## Contents

### Organization of the Body

## The Human Body: An Orientation

- 1.1 Form (anatomy) determines function (physiology) 32
- 1.2 The body's organization ranges from atoms to the entire organism 34
- 1.3 What are the requirements for life? 35
- 1.4 Homeostasis is maintained by negative feedback 39
- 1.5 Anatomical terms describe body directions, regions, and planes 42 metables at an interest and an inter
- A CLOSER LOOK Medical Imaging: Illuminating the Body 46
- 1.6 Many internal organs lie in membrane-lined body cavities 48

## Chemistry Comes Alive 53

#### PART 1 BASIC CHEMISTRY

- 2.1 Matter is the stuff of the universe and energy moves matter 54
- 2.2 The properties of an element depend on the structure of its atoms 55

25 The Urinary System 1008

- 2.3 Atoms bound together form molecules; different molecules can make mixtures 58
- 2.4 Three types of chemical bonds are ionic, covalent, and hydrogen 61
- 2.5 Chemical reactions occur when electrons are shared, gained, or lost 65

#### **BIOCHEMISTRY**

- 2.6 Inorganic compounds include water, salts, and many acids and bases 68
- 2.7 Organic compounds are made by dehydration synthesis and broken down by hydrolysis 71

- 2.8 Carbohydrates provide an easily used energy source for the body 73
- 2.9 Lipids insulate body organs, build cell membranes, and provide stored energy 75
- 2.10 Proteins are the body's basic structural material and have many vital functions 78
- 2.11 DNA and RNA store, transmit, and help express genetic information 83
- 2.12 ATP transfers energy to other compounds 85

## **3** Cells: The Living Units

3.1 Cells are the smallest unit of life 91

### PART 1 PLASMA MEMBRANE

3.2 The plasma membrane is a double layer of phospholipids with embedded proteins 93

FOCUS FIGURE 3.1 The Plasma Membrane 94

- 3.3 Passive membrane transport is diffusion of molecules down their concentration gradient 98
- 3.4 Active membrane transport directly or indirectly uses ATP 103

FOCUS FIGURE 3.2 Primary Active Transport: The Na<sup>+</sup>-K<sup>+</sup> Pump 104

- 3.5 Selective diffusion establishes the membrane potential 109
- 3.6 Cell adhesion molecules and membrane receptors allow the cell to interact with its environment 111

Activity 521

FOCUS FIGURE 3.3 G Proteins 112

#### THE CYTOPLASM The Autonomic Nervous System 503

- 3.7 Cytoplasmic organelles each perform a specialized task 113
- 3.8 Cilia and microvilli are two main types of cellular extensions 120

DEPTS	NUCLEUS	121
THE LA	NUCLEUS	

- 3.9 The nucleus includes the nuclear envelope, the nucleolus, and chromatin 121
- 3.10 The cell cycle consists of interphase and a mitotic phase 126
- 3.11 Messenger RNA carries instructions from DNA for building proteins 128

FOCUS FIGURE 3.4 Mitosis 130

FOCUS FIGURE 3.5 Translation 136

3.12 Autophagy and proteasomes dispose of unneeded organelles and proteins; apoptosis disposes of unneeded cells 138

DEVELOPMENTAL ASPECTS of Cells 139

## 4 Tissue: The Living Fabric 145

- Tissue samples are fixed, sliced, and stained for microscopy 147
- **4.2** Epithelial tissue covers body surfaces, lines cavities, and forms glands 147
- Connective tissue is the most abundant and widely distributed tissue in the body 156
- 44 Muscle tissue is responsible for body movement 168
- Nervous tissue is a specialized tissue of the nervous system 170
- The cutaneous membrane is dry; mucous and serous membranes are wet 171
- Tissue repair involves inflammation, organization, and regeneration 172
- **LOSER LOOK** Cancer—The Intimate Enemy 174

DEVELOPMENTAL ASPECTS of Tissues 176

## **WIT 2** Covering, Support, and Movement of the Body

## 5 The Integumentary System 180

- The skin consists of two layers: the epidermis and dermis 180
- The epidermis is a keratinized stratified squamous epithelium 182
- The dermis consists of papillary dermis and reticular dermis 184
- Melanin, carotene, and hemoglobin determine skin color 186
- 55 Hair consists of dead, keratinized cells 187

- 5.6 Nails are scale-like modifications of the epidermis
- 5.7 Sweat glands help control body temperature, and sebaceous glands secrete sebum 191
- 5.8 First and foremost, the skin is a barrier 193
- **5.9** Skin cancer and burns are major challenges to the body 195

**DEVELOPMENTAL ASPECTS** of the Integumentary System 197

**SYSTEM CONNECTIONS** 198

## 6 Bones and Skeletal Tissues 203

- **6.1** Hyaline, elastic, and fibrocartilage help form the skeleton 204
- 6.2 Bones perform several important functions 205
- 6.3 Bones are classified by their location and shape 206
- **6.4** The gross structure of all bones consists of compact bone sandwiching spongy bone 206
- **6.5** Bones develop either by intramembranous or endochondral ossification 214
- **6.6** Bone remodeling involves bone deposition and removal 218
- **6.7** Bone repair involves hematoma and callus formation, and remodeling 220
- **6.8** Bone disorders result from abnormal bone deposition and resorption 223

DEVELOPMENTAL ASPECTS of Bones 224

SYSTEM CONNECTIONS 226

## **The Skeleton** 229

## PART 1 THE AXIAL SKELETON 229

- 7.1 The skull consists of 8 cranial bones and 14 facial bones 231
- **7.2** The vertebral column is a flexible, curved support structure 248
- 7.3 The thoracic cage is the bony structure of the chest 254

#### PART 2 THE APPENDICULAR SKELETON 257

- 7.4 Each pectoral girdle consists of a clavicle and a scapula 257
- 7.5 The upper limb consists of the arm, forearm, and hand 260
- **7.6** The hip bones attach to the sacrum, forming the pelvic girdle 266
- 7.7 The lower limb consists of the thigh, leg, and foot 270

**DEVELOPMENTAL ASPECTS** of the Skeleton 276

## 8 Joints 281

- 8.1 Joints are classified into three structural and three functional categories 281
- **8.2** In fibrous joints, the bones are connected by fibrous tissue 282
- **8.3** In cartilaginous joints, the bones are connected by cartilage 283
- 8.4 Synovial joints have a fluid-filled joint cavity 284

FOCUS FIGURE 8.1 Synovial Joints 292

- 8.5 Five examples illustrate the diversity of synovial joints 294
- **8.6** Joints are easily damaged by injury, inflammation, and degeneration 302

A CLOSER LOOK Joints: From Medieval Armor to Bionic Humans 304

DEVELOPMENTAL ASPECTS of Joints 305

## 9 Muscles and Muscle Tissue 309

- 9.1 There are three types of muscle tissue 310
- **9.2** A skeletal muscle is made up of muscle fibers, nerves, blood vessels, and connective tissues 311
- 9.3 Skeletal muscle fibers contain calcium-regulated molecular motors 314
- 9.4 Motor neurons stimulate skeletal muscle fibers to contract 320

FOCUS FIGURE 9.1 Events at the Neuromuscular Junction 322

FOCUS FIGURE 9.2 Excitation-Contraction Coupling 324

FOCUS FIGURE 9.3 Cross Bridge Cycle 327

- **9.5** Temporal summation and motor unit recruitment allow smooth, graded skeletal muscle contractions 328
- 9.6 ATP for muscle contraction is produced aerobically or anaerobically 333
- **9.7** The force, velocity, and duration of skeletal muscle contractions are determined by a variety of factors 336
- 9.8 How does skeletal muscle respond to exercise? 339
- 9.9 Smooth muscle is nonstriated involuntary muscle 340

DEVELOPMENTAL ASPECTS of Muscles 346

A CLOSER LOOK Athletes Looking Good and Doing Better with Anabolic Steroids? 347

7.7 The lower limb consists of the thigh, leg, and foot, 1270

girdle 266

#### **SYSTEM CONNECTIONS** 348

## 10 The Muscular System 353

- 10.1 For any movement, muscles can act in one of three ways 354
- 10.2 How are skeletal muscles named? 354

FOCUS FIGURE 10.1 Muscle Action 355

- **10.3** Fascicle arrangements help determine muscle shape and force 356
- 10.4 Muscles acting with bones form lever systems 357
- 10.5 A muscle's origin and insertion determine its action 362
- Table 10.1 Muscles of the Head, Part I: Facial Expression 363
- **Table 10.2** Muscles of the Head, Part II: Mastication and Tongue Movement 366
- **Table 10.3** Muscles of the Anterior Neck and Throat:

  Swallowing 368
- **Table 10.4** Muscles of the Neck and Vertebral Column: Head Movements and Trunk Extension 370
- Table 10.5 Deep Muscles of the Thorax: Breathing 374
- **Table 10.6** Muscles of the Abdominal Wall: Trunk Movements and Compression of Abdominal Viscera 376
- **Table 10.7** Muscles of the Pelvic Floor and Perineum: Support of Abdominopelvic Organs 378
- **Table 10.8** Superficial Muscles of the Anterior and Posterior Thorax: Movements of the Scapula and Arm 380
- **Table 10.9** Muscles Crossing the Shoulder Joint: Movements of the Arm (Humerus) 384
- **Table 10.10** Muscles Crossing the Elbow Joint: Flexion and Extension of the Forearm 387
- **Table 10.11** Muscles of the Forearm: Movements of the Wrist, Hand, and Fingers 388
- **Table 10.12** Summary: Actions of Muscles Acting on the Arm, Forearm, and Hand 392
- **Table 10.13** Intrinsic Muscles of the Hand: Fine Movements of the Fingers 394
- **Table 10.14** Muscles Crossing the Hip and Knee Joints: Movements of the Thigh and Leg 397
- **Table 10.15** Muscles of the Leg: Movements of the Ankle and Toes 404
- Table 10.16 Intrinsic Muscles of the Foot: Toe Movement and Arch Support 410
- **Table 10.17** Summary: Actions of Muscles Acting on the Thigh, Leg, and Foot 414

5.5 Hair consists of dead, keratinized cells 0517 anoisnesses

### **WIIIT 3** Regulation and Integration of the Body

# 11 Fundamentals of the Nervous System and Nervous Tissue 420

- The nervous system receives, integrates, and responds to information 421
- Neuroglia support and maintain neurons 422
- Neurons are the structural units of the nervous system 424
- The resting membrane potential depends on differences in ion concentration and permeability 431
- FIGURE 11.1 Resting Membrane Potential 433
- Graded potentials are brief, short-distance signals within a neuron 435
- Action potentials are brief, long-distance signals within a neuron 436
- FOCUS FIGURE 11.2 Action Potential 438
- Synapses transmit signals between neurons 443
- FOCUS FIGURE 11.3 Chemical Synapse 446
- Postsynaptic potentials excite or inhibit the receiving neuron 447
- The effect of a neurotransmitter depends on its receptor 449
- FIGURE 11.4 Postsynaptic Potentials and Their Summation 450
- Neurons act together, making complex behaviors possible 457
- **DEVELOPMENTAL ASPECTS** of Neurons 458
- **ELOSER LOOK** Pleasure and Addiction 460

## 12 The Central Nervous System 466

- Folding during development determines the complex structure of the adult brain 467
- The cerebral hemispheres consist of cortex, white matter, and the basal nuclei 471
- The diencephalon includes the thalamus, hypothalamus, and epithalamus 479
- The brain stem consists of the midbrain, pons, and medulla oblongata 482
- The cerebellum adjusts motor output, ensuring coordination and balance 486
- Functional brain systems span multiple brain structures 488

- **12.7** The interconnected structures of the brain allow higher mental functions 490
- **12.8** The brain is protected by bone, meninges, cerebrospinal fluid, and the blood brain barrier 496
- **12.9** Brain injuries and disorders have devastating consequences 500
- **12.10** The spinal cord is a reflex center and conduction pathway 502
- **12.11** Neuronal pathways carry sensory and motor information to and from the brain 508
- **DEVELOPMENTAL ASPECTS** of the Central Nervous System 514

## 13 The Peripheral Nervous System and Reflex Activity 521

#### PART 1 SENSORY RECEPTORS AND SENSATION 522

- **13.1** Sensory receptors are activated by changes in the internal or external environment 522
- **13.2** Receptors, ascending pathways, and cerebral cortex process sensory information 525

## PART 2 TRANSMISSION LINES: NERVES AND THEIR STRUCTURE AND REPAIR 528

- **13.3** Nerves are cordlike bundles of axons that conduct sensory and motor impulses 528
- 13.4 There are 12 pairs of cranial nerves 530
- 13.5 31 pairs of spinal nerves innervate the body 539

### PART 3 MOTOR ENDINGS AND MOTOR ACTIVITY 549

- **13.6** Peripheral motor endings connect nerves to their effectors 549
- 13.7 There are three levels of motor control 549

#### PART 4 REFLEX ACTIVITY 551

- 13.8 The reflex arc enables rapid and predictable responses 551
- **13.9** Spinal reflexes are somatic reflexes mediated by the spinal cord 552

FOCUS FIGURE 13.1 Stretch Reflex 554

**DEVELOPMENTAL ASPECTS** of the Peripheral Nervous System 558

# 14 The Autonomic Nervous System 563

**14.1** The ANS differs from the somatic nervous system in that it can stimulate or inhibit its effectors 564

21.1 Surfaced as established the forest and the surfaced as th

14.2 The ANS consists of th	e parasympathetic and
sympathetic divisions	functions 490 662

- **14.3** Long preganglionic parasympathetic fibers originate in the craniosacral CNS 568
- **14.4** Short preganglionic sympathetic fibers originate in the thoracolumbar CNS 570
- **14.5** Visceral reflex arcs have the same five components as somatic reflex arcs 574
- **14.6** Acetylcholine and norepinephrine are the major ANS neurotransmitters 575
- **14.7** The parasympathetic and sympathetic divisions usually produce opposite effects 577
- 14.8 The hypothalamus oversees ANS activity 579
- **14.9** Most ANS disorders involve abnormalities in smooth muscle control 580

DEVELOPMENTAL ASPECTS of the ANS 580

SYSTEM CONNECTIONS 582

nt 522

## 15 The Special Senses 585

### PART 1 THE EYE AND VISION 586

- **15.1** The eye has three layers, a lens, and humors, and is surrounded by accessory structures 586
- 15.2 The cornea and lens focus light on the retina 595
- **15.3** Phototransduction begins when light activates visual pigments in retinal photoreceptors 599
- **15.4** Visual information from the retina passes through relay nuclei to the visual cortex 605

#### PART 2 THE CHEMICAL SENSES: SMELL AND TASTE 607

- **15.5** Airborne chemicals are detected by olfactory receptors in the nose 607
- **15.6** Dissolved chemicals are detected by receptor cells in taste buds 610

#### PART 3 THE EAR: HEARING AND BALANCE 612

- 15.7 The ear has three major areas 612
- **15.8** Sound is a pressure wave that stimulates mechanosensitive cochlear hair cells 617
- **15.9** Sound information is processed and relayed through brain stem and thalamic nuclei to the auditory cortex 621
- **15.10** Hair cells in the maculae and cristae ampullares monitor head position and movement 622
- **15.11** Ear abnormalities can affect hearing, equilibrium, or both 626

**DEVELOPMENTAL ASPECTS** of the Special Senses 627

## 16 The Endocrine System 633

- **16.1** The endocrine system is one of the body's two major control systems 634
- 16.2 The chemical structure of a hormone determines how it acts 635
- **16.3** Hormones act through second messengers or by activating specific genes 635
- 16.4 Three types of stimuli cause hormone release 639
- **16.5** Cells respond to a hormone if they have a receptor for that hormone 640
- **16.6** The hypothalamus controls release of hormones from the pituitary gland in two different ways 641

Focus FIGURE 16.1 Hypothalamus and Pituitary Interactions 642

- 16.7 The thyroid gland controls metabolism 649
- **16.8** The parathyroid glands are primary regulators of blood calcium levels 653
- **16.9** The adrenal glands produce hormones involved in electrolyte balance and the stress response 654
- 16.10 The pineal gland secretes melatonin 659

FOCUS FIGURE 16.2 Stress and the Adrenal Gland 660

**16.11** The pancreas, gonads, and most other organs secrete hormones 662

A CLOSER LOOK Sweet Revenge: Taming the Diabetes Monster? 665

**DEVELOPMENTAL ASPECTS** of the Endocrine System 668

**SYSTEM CONNECTIONS** 669

### UNIT 4 Maintenance of the Body

## 17 Blood 674

- **17.1** The functions of blood are transport, regulation, and protection 675
- 17.2 Blood consists of plasma and formed elements 675
- **17.3** Erythrocytes play a crucial role in oxygen and carbon dioxide transport 677
- 17.4 Leukocytes defend the body 683
- 17.5 Platelets are cell fragments that help stop bleeding 689
- 17.6 Hemostasis prevents blood loss 689
- 17.7 Transfusion can replace lost blood 695
- 17.8 Blood tests give insights into a patient's health 698

DEVELOPMENTAL ASPECTS of Blood 698

## 18 The Cardiovascular System: The Heart 702

- **18.1** The heart has four chambers and pumps blood through the pulmonary and systemic circuits 703
- 18.2 Heart valves make blood flow in one direction 711
- 18.3 Blood flows from atrium to ventricle, and then to either the lungs or the rest of the body 712
- FOCUS FIGURE 18.1 Blood Flow through the Heart 713
- 18.4 Intercalated discs connect cardiac muscle fibers into a functional syncytium 715
- 13.5 Pacemaker cells trigger action potentials throughout the heart 718
- The cardiac cycle describes the mechanical events associated with blood flow through the heart 724
- FOCUS FIGURE 18.2 The Cardiac Cycle 726
- Stroke volume and heart rate are regulated to alter cardiac output 728
- DEVELOPMENTAL ASPECTS of the Heart 732

## 19 The Cardiovascular System: Blood Vessels 738

#### BLOOD VESSEL STRUCTURE AND FUNCTION 739

- 19.1 Most blood vessel walls have three layers 741
- Arteries are pressure reservoirs, distributing vessels, or resistance vessels 742
- 19.3 Capillaries are exchange vessels 742
- 19.4 Veins are blood reservoirs that return blood toward the heart 744
- Anastomoses are special interconnections between blood vessels 746

#### PHYSIOLOGY OF CIRCULATION 746

- Blood flows from high to low pressure against resistance 746
- Blood pressure decreases as blood flows from arteries through capillaries and into veins 748
- Blood pressure is regulated by short- and long-term controls 750
- Intrinsic and extrinsic controls determine blood flow through tissues 757
- of nutrients and gases, and bulk flow of fluids 762
- FOCUS FIGURE 19.1 Bulk Flow across Capillary Walls 764

## PART 3 CIRCULATORY PATHWAYS: BLOOD VESSELS OF THE BODY 766

- **19.11** The vessels of the systemic circulation transport blood to all body tissues 767
- Table 19.3 Pulmonary and Systemic Circulations 768
- **Table 19.4** The Aorta and Major Arteries of the Systemic Circulation 770
- Table 19.5 Arteries of the Head and Neck 772
- Table 19.6 Arteries of the Upper Limbs and Thorax 774
- Table 19.7 Arteries of the Abdomen 776
- Table 19.8 Arteries of the Pelvis and Lower Limbs 780
- **Table 19.9** The Venae Cavae and the Major Veins of the Systemic Circulation 782
- Table 19.10 Veins of the Head and Neck 784
- Table 19.11 Veins of the Upper Limbs and Thorax 786
- Table 19.12 Veins of the Abdomen 788
- Table 19.13 Veins of the Pelvis and Lower Limbs 790
- **DEVELOPMENTAL ASPECTS** of Blood Vessels 791
- A CLOSER LOOK Atherosclerosis? Get Out the Cardiovascular Drain Cleaner 792

#### **SYSTEM CONNECTIONS** 793

# 20 The Lymphatic System and Lymphoid Organs and Tissues 79

- **20.1** The lymphatic system includes lymphatic vessels, lymph, and lymph nodes 799
- 20.2 Lymphoid cells and tissues are found in lymphoid organs and in connective tissue of other organs 802
- 20.3 Lymph nodes cleanse lymph and house lymphocytes 803
- 20.4 The spleen removes bloodborne pathogens and aged red blood cells 805
- 20.5 MALT guards the body's entryways against pathogens 806
- 20.6 T lymphocytes mature in the thymus 808
- **DEVELOPMENTAL ASPECTS** of the Lymphatic System and Lymphoid Organs and Tissues 808

#### SYSTEM CONNECTIONS 810

## 21 The Immune System: Innate and Adaptive Body Defenses 813

#### PART 1 INNATE DEFENSES 814

21.1 Surface barriers act as the first line of defense to keep invaders out of the body 814

21.2 Innate internal defenses are cells and chemicals that act as the second line of defense 815

#### PART 2 ADAPTIVE DEFENSES 822

- 21.3 Antigens are substances that trigger the body's adaptive defenses 823
- 21.4 B and T lymphocytes and antigen-presenting cells are cells of the adaptive immune response 824
- 21.5 In humoral immunity, antibodies are produced that target extracellular antigens 828
- 21.6 Cellular immunity consists of T lymphocytes that direct adaptive immunity or attack cellular targets 833

FOCUS FIGURE 21.1 An Example of a Primary Immune Response 840

#### A CLOSER LOOK COVID-19 843

21.7 Insufficient or overactive immune responses create problems 844

**DEVELOPMENTAL ASPECTS** of the Immune System 847

## 22 The Respiratory System 852

#### PART 1 FUNCTIONAL ANATOMY 854

- **22.1** The upper respiratory system warms, humidifies, and filters air 854
- 22.2 The lower respiratory system consists of conducting and respiratory zone structures 858
- 22.3 Each multilobed lung occupies its own pleural cavity 867

#### PART 2 RESPIRATORY PHYSIOLOGY 868

- 22.4 Volume changes cause pressure changes, which cause air to move 868
- 22.5 Measuring respiratory volumes, capacities, and flow rates helps us assess ventilation 874
- 22.6 Gases exchange by diffusion between the blood, lungs, and tissues 876
- 22.7 Oxygen is transported by hemoglobin, and carbon dioxide is transported in three different ways 881

FOCUS FIGURE 22.1 The Oxygen-Hemoglobin Dissociation Curve 882

- 22.8 Respiratory centers in the brain stem control breathing with input from chemoreceptors and higher brain centers 887
- 22.9 Exercise and high altitude bring about respiratory adjustments 891
- 22.10 Respiratory diseases are major causes of disability and death 892

**DEVELOPMENTAL ASPECTS** of the Respiratory System 894

## SYSTEM CONNECTIONS 896

## 23 The Digestive System 902

### PART 1 OVERVIEW OF THE DIGESTIVE SYSTEM 903

- 23.1 What major processes occur during digestive system activity? 904
- 23.2 The GI tract has four layers and is usually surrounded by peritoneum 905
- 23.3 The GI tract has its own nervous system called the enteric nervous system 908

## PART 2 FUNCTIONAL ANATOMY OF THE DIGESTIVE SYSTEM 909

- 23.4 Ingestion occurs only at the mouth 910
- 23.5 The pharynx and esophagus move food from the mouth to the stomach 915
- 23.6 The stomach temporarily stores food and begins protein digestion 918
- 23.7 The liver secretes bile; the pancreas secretes digestive enzymes 927
- 23.8 The small intestine is the major site for digestion and absorption 934
- 23.9 The large intestine absorbs water and eliminates feces 940

## PART 3 PHYSIOLOGY OF DIGESTION AND ABSORPTION 946

- 23.10 Digestion hydrolyzes food into nutrients that are absorbed across the gut epithelium 946
- 23.11 How is each type of nutrient processed? 946

DEVELOPMENTAL ASPECTS of the Digestive System 952

#### SYSTEM CONNECTIONS 954

## 24 Nutrition, Metabolism, and Energy Balance 960

#### PART 1 NUTRIENTS 961

- 24.1 Carbohydrates, lipids, and proteins supply energy and are used as building blocks 961
- 24.2 Most vitamins act as coenzymes; minerals have many roles in the body 965

#### PART 2 METABOLISM 967

- 24.3 Metabolism is the sum of all biochemical reactions in the body 968
- 24.4 Carbohydrate metabolism is the central player in ATP production 970

FOCUS FIGURE 24.1 Oxidative Phosphorylation 975

24.5 Lipid n	netabolism	is key for	long-term	energy	storage	and
release	980					

- 24.5 Amino acids are used to build proteins or for energy 982
- Energy is stored in the absorptive state and released in the postabsorptive state 983
- The liver metabolizes, stores, and detoxifies 989
- **LOSER LOOK** Obesity: Magical Solution Wanted 992

#### 29.1 Genes are the vocabular 466 de 30 MALAN (ESPA) ENERGY BALAN (

- Neural and hormonal factors regulate food intake 994
- Thyroxine is the major hormone that controls basal metabolic rate 996
- The hypothalamus acts as the body's thermostat 997
- **DEVELOPMENTAL ASPECTS** of Nutrition and Metabolism 1002

## 25 The Urinary System 1008

- The kidneys have three distinct regions and a rich blood supply 1009
- 252 Nephrons are the functional units of the kidney 1012
- Overview: Filtration, absorption, and secretion are the key processes of urine formation 1017
- Unine formation, step 1: The glomeruli make filtrate 1018
- Urine formation, step 2: Most of the filtrate is reabsorbed into the blood 1023
- Urine formation, step 3: Certain substances are secreted into the filtrate 1028
- The kidneys create and use an osmotic gradient to regulate urine concentration and volume 1029
- FOCUS FIGURE 25.1 Medullary Osmotic Gradient 1030
- Renal function is evaluated by analyzing blood and urine 1034
- The ureters, bladder, and urethra transport, store, and eliminate urine 1036
- DEVELOPMENTAL ASPECTS of the Urinary System 1040

## 26 Fluid, Electrolyte, and Acid-Base Balance 1046

- Body fluids consist of water and solutes in three main compartments 1047
- 25.2 Both intake and output of water are regulated 1050
- Sodium, potassium, calcium, and phosphate levels are tightly regulated 1053

- 26.4 Chemical buffers and respiratory regulation rapidly minimize pH changes 1060
- **26.5** Renal regulation is a long-term mechanism for controlling acid-base balance 1063
- 26.6 Abnormalities of acid-base balance are classified as metabolic or respiratory 1067
- A CLOSER LOOK Sleuthing: Using Blood Values to Determine the Cause of Acidosis or Alkalosis 1068
- **DEVELOPMENTAL ASPECTS** of Fluid, Electrolyte, and Acid-Base Balance 1069

bas evitauhorage sausa anoitagiani hettimaast vilsuva2 Er Eccause

#### **SYSTEM CONNECTIONS** 1070

### **UNIT 5** Continuity

## 27 The Reproductive System 1075

**27.1** The male and female reproductive systems share common features 1076

### PART 1 ANATOMY OF THE MALE REPRODUCTIVE SYSTEM 1081

- 27.2 The testes are enclosed and protected by the scrotum 1082
- 27.3 Sperm travel from the testes to the body exterior through a system of ducts 1084

uterine wall, triggering placenta formation

- 27.4 The penis is the copulatory organ of the male 1084
- 27.5 The male accessory glands produce the bulk of semen 1086

## PART 2 PHYSIOLOGY OF THE MALE REPRODUCTIVE SYSTEM 1087

- **27.6** The male sexual response includes erection and ejaculation 1087
- **27.7** Spermatogenesis is the sequence of events that leads to formation of sperm 1088
- 27.8 Male reproductive function is regulated by hypothalamic, anterior pituitary, and testicular hormones 1093

## PART 3 ANATOMY OF THE FEMALE REPRODUCTIVE SYSTEM 1094

- 27.9 Immature eggs develop in follicles in the ovaries 1095
- 27.10 The female duct system includes the uterine tubes, uterus, and vagina 1096
- 27.11 The external genitalia of the female include those structures that lie external to the vagina 1101
- 27.12 The mammary glands produce milk 1102

## PART 4 PHYSIOLOGY OF THE FEMALE REPRODUCTIVE SYSTEM 1103

- 27.13 Oogenesis is the sequence of events that leads to the formation of ova 1103
- **27.14** The ovarian cycle consists of the follicular phase and the luteal phase 1107
- 27.15 Female reproductive function is regulated by hypothalamic, anterior pituitary, and ovarian hormones 1108
- 27.16 The female sexual response is more diverse and complex than that of males 1112

#### PART 5 SEXUALLY TRANSMITTED INFECTIONS 1114

27.17 Sexually transmitted infections cause reproductive and other disorders 1114

**DEVELOPMENTAL ASPECTS** of the Reproductive System 1115

**SYSTEM CONNECTIONS** 1119

# 28 Pregnancy and Human Development 1125

**28.1** Fertilization combines the sperm and egg chromosomes, forming a zygote 1126

FOCUS FIGURE 28.1 Sperm Penetration and the Blocks to Polyspermy 1128

- 28.2 Embryonic development begins as the zygote undergoes cleavage and forms a blastocyst en route to the uterus 1131
- 28.3 Implantation occurs when the embryo burrows into the uterine wall, triggering placenta formation 1132
- **28.4** Embryonic events include gastrula formation and tissue differentiation, which are followed by rapid growth of the fetus 1136

FOCUS FIGURE 28.2 Fetal and Newborn Circulation 1142

- 28.5 During pregnancy, the mother undergoes anatomical, physiological, and metabolic changes 1146
- 28.6 The three stages of labor are the dilation, expulsion, and placental stages 1148
- 28.7 An infant's extrauterine adjustments include taking the first breath and closure of vascular shunts 1150

22. 10 Resphaloryemiges entrot leave to be set designed and

Rish mature aggs developing folligles in the ovaries in 19

27.11 The external genitalia of the female include indeed

27.12 The mammary glands produce milk 1162 atseb

28.8 Lactation is milk secretion by the mammary glands in response to prolactin 1150

A CLOSER LOOK Contraception 1152

28.9 Assisted reproductive technology may help an infertile couple have offspring 1153

## 24.8 The liver metabolizes, stores, and detoxifies 989 Heredity 1158 Both Made Both Made Both 1158

- 29.1 Genes are the vocabulary of genetics 1159
- 29.2 Genetic variation results from independent assortment, crossing over, and random fertilization 1160
- 29.3 Several patterns of inheritance have long been known 1162
- **29.4** Environmental factors may influence or override gene expression 1165
- **29.5** Factors other than nuclear DNA sequence can determine inheritance 1165
- 29.6 Genetic screening is used to detect genetic disorders 1167

25.3 Overview: Filtration, absorp

### Appendices

Answers Appendix 1173

- A The Metric System 1190
- B Functional Groups in Organic Molecules 1192
- C The Amino Acids 1193
- D Two Important Metabolic Pathways 1194
- E Periodic Table of the Elements 1197
- F Reference Values for Selected Blood and Urine Studies 1198

25.7 The kidneys create and use an osmotic gradient

25.9 The ureters, bladder, and urethratransportstored and

ZO Fluid, Electrolyte, and Addase

26.1 Body fluids consist of water and solutes in three maintenants

compartments 1047 compartments 1047 all biochemical reactions in the

26.3 Sodium apotessium calcium and phosphate levels are 26.4

26.2 Both intake and output of water are regulated v1950

DEVELOPMENTAL ASPECTS of the Uninan/CSystemal ATUAID

Glossary 1203

Photo and Illustration Credits 1225

25.8 Renal function is evaluated by analyzing bloods of xabrily with the contraction of t