

Appendix A

Table of Measurements

Table A.1 Table of Measurements			
Unit	Metric Equivalent	Symbol	U.S. Equivalent
Measures of Length			
1 kilometer	= 1000 meters	km	0.62137 mile
1 meter	= 10 decimeters or 100 centimeters	m	39.37 inches
1 decimeter	= 10 centimeters	dm	3.937 inches
1 centimeter	= 10 millimeters	cm	0.3937 inch
1 millimeter	= 1000 micrometers	mm	
1 micrometer	= 1/1000 millimeter or 1000 nanometers	μm	
1 nanometer	= 10 angstroms or 1000 picometers	nm	
1 angstrom	= 1/10,000,000 millimeter	Å	
1 picometer	= 1/1,000,000,000 millimeter	pm	
Measures of Volume			
1 cubic meter	= 1000 cubic decimeters	m ³	1.308 cubic yards
1 cubic decimeter	= 1000 cubic centimeters	dm ³	0.03531 cubic foot
1 cubic centimeter	= 1000 cubic millimeters or 1 milliliter	cm ³ (cc)	0.06102 cubic inch
Measures of Capacity			
1 kiloliter	= 1000 liters	kL	264.18 gallons
1 liter	= 10 deciliters	L	1.0567 quarts
1 deciliter	= 100 milliliters	dL	0.4227 cup
1 milliliter	= volume of 1 gram of water at standard temperature and pressure	mL	0.3381 ounce
Measures of Mass			
1 kilogram	= 1000 grams	kg	2.2046 pounds
1 gram	= 100 centigrams or 1000 milligrams	g	0.0353 ounce
1 centigram	= 10 milligrams	cg	0.1543 grain
1 milligram	= 1/1000 gram	mg	

Note that a micrometer was formerly called a micron (μ), and a nanometer was formerly called a millimicron (mμ).

Appendix B

Scientific Notation

Very large numbers with many zeros such as 1,000,000,000,000,000 or very small numbers such as 0.0000000000000001 are very cumbersome to work with. Consequently, the numbers are expressed in a kind of mathematical shorthand known as scientific notation. Scientific notation has the following form:

$$M \times 10^n$$

where n specifies how many times the number M is raised to the power of 10. The exponent n has two meanings, depending on its sign. If n is positive, M is multiplied by 10^n times. For example, if $n = 2$ and $M = 1.2$, then

$$1.2 \times 10^2 = 1.2 \times 10 \times 10 = 120$$

In other words, if n is positive, the decimal point of M

is moved to the right n times. In this case the decimal point of 1.2 is moved two places to the right.

$$\overset{1,20.}{1.2}$$

If n is negative, M is divided by 10^n times.

$$1.2 \times 10^{-2} = \frac{1.2}{(10 \times 10)} = \frac{1.2}{100} = 0.012$$

In other words, if n is negative, the decimal point of M is moved to the left n times. In this case the decimal point of 1.2 is moved two places to the left.

$$0.012$$

If M is the number 1.0, it often is not expressed in scientific notation. For example, 1.0×10^2 is the same thing as 10^2 , and 1.0×10^{-2} is the same thing as 10^{-2} .

Two common examples of the use of scientific notation in chemistry are Avogadro's number and pH. Avogadro's number, 6.023×10^{23} , is the number of atoms in 1 molar mass of an element. Thus

$$6.023 \times 10^{23} = 602,300,000,000,000,000,000$$

which is a very large number of atoms.

The pH scale is a measure of the concentration of hydrogen ions in a solution. A neutral solution has 10^{-7} moles of hydrogen ions per liter. In other words

$$10^{-7} = 0.0000001$$

which is a very small amount (1 ten-millionth of a gram) of hydrogen ions.

Appendix C

Solution Concentrations

Physiologists often express solution concentration in terms of percent, molarity, molality, and equivalents.

Percent

The weight-volume method of expressing percent concentrations states the weight of a solute in a given volume of solvent. For example, to prepare a 10% solution of sodium chloride, 10 g of sodium chloride is dissolved in a small amount of water (solvent) to form a salt solution. Then additional water is added to the salt solution to form 100 mL of salt solution. Note that the sodium chloride was dissolved in water and then diluted to the required volume. The sodium chloride was not dissolved directly in 100 mL of water.

Molarity

Molarity determines the number of moles of solute dissolved in a given volume of solvent. A 1 molar (1 M) solution is made by dissolving 1 mole (mol) of a substance in enough water to make 1 L of solution. For example, 1 mol of sodium chloride solution is made by dissolving 58.44 g of sodium chloride in enough water to make 1 L of solution. One mol of glucose solution is made by dissolving 180.2 g of glucose in enough water to make 1 L of solution. Both solutions have the same number (Avogadro's number) of formula units (NaCl) and molecules (glucose) in solution.

Molality

Although 1 M solutions have the same number of solute molecules, they don't have the same number of solvent (water) molecules. Because 58.5 g of sodium chloride occupies less volume than 180 g of glucose, the sodium chloride solution has more water molecules. **Molality** is a method of calculating concentrations that takes into account the number of solute and solvent molecules. A 1 molal solution (1 *m*) is 1 mol of a substance dissolved in 1 kg of water. Thus all 1-molal solutions have the same number of solvent molecules.

When sodium chloride, which is an ionic compound, is dissolved in water it dissociates to form two ions, a sodium cation (Na^+) and a chloride anion (Cl^-). Glucose does not dissociate when dissolved in water, however, because it's a molecule. Thus, the sodium chloride solution contains twice as many particles as the glucose solution (one Na^+ and one Cl^- for each glucose molecule). To report the concentration of these substances in a way that reflects the number of particles in a given mass of solvent the concept of **osmolality** is used. The osmolality of a solution is the molality of the solution times the number of particles into which the solute dissociates in 1 kg of solvent. Thus 1 mol of sodium chloride in 1 kg of water is a 2 osmolal (osm) solution because sodium chloride dissociates to form two ions.

The osmolality of a solution is a reflection of the number, not the type, of particles in a solution. Thus a 1 osm solution contains 1 osm of particles per kilogram of solvent, but the particles may be all one type or a complex mixture of different types.

The concentration of particles in body fluids is so low that the measurement milliosmole (mOsm), 1/1000 of an osmole, is used. Most body fluids have an osmotic concentration of approximately 300 mOsm and consist of many different ions and molecules. The osmotic concentration of body fluids is important because it influences the movement of water into or out of cells (see chapter 3).

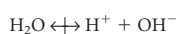
Equivalents

Equivalents are a measure of the concentrations of ionized substances. One equivalent (Eq) is 1 mol of an ionized substance multiplied by the absolute value of its charge. For example, 1 mol of NaCl dissociates into 1 mol of Na^+ and 1 mol of Cl^- . Thus there is 1 Eq of Na^+ (1 mol \times 1) and 1 Eq of Cl^- (1 mol \times 1). One mole of CaCl_2 dissociates into 1 mol of Ca^{2+} and 2 mol of Cl^- . Thus there are 2 Eq of Ca^{2+} (1 mol \times 2) and 2 Eq of Cl^- (2 mol \times 1). In an electrically neutral solution the equivalent concentration of positively charged ions is equal to the equivalent concentration of the negatively charged ions. One milliequivalent (mEq) is 1/1000 of an equivalent.

Appendix D

pH

Pure water weakly dissociates to form small numbers of hydrogen and hydroxide ions:



At 25°C the concentration of both hydrogen ions and hydroxide ions is 10^{-7} mol/L. Any solution that

has equal concentrations of hydrogen and hydroxide ions is considered **neutral**. A solution is an **acid** if it has a higher concentration of hydrogen ions than hydroxide ions, and a solution is a **base** if it has a lower concentration of hydrogen ions than hydroxide ions. In any aqueous solution (at 25°C) the hy-

drogen ion concentration $[\text{H}^+]$ times the hydroxide ion concentration $[\text{OH}^-]$ is a constant that is equal to 10^{-14} .

$$[\text{H}^+] \times [\text{OH}^-] = 10^{-14}$$

Consequently, as the hydrogen ion concentration

Appendix E

decreases, the hydroxide ion concentration increases, and vice versa. For example:

	[H ⁺]	[OH ⁻]
Acidic solution	10 ⁻³	10 ⁻¹¹
Neutral solution	10 ⁻⁷	10 ⁻⁷
Basic solution	10 ⁻¹²	10 ⁻²

Although the acidity or basicity of a solution could be expressed in terms of either hydrogen or hydroxide ion

concentration, it's customary to use hydrogen ion concentration. The pH of a solution is defined as

$$\text{pH} = -\log_{10}(\text{H}^+)$$

Thus a neutral solution with 10⁻⁷ mol of hydrogen ions per liter has a pH of 7

$$\begin{aligned} \text{pH} &= -\log_{10}(\text{H}^+) \\ &= -\log_{10}(10^{-7}) \end{aligned}$$

$$\begin{aligned} &= -(-7) \\ &= 7 \end{aligned}$$

In simple terms, to convert the hydrogen ion concentration to the pH scale, the exponent of the concentration (e.g., -7) is used, and it's changed from a negative to a positive number. Thus an acidic solution with 10⁻³ mol of hydrogen ions/L has a pH of 3, whereas a basic solution with 10⁻¹² hydrogen ions/L has a pH of 12.

Appendix E

Reference Laboratory Values

Table E.1 Blood, Plasma, or Serum Values

Test	Normal Values	Clinical Significance
Acetoacetate plus acetone	0.32–2 mg/100 mL	Values increase in diabetic acidosis, fasting, high-fat diet, and toxemia of pregnancy
Ammonia	80–110 μg/100 mL	Values decrease with proteinuria and as a result of severe burns and increase in multiple myeloma
Amylase	4–25 U/mL*	Values increase in acute pancreatitis, intestinal obstruction, and mumps; values decrease in cirrhosis of the liver, toxemia of pregnancy, and chronic pancreatitis
Barbiturate	0	Coma level: phenobarbital, approximately 10 mg/100 mL; most other drugs, 1–3 mg/100 mL
Bilirubin	0.4 mg/100 mL	Values increase in conditions causing red blood cell destruction of biliary obstruction or liver inflammation
Blood volume	8.5%–9% of body weight in kilograms	
Calcium	8.5–10.5 mg/dL	Values increase in hyperparathyroidism, vitamin D hypervitaminosis; values decrease in hypoparathyroidism, malnutrition, and severe diarrhea
Carbon dioxide content	24–30 mEq/L 20–26 mEq/L in infants (as HCO ₃ ⁻)	Values increase in respiratory diseases, vomiting, and intestinal obstruction; they decrease in acidosis, nephritis, and diarrhea
Carbon monoxide	0	Symptoms with over 20% saturation
Chloride	100–106 mEq/L	Values increase in Cushing's syndrome, nephritis, and hyperventilation; they decrease in diabetic acidosis, Addison's disease, and diarrhea and after severe burns
Creatine phosphokinase (CPK)	Female 5–35 mU/mL Male 5–55 mU/mL	Values increase in myocardial infarction and skeletal muscle diseases such as muscular dystrophy
Creatinine	0.6–1.5 mg/100 mL	Values increase in certain kidney diseases
Ethanol	0	0.3%–0.4%, marked intoxication 0.4%–0.5%, alcoholic stupor 0.5% or over, alcoholic coma
Glucose	Fasting 70–110 mg/100 mL	Values increase in diabetes mellitus, liver diseases, nephritis, hyperthyroidism, and pregnancy; they decrease in hyperinsulinism, hypothyroidism, and Addison's disease
Iron	50–150 μg/100 mL	Values increase in various anemias and liver disease; they decrease in iron deficiency anemia

*A unit (U) is the quantity of a substance that has a physiologic effect.

Table E.1 *continued*

Test	Normal Values	Clinical Significance
Lactic acid	0.6–1.8 mEq/L	Values increase with muscular activity and in congestive heart failure, severe hemorrhage, shock, and anaerobic exercise
Lactic dehydrogenase	60–120 U/mL	Values increase in pernicious anemia, myocardial infarction, liver diseases, acute leukemia, and widespread carcinoma
Lipids	Cholesterol 120–220 mg/100 mL Cholesterol esters 60%–75% of cholesterol Phospholipids 9–16 mg/100 mL as lipid phosphorus Total fatty acids 190–420 mg/100 mL Total lipids 450–1000 mg/100 mL Triglycerides 40–150 mg/100 mL	Increased values for cholesterol and triglycerides are connected with increased risk of cardiovascular disease, such as heart attack and stroke
Lithium	Toxic levels 2 mEq/L	
Osmolality	285–295 mOsm/kg water	
Oxygen saturation (arterial) see Po ₂	96%–100%	
Pco ₂	35–43 mm Hg	Values decrease in acidosis, nephritis, and diarrhea; they increase in respiratory diseases, intestinal obstruction, and vomiting
pH	7.35–7.45	Values decrease as a result of hypoventilation, severe diarrhea, Addison's disease, and diabetic acidosis; values increase due to hyperventilation, Cushing's syndrome, and vomiting
Po ₂	75–100 mm Hg (breathing room air)	Values increase in polycythemia and decrease in anemia and obstructive pulmonary diseases
Phosphatase (acid)	Male: total 0.13–0.63 U/mL Female: total 0.01–0.56 U/mL	Values increase in cancer of the prostate gland, hyperparathyroidism, some liver diseases, myocardial infarction, and pulmonary embolism
Phosphatase (alkaline)	13–39 IU/L* (infants and adolescents up to 104 IU/L)	Values increase in hyperparathyroidism, some liver diseases, and pregnancy
Phosphorus (inorganic)	3–4.5 mg/100 mL (infants in first year up to 6 mg/100 mL)	Values increase in hypoparathyroidism, acromegaly, vitamin D hypervitaminosis, and kidney diseases; they decrease in hyperparathyroidism
Potassium	3.5–5 mEq/100 mL	
Protein	Total 6–8.4 g/100 mL Albumin 3.5–5 g/100 mL Globulin 2.3–3.5 g/100 mL	Total protein values increase in severe dehydration and shock; they decrease in severe malnutrition and hemorrhage
Salicylate Therapeutic Toxic	0	20–25 mg/100 mL Over 30 mg/100 mL Over 20 mg/100 mL after age 60
Sodium	135–145 mEq/L	Values increase in nephritis and severe dehydration; they decrease in Addison's disease, myxedema, kidney disease, and diarrhea
Sulfonamide Therapeutic	0	5–15 mg/100 mL
Urea nitrogen	8–25 mg/100 mL	Values increase in response to increased dietary protein intake; values decrease in impaired renal function
Uric acid	3–7 mg/100 mL	Values increase in gout and toxemia of pregnancy and as a result of tissue damage

Table E.2 Blood Count Values		
Test	Normal Values	Clinical Significance
Clotting (coagulation) time	5–10 minutes	Values increase in afibrinogenemia and hyperheparinemia, severe liver damage
Fetal hemoglobin	Newborns: 60%–90% Before age 2: 0%–4% Adults: 0%–2%	Values increase in thalassemia, sickle-cell disease, and leakage of fetal blood into maternal bloodstream during pregnancy
Hemoglobin	Male: 14–16.5 g/100 mL Female: 12–15 g/100 mL Newborn: 14–20 g/100 mL	Values decrease in anemia, hyperthyroidism, cirrhosis of the liver, and severe hemorrhage; values increase in polycythemia, congestive heart failure, obstructive pulmonary disease, high altitudes
Hematocrit	Male: 40%–54% Female: 38%–47%	Values increase in polycythemia, severe dehydration, and shock; values decrease in anemia, leukemia, cirrhosis, and hyperthyroidism
Ketone bodies	0.3–2 mg/100 mL Toxic level: 20 mg/100 mL	Values increase in ketoacidosis, fever, anorexia, fasting, starvation, high-fat diet
Platelet count	250,000–400,000/mm ³	Values decrease in anemias and allergic conditions and during cancer chemotherapy; values increase in cancer, trauma, heart disease, and cirrhosis
Prothrombin time	11–15 seconds	Values increase in prothrombin and vitamin deficiency, liver disease, and hypervitaminosis A
Red blood cell count	Males: 4.6–6.2 million/mm ³ Females: 4.2–5.4 million/mm ³	Values decrease in systemic lupus erythematosus, anemias, and Addison's disease; values increase in polycythemia and dehydration and following hemorrhage
Reticulocyte count	1%–3%	Values decrease in iron-deficiency and pernicious anemia and radiation therapy; values increase in hemolytic anemia, leukemia, and metastatic carcinoma
White blood cell count, differential	Neutrophils 60%–70% Eosinophils 2%–4% Basophils 0.5%–1% Lymphocytes 20%–25% Monocytes 3%–8%	Neutrophils increase in acute infections; eosinophils and basophils increase in allergic reactions; monocytes increase in chronic infections; lymphocytes increase during antigen–antibody reactions
White blood cell count, total	5000–9000/mm ³	Values decrease in diabetes mellitus, anemias, and following cancer chemotherapy; values increase in acute infections, trauma, some malignant diseases, and some cardiovascular diseases

Table E.3 Urine Values

Test	Normal Values	Clinical Significance
Acetone and acetoacetate	0	Values increase in diabetic acidosis and during fasting
Albumin	0 to trace	Values increase in glomerular nephritis and hypertension
Ammonia	20–70 mEq/L	Values increase in diabetes mellitus and liver disease
Bacterial count	Under 10,000/mL	Values increase in urinary tract infection
Bile and bilirubin	0	Values increase in biliary tract obstruction
Calcium	Under 250 mg/24 h	Values increase in hyperparathyroidism and decrease in hypoparathyroidism
Chloride	110–254 mEq/24 h	Values decrease in pyloric obstruction and diarrhea; values increase in Addison's disease and dehydration
Potassium	25–100 mEq/L	Values decrease in diarrhea, malabsorption syndrome, and adrenal cortical insufficiency; values increase in chronic renal failure, dehydration, and Cushing's syndrome
Sodium	75–200 mg/24 h	Values decrease in diarrhea, acute renal failure, and Cushing's syndrome; values increase in dehydration, starvation, and diabetic acidosis
Creatinine clearance	100–140 mL/min	Values increase in renal diseases
Creatinine	1–2 g/24 h	Values increase in infections and decrease in muscular atrophy, anemia, and certain kidney diseases
Glucose	0	Values increase in diabetes mellitus and certain pituitary gland disorders
Urea clearance	Over 40 mL of blood cleared of urea per minute	Values increase in certain kidney diseases
Urea	25–35 g/24 h	Values decrease in complete biliary obstruction and severe diarrhea; values increase in liver diseases and hemolytic anemia
Uric acid	0.6– 1 g/24 h	Values increase in gout and decrease in certain kidney diseases
Casts		
Epithelial	Occasional	Increase in nephrosis and heavy-metal poisoning
Granular	Occasional	Increase in nephritis and pyelonephritis
Hyaline	Occasional	Increase in glomerular membrane damage and fever
Red blood cell	Occasional	Values increase in pyelonephritis; blood cells appear in urine in response to kidney stones and cystitis
White blood cell	Occasional	Values increase in kidney infections
Color	Amber, straw, transparent yellow	Varies with hydration, diet, and disease states
Odor	Aromatic	Becomes acetone-like in diabetic ketosis
Osmolality	500–800 mOsm/kg water	Values decrease in aldosteronism and diabetes insipidus; values increase in high-protein diets, heart failure, and dehydration
pH	4.6–8	Values decrease in acidosis, emphysema, starvation, and dehydration; values increase in urinary tract infections and severe alkalosis

Table E.4 Hormone Levels

Test	Normal Values
Steroid hormones	
Aldosterone	Excretion: 5–19 mg/24 h*
Fasting at rest, 210 mEq sodium diet	Supine: 48 ± 29 pg/mL† Upright: 65 ± 23 pg/mL
Fasting at rest, 10 mEq sodium diet	Supine: 175 ± 75 pg/m Upright: 532 ± 228 pg/mL
Cortisol	
Fasting	8 A.M.: 5–25 µg/100 mL
At rest	8 P.M.: Below 10 µg/100 mL
Testosterone	Adult male: 300–1100 ng/100 mL‡ Adolescent male: over 100 ng/100 mL Female: 25–90 ng/100 mL
Peptide hormones	
Adrenocorticotropin (ACTH)	15–170 pg/mL
Calcitonin	Undetectable in normals
Growth hormone (GH)	
Fasting, at rest	Below 5 ng/mL
After exercise	Children: over 10 ng/mL Male: below 5 ng/mL Female: up to 30 ng/mL
Insulin	
Fasting	6–26 µU/mL
During hypoglycemia	Below 20 µU/mL
After glucose	Up to 150 µU/mL
Luteinizing hormone (LH)	Male: 6–18 mU/mL Preovulatory or postovulatory female: 5–22 mU/mL Midcycle peak 30–250 mU/mL
Parathyroid hormone	Less than 10 microl equiv/L
Prolactin	2–15 ng/mL
Renin activity	
Normal diet	
Supine	1.1 ± 0.8 ng/mL/h
Upright	1.9 ± 1.7 ng/mL/h
Low-sodium diet	
Supine	2.7 ± 1.8 ng/mL/h
Upright	6.6 ± 2.5 ng/mL/h
Thyroid-stimulating hormone (TSH)	0.5–3.5 µU/mL
Thyroxine-binding globulin	15.25 µg T ₄ /100 mL
Total thyroxine	4–12 µg/100 mL

*1 microgram (1 µg) is equal to 10⁻⁶ g.

†1 picogram (1 pg) is equal to 10⁻¹² g.

‡1 nanogram (1 ng) is equal to 10⁻⁹ g.

Appendix F

Answers To Review and Comprehension Questions

Chapter One

1. a; 2. b; 3. a; 4. c; 5. d; 6. e; 7. a; 8. b; 9. c; 10. d; 11. d; 12. c; 13. d; 14. d; 15. a; 16. b; 17. b; 18. a; 19. e; 20. c; 21. a; 22. b; 23. a; 24. b; 25. e

Chapter Two

1. e; 2. a; 3. b; 4. b; 5. a; 6. d; 7. b; 8. e; 9. c; 10. e; 11. c; 12. d; 13. a; 14. b; 15. c; 16. c; 17. d; 18. c; 19. d; 20. e; 21. b; 22. a; 23. b; 24. d; 25. b; 26. a; 27. c; 28. d; 29. a; 30. e

Chapter Three

1. a; 2. e; 3. c; 4. d; 5. e; 6. c; 7. e; 8. d; 9. b; 10. b; 11. a; 12. b; 13. b; 14. a; 15. d; 16. d; 17. b; 18. b; 19. c; 20. e; 21. c; 22. c; 23. b; 24. c; 25. d; 26. c; 27. a; 28. d; 29. e; 30. e

Chapter Four

1. e; 2. c; 3. a; 4. a; 5. b; 6. d; 7. c; 8. d; 9. d; 10. b; 11. a; 12. b; 13. b; 14. e; 15. a; 16. d; 17. b; 18. b; 19. d; 20. d; 21. a; 22. b; 23. e; 24. b; 25. c; 26. c; 27. b; 28. c; 29. b; 30. d

Chapter Five

1. e; 2. a; 3. b; 4. a; 5. b; 6. b; 7. d; 8. e; 9. b; 10. a; 11. c; 12. d; 13. e; 14. c; 15. d; 16. b; 17. c; 18. c; 19. d; 20. b; 21. c; 22. b; 23. a; 24. b; 25. a; 26. d; 27. c; 28. d; 29. c; 30. c

Chapter Six

1. e; 2. e; 3. d; 4. a; 5. c; 6. e; 7. d; 8. b; 9. d; 10. c; 11. e; 12. a; 13. a; 14. b; 15. e; 16. c; 17. a; 18. c; 19. e; 20. d; 21. a; 22. b; 23. c; 24. e; 25. a; 26. e; 27. c; 28. e; 29. d; 30. a

Chapter Seven

1. c; 2. c; 3. e; 4. d; 5. c; 6. d; 7. c; 8. a; 9. d; 10. a; 11. b; 12. a; 13. a; 14. c; 15. a; 16. b; 17. c; 18. a; 19. d; 20. e; 21. c; 22. b; 23. c; 24. a; 25. b; 26. c; 27. b; 28. c; 29. a; 30. a

Chapter Eight

1. e; 2. b; 3. d; 4. d; 5. a; 6. e; 7. d; 8. e; 9. c; 10. d; 11. b; 12. a; 13. b; 14. e; 15. a; 16. d; 17. c; 18. d; 19. e; 20. a; 21. c; 22. b; 23. c; 24. d; 25. b; 26. b; 27. a; 28. c; 29. c

Chapter Nine

1. c; 2. e; 3. a; 4. d; 5. c; 6. e; 7. b; 8. a; 9. b; 10. b; 11. d; 12. b; 13. d; 14. c; 15. e; 16. e; 17. d; 18. c; 19. c; 20. a; 21. d; 22. b; 23. d; 24. a; 25. d; 26. c; 27. c; 28. c; 29. c; 30. b

Chapter Ten

1. d; 2. b; 3. c; 4. c; 5. c; 6. c; 7. d; 8. d; 9. b; 10. c; 11. a; 12. a; 13. c; 14. d; 15. a; 16. b; 17. d; 18. b; 19. a; 20. d; 21. a; 22. c; 23. a; 24. a; 25. d; 26. c; 27. b; 28. b; 29. d

Chapter Eleven

1. a; 2. b; 3. b; 4. a; 5. c; 6. c; 7. b; 8. a; 9. c; 10. a; 11. b; 12. d; 13. a; 14. c; 15. b; 16. a; 17. a; 18. b; 19. d; 20. c; 21. e; 22. b; 23. d; 24. d; 25. b; 26. b; 27. e; 28. e; 29. b; 30. a

Chapter Twelve

1. d; 2. c; 3. c; 4. d; 5. b; 6. b; 7. d; 8. c; 9. c; 10. b; 11. e; 12. c; 13. d; 14. d; 15. c; 16. e; 17. c; 18. d; 19. c; 20. d

Chapter Thirteen

1. c; 2. b; 3. e; 4. c; 5. d; 6. b; 7. b; 8. b; 9. c; 10. a; 11. e; 12. d; 13. d; 14. a; 15. c; 16. d; 17. b; 18. b; 19. a; 20. a; 21. d; 22. a; 23. b; 24. b; 25. e; 26. b; 27. c; 28. e; 29. c; 30. b; 31. b

Chapter Fourteen

1. c; 2. d; 3. d; 4. c; 5. a; 6. d; 7. b; 8. e; 9. a; 10. b; 11. b; 12. e; 13. c; 14. c; 15. b; 16. d; 17. a; 18. b; 19. b; 20. d; 21. b; 22. b; 23. d; 24. e; 25. d; 26. b; 27. b; 28. d; 29. e; 30. e

Chapter Fifteen

1. e; 2. e; 3. c; 4. a; 5. b; 6. e; 7. b; 8. a; 9. c; 10. d; 11. b; 12. b; 13. c; 14. d; 15. c; 16. b; 17. a; 18. d; 19. c; 20. d; 21. e; 22. a; 23. d; 24. c; 25. a; 26. a; 27. b; 28. d; 29. a; 30. c

Chapter Sixteen

1. e; 2. d; 3. d; 4. a; 5. e; 6. b; 7. d; 8. e; 9. d; 10. d; 11. d; 12. a; 13. a; 14. c; 15. e; 16. a; 17. d; 18. a; 19. e; 20. c

Chapter Seventeen

1. c; 2. c; 3. b; 4. e; 5. d; 6. b; 7. a; 8. e; 9. b; 10. a; 11. c; 12. e; 13. c; 14. e; 15. a; 16. d; 17. c; 18. d; 19. a; 20. c

Chapter Eighteen

1. e; 2. d; 3. e; 4. b; 5. a; 6. c; 7. b; 8. b; 9. e; 10. c; 11. d; 12. e; 13. a; 14. d; 15. b; 16. c; 17. a; 18. a; 19. d; 20. c; 21. d; 22. e; 23. e; 24. d; 25. b; 26. d; 27. a; 28. d; 29. a; 30. b; 31. e; 32. c; 33. c; 34. e; 35. d

Chapter Nineteen

1. e; 2. c; 3. a; 4. e; 5. d; 6. a; 7. e; 8. d; 9. b; 10. c; 11. d; 12. b; 13. b; 14. a; 15. c; 16. b; 17. b; 18. e; 19. e; 20. b; 21. a; 22. a; 23. d; 24. a; 25. d; 26. c; 27. c; 28. c; 29. d; 30. b

Chapter Twenty

1. d; 2. e; 3. c; 4. a; 5. b; 6. d; 7. c; 8. c; 9. a; 10. a; 11. c; 12. d; 13. a; 14. b; 15. e; 16. a; 17. a; 18. b; 19. e; 20. b; 21. c; 22. d; 23. a; 24. a; 25. d; 26. c; 27. c; 28. c; 29. e; 30. c

Chapter Twenty-One

1. b; 2. a; 3. a; 4. d; 5. d; 6. b; 7. c; 8. d; 9. a; 10. a; 11. d; 12. e; 13. c; 14. a; 15. c; 16. b; 17. b; 18. d; 19. a; 20. e; 21. d; 22. b; 23. b; 24. b; 25. d; 26. a; 27. d; 28. c; 29. b; 30. e

Chapter Twenty-Two

1. d; 2. c; 3. a; 4. b; 5. a; 6. e; 7. d; 8. d; 9. e; 10. b; 11. a; 12. d; 13. d; 14. e; 15. d; 16. b; 17. e; 18. e; 19. a; 20. d; 21. c; 22. a; 23. b; 24. c; 25. a; 26. d; 27. d; 28. d; 29. d; 30. c

Chapter Twenty-Three

1. a; 2. b; 3. e; 4. d; 5. e; 6. c; 7. d; 8. b; 9. c; 10. b; 11. d; 12. a; 13. d; 14. c; 15. c; 16. d; 17. c; 18. d; 19. b; 20. d; 21. b; 22. c; 23. b; 24. b; 25. c; 26. a; 27. c; 28. a; 29. d; 30. d

Chapter Twenty-Four

1. a; 2. d; 3. e; 4. d; 5. a; 6. b; 7. a; 8. b; 9. a; 10. c; 11. b; 12. d; 13. c; 14. d; 15. e; 16. b; 17. d; 18. d; 19. e; 20. e; 21. b; 22. b; 23. b; 24. a; 25. e; 26. e; 27. e; 28. a; 29. c; 30. a

Chapter Twenty-Five

1. d; 2. c; 3. a; 4. e; 5. b; 6. d; 7. e; 8. e; 9. b; 10. a; 11. d; 12. b; 13. d; 14. a; 15. e; 16. c; 17. a; 18. b; 19. a; 20. b

Chapter Twenty-Six

1. d; 2. b; 3. d; 4. c; 5. e; 6. e; 7. b; 8. b; 9. d; 10. e; 11. a; 12. b; 13. b; 14. b; 15. a; 16. a; 17. c; 18. d; 19. c; 20. b; 21. e; 22. d; 23. e; 24. d; 25. d; 26. c; 27. e; 28. a; 29. b; 30. c

Chapter Twenty-Seven

1. b; 2. a; 3. b; 4. c; 5. d; 6. a; 7. a; 8. a; 9. b; 10. a; 11. b; 12. d; 13. a; 14. a; 15. b; 16. d; 17. a; 18. c; 19. c; 20. d

Chapter Twenty-Eight

1. e; 2. a; 3. a; 4. b; 5. d; 6. e; 7. b; 8. b; 9. d; 10. c; 11. b; 12. c; 13. a; 14. e; 15. a; 16. b; 17. d; 18. c; 19. b; 20. a; 21. a; 22. c; 23. a; 24. c; 25. e; 26. e; 27. c; 28. d; 29. c; 30. a

Chapter Twenty-Nine

1. d; 2. e; 3. a; 4. a; 5. d; 6. a; 7. c; 8. c; 9. b; 10. c; 11. a; 12. a; 13. e; 14. d; 15. c; 16. c; 17. e; 18. a; 19. b; 20. d; 21. a; 22. c; 23. d; 24. c; 25. c; 26. b; 27. c; 28. c; 29. d

Appendix G

Answers to Critical Thinking Questions

Chapter 1

1. Student B is correct. Body temperature begins to rise as a result of exposure to the hot environment. Sweating eliminates heat from the body and lowers body temperature. Body temperature returning to its ideal normal value is an example of negative feedback. Student A probably thought that it was positive feedback because sweating continued to increase. Sweating, however, is the response. The variable being regulated by sweating is body temperature.
2. Answer *e* is correct. Positive-feedback mechanisms result in movement away from homeostasis and are usually harmful. The continually decreasing blood pressure is an example. Negative-feedback mechanisms result in a return to homeostasis. The elevated heart rate is a negative-feedback mechanism that attempts to return blood pressure back to a normal value. In this case, the negative-feedback mechanism was inadequate to restore homeostasis, and medical intervention (a transfusion) was necessary.
3. When a boy is standing on his head, his nose is superior to his mouth. Remember that directional terms refer to a person in the anatomic position, not to the body's current position.
4.
 - a. Inferior or caudal
 - b. Anterior, ventral, or superficial
 - c. Proximal, superior, or cephalic
 - d. Medial
5. The esophagus is located in the left-upper quadrant and the epigastric region. The urinary bladder is located in the left-lower and right-lower quadrants and is in the hypogastric region.
6. Answer *a* is correct. The best way to reach the anterior surface of the heart begins with the patient lying on his or her back so that the anterior surfaces of the thorax and heart are facing the surgeon. The heart is located in the anterior portion of the thoracic cavity within the mediastinum and is surrounded by the pericardial cavity. The pericardial cavity is lined with the pericardial serous membranes, through which a cut can be made to reach the heart.
7. The uterus is located in the pelvic cavity. The pelvic cavity, however, is surrounded by the bones of the pelvis and doesn't increase in size during pregnancy. Instead, as the fetus grows the expanding uterus must move into the abdominal cavity, thereby crowding abdominal organs and dramatically increasing the size of the abdominal cavity.
8. After passing through the left thoracic wall, the first membrane encountered is the parietal pleura. Continuing through the pleural cavity the visceral pleura of the left lung and then the left lung are pierced. Leaving the lung the bullet penetrates the visceral pleura, the pleural cavity, and the parietal

pleura (remember that the lung is surrounded by a double-membrane sac). Next the parietal pericardium, the pericardial cavity, the visceral pericardium, and the heart are penetrated.

9. After passing through the abdominal wall, the parietal peritoneum is pierced. In passing through the stomach, the visceral peritoneum, the stomach itself, and the visceral peritoneum on the other side of the stomach are penetrated. Because the diaphragm is lined inferiorly by parietal peritoneum and superiorly by parietal pleura, these are the next two membranes pierced. The pole then passes through the pleural space and visceral pleura to enter the lung.

Chapter 2

1. An atom of iron has 26 protons (the atomic number), 30 neutrons (the mass number minus the atomic number), and 26 electrons (because the number of electrons is equal to the number of protons). If an atom of iron loses three electrons, it has three more protons (positive charges) than electrons (negative charges). Therefore the iron ion has an overall charge of $+3$, which is represented symbolically as Fe^{3+} .
2. The formation of free fatty acids and glycerol from a triglyceride is a decomposition reaction because a larger molecule breaks down into smaller molecules. All of the decomposition reactions in the body are collectively referred to as catabolism. This reaction can also be classified as a hydrolysis reaction because as part of the reaction a water molecule is split into hydrogen, which becomes part of the glycerol molecule, and hydroxide, which becomes part of a fatty acid molecule.
3. The slight amount of heat functions as activation energy and starts a chemical reaction. The reaction releases a large amount of heat, thus causing the solution to become hot.
4. Heating (boiling) has destroyed the ability of the molecules in one or both of the solutions to function in the chemical reaction. This is called denaturation. There are two possibilities as to what is denatured. It could be the reactants themselves or an enzyme that catalyzes the reaction.
5. Muscle contains proteins. To increase muscle mass, proteins must be synthesized from amino acids. The synthesis of molecules in living organisms requires the input of energy. That energy comes from the potential energy stored in the chemical bonds of food molecules, which is released during the decomposition of food molecules.
6. Remember that pH is a measure of hydrogen ion concentration. If equal amounts of solutions A and B are mixed, the resulting hydrogen ion concentration is the average value of the two solutions, that is, the pH is $(8 + 2)/2 = 5$. A pH of 5 is acidic. This question illustrates an

important point: The pH of a solution can be changed by adding a more acidic or basic solution to it.

7. The sodium bicarbonate dissociates, thereby increasing the amount of bicarbonate ions in the solution. The bicarbonate ions combine with hydrogen ions to form carbonic acid, which becomes carbon dioxide and water. The decrease in hydrogen ions causes the pH of the solution to increase (become more alkaline).
8. As A and B are added to the solution, the enzyme E catalyzes the formation of C. However, when C binds to the active site of E, the ability of E to catalyze the formation of C is blocked. As more and more C is produced, the rate of formation of C is slowed. Because the reaction of C with E is reversible, there will always be some E that has a functional (not blocked) active site, and some A will therefore always combine with B.
9. One might try heating the substances because proteins can be denatured and can coagulate (like frying an egg). Another possibility is to try dissolving the substances in water. Most lipids are insoluble in water, while many proteins are either soluble in water or form colloids with water.
10. Most proteins (i.e., a typical protein) contain sulfur, which is not found in phospholipids. Typical phospholipids and proteins contain carbon, hydrogen, oxygen, nitrogen, and phosphate.

Chapter 3

1. The cells within the wound swell with water and lyse by the introduction of a hypotonic solution. This kills potentially metastatic cells that may still be present in the wound.
2. Water moves by osmosis from solution B into solution A. Because solution A is hyperosmotic to solution B, solution A has more solutes and less water than does solution B. Water therefore moves from solution B (with more water) to solution A (with less water).
3. Answer *b* is correct. Because the solution is isotonic, there is no exchange of water. Because the solution contains the same concentration of all substances except that it has no urea, only a net movement of urea occurs across the membrane.
4. Answer *b* is correct. At point A on the graph, the extracellular concentration is equal to the intracellular concentration. If movement were by simple diffusion or by facilitated diffusion, at this point the rate of movement would be zero. Because it is not zero, it's reasonable to conclude that the mechanism involved is active transport.
5. A reduced intracellular K^+ concentration reduces the concentration difference for K^+ across the plasma membrane. Thus, the rate at which K^+ diffuses out of the cell is reduced, and a smaller

charge difference is required across the plasma membrane to oppose the diffusion of the K^+ out of the cell. The potential difference across the plasma membrane is therefore reduced.

- Because the drug inhibits mRNA synthesis, protein synthesis is stopped. If the cell releases proteins as they were synthesized, the rate of protein secretion dramatically decreases following the administration of the drug. On the other hand, if the cell releases stored proteins, the rate of secretion at first is normal and then gradually declines.
- The well-developed rough endoplasmic reticulum is indicative of protein synthesis, and a well-developed Golgi apparatus is indicative of secretion. It's likely that this cell synthesizes and secretes proteins.

Chapter 4

- The tissue is epithelial tissue, as it is lining a free surface, and the epithelium is stratified because it consists of more than one layer. The types of stratified epithelium are stratified squamous, stratified cuboidal, stratified columnar, or transitional epithelium. The structure of the cells in the surface layers enables the determination of a specific tissue type. Flat cells in the surface layer indicate stratified squamous epithelium. Cuboidal cells in the surface layer indicate stratified cuboidal epithelium, and columnar cells in the surface layer point to stratified columnar epithelium. The surface cells of transitional epithelium are roughly cuboidal with cubelike or columnar cells beneath them. When transitional epithelium is stretched, the surface cells are still roughly cuboidal, but underlying layers can be somewhat flattened.
- In general, epithelial cells undergo cell division (mitosis) in response to injury, and the newly produced cells replace the damaged cells. If the basement membrane is destroyed, however, nothing is present to provide scaffolding for the newly formed epithelial cells. Without the basement membrane, there's not an effective way for the newly formed epithelial cells to repair a structure such as a kidney tubule. Since the basement membranes appear to be mostly present, the person is likely to survive and the kidney will regain most of its ability to function.
- Epithelium that functions to resist abrasion is stratified squamous epithelium. The moist stratified squamous epithelium lining the mouth and the keratinized stratified squamous epithelium of the skin are examples. The cells at the surface are flattened, and when scraped away due to abrasion they are replaced by the cells beneath them. In contrast epithelial cells that carry out absorption are either simple cuboidal or simple columnar. Because they are one layer thick, they are more susceptible to damage and are not resistant to abrasion. In addition, these cells are large in volume, which allows them to contain the organelles involved in transport, such as mitochondria to produce ATP in the case of active transport. The surface of the cells that absorb are likely to contain microvilli, which increases the surface area for absorption. The flat cells that resist abrasion have no microvilli.

- Glands producing merocrine secretions do so with no loss of actual cellular material, whereas glands producing holocrine secretions shed entire cells. The cells rupture and die, and the entire cell becomes part of the secretion. You could chemically analyze the secretions for the types of molecules found in cellular organelles. For example, if phospholipids and proteins normally found in membranes are in the secretion, then the secretion is a holocrine secretion. If the secretion is watery or contains products that are not found in membranes or organelles, it's a merocrine secretion.
- The statement is not appropriate. A tissue capable of contracting is muscle. Both cardiac muscle and smooth muscle cells are mononucleated, although some cardiac muscle cells can have two nuclei, and they are both under involuntary control. Cardiac muscle is striated, and smooth muscle is not, however.
- Histamine is one of the mediators of inflammation released in response to tissue damage. Several other mediators of inflammation, however, are released during inflammation in addition to histamine. Antihistamines might reduce the inflammatory response somewhat, but it's not likely to have a major effect because of the other mediators of inflammation released at the same time. In certain types of inflammatory responses, such as allergic responses, histamines are released in large amounts. Under these conditions, antihistamines do reduce the inflammatory response.

Chapter 5

- Yes, the skin (dermis) can be overstretched due to obesity.
- The stratum corneum, the outermost layer of the skin, consists of many rows of flat, dead epithelial cells. The many rows of cells, which are continuously shed and replaced, are responsible for the protective function of the integument. In infants, there are fewer rows of cells, resulting in skin that's more easily damaged than that in adults.
- Melanocytes produce melanin, which protects underlying tissue from ultraviolet radiation. Therefore, we expect melanocytes to be as superficial as possible. Also recall that melanin production varies depending on exposure to the sun. Response to stimulation is a characteristic of living cells. Thus, melanocytes should be found in the most superficial living layer of the epidermis, the stratum basale.
- When first exposed to the cold temperature just before starting the run, the blood vessels in the skin constrict to conserve heat. This produces a pale skin color. Dilation of the skin blood vessels doesn't occur at this time because the skin has not been exposed to the cold long enough to cause the skin temperature to fall below 15°C . After running for awhile, as a result of the excess heat generated by the exercise, the blood vessels in the skin dilate. This results in heat loss and helps to prevent overheating. Increased blood flow through the skin causes it to turn red. After the run, the body still has excess heat to eliminate, so the skin remains red for some time.

- Eyelashes have a short growth stage (30 days) and are therefore short. Fingernails grow continuously but are short because they are cut, broken off, or worn down.
- Several methods have some degree of success in treating acne: (a) Kill the bacteria. One effective agent is benzoyl peroxide, found in some acne medications. (b) Prevent blockage of the hair follicle. A vitamin A derivative (tretinoin; Retin-A) has proven effective in keeping the follicular epithelial cells and sebum from building up and closing off the hair follicle. (c) Unplug the follicle. Some sulfur compounds (Acnederm) speed up peeling of the skin and thus unplug the follicle.
- Probably not, because following removal of the nail from the nail fold, it may grow back into the nail fold and the ingrown toenail would reoccur. One solution is to remove the small part of the nail responsible for the ingrown toenail. Prior to this drastic approach, sterile gauze can be placed between the nail and the nail fold to force the nail away from the nail fold. After the nail fold is healed, the gauze can be removed.

Chapter 6

- Normally bone matrix and bone trabeculae are organized to be strongest along lines of stress. Random organization of the collagen fibers of bone matrix results in weaker bones. In addition, the reduced amount of trabecular bone makes the bone weaker. Fractures of the bone can occur when the weakened bone is subjected to stress.
- Replacement of cartilage of the epiphyseal plate by bone normally occurs on the diaphyseal side of the plate. As growth ceases, the cartilage cells stop dividing and producing new cartilage. Replacement of cartilage with bone continues from the diaphyseal side, and eventually all of the cartilage of the plate is bone.
- Mechanical stress applied to bone stimulates osteoblast activity, so the patient with a walking cast should heal faster.
- Osteoporosis is depletion of bone matrix that results when more bone is destroyed than is formed. Because mechanical stress stimulates bone formation (osteoblast activity), running helps to prevent osteoporosis in the bones being stressed. This includes the bones of the lower limbs and the spine.
- The loss of bone density results because the bones are not bearing weight in the weightless environment. Therefore osteoblasts are not sufficiently stimulated and bone resorption exceeds bone building. Bone loss can be slowed by stressing the bones using exercises against resistance such as cycling.
- The kidneys are the site of production of active vitamin D (see chapter 5), which is needed for calcium absorption in the small intestine. Kidney failure can result in inadequate vitamin D production, too little uptake of calcium, and therefore osteomalacia.
- Testosterone normally causes a spurt of growth at puberty followed by slower growth and closure of the epiphyseal plate. Without testosterone, growth is slower, but proceeds longer, resulting in a taller-than-normal person.

8. Blood vessels in central canals run parallel to the long axis of the bone, and perforating canals run at approximately a right angle to the central canals. Thus, perforating canals connect to central canals, which allows blood vessels in the perforating canals to connect with blood vessels in the central canals. After a fracture, blood flow through the central canals stops back to the point where the blood vessels in the central canals connect to the blood vessels in the perforating canals. The regions of bone on either side of the fracture associated with this lack of blood delivery die.
9. Hyperthyroidism stimulates increased bone breakdown and could cause osteitis fibrosa cystica, a condition in which the bone is eaten away as calcium is released from the bone. The result can be a deformed bone that is likely to fracture. Vitamin D therapy might help because vitamin D promotes an increase in blood calcium levels (see chapter 5) and therefore increased deposition of calcium in bone.

Chapter 7

1. An infection in the nasal cavity could spread to adjacent cavities and fossae, including the paranasal sinuses: (1) frontal, (2) maxillary, (3) ethmoidal, and (4) sphenoidal; (5) the orbit (through the nasolacrimal duct); (6) the cranial cavity (through the cribriform plate); and (7) the throat (through the posterior opening of the nasal cavity).
2. Falling on the top of the head could drive the occipital condyles into the superior articulating processes of the atlas, causing a fracture. An uppercut to the jaw would slightly lift the occipital condyles away from the superior articulating processes of the atlas and usually doesn't result in a fractured atlas. Such a blow to the jaw can, however, fracture the temporal bone where it articulates with the mandible.
3. Forceful rotation of the vertebral column is most likely to damage the articular processes, especially in the lumbar region, where the articular processes tend to prevent excessive rotation (the superior articular processes face medially and the inferior articular processes face laterally).
4. Weaker back muscles on one side could cause the vertebral column to bend laterally (scoliosis) toward the opposite side. Lordosis can result from pregnancy. As the fetus causes the abdomen to move anteriorly, the thorax and head tend to pull posteriorly, to restore the center of gravity. This posture increases the lumbar curvature. The same effect can be seen in people who are "pot-bellied."
5. If the ulna and radius become fused, the radius can no longer rotate relative to the ulna, and, as a result, most of the rotation of the forearm and hand is lost.
6. Measure from the anterior superior iliac spine (a "stationary" point relative to the limb, which can be easily found as a surface landmark) to the lateral malleolus. The inferior side of the foot could also be used, if the person is standing on a flat surface. A defect of the foot or ankle may occur, however, in which the ankle on one side is elevated. If the length of the thigh is the only part to be measured, measure to the lateral epicondyle.

7. The ischial tuberosity is the bony protuberance.
8. Women's hips are wider than men's. As the knees are positioned toward the midline the slope of the femur from its proximal end toward its distal end is greater in women, and as a result, women tend to be knock-kneed more often than men.
9. The lateral malleolus extends further distally than does the medial malleolus, thus making it more difficult to turn the foot laterally than medially. The styloid process of the radius extends further distally than the styloid process of the ulna, thus making it more difficult to cock the wrist toward the thumb (laterally) than toward the little finger (medially).
10. Landing on the heels could fracture the calcaneus. Heavy objects, such as Hefty Stomper, landing on the dorsal surface of the foot could fracture the metatarsals or even the tarsals.

Chapter 8

1. If the sternocostal synchondrosis were to ossify, becoming a synostosis, there would no longer be any stretch through the costal cartilage, the thorax could not expand, and, as a result, respiration would be severely hampered.
2. a. Suture, little or no movement.
b. Syndesmosis, some movement.
c. Complex synovial joints: the humeroulnoradial joint is a hinge joint, the radioulnar joint is a pivot joint. All have considerable movement.
3. a. Flexion and supination
b. Flexion of the thigh and extension of the leg
c. Abduction of the arm
d. Flexion of the leg and plantar flexion of the foot
4. The anterior drawer test determines the integrity of the anterior cruciate ligament, and the posterior drawer test determines the integrity of the posterior cruciate ligament. Unusual movement during the posterior drawer test indicates damage to the posterior cruciate ligament.

Chapter 9

1. Botulism poisoning results from the consumption of botulinum toxin produced by the bacterium *Clostridium botulinum*. The toxin binds to presynaptic nerve terminals and prevents the release of acetylcholine. Thus, action potentials in nerves cannot produce action potentials in skeletal muscles, and the result is paralysis of skeletal muscles, which explains the difficulty in breathing and swallowing. Other reasonable explanations are that the toxin binds to and blocks the receptors for acetylcholine, that the toxin blocks the entry of Ca^{2+} into the presynaptic terminal and thus prevents acetylcholine release, or that the toxin specifically prevents entry of ions through Na^{+} channels of skeletal muscle cells.
2. Muscular dystrophy results from gradual atrophy of skeletal muscle fibers and their replacement with connective tissue. Myasthenia gravis results from the degeneration of the receptors for acetylcholine on the postsynaptic membranes of skeletal muscle cells. If an inhibitor of acetylcholinesterase is administered, the result should be an increase in the concentration of

acetylcholine in the nerve muscle synapse. Thus, more acetylcholine is available to bind to acetylcholine receptors. In people suffering from myasthenia gravis, the increased concentration of acetylcholine in the synapse allows acetylcholine to bind a greater percentage of the acetylcholine receptors present and causes the muscle contractions to increase in strength. In people who have muscular dystrophy, the muscle contractions don't increase in strength because muscle atrophy is the cause of the weakness. The additional acetylcholine in the neuromuscular synapse has no effect on the weakened muscle fibers.

3. Placing sarcoplasmic reticulum from skeletal muscle cells into the beaker would remove calcium from the solution because sarcoplasmic reticulum transports Ca^{2+} from the solution into the sarcoplasmic reticulum. In addition, ATP would have to be added for two reasons: (1) the sarcoplasmic reticulum actively transports calcium and, therefore, requires ATP; and (2) ATP must bind to the heads of the myosin molecules before the myosin heads can release from the active sites on the actin molecules.
4. A lower-than-normal temperature decreases the rate of all of the processes that occur in the lag phase of muscular contraction because a lower temperature decreases the rate of all chemical reactions and the rate of ion diffusion. As a consequence, the lag phase requires a longer time.
5. Start with a subthreshold stimulus and increase the stimulus strength by very small increments. Apply the stimulus to the nerve of muscle A and muscle B. If the number of motor units is the same for both preparations, each time the stimulus strength is increased the degree of tension produced by the muscles would also increase to the same degree in each muscle. If one muscle has more motor units than the other, the muscle with the greater number of motor units would exhibit a greater number of separate increases in tension, and the magnitude of the increases in tension would be smaller than those seen in the muscle with fewer motor units.
6. When a muscle slowly lifts an object, the contraction starts with a small number of motor units being stimulated. Each motor unit is stimulated tetanically. As the contraction continues, more and more motor units are recruited to lift the object slowly. To lower the object, the number of motor units stimulated tetanically is reduced slowly and the tension produced by the muscle decreases. In a muscle twitch, a stimulus causes a single action potential in all of the muscle fibers responding to the stimulus. The stimulated muscle fibers contract in an all-or-none fashion and then relax. Both contraction and relaxation occur quickly.
7. The shape of an active tension curve for skeletal muscle can be seen in figure 9.20. In contrast, an active tension curve is much flatter for smooth muscle. That is, for each increase in the length of a muscle fiber there is little change in the active tension produced by the smooth muscle fiber. Smooth muscle has, as one of its major characteristics, the ability to increase in length without much increase in the tension produced by the smooth muscle cells.

8. Both the 100 m run and weight lifting involve rapid and intense contractions of skeletal muscles that are completed quickly. These contractions depend on anaerobic metabolism for a significant amount of the ATP produced. In contrast, the 10,000 m run involves sustained muscular contractions that are not as rapid, but the slower contractions are repeated many times during the run. Aerobic metabolism produces the majority of the ATP for the 10,000 m run. Anaerobic metabolism is associated with a decrease in creatine phosphate, an increase in creatine, an increase in lactic acid, and a decrease in glycogen, and the enzymes responsible for anaerobic metabolism function more rapidly. Aerobic metabolism is associated with increased enzyme activity in the mitochondria and an increase in carbon dioxide production. Oxygen is used more rapidly during aerobic metabolism.
9. During intense exercise it's possible to experience physiologic contracture. Being unable to either contract or relax the muscles for a short time while exercising suggests the existence of physiologic contracture.
10. Smooth muscle depends almost entirely on aerobic metabolism to produce the ATP required for muscle contraction. If the blood supply to smooth muscle fibers is decreased the smooth muscle, therefore, cannot maintain contractions.
11. During the 100 m race Shorty depended on ATP produced by anaerobic metabolism. That produced an oxygen debt at the end of the run, which resulted in an elevated rate of respiration for a time. During the longer and slower run most of the ATP for muscle contractions was produced by aerobic respiration, and very little oxygen debt developed. Prolonged aerobic respiration is required to "pay back" the oxygen debt. Shorty's rate of respiration was, therefore, prolonged after the 100 m race but not after the longer but slower run.
12. High blood K^+ concentration also results in depolarization of smooth muscle plasma membranes. Depolarization of the smooth muscle plasma membrane results in increased muscle contractions and increased permeability of the plasma membrane to both Na^+ and Ca^{2+} , which results in further depolarization and an increase in the intracellular concentration of Ca^{2+} . These changes result in the production of action potentials and muscle contractions.
13. The muscles would contract. ATP would be available to bind to the myosin heads, thus allowing myosin molecules to be released from actin molecules. The cross-bridges would immediately re-form, and complete cross-bridge cycling would result in contraction of the muscle fibers. As long as Ca^{2+} were present at high concentrations in the sarcoplasm, contraction of the muscles would occur. If the sarcoplasmic reticulum were intact, ATP would be available to drive the active transport of Ca^{2+} into the sarcoplasmic reticulum. As the Ca^{2+} decreased in the sarcoplasm, relaxation would result. If the sarcoplasmic reticulum were not intact, however, and could not transport Ca^{2+} into the sarcoplasmic reticulum as fast as they leak out, the muscle would remain contracted until it fatigued.

14. Hormones can bind to ligand-gated Ca^{2+} channels, and the channels, in response, open. Ca^{2+} diffuse into the cell and cause contraction to occur. Only a small amount of depolarization results as Ca^{2+} diffuse into the cell, and since Na^+ channels don't open, a large change in the resting membrane potential doesn't occur.
15. In experiment A, the students used anaerobic respiration as they started to run in place, but aerobic respiration also increased to meet most of their energy needs. When they stopped, their respiration rate was increased over resting levels because of repayment of the oxygen debt due to anaerobic respiration. In experiment B almost all of the student's respiration came from anaerobic respiration because the students held their breath while running large. Consequently, the students had a much larger oxygen debt. The student's respiratory rate and depth was greater than in experiment A, or that their respiration rates were elevated for a longer period of time than in experiment A.

Chapter 10

1. Muscle	Action	Synergist	Antagonist
Longus capitis	Flexes neck	Rectus capitis anterior Longus colli	Most of the posterior neck muscles
Erector spinae	Extends vertebral column	Interspinales Multifidus Semispinalis thoracis	Most anterior abdominal muscles
Coraco-brachialis	Adducts arm	Latissimus dorsi Pectoralis major Teres major Teres minor	Deltoid Supra-spinatus
	Flexes arm	Deltoid (anterior) Pectoralis major Biceps brachii	Deltoid (posterior) Latissimus dorsi Teres major Teres minor Infra-spinatus Sub-scapularis Triceps brachii
2. Biceps brachii: Pull-ups with hands supinated Triceps brachii: Push-ups		Deltoid: Abduction of the arms to shoulder height, with weights in the hands (abduction past shoulder height involves mostly scapular rotation by the trapezius) Rectus abdominis: Sit-ups to 45 degrees (sit-ups past 45 degrees involve mostly the psoas major) Quadriceps femoris: Extending the legs against a force Gastrocnemius: Plantar flexion of the feet against a force, such as toe raises with a weight on the shoulders	

3. The brachioradialis originates on the humerus and inserts onto the distal end of the radius. The fulcrum of this lever system is the elbow joint. With a weight held in the hand, the force, applied between the weight and the fulcrum, is a class III lever system. With the weight on the forearm, the weight is between the force and the fulcrum and is a class II lever system. A greater weight can be lifted if placed on the forearm rather than in the hand, but weights placed on the forearm cannot be lifted as far.
4. The muscles that flex the head also oppose extension of the neck. In an accident causing hyperextension of the neck, these muscles could be stretched and torn. The muscles involved could include the sternocleidomastoid, longus capitis, rectus capitis anterior, and longus colli. Automobile headrests are designed so that, if adjusted correctly, the back of the head hits the headrest during a rear-end accident, thereby preventing hyperextension of the neck.
5. The only muscle that elevates the lower eyelid is the orbicularis oculi, which "closes the eye." With this muscle not functioning, the lower eyelid would droop. The levator anguli oris, which elevates the angle of the mouth, was also apparently affected allowing the corner of the mouth to droop. The zygomaticus major may also have been affected, as it inserts onto the corner of the mouth (see figure 10.7).
6. The genioglossus muscle protrudes the tongue. If it becomes relaxed, or paralyzed, the tongue may fall back and obstruct the airway. This can be prevented or reversed by pulling forward and down on the mandible, thus opening the mouth. The genioglossus originates on the genu of the mandible. As the mandible is pulled down and forward, the genioglossus is pulled forward with the mandible, thus pulling the tongue forward also.
7. The rotator cuff muscles are the primary muscles holding the head of the humerus in the glenoid fossa, especially the supraspinatus. In fact, a torn rotator cuff, which usually involves a tear of the supraspinatus muscle, often results in dislocation of the shoulder.
8. With the quadriceps femoris paralyzed, the leg could not be extended, and the lower limb could not bear weight unless the knee were passively extended, such as by pushing back on the distal end of the thigh with the hand. Walking would be almost impossible, except by taking very small steps and by pushing back on the knee with each step, or by bracing the knee in an extended position.
9. Speedy has ruptured the calcaneal tendon, and the gastrocnemius and soleus muscles have retracted, thereby causing the abnormal bulging of the calf muscles. Because the major plantar flexors are no longer connected to the calcaneus, the runner cannot plantar flex the foot, and the foot is abnormally dorsiflexed because the antagonists have been disconnected.

Chapter 11

1. A reduced intracellular concentration of K^+ causes depolarization of the resting membrane potential. Because the intracellular concentration

of K^+ is reduced, the concentration gradient for potassium from the inside to the outside of the plasma membrane is also reduced. Thus the rate at which K^+ diffuse out of the cell is reduced, and a smaller charge difference across the plasma membrane is required to oppose the diffusion of the K^+ out of the cell. Therefore, the potential difference across the plasma membrane is reduced, and the cell is depolarized.

- Because the plasma membrane is much less permeable to Na^+ than to K^+ , changes in the extracellular concentration of Na^+ effect the resting membrane potential less than do changes in the extracellular concentration of K^+ . Therefore, increases in extracellular Na^+ have a minimal effect on the resting membrane potential. Because the membrane is much more permeable to Na^+ during the action potential, the elevated concentration of Na^+ in the extracellular fluid results in Na^+ diffusing into the cell at a more rapid rate during the action potential, resulting in a greater degree of depolarization during the depolarization phase of the action potential.
- Because lithium ions reduce the permeability of plasma membranes to Na^+ , the Na^+ channels in the plasma membrane tend to remain closed. A normal stimulus causes Na^+ channels to open, allowing Na^+ to diffuse into the cell, thereby resulting in depolarization. The cell is less sensitive to stimuli because the membrane is less permeable to Na^+ .
- Smooth muscle cells contract spontaneously in response to spontaneous depolarizations that produce action potentials. One way action potentials can be produced spontaneously is if membrane permeability to Na^+ spontaneously increases. As a result, a few Na^+ enter the smooth muscle cells and cause a slight depolarization of the plasma membrane. The small depolarization can cause voltage-gated Na^+ channels to open, which results in further depolarization, thereby stimulating additional voltage-gated ion channels to open. This positive-feedback cycle can continue until the plasma membrane is depolarized to its threshold level and an action potential is produced.
- Action potential conduction along a myelinated nerve fiber is more energy efficient because the action potential is propagated by saltatory conduction, which produces action potentials at the nodes of Ranvier. Compared to an unmyelinated nerve fiber, only a small portion of the myelinated neuron's membrane has action potentials. Thus there is less flow of sodium into the neuron (depolarization) and less flow of potassium out of the neuron (repolarization). Consequently, the sodium–potassium exchange pump has to move fewer ions in order to restore ion concentrations. Because the sodium–potassium exchange pump requires ATP, myelinated axons use less ATP than unmyelinated axons.
- The inhibitory neuromodulator causes the postsynaptic neuron to become less sensitive to excitatory stimuli, probably by causing hyperpolarization of the postsynaptic neuron. As a result, the excitatory neurotransmitter released

from the excitatory neuron is less likely to produce postsynaptic action potentials.

- With aging, there's a decrease in the amount of myelin surrounding axons, which decreases the speed of action potential propagation. At synapses there's also an increase in the time it takes for action potentials in the presynaptic terminal to cause the production of action potentials in the postsynaptic membrane. It's believed this results from a reduced release of neurotransmitter by the presynaptic terminal and a reduced number of receptors in the postsynaptic membrane.
- Organophosphates inhibit acetylcholinesterase, thereby causing an increase in acetylcholine in the synaptic cleft leading to overproduction of action potentials, tetany of muscles, and possible death resulting from respiratory failure (see chapter 11). Curare is the best antidote because it blocks the effect of acetylcholine and acts to counteract the organophosphate. Too much curare, however, could cause flaccid paralysis of the respiratory muscles. Injecting acetylcholine would make the effect of the organophosphate worse. Potassium chloride causes depolarization of muscle cell membranes, thereby making them more sensitive to acetylcholine.
- If the motor neurons supplying skeletal muscle are innervated by both excitatory and inhibitory neurons, then blocking the activity of the inhibitory neurons with strychnine results in overstimulation of the motor neurons by the excitatory neurons.

Chapter 12

- If the neuron with its cell body in the cerebrum is an inhibitory neuron and if it also synapses with the motor neuron of a reflex arc, then stimulation of the cerebral neuron could inhibit the reflex.
- The phrenic nerve is cut in the thorax, and the surgery is performed while the lung is being removed.
- The ulnar nerve supplies the medial third of the hand, little finger, and medial half of the ring finger. The median nerve supplies the lateral two-thirds of the palm and thumb, and the surface of the index, middle, and lateral half of the ring finger. The radial nerve supplies the lateral two-thirds of the dorsum of the hand.
- Pulling on the upper limb when it is raised over the head can damage the lower brachial plexus, in this case, the origin of the ulnar nerve. The ulnar nerve innervates muscles that abduct/adduct the fingers and flex the wrist.
- The ischiadic nerve has rootlets from L4–S3. Depending on the rootlet compressed, pain can be felt in different locations.
 - Obturator nerve
 - Femoral nerve
 - Ischiadic (tibial) nerve
 - Obturator nerve
 - Obturator nerve, some from femoral nerve

Chapter 13

- A condition in which a patient loses all sense of feeling in the left side of the back, below the upper limb, and extending in a band around to the chest, also below the upper limb, but where all sensation on the right is normal, suggests that the patient's dorsal roots have been damaged on the left side adjacent to the part of the spinal cord supplying that part of the body. (The basis of this condition is explained more fully in chapter 14.)
- The skull restricts the growth of the brain. The surface area of the cerebral cortex increases as more neurons migrate into the cortex and as more synapses are formed. As the cerebral cortex increases in area, it becomes folded. This folding allows a greater surface area to be housed in a much smaller volume.
- If CSF does not drain properly, the fluid accumulates and exerts pressure on the brain (hydrocephalus). In the developing fetus, the ventricles enlarge because of the excess fluid pressure. The head also enlarges because the skull bones have not fused. The expansion of the head is not sufficient, however, to relieve all the pressure exerted on the developing brain by the expanding ventricles. As a result, the cerebral cortex becomes proportionately thinner as it's compressed between the ventricles and skull. In many cases, less gyri form in the cerebral cortex. Brain damage may or may not result, depending on the amount of excess CSF, the ventricular pressure generated, and the areas of the brain damaged by the pressure.
- Enlargement of the lateral and third ventricles, without enlargement of the fourth ventricle, suggests a blockage between the third and fourth ventricles in the cerebral aqueduct. This defect is called aqueductal stenosis and is a common congenital problem.
- Blood in the CSF taken through a spinal tap indicates the presence of blood in the subarachnoid space and suggests that the patient has a damaged blood vessel in the subarachnoid space.

Chapter 14

- The first sensations that occur when a woman picks up an apple and bites into it are visual (special), tactile (general), and proprioceptive (general). The woman holds the apple in her hand and looks at it. The tactile sensations from mechanoreceptors in the hand tell her that the apple is firm and smooth. The proprioceptive sensations originating in the joints of the hand tell the woman the size and shape of the apple. Visual input also tells her the size of the apple, and that it has a smooth surface, as well as its color. As the woman bites into the apple and begins to chew, proprioceptive sensations from the teeth and jaw provide information as to how widely the jaws must be opened to accommodate the bite and how hard to bite down. Tactile sensations originating in the tongue and cheeks tell the person the location of the bite of apple and its texture as it is moved about in the mouth. Taste sensations (special, chemoreceptor) from

the tongue provide information that the apple has characteristics of being both sweet and sour. Olfactory sensations (special) provide more specific information that the “fruity taste” is that of an apple.

2. a. The most likely explanation is that the olfactory neurons accommodate and no longer respond to odor stimulus.
- b. The fact that one can hear the sound when one tries indicates that the hair cells in the spiral organ have not accommodated and are still able to detect the sound stimulus. Many action potentials arriving in the brain are prevented from causing conscious perception, until we consciously “pay attention” to the stimulus. For example, you may not be paying attention to general conversations in a crowded room or hall, until someone says your name. The sound of your name leaps out of the surrounding babble, and you are suddenly interested in what was being said by the person who spoke your name.
3. The fibers of the dorsal-column/medial-lemniscal system carry two-point discrimination and proprioceptive information. Primary neurons from the right side of the body ascend the spinal cord in the dorsal column and synapse with secondary neurons in the medulla oblongata. The secondary neurons cross over in the upper medulla and ascend through the left side of the pons to the thalamus. A patient suffering from a loss of two-point discrimination and proprioception on the right side of the body as a result of a lesion in the medial lemniscal system in the pons has a lesion in the left side of the pons.
4. The fibers of the lateral spinothalamic tract carry impulses for pain and temperature. A lesion in the area where these fibers decussate results in the bilateral loss of pain and temperature sensations only at the level of the lesion, and there is no loss of sensation below the lesion. This occurs because fibers decussating above or below the lesion, as well as tracts that pass lateral to the lesion, are unaffected.
5. The damaged tracts are the lateral corticospinal tract, controlling motor functions on the right side of the body, and the lateral spinothalamic tract for pain and temperature sensations from the left side of the body. Damage to these tracts in the right side of the spinal cord produces the observed symptoms, because, in the cord, the lateral spinothalamic tract crosses over at the level of entry, and is, therefore, located on the opposite side of the cord from its peripheral nerve endings, whereas the corticospinal tract lies on the same side of the cord as its target muscles.
6. Complete unilateral transection of the right side of the spinal cord results in loss of motor function (lateral corticospinal tract), proprioception, and two-point discrimination (dorsal-column/medial-lemniscal system) on the same side of the body as the lesion, below the level of the lesion. Pain and temperature sensations (lateral spinothalamic tract) are lost on the opposite side of the body from below the level of the lesion. These symptoms describe the Brown-Séquard syndrome. Light touch is not

greatly affected on either side because of the large number of collateral branches in the anterior spinothalamic tract.

7. The right cerebral cortex controls the left side of the body. The motor cortex has a topographic representation of the opposite side of the body, with the hand, forearm, arm, and shoulder located approximately in the center of the precentral gyrus. The lesion is therefore in the center of the right precentral gyrus of the cerebrum. Some grosser control of the left-upper limb may still exist because of the indirect pathways, but there would be spastic paralysis.
8. Damage to the cerebellum can result in decreased muscle tone, balance impairment, a tendency to overshoot when reaching for or touching something, and an intention tremor. These symptoms are opposite to those seen with basal ganglia dysfunction. Cerebellar dysfunction exhibits very similar symptoms to those seen in an inebriated person, and the same tests could be applied, such as having the person touch their nose or walk a straight line.
9. Memory storage for the 10 minutes prior to the accident was in short-term memory and was disrupted before it could be transferred to long-term memory. Additional information: Anytime a person suffers a concussion there’s a possibility that he or she may later develop postconcussion syndrome. Symptoms include muscle tension or migraine headaches, reduced alcohol tolerance, difficulty learning new things, reduction in creativity and motivation, fatigue, and personality changes, and the syndrome may last a month to a year. Postconcussion syndrome may be the result of a slowly occurring subdural hematoma, which may be missed by an early examination.

Chapter 15

1. The first sensations that occur when a person picks up an apple and bites into it are visual. The person holds the apple in his hand and looks at it. Visual input (which stimulates light receptors) tells him the size of the apple, and that it has a smooth surface, as well as its color. As the person bites into the apple and begins to chew, taste sensations (chemoreceptors) from the tongue provide information that the apple has characteristics of being both sweet and sour. Olfactory sensations (hemoreceptors) provide more specific information that the “fruity taste” is that of an apple.
2. The lens of the eye is biconvex and causes light rays to converge. If the lens is removed, then the replacement lens should also cause light rays to converge. A biconvex lens or a lens with a single convex surface would work. Bifocals or trifocals could also be recommended because of the loss of accommodation.
3. The light reflected by the tapetum lucidum could stimulate photoreceptors and increase the sensitivity of the eye to light, which could be an advantage when light levels are low. Because the same light image could stimulate different photoreceptors, however, there is a loss of visual acuity and a blurring of vision.
4. Carrots contain vitamin A (retinoic acid), which can be used to form retinal. Retinal and opsin combine to form rhodopsin, which is found in rods. Rhodopsin is necessary for rods to respond to low levels of light. Lack of vitamin A can result in lack of rhodopsin and night blindness.
5. By looking a few inches to the side, the image of the needle and thread is projected to the periphery of the retina, where there is the highest concentration of rods. The rods function better than cones in low-light intensities. If Jean looks directly at the needle and thread, their image falls on the macula, which has few rods and mostly cones, which don’t function well in dim light. By looking to the side, however, she is using a part of the retina where the photoreceptor cells are not as densely packed as in the macula, and the image is fuzzy rather than sharp.
6. This phenomenon is called a negative afterimage. While staring at the clock, the darkest portion of the image (the black clock) causes dark adaptation in part of the retina. That is, part of the retina becomes more sensitive to light. At the same time the lightest part of the image (the white wall) causes light adaptation in the rest of the retina, and that part of the retina becomes less sensitive to light. When the man looks at a black wall, the dark adapted portion of the retina, which is more sensitive to light, produces more action potentials than does the light adapted part of the retina. Consequently, he perceives a light clock against a darker background.
7. A lesion of the optic chiasma results in visual loss in both the right and left temporal fields, a condition called bitemporal hemianopia, or tunnel vision. Tunnel vision can cause problems for normal functions, such as when driving a car, because the peripheral vision is severely limited. The occurrence of this condition can also suggest a much more serious problem, such as a pituitary tumor, which sits just posterior to the optic chiasma.
8. The most likely area damaged is the spiral organ, where waves result in the production of action potentials. The action is much like ocean waves breaking on the shore during a violent storm as compared to those breaking in from a calm ocean. Specifically, damage likely occurs in the part of the spiral organ near the oval window, because it is this part of the basilar membrane that vibrates the most in response to high-frequency sounds.
9. Normally, as pressure changes, the auditory tubes open to allow an equalization of pressure between the middle ear and the external environment. If this doesn’t occur, then the buildup of pressure in the middle ear can rupture the tympanic membrane, or the pressure can be transmitted to the inner ear and cause sensorineural damage.
10. Normally, airborne sounds cause the tympanic membrane to vibrate, resulting in movement of the middle ear ossicles and the production of waves in the perilymph of the scala vestibuli. Vibration of the skull bones can also cause vibration of the perilymph in the scala vestibuli.

Chapter 16

1. The sympathetic division of the ANS is responsible for dilation of the pupil. Preganglionic fibers from the upper thoracic region of the spinal cord pass through spinal nerves (T1 and T2), into the white rami communicantes, and into the sympathetic chain ganglia. The preganglionic fibers ascend the sympathetic chain and synapse with postganglionic neurons in the superior cervical sympathetic chain ganglia. The axons of the postganglionic neurons leave the sympathetic chain ganglia as small nerves that project to the pupil of the eye.
2. Reduced salivary and lacrimal gland secretions could indicate damage to the facial nerves, which innervate the submandibular, sublingual, and lacrimal glands. The glossopharyngeal nerves innervate the parotid glands but not the lacrimal glands.
3. Cutting the preganglionic fibers in the white rami of T2–T3 is the best way to eliminate innervation of the blood vessels in the skin. Cutting the gray rami at levels T2–T3 is inappropriate because the postganglionic fibers that innervate the hand blood vessels exit from the first thoracic and inferior cervical sympathetic chain ganglia. Cutting the spinal nerves is inappropriate because it eliminates all sensory and motor functions to the area supplied.
4.
 - a. Pelvic nerves
 - b. Gray rami
 - c. Vagus nerves
 - d. Cranial nerves
 - e. Pelvic nerves
5. The parasympathetic division innervates the heart through the vagus nerves. The postganglionic nerve fibers of the vagus nerves release acetylcholine, which reduces heart rate. Methacholine can bind to the same receptors as acetylcholine and reduce heart rate. Side effects result from stimulating other parasympathetic effector organs. For example, stimulating the salivary glands results in increased salivation. Dilation of the pupils and sweating are effects expected from sympathetic stimulation. The muscles of respiration are not regulated by the ANS, but they do respond to acetylcholine through somatic neurons. Methacholine would be expected to make contractions of respiratory muscles more likely.
6. One would expect mostly parasympathetic effects, because the effects of acetylcholine are enhanced: blurring of vision as a result of contraction of ciliary muscles, excess tear formation because of overstimulation of the lacrimal glands, frequent or involuntary urination because of overstimulation of the urinary bladder. Pallor resulting from vasoconstriction in the skin is a sympathetic effect that would not be expected because skin blood vessels respond to norepinephrine. Muscle twitching or cramps of skeletal muscles might occur because they normally respond to acetylcholine.
7. Epinephrine causes vasoconstriction and confines the drug to the site of administration. This increases the duration of action of the drug

locally and decreases systemic effects.

Vasoconstriction also reduces bleeding if a dry field (an area clear of blood on its surface) is required.

8. Because normal action potentials are produced, the drug doesn't act at the synapse between the preganglionic and postganglionic neurons. Because injected norepinephrine works, sympathetic receptors in the heart are functioning and are not affected by the drug. Therefore, the drug must somehow affect the postganglionic neurons. Possibly it inhibits neurotransmitter production or release from the postganglionic neurons.
 9. Because cutting the white rami of T1–T4 doesn't affect the action of the drug, sympathetic preganglionic neurons in the spinal cord and sympathetic centers in the brain can be ruled out as a site of action. Because cutting the vagus nerves eliminates the effect of the drug, the drug cannot be acting at the synapse between the preganglionic neurons and the postganglionic neurons, or between the synapse of the postganglionic neuron and the effector organ of either division of the ANS. The drug must, therefore, excite parasympathetic centers in the brainstem, resulting in a decrease in heart rate.
 10.
 - a. Responses in a person who is extremely angry are primarily controlled by the sympathetic division of the ANS. These responses include increased heart rate and blood pressure, decreased blood flow to the internal organs, increased blood flow to skeletal muscles, decreased contractions of the intestinal smooth muscle, flushed skin in the face and neck region, and dilation of the pupils of the eyes.
 - b. For a person who has just finished eating and is now relaxing, the parasympathetic reflexes are more important than sympathetic reflexes. The blood pressure and heart rate are at normal resting levels, the blood flow to the internal organs is greater, contractions of smooth muscle in the intestines are greater, and secretions that achieve digestion are more active. If the urinary bladder or the colon becomes distended, autonomic reflexes that result in urination or defecation can result. Blood flow to the skeletal muscles is reduced.
- ## Chapter 17
1. Liver and kidney disease increases the concentration of this hormone in the blood, and the concentration would remain high for a longer time. The liver modifies the hormone to cause it to be excreted by the kidney more rapidly. In the case of liver disease, the hormone is not modified and excreted rapidly. Therefore, the concentration becomes higher than normal and the concentration of the hormone remains high for longer than normal. A similar result is seen if the kidney is diseased and the hormone cannot be excreted rapidly.
 2. Secretion of hormones is usually controlled by a negative-feedback mechanism. If a hormone controls the concentration of a substance in the circulatory system, the hormone is secreted in smaller amounts if the substance increases in the circulatory system. If a tumor begins to secrete the substance in large amounts, the presence of the substance has a negative-feedback effect on the secretion of the hormone and the concentration of the hormone in the circulatory system is very low.
 3. Usually intracellular mediator mechanisms respond quickly, and the effect of the hormone is brief. Intracellular receptor mechanisms usually take a long time (several hours) to respond, and their effects last much longer. If the hormone is large and water-soluble, it's probably functioning through an intracellular mediator mechanism, or if the hormone is lipid-soluble, it's probably an intracellular receptor mechanism. If you have the ability to monitor the concentration of a suspected intracellular mediator and it increases in response to the hormone, or if you can inhibit the synthesis of an intracellular mediator and it prevents the target cells' response to the hormone, it's an intracellular mediator mechanism. If you can inhibit the synthesis of mRNA and this inhibits the action of the hormone, or if you can measure an increase in mRNA synthesis in response to the hormone, then the mechanism is an intracellular receptor mechanism.
 4. When the hormone binds to its receptor, the α subunit of the G protein is released. GTP must bind to the α subunit, however, before it can have its normal effect. If the α subunit cannot bind GTP, the hormone, therefore, has no effect on the target tissue.
 5. Inhibitors of prostaglandin synthesis reduce prostaglandin synthesis in all tissues, not just in those tissues in which prostaglandins produce undesirable effects. Symptoms such as inflammation, vomiting, and fever are reduced. Because prostaglandins also play a role in producing beneficial effects in some tissues, however, these benefits would not occur normally. Inhibitors of prostaglandin synthesis may cause labor to be delayed or produce other undesirable responses due to their inhibitory effects on the synthesis of prostaglandins.
 6. Phosphodiesterase causes the conversion of cAMP to AMP, thus reducing the concentration of cAMP. A drug that inhibits phosphodiesterase, therefore, increases the amount of cAMP in cells where cAMP is produced. Therefore, an inhibitor of phosphodiesterase increases the response of a tissue to a hormone that has cAMP as an intracellular mediator.
 7. A short half-life for epinephrine allows epinephrine to produce a short-lived response. The response to a potentially harmful or dangerous situation is terminated shortly after the harmful or dangerous situation passes. If epinephrine had a long half-life, the heart rate and blood glucose would be elevated for a long time, even if the harmful or dangerous situation was very brief.
 8. Because thyroid hormones are important in regulating the basal metabolic rate, a long half-life is an advantage. Thyroid hormones are secreted and have a prolonged effect without large fluctuations in the basal metabolic rate. If thyroid hormones had a short half-life, the basal

metabolic rate might fluctuate with changes in the rate of secretion of thyroid hormones.

Certainly the rate of secretion of thyroid hormones would have to be controlled within narrow limits if it did have a short half-life.

9. If liver disease results in a decrease of plasma proteins to which thyroid hormones bind, higher-than-normal concentrations of free (unbound) thyroid hormones occur in the circulatory system. Because of the higher-than-normal concentration of thyroid hormones that are unbound, the responses to thyroid hormones increase. In addition, the half-life of the thyroid hormones is shortened. Thus, as thyroid hormone secretion increases, the concentration of thyroid hormone also increases. As the thyroid hormone secretion decreases, the concentration of thyroid hormone also decreases. Thyroid hormones fluctuate in concentration in the circulatory system more than normal.
10. Elevated GnRH levels in the blood as a result of the GnRH-secreting tumor causes down-regulation of GnRH receptors in the anterior pituitary. This decreases the ability of GnRH to stimulate the anterior pituitary, and the rate of luteinizing hormone and follicle-stimulating hormone secretion by the anterior pituitary decreases and remains decreased as long as the GnRH levels are chronically elevated. Therefore, the functions of the reproductive system controlled by luteinizing hormone and follicle-stimulating hormone decrease.
11. Insulin levels normally change in order to maintain normal blood sugar levels, despite periodic fluctuations in sugar intake. A constant supply of insulin from a skin patch might result in insulin levels that are too low when blood sugar levels are high (after a meal) and might be too high when blood sugar levels are low (between meals). In addition, insulin is a protein hormone that would not readily diffuse through the lipid barrier of the skin (see Chapter 5). Estrogen is a lipid soluble steroid hormone.

Chapter 18

1. The hypothalamohypophyseal portal system allows neurohormones that function as releasing and inhibiting hormones, which are secreted by neurons in the hypothalamus, to be carried directly from the hypothalamus to the anterior pituitary gland. Consequently, the releasing and inhibiting hormones are not diluted nor are they destroyed by the enzymes, which are abundant in the kidneys, liver, lungs, and general circulation, before they reach the anterior pituitary. Also the time it takes for releasing and inhibiting hormones to reach the anterior pituitary is less than if they were secreted into the general circulation.
2. A hot environment increases ADH secretion. Because the amount of water lost in the form of sweat can be quite large, and because sweat is more dilute than the body fluids, sweating gradually increases the osmolality of the body fluids. The increasing osmolality of body fluids stimulates an increase in ADH secretion. Thus, a hot environment can result in increased ADH secretion because of an increasing osmolality of

the body fluids. Increased ADH secretion in a hot environment reduces the amount of water lost in the form of urine. Therefore, water is conserved.

3. Polydipsia and polyuria are consistent with either diabetes mellitus or diabetes insipidus. Diabetes mellitus, however, is consistent with an increased urine osmolality because of the large amount of glucose lost in the urine. Diabetes insipidus is consistent with urine with a low specific gravity because little water is reabsorbed by the kidney. Thus urine has an osmolality close to that of the body fluids, and the rapid loss of dilute urine results in a decrease in blood pressure. Thus polyuria with a low specific gravity is not consistent with diabetes mellitus but is consistent with diabetes insipidus. Administration of ADH reverses the symptoms of diabetes insipidus. Neither polydipsia nor polyuria results from a lack of glucagon or aldosterone.
4. The symptoms are consistent with acromegaly, which is a consequence of elevated GH secretion after the epiphyses have closed. Increased GH causes enlarged finger bones, growth of bony ridges over the eyes, and increased growth of the jaw. The anterior pituitary tumor increases pressure at the base of the brain near the optic nerves as it enlarges. The pituitary rests in the sella turcica of the sphenoid bone; as it enlarges pressure increases because the pituitary is nearly surrounded by rigid bone and the brain is located just superior to the pituitary. As the anterior pituitary enlarges because of a tumor, it pushes superiorly and pressure is applied to the ventral portion of the brain. The GH also causes bone deposition on the inner surface of skull bones, which also increases the pressure inside the skull.
5. If hyperthyroidism results from a pituitary abnormality, laboratory tests should show elevated TSH levels in the circulatory system in addition to elevated T_3 and T_4 levels. If hyperthyroidism results from the production of a nonpituitary thyroid-stimulating substance, laboratory tests should also show elevated T_3 and T_4 levels, but TSH levels would be low because of the negative-feedback effects of T_3 and T_4 on the hypothalamus and pituitary gland.
6. The second student is correct. Low levels of vitamin D reduce calcium uptake in the gastrointestinal tract, which results in a decreased blood level of calcium ions. As blood calcium levels decrease, the rate of PTH secretion would increase. Parathyroid hormone increases bone breakdown, which maintains blood calcium levels, even if vitamin D deficiency exists for a prolonged time. Osteomalacia results because of the increased bone reabsorption necessary to maintain normal blood calcium levels.
7. A glucose tolerance test can distinguish between these conditions. The person would consume glucose after a period of fasting. Over the next few hours the blood glucose levels in a healthy person increase and then return to fasting levels. The blood glucose levels always remain within the normal range, however. In a person with diabetes, the blood glucose levels increase to above-normal levels and remain elevated for several hours. In a person who secretes large

amounts of insulin, blood glucose levels would increase, and then they would decrease to below-normal levels within a relatively short time.

8. Because the person is a diabetic and probably is taking insulin, the condition is more likely to be insulin shock than a diabetic coma. To confirm the condition, however, a blood sample should be taken. If the condition is due to a diabetic coma, then the blood glucose levels will be elevated. If the condition is due to insulin shock, the blood glucose levels will be below normal. In the case of insulin shock, glucose can be administered intravenously. In the case of diabetic coma, insulin should be administered. An isotonic solution containing insulin can be administered to reduce the osmolality of the extracellular fluid.
9. Adrenal diabetes results from elevated and uncontrolled secretion of glucocorticoid hormones, such as cortisol, from the adrenal gland. Because glucocorticoid hormones increase blood glucose levels, elevated secretion of these hormones results in elevated blood glucose levels and symptoms similar to diabetes mellitus. Pituitary diabetes results from elevated secretion of GH from the anterior pituitary. Elevated GH causes an increase in blood glucose levels and, therefore, produces symptoms similar to diabetes mellitus. Prolonged elevation of both glucocorticoids and growth hormone secretion can lead to the development of diabetes mellitus if the insulin-secreting cells of the pancreatic islets degenerate because of the prolonged need to secrete insulin in response to the elevated blood glucose levels.
10. Elevated epinephrine from the adrenal medulla promotes elevated blood pressure and increases the work load on the heart, increases the rate of metabolism, and results in increased sweating and nervousness. The risk of heart attack and stroke are increased. Elevated cortisol causes hyperglycemia and can lead to diabetes mellitus, a depressed immune system with increased susceptibility to infections, and destruction of proteins leading to tissue wasting.

Chapter 19

1. Because of the rapid destruction of the red blood cells we would expect erythropoiesis to increase in an attempt to replace the lost red blood cells. The reticulocyte count would therefore be above normal. Jaundice is a symptom of hereditary hemolytic anemia because the destroyed red blood cells release hemoglobin, which is converted into bilirubin. Removal of the spleen cures the disease because the spleen is the major site of red blood cell destruction.
2. Blood doping increases the number of red blood cells in the blood, thereby increasing its oxygen-carrying capacity. The increased number of red blood cells also makes it more difficult for the blood to flow through the blood vessels, increasing the heart's workload.
3. Symptoms resulting from decreased red blood cells are associated with a decreased ability of the blood to carry oxygen: shortness of breath, weakness, fatigue, and pallor. Symptoms resulting from decreased platelets are associated with a decreased ability to form platelet plugs

and clots: small areas of hemorrhage in the skin (petechiae), bruises, and decreased ability to stop bleeding. Symptoms resulting from decreased white blood cells could include an increased susceptibility to infections.

4. Hypoventilation results in decreased blood oxygen levels, which stimulates erythropoiesis. Therefore, the number of red blood cells increases and produces secondary polycythemia.
5. Removal of the stomach removes intrinsic factor, which is necessary for vitamin B₁₂ absorption. Therefore, the patient develops pernicious anemia. Lack of stomach acid can decrease iron absorption in the small intestine and result in iron-deficiency anemia.
6. Vitamin B₁₂ and folic acid are necessary for blood cell division. Lack of these vitamins results in pernicious anemia. Iron is necessary for the production of hemoglobin. Lack of iron results in iron-deficiency anemia. Vitamin K is necessary for the production of many blood clotting factors. Lack of vitamin K can greatly increase blood clotting time, resulting in excessive bleeding.

Chapter 20

1. The walls of the ventricles are thicker than the walls of the atria because the ventricles must produce a greater pressure to pump blood into the arteries. Only a small pressure is required to pump blood from the atria into the ventricles during diastole. The wall of the left ventricle is thicker than the wall of the right ventricle because the left ventricle produces a much greater pressure to force blood through the aorta than the right ventricle produces to move blood through the pulmonary trunk and pulmonary arteries.
2. During systole, the cardiac muscle in the right and left ventricles contracts, which compresses the coronary arteries. During diastole, the cardiac muscle of the ventricles relaxes and blood flow through the coronary arteries increases. The diastolic pressure is sufficient to cause blood to flow through coronary arteries during diastole.
3. A drug that prolongs the plateau of cardiac muscle cell action potentials prolongs the time each action potential exists and increases the refractory period. Therefore, the drug would slow the heart. A drug that shortens the plateau shortens the length of time each action potential exists and shortens the refractory period. Therefore, the drug could allow the heart rate to increase further.
4. Endurance-trained athletes have decreased heart rates because their cardiac muscle undergoes hypertrophy in response to exercise. The hypertrophied cardiac muscle causes the stroke volume to increase substantially. The increased stroke volume is sufficient to maintain an adequate cardiac output and blood pressure even though the heart rate is slower.
5. The two heartbeats occurring close together can be heard through the stethoscope, because the heart valves open and close normally during each of the heartbeats even if they are close together. The second heartbeat, however, produces a greatly reduced stroke volume because there's not enough time for the ventricles to fill with blood between the first and second contraction of the heart. Thus, the preload is reduced. Because the preload is reduced, the second heartbeat has a greatly reduced stroke volume. The reduced stroke volume fails to produce a normal pulse. The pulse deficit, therefore, results from the reduced stroke volume of the second of the two beats that are very close together.
6. Aerobic training causes hypertrophy of the cardiac muscle in the heart and causes the heart to produce a greater stroke volume as a consequence. The heart rate can decrease while the cardiac output remains the same because cardiac output is equal to the stroke volume times the heart rate. If the stroke volume increases, the heart rate can decrease and the cardiac output can remain the same.
7. Atrial contractions complete ventricular filling, but atrial contractions are not primarily responsible for ventricular filling. Therefore, if the atria are fibrillating, blood can still flow into the ventricles and ventricular contractions can occur. As long as the ventricles contract rhythmically the heart can pump an adequate amount of blood even though the atria are fibrillating. If the ventricles undergo fibrillation, however, they cannot fill with blood and cannot function as pumps. Thus the stroke volume will become too low to maintain adequate blood flow to tissues.
8. The results depend on Cee Saw's response to the conditions of the laboratory. First, as Cee Saw's head is lowered, gravity causes blood pressure in the carotid sinuses and aortic arch to increase. The increased blood pressure stimulates baroreceptors, which detect the increased blood pressure and send action potentials indicating that blood pressure increased to the cardioregulatory center in the medulla oblongata along sensory nerve fibers. The cardioregulatory center increases parasympathetic stimulation and reduces sympathetic stimulation of the heart. Thus the heart rate decreases. Second, if, as her head is lowered, Cee Saw becomes excited, the sympathetic division of the ANS becomes more active. The resulting increase in sympathetic stimulation of the heart causes the heart rate to increase.
9. After Cee Saw is tilted so that her head is higher than her feet for a few minutes, the regulatory mechanisms that control blood pressure adjust so that the heart pumps sufficient blood to supply the needs of her tissues. If she is then tilted so that her head is higher than her feet, gravity would cause blood to flow toward her feet, and the blood pressure in the carotid sinus and aortic arch would decrease. The decrease in blood pressure would be detected by the baroreceptors in these vessels and would activate baroreceptor reflexes. The result is increased sympathetic and decreased parasympathetic stimulation of the heart and an increase in the heart rate. The increased heart rate would function to increase the blood pressure to its normal value.
10. An ECG measures the electrical activity of the heart and does not indicate a slight heart murmur. Heart murmurs are detected by

listening to the heart sounds. The boy may have a heart murmur, but the mother does not understand the basis for making such a diagnosis.

11. When both common carotid arteries are clamped, the blood pressure within the internal carotid arteries drops dramatically. The decreased blood pressure is detected, and the baroreceptor reflex increases heart rate and stroke volume. The resulting increase in cardiac output causes the increase in blood pressure.
12. Venous return declines markedly in hemorrhagic shock because of the loss of blood volume. With decreased venous return, stroke volume decreases (Starling's law of the heart). The decreased stroke volume results in a decreased cardiac output, which produces a decreased blood pressure. In response to the decreased blood pressure, the baroreceptor reflex causes an increase in heart rate in an attempt to restore normal blood pressure. However, with inadequate venous return the increased heart rate is not able to restore normal blood pressure.

Chapter 21

1. a. Aorta, left coronary artery, circumflex artery, posterior interventricular artery; or aorta, right coronary artery, posterior interventricular artery
- b. Aorta, brachiocephalic artery, right common carotid artery, right internal carotid artery; or aorta, left common carotid artery, left internal carotid artery
- c. Aorta, brachiocephalic artery, right subclavian artery, right vertebral artery, basilar artery; or aorta, left subclavian artery, left vertebral artery, basilar artery
- d. Aorta, left or right common carotid artery, left or right external carotid artery
- e. Aorta, left subclavian artery, axillary artery, brachial artery, radial or ulnar artery, deep or superficial palmar arch, digital artery (on the right: the brachiocephalic artery would be included)
- f. Aorta, common iliac artery, external iliac artery, femoral artery, popliteal artery, anterior tibial artery
- g. Aorta, celiac artery, common hepatic artery
- h. Aorta, superior mesenteric artery, intestinal branches
- i. Aorta, left or right internal iliac artery
2. a. Great cardiac vein, coronary sinus; or anterior cardiac vein
- b. Transverse sinus, sigmoid sinus, internal jugular vein, brachiocephalic vein, superior vena cava
- c. Retromandibular vein, external jugular vein, subclavian vein, brachiocephalic vein, superior vena cava
- d. Deep: vein of hand, radial or ulnar vein, brachial vein, axillary vein, subclavian vein, brachiocephalic vein, superior vena cava
Superficial: vein of hand, radial or ulnar vein, cephalic or basilic vein, axillary vein, subclavian vein, brachiocephalic vein, superior vena cava

- e. Deep: vein of foot, dorsalis veins of foot, anterior tibial vein, popliteal vein, femoral vein, external iliac vein, common iliac vein, inferior vena cava
Superficial: vein of foot, great saphenous vein, external iliac vein, common iliac vein, inferior vena cava; or vein of foot, small saphenous vein, popliteal vein, femoral vein, external iliac vein, common iliac vein, inferior vena cava
- f. Gastric vein or gastroepiploic vein, hepatic portal vein, hepatic sinusoids, hepatic vein, inferior vena cava
- g. Renal vein, inferior vena cava
- h. Hemiazygous vein or accessory hemiazygous vein, azygous vein, superior vena cava
3. A superficial vessel would be easiest, such as the right cephalic or basilic vein. The catheter is passed through the cephalic (or brachial) vein and the superior vena cava to the right atrium. Because the pulmonary veins are not readily accessible, dye would not normally be placed directly into them. Instead, the dye would be placed in the right atrium using the procedure just described. The dye passes from the right atrium into the right ventricle, the pulmonary arteries, the lungs, the pulmonary veins, and into the left atrium. If the catheter has to be placed in the left atrium, it could be inserted through an artery, such as the femoral artery, and passed via the aorta to the left ventricle and then into the left atrium.
4. The viscosity of the blood is affected primarily by the hematocrit. As hematocrit increases, the viscosity of the blood increases logarithmically, so that even a small increase in hematocrit results in a large increase in viscosity. Greater force is therefore not needed to cause blood to flow through the blood vessels. With the increased blood volume, blood flow through vessels is adequate without an increase in viscosity.
5. The resistance to blood flow is less in the vena cavae for two reasons: first, the diameter of one vena cava is greater than the diameter of the aorta and second, an increased diameter of a blood vessel reduces resistance to flow (see Poiseuille's law). In addition, there are two venae cavae, the superior vena cava and the inferior vena cava, but only one aorta. The blood flow through the aorta and the venae cavae is about equal, but the velocity of blood flow is much higher in the aorta than it is in the venae cavae.
6. According to Laplace's law, as the diameter of a blood vessel increases, the force applied to the vessel wall increases, even if the pressure remains constant. The increased connective tissue found in the walls of the large blood vessels therefore makes the wall of those vessels stronger and more capable of resisting the force applied to the wall.
7. Veins and lymphatic vessels have one-way valves in them. Massage creates a cycle of increasing and decreasing pressure to the veins, which rhythmically compresses them. The compression of the veins forces fluid to move out of the limb through both veins and lymphatic vessels. The movement of fluid through the veins lowers the pressure within the venous end of the capillary. Thus the forces that move fluid into the

capillaries at their venous ends are greater and they move more interstitial fluid into the capillaries. Compression of the lymphatic capillaries also causes more lymphatic fluid to move into the lymphatic vessels. Because there is less fluid in the limb, the edema decreases.

8. The nursing student's diagnosis was incorrect. Blood pressure measurements are normally made in either the right or left arm, both of which are close to the level of the heart. Blood pressure taken in the leg is influenced by pressure created by the pumping action of the heart, but the effect of gravity on the blood, as it flows into the leg, also influences the blood pressure in a substantial way. In this case gravity increases blood pressure from about 120 mm Hg for the systolic pressure to 200 mm Hg.
9. Decreased liver function includes a decrease in the synthesis of plasma proteins. Consequently the concentration of plasma proteins decreases, and the colloid osmotic pressure of the blood decreases. Therefore, less water moves by osmosis into the capillaries at the venous ends and the result is edema.
10. Chemoreceptors in the medulla oblongata detect carbon dioxide and the pH of the blood. The normal blood levels of CO₂ and pH stimulate these chemoreceptors, which in turn stimulate the vasomotor center. The vasomotor center keeps blood vessels partially constricted under resting conditions. This basal level of activity is called the vasomotor tone. Blowing off CO₂ reduces the blood levels of carbon dioxide and increases the pH of the body fluids. These changes reduce vasomotor tone and result in vasodilation. If a person hyperventilates and blows off CO₂, the stimulus to the vasomotor center decreases, which results in a decrease in vasomotor tone. The decrease in vasomotor tone results in a decrease in systemic blood pressure. If the blood pressure decreases enough, the blood flow to the brain decreases and can cause a sensation of dizziness or can even cause a person to lose consciousness.
11. Epinephrine is secreted from the adrenal medulla in response to stressful stimuli and the epinephrine stimulates responses that are consistent with increased physical activity. Vasoconstriction of the blood vessels in the skin shunts blood away from the skin to skeletal muscles. Vasodilation occurs in blood vessels of exercising skeletal muscles. Blood flow through the exercising skeletal muscles therefore increases. Because epinephrine causes vasodilation of the blood vessels of cardiac muscle, blood flow through the cardiac muscle increases. This response is consistent with the increased work performed by the heart under conditions of increased physical activity.
12. The hot Jacuzzi increases Skinny's skin and body temperature. As a result, the blood vessels of the skin dilate. Because the blood vessels dilate, peripheral resistance decreases, causing the blood pressure to decrease. The baroreceptors of the carotid sinus and aortic arch detect the decrease in blood pressure and send action potentials to the cardioregulatory center in the medulla oblongata. As a result, the sympathetic

stimulation to the heart increases and the heart rate, in response, increases also. The increased heart rate elevates the blood pressure back to within its normal range of values.

Chapter 22

- Elevation of the limb reduces blood pressure in the limb, resulting in less fluid movement from the blood into the tissues (see chapter 21). Thus, the edema is reduced as the lymphatic system removes fluid from the tissues faster than it enters them. Massage moves lymph through the lymphatic vessels in the same fashion as contraction of skeletal muscle. The application of pressure periodically to lymphatic vessels forces lymph to flow toward the trunk of the body, but valves prevent the flow of lymph in the reverse direction. The removal of lymph from the tissue helps to relieve edema.
- Normally T cells are processed in the thymus and then migrate to other lymphatic tissues. Without the thymus this processing is prevented. Because there are normally five T cells for every one B cell, the number of lymphocytes is greatly reduced. The loss of T cells results in an increased susceptibility to infection and an inability to reject grafts because of the loss of cell-mediated immunity. In addition, since helper T cells are involved with activation of B cells, antibody-mediated immunity is also depressed.
- That there is no immediate effect indicates there is a reservoir of T cells in the lymphatic tissue. As the reservoir is depleted through time, the number of lymphocytes decreases and cell-mediated immunity is depressed, the animal is more susceptible to infections, and the ability to reject grafts decreases. The ability to produce antibodies decreases because of the loss of helper T cells that are normally involved with the activation of B cells.
- Injection B results in the greatest amount of antibody production. At first, the antigen causes a primary response. A few weeks later, the slowly released antigen causes a secondary response, resulting in a greatly increased production of antibodies. Injection A doesn't cause a secondary response because all of the antigen is eliminated by the primary response.
- If the patient has already been vaccinated, the booster shot stimulates a memory (secondary) response and rapid production of antibodies against the toxin. If the patient has never been vaccinated, vaccinating now is not effective because there's not enough time for the patient to develop his or her own primary response. Therefore, antiserum is given to provide immediate, but temporary, protection. Sometimes both are given: The antiserum provides short-term protection and the tetanus vaccine stimulates the patient's immune system to provide long-term protection. If the shots are given at the same location in the body, the antiserum (antibodies against the tetanus toxin) could cancel the effects of the tetanus vaccine (tetanus toxin altered to be nonharmful).
- The infant's antibody-mediated immunity is not functioning properly, whereas his cell-mediated immunity is working properly. This explains the

Appendix G

A-19

susceptibility to extracellular bacterial infections and the resistance to intracellular viral infections. It took so long to become apparent because IgG from the mother crossed the placenta and provided the infant with protection. The infant began to get sick after these antibodies degraded.

- Bone marrow is the source of the lymphocytes responsible for adaptive immunity. If successful, the transplanted bone marrow starts producing lymphocytes and the baby has a functioning immune response. In this case, there's a graft versus host rejection in which the lymphocytes in the transplanted red marrow mount an immune attack against the baby's tissues, resulting in death.
- At the first location an antibody-mediated response results in an immediate hypersensitivity reaction, which produces inflammation. Most likely the response resulted from IgE antibodies. At the second location a cell-mediated response results in a delayed hypersensitivity reaction, which produces inflammation. This probably involves the release of cytokines and the lysis of cells. At the other locations there is neither an antibody-mediated nor a cell-mediated response.
- The ointment is a good idea for the poison ivy, which causes a delayed hypersensitivity reaction, for example, too much inflammation. For the scrape it's a bad idea, because a normal amount of inflammation is beneficial and helps to fight infection in the scrape.
- Because antibodies and cytokines both produce inflammation, the fact that the metal in the jewelry results in inflammation is not enough information to answer the question. However, the fact that it took most of the day (many hours) to develop the reaction indicates a delayed hypersensitivity reaction and therefore cytokines.

Chapter 23

- Minute respiratory volume is equal to the respiration rate times the tidal volume. With a respiration rate of 12 breaths per minute and a tidal volume of 500 mL per breath, normal minute ventilation is 6000 mL/min (12×500). Rapid (24 breaths per minute), shallow (250 mL per breath) breathing results in the same minute ventilation, that is, 6000 mL/min (24×250). Alveolar ventilation rate (V_A) is the respiratory rate (frequency; f) times the difference between the tidal volume (V_T) and dead space (V_D).

$$V_A = f(V_T - V_D)$$

Normal resting $V_A = 12 \times (500 - 150) = 4200\text{mL/min}$

In this case of rapid shallow breathing,

$$V_A = 24 \times (250 - 150) = 2400\text{mL/min}$$

Thus, even though the minute ventilation is the same in both cases, the alveolar ventilation rate is less during rapid, shallow breathing because there's less effective exchange of gases between the atmosphere and the dead space. Because there's less exchange of gases, the partial pressures of alveolar gases become closer to the partial pressure of blood gases. Consequently, the alveolar partial pressure of O_2 decreases and the alveolar partial pressure of CO_2 increases. This decreases the concentration gradients for

gases, resulting in less gas exchange between alveolar air and blood.

- We expect vital capacity to be greatest when standing because the abdominal organs move inferiorly, thereby allowing greater depression of the diaphragm and a greater inspiratory reserve volume.
- The hose increases dead space and therefore decreases alveolar ventilation. Ima Diver has to compensate by increasing respiratory rate or tidal volume. If the hose is too long, she won't be able to compensate. Furthermore, with a long hose, air is simply moved back and forth in the hose with little exchange of air between the atmosphere and the lungs taking place. Another consideration is the effect of water pressure on the thorax, which decreases compliance and increases the work of ventilation. In fact, a few feet underwater there's enough pressure on the thorax to prevent the intake of air through even a short hose connected to the atmosphere.
- The increase in atmospheric pressure increases the partial pressure of oxygen. According to Henry's law, as the partial pressure of oxygen increases, the amount of oxygen dissolved in the body fluids increases. The increase in dissolved oxygen is detrimental to the gangrene bacteria. Because hemoglobin is already saturated with oxygen, the HBO treatment doesn't increase the ability of hemoglobin to pick up oxygen in the lungs.
- Compression causes a decrease in thoracic volume and therefore lung volume. Consequently, pressure in the lungs increases over atmospheric pressure and air moves out of the lungs. Raising the arms expands the thorax and lungs. This results in a lower-than-atmospheric pressure in the lungs, and air moves into the lungs.
- The victim's lungs expand because of the pressure generated by the rescuer's muscles of expiration. This fills the lungs with air that has a greater pressure than atmospheric pressure. Air flows out of the victim's lungs as a result of this pressure difference and because of the recoil of the thorax and lungs. Although the partial pressure of oxygen of the rescuer's expired air is less than atmospheric, enough oxygen can be provided to sustain the victim. The lower partial pressure of oxygen could also activate the chemoreceptor reflex and stimulate the victim to breathe. In addition, the rescuer's partial pressure of carbon dioxide is higher than atmospheric and this could activate the chemosensitive area in the medulla.
- All else being equal (i.e., the thickness of the respiratory membrane, the diffusion coefficient of the gas, and the surface area of the respiratory membrane), diffusion is a function of the partial pressure difference of the gas across the respiratory membrane. The greater the difference in partial pressure, the greater the rate of diffusion. The greatest rate of oxygen diffusion should therefore occur at the end of inspiration when the partial pressure of oxygen in the alveoli is at its highest. The greatest rate of carbon dioxide diffusion should occur at the end of inspiration when the partial pressure of carbon dioxide in the alveoli is at its lowest.
- Because the partial pressure of oxygen at high altitudes decreases, a shift to the left is advantageous. Such a shift enables hemoglobin to pick up more oxygen at a lower partial pressure of oxygen.
- Cutting the phrenic nerves eliminates contraction of the diaphragm. Tidal volume decreases drastically, and death probably results. Cutting the intercostal nerves eliminates raising of the ribs and sternum and decreases tidal volume, unless the diaphragm compensates. Cutting the vagus nerves eliminates the Hering-Breuer reflex and results in a greater-than-normal inspiration. This increases tidal volume.
- While hyperventilating and making ready to leave your instructor behind, you might make the following arguments:
 - Hyperventilation increases the oxygen content of the air in the lungs; therefore, you would have more oxygen to use when holding your breath.
 - It's hemoglobin that is saturated. Hyperventilation increases the amount of oxygen dissolved in the blood plasma.
 - Hyperventilation decreases the amount of carbon dioxide in the blood. This makes it possible to hold one's breath for a longer time because of a decreased urge to take a breath.
 - Hyperventilation activates alveoli not in use because increasing alveolar oxygen and decreasing alveolar carbon dioxide causes lung arterioles to relax, thereby increasing blood flow through the lungs.

Chapter 24

- With the loss of the swallowing reflex, the vocal folds no longer occlude the glottis. Consequently, vomit can enter the larynx and block the respiratory tract.
- Without adequate amounts of hydrochloric acid, the pH in the stomach is not low enough for the activation of pepsin. This loss of pepsin function results in inadequate protein digestion. If the food is well chewed, however, proteolytic enzymes in the small intestine (e.g., trypsin, chymotrypsin) can still digest the protein. If the stomach secretion of intrinsic factor decreases, the absorption of vitamin B_{12} is hindered. Inadequate amounts of vitamin B_{12} can result in decreased red blood cell production (pernicious anemia).
- Even though ulcers are apparently ultimately caused by bacteria, overproduction of hydrochloric acid due to stress is a possible contributing factor. Reducing hydrochloric acid production is recommended. In addition to antibiotic therapy, commonly recommended solutions include relaxation, drugs that reduce stomach acid secretion, and antacids to neutralize the hydrochloric acid. Smaller meals are also advised because distension of the stomach stimulates acid production. Proper diet is also important. The patient is also advised to avoid alcohol, caffeine, and large amounts of protein because they stimulate acid production. Ingestion of fatty acids is recommended because they inhibit acid production by causing release of gastric inhibitory polypeptide and cholecystokinin. Stress also stimulates the

sympathetic nervous system, which inhibits duodenal gland secretion. As a result, the duodenum has less of a mucous coating and is more susceptible to gastric acid and enzymes. Relaxing after a meal helps decrease sympathetic activities and increase parasympathetic activities.

4. Lack of bile due to blockage of the common bile duct can result in jaundice (due to an accumulation of bile pigments in the blood) and clay-colored stools (due to lack of bile pigments in the feces). Blockage of the bile duct causes abdominal pain, nausea, and vomiting. Fat absorption is impaired because of the absence of bile salts in the duodenum and a loose, bulky stool would result. Lack of fat absorption reduces the absorption of fat-soluble vitamins such as vitamin K, resulting in lack of normal clotting function.
5. The patient would still be able to defecate. Following a meal the gastrocolic and duodenocolic reflexes could initiate mass movement of the feces into the rectum. In the rectum, local reflexes and the defecation reflex (integrated in the sacral level of the cord and not requiring connections to high brain centers) would cause defecation. Awareness of the need to defecate would be lost (due to loss of sensory input to the brain) and the ability to voluntarily prevent defecation via the external anal sphincter would also be lost.
6. The accumulation of materials above the site of impaction and the action of bacteria on the material would result in an increase in osmotic pressure in the area. Water would move by osmosis into the colon above the site of impaction. Bowel impaction is very dangerous and must be treated quickly. The increased volume and distention of the digestive tract above the site of impaction causes compression of the mucosa. This compression can occlude blood vessels in the mucosa and lead to necrosis. Necrosis of the mucosa results in increased permeability of the mucosa, thus allowing toxic organisms and substances in the digestive tract to enter the circulation, resulting in septic shock.

Chapter 25

1. In figure 25.2, the Daily Value for saturated fat is listed as less than 20 g for a 2000 kcal/day diet. The % Daily Values appearing on food labels are based on a 2000 kcal/day diet. Therefore, the % Daily Value for saturated fat for one serving of this food is 10% ($2/20 = .10$, or 10%).
2. According to the Daily Value guidelines, total fats should be no more than 30% of total kilocaloric intake. For someone consuming 3000 kcal/day this is 900 kcal ($3000 \text{ kcal} \times 0.30$). There are 9 kcal in a gram of fat. Therefore, the maximum amount (weight) of fats the active teenage boy should consume is 100 g (900/9).
3. The % Daily Value is the amount of the nutrient in one serving divided by its Daily Value. Therefore the % Daily Value is 10% ($10/100 = .10$, or 10%).
4. The % Daily Value for one serving of the food is 10% (see answer to question 3). Since there are four servings in the package, if the teenager eats half of the food in the package, he consumes two servings. Thus, he eats 20% ($10\% \times 2$) of the recommended maximum total fat.

5. The protein in meat contains all of the essential amino acids and is a complete protein food. Although plants contain proteins, a variety of different plants must be consumed to ensure that all the essential amino acids are included in adequate amounts. Also, plants contain less protein per unit weight than meat, so a larger quantity of plants must be consumed to get the same amount of protein.
6. Copper is necessary for proper functioning of the electron-transport chain. Inadequate copper in the diet results in reduced ATP production, that is, not enough energy.
7. Fasting can be damaging because proteins are used to produce glucose. The glucose enters the blood and provides an energy source for the brain. This breakdown of proteins can damage tissues such as muscle and disrupt chemical reactions regulated by enzyme systems. A single day without food, however, is unlikely to cause permanent harm.
8. Weight is lost when kilocalories used per day exceeds kilocalories ingested per day. About 60% of the kilocalories used per day is due to basal metabolic rate. A person with a high basal metabolic rate loses weight faster than a person with a low basal metabolic rate, all else being equal. Another factor to consider is the amount of physical activity, which accounts for about 30% of kilocalories used per day. An active person loses more weight than a sedentary person does.
9. Amino acids, derived from ingested proteins, are necessary to build muscles. As Lotta and her friend discovered, excess proteins don't accelerate this process. Excess proteins can be used as an energy source in oxidative deamination, for the formation of the intermediate molecules of carbohydrate metabolism, or in gluconeogenesis. Excess proteins are also converted into storage molecules through glycogenesis or lipogenesis. Lotta is in positive nitrogen balance because the amount of nitrogen she gains from her diet is greater than the amount she loses by excretion. Some of the nitrogen in the amino acids she ingests is incorporated into the proteins of her muscles as they enlarge.
10. No, this approach doesn't work because he is not losing stored energy from adipose tissue. In the sauna, he gains heat, primarily by convection from the hot air and by radiation from the hot walls. The evaporating sweat is removing heat gained from the sauna. The loss of water will make him thirsty, and he will regain the lost weight from fluids he drinks and food he eats.

Chapter 26

1. The large volume of hypoosmotic fluid ingested increases blood volume and causes blood osmolality to decrease. The increased blood volume is detected by baroreceptors, and the decreased blood osmolality is detected by osmoreceptors in the hypothalamus. The response to these stimuli is inhibition of ADH secretion. The alcohol in the beer also inhibits ADH secretion. The increased volume inhibits the renin-angiotensin-aldosterone mechanism,

which, in turn, inhibits aldosterone secretion. The changes in aldosterone, however, take much longer to influence kidney function than changes in ADH. As a result of these changes a large volume of dilute urine is produced until the blood osmolality and blood volume return to normal.

2. Once the salt is absorbed, the osmolality of the blood increases. The increased osmolality of blood is detected by osmoreceptor neurons in the hypothalamus, thereby stimulating ADH secretion and inhibiting aldosterone secretion. A small volume of concentrate urine is produced as a result, until the excess salt is eliminated and the blood osmolality returns to its normal value.
3. The hypoosmotic sweat loss results in more loss of water than electrolytes. This simultaneously decreases plasma volume and increases blood osmolality, thereby stimulating increased ADH secretion. In addition, the decreased plasma volume stimulates the renin-angiotensin-aldosterone mechanism, resulting in a decreased glomerular filtration rate and increased aldosterone secretion. The effect of the changes is to produce a small amount of concentrated urine.
4. The loss of sweat results in a loss of water and electrolytes. Replacing just the water restores blood volume and also decreases blood osmolality. At first, the decreased osmolality inhibits ADH secretion, and dilute urine is produced. As blood volume decreases as a result of urine production, however, ADH secretion and the renin-angiotensin-aldosterone mechanisms are stimulated. Consequently, urine concentration increases, and only a small amount of urine is produced.
5. As aldosterone levels decrease, sodium reabsorption in the nephron decreases and, consequently, plasma sodium levels decrease. The sodium is lost in the urine, and water follows the sodium by osmosis. Thus, a large amount of urine that has a high concentration of sodium is produced. The loss of water reduces blood volume, which causes the low blood pressure. As aldosterone levels decrease potassium secretion into the nephron decreases, resulting in an increase in plasma potassium levels. The increased extracellular potassium causes depolarization of nerve and muscle membranes, leading to tremors of skeletal muscles and cardiac arrhythmias including fibrillation.
6. There are several ways to decrease glomerular filtration rate:
 - a. Decrease hydrostatic pressure in the glomerulus.
 1. Decrease systemic arterial blood pressure.
 - a. Decrease extracellular fluid volume.
 - b. Decrease peripheral resistance.
 - c. Decrease cardiac output.
 2. Constrict or occlude the afferent arteriole.
 3. Relax the efferent arteriole.
 - b. Increase glomerular capsule pressure.
 - c. Increase the colloid osmotic pressure of the plasma.
 - d. Decrease the permeability of the filtration barrier.
 - e. Decrease the total area of the glomeruli available for filtration.

Appendix G

A-21

7. Assume that the ascending limb of the loop of Henle and the distal tubules are impermeable to sodium and other ions but actively pump out water. Other characteristics of the kidney are assumed to be unchanged. As the urine moves up the ascending limb it becomes hyperosmotic, because sodium remains behind as water is pumped out. Assuming that the collecting ducts are impermeable to sodium, upon reaching the collecting ducts the presence or absence of ADH determines the final concentration of the urine. If ADH is absent, there's little or no exchange of water as the urine passes down the collecting ducts and a hyperosmotic urine will be produced. On the other hand, if ADH is present, water moves from the interstitial fluid into the collecting ducts, thus diluting the urine and producing a hypoosmotic urine.
8. Urea is partially responsible for the high osmolality of the interstitial fluid in the medulla of the kidney. Since a high osmolality of the interstitial fluid must exist for the kidney to produce a concentrated urine, a small amount of urea in the kidney results in the production of dilute urine by the kidney.
9. A low-salt diet tends to reduce the osmolality of the blood. Consequently, ADH secretion is inhibited, producing dilute urine and thus eliminating water. This in turn reduces blood volume and blood pressure.
10. As the loops of Henle become longer, the mechanisms that increase concentration of the interstitial fluid of the medulla become more efficient, thus raising the concentration of the interstitial fluid. The maximum concentration for urine is determined by the concentration of the interstitial fluid deep in the medulla of the kidneys. The higher the concentration of interstitial fluid in the medulla of the kidney, the greater the concentration of the urine the kidney is able to produce.

Chapter 27

1. When excess glucose is not reabsorbed it osmotically obligates water to remain in the nephron. This results in a large production of urine, called polyuria, with a consequent loss of water, salts, and glucose. The loss of water can be compensated for by increasing fluid intake. The intense thirst that stimulates increased fluid intake is called polydipsia. The loss of salts can be compensated for by increasing the salt intake. The high glucose levels in the blood would increase the blood osmolality, thus stimulating the secretion of ADH. This increases the permeability of the distal convoluted tubule and collecting duct to water. Normally, this would allow reabsorption of water from the collecting ducts and thus conserve water. If glucose levels in the urine are high enough, however, water loss increases even with high levels of ADH being present.
2. When ADH levels first increase the reabsorption of water increases and urinary output is reduced. This also causes an increase in blood volume and, therefore, an increase in blood pressure. The increased blood pressure increases glomerular filtration rate, which increases urinary output to normal levels. In addition, the increased blood

volume inhibits the renin-angiotensin-aldosterone mechanism, inhibits aldosterone secretion, and stimulates natriuretic hormone secretion. These responses also increase urinary output.

3. Elevated ammonia ions in the urine results from an increased secretion of H^+ . Increased secretion of H^+ occurs in response to either metabolic or respiratory acidosis. Because an elevated respiratory rate increases blood pH, the most logical conclusion is that the condition is metabolic acidosis, and the observed increase in respiration rate compensates for the metabolic acidosis by lowering H^+ levels.
4. Diarrhea is one of the most common causes of metabolic acidosis, resulting from the loss of bicarbonate ions. Increasing the respiration rate and producing an acidic urine both help to increase the blood pH.
5. Blocking H^+ secretion produces acidosis. Because H^+ are exchanged for Na^+ , the Na^+ remain in the urine as sodium bicarbonate. This effectively prevents the reabsorption of HCO_3^- and produces an alkaline urine. The blood pH is reduced because H^+ are not being secreted as rapidly by the nephron. The respiration rate increases because of the stimulatory effect of decreased blood pH on the respiratory center.
6. Breathing through the glass tube increases the dead air space and decreases the efficiency of gas exchange. Consequently, blood carbon dioxide levels increase and produce a decrease in blood pH. Compensatory responses include an increased respiration rate and the production of acidic urine.
7. A major effect of alkalosis is hyperexcitability of the nervous system. If the girl is prone to having convulsions, then inducing alkalosis might result in a seizure. This could be accomplished by having the girl hyperventilate. The resulting loss of carbon dioxide from the blood causes an increase in blood pH.
8. At high altitudes, we expect stimulation of the chemoreceptor reflex and an increase in respiration rate. This could result in hyperventilation, a decrease in blood carbon dioxide, and respiratory alkalosis. The increased secretion of hydrochloric acid into the stomach could also increase blood pH and contribute to the problem. The kidney produces a more alkaline urine.

Chapter 28

1. Removing the testes would eliminate the major source of testosterone. Blood levels of testosterone would therefore decrease. Because testosterone has a negative-feedback effect on the hypothalamus and pituitary gland, GnRH, FSH, and LH secretion would increase and the blood levels of these hormones would increase.
2. Prior to puberty, the levels of GnRH are very low because the hypothalamus is very sensitive to the inhibitory effects of testosterone. Since GnRH levels are low, so are FSH and LH levels. Loss of the testes and testosterone production would result in an increase in GnRH, FSH, and LH levels. Because little testosterone is produced the boy would not develop sexually and would have no sex drive. Small amounts of androgens would be produced

because the adrenal cortex produces some androgens. He would be taller than normal as an adult, with thin bones and weak musculature. His voice would not deepen and the normal masculine distribution of hair would not develop.

3. Ideally the pill would inhibit spermatogenesis. Using the same approach as in females, inhibition of FSH and LH secretion should work. It's known that chronic administration of GnRH suppresses FSH and LH levels enough to cause infertility, through down-regulation. Lack of LH can also result in reduced testosterone levels and a loss of sex drive, however. Some evidence indicates that administration of testosterone in the proper amounts would reduce FSH and LH secretion, thus leading to a reduced sperm cell production. The testosterone, however, maintains normal sex drive. The technique appears to work for a large percentage of males, resulting in a sperm concentration in the semen that's too low to result in fertilization. The technique is not sufficiently precise, however, to be used as a standard birth-control technique.
4. In a postmenopausal woman the ovaries have stopped producing estrogen and progesterone. Without the negative-feedback effect of these hormones the levels of GnRH, FSH, and LH increase. Removal of the nonfunctioning ovaries in a postmenopausal woman doesn't change the level of any of these hormones or produce any symptoms not already occurring due to the lack of ovarian function.
5. Answer *e* is correct. The secretory phase of the menstrual cycle occurs after ovulation. It is following ovulation that the corpus luteum forms and produces progesterone. In addition, the progesterone acts on the endometrium of the uterus to cause its maximum development. Progesterone secretion therefore reaches its maximum levels and the endometrium reaches its greatest degree of development during the secretory phase of the menstrual cycle.
6. The removal of the ovaries from a 20-year-old woman eliminates the major site of estrogen and progesterone production, thereby causing an increase in GnRH, FSH, and LH levels due to lack of negative feedback. One expects to see the symptoms of menopause such as cessation of menstruation and reduction in the size of the uterus, vagina, and breasts. There may also be a temporary reduction in sex drive.
7. It's clear that estrogen and progesterone administration resulted in a large decrease in the amount of LH in the plasma the day of ovulation. The differences in plasma LH levels between the groups at other times are very small. The incidence of pregnancies suggests that the reduced plasma LH levels may result in no ovulation.
8. The progesterone inhibits GnRH in the hypothalamus. Consequently, the anterior pituitary is not stimulated to produce LH and FSH. Lack of LH prevents ovulation and lack of FSH prevents development of the follicles. LH also is required for maturation of follicles prior to ovulation. Without follicle development, there's inadequate estrogen production, which causes the hot flash symptoms.

9. GnRH administered either before or after the normal time of ovulation doesn't result in ovulation, because the anterior pituitary is less sensitive to the effect of GnRH during those times. Also, follicles in the ovary are not adequately developed. The concentration of GnRH must be controlled carefully because too little results in inadequate FSH and LH being released from the anterior pituitary. Too little FSH and LH fails to cause ovulation. Too much GnRH given at the proper time results in the maturation of more than one follicle and the release of an oocyte from more than one of the follicles. If the oocytes are fertilized, multiple pregnancies can result.

Chapter 29

1. Postovulatory age, the approximate length of time the embryo has been developing, is 14 days less than the time since the last menstrual period (LMP). In this case, the postovulatory age is 30 days (44 – 14). By this time the neural tube has closed, the somites have formed, the digestive tract is developing, the limb buds have appeared, a tubular beating heart is present, and the lungs are developing. Based on reproductive structures, which are just forming, male and female embryos are indistinguishable at this age.
2. The fever would have occurred on day 21–31 of development, which is during part of the time of neural tube closure (days 18–25). If the fever prevented neural tube closure, the child could be born with anencephalus or spina bifida.
3. The limb buds develop in a proximal-to-distal sequence. If the apical ectodermal ridge is damaged during embryonic development when the limb bud is about one-half grown, the proximal structures, the arm and forearm, develop normally, but the distal structures, the wrist and hand, do not form normally. Depending on the degree of damage, the wrist and hand could be completely absent or underdeveloped.
4. The mesonephric duct system develops, because of testosterone, to form portions of the male reproductive duct system. Without the production of Müllerian-inhibiting hormone, the paramesonephric duct system also develops to form the uterus and uterine tubes. Although ovaries are present, the clitoris may be enlarged because of testosterone to produce somewhat the appearance of male external genitalia. The amount of masculinization would depend on the levels of testosterone and how long it was administered. High levels of testosterone over an extended period would completely masculinize the external genitalia.
5. This total Apgar score of 5 indicates: appearance (A, 0) white or blue; pulse (P, 1) low; grimace (G, 1) slight; activity (A, 1) little movement and poor muscle tone; and respiration (R, 2) normal. The white or blue appearance (A, 0) is consistent with a poor circulation indicated by a reduced pulse (P, 1). The reduced heart rate, resulting in the low pulse, may indicate a circulatory system problem. The reduced reflexes and motor activity (G, 1; A, 1) could result from the lack of oxygen in the muscles resulting from poor circulation. Because the infant has poor circulation despite a normal respiration, clearing the airway (if obstructed) and administering oxygen are in order. This Apgar score could have several causes, and additional information is necessary to determine the actual cause.
6. Suckling the breast stimulates the release of oxytocin from the neurohypophysis (posterior pituitary). Once the oxytocin is in the blood, it travels to both breasts and causes milk letdown.
7. If both parents are heterozygous for dimpled cheeks, then the child could receive a recessive gene for no dimples from each parent, resulting in the homozygous recessive condition with no dimples in the cheeks.
8. It's not possible at present to determine by phenotype if a child is homozygous or heterozygous for tongue rolling. Even if it were possible to determine that the child was heterozygous, that's not very strong evidence that the recessive allele came from the proposed father.
9. Hemophilia is a sex-linked trait. Since the father has hemophilia he must be X^hY . If the mother were X^HX^h , all their children would be normal. For half of the children to have hemophilia, she must be X^HX^h .