower than the right lung. The left lung has a concave region on the mediastinal surface called the cardiac notch that allows space for the heart. **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. **41** Lung compliance refers to the ability of lung tissue to stretch under pressure, which is determined in part by the surface tension of the alveoli and the ability of the connective tissue to stretch. Lung compliance plays a role in determining how much the lungs can change in volume, which in turn helps to determine pressure and air movement. **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. **43** Respiratory rate is defined as the number of breaths taken per minute. Respiratory rate is controlled by the respiratory center, located in the medulla oblongata. Conscious thought can alter the normal respiratory rate through control by skeletal muscle, although one cannot consciously stop the rate altogether. A typical resting respiratory rate is about 14 breaths per minute. **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. **45** The damaged alveoli will have insufficient ventilation, causing the partial pressure of oxygen in the alveoli to decrease. As a result, the pulmonary capillaries serving these alveoli will constrict, redirecting blood flow to other alveoli that are receiving sufficient ventilation. **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. **47** The relationship between the partial pressure of oxygen and the binding of hemoglobin to oxygen is described by the oxygen–hemoglobin saturation/dissociation curve. As the partial pressure of oxygen increases, the number of oxygen molecules bound by hemoglobin increases, thereby increasing the saturation of 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. **49** There are three neural factors that play a role in the increased ventilation observed during exercise. Because this increased ventilation occurs at the beginning of exercise, it is unlikely that only blood oxygen and carbon dioxide levels are involved. The first neural factor is the psychological stimulus of making a conscious decision to exercise. The second neural factor is the stimulus of motor neuron activation by the skeletal muscles, which are involved in exercise. The third neural factor is activation of the proprioceptors located in the muscles, joints, and tendons that stimulate activity in the respiratory centers. **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. **51** At about week 28, enough alveolar precursors have matured so that a baby born prematurely at this time can usually breathe on its own. Other structures that develop about this time are pulmonary capillaries, expanding to create a large surface area for gas exchange. Alveolar ducts and alveolar precursors have also developed. **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. **2** Answers may vary. **3** Answers may vary. **4** Answers may vary. **5** Answers may vary. **6** Answers may vary. **7** Answers may vary. **8** A **9** A **10** D **11** D **12** B **13** D **14** A **15** C **16** B **17** A **18** D **19** C **20** A **21** D **22** B **23** B **24** B **25** D **26** A **27** D **28** C **29** A **30** B **31** D **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. **34** The lamina propria of the mucosa contains lymphoid tissue that makes up the MALT and responds to pathogens encountered in the alimentary canal. **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. **36** The smell of food initiates long reflexes, which result

in the secretion of digestive juices. **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. **38** The incisors. Since these teeth are used for tearing off pieces of food during ingestion, the player will need to ingest foods that have already been cut into bite-sized pieces until the broken teeth are replaced. **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. **40** If the lower esophageal sphincter does not close completely, the stomach's acidic contents can back up into the esophagus, a phenomenon known as GERD. **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. **42** The mucosal barrier protects the stomach from self-digestion. It includes a thick coating of bicarbonate-rich mucus; the mucus is physically protective, and bicarbonate neutralizes gastric acid. Epithelial cells meet at tight junctions, which block gastric juice from penetrating the underlying tissue layers, and stem cells quickly replace sloughed off epithelial mucosal cells. **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. **44** Nutrients from the breakdown of carbohydrates and proteins are absorbed through a capillary bed in the villi of the small intestine. Lipid breakdown products are absorbed into a lacteal in the villi, and transported via the lymphatic system to the bloodstream. **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. **46** The mucosa of the small intestine includes circular folds, villi, and microvilli. The wall of the large intestine has a thick mucosal layer, and deeper and more abundant mucus-secreting glands that facilitate the smooth passage of feces. There are three features that are unique to the large intestine: teniae coli, haustra, and epiploic appendages. **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. **48** The hepatocytes are the main cell type of the liver. They process, store, and release nutrients into the blood. Radiating out from the central vein, they are tightly packed around the hepatic sinusoids, allowing the hepatocytes easy access to the blood flowing through the sinusoids. **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 chime in the intestine. **50** Intrinsic factor secreted in the stomach binds to the large B_{12} compound, creating a combination that can bind to mucosal receptors in the ileum.

Chapter 24

1 C **2** B **3** A **4** B **5** C **6** B **7** C **8** D **9** A **10** D **11** D **12** A **13** C **14** B **15** C **16** D **17** A **18** B **19** D **20** A **21** C **22** B **23** D **24** A **25** C **26** C **27** A **28** C **29** B **30** An increase or decrease in lean muscle mass will result in an increase or decrease in metabolism. **31** Addison's disease is characterized by low cortisol levels. One way to treat the disease is by giving cortisol to the patient. **32** Glucose is oxidized during glycolysis, creating pyruvate, which is processed through the Krebs cycle to produce NADH, $FADH_2$, ATP, and CO_2. The $FADH_2$ and NADH yield ATP. **33** Upon entry into the cell, hexokinase or glucokinase phosphorylates glucose, converting it into glucose-6-phosphate. In this form, glucose-6-phosphate is trapped in the cell. Because all of the glucose has been phosphorylated, new glucose molecules can be transported into the cell according to its concentration gradient. **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. **35** If diabetes is uncontrolled, the glucose in the blood is not being taken up and processed by the cells. Although blood glucose levels are high, there is no glucose available to the cells to be converted into energy. Because glucose is lacking, the body turns to other energy sources, including ketones. A side effect of using ketones as fuel is a sweet alcohol smell on the breath. **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. **37** Trypsin and chymotrypsin are released as inactive proenzymes. They are only activated in the small intestine, where they act upon ingested proteins in the food. This helps avoid unintended breakdown of the pancreas or small intestine. **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. **39** When triglycerides and fatty acids are broken down, acetyl CoA is created. If excess acetyl CoA is generated in this process, the excess is used in ketogenesis or the creation of ketones. This creation results from the conversion of acetyl CoA by thiolase into acetoacetyl CoA. This acetoacetyl CoA is subsequently converted into β-hydroxybutyrate, the most common ketone in the body. **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. **41** The ingestion of food stimulates digestion and processing of the carbohydrates, proteins, and fats. This breakdown of food triggers glycolysis, the Krebs cycle, the electron transport chain, fatty acid oxidation, lipogenesis, and amino acid oxidation to produce energy. Heat is a byproduct of those reactions. **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. **43** Although these foods technically do not have fat added, many times a significant amount of sugar is added to sweeten the food and make it taste better. These foods are non-fat; however, they can lead to significant fat storage or weight gain because the excess sugar is broken down into pyruvate, but overloads the Krebs cycle. When this happens, the sugar is converted into fat through lipogenesis and stored in adipose tissues.

Chapter 25

1 B **2** C **3** D **4** C **5** B **6** C **7** D **8** A **9** A **10** B **11** C **12** C **13** B **14** D **15** B **16** B **17** A **18** B **19** B **20** A **21** C **22** D **23** D **24** A **25** D **26** A **27** B **28** B **29** C **30** D **31** The presence of white blood cells found in the urine suggests urinary tract infection. **32** Diabetes mellitus would result in urine containing glucose, and diabetes insipidus would produce urine with very low osmolarity (low specific gravity, dilute). **33** The longer urethra of males means bacteria must travel farther to the bladder to cause an infection. **34** Forceful urination is accomplished by contraction of abdominal muscles. **35** Retroperitoneal anchoring, renal fat pads, and ribs provide protection to the kidney. **36** The renal portal system has an artery between the first and second capillary bed. The others have a vein. **37** The structures found in the renal hilum are arteries, veins, ureters, lymphatics, and nerves. **38** The structures that make up the renal corpuscle are the glomerulus, Bowman's capsule, and PCT. **39** The major structures comprising the filtration membrane are fenestrations and podocyte fenestra, fused basement membrane, and filtration slits. **40** Net filtration pressure (NFP) = glomerular blood hydrostatic pressure (GBHP) – [capsular hydrostatic pressure (CHP) + blood colloid osmotic pressure (BCOP)] **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. **42** The vasa recta and loop of Henle are involved in countercurrent multiplication. **43** The approximate osmolarities are: CT = 300; deepest loop = 1200; DCT = 100; and collecting ducts = 100–1200. **44** Sodium concentration in the filtrate increases when GFR increases; it will decrease when GFR decreases. **45** To excrete more Na^+ in the urine, increase the flow rate. **46** The liver produces angiotensinogen, the lungs produce ACE, and the kidneys produce renin. **47** PTH affects absorption and reabsorption of calcium. **48** When first discovered, it was named for its known activity—vasoconstriction. **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. **50** Protein has osmotic properties. If there is not enough protein in the blood, water will be attracted to the interstitial space and the cell cytoplasm resulting in tissue edema. **51** The three electrolytes are most closely regulated by the kidney are calcium, sodium, and potassium.

Chapter 26

1 The interstitial fluid (IF). **2** Fluid enters the capillaries from interstitial spaces. **3** Drinking seawater dehydrates the body as the body must pass sodium through the kidneys, and water follows. **4** Because oxygen is reduced, the respiratory rate increases to accommodate, and hyperventilation removes CO_2 faster than normal, resulting in alkalosis. **5** A **6** B **7** C **8** C **9** D **10** A **11** B **12** B **13** A **14** A **15** B **16** C **17** B **18** C **19** B **20** A **21** B **22** C **23** D **24** A **25** B **26** B **27** C **28** A **29** C **30** B **31** There are additional negatively charged molecules in plasma besides chloride. The additional sodium balances the total negative charges. **32** Fluid is moved by a combination of osmotic and hydrostatic pressures. The osmotic pressure results from differences in solute concentrations across cell membranes. Hydrostatic pressure results from the pressure of blood as it enters a capillary system, forcing some fluid out of the vessel into the surrounding tissues. **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. **34** Any imbalance of water entering or leaving the body will create an osmotic imbalance that will adversely affect cell and tissue function. **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. **36** Without having an absolute excess or deficiency of a substance, one can have too much or too little of that substance in a given compartment. Such a relative increase or decrease is due to a redistribution of water or the ion in the body's compartments. This may be due to the loss of water in the blood, leading to a hemoconcentration or dilution of the ion in tissues due to edema. **37** Bicarbonate ions are freely filtered through the glomerulus. They cannot pass freely into the renal tubular cells and must be converted into 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 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. **38** Carbonic acid blood levels are controlled through the respiratory system by the expulsion of CO_2 from the lungs. The formula for the production of bicarbonate ions is reversible if the concentration of CO_2 decreases. As this happens in the lungs, carbonic acid is converted into a gas, and the concentration of the acid decreases. The rate of respiration determines the amount of CO_2 exhaled. If the rate increases, less acid is in the blood; if the rate decreases, the blood can become more acidic. **39** Respiratory acidosis is present as evidenced by the decreased pH and increased pCO_2, with some compensation as shown by the increased total HCO_3^-. His asthma has compromised his respiratory functions, and excess CO_2 is being retained in his blood. **40** Metabolic alkalosis is present as evidenced by the increased pH and increased HCO_3^-, without compensation as seen in the normal pCO_2. The bulimia has caused excessive loss of hydrochloric acid from the stomach and a loss of hydrogen ions from the body, resulting in an excess of bicarbonate ions in the blood.

Chapter 27

1 Sperm remain in the epididymis until they degenerate. **2** Sperm enter the prostate. **3** The fimbriae sweep the oocyte into the uterine tube. **4** The oocyte may not enter the tube and may enter the pelvic cavity. **5** The testes are located in the abdomen. **6** b **7** a **8** b **9** a **10** c **11** d **12** a **13** b **14** c **15** b **16** d **17** c **18** b **19** d **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. **21** Unlike somatic cells, sperm are haploid. They also have very little cytoplasm. They have a head with a compact nucleus covered by an acrosome filled with enzymes, and a mid-piece filled with mitochondria that power their movement. They are motile because of their tail, a structure containing a flagellum, which is specialized for movement. **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. **23** During sexual arousal, nitric oxide (NO) is released from nerve endings near blood vessels within the corpora cavernosa and corpus spongiosum. The release of NO activates a signaling pathway that results in relaxation of the smooth muscles that surround the penile arteries, causing them to dilate. This dilation increases the amount of blood that can enter the penis, and induces the endothelial cells in the penile arterial walls to secrete NO, perpetuating the vasodilation. The rapid increase in blood volume fills the erectile chambers, and the increased pressure of the filled chambers compresses the thin-walled penile venules, preventing venous drainage of the penis. An erection is the result of this increased blood flow to the penis and reduced blood return from the penis. **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. **25** The sperm must swim upward in the vagina, through the cervix, and then through the body of the uterus to one or the other of the two uterine tubes. Fertilization generally occurs in the uterine tube. **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. **27** As a result of the degradation of the corpus luteum, a decline in progesterone concentrations triggers the shedding of the endometrial lining, marking the menses phase of the menstrual cycle. Low progesterone levels also reduce the negative feedback that had been occurring at the hypothalamus and pituitary, and result in the release of GnRH and, subsequently, FSH and LH. FSH stimulates tertiary follicles to grow and granulosa and theca cells begin to produce increased amounts of estrogen. High estrogen concentrations stimulate the endometrial lining to rebuild, marking the proliferative phase of the menstrual cycle. The high estrogen concentrations will eventually lead to a decrease in FSH because of negative feedback, resulting in atresia of all but one of the developing tertiary follicles. The switch to positive feedback that occurs with elevated estrogen production from the dominant follicle stimulates the LH surge that will trigger ovulation. The luteinization of the granulosa cells of the collapsed follicle forms the progesterone-producing corpus luteum. Progesterone from the corpus luteum causes the endometrium to prepare for implantation, in part by secreting nutrient-rich fluid. This marks the secretory phase of the menstrual cycle. Finally, in a non-fertile cycle, the corpus luteum will degrade and menses will occur. **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. **29** As an individual approaches puberty, two changes in sensitivity occur. The first is a decrease of sensitivity in the hypothalamus and pituitary to negative feedback, meaning that it takes increasingly larger concentrations of sex steroid hormones to stop the production of LH and FSH. The second change in sensitivity is an increase in the sensitivity of the gonads to the FSH and LH signals, meaning that the gonads of adults are more responsive to gonadotropins than are the gonads of children. As a result of these two changes, the levels of LH and FSH slowly increase and lead to the enlargement and maturation of the gonads, which in turn leads to secretion of higher levels of sex hormones and the initiation of spermatogenesis and folliculogenesis. **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. **31** If the *SRY* gene were not functional, the XY individual would be genetically a male, but would develop female reproductive structures.

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. **2** Neurulation starts in week 4. **3** A regular heartbeat can be detected at approximately 8 weeks. **4** C **5** A **6** B **7** C **8** A **9** D **10** B **11** A **12** B **13** C **14** A **15** C **16** B **17** C **18** A **19** C **20** B **21** D **22** B **23** A **24** B **25** C **26** B **27** A **28** D **29** C **30** C **31** D **32** 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** Sherrise's concern is valid. Sperm may be viable for up to 4 days; therefore, it is entirely possible that capacitated sperm are still residing in her uterine tubes and could fertilize the oocyte she has just ovulated. **34** The timing of this discomfort and bleeding suggests that it is probably caused by implantation of the blastocyst into the uterine wall. **35** Folate, one of the B vitamins, is important for the healthy formation of the embryonic neural tube, which occurs in the first few weeks following conception—often before a woman even realizes she is pregnant. A folate-deficient environment increases the risk of a neural tube defect, such as spina bidifa, in the newborn. **36** 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** Premature lungs may not have adequate surfactant, a molecule that reduces surface tension in the lungs and assists proper lung expansion after birth. If the lungs do not expand properly, the newborn will develop hypoxia and require supplemental oxygen or other respiratory support. **38** 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** Janine is 41 weeks pregnant, and the mild contractions she has been experiencing "for days" have dilated her cervix to 2 cm. These facts suggest that she is in labor, but that the labor is not progressing appropriately. Pitocin is a pharmaceutical preparation of synthetic prostaglandins and oxytocin, which will increase the frequency and strength of her contractions and help her labor to progress to birth. **40** 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** The newborn's kidneys are immature and inefficient at concentrating urine. Therefore, newborns produce very dilute urine—in a sense, wasting fluid. This increases their risk for dehydration, and makes it critical that caregivers provide newborns with enough fluid, especially during bouts of vomiting or diarrhea. **42** 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** It takes time to establish a balance between milk supply and milk demand. When breastfeeding stops abruptly, it takes time for the supply to fall. Excessive milk supply creates breast engorgement and leakage. **44** 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. **45** The only way an affected daughter could be born is if the female carrier mated with a male who was affected. In this case, 50 percent of the daughters would be affected. Alternatively, but exceedingly unlikely, the daughter could become affected by a spontaneous mutation.