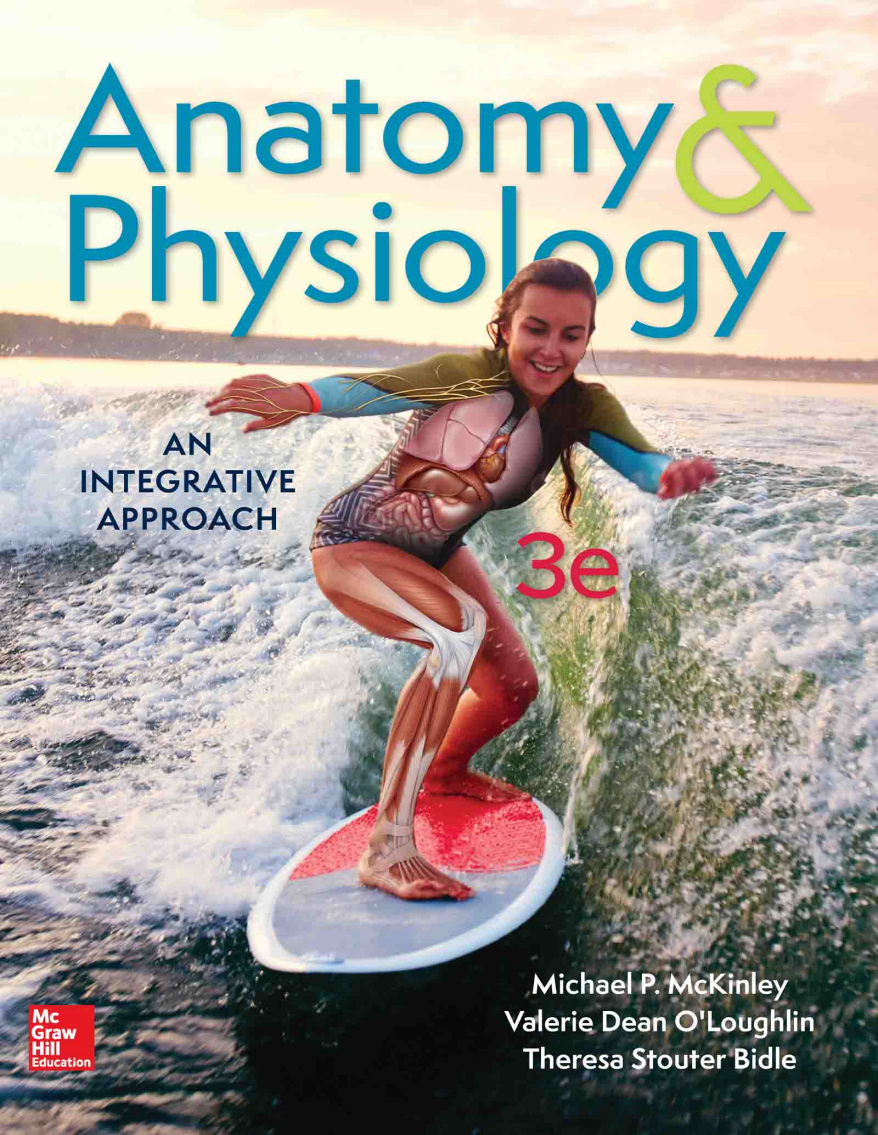


Anatomy & Physiology



AN
INTEGRATIVE
APPROACH

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Michael P. McKinley
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and Theresa Bidle*

Dedications

*I am indebted to Jan (my wife); Renee, Ryan, and Shaun
(my children); and Connor, Eric, Patrick,
Keighan, Aydan, and Abbygail (my grandchildren).
They are the love of my life and my inspiration always.*

—Michael P. McKinley

*To my husband Bob and my daughter Erin:
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—Valerie Dean O’Loughlin

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and my daughter Stephanie for the many ways
that they have supported me during this project.*

—Terri Stouter Bidle

brief contents

PART I: ORGANIZATION OF THE HUMAN BODY

Chapter 1	The Sciences of Anatomy and Physiology	1
Chapter 2	Atoms, Ions, and Molecules	31
Chapter 3	Energy, Chemical Reactions, and Cellular Respiration	72
Chapter 4	Biology of the Cell	104
Chapter 5	Tissue Organization	153

PART II: SUPPORT AND BODY MOVEMENT

Chapter 6	Integumentary System	187
Chapter 7	Skeletal System: Bone Structure and Function	213
Chapter 8	Skeletal System: Axial and Appendicular Skeleton	241
Chapter 9	Skeletal System: Articulations	299
Chapter 10	Muscle Tissue	333
Chapter 11	Muscular System: Axial and Appendicular Muscles	374

PART III: COMMUNICATION AND CONTROL

Chapter 12	Nervous System: Nervous Tissue	438
Chapter 13	Nervous System: Brain and Cranial Nerves	485
Chapter 14	Nervous System: Spinal Cord and Spinal Nerves	539
Chapter 15	Nervous System: Autonomic Nervous System	582
Chapter 16	Nervous System: Senses	610
Chapter 17	Endocrine System	662

PART IV: MAINTENANCE AND REGULATION

Chapter 18	Cardiovascular System: Blood	711
Chapter 19	Cardiovascular System: Heart	741
Chapter 20	Cardiovascular System: Vessels and Circulation	786
Chapter 21	Lymphatic System	843
Chapter 22	Immune System and the Body's Defense	859
Chapter 23	Respiratory System	900
Chapter 24	Urinary System	954
Chapter 25	Fluid and Electrolytes	1000
Chapter 26	Digestive System	1034
Chapter 27	Nutrition and Metabolism	1082

PART V: REPRODUCTION

Chapter 28	Reproductive System	1104
Chapter 29	Development, Pregnancy, and Heredity	1149

contents

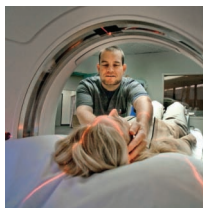
About the Authors iii
Brief Contents v
Preface xvi
Guided Tour xxii

■ ORGANIZATION OF THE HUMAN BODY

CHAPTER 1

The Sciences of Anatomy and Physiology 1

- 1.1 Anatomy and Physiology Compared 2
 - 1.1a Anatomy: Details of Structure and Form 2
 - 1.1b Physiology: Details of Function 3
- 1.2 Anatomy and Physiology Integrated 3
- 1.3 How to Study Anatomy and Physiology Effectively 3



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INTEGRATE: CONCEPT OVERVIEW

Comparing How Anatomists and Physiologists Examine the Human Body 4

- 1.4 The Body's Levels of Organization 7
 - 1.4a Characteristics That Describe Living Things 7
 - 1.4b The View from Simplest to Most Complex 8
 - 1.4c Introduction to Organ Systems 8
- 1.5 The Precise Language of Anatomy and Physiology 9
 - 1.5a Anatomic Position 13
 - 1.5b Sections and Planes 13
 - 1.5c Anatomic Directions 14
 - 1.5d Regional Anatomy 14
 - 1.5e Body Cavities and Membranes 14
 - 1.5f Abdominopelvic Regions and Quadrants 18
- 1.6 Homeostasis: Keeping Internal Conditions Stable 19
 - 1.6a Components of Homeostatic Systems 19
 - 1.6b Homeostatic Systems Regulated by Negative Feedback 21

INTEGRATE: CONCEPT OVERVIEW

Negative Feedback Mechanisms for Regulating Body Temperature 22

- 1.6c Homeostatic Systems Regulated by Positive Feedback 24
- 1.7 Homeostasis, Health, and Disease 25

CHAPTER 2

Atoms, Ions, and Molecules 31

- 2.1 Atomic Structure 32
 - 2.1a Matter, Atoms, Elements, and the Periodic Table 32
 - 2.1b Isotopes 34
 - 2.1c Chemical Stability and the Octet Rule 34
- 2.2 Ions and Ionic Compounds 36
 - 2.2a Ions 36
 - 2.2b Ionic Bonds 37
- 2.3 Covalent Bonding, Molecules, and Molecular Compounds 38
 - 2.3a Chemical Formulas: Molecular and Structural 38
 - 2.3b Covalent Bonds 39
 - 2.3c Nonpolar, Polar, and Amphipathic Molecules 41
 - 2.3d Intermolecular Attractions 42
- 2.4 Molecular Structure and Properties of Water 43
 - 2.4a Molecular Structure of Water 43
 - 2.4b Properties of Water 44
 - 2.4c Water as the Universal Solvent 44
- 2.5 Acidic and Basic Solutions, pH, and Buffers 46
 - 2.5a Water: A Neutral Solvent 46



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INTEGRATE: CONCEPT OVERVIEW

Water's Roles in the Body 47

- 2.5b Acids and Bases 48
- 2.5c pH, Neutralization, and the Action of Buffers 48
- 2.6 Water Mixtures 49
 - 2.6a Categories of Water Mixtures 49
 - 2.6b Expressions of Solution Concentration 50
- 2.7 Biological Macromolecules 51
 - 2.7a General Characteristics 51
 - 2.7b Lipids 53
 - 2.7c Carbohydrates 56
 - 2.7d Nucleic Acids 57
 - 2.7e Proteins 59

INTEGRATE: CONCEPT OVERVIEW

Biological Macromolecules 62

- 2.8 Protein Structure 64
 - 2.8a Categories of Amino Acids 64
 - 2.8b Amino Acid Sequence and Protein Conformation 66

CHAPTER 3

Energy, Chemical Reactions, and Cellular Respiration 72

- 3.1 Energy 73
 - 3.1a Classes of Energy 73
 - 3.1b Forms of Energy 73
 - 3.1c Laws of Thermodynamics 75

INTEGRATE: CONCEPT OVERVIEW

Energy as It Relates to Human Body Function 76

- 3.2 Chemical Reactions 78
 - 3.2a Chemical Equations 78
 - 3.2b Classification of Chemical Reactions 78
 - 3.2c Reaction Rates and Activation Energy 82
- 3.3 Enzymes 83
 - 3.3a Function of Enzymes 83
 - 3.3b Enzyme Structure and Location 84
 - 3.3c Mechanism of Enzyme Action 84
 - 3.3d Classification and Naming of Enzymes 84
 - 3.3e Enzymes and Reaction Rates 86
 - 3.3f Controlling Enzymes 87
 - 3.3g Metabolic Pathways and Multienzyme Complexes 87

- 3.4 Cellular Respiration 89
 - 3.4a Overview of Glucose Oxidation 89

INTEGRATE: CONCEPT OVERVIEW

- How Enzymes Work 90
 - 3.4b Glycolysis 93
 - 3.4c Intermediate Stage 94
 - 3.4d Citric Acid Cycle 94
 - 3.4e The Electron Transport System 97
 - 3.4f ATP Production 99
 - 3.4g The Fate of Pyruvate with Insufficient Oxygen 99
 - 3.4h Other Fuel Molecules That Are Oxidized in Cellular Respiration 100

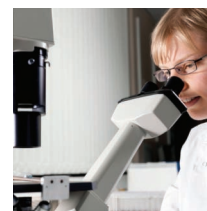
CHAPTER 4

Biology of the Cell 104

- 4.1 Introduction to Cells 105
 - 4.1a How Cells Are Studied 105
 - 4.1b Cell Size and Shape 105
 - 4.1c Common Features and General Functions 106
- 4.2 Chemical Structure of the Plasma Membrane 108
 - 4.2a Lipid Components 108
 - 4.2b Membrane Proteins 109
- 4.3 Membrane Transport 111
 - 4.3a Passive Processes: Diffusion 111
 - 4.3b Passive Processes: Osmosis 113
 - 4.3c Active Processes 115



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- 4.4 Resting Membrane Potential 121**
 - 4.4a Introduction 121
 - 4.4b Establishing and Maintaining an RMP 121

INTEGRATE: CONCEPT OVERVIEW

Passive and Active Processes of Membrane Transport 122

- 4.5 Cell Communication 124**
 - 4.5a Direct Contact Between Cells 124
 - 4.5b Ligand-Receptor Signaling 125
- 4.6 Cellular Structures 126**
 - 4.6a Membrane-Bound Organelles 126
 - 4.6b Non-Membrane-Bound Organelles 129
 - 4.6c Structures of the Cell's External Surface 132
 - 4.6d Membrane Junctions 133

4.7 Structure of the Nucleus 133

INTEGRATE: CONCEPT OVERVIEW

Cellular Structures and Their Functions 134

- 4.7a Nuclear Envelope and Nucleolus 136
- 4.7b DNA, Chromatin, and Chromosomes 136
- 4.8 Function of the Nucleus and Ribosomes 137**
 - 4.8a Transcription: Synthesizing RNA 137
 - 4.8b Translation: Synthesizing Protein 139
 - 4.8c DNA as the Control Center of a Cell 142

4.9 Cell Division 143

- 4.9a Cellular Structures 143
- 4.9b The Cell Cycle 143

4.10 Cell Aging and Death 146

CHAPTER 5

Tissue Organization 153

- 5.1 Epithelial Tissue: Surfaces, Linings, and Secretory Functions 154**
 - 5.1a Characteristics of Epithelial Tissue 154
 - 5.1b Functions of Epithelial Tissue 155
 - 5.1c Classification of Epithelial Tissue 155



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INTEGRATE: CONCEPT OVERVIEW

The Relationship Between Epithelial Tissue Type and Function 160

- 5.1d Glands 162

5.2 Connective Tissue: Cells in a Supportive Matrix 164

- 5.2a Characteristics of Connective Tissue 164
- 5.2b Functions of Connective Tissue 166
- 5.2c Embryonic Connective Tissue 167
- 5.2d Classification of Connective Tissue 167

INTEGRATE: CONCEPT OVERVIEW

The Relationship Between Connective Tissue Type and Function 174

5.3 Muscle Tissue: Movement 176

5.4 Nervous Tissue: Information Transfer and Integration 177

5.5 Integration of Tissues in Organs and Body Membranes 178

- 5.5a Organs 178
- 5.5b Body Membranes 178

5.6 Tissue Development and Aging 179

- 5.6a Tissue Development 179
- 5.6b Tissue Modification 180
- 5.6c Aging of Tissues 183

SUPPORT AND BODY MOVEMENT

CHAPTER 6

Integumentary System 187

- 6.1 Composition and Functions of the Integument 188**
 - 6.1a Epidermis 188
 - 6.1b Dermis 193
 - 6.1c Subcutaneous Layer 195
 - 6.1d Functions of the Integument 196



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INTEGRATE: CONCEPT OVERVIEW

How Integument Form Influences Its Functions 199

6.2 Integumentary Structures Derived from Epidermis 200

- 6.2a Nails 200
- 6.2b Hair 201
- 6.2c Exocrine Glands of the Skin 203

6.3 Repair and Regeneration of the Integumentary System 205

6.4 Development and Aging of the Integumentary System 206

- 6.4a Development of the Integument and Its Derivatives 208
- 6.4b Aging of the Integument 208

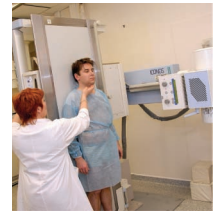
CHAPTER 7

Skeletal System: Bone Structure and Function 213

7.1 Introduction to the Skeletal System 214

7.2 Bone: The Major Organ of the Skeletal System 214

- 7.2a General Functions 214
- 7.2b Classification of Bones 215
- 7.2c Gross Anatomy of Bones 215
- 7.2d Bone Marrow 218
- 7.2e Microscopic Anatomy: Bone Connective Tissue 219
- 7.2f Microscopic Anatomy: Hyaline Cartilage Connective Tissue 223



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7.3 Cartilage Growth 223

7.4 Bone Formation 225

- 7.4a Intramembranous Ossification 225

INTEGRATE: CONCEPT OVERVIEW

The Process of Endochondral Ossification 226

- 7.4b Endochondral Ossification 227

7.5 Bone Growth and Bone Remodeling 230

- 7.5a Bone Growth 230
- 7.5b Bone Remodeling 231
- 7.5c Hormones That Influence Bone Growth and Bone Remodeling 232

7.6 Regulating Blood Calcium Levels 233

- 7.6a Activation of Vitamin D to Calcitriol 233
- 7.6b Parathyroid Hormone and Calcitriol 234
- 7.6c Calcitonin 235

7.7 Effects of Aging 235

7.8 Bone Fracture and Repair 236

CHAPTER 8

Skeletal System: Axial and Appendicular Skeleton 241

8.1 Components of the Skeleton 242

- 8.1a Axial and Appendicular Skeleton 242
- 8.1b Bone Markings 243

8.2 Bones and Features of the Skull 244

- 8.2a General Anatomy of the Skull 244
- 8.2b Views of the Skull and Landmark Features 245
- 8.2c Sutures 258
- 8.2d Orbital and Nasal Complexes, Paranasal Sinuses 260

8.3 Bones Associated with the Skull 261

8.4 Sex and Age Determination from Analysis of the Skull 262

- 8.4a Sex Differences in the Skull 262
- 8.4b Aging of the Skull 262

8.5 Bones of the Vertebral Column 264

- 8.5a Types of Vertebrae 264
- 8.5b Spinal Curvatures 265
- 8.5c Vertebral Anatomy 266

8.6 Bones of the Thoracic Cage 271

- 8.6a Sternum 272
- 8.6b Ribs 272

8.7 The Upper and Lower Limbs: A Comparison 273

INTEGRATE: CONCEPT OVERVIEW

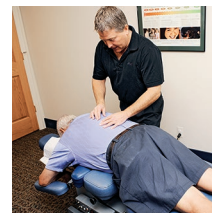
Similarities Between the Upper Limb and Lower Limb Skeletons 274

8.8 The Pectoral Girdle and Its Functions 276

- 8.8a Clavicle 276
- 8.8b Scapula 276

8.9 Bones of the Upper Limb 277

- 8.9a Humerus 277
- 8.9b Radius and Ulna 279
- 8.9c Carpals, Metacarpals, and Phalanges 280



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8.10 The Pelvic Girdle and Its Functions 281

- 8.10a Os Coxae 282
- 8.10b True and False Pelvis 284
- 8.10c Sex Differences in the Pelvis 284
- 8.10d Age Differences in the Ossa Coxae 286

8.11 Bones of the Lower Limb 286

- 8.11a Femur and Patella 286
- 8.11b Tibia and Fibula 288
- 8.11c Tarsals, Metatarsals, and Phalanges 290
- 8.11d Arches of the Foot 291

8.12 Development of the Skeleton 293

CHAPTER 9

Skeletal System: Articulations 299

9.1 Classification of Joints 300

INTEGRATE: CONCEPT OVERVIEW

The Relationship Between Mobility and Stability in Joints 301

9.2 Fibrous Joints 302

- 9.2a Gomphoses 302
- 9.2b Sutures 302
- 9.2c Syndesmoses 303

9.3 Cartilaginous Joints 303

- 9.3a Synchondroses 303
- 9.3b Symphyses 304

9.4 Synovial Joints 304

- 9.4a Distinguishing Features and Anatomy of Synovial Joints 304
- 9.4b Classification of Synovial Joints 306

9.5 The Movements of Synovial Joints 306

- 9.5a Gliding Motion 306

INTEGRATE: CONCEPT OVERVIEW

Synovial Joints 307

- 9.5b Angular Motion 308
- 9.5c Rotational Motion 310
- 9.5d Special Movements 311

9.6 Synovial Joints and Levers 312

- 9.6a Terminology of Levers 312
- 9.6b Types of Levers 312

9.7 Features and Anatomy of Selected Joints 313

- 9.7a Temporomandibular Joint 314
- 9.7b Shoulder Joint 315
- 9.7c Elbow Joint 319
- 9.7d Hip Joint 321
- 9.7e Knee Joint 323
- 9.7f Talocrural (Ankle) Joint 326

9.8 Development and Aging of the Joints 328

CHAPTER 10

Muscle Tissue 333

10.1 Introduction to Skeletal Muscle 334

- 10.1a Functions of Skeletal Muscle 334
- 10.1b Characteristics of Skeletal Muscle 334

10.2 Anatomy of Skeletal Muscle 335

- 10.2a Gross Anatomy of Skeletal Muscle 335
- 10.2b Microscopic Anatomy of Skeletal Muscle 336
- 10.2c Innervation of Skeletal Muscle Fibers 341
- 10.2d Skeletal Muscle Fibers at Rest 342

10.3 Physiology of Skeletal Muscle Contraction 343

- 10.3a Neuromuscular Junction: Excitation of a Skeletal Muscle Fiber 344
- 10.3b Sarcolemma, T-tubules, and Sarcoplasmic Reticulum: Excitation-Contraction Coupling 344
- 10.3c Sarcomere: Crossbridge Cycling 346

INTEGRATE: CONCEPT OVERVIEW

Skeletal Muscle Contraction 350

- 10.3d Skeletal Muscle Relaxation 352

10.4 Skeletal Muscle Metabolism 353

- 10.4a Supplying Energy for Skeletal Muscle Metabolism 353
- 10.4b Oxygen Debt 355

10.5 Skeletal Muscle Fiber Types 355

- 10.5a Criteria for Classification of Muscle Fiber Types 355

- 10.5b Classification of Muscle Fiber Types 356

- 10.5c Distribution of Muscle Fiber Types 357

10.6 Muscle Tension in Skeletal Muscle 357

- 10.6a Muscle Twitch 357

- 10.6b Changes in Stimulus Intensity: Motor Unit Recruitment 358

- 10.6c Changes in Stimulus Frequency: Wave Summation, Incomplete Tetanus, and Tetanus 359

10.7 Factors Affecting Skeletal Muscle Tension Within the Body 359

- 10.7a Muscle Tone 359

- 10.7b Isometric Contractions and Isotonic Contractions 360

- 10.7c Length-Tension Relationship 361

- 10.7d Muscle Fatigue 362

10.8 Effects of Exercise and Aging on Skeletal Muscle 363

- 10.8a Effects of Exercise 363

- 10.8b Effects of Aging 363

10.9 Cardiac Muscle Tissue 364

10.10 Smooth Muscle Tissue 365

- 10.10a Location of Smooth Muscle 365

- 10.10b Microscopic Anatomy of Smooth Muscle 365

- 10.10c Mechanism of Smooth Muscle Contraction 366

- 10.10d Controlling Smooth Muscle 368

- 10.10e Functional Categories of Smooth Muscle 368



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CHAPTER 11

Muscular System: Axial and Appendicular Muscles 374

11.1 Skeletal Muscle Composition and Actions 377

- 11.1a Skeletal Muscle Attachments 377

- 11.1b Organizational Patterns of Skeletal Muscle Fibers 377

- 11.1c Actions of Skeletal Muscles 378

11.2 Skeletal Muscle Naming 379

11.3 Muscles of the Head and Neck 380

- 11.3a Muscles of Facial Expression 380

- 11.3b Extrinsic Eye Muscles 384

- 11.3c Muscles of the Oral Cavity and Pharynx 386

- 11.3d Muscles of the Anterior Neck: The Hyoid Muscles 387

- 11.3e Muscles That Move the Head and Neck 390

11.4 Muscles of the Vertebral Column 392

11.5 Muscles of Respiration 395

11.6 Muscles of the Abdominal Wall 396

11.7 Muscles of the Pelvic Floor 398

11.8 Muscles of the Pectoral Girdle and Upper Limb 403

- 11.8a Muscles That Move the Pectoral Girdle 403

- 11.8b Muscles That Move the Glenohumeral Joint/Arm 406

- 11.8c Arm and Forearm Muscles That Move the Elbow Joint/Forearm 409

INTEGRATE: CONCEPT OVERVIEW

Muscle Compartmentalization 410

- 11.8d Forearm Muscles That Move the Wrist Joint, Hand, and Fingers 414

- 11.8e Intrinsic Muscles of the Hand 419

11.9 Muscles of the Pelvic Girdle and Lower Limb 421

- 11.9a Muscles That Move the Hip Joint/Thigh 421

- 11.9b Thigh Muscles That Move the Knee Joint/Leg 425

- 11.9c Leg Muscles That Move the Ankle, Foot, and Toes 428

- 11.9d Intrinsic Muscles of the Foot 433

COMMUNICATION AND CONTROL

CHAPTER 12

Nervous System: Nervous Tissue 438

12.1 Introduction to the Nervous System 439

- 12.1a General Functions of the Nervous System 439

- 12.1b Organization of the Nervous System 439

- 12.1c Nerves and Ganglia 440

12.2 Nervous Tissue: Neurons 442

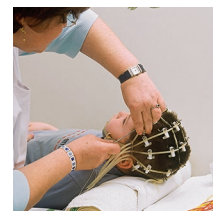
- 12.2a General Characteristics of Neurons 442



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- 12.2b Neuron Structure 443
- 12.2c Neuron Transport 445
- 12.2d Classification of Neurons 446

12.3 Synapses 447

12.4 Nervous Tissue: Glial Cells 448

- 12.4a General Characteristics of Glial Cells 448
- 12.4b Types of Glial Cells 449
- 12.4c Myelination 450

12.5 Axon Regeneration 453

12.6 Plasma Membrane of Neurons 454

- 12.6a Types of Pumps and Channels 454
- 12.6b Distribution of Pumps and Channels 455

12.7 Introduction to Neuron Physiology 457

- 12.7a Neurons and Ohm's Law 457
- 12.7b Neurons at Rest 458

12.8 Physiologic Events in the Neuron Segments 460

- 12.8a Receptive Segment 460
- 12.8b Initial Segment 463
- 12.8c Conductive Segment 465
- 12.8d Transmissive Segment 470

INTEGRATE: CONCEPT OVERVIEW

Events of Neuron Physiology 472

12.9 Characteristics of Action Potentials 474

- 12.9a Graded Potentials Versus Action Potentials 474
- 12.9b Velocity of Action Potential Propagation 475
- 12.9c Frequency of Action Potentials 475

12.10 Neurotransmitters and Neuromodulation 476

- 12.10a Classification of Neurotransmitters 476
- 12.10b Features of Neurotransmitters 476
- 12.10c Neuromodulation 478

12.11 Neural Integration and Neuronal Pools of the CNS 480

CHAPTER 13

Nervous System: Brain and Cranial Nerves 485

13.1 Brain Organization and Development 486

- 13.1a Overview of Brain Anatomy 486
- 13.1b Development of Brain Divisions 490
- 13.1c Gray Matter and White Matter Distribution 492

13.2 Protection and Support of the Brain 494

- 13.2a Cranial Meninges 494
- 13.2b Brain Ventricles 497
- 13.2c Cerebrospinal Fluid 497
- 13.2d Blood-Brain Barrier 500

13.3 Cerebrum 500

- 13.3a Cerebral Hemispheres 501
- 13.3b Lobes of the Cerebrum 501

INTEGRATE: CONCEPT OVERVIEW

Anatomic and Functional Areas of the Cerebrum 503

- 13.3c Functional Areas of the Cerebrum 504
- 13.3d Central White Matter 507
- 13.3e Cerebral Lateralization 508
- 13.3f Cerebral Nuclei 509

13.4 Diencephalon 511

- 13.4a Epithalamus 511
- 13.4b Thalamus 512
- 13.4c Hypothalamus 512

13.5 Brainstem 513

- 13.5a Midbrain 514
- 13.5b Pons 515
- 13.5c Medulla Oblongata 516

13.6 Cerebellum 517

- 13.6a Structural Components of the Cerebellum 517
- 13.6b Functions of the Cerebellum 517

13.7 Functional Brain Systems 519

- 13.7a Limbic System 519
- 13.7b Reticular Formation 520

13.8 Integrative Functions and Higher-Order Brain Functions 521

- 13.8a Development of Higher-Order Brain Functions 521
- 13.8b Electroencephalogram 521
- 13.8c Sleep 522
- 13.8d Cognition 522

- 13.8e Memory 523
- 13.8f Emotion 523
- 13.8g Language 525

13.9 Cranial Nerves 526

CHAPTER 14

Nervous System: Spinal Cord and Spinal Nerves 539

14.1 Overview of the Spinal Cord and Spinal Nerves 540

- 14.1a General Functions 540
- 14.1b Spinal Cord Gross Anatomy 540
- 14.1c Spinal Nerve Identification and Gross Anatomy 540

14.2 Protection and Support of the Spinal Cord 542

14.3 Sectional Anatomy of the Spinal Cord and Spinal Roots 545

- 14.3a Distribution of Gray Matter 545
- 14.3b Distribution of White Matter 546

14.4 Sensory and Motor Pathways 548

- 14.4a Overview of Conduction Pathways 548
- 14.4b Sensory Pathways 548
- 14.4c Motor Pathways 552

INTEGRATE: CONCEPT OVERVIEW

Differences Between Sensory and Motor Pathways 554

14.5 Spinal Nerves 555

- 14.5a General Distribution of Spinal Nerves 555
- 14.5b Nerve Plexuses 557
- 14.5c Intercostal Nerves 557
- 14.5d Cervical Plexuses 558
- 14.5e Brachial Plexuses 559
- 14.5f Lumbar Plexuses 565
- 14.5g Sacral Plexuses 567

14.6 Reflexes 571

- 14.6a Characteristics of Reflexes 571
- 14.6b Components of a Reflex Arc 571
- 14.6c Classifying Spinal Reflexes 572
- 14.6d Spinal Reflexes 573
- 14.6e Reflex Testing in a Clinical Setting 576

14.7 Development of the Spinal Cord 577

CHAPTER 15

Nervous System: Autonomic Nervous System 582

15.1 Comparison of the Somatic and Autonomic Nervous Systems 583

- 15.1a Functional Organization 583
- 15.1b Lower Motor Neurons of the Somatic Versus Autonomic Nervous System 584
- 15.1c CNS Control of the Autonomic Nervous System 585

15.2 Divisions of the Autonomic Nervous System 586

- 15.2a Functional Differences 586
- 15.2b Anatomic Differences in Lower Motor Neurons 586
- 15.2c Degree of Response 587

15.3 Parasympathetic Division 588

- 15.3a Cranial Components 588
- 15.3b Pelvic Splanchnic Nerves 590

15.4 Sympathetic Division 590

- 15.4a Organization and Anatomy of the Sympathetic Division 590
- 15.4b Sympathetic Pathways 594

15.5 Autonomic Plexuses and the Enteric Nervous System 596

- 15.5a Autonomic Plexuses 596
- 15.5b Enteric Nervous System 597

15.6 Comparison of Neurotransmitters and Receptors of the Two Divisions 597

- 15.6a Overview of ANS Neurotransmitters 597
- 15.6b Cholinergic Receptors 598
- 15.6c Adrenergic Receptors 599

15.7 Interactions Between the Parasympathetic and Sympathetic Divisions 600

- 15.7a Autonomic Tone 600

INTEGRATE: CONCEPT OVERVIEW

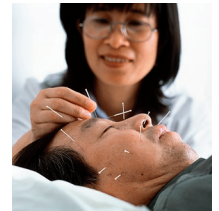
Comparison of the Parasympathetic and Sympathetic Divisions of the ANS 602



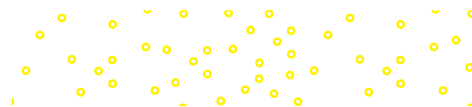
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- 15.7b Dual Innervation 604
- 15.7c Systems Controlled Only by the Sympathetic Division 605

15.8 Autonomic Reflexes 605

CHAPTER 16

Nervous System: Senses 610

16.1 Introduction to Sensory Receptors 611

- 16.1a General Function of Sensory Receptors 611
- 16.1b General Structure of Sensory Receptors 611
- 16.1c Sensory Information Provided by Sensory Receptors 612
- 16.1d Sensory Receptor Classification 612



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16.2 The General Senses 614

- 16.2a Tactile Receptors 614
- 16.2b Referred Pain 617

16.3 Olfaction and Gustation 618

- 16.3a Olfaction: The Sense of Smell 618
- 16.3b Gustation: The Sense of Taste 620

16.4 Visual Receptors 622

- 16.4a Accessory Structures of the Eye 622
- 16.4b Eye Structure 624
- 16.4c Physiology of Vision: Refraction and Focusing of Light 631
- 16.4d Physiology of Vision: Phototransduction 634
- 16.4e Visual Pathways 637

16.5 Hearing and Equilibrium Receptors 639

- 16.5a Ear Structure 639

INTEGRATE: CONCEPT OVERVIEW

How We See 640

- 16.5b Hearing 645
- 16.5c Auditory Pathways 650

INTEGRATE: CONCEPT OVERVIEW

How We Hear 652

- 16.5d Equilibrium and Head Movement 654

CHAPTER 17

Endocrine System 662

17.1 Introduction to the Endocrine System 663

- 17.1a Overview of the Endocrine System 663
- 17.1b Comparison of the Two Control Systems 664
- 17.1c General Functions of the Endocrine System 664



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17.2 Endocrine Glands 664

- 17.2a Location of the Major Endocrine Glands 664
- 17.2b Stimulation of Hormone Synthesis and Release 665

17.3 Categories of Hormones 667

- 17.3a Circulating Hormones 667
- 17.3b Local Hormones 668

17.4 Hormone Transport 669

- 17.4a Transport in the Blood 669
- 17.4b Levels of Circulating Hormone 669

17.5 Target Cells: Interactions with Hormones 670

- 17.5a Lipid-Soluble Hormones 671
- 17.5b Water-Soluble Hormones 672

17.6 Target Cells: Degree of Cellular Response 674

- 17.6a Number of Receptors on a Target Cell 674
- 17.6b Hormone Interactions on a Target Cell 674

17.7 The Hypothalamus and the Pituitary Gland 675

- 17.7a Anatomic Relationship of the Hypothalamus and the Pituitary Gland 675

INTEGRATE: CONCEPT OVERVIEW

Endocrine System: Major Control System of the Body 676

- 17.7b Interactions Between the Hypothalamus and the Posterior Pituitary Gland 679
- 17.7c Interactions Between the Hypothalamus and the Anterior Pituitary Gland 679
- 17.7d Growth Hormone: Its Regulation and Effects 681

17.8 Thyroid Gland 684

- 17.8a Anatomy of the Thyroid Gland 684
- 17.8b Thyroid Hormone: Its Regulation and Effects 685
- 17.8c Calcitonin: Its Regulation and Effects 689

17.9 Adrenal Glands 689

- 17.9a Anatomy of the Adrenal Glands 689
- 17.9b Cortisol: Its Regulation and Effects 691

17.10 The Pancreas 695

- 17.10a Anatomy of the Pancreas 695
- 17.10b Pancreatic Hormones 696

17.11 Other Endocrine Glands 698

- 17.11a Pineal Gland 698
- 17.11b Parathyroid Glands 699
- 17.11c Structures with an Endocrine Function 699

17.12 Aging and the Endocrine System 700

Major Regulatory Hormones of the Human Body 705

MAINTENANCE AND REGULATION

CHAPTER 18

Cardiovascular System: Blood 711

18.1 Functions and General Composition of Blood 712

- 18.1a Functions of Blood 712
- 18.1b Physical Characteristics of Blood 712
- 18.1c Components of Blood 713

18.2 Composition of Blood Plasma 715

- 18.2a Plasma Proteins 716
- 18.2b Other Solutes 717

18.3 Formed Elements in the Blood 718

- 18.3a Hemopoiesis 718
- 18.3b Erythrocytes 721

INTEGRATE: CONCEPT OVERVIEW

Recycling and Elimination of Erythrocyte Components 725

- 18.3c Leukocytes 729
- 18.3d Platelets 732

18.4 Hemostasis 732

- 18.4a Vascular Spasm 732
- 18.4b Platelet Plug Formation 733
- 18.4c Coagulation Phase 734
- 18.4d Elimination of the Clot 737

18.5 Development and Aging of Blood 737

CHAPTER 19

Cardiovascular System: Heart 741

19.1 Introduction to the Cardiovascular System 742

- 19.1a General Function 742
- 19.1b Overview of Components 743
- 19.1c Pulmonary and Systemic Circulation 744

INTEGRATE: CONCEPT OVERVIEW

Blood Flow Through the Heart and Circulatory Routes 746

19.2 The Heart Within the Thoracic Cavity 748

- 19.2a Location and Position of the Heart 748
- 19.2b The Pericardium 748

19.3 Heart Anatomy 749

- 19.3a Superficial Features of the Heart 749
- 19.3b Layers of the Heart Wall 752
- 19.3c Heart Chambers 753
- 19.3d Heart Valves 753
- 19.3e Fibrous Skeleton of the Heart 756
- 19.3f Microscopic Structure of Cardiac Muscle 756

19.4 Coronary Vessels: Blood Supply Within the Heart Wall 758

- 19.4a Coronary Arteries 759
- 19.4b Coronary Veins 760

19.5 Anatomic Structures Controlling Heart Activity 760

- 19.5a The Heart's Conduction System 760
- 19.5b Innervation of the Heart 760

19.6 Stimulation of the Heart 762

- 19.6a Nodal Cells at Rest 762
- 19.6b Electrical Events at the SA Node: Initiation of the Action Potential 763



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19.6c Conduction System of the Heart: Spread of the Action Potential 764

19.7 Cardiac Muscle Cells 765

- 19.7a Cardiac Muscle Cells at Rest 765
- 19.7b Electrical and Mechanical Events of Cardiac Muscle Cells 765
- 19.7c Repolarization and the Refractory Period 767
- 19.7d The ECG Recording 768

19.8 The Cardiac Cycle 770

- 19.8a Overview of the Cardiac Cycle 770
- 19.8b Events of the Cardiac Cycle 772

INTEGRATE: CONCEPT OVERVIEW

Changes Associated with a Cardiac Cycle 774

19.9 Cardiac Output 775

- 19.9a Introduction to Cardiac Output 775
- 19.9b Variables That Influence Heart Rate 776
- 19.9c Variables That Influence Stroke Volume 777
- 19.9d Variables That Influence Cardiac Output 779

19.10 Development of the Heart 780

CHAPTER 20

Cardiovascular System: Vessels and Circulation 786

20.1 Structure and Function of Blood Vessels 787

- 20.1a General Structure of Vessels 787
- 20.1b Arteries 789
- 20.1c Capillaries 791
- 20.1d Veins 795
- 20.1e Pathways of Blood Vessels 795



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INTEGRATE: CONCEPT OVERVIEW

How Blood Vessel Form Influences Function 796

20.2 Total Cross-Sectional Area and Blood Flow Velocity 797

20.3 Capillary Exchange 798

- 20.3a Diffusion and Vesicular Transport 798
- 20.3b Bulk Flow 798
- 20.3c Net Filtration Pressure 799
- 20.3d Role of the Lymphatic System 800

20.4 Local Blood Flow 800

- 20.4a Degree of Vascularization and Angiogenesis 800
- 20.4b Myogenic Response 801
- 20.4c Local, Short-Term Regulation 801
- 20.4d Relationship of Local and Total Blood Flow 802

20.5 Blood Pressure, Resistance, and Total Blood Flow 803

- 20.5a Blood Pressure 803
- 20.5b Resistance 808
- 20.5c Relationship of Blood Flow to Blood Pressure Gradients and Resistance 809

20.6 Regulation of Blood Pressure and Blood Flow 810

- 20.6a Neural Regulation of Blood Pressure 810
- 20.6b Hormonal Regulation of Blood Pressure 812

INTEGRATE: CONCEPT OVERVIEW

Factors That Regulate Blood Pressure 814

20.7 Blood Flow Distribution During Exercise 816

20.8 Pulmonary Circulation 816

- 20.8a Blood Flow Through the Pulmonary Circulation 816
- 20.8b Characteristics of the Pulmonary Circulation 817

20.9 Systemic Circulation: Vessels from and to the Heart 818

- 20.9a General Arterial Flow Out of the Heart 818
- 20.9b General Venous Return to the Heart 820

20.10 Systemic Circulation: Head and Trunk 820

- 20.10a Head and Neck 820
- 20.10b Thoracic and Abdominal Walls 824
- 20.10c Thoracic Organs 826
- 20.10d Gastrointestinal Tract 827
- 20.10e Posterior Abdominal Organs, Pelvis, and Perineum 830

20.11 Systemic Circulation: Upper and Lower Limbs 832

- 20.11a Upper Limb 832
- 20.11b Lower Limb 834

20.12 Comparison of Fetal and Postnatal Circulation 837

- 20.12a Fetal Circulation 837
- 20.12b Postnatal Changes 837

CHAPTER 21

Lymphatic System 843

21.1 Lymph and Lymph Vessels 845

- 21.1a Lymph and Lymphatic Capillaries 845
- 21.1b Lymphatic Vessels, Trunks, and Ducts 846

21.2 Overview of Lymphatic Tissue and Organs 848

21.3 Primary Lymphatic Structures 849

- 21.3a Red Bone Marrow 849
- 21.3b Thymus 849

21.4 Secondary Lymphatic Structures 850

- 21.4a Lymph Nodes 850
- 21.4b Spleen 852
- 21.4c Tonsils 854
- 21.4d Lymphatic Nodules and MALT 854

INTEGRATE: CONCEPT OVERVIEW

Relationship of the Lymphatic System to Both the Cardiovascular System and Immune System 855

CHAPTER 22

Immune System and the Body's Defense 859

22.1 Overview of Diseases Caused by Infectious Agents 860

22.2 Overview of the Immune System 861

- 22.2a Immune Cells and Their Locations 861
- 22.2b Cytokines 862
- 22.2c Comparison of Innate Immunity and Adaptive Immunity 863

22.3 Innate Immunity 864

- 22.3a Preventing Entry 864
- 22.3b Nonspecific Internal Defenses: Cells 866
- 22.3c Nonspecific Internal Defenses: Antimicrobial Proteins 867
- 22.3d Nonspecific Internal Defenses: Inflammation 868
- 22.3e Nonspecific Internal Defenses: Fever 871

INTEGRATE: CONCEPT OVERVIEW

Innate Immunity 872

22.4 Adaptive Immunity: An Introduction 874

- 22.4a Antigens 874
- 22.4b General Structure of Lymphocytes 875
- 22.4c Antigen-Presenting Cells and MHC Molecules 876
- 22.4d Overview of Life Events of Lymphocytes 881

22.5 Formation and Selection of T-Lymphocytes in Primary Lymphatic Structures 881

- 22.5a Formation of T-Lymphocytes 881
- 22.5b Selection and Differentiation of T-Lymphocytes 882
- 22.5c Migration of T-Lymphocytes 882

22.6 Activation and Clonal Selection of Lymphocytes 883

- 22.6a Activation of T-Lymphocytes 883
- 22.6b Activation of B-Lymphocytes 884
- 22.6c Lymphocyte Recirculation 884

22.7 Effector Response at Infection Site 885

- 22.7a Effector Response of T-Lymphocytes 885
- 22.7b Effector Response of B-Lymphocytes 886

22.8 Immunoglobulins 886

- 22.8a Structure of Immunoglobulins 887
- 22.8b Actions of Antibodies 887
- 22.8c Classes of Immunoglobulins 887

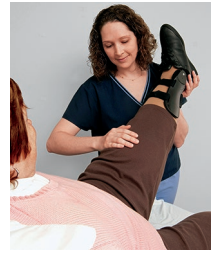
22.9 Immunologic Memory and Immunity 889

- 22.9a Immunologic Memory 889

INTEGRATE: CONCEPT OVERVIEW

Adaptive Immunity 890

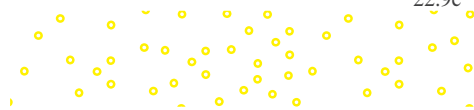
- 22.9b Measure of Immunologic Memory 892
- 22.9c Active and Passive Immunity 893



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CHAPTER 23

Respiratory System 900

23.1 Introduction to the Respiratory System 901

- 23.1a General Functions of the Respiratory System 901
- 23.1b General Organization of the Respiratory System 901
- 23.1c Respiratory Mucosa 902

23.2 Upper Respiratory Tract 903

- 23.2a Nose and Nasal Cavity 903
- 23.2b Paranasal Sinuses 904
- 23.2c Pharynx 906

23.3 Lower Respiratory Tract 907

- 23.3a Larynx 907
- 23.3b Trachea 909
- 23.3c Bronchial Tree 910
- 23.3d Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli 914
- 23.3e Respiratory Membrane 917

23.4 Lungs 917

- 23.4a Gross Anatomy of the Lung 917
- 23.4b Circulation to and Innervation of the Lungs 919
- 23.4c Pleural Membranes and Pleural Cavity 921
- 23.4d How Lungs Remain Inflated 922

23.5 Respiration: Pulmonary Ventilation 922

- 23.5a Introduction to Pulmonary Ventilation 923
- 23.5b Mechanics of Breathing 924
- 23.5c Nervous Control of Breathing 928
- 23.5d Airflow, Pressure Gradients, and Resistance 932
- 23.5e Pulmonary and Alveolar Ventilation 933
- 23.5f Volume and Capacity 933

23.6 Respiration: Alveolar and Systemic Gas Exchange 935

- 23.6a Chemical Principles of Gas Exchange 935
- 23.6b Alveolar Gas Exchange (External Respiration) 937
- 23.6c Systemic Gas Exchange (Internal Respiration) 938

23.7 Respiration: Gas Transport 940

- 23.7a Oxygen Transport 940
- 23.7b Carbon Dioxide Transport 940
- 23.7c Hemoglobin as a Transport Molecule 941

23.8 Breathing Rate and Homeostasis 945

- 23.8a Effects of Hyperventilation and Hypoventilation on Cardiovascular Function 945

INTEGRATE: CONCEPT OVERVIEW

- The Movement of Oxygen and Carbon Dioxide 947
- 23.8b Breathing and Exercise 948

CHAPTER 24

Urinary System 954

24.1 Introduction to the Urinary System 955

24.2 Gross Anatomy of the Kidney 957

- 24.2a Location and Support 957
- 24.2b Sectional Anatomy of the Kidney 958
- 24.2c Innervation of the Kidney 959

24.3 Functional Anatomy of the Kidney 959

- 24.3a Nephron 959
- 24.3b Collecting Tubules and Collecting Ducts 963
- 24.3c Juxtaglomerular Apparatus 964

24.4 Blood Flow and Filtered Fluid Flow 964

- 24.4a Blood Flow Through the Kidney 964
- 24.4b Filtrate, Tubular Fluid, and Urine Flow 966

24.5 Production of Filtrate Within the Renal Corpuscle 967

- 24.5a Overview of Urine Formation 967
- 24.5b Filtration Membrane 968
- 24.5c Formation of Filtrate and Its Composition 969
- 24.5d Pressures Associated with Glomerular Filtration 969
- 24.5e Regulation of Glomerular Filtration Rate 970

INTEGRATE: CONCEPT OVERVIEW

- Glomerular Filtration and Its Regulation 974



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24.6 Reabsorption and Secretion in Tubules and Collecting Ducts 975

- 24.6a Overview of Transport Processes 975
- 24.6b Transport Maximum and Renal Threshold 976
- 24.6c Substances Reabsorbed Completely 976
- 24.6d Substances with Regulated Reabsorption 977
- 24.6e Substances Eliminated as Waste Products 982
- 24.6f Establishing the Concentration Gradient 984

INTEGRATE: CONCEPT OVERVIEW

- Tubular Reabsorption and Tubular Secretion 986

24.7 Evaluating Kidney Function 987

- 24.7a Measuring Glomerular Filtration Rate 987
- 24.7b Measuring Renal Plasma Clearance 987

24.8 Urine Characteristics, Transport, Storage, and Elimination 988

- 24.8a Characteristics of Urine 988
- 24.8b Urinary Tract (Ureters, Urinary Bladder, Urethra) 990
- 24.8c Micturition 994

CHAPTER 25

Fluid and Electrolytes 1000

25.1 Body Fluids 1001

- 25.1a Percentage of Body Fluid 1001
- 25.1b Fluid Compartments 1001

25.2 Fluid Balance 1004

- 25.2a Fluid Intake and Fluid Output 1004
- 25.2b Fluid Imbalance 1005
- 25.2c Regulation of Fluid Balance 1007

25.3 Electrolyte Balance 1008

- 25.3a Nonelectrolytes and Electrolytes 1008
- 25.3b Major Electrolytes: Location, Functions, and Regulation 1009

25.4 Hormonal Regulation 1013

- 25.4a Angiotensin II 1013
- 25.4b Antidiuretic Hormone 1014
- 25.4c Aldosterone 1016
- 25.4d Atrial Natriuretic Peptide 1017

25.5 Acid-Base Balance 1019

- 25.5a Categories of Acid 1019
- 25.5b The Kidneys and Regulation of Fixed Acids 1019
- 25.5c Respiration and Regulation of Volatile Acid 1021
- 25.5d Chemical Buffers 1022

INTEGRATE: CONCEPT OVERVIEW

- Maintaining Acid-Base Balance 1023

25.6 Disturbances to Acid-Base Balance 1024

- 25.6a Overview of Acid-Base Imbalances 1024
- 25.6b Respiratory-Induced Acid-Base Disturbances 1025
- 25.6c Metabolic-Induced Acid-Base Disturbances 1025
- 25.6d Compensation 1027

CHAPTER 26

Digestive System 1034

26.1 Introduction to the Digestive System 1035

- 26.1a Organization of the Digestive System 1035
- 26.1b General Functions of the Digestive System 1036
- 26.1c Gastrointestinal Tract Wall 1036
- 26.1d Overview of the Regulation of the Digestive System 1038
- 26.1e Serous Membranes of the Abdominal Cavity 1038

26.2 Upper Gastrointestinal Tract 1040

- 26.2a Overview of the Upper Gastrointestinal Tract Organs 1040
- 26.2b Oral Cavity and Salivary Glands 1040
- 26.2c Pharynx and Esophagus 1044
- 26.2d Stomach 1047

26.3 Lower Gastrointestinal Tract 1054

- 26.3a Overview of the Lower Gastrointestinal Tract Organs 1054
- 26.3b Small Intestine 1054
- 26.3c Accessory Digestive Organs and Ducts 1058
- 26.3d Large Intestine 1064



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26.4 Nutrients and Their Digestion 1069

- 26.4a Carbohydrate Digestion 1069
- 26.4b Protein Digestion 1071
- 26.4c Lipid Digestion 1073
- 26.4d Nucleic Acid Digestion 1075

INTEGRATE: CONCEPT OVERVIEW

- Nutrients and Their Digestion 1076
 - 26.4e Water, Electrolyte, and Vitamin Absorption 1078

CHAPTER 27

Nutrition and Metabolism 1082

27.1 Introduction to Nutrition 1083

27.2 Macronutrients 1083

- 27.2a Carbohydrates 1083
- 27.2b Lipids 1084
- 27.2c Proteins 1084

27.3 Micronutrients 1085

- 27.3a Vitamins 1085
- 27.3b Minerals 1086

27.4 Guidelines for Adequate Nutrition 1088

27.5 Regulating Blood Levels of Nutrients 1089

- 27.5a Absorptive State 1089
- 27.5b Postabsorptive State 1090

27.6 Functions of the Liver 1090

- 27.6a Cholesterol Synthesis 1090
- 27.6b Transport of Lipids 1092
- 27.6c Integration of Liver Structure and Function 1093

INTEGRATE: CONCEPT OVERVIEW

- Liver Structure and Function 1094

27.7 Central Role of Cellular Respiration 1096

- 27.7a ATP Generation 1096
- 27.7b Interconversion of Nutrient Biomolecules and Their Building Blocks 1096

27.8 Energy and Heat 1098

- 27.8a Metabolic Rate 1098
- 27.8b Temperature Regulation 1098



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28.4 Male Reproductive System 1129

- 28.4a Scrotum 1129
- 28.4b Testes and Spermatogenesis 1131
- 28.4c Duct System in the Male Reproductive Tract 1136
- 28.4d Accessory Glands and Semen Production 1138
- 28.4e Penis 1139
- 28.4f Male Sexual Response 1140

28.5 Development and Aging of the Female and Male Reproductive Systems 1140

- 28.5a Genetic Versus Phenotypic Sex 1140
- 28.5b Formation of Indifferent Gonads and Genital Ducts 1141
- 28.5c Internal Genitalia Development 1142
- 28.5d External Genitalia Development 1142
- 28.5e Puberty 1144
- 28.5f Menopause and Male Climacteric 1144

CHAPTER 29

Development, Pregnancy, and Heredity 1149

29.1 Overview of the Prenatal Period 1150

29.2 Pre-Embryonic Period 1151

- 29.2a Fertilization 1152
- 29.2b Cleavage 1153
- 29.2c Implantation 1155
- 29.2d Formation of the Bilaminar Germinal Disc and Extraembryonic Membranes 1156
- 29.2e Development of the Placenta 1157

29.3 Embryonic Period 1158

- 29.3a Gastrulation and Formation of the Primary Germ Layers 1159
- 29.3b Folding of the Embryonic Disc 1160
- 29.3c Organogenesis 1163

29.4 Fetal Period 1163

29.5 Effects of Pregnancy on the Mother 1166

- 29.5a The Course of Pregnancy 1166
- 29.5b Hormonal Changes 1166
- 29.5c Uterine and Mammary Gland Changes 1167
- 29.5d Digestive System, Nutrient, and Metabolic Changes 1168
- 29.5e Cardiovascular and Respiratory System Changes 1169
- 29.5f Urinary System Changes 1169

29.6 Labor (Parturition) and Delivery 1170

- 29.6a Factors That Lead to Labor 1170
- 29.6b False Labor 1170
- 29.6c Initiation of True Labor 1171
- 29.6d Stages of True Labor 1172

29.7 Postnatal Changes for the Newborn 1174

29.8 Changes in the Mother After Delivery 1174

- 29.8a Hormonal Changes 1174
- 29.8b Blood Volume and Fluid Changes 1175
- 29.8c Lactation 1175
- 29.8d Uterine Changes 1177

29.9 Heredity 1177

- 29.9a Overview of Human Genetics 1177

INTEGRATE: CONCEPT OVERVIEW

- Anatomic and Physiologic Changes That Occur in the Mother 1178

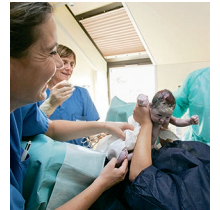
- 29.9b Patterns of Inheritance 1180
- 29.9c Sex-Linked Inheritance 1181
- 29.9d Penetrance and Environmental Influences on Heredity 1182

Appendix A A-1

Appendix B B-1

Glossary G-1

Index I-1



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REPRODUCTION

CHAPTER 28

Reproductive System 1104

28.1 Overview of Female and Male Reproductive Systems 1105

- 28.1a Common Elements of the Two Systems 1105
- 28.1b Sexual Maturation in Females and Males 1105
- 28.1c Anatomy of the Perineum 1105

28.2 Gametogenesis 1106

- 28.2a A Brief Review of Heredity 1106
- 28.2b An Overview of Meiosis 1107
- 28.2c Meiosis I: Reduction Division 1108
- 28.2d Meiosis II: Separation of Sister Chromatids 1110

28.3 Female Reproductive System 1111

- 28.3a Ovaries 1112
- 28.3b Oogenesis and the Ovarian Cycle 1115
- 28.3c Uterine Tubes, Uterus, and Vagina 1119
- 28.3d Uterine (Menstrual) Cycle and Menstruation 1122
- 28.3e External Genitalia 1123

INTEGRATE: CONCEPT OVERVIEW

- The Interrelationships Between Hormones, the Ovarian Cycle, and the Uterine (Menstrual) Cycle 1124

- 28.3f Mammary Glands 1126
- 28.3g Female Sexual Response 1127



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CLINICAL VIEW BOXES

CHAPTER 1

- 1.1 Etiology (Causes) and Pathogenesis (Development) of Disease 3
- 1.2 Establishing Normal Ranges for Clinical Practice 25
- 1.3 Clinicians' Use of Scientific Method 25
- 1.4 Medical Imaging 26

CHAPTER 2

- 2.1 Medical Imaging of the Thyroid Gland Using Iodine Radioisotopes 35
- 2.2 Surface Tension and Surfactant 44
- 2.3 Fatty Acids: Saturated, Unsaturated, and Trans Fats 56

CHAPTER 3

- 3.1 Drugs as Enzyme Inhibitors 88
- 3.2 Lactose Intolerance 91
- 3.3 Cyanide Poisoning 99

CHAPTER 4

- 4.1 Familial Hypercholesteremia 119
- 4.2 Lysosomal Storage Diseases 128
- 4.3 Tumors 147

CHAPTER 5

- 5.1 Scurvy 166
- 5.2 What Are You Planning to Do with Your Baby's Umbilical Cord? 167
- 5.3 Marfan Syndrome 169
- 5.4 Stem Cells 181
- 5.5 Gangrene 182
- 5.6 Tissue Transplant 183

CHAPTER 6

- 6.1 UV Radiation, Sunscreens, and Sunless Tanners 192
- 6.2 Tattoos 194
- 6.3 Nail Disorders 200
- 6.4 Acne and Acne Treatments 204
- 6.5 Psoriasis 206
- 6.6 Burns 207
- 6.7 Botox and Wrinkles 208

CHAPTER 7

- 7.1 Bone Marrow Transplant 218
- 7.2 Osteitis Deformans 220
- 7.3 Forensic Anthropology: Determining Age at Death 229
- 7.4 Achondroplastic Dwarfism 231
- 7.5 Why Are Males Typically Taller Than Females? 232
- 7.6 Rickets 234
- 7.7 Osteoporosis 235
- 7.8 Bone Scans 237

CHAPTER 8

- 8.1 Cleft Lip and Palate 257
- 8.2 Craniosynostosis and Plagiocephaly 259

- 8.3 Spinal Curvature Abnormalities 265
- 8.4 Herniated Discs 268
- 8.5 Coccyx (Tailbone) Injury 271
- 8.6 Sternal Foramen 272
- 8.7 Variations in Rib Development 272
- 8.8 Scaphoid Fractures 281
- 8.9 Pathologies of the Foot 290
- 8.10 Limb Malformations 294

CHAPTER 9

- 9.1 Costochondritis 303
- 9.2 "Cracking Knuckles" 305
- 9.3 TMJ Disorders 314
- 9.4 Shoulder Joint Dislocations 317
- 9.5 Subluxation of the Head of the Radius 319
- 9.6 Fracture of the Femoral Neck 323
- 9.7 Knee Ligament and Cartilage Injuries 325
- 9.8 Ankle Sprains and Pott Fractures 327
- 9.9 Arthritis 328

CHAPTER 10

- 10.1 Muscular Dystrophy 341
- 10.2 Myasthenia Gravis (MG) 343
- 10.3 Muscular Paralysis and Neurotoxins 352
- 10.4 Rigor Mortis 352
- 10.5 Creatine Kinase Blood Levels as a Diagnostic Tool 353
- 10.6 Isometric Contraction and Increase in Blood Pressure 360
- 10.7 Muscle Pain Associated with Exercise 362
- 10.8 Unbalanced Skeletal Muscle Development 363
- 10.9 Anabolic Steroids as Performance-Enhancing Compounds 364

CHAPTER 11

- 11.1 Intramuscular Injections 378
- 11.2 Idiopathic Facial Nerve Paralysis (Bell Palsy) 380
- 11.3 Strabismus and Diplopia 385
- 11.4 Congenital Muscular Torticollis 393
- 11.5 Hernias 398
- 11.6 Rotator Cuff Injuries 406
- 11.7 Lateral Epicondylitis ("Tennis Elbow") 414
- 11.8 Carpal Tunnel Syndrome 416
- 11.9 Shin Splints and Compartment Syndrome 421
- 11.10 Plantar Fasciitis 433

CHAPTER 12

- 12.1 Pathogenic Agents and Fast Axonal Transport 445
- 12.2 Tumors of the Central Nervous System 449
- 12.3 Nervous System Disorders Affecting Myelin 451
- 12.4 Local Anesthetics 468

- 12.5 Neurotoxicity 470
- 12.6 Altered Acetylcholine Function and Changes in Breathing 478

CHAPTER 13

- 13.1 Traumatic Brain Injuries: Concussion and Contusion 486
- 13.2 Neural Tube Defects 491
- 13.3 Meningitis and Encephalitis 495
- 13.4 Epidural and Subdural Hematomas 496
- 13.5 Hydrocephalus 498
- 13.6 Mapping Functional Brain Regions 505
- 13.7 Autism Spectrum Disorder 506
- 13.8 Epilepsy and Cerebral Lateralization 509
- 13.9 Cerebrovascular Accident 509
- 13.10 Brain Ailments and Disorders 510
- 13.11 Effects of Alcohol and Drugs on the Cerebellum 518
- 13.12 Pathologic States of Unconsciousness 521
- 13.13 Alzheimer Disease: The "Long Goodbye" 524
- 13.14 Amnesia 524
- 13.15 Dyslexia 525

CHAPTER 14

- 14.1 Lumbar Puncture 544
- 14.2 Poliomyelitis 546
- 14.3 Treating Spinal Cord Injuries 553
- 14.4 Shingles 556
- 14.5 Brachial Plexus Injuries 564
- 14.6 Sacral Plexus Injuries 567

CHAPTER 15

- 15.1 Horner Syndrome 593
- 15.2 Epinephrine for Treatment of Asthma 600
- 15.3 Raynaud Syndrome 604
- 15.4 Autonomic Dysreflexia 605

CHAPTER 16

- 16.1 Phantom Pain 618
- 16.2 Eye Infections 622
- 16.3 Detached Retina 627
- 16.4 Macular Degeneration 629
- 16.5 Cataracts 630
- 16.6 Glaucoma 631
- 16.7 Functional Visual Impairments 632
- 16.8 Color Blindness 634
- 16.9 Otitis Media 643
- 16.10 Cochlear Implants 650
- 16.11 Deafness 651
- 16.12 Motion Sickness 654

CHAPTER 17

- 17.1 Synthesis of Eicosanoids 669
- 17.2 Hormone Analogs 675
- 17.3 Hypophysectomy 681
- 17.4 Disorders of Growth Hormone Secretion 684

- 17.5** Disorders of Thyroid Hormone Secretion 688
- 17.6** Disorders in Adrenal Cortex Hormone Secretion 693
- 17.7** The Stress Response (General Adaptation Syndrome) 694
- 17.8** Conditions Resulting in Abnormal Blood Glucose Levels 697

CHAPTER 18

- 18.1** Blood Doping 721
- 18.2** Anemia 724
- 18.3** Transfusions 726
- 18.4** Whole Blood Versus Plasma Donations: What's the Difference? 726
- 18.5** Fetal Hemoglobin and Physiologic Jaundice 727
- 18.6** Rh Incompatibility and Pregnancy 729
- 18.7** Leukemia 732
- 18.8** Bleeding and Blood Clotting Disorders 735

CHAPTER 19

- 19.1** Congestive Heart Failure 744
- 19.2** Pericarditis 749
- 19.3** Teenage Athletes and Sudden Cardiac Death 754
- 19.4** Heart Sounds and Heart Murmurs 755
- 19.5** Coronary Heart Disease, Angina Pectoris, and Myocardial Infarction 759
- 19.6** Ectopic Pacemaker 765
- 19.7** Cardiac Arrhythmia 770
- 19.8** Bradycardia and Tachycardia 779

CHAPTER 20

- 20.1** Atherosclerosis 790
- 20.2** Aneurysm 791
- 20.3** Tumor Angiogenesis 801
- 20.4** Detecting a Pulse Point 805
- 20.5** Cerebral Edema 806
- 20.6** Deep Vein Thrombosis 806
- 20.7** Varicose Veins 806
- 20.8** Circulatory Shock 807
- 20.9** Measuring Blood Pressure 814
- 20.10** Hypertension and Hypotension 815
- 20.11** Patent Ductus Arteriosus 838

CHAPTER 21

- 21.1** Metastasis 845
- 21.2** Lymphedema 848
- 21.3** Lymphoma 852
- 21.4** Splenectomy 853
- 21.5** Tonsillitis and Tonsillectomy 854

CHAPTER 22

- 22.1** Pus and Abscesses 870
- 22.2** Applying Ice for Acute Inflammation 870
- 22.3** Chronic Inflammation 871
- 22.4** Autoimmune Disorders 875

- 22.5** Organ Transplants and MHC Molecules 879
- 22.6** Regulatory T-Lymphocytes and Tumors 883
- 22.7** Vaccinations 892
- 22.8** Hypersensitivities 894
- 22.9** HIV and AIDS 895

CHAPTER 23

- 23.1** Runny Nose 905
- 23.2** Sinus Infections and Sinus Headaches 905
- 23.3** Laryngitis 909
- 23.4** Tracheotomy 910
- 23.5** Bronchitis 912
- 23.6** Asthma 913
- 23.7** Pneumonia 916
- 23.8** Smoking 920
- 23.9** Lung Cancer 921
- 23.10** Pleurisy and Pleural Effusion 922
- 23.11** Pneumothorax and Atelectasis 922
- 23.12** Apnea 930
- 23.13** Hypoxic Drive 931
- 23.14** Minimal Volume 933
- 23.15** Decompression Sickness and Hyperbaric Oxygen Chambers 937
- 23.16** Emphysema 938
- 23.17** Respiratory Diseases and Efficiency of Alveolar Gas Exchange 939
- 23.18** Measuring Blood Oxygen Levels with a Pulse Oximeter 940
- 23.19** Cystic Fibrosis 945

CHAPTER 24

- 24.1** Renal Ptosis and Hydronephrosis 958
- 24.2** Kidney Variations and Anomalies 959
- 24.3** Glucosuria 976
- 24.4** Diuretics 985
- 24.5** Renal Failure, Dialysis, and Kidney Transplant 988
- 24.6** Intravenous Pyelogram 991
- 24.7** Renal Calculi 992
- 24.8** Urinary Tract Infections 994
- 24.9** Impaired Urination 995

CHAPTER 25

- 25.1** Intravenous (IV) Solution 1005
- 25.2** Hemorrhaging 1005
- 25.3** Dehydration in Infants and the Elderly 1006
- 25.4** Angiotensin-Converting Enzyme (ACE) Inhibitors 1013
- 25.5** Diabetes Insipidus 1016
- 25.6** How Does Vomiting or Diarrhea Alter Blood H⁺ Concentration? 1021
- 25.7** Lactic Acidosis and Ketoacidosis 1027
- 25.8** Arterial Blood Gas (ABG) and Diagnosing Different Types of Acid-Base Disturbances 1028

CHAPTER 26

- 26.1** Peritonitis 1039
- 26.2** Reflux Esophagitis and Gastroesophageal Reflux Disease (GERD) 1045
- 26.3** Achalasia 1046
- 26.4** Gastric Bypass 1047
- 26.5** Peptic Ulcers 1052
- 26.6** Vomiting 1054
- 26.7** Inflammatory Bowel Disease and Irritable Bowel Syndrome 1055
- 26.8** Cirrhosis of the Liver 1061
- 26.9** Gallstones (Cholelithiasis) 1062
- 26.10** Pancreatic Cancer 1063
- 26.11** Appendicitis 1064
- 26.12** Colorectal Cancer 1066
- 26.13** Fecal Transplant 1067
- 26.14** Diverticulosis and Diverticulitis 1067
- 26.15** Constipation and Diarrhea 1069
- 26.16** Celiac Disease (Gluten-Sensitive Enteropathy) 1071
- 26.17** Cystic Fibrosis and the Pancreas 1075

CHAPTER 27

- 27.1** High Fructose Corn Syrup 1084
- 27.2** Iron Deficiency 1087
- 27.3** Obesity 1089
- 27.4** Blood Cholesterol Levels 1092
- 27.5** Heat-Related Illnesses 1099
- 27.6** Hypothermia, Frostbite, and Dry Gangrene 1099

CHAPTER 28

- 28.1** Nondisjunction 1110
- 28.2** Ovarian Cancer 1116
- 28.3** Tubal Pregnancy 1121
- 28.4** Endometriosis 1121
- 28.5** Cervical Cancer 1122
- 28.6** Breast Cancer 1126
- 28.7** Contraception Methods 1128
- 28.8** Sexually Transmitted Infections 1135
- 28.9** Paternal Age Risks for Disorders in the Offspring 1136
- 28.10** Benign Prostatic Hyperplasia and Prostate Cancer 1138
- 28.11** Circumcision 1139
- 28.12** Intersex Conditions (Disorders of Sex Development) 1142

CHAPTER 29

- 29.1** Chromosomal Abnormalities and Spontaneous Abortion 1156
- 29.2** Infertility and Infertility Treatments 1165
- 29.3** Gestational Diabetes 1166
- 29.4** Hyperemesis Gravidarum 1168
- 29.5** Preeclampsia 1169
- 29.6** Inducing Labor 1170
- 29.7** Anesthetic Procedures to Facilitate True Labor 1172
- 29.8** Fetal Positioning and the Dilation Stage 1172
- 29.9** Genetics of Familial Hypercholesterolemia 1181

preface

Human anatomy and physiology is a fascinating subject. However, students can be overwhelmed by the complexity, the interrelatedness of concepts from different chapters, and the massive amount of material in the course. Our goal was to create a textbook to guide students on a clearly written and expertly illustrated beginner's path through the human body.

An Integrative Approach

One of the most daunting challenges that students face in mastering concepts in an anatomy and physiology course is integrating related content from numerous chapters. Understanding a topic like blood pressure, for example, requires knowledge from the chapters on the heart, blood vessels, kidneys, and how these structures are regulated by the nervous and endocrine systems. The usefulness of a human anatomy and physiology text is dependent in part on how successfully it helps students integrate these related concepts. Without this, students are only acquiring what seems like unrelated facts without seeing how they fit into the whole.

To adequately explain such complex concepts to beginning students in our own classrooms, we as teachers present multiple topics over the course of many class periods, all the while balancing these detailed explanations with refreshers of content previously covered and intermittent glimpses of the big picture. Doing so ensures that students learn not only the individual pieces, but also how the pieces ultimately fit together. This book represents our best effort to replicate this teaching process. In fact, it is the effective integration of concepts throughout the text that makes this book truly unique from other undergraduate anatomy and physiology texts.

Our goal of emphasizing the interrelatedness of body systems and the connections between form and function necessitates a well-thought-out pedagogical platform to deliver the content. First and foremost, we have written a very user-friendly text with concise, accurate descriptions that are thorough, but don't overwhelm readers with nonessential details. The text narrative is deeply integrated with corresponding illustrations drawn specifically to match the textual explanations. In addition, we have included a set of "Integrate" features that support our theme and work together to give the student a well-rounded introduction to anatomy and physiology. **Integrate: Concept Overview** figures are one- or two-page visual summaries that aggregate related concepts in a big-picture view. These comprehensive figures link multiple sections of a chapter together in a cohesive snapshot ideal for study and review. **Integrate: Concept Connections** boxes provide glimpses of how concepts at hand will play out in upcoming chapters, and also pull vital information from earlier chapters back into the discussion at crucial points when relevant to a new topic. **Integrate: Clinical View** discussions apply concepts from the surrounding narrative to practical or clinical contexts, providing examples of what can go wrong in the human body to help crystallize understanding of the "norm." **Integrate: Learning Strategy** boxes infuse each chapter with practical study tips to understand and remember information. Learning strategies include mnemonics, analogies, and kinesthetic activities that students can perform to relate the anatomy and physiology to their own bodies. Finally, the

digital assets that accompany our book are tied to each section's learning objectives and previewed in the **Integrate: Online Study Tools** boxes at the end of each chapter.

Chapter Organization

In order to successfully execute an integrative approach, foundational topics must be presented at the point when it matters most for understanding. This provides students with a baseline of knowledge about a given concept before it comes time to apply that information in a more complex situation. Topics are thus subdivided and covered in this sequence:

- **Chapter 2: Atoms, Ions, and Molecules** Most students taking an A&P course have limited or no chemistry background, which requires a textbook to provide a detailed, organized treatment of atomic and molecular structure, bonding, water, and biological macromolecules as a basis to understanding physiological processes.
- **Chapter 3: Energy, Chemical Reactions, and Cellular Respiration** ATP is essential to all life processes. A solid understanding of ATP furthers student comprehension of movement of materials across a membrane, muscle contractions, production of needed replacement molecules and structures in cells, action potentials in nerves, pumping of the heart, and removal of waste materials in the kidneys. This textbook elevates the importance of the key concept of ATP by teaching it early. We then utilize this knowledge in later chapters as needed, expanding on what has already been introduced rather than re-teaching it entirely.
- **Chapter 13: Nervous System: Brain and Cranial Nerves and Chapter 14: Nervous System: Spinal Cord and Spinal Nerves** Instead of subdividing the nervous system discussion into separate central nervous system (CNS) and peripheral nervous system (PNS) chapters, nervous system structures are grouped by region. Thus, students can integrate the cranial nerves with their respective nuclei in the brain, and they can integrate the spinal cord regions with the specific spinal nerves that originate from these regions.
- **Chapter 17: Endocrine System** We have organized both the endocrine system chapter and the specific coverage of the many hormones released from endocrine glands to most effectively and efficiently guide students in understanding how this system of control functions in maintaining homeostasis. Within the chapter on the endocrine system, we provide an introduction and general discussion of the endocrine system's central concepts and describe selected representative hormones that maintain body homeostasis. Details of the actions of most other hormones—which require an understanding of specific anatomic structures covered in other chapters—are described in those chapters; for example, sex hormones are discussed in Chapter 28: Reproductive System. Learning the various hormones is facilitated by the inclusion of a "template" figure for each major hormone; each visual template includes the same components (stimulus,

receptor, control center, and effectors) organized in a similar layout. In addition, information on each major hormone described in this text can be quickly accessed in the summary tables following chapter 17.

- **Chapter 21: Lymphatic System and Chapter 22: Immune System and the Body's Defense** A single chapter that discusses both the lymphatic system and immune system is overwhelming for most students. Thus, we separated the discussion into two separate chapters. The lymphatic system chapter focuses on the anatomic structures that compose the system, and provides a brief functional overview of each structure. This allows us to provide a thorough discussion and overview of the immune system in a separate chapter, where we frequently reference and integrate material from the earlier chapter.
- **Chapter 29: Development, Pregnancy, and Heredity** Coverage of heredity is included in the chapter on pregnancy and human development as a natural extension of Chapter 28: Reproductive System. This introduction will serve well as a precursor for students who follow their A&P course with a genetics course.

Changes to the Third Edition

Real student data points derived from thousands of SmartBook users have guided the revision process for this edition. In addition, this revision has been informed by dozens of chapter reviews by A&P instructors. The following global changes have been implemented throughout all chapters:

- Additional references were added to concepts previously covered, as well as to related material in upcoming sections and chapters, to further connect concepts.
- Terminology has been updated and definitions are added throughout.
- New “What Do You Think?” and “What Did You Learn?” questions were added throughout the text.

Chapter 1

- New section added about how best to study A&P
- Revised: figure 1.8, figure 1.9, figure 1.13
- Clinical View 1.1: Etiology (Causes) and Pathogenesis (Development) of Disease updated to include more detail on sonography and imaging; added new photos and labeling to images

Chapter 2

- Moved description of inorganic and organic molecules from section 2.7: Biological Molecules to beginning of section 2.4: Molecular Structure of Water and the Properties of Water
- Revised: figure 2.1b, figure 2.9, figure 2.10, figure 2.13, figure 2.17, figure 2.19, figure 2.20, figure 2.21, figure 2.22, figure 2.24, figures within table 2.4

Chapter 3

- Revised: figure 3.1, figure 3.3, figure 3.6, figure 3.7, figure 3.10, figure 3.13, figure 3.14, figure 3.16, figure 3.18, figure 3.19
- Revised coverage of ATP cycling in section 3.2b: Classification of Chemical Reactions

Chapter 4

- Revised: figure 4.4, figure 4.5, figure 4.6, figure 4.7, figure 4.9, figure 4.10, figure 4.11, figure 4.14, figure 4.15, figure 4.17, figure 4.18, figure 4.19, figure 4.20, figure 4.21, figure 4.23, figure 4.27, figure 4.28, figure 4.30, figure 4.32, figure 4.39, figure 4.42 (several new photos)
- New figure 4.38 on genetic code
- Modified section 4.1a: How Cells Are Studied
- Updated section 4.2b: Membrane Proteins
- Revised section 4.3: Membrane Transport
- Revised and reorganized section 4.6b: Non-Membrane-Bound Organelles

Chapter 5

- Updated art in tables 5.2, 5.3
- Revised: figure 5.4, figure 5.8, figure 5.10, figure 5.11, figure 5.12
- Modified section 5.2b: Functions of Connective Tissue
- Updated text in tables 5.6, 5.10
- Removed coverage of perichondrium (covered in Chapter 7)
- Modified section 5.5b: Body Membranes
- Updated Clinical View 5.4: Stem Cells
- Revised Clinical View 5.5: Gangrene
- Updated Chapter Summary to include lymph in discussion of fluid connective tissue

Chapter 6

- Updated terminology to use “keratinocyte” instead of “cell” where appropriate
- Updated section on stratum corneum to include coverage of dermidicin
- Removed reference to human pheromones

Chapter 7

- In section 7.2, added information on the appearance of living bone
- Revised: figure 7.4, figure 7.11, figure 7.15
- Revised discussion of exercise in space
- Clinical View 7.7: Osteoporosis—added information on DEXA scans

Chapter 8

- Table 8.1 revised to include parietal foramina
- Revised: figure 8.5, figure 8.7a, figure 8.11, figure 8.12a, figure 8.14, figure 8.22a, figure 8.31, figure 8.34b
- In section 8.2b: Views of the Skull and Landmark Features, revised sella turcica information to include hypophyseal fossa
- Table 8.2 and table 8.3 figures were revised to improve clarity and accuracy
- Revised Clinical View 8.2: Craniosynostosis and Plagiocephaly
- In section 8.3: Bones Associated with the Skull, revised information on functions of the hyoid bone's cornua and body
- Revised figure in Clinical View 8.4: Herniated Discs
- Table 8.6 text and figures updated regarding width of pelvis and ilia

Chapter 9

- Reversed order of sections 9.5 and 9.6, so Movements of Synovial Joints are discussed prior to Synovial Joints and Levers
- Table 9.1 simplified
- Revised: figure 9.2, figure 9.3, figure 9.6, figure 9.14
- Modified description of synovial membrane

Chapter 10

- Updated section 10.1a: Functions of Skeletal Muscle and section 10.1b: Characteristics of Skeletal Muscle Cells
- Revised section 10.2a: Gross Anatomy of Skeletal Muscle
- Revised section 10.2b: Microscopic Anatomy of Skeletal Muscle to add details of triad
- Revised section 10.4: Skeletal Muscle Metabolism
- Revised section 10.8: Effects of Exercise and Aging on Skeletal Muscle
- New Concept Connection on Excitability
- New Learning Strategy on prefixes *myo-*, *mys-*, *sarco-*
- New Concept Connection on connective tissue coverings
- New Clinical View 10.1: Muscular Dystrophy
- New Concept Connection on nervous system diseases that influence muscle function
- New Clinical View 10.9: Unbalanced Skeletal Muscle Development
- New Concept Connection on Myogenic Response
- Revised: figure 10.1, figure 10.3, figure 10.6, figure 10.7, figure 10.9, figure 10.10, figure 10.11, figure 10.12, figure 10.14, figure 10.15, figure 10.16, figure 10.17, figure 10.20, figure 10.21, figure 10.22, figure 10.30
- Revised figure in Learning Strategy on sarcomere shortening
- New: figure 10.17 on ATP for muscle metabolism; figure 10.21 on recruitment; figure 10.24 comparing isometric and isotonic contractions; figure 10.26 on maximizing force of contractions

Chapter 11

- Replaced the terms *origin* and *insertion* with *superior attachment* and *inferior attachment* where appropriate
- Revised Clinical View 11.2: Idiopathic Facial Nerve Paralysis (Bell Palsy) to include information on Lyme disease effects
- New photo in Clinical View 11.2: Idiopathic Facial Nerve Paralysis (Bell Palsy)
- Revised: table 11.3, table 11.8, table 11.18
- Revised: figure 11.17, figure 11.19, figure 11.21b, figure 11.22
- New photo in Clinical View 11.7: Lateral Epicondylitis (“Tennis Elbow”)
- Revised figure in Clinical View 11.8: Carpal Tunnel Syndrome

Chapter 12

- Revised section 12.2b: Neuron Structure
- Added section 12.1c: Nerves and Ganglia
- New Concept Connection on bundling by connective tissue
- New Concept Connection on excitability
- New Learning Strategy on glial cells
- Clinical View 12.3: Nervous System Disorders Affecting Myelin now includes Zika virus as it relates to Guillain-Barré syndrome

- New Learning Strategy on states of voltage-gated Na⁺ channels
- Revised Clinical View 12.6: Altered Acetylcholine Function and Changes in Breathing
- Section 12.1c: Nerves and Ganglia was previously section 12.2e (moved forward in the chapter)
- Revised: figure 12.3, figure 12.5, figure 12.6, figure 12.7, figure 12.9b, figure 12.10, figure 12.11, figure 12.14, figure 12.16, figure 12.17, figure 12.18, figure 12.21, figure 12.22, figure 12.23, figure 12.24, figure 12.25
- New Clinical View 12.1: Pathogenic Agents and Fast Axonal Transport figure of axonal transport for how pathogenic organisms move to cell body
- New illustration of battery for text discussion on Ohm’s Law (pg. 457)
- New figure 12.13: Neuron’s and Ohm’s Law
- New photo in figure 12.17

Chapter 13

- Revised section 13.1: Brain Organization and Development
- Revised Clinical View 13.1: Traumatic Brain Injuries: Concussion and Contusion
- Revised section 13.1c: Gray Matter and White Matter Distribution
- Revised: figure 13.1, figure 13.4, figure 13.5, figure 13.9, figure 13.12, figure 13.14, figure 13.21, figure 13.23b, figure 13.24a, figure 13.25, figure 13.30, figure 13.31
- Revised table 13.2, table 13.4, table 13.5
- Updated Clinical View 13.3: Meningitis and Encephalitis
- Revised Clinical View 13.6: Mapping Functional Brain Regions
- New Learning Strategy on functions of the hypothalamus
- Revised coverage of medulla autonomic centers

Chapter 14

- Revised section 14.1: Overview of the Spinal Cord and Spinal Nerves reorganized to provide an overview of the chapter content; section 14.1c: Spinal Nerve Identification and Gross Anatomy now contains content on spinal roots that was moved from section 14.5a
- Section 14.2: Protection and Support of the Spinal Column revised to include more explanation on vertebral column
- Section 14.3: Sectional Anatomy of the Spinal Cord and Spinal Roots provides more information on functional relationship between gray matter and spinal nerve roots, sensory receptors, and effectors.
- Section 14.5a: General Distribution of Spinal Nerves
- Revised: figure 14.1, figure 14.2, figure 14.4, figure 14.5, figure 14.6, figure 14.10, figure 14.14, figure 14.18c

Chapter 15

- Section 15.3b: Pelvic Splanchnic Nerves rearranged to discuss parasympathetic cranial nerve physiology first, followed by anatomy
- Section 15.5: Autonomic Plexuses and the Enteric Nervous System moved forward to appear after discussion of sympathetic and parasympathetic systems
- New section 15.5b: Enteric Nervous System
- New Learning Strategy on parasympathetic division

- Updated Clinical View 15.3: Raynaud Syndrome, with photo added
- Revised: figure 15.4, figure 15.6, figure 15.7b, figure 15.10, figure 15.11

Chapter 16

- New Clinical View 16.2: Eye Infections
- Revised: figure 16.2, figure 16.3, figure 16.5, figure 16.7, figure 16.8, figure 16.10, figure 16.15, figure 16.18, figure 16.22, figure 16.26, figure 16.27, figure 16.28

Chapter 17

- Section 17.1a: Overview of Endocrine System rewritten and expanded
- Revised: Section 17.1b: Comparison of the Two Control Systems
- Section 17.1c: General Functions of the Endocrine System contains added examples for each function of the endocrine system
- Section 17.3b: Local Hormones rewritten, now includes new Concept Connection on local hormones that act as vasoactive substances; new Clinical View 17.1: Synthesis of Eicosanoids
- Section 17.7b: Interactions Between the Hypothalamus and the Posterior Pituitary Gland contains expanded description of ADH and oxytocin
- Section 17.7c: Interactions Between the Hypothalamus and the Anterior Pituitary Gland reorganized and updated to add explanation for figure 17.12
- Revised: figure 17.1, figure 17.5, figure 17.7, figure 17.8, figure 17.10, figure 17.11, figure 17.12, figure 17.14, figure 17.16, figure 17.17, figure 17.18, figure 17.19, figure 17.20, figure 17.22, figure 17.23

Chapter 18

- Clinical View 18.3: Transfusions updated to include information on donor wait times between transfusions
- New Clinical View 18.4: Whole Blood Versus Plasma Donations: What's the Difference?
- New Clinical View 18.5: Fetal Hemoglobin and Physiologic Jaundice
- New Learning Strategy on Blood Types
- Revised: figure 18.5a, 18.7, figure 18.8, figure 18.11 (colorized micrograph of blood clotting), figure 18.12

Chapter 19

- Section 19.1a: General Function contains expanded content of the function of the cardiovascular system in transporting blood, including a new Concept Connection that provides examples of body systems dependent on blood transport
- Section 19.1b: Overview of Components revised to further describe circulation routes through the right and left sides of the heart
- New Clinical View 19.1: Congestive Heart Failure
- Section 19.2b: The Pericardium contains added description of pericardial sac
- Section 19.3a: Superficial Features of the Heart contains added explanation to align with figure 19.7
- Revised Clinical View 19.5: Coronary Heart Disease, Angina Pectoris, and Myocardial Infarction to add content on coronary heart disease

- Added Concept Connection to describe a sinus
- Added Concept Connection on resting membrane potential
- Added Concept Connection on nodal cells compared to neurons
- Added Concept Connection on conductivity
- Section 19.7b: Electrical and Mechanical Events of Cardiac Muscle Cells has been revised to add details on triad
- Revised: figure 19.2, figure 19.3, figure 19.7, figure 19.11, figure 19.13, figure 19.14, figure 19.16, figure 19.18, figure 19.19, figure 19.20, figure 19.21, figure 19.22

Chapter 20

- Revised: figure 20.1, figure 20.3, figure 20.4, figure 20.5, figure 20.7, figure 20.14, figure 20.18, figure 20.19, figure 20.20, figure 20.22, figure 20.26, figure 20.27

Chapter 21

- Revised Learning Strategy on lymphocytes to describe origin of name for B-lymphocytes
- Revised: figure 21.1, figure 21.6, figure 21.9

Chapter 22

- New Table 22.5: Actions of Antibodies Following Antigen Binding
- Section 22.1: Overview of Diseases Caused by Infectious Agents revised to update definition of bacteria
- New Learning Strategy on the study of the immune system
- Revised Section 22.3a: Preventing Entry
- New Learning Strategy on CD4/CD8 with MHC Class I/II
- Section 22.5b: Selection and Differentiation of T-Lymphocytes rearranged for better alignment of illustration and text
- Section 22.8b: Action of Antibodies reorganized into table format for clarity
- Revised: figure 22.1, figure 22.2, figure 22.3, figure 22.4, figure 22.7, figure 22.8, figure 22.10, figure 22.12, figure 22.13, figure 22.14, figure 22.15, figure 22.16, figure 22.17, figure 22.19, figure 22.20

Chapter 23

- New Learning Strategy on structural and functional organization of the respiratory system
- Revised Section 23.3b: Trachea
- New Clinical View 23.4: Tracheotomy
- Clinical View 23.5: Bronchitis now includes coverage on exercise-induced asthma
- Revised Section 23.3c: Bronchial Tree
- Revised Section 23.3d: Respiratory Zone: Respiratory Bronchioles, Alveolar Ducts, and Alveoli
- New Clinical View 23.7: Pneumonia
- New photos of lungs in Clinical View 23.8: Smoking
- Revised: figure 23.3, figure 23.5, figure 23.6, figure 23.8, figure 23.9, figure 23.10, figure 23.11, figure 23.14, figure 23.19, figure 23.14, figure 23.16, figure 23.19, figure 23.21, figure 23.23, figure 23.25, figure 23.26, figure 23.31
- New figure 23.27: Changes in Respiratory Gas Partial Pressures Within the Blood

Chapter 24

- New figure in Clinical View 24.1: Renal Ptosis and Hydronephrosis
- Section 24.3c: Juxtaglomerular Apparatus revised to expand coverage of mesangial cells
- Concept Connection on blood pressure expanded
- Revised: figure 24.2, figure 24.3, figure 24.4, figure 24.5, figure 24.6, figure 24.7, figure 24.9, figure 24.11, figure 24.13, figure 24.14, figure 24.15, figure 24.16, figure 24.18, figure 24.19, figure 24.22, figure 24.23, figure 24.24, figure 24.26, figure 24.27, figure 24.28

Chapter 25

- Section 25.1: Body Fluids introduction revised to emphasize the main points of the chapter
- Figure 25.2: Percentages of Solute in Body Fluids is new and contains the information from previous edition's Table 25.1
- New Clinical View 25.2: Hemorrhaging
- New Clinical View 25.4: Angiotensin-Converting Enzyme (ACE) Inhibitors
- Section 25.3b: Major Electrolytes: Location, Functions, and Regulation revised to integrate concepts of acid-base balance and hyperkalemia and hypokalemia
- Section 25.5: Acid-Base Balance revised for increased readability
- Section 25.5c: Respiration and Regulation of Volatile Acid has tighter integration with concepts in Chapter 23: Respiratory System
- New Learning Strategy on Type A and Type B Intercalated Cells
- Section 25.6: Disturbances to Acid-Base Balance is revised for increased readability and tighter integration with Clinical View 25.8: Arterial Blood Gas (ABG) and Diagnosing Different Types of Acid-Base Disturbances
- Section 25.6b: Respiratory-Induced Acid-Base Disturbances includes normal values for arterial blood gas
- New: figure 25.2, figure 25.12, figure 25.16
- Revised: figure 25.1, figure 25.4, figure 25.5, figure 25.6, figure 25.7, figure 25.8, figure 25.9, figure 25.10, figure 25.11, figure 25.12, figure 25.13, figure 25.14, figure 25.15

Chapter 26

- Sections 26.1b, 26.1c, 26.1d, and 26.1e revised for readability
- New Learning Strategy for layers of muscularis in GI tract wall
- New Clinical View 26.3: Achalasia
- New Learning Strategy on gastric gland secretions for parietal cells and chief cells
- Sections 26.3b: Small Intestine and 26.3c: Accessory Digestive Organs and Ducts revised
- New Clinical View 26.10: Pancreatic Cancer
- New Clinical View 26.13: Fecal Transplant
- New Learning Strategy on lipid digestion and absorption
- New Clinical View 26.17: Cystic Fibrosis and the Pancreas
- New Section 26.4e: Water, Electrolyte, and Vitamin Absorption
- Revised: figure 26.2c, figure 26.6, figure 26.8, figure 26.13, figure 26.14, figure 26.15, figure 26.16, figure 26.18, figure 26.20, figure 26.22, figure 26.29

Chapter 27

- New Clinical View 27.3: Obesity
- New Clinical View 27.5: Heat Related Illnesses
- Expanded Clinical View 27.6: Hypothermia, Frostbite, and Dry Gangrene

Chapter 28

- Sections 28.3a: Ovaries and 28.3b: Oogenesis and the Ovarian Cycle discussion on primary and secondary follicles revised, and discussion on antral follicles expanded
- Revised information on ovarian ligaments
- Revised Clinical View 28.2: Ovarian Cancer with current statistics
- Revised Clinical View 28.5: Cervical Cancer to include information on recommendations for vaccination
- Updated Clinical View 28.6: Breast Cancer
- Revised: figure 28.4, figure 28.5, figure 28.6, figure 28.7, figure 28.9, figure 28.11, figure 28.12, figure 28.15, figure 28.16, figure 28.18, figure 28.19d

Chapter 29

- Revised Clinical View 29.2: Infertility and Infertility Treatments
- Revised Clinical View 29.3: Gestational Diabetes
- Revised: figure 29.1, figure 29.3, figure 29.4, figure 29.7, figure 29.16

We Welcome Your Input!

We hope you enjoy reading this textbook, and that it becomes central to mastering the concepts in your anatomy and physiology course. This text is a product that represents over 75 years of combined teaching experience in anatomy and physiology. We are active classroom instructors, and are well aware of the challenges that current students face in mastering these subjects. We have taken what we have learned in the classroom and have created a textbook truly written for students.

Please let us know what you think about this text. We welcome your thoughts and suggestions for improvement, and look forward to your feedback!

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Finally, we could not have performed this effort were it not for the love and support of our families. Jan, Renee, Ryan, and Shaun McKinley; Bob and Erin O'Loughlin; and Jay and Stephanie Bidle—thank you and we love you! We are blessed to have you all.

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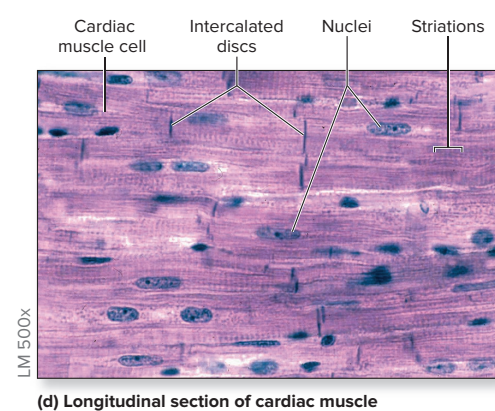
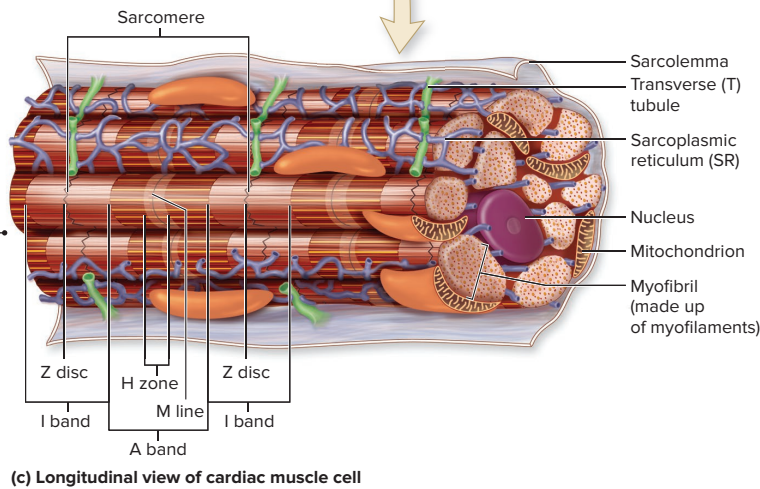
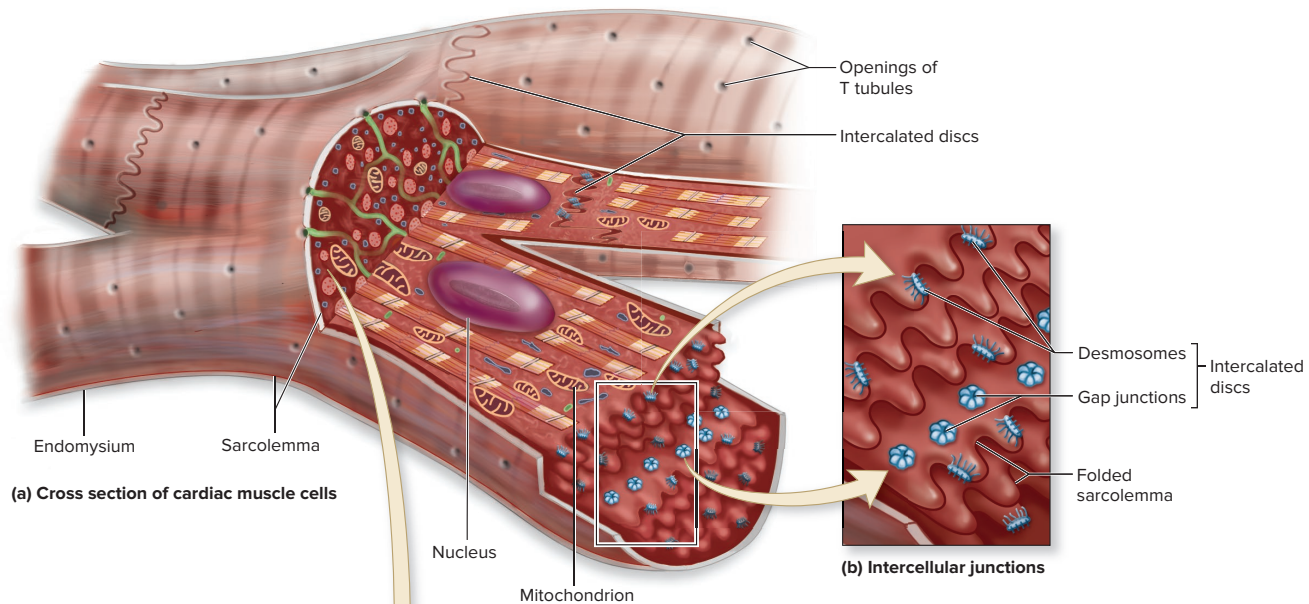
guided tour

Fully Integrated Content and Pedagogy

Anatomy and Physiology: An Integrative Approach is structured around a tightly integrated learning system that combines illustrations and photos with textual descriptions; focused discussions with big-picture summaries; previously learned material with new content; factual explanations with practical and clinical examples; and bite-sized topical sections with multi-tiered assessment.

Unparalleled Art Program

In a visually oriented subject like A&P, quality illustrations are crucial to understanding and retention. The brilliant illustrations in *Anatomy and Physiology: An Integrative Approach* have been carefully rendered to convey realistic, three-dimensional detail while incorporating pedagogical conventions that help deliver a clear message. Each figure has been meticulously reviewed for accuracy and consistency, and precisely labeled to coordinate with the text discussions.



Rich Detail

Vibrant colors and three-dimensional shading make it easy to envision body structures and processes.

Photographs

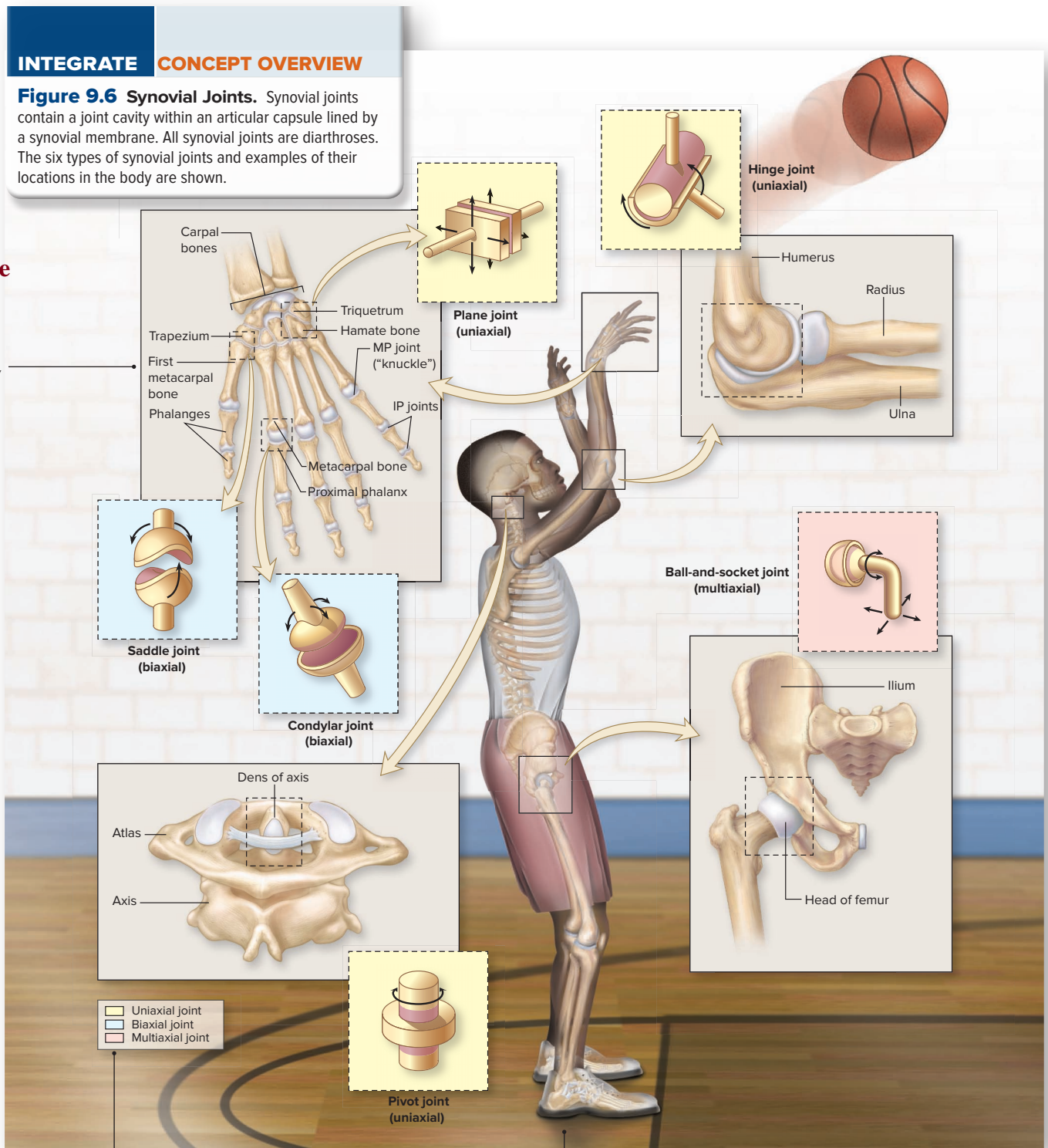
Atlas-quality micrographs and cadaver images are frequently paired with illustrations to expose students to the appearance of real anatomic structures.

INTEGRATE CONCEPT OVERVIEW

Figure 9.6 Synovial Joints. Synovial joints contain a joint cavity within an articular capsule lined by a synovial membrane. All synovial joints are diarthroses. The six types of synovial joints and examples of their locations in the body are shown.

Multilevel Perspective

Microscopic structures are connected to macroscopic views to show changes in perspective between increasingly detailed drawings.



Color Coding

Many figures use color coding to organize information and clarify concepts for visual learners.

Real-Life Context

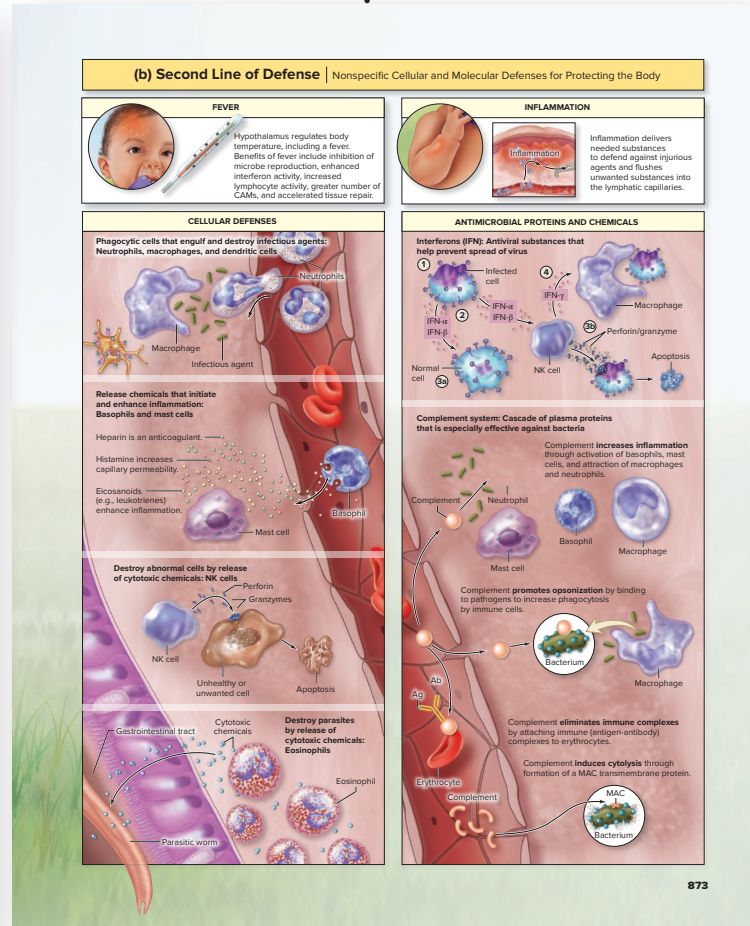
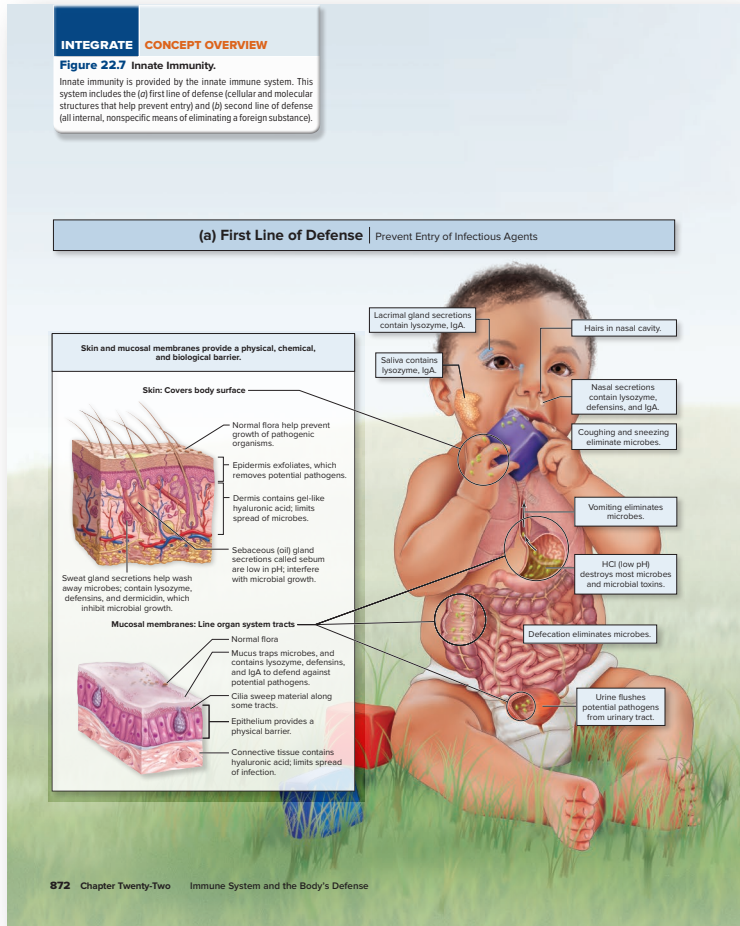
Illustrations include depictions of realistic people and situations to make figures more relevant and memorable.

Integrative Visual Summaries

The groundbreaking **Integrate: Concept Overview** figures combine multiple concepts into one big-picture summary. These striking, visually dynamic presentations offer a review of previously covered material in a creatively designed environment to emphasize how individual parts fit together in the understanding of a larger mechanism or concept.

Integrate: Concept Overview Figures

Multifaceted concepts are brought together in captivating one- or two-page visual presentations.



Practical and Clinical Applications

Integrating familiar contexts into the study of A&P makes seemingly abstract concepts more relevant and memorable.

Integrate: Learning Strategy boxes provide simple, practical advice for learning the material. **Integrate: Clinical View** readings offer insight on how complex physiologic processes or anatomic relationships affect body functioning.

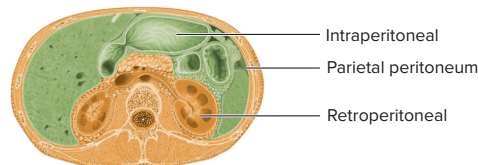
INTEGRATE

LEARNING STRATEGY

Learning Strategies

Classroom tried-and-tested learning strategies offer everyday analogies, mnemonics, and useful tips to aid understanding and memory.

To understand the retroperitoneal position of the kidneys, imagine placing an eraser against a blackboard, which represents the posterior abdominal wall. Then hang a cloth that represents the parietal peritoneum so that the eraser is between the blackboard and the sheet. The eraser, which is located posterior to the sheet (the *parietal peritoneum*), is in a region called retroperitoneal. Structures that would be in front of (and enclosed by) the sheet are described as being *intrapertoneal*.



Clinical View

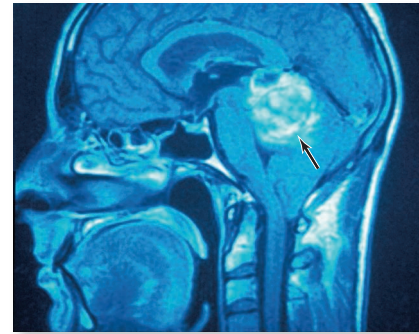
Interesting clinical sidebars reinforce or expand upon the facts discussed within the narrative. The clinical views are adjacent to the facts in the narrative (rather than placed at the end of the chapter) so students may immediately make connections between the narrative and real-life applications.

INTEGRATE

CLINICAL VIEW 12.2

Tumors of the Central Nervous System

Neoplasms resulting from unregulated cell growth, commonly known as **tumors**, sometimes occur within the central nervous system (CNS). A tumor that originates within the organ where it is found is called a **primary tumor**. Because most mature neurons cannot undergo mitosis, primary CNS tumors typically originate in supporting tissues within the brain or spinal cord that have retained the capacity to undergo mitosis: the meninges (protective membranes of the CNS) or the glial cells. Glial cell tumors, termed **gliomas**, may be either relatively benign and slow-growing or malignant (capable of metastasizing or spreading to distant sites).



An MRI shows a glioma (arrow).
©Simon Fraser/Science Source

Concept Integration

Both backward and forward references are supplied throughout the text to remind the reader of the significance of previously covered material, and to foreshadow how knowledge of a topic at hand will come into play in a later discussion. Simple references appear in the flow of the text, while more detailed refreshers are presented in **Integrate: Concept Connection** boxes.



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11.9c Leg Muscles That Move the Ankle, Foot, and Toes

LEARNING OBJECTIVES

35. Compare and contrast the muscles of the three compartments of the leg and their actions.
36. Distinguish between the muscles of the superficial layer and deep layer of the leg's posterior compartment.

The muscles that move the ankle, foot, and toes are housed within the leg and are called the **crural muscles**. Some of these muscles also help flex the leg. The deep fascia partitions the leg musculature into three compartments (anterior, lateral, and posterior), each with its own blood supply and innervation, and muscles in the same compartment tend to share common functions (see figure 11.23).

INTEGRATE

CONCEPT CONNECTION

You will learn in section 20.5a that venous circulation of the lower limb is reliant upon the muscular system. Specifically, the regular contraction and relaxation of the leg muscles works as a skeletal muscle "pump" to propel venous blood from the lower limb back to the torso. When the lower limbs are immobile for long periods of time (e.g., during long plane rides or when a person is bedridden), the skeletal muscle pump is inactive, and the risk of developing a blood clot in the lower limb veins increases (see Clinical View 20.6: "Deep Vein Thrombosis").

INTEGRATE

CLINICAL VIEW 20.6

Deep Vein Thrombosis

Deep vein thrombosis (throm-bō'sis; a clotting) (**DVT**) refers to a **thrombus** (blood clot) in a vein. The most common site for the thrombus is a vein in the sural region (calf). DVT typically occurs in individuals with heart disease or those who are inactive or immobile for a long period of time, such as bedridden patients. Even healthy individuals who have been on a long airline trip may develop DVT.

Initial signs of DVT include fever, tenderness and redness in the affected area, severe pain and swelling in the areas drained by the affected vein, and rapid heartbeat. The most serious complication of DVT is a **pulmonary embolus** (em'bō-lūs; a plug), in which a blood clot breaks free and is transported to the lung, eventually blocking a branch of the pulmonary artery and potentially causing respiratory failure and death. If a DVT is diagnosed, the patient is given anticoagulation medication, such as *low-molecular-weight heparin*, to help prevent further clotting and break up the existing clot.

Integrated Assessments

Throughout each chapter, sections begin with learning objectives and end with questions intended to assess whether those objectives have been met. Critical-thinking questions within the narrative prompt students to apply the material as they read. A set of tiered questions at the end of the chapter, as well as additional online problems, further challenge students to master the material.

What Do You Think?

These critical-thinking questions engage students in application or analysis and encourage them to think more globally about the content.

WHAT DO YOU THINK?

- 3 What type of connective tissue have you damaged when you sprain your ankle?

WHAT DID YOU LEARN?

- 12 Compare loose connective tissue to dense connective tissue with respect to fiber density, fiber distribution, and the amount of ground substance.
- 13 Describe the composition and location of fibrocartilage.
- 14 Why is blood considered a connective tissue?

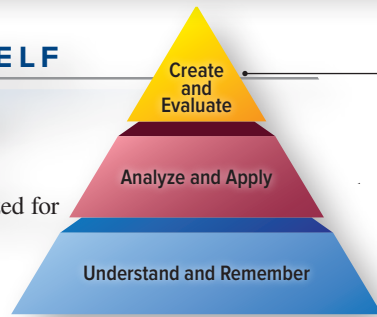
What Did You Learn?

These mini self-tests at the end of each section help students determine whether they have a sufficient grasp of the information before moving on to the next section.

CHALLENGE YOURSELF

Do You Know the Basics?

1. Which tissue contains a calcified ground substance and is specialized for structural support?
 - a. muscle tissue
 - b. dense regular connective tissue
 - c. areolar connective tissue
 - d. bone connective tissue



Challenge Yourself

Assessments at the end of each chapter are correlated with Bloom's Taxonomy and progress through knowledge-, application-, and synthesis-level questions. The "Can You Apply ..." and "Can You Synthesize ..." question sets are clinically oriented to encourage concept application, and expose students who may be pursuing health-related careers to problem solving in clinical contexts.

Can You Apply What You've Learned?

1. John is a 53-year-old construction worker who has come into your office complaining of a sore knee joint. You see a buildup of fluid close to the patella (kneecap) but deep to the skin and suspect the soreness is due to bursitis, an inflammation of membranes that surround some joints. Which type of body membrane is inflamed?
 - a. cutaneous membrane
 - b. serous membrane
 - c. synovial membrane
 - d. mucous membrane

Can You Synthesize What You've Learned?

1. During a microscopy exercise in the anatomy laboratory, a student makes the following observations about a tissue section: (a) The section contains some different types of scattered protein fibers—that is, they exhibit different widths, some are branched, and some are long and unbranched. (b) The observed section has some "open spaces"—that is, places between both cells and the fibers that appear clear with no recognizable features. (c) Several connective tissue cell types are scattered throughout the section, but these cells are not grouped tightly

Integrated Digital and Textbook

Each chapter ends with a listing of online tools that may be used to study and master the concepts presented.

INTEGRATE

ONLINE STUDY TOOLS



connect | SMARTBOOK® | APIR

The following study aids may be accessed through Connect.

Concept Overview Interactive: Figure 10.16: Skeletal Muscle Contraction

Clinical Case Study: Progressive Weakness in a Young Woman

Interactive Questions: This chapter's content is served up in a number of multimedia question formats for student study

SmartBook: Topics and terminology include introduction to skeletal muscle; anatomy and physiology of skeletal muscle; skeletal muscle metabolism; skeletal muscle fiber types; measurement of skeletal muscle tension; factors affecting skeletal muscle tension; effects of exercise and aging on skeletal muscle; cardiac muscle tissue; smooth muscle tissue

Anatomy & Physiology Revealed: Topics include skeletal muscle; skeletal muscle striations; sarcomere; sliding filament; neuromuscular junction; excitation-contraction coupling; crossbridge cycle; cardiac muscle; smooth muscle

Animations: Topics include skeletal muscle; function of the neuromuscular junction; action potentials and muscle contraction; sarcomere shortening; breakdown of ATP and crossbridge movement during muscle contraction; mechanics of single fiber contraction; activation of contraction in smooth vs. skeletal muscle

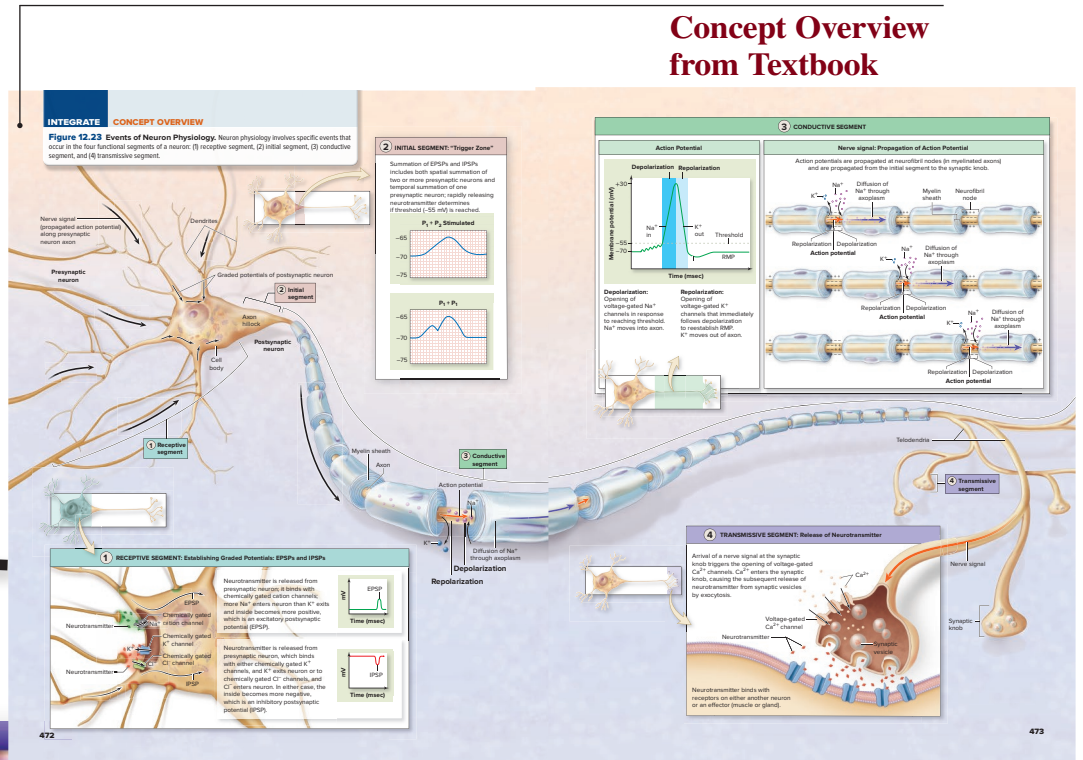
Concept Overviews into Digital Learning

Selected **Concept Overview Figures** from the textbook have been transformed into interactive study modules. This digital transformation process was guided by anatomy and physiology professors who reviewed the modules throughout the development process. Interactive Concept Overview Figures also have assessable, autograded learning activities in Connect®, and are also provided separately to instructors as classroom presentation tools.

Concept Overview Interactives are available for the following topics:

- Membrane Transport
- Muscle Contraction
- Neuron Physiology
- Endocrine System (New)
- Cardiac Cycle
- Blood Pressure (New)
- Innate Immunity (New)
- Adaptive Immunity (New)
- Respiration
- Glomerular Filtration
- Tubular Resorption/Secretion

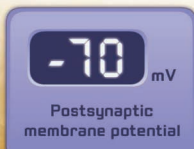
Concept Overview from Textbook



2 The Receptive Segment

Postsynaptic Potentials: IPSP

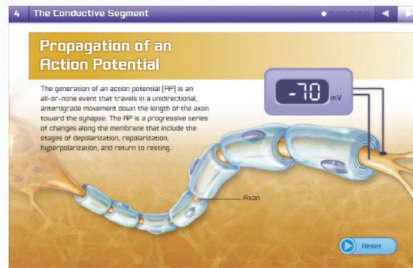
The second type of graded PSP is an inhibitory postsynaptic potential (IPSP). An IPSP takes place when a local region of the cell membrane is hyperpolarized.



Click and drag the nerve impulse to the synaptic knob to release neurotransmitters and cause a postsynaptic response.

Interactive Presentation Study Tool

Propagation of an Action Potential
 Read the overview and complete the interactivities that follow:
 The generation of an action potential, or nerve impulse, occurs once sufficient EPSPs have depolarized the neuron to threshold. The action potential begins at the initial segment (also known as the axon hillock) and travels down the length of the axon towards the axon terminal.
 Each unmyelinated segment of the axonal membrane goes through a series of events which generates an action potential. These include depolarization, repolarization, hyperpolarization, and return to the resting membrane potential. Each event results in specific changes of the membrane potential caused by the opening and closing of voltage-gated sodium and potassium channels.



WORTH 1000 points

QUESTION PREVIOUS | **Concept Check** | Next Question | Skip Question | Flag Question

1. When voltage-gated sodium channels are open, sodium flows _____ the neuron making the inside of the cell more _____.

2. The following information best describes the _____ phase of an _____ action potential:
 • A membrane potential reading of +10 mV
 • Inactivated voltage-gated sodium channels
 • Open voltage-gated potassium channels

Assessable Autograded Activity in Connect

Lab Manual Options to Fit Your Course

Anatomy & Physiology Laboratory Manual by Christine Eckel, Kyla Ross, and Theresa Bidle is a laboratory manual specifically developed for the McKinley/O’Loughlin/Bidle *Anatomy and Physiology: An Integrative Approach* text:

- Three versions are available including main, cat, and fetal pig.
- Each chapter opens with a set of learning objectives that are keyed to the post-laboratory worksheet to ensure student understanding of each chapter’s objectives.
- The manual includes the highest-quality photographs and illustrations of any laboratory manual in the market.
- Laboratory exercises are “how-to” guides that involve touch, dissection, observation, experimentation, and critical-thinking exercises.
- In-chapter learning activities offer a mixture of labeling exercises, sketching activities, table completion exercises, data recording, palpation of surface anatomy, and other sources of learning.
- Numerous exercises throughout the manual utilize Physiology Interactive Lab Simulations (Ph.I.L.S.) 4.0 Online to provide additional student understanding of physiology.
- Pre-Laboratory Worksheet questions and Post-Laboratory Worksheet questions from each chapter are assignable in Connect.
- Ph.I.L.S. 4.0 is included with each new laboratory manual.

Laboratory Manual for Human Anatomy & Physiology by Terry Martin is written to coincide with any A&P textbook:

- Three versions available, including main, cat, and fetal pig
- Includes Ph.I.L.S. 4.0 Online
- Outcomes and assessments format
- Clear, concise writing style

Student Supplements

McGraw-Hill offers various tools and technology products to support the textbook. Students can order supplemental study materials by contacting their campus bookstore or online at <https://create.mheducation.com/shop/>

Instructor Supplements

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Top 10 Tips to Thrive in Your Anatomy & Physiology Course

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1 Preview

Preview assigned material before lecture. Lecture will make much more sense if you've previewed what will be discussed.

2 Look

Look at the images to be covered in lecture. Anatomy and Physiology is a very visual course.

3 Review

Review the prior lecture's material by re-writing your notes or making summary tables/flow charts.

4 Visuals and Notes

Always study your notes along with related visuals. You need to be able to combine visual images with black and white text.

5 Avoid Cramming

Study anatomy and physiology every day or at least every other day. More frequent studying is preferable to studying only two or three days per week. Set a schedule where you spend some time every day either previewing or reviewing anatomy and physiology information.

6 Organize

Organize the course material in a manner that makes the most sense to you. You can create notecards that summarize similar information, design a flow chart, draw simple line diagrams, create mnemonics, or create a table or chart of information.

7 Quiz Yourself

Make your own exam questions. This is a great technique to utilize once you have done a fair amount of studying. Ensure you don't shy away from quizzing yourself on topics you're not confident about.

8 Explain

You master a concept best when you are able to explain it. Practice explaining what you've learned—a process or concept—to someone who knows nothing about anatomy and physiology, or to a fellow classmate.

9 Study Group

Meet weekly or before every exam with several other students to learn the material. Assign each member different challenging topics and have that person teach it to the others in the group. You could also create a few questions on certain topics and then meet and share them with your group. Through the process of creating the questions you will become an "expert" in those topics and could better explain/clarify this information to each other.

10 Office Hours

Make appointments to meet with your instructor to clarify information.

McGraw-Hill Connect[®] is a highly reliable, easy-to-use homework and learning management solution that utilizes learning science and award-winning adaptive tools to improve student results.

Homework and Adaptive Learning

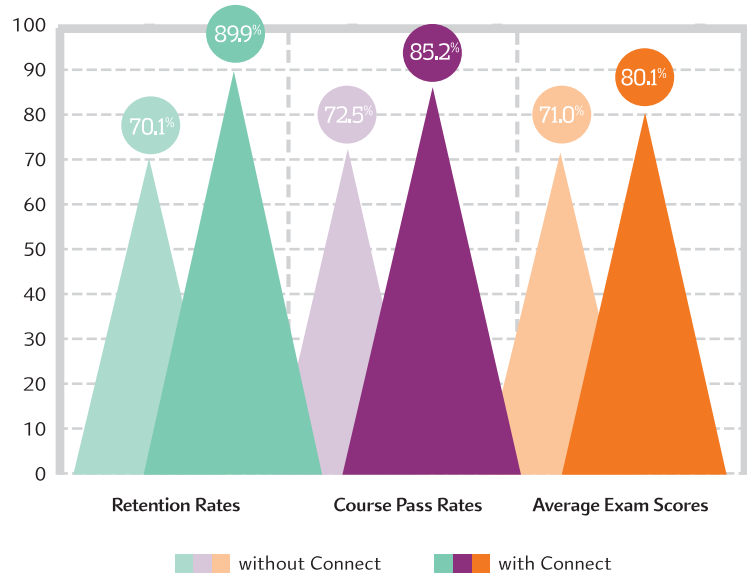
- Connect's assignments help students contextualize what they've learned through application, so they can better understand the material and think critically.
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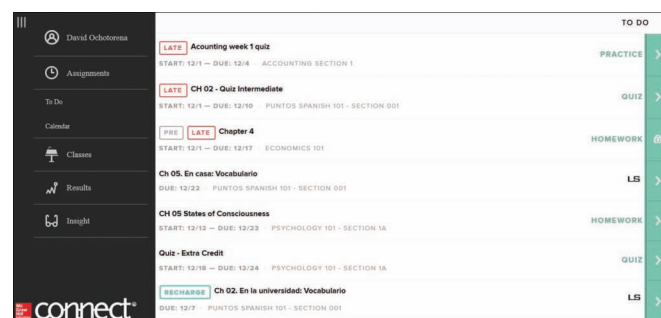
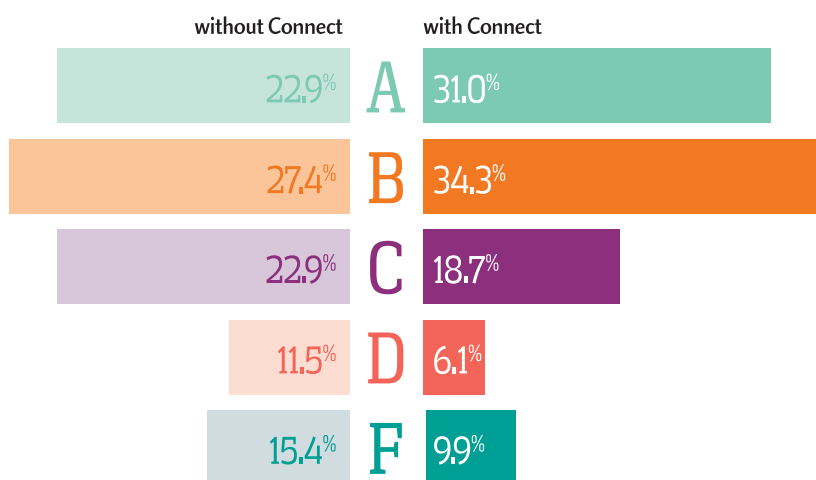
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Impact on Final Course Grade Distribution



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As and **Bs** when they
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3.2

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Bringing to life complex processes is a challenge. Ph.I.L.S. 4.0 is the perfect way to reinforce key physiology concepts with powerful lab experiments. Tools like Concept Overview Interactives, Ph.I.L.S., and world-class animations make it easier than ever.

Ph.I.L.S.

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The Sciences of Anatomy and Physiology

INTEGRATE



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CAREER PATH

Medical Imaging Technologist

A medical imaging technologist is trained to utilize a variety of imaging techniques, such as magnetic resonance imaging (MRI), computed tomography (CT), and sonography. The technologist must be able to correctly interpret the physician's instructions, operate the imaging machinery, and communicate with the patient during the procedure. The accompanying image shows a CT technician positioning a patient for a cranial CT scan. This technician must understand relevant brain anatomy and be able to interpret the sectional images produced of the brain.

1.1 Anatomy and Physiology Compared

- 1.1a Anatomy: Details of Structure and Form
- 1.1b Physiology: Details of Function

1.2 Anatomy and Physiology Integrated

INTEGRATE: CONCEPT OVERVIEW

Comparing How Anatomists and Physiologists Examine the Human Body

1.3 How to Study Anatomy and Physiology Effectively

1.4 The Body's Levels of Organization

- 1.4a Characteristics That Describe Living Things
- 1.4b The View from Simplest to Most Complex
- 1.4c Introduction to Organ Systems

1.5 The Precise Language of Anatomy and Physiology

- 1.5a Anatomic Position
- 1.5b Sections and Planes

- 1.5c Anatomic Directions
- 1.5d Regional Anatomy
- 1.5e Body Cavities and Membranes
- 1.5f Abdominopelvic Regions and Quadrants

1.6 Homeostasis: Keeping Internal Conditions Stable

- 1.6a Components of Homeostatic Systems
- 1.6b Homeostatic Systems Regulated by Negative Feedback

INTEGRATE: CONCEPT OVERVIEW

Negative Feedback Mechanisms for Regulating Body Temperature

- 1.6c Homeostatic Systems Regulated by Positive Feedback

1.7 Homeostasis, Health, and Disease



Module 1: Body Orientation

You are about to embark on an adventure into the amazing world of human anatomy and physiology. Both fields explore the incredible workings of the human body. Anatomy studies the form and structure of the body, whereas physiology examines how the body functions. In this book, you will learn that structure and function are inseparable. Together, these applied sciences provide the basis for understanding health and human performance.

We introduce you to a number of concepts in this chapter that will be used throughout the text and will prove central to your study of anatomy and physiology. These diverse topics include: (1) a comparison of the disciplines of anatomy and physiology; (2) study tips for how to most effectively study for this course; (3) the body's levels of organization; (4) the basic vocabulary of anatomy and physiology that is derived from both Greek and Latin; (5) the core features of homeostasis, which is the general regulatory process for maintaining a healthy body; as well as (6) the general relationship between homeostasis, health, and disease. We welcome you to the exciting and challenging study of human anatomy and physiology!

1.1 Anatomy and Physiology Compared

In this section, we compare anatomy and physiology and present the general subdivisions of these sciences.

Anatomy is the study of structure and form. The word *anatomy* is derived from the Greek word *anatome*, which means to cut apart or dissect. Anatomists are scientists who study the form and structure of organisms. Specifically, they examine the relationships among parts of the body as well as the structure of individual organs. **Physiology** is the study of function of the body parts. Physiologists are scientists who examine how organs and body systems function under normal circumstances, as well as how the functioning of these organs may be altered via medication or disease. For example, when studying blood capillaries (the smallest of blood vessels), an anatomist may describe the composition of the thin wall. In contrast, a physiologist will explain how the thin wall promotes gas and nutrient exchange between the blood within the capillary and the tissue cells external to the capillary.

Anatomists and physiologists are professionals who use the scientific method to explain and understand the workings of the body. The **scientific method** is a systematic and rigorous process by which scientists:

- Examine natural events (or phenomena) through observation
- Develop a hypothesis (possible explanation) for explaining these phenomena
- Experiment and test the hypothesis through the collection of data
- Determine if the data support the hypothesis, or if the hypothesis needs to be rejected or modified

For example, early anatomists and physiologists used the scientific method to explain how blood circulates through the body. Today, we continue to use the scientific method for a variety of topics, such as to understand how the brain stores memories or explain how cancer may spread throughout the body.

Throughout this text, we have attempted to integrate the study of both anatomy and physiology, showing how form and function are interrelated.

1.1a Anatomy: Details of Structure and Form

LEARNING OBJECTIVES

1. Describe the science of anatomy.
2. List the subdivisions in both microscopic and gross anatomy.

The discipline of anatomy is extremely broad and can be divided into several more specific fields. **Microscopic anatomy** examines structures that cannot be seen by the unaided eye. For most of these studies, scientists prepare individual cells or thin slices of body structures and examine these specimens under the microscope. Microscopic anatomy has several subdivisions with two main divisions:

- **Cytology** (sī-tol'ō-jē; *kytos* = a hollow [cell], *logos* = study), or *cellular anatomy*, is the study of body cells and their internal structure.

- **Histology** (his-tol'ō-jē; *histos* = web, tissue) is the study of body tissues.

Gross anatomy, also called *macroscopic anatomy*, investigates the structure and relationships of body parts that are visible to the unaided eye, such as the intestines, stomach, brain, heart, and kidneys. In these macroscopic investigations, specimens or their parts are often dissected (cut open) for examination. Gross anatomy may be approached in several ways:

- **Systemic anatomy** studies the anatomy of each functional body system. For example, studying the urinary system would involve examining the kidneys (where urine is formed) and the organs of urine transport (ureters and urethra) and storage (urinary bladder). Most undergraduate anatomy and physiology classes use this systemic approach.
- **Regional anatomy** examines all of the structures in a particular region of the body as a complete unit. For example, one may study the axillary (armpit) region of the body, and in so doing examine the blood vessels (axillary artery and vein), nerves (branches of the brachial plexus), lymph nodes (axillary lymph nodes), musculature, connective tissue, and skin. Most medical school gross anatomy courses are taught using a regional anatomy approach.
- **Surface anatomy** focuses on both superficial anatomic markings and the internal body structures that relate to the skin covering them. Health-care providers use surface features to identify and locate important landmarks, such as pulse locations or the proper body region on which to perform cardiopulmonary resuscitation (CPR). Most anatomy and physiology classes also instruct students on important surface anatomy locations.
- **Comparative anatomy** examines the similarities and differences in the anatomy of different species. For example, a comparative anatomy class may examine limb structure in humans, chimps, dogs, and cats.
- **Embryology** (em'brē-ol'ō-jē; *embryon* = young one) is the discipline concerned with developmental changes occurring from conception to birth.

Several specialized branches of anatomy focus on the diagnosis of medical conditions or the advancement of basic scientific research.

Pathologic (path-ō-loj'ik; *pathos* = disease) **anatomy** examines all anatomic changes resulting from disease. Both gross anatomic changes and microscopic structures are examined. **Radiographic anatomy** investigates the relationships among internal structures that may be visualized by specific scanning procedures, such as sonography, magnetic resonance imaging (MRI), or x-ray. (See Clinical View 1.4: "Medical Imaging.")

It may seem as though nothing new can be learned about anatomy—after all, the body has been much the same for thousands of years. Yet in fact, new information is being learned from ongoing anatomic studies, some of which displace the traditional thinking about the workings of various organs. Never forget that anatomy is a dynamic, changing science, not a static, unchanging one.



WHAT DID YOU LEARN?

1

How might knowledge of surface anatomy be important for a health-care worker during a CPR emergency?

1.1b Physiology: Details of Function



LEARNING OBJECTIVES

3. Describe the science of physiology.
4. List the subdivisions in physiology.

Physiologists examine the function of various organ systems, and they typically focus on the molecular or cellular level. Thus, a basic knowledge of both chemistry and cells is essential in understanding physiology, and that's why we've included several early chapters on these topics. Mastery of these early chapters on chemistry and cells is critical to understanding the physiologic concepts that are covered throughout the text.

The discipline of physiology parallels anatomy because it also is very broad and may be subdivided into smaller groups. Many specific physiology subdisciplines focus their studies on a particular body system. For example, **cardiovascular physiology** examines the functioning of the heart, blood vessels, and blood. Cardiovascular physiologists examine how the heart pumps the blood, what are the parameters for healthy blood pressure, and details of the cellular exchange mechanisms by which respiratory gases, nutrients, and wastes move between blood and body structures. Other examples include **neurophysiology** (which examines how nerve impulses are propagated throughout the nervous system), respiratory physiology (which studies how respiratory gases are transferred by gas exchange between the lungs and the blood vessels), and **reproductive physiology** (which explores how the regulation of reproductive hormones can drive the reproductive cycle and influence sex cell production and maturation).

Pathophysiology investigates the relationship between the functioning of an organ system and disease or injury to that organ system. For example, a pathophysiologist would examine how blood pressure, contractile force of the heart, and both gas and nutrient exchange may be affected in an individual afflicted with heart disease.



WHAT DID YOU LEARN?

- 2 What is the relationship between anatomy and physiology?
- 3 _____ physiology examines how the heart, blood vessels, and blood function.

INTEGRATE



CLINICAL VIEW 1.1

Etiology (Causes) and Pathogenesis (Development) of Disease

All health-care professionals must understand both how body structures function normally and how disease or injury can affect them. Throughout the chapters in this book, Clinical View boxes (which are always enclosed in the color *blue*) provide you with selected pathologies and how these pathologies affect the anatomy and physiology of those structures.

1.2 Anatomy and Physiology Integrated



LEARNING OBJECTIVE

5. Explain how the studies of form and function are interrelated.

The sciences of anatomy and physiology are intertwined; one must have some understanding of anatomic form to study physiologic function of a structure. Likewise, one cannot adequately describe and understand the anatomic form of an organ without learning that organ's function. This interdependence of the study of anatomy and physiology reflects the inherent and important interrelationship of how the structure and form of a component of the body determine how it functions. This concept is central to mastering the study of anatomy and physiology.

Integrating the disciplines of anatomy and physiology, rather than trying to separate discussion of form and function, is the most effective way to learn about both fields. Anatomists and physiologists may be describing the organs slightly differently, but both disciplines must use information from the other field for a full understanding of the organ system. You cannot fully understand *how* the small intestine propels food and digests or absorbs nutrients unless you also know about the *structure* of the small intestine wall. **Figure 1.1** visually compares how anatomists and physiologists examine the human body, using the small intestine as an example. Note that anatomists (left side of the figure) tend to focus on the form and structure, whereas physiologists (right side of figure) focus on the mechanisms and functions of these structures. However, both anatomists and physiologists understand that the form and function of structures are interrelated. Throughout this text, we integrate these disciplines so you can more easily see that anatomic form and physiologic function are inseparable.

Note that figure 1.1 is an example of a central feature of this text called **Concept Overview (COV) figures**. These specialized illustrations are included in each chapter (e.g., figures 4.19 and 23.31) and are designed to help you to visually connect and integrate content that has been previously discussed within the chapter.



WHAT DID YOU LEARN?

- 4 Compare and contrast how anatomists and physiologists specifically describe the small intestine.

1.3 How to Study Anatomy and Physiology Effectively



LEARNING OBJECTIVE

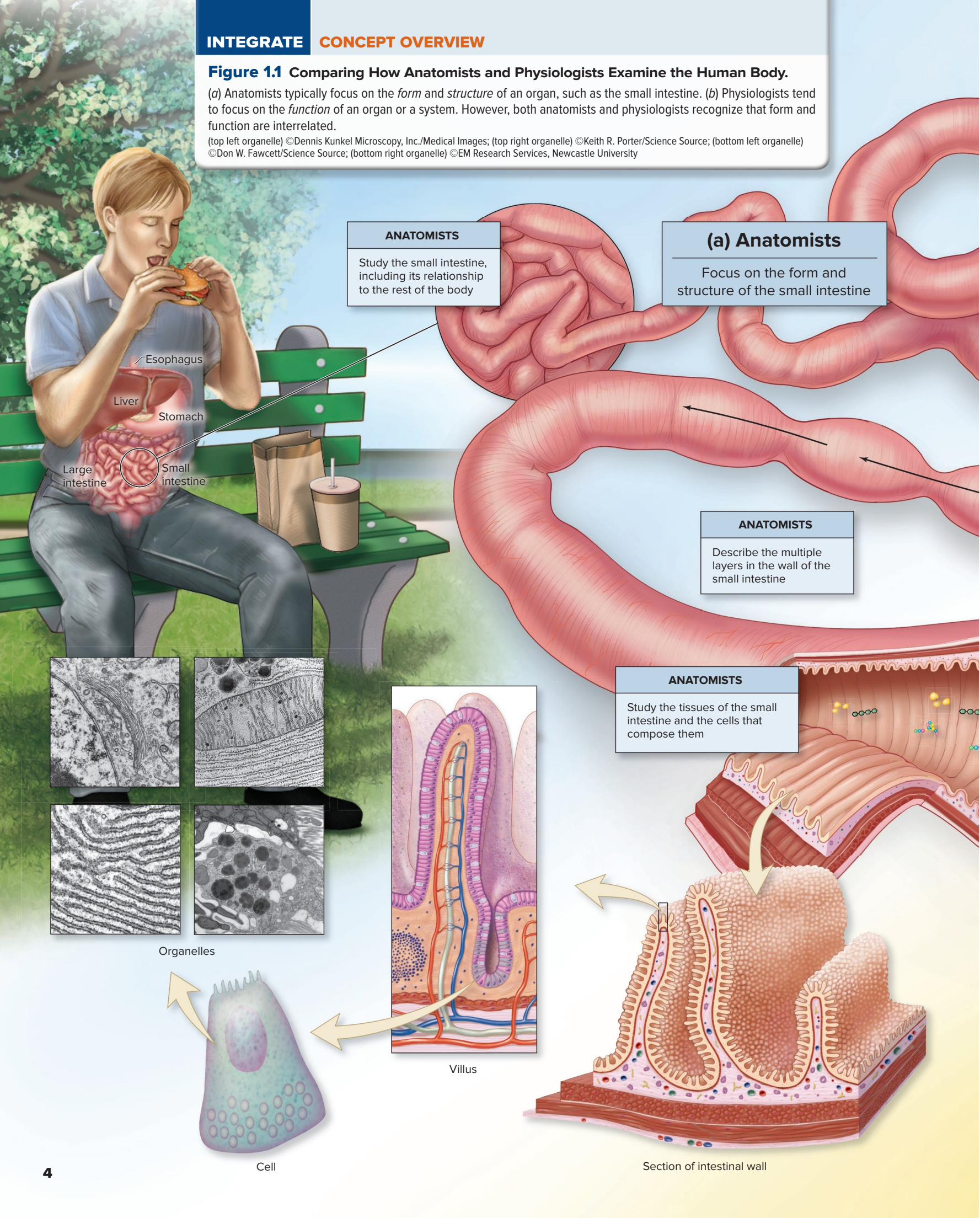
6. Describe best practices for studying anatomy and physiology effectively.

Anatomy and Physiology (A&P) is a content dense course that sometimes may overwhelm learners new to the subject. Success in the course requires careful time management and appropriate study skills for comprehending the material. When we teach our courses, we often encounter students who simply need to adopt more effective study strategies to perform well. In this section, we discuss some of these strategies.

Figure 1.1 Comparing How Anatomists and Physiologists Examine the Human Body.

(a) Anatomists typically focus on the *form* and *structure* of an organ, such as the small intestine. (b) Physiologists tend to focus on the *function* of an organ or a system. However, both anatomists and physiologists recognize that form and function are interrelated.

(top left organelle) ©Dennis Kunkel Microscopy, Inc./Medical Images; (top right organelle) ©Keith R. Porter/Science Source; (bottom left organelle) ©Don W. Fawcett/Science Source; (bottom right organelle) ©EM Research Services, Newcastle University

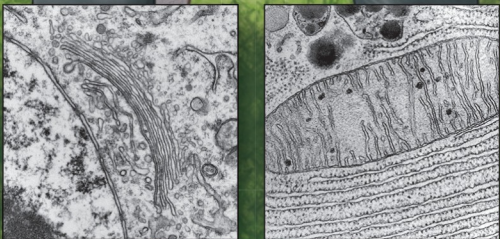


ANATOMISTS
Study the small intestine, including its relationship to the rest of the body

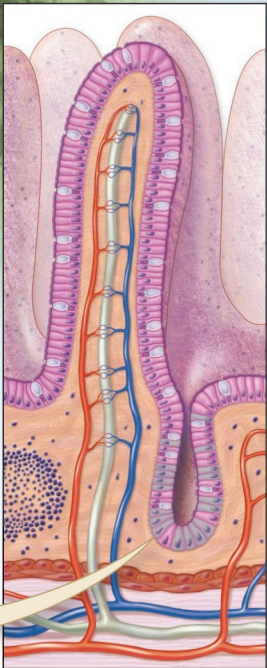
(a) Anatomists
Focus on the form and structure of the small intestine

ANATOMISTS
Describe the multiple layers in the wall of the small intestine

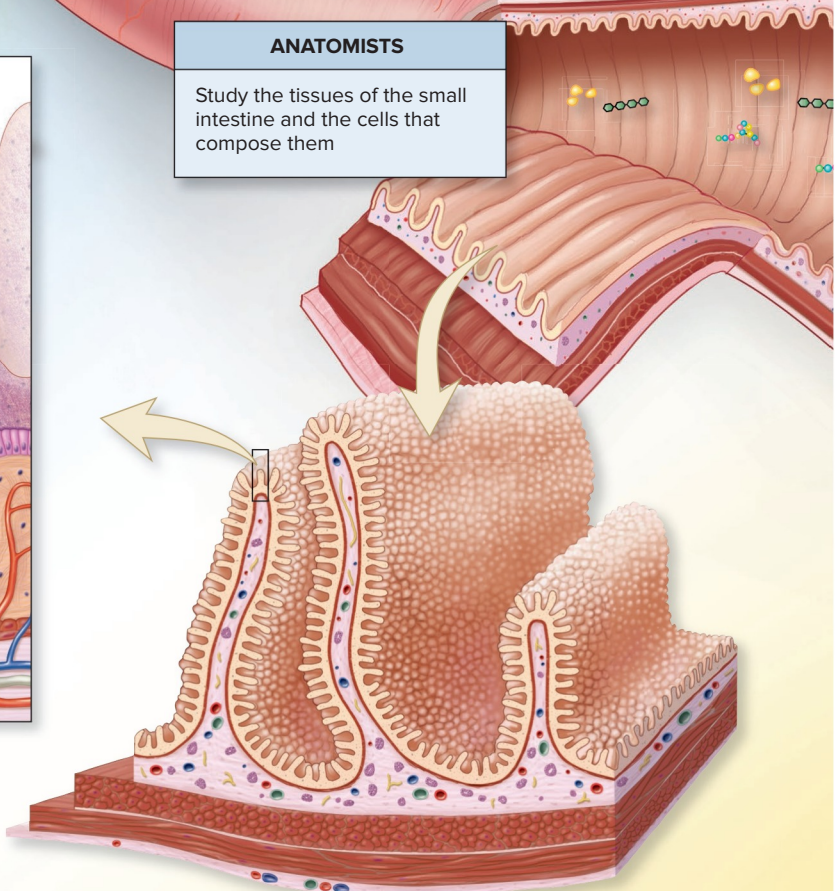
ANATOMISTS
Study the tissues of the small intestine and the cells that compose them



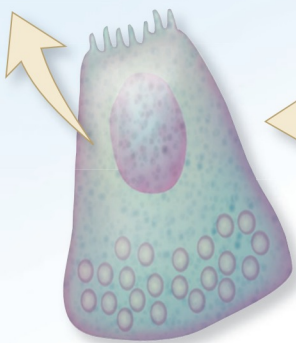
Organelles



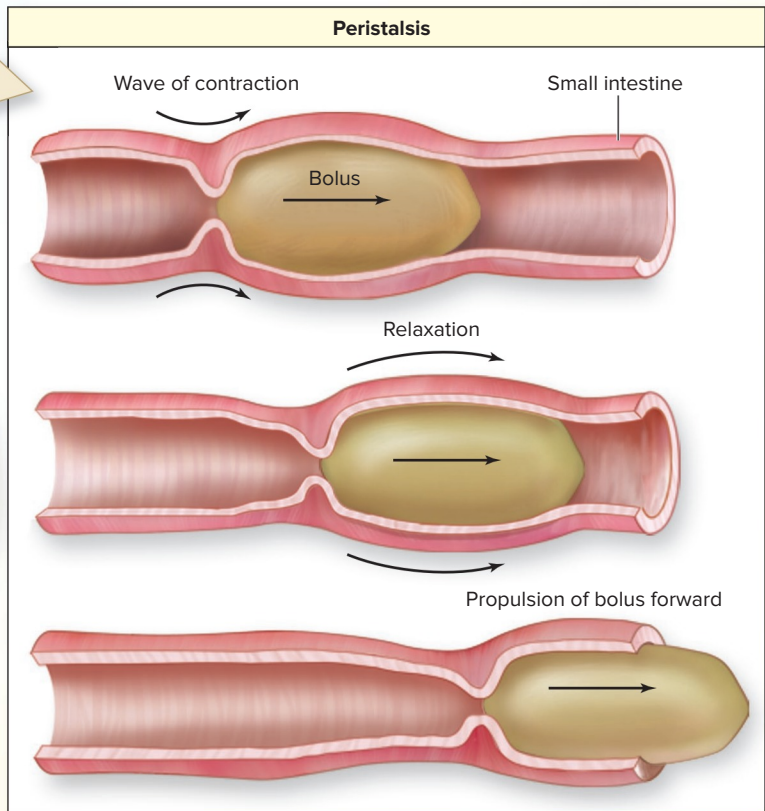
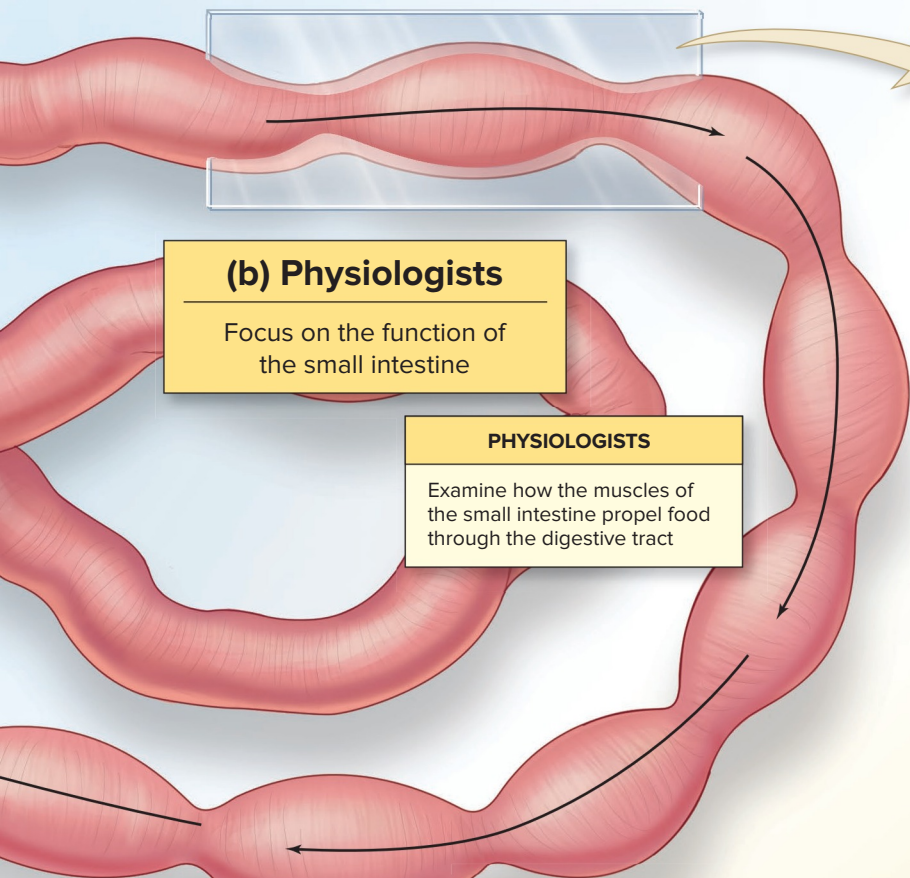
Villus



Section of intestinal wall

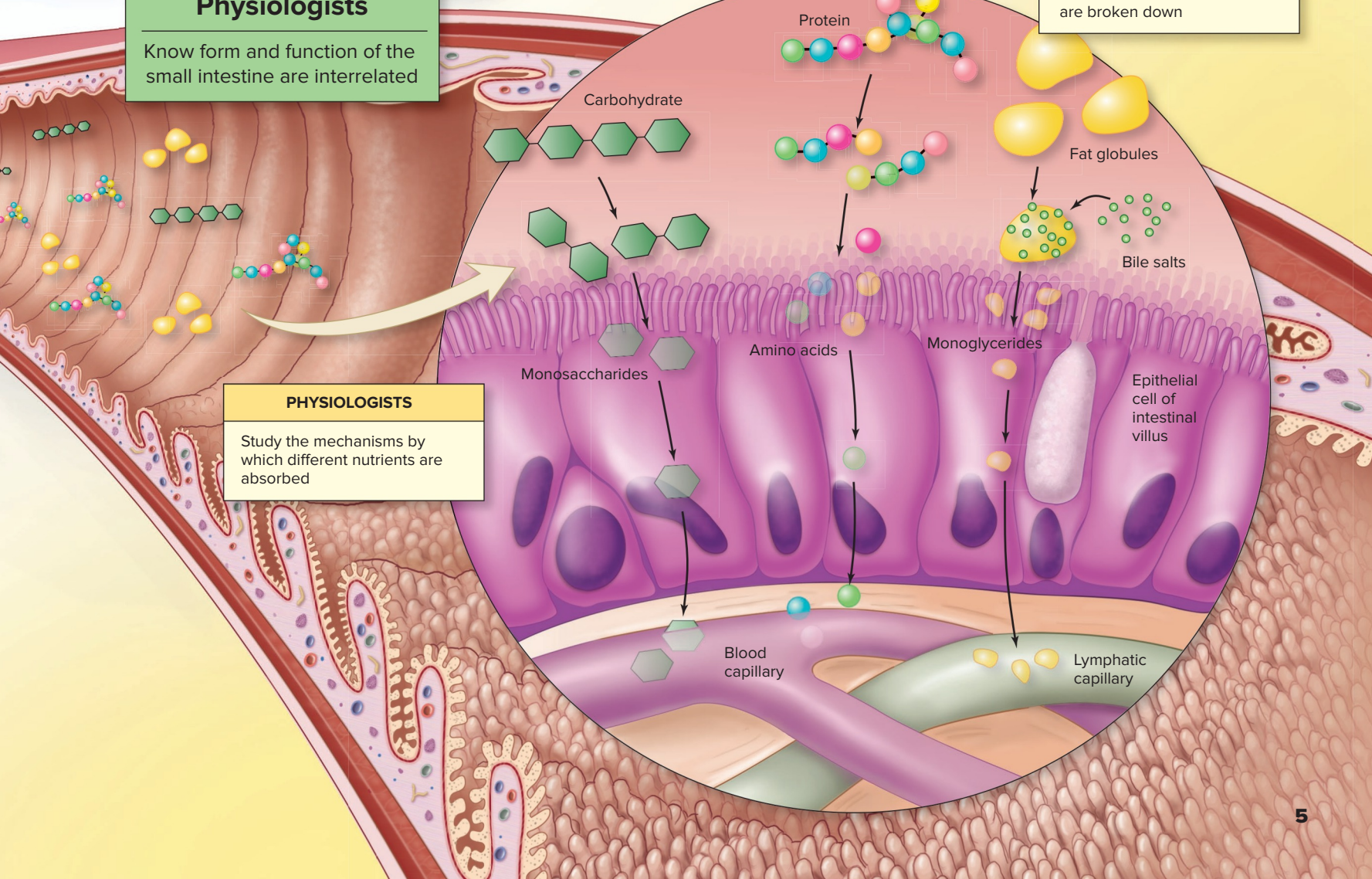


Cell



Anatomists and Physiologists
Know form and function of the small intestine are interrelated

PHYSIOLOGISTS
Describe the mechanisms by which different nutrients are broken down



How NOT to Study for A&P

- 1. Wait until the last minute to study.** As previously mentioned, A&P is content rich and requires the learner to be able to understand many complex processes. Beginning your studying a few days before an exam is simply *not* enough time for you to understand the material and truly learn it.
- 2. Study for long periods of time without breaks.** Your brain works best if you study for shorter periods of time (½ hour or less) and then take a short break before studying again. A 4-hour marathon study session will just leave you feeling overwhelmed, and you likely will not remember anything you studied.
- 3. Study with multiple distractions.** Do you try to study with the TV on, your phone available to answer texts, and your computer open to your social media account? If so, the time you think you are spending studying is not effective. For each time you take a break to answer a text, check email, or listen to TV, you are not focusing on the material. Multitasking is a myth—in reality, you are quickly switching from one task to another without staying focused on any one thing. This type of study method is disjointed and will prevent you from engaging in the material.
- 4. Simply passively read over your notes.** Don't simply read over your notes multiple times as a form of studying. This study method is referred to as *passive learning*—it is called *passive* because the person doesn't have to do much in the process! Although you may *think* you are learning the material, in fact, you are only acquiring a superficial recognition of the material. Unless you practice quizzing yourself over the material to repeatedly *retrieve* the material from your memory and do other active learning methods, your brain will not be able to quickly access what you've learned for an exam. Students who rely solely on re-reading their notes often will say, "I recognized the material on the exam, but I wasn't sure of what answer to choose."
- 5. Study by yourself only.** When you study by yourself only, you can't accurately gauge if you know the material well and can explain it to others. You also are more likely to reinforce a misconception if you don't have a study partner who can help you work through some of the more difficult concepts.

So now that we've discussed some of the big mistakes in studying A&P, what are more effective ways of studying? The following is a list of best practices for studying.

Best Practices for Studying A&P

- 1. Schedule regular daily study sessions well before the upcoming exam.** Your studying should begin the first week of class and should be a part of a daily or every-other-day schedule. Do not wait until the week prior to an exam to first become acquainted with the material! The night after a lecture or lab, review the material you've learned with some of the methods outlined in this list. Connect the material you are learning with A&P material previously covered. If you follow this plan, then you may spend the week prior to the exam reviewing material you've already studied, rather than starting your study process.
- 2. Study for multiple, short periods of time.** During these daily (or every-other-day) study periods, set a timer for ½ hour or a little less and promise yourself you will focus just on the A&P material at hand. Select a study topic that you can review effectively in that ½ hour. For example, you could compare and contrast the epidermis and the dermis of

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LEARNING STRATEGY



Learning Strategy boxes like this one (which are always enclosed in the color *green*) provide you with helpful analogies, memory aids, and other study tips to help you better understand and learn the material. Look for these boxes throughout each chapter.

the skin during that time. After ½ hour has passed, reward yourself with a short (~5-minute) break, and then reset the timer to study again. After three of these short periods, reward yourself with a longer break. You will be able to review more material, and *remember* the material you've reviewed, better than if you tried to study in one long 4-hour block.

- 3. Minimize your distractions.** Put away the phone, turn off the TV, and shut down your email. Research has shown that people don't multitask—rather, the brain jumps from one task to another quickly, so the activity for each task is disjointed and may not be well organized. You will be amazed at how much more efficient your studying becomes when you minimize the distractions and focus on the material. If you use the timer technique mentioned previously (study for ½ hour with no distractions), you can reward yourself during those short breaks by looking at your texts or social media.
- 4. Utilize active learning methods when you study.** *Active learning* is defined as a process by which you are engaged in the material, problem solving, and applying what you've learned to previous knowledge. It is the opposite of passive learning. Examples of active learning include
 - a. Make your own tables to organize material.** Take your lecture notes and reorganize them into tabular form. For example, you can group muscles of similar functions. The act of writing out the muscles and reorganizing the information in tabular form will help you remember the material better than if you just read over your notes.
 - b. Draw and label anatomic structures.** Make your own sketches of organs and tissues, and label the key features. When you draw, you are integrating multiple pieces of information into one diagram. You don't have to be an artist and the drawing doesn't have to be pretty—rather, it simply has to make sense to you.
 - c. Make flowcharts of physiological processes.** Map out the pathway that filtrate becomes urine in the kidney. Create a flowchart to illustrate how blood travels from the heart to the lungs, and back to the heart.
 - d. Quiz yourself repeatedly on the material.** Educational research has shown that long-term learning is most likely to occur when an individual practices and retrieves that material on multiple occasions. Your textbook has multiple opportunities to quiz yourself—you can use the end-of-chapter questions, LearnSmart modules associated with the e-text, and the quizzing feature in the Anatomy and Physiology | Revealed program associated with the McGraw-Hill Connect site. If you are studying with a partner, take turns quizzing each other. When you can retrieve the information accurately, you know the material. You do not want to wait until you are taking the exam to determine if you can do this.

INTEGRATE

CONCEPT CONNECTION

Throughout future chapters, **Concept Connection** boxes like this one (which are always enclosed in the color *orange*) will highlight how various organ systems do not work in isolation, but rather are interconnected to carry out overlapping functions. For example, the cardiovascular system and respiratory system work together in the transport of respiratory gases (oxygen and carbon dioxide) by the blood throughout the body.

- e. **Explain/teach a concept to a partner.** There is a saying that when one person teaches another, both learn. Your teachers have reinforced their A&P knowledge by teaching students year after year. As you are learning new concepts, meet with a study partner and explain that concept to him or her in your own words. The act of explaining the concept and answering your partner's questions will help *you* solidify your knowledge. Utilize the Concept Overview (COV) figures (e.g., figure 1.1) in the textbook to explain concepts to someone else.
5. **Study with a partner or group.** A lot of the active study methods mentioned work best when you are studying with a partner. It is difficult to quiz yourself and know for sure if you truly understand a concept. You and your study partner can each help determine where gaps in knowledge are, keep study sessions focused and on track, and serve as a “sounding board” when trying to explain a concept.
6. **Utilize all of the resources your textbook has to offer.** Your textbook and its accompanying digital platform contain numerous resources to help you learn anatomy and physiology more efficiently. So don't just read the text—use the following aids provided in each chapter of the text:
 - a. **Integrate: Learning Strategy boxes.** These boxes provide analogies, mnemonics, and study tips to help you learn the material.
 - b. **Integrate: Concept Connection boxes.** These boxes provide summaries of topics that may be discussed and presented across multiple chapters, such as acid-base balance or hormonal regulation of growth. Read these boxes to help you connect material among different chapters.
 - c. **Integrate: Concept Overview figures.** Each chapter has one or more of these figures, designed to provide a big-picture summary of a major concept in that chapter. For example, Figure 1.1 provides a comparison of how anatomists and physiologists study the body. Let these figures guide your explanation of a concept to a study partner.
 - d. **Integrated, multiple assessments in each chapter.** As you read, write out your answers for the What Did You Learn? questions at the end of each section of text. When you are done reading a chapter, use the end-of-chapter questions to test your knowledge.
 - e. **LearnSmart.** Each chapter is associated with an interactive e-module that allows you to test yourself on concepts you have read. The program will highlight topics you have not yet mastered and create a study plan for you about these topics.
 - f. **Anatomy and Physiology | REVEALED (APR).** APR is an interactive cadaver dissection tool that allows you to highlight anatomic features and review lab and lecture concepts. You can view both gross anatomy and histology concepts, watch

animations about particular physiologic processes, and test yourself with the lab quiz tool.

This list of best practices is not exhaustive; you may have some additional study strategies that are equally effective. Although we cannot guarantee you will earn an A, we *can* be reasonably certain that your understanding of anatomy and physiology will greatly increase if you adopt the best practices outlined here. We encourage you to use these best practices for your other courses as well.



WHAT DID YOU LEARN?

- 5 Why would studying with a partner be more effective than just studying alone?

1.4 The Body's Levels of Organization

Scientists group the body's components into an organizational hierarchy of form and function. In thinking about these levels, it is helpful to know the characteristics common to living things and how each organizational level supports these characteristics. For example, the organ system concept allows functions to be considered as an interaction between many organs.

1.4a Characteristics That Describe Living Things



LEARNING OBJECTIVE

7. List the characteristics common to all living things.

Several distinctive properties are common to all organisms, including humans:

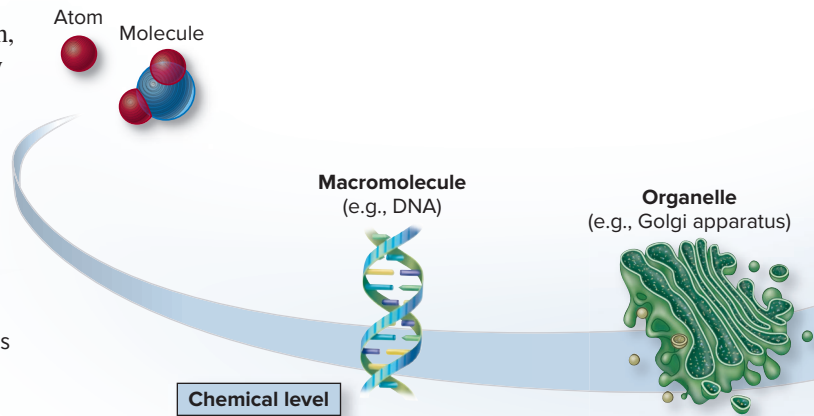
- **Organization.** All organisms exhibit a complex structure and order. In section 1.4b, we describe the increasingly complex levels of organization of the human body.
- **Metabolism.** All organisms engage in **metabolism** (mĕ-tab'ō-lizm; *metabole* = change), which is defined as the sum of all of the chemical reactions that occur within the body. Metabolism consists of both **anabolism** (ă-nab'ō-lizm; *anabole* = a raising up), in which small molecules are joined to form larger molecules, and **catabolism** (kă-tab'ō-lizm; *katabole* = a casting down), in which large molecules are broken down into smaller molecules. An example of a metabolic reaction is the use of cellular energy (called ATP; see section 2.7d) for muscle contraction (see section 10.3). The concepts of chemical reactions and metabolism are discussed in sections 3.2a and 3.2b, respectively.



WHAT DO YOU THINK?

- 1 When you digest a meal, what type of metabolic reactions do you think you are utilizing primarily: *anabolic* or *catabolic* chemical reactions? Why?
- **Growth and development** During their lifetime, organisms assimilate materials from their environment and often exhibit increased size (growth) and increased specialization as related to form and function (development). As the human body grows and develops, structures such as the brain become more complex and elaborately integrated.

- **Responsiveness.** All organisms exhibit **responsiveness**, which is the ability to detect and react to **stimuli** (changes in the external or internal environment). A stimulus to the skin of the hands, such as an extremely hot temperature, causes the human to withdraw the hand from the stimulus so as to prevent injury or damage. Responsiveness occurs at almost all levels of organization.
- **Regulation.** An organism must be able to adjust internal bodily function in response to environmental changes. When body temperature rises, more blood is circulated near the body's surface to facilitate heat loss, and thus return body temperature to within the normal range. (The process of maintaining body structures and function is called homeostasis, which is discussed in greater depth in section 1.6.)
- **Reproduction.** All organisms produce new cells for growth, maintenance, and repair. The somatic (body) cells divide by a process called mitosis (see section 4.9), whereas sex cells (called gametes) are produced by another type of cell division called meiosis (see section 28.2). The sex cells, under the right conditions, have the ability to develop into a new living organism.



The **organ level** is composed of organs. An **organ** contains two or more tissue types that work together to perform specific, complex functions. The small intestine is an example of an organ that is composed of all four tissue types, which work together to process and absorb digested nutrients. The general features of body tissues and their organization within organs are covered in chapter 5.

The **organ system level** contains multiple related organs that work together to coordinate activities and achieve a common function. For example, the organs of the digestive system (e.g., oral cavity, stomach, small and large intestine, and liver) work together to digest food particles, absorb nutrients, and expel the waste products. The 11 organ systems are introduced in section 1.4c.



WHAT DID YOU LEARN?

6

What does it mean if an organism is “responsive,” and how does this characteristic relate to the survival of this organism?

1.4b The View from Simplest to Most Complex



LEARNING OBJECTIVE

8. Describe the levels of organization in the human body.

Anatomists and physiologists recognize several levels of increasingly complex organization in humans, as illustrated in **figure 1.2**. These levels, from simplest to most complex, are the chemical level, cellular level, tissue level, organ level, organ system level, and organismal level.

The **chemical level** is the simplest level, and it involves atoms and molecules. **Atoms** are the smallest units of matter that exhibit the characteristics of an element, such as carbon and hydrogen. When two or more atoms combine, they form a **molecule**. Examples of molecules include a sugar, a water molecule, or a vitamin. More complex molecules are called **macromolecules** and include some proteins and the deoxyribonucleic acid (DNA) molecules. Macromolecules form specialized microscopic subunits in cells, called **organelles**. Chemical structures are described in chapter 2.

The **cellular level** consists of **cells**, which are the smallest living structures and serve as the basic units of structure and function in organisms. Cells and their components are formed from the atoms and molecules from the chemical level. The structures of cells vary widely, reflecting the specializations needed for their different functions. For example, a skeletal muscle cell may be very long and contain numerous organized protein filaments that aid in muscle contraction, whereas a red blood cell is small and has a flattened disc shape that facilitates the quick and effective exchange of respiratory gases. Cells and cellular organelles are discussed in chapter 4.

The **tissue level** consists of **tissues**, which are groups of similar cells that perform common functions. There are four major types of tissues. Epithelial tissue covers exposed surfaces and lines body cavities. Connective tissue protects, supports, and binds structures and organs. Muscle tissue produces movement. Finally, nervous tissue conducts nerve impulses for communication.

The highest level of structural organization in the body is the **organismal level**. All body systems function interdependently in an **organism**, which is the living person.



WHAT DID YOU LEARN?

7

Does a higher level of organization contain all the levels beneath it? Explain.

1.4c Introduction to Organ Systems



LEARNING OBJECTIVE

9. Compare the organ systems of the human body.

All organisms must exchange nutrients, wastes, and gases with their environment to remain alive and healthy. Simple organisms (e.g., bacteria) may exchange these substances directly across their surface cell boundaries. In contrast, complex, multicellular organisms require sophisticated organ systems with specialized structures and functions to perform the many activities required for the routine events of life. In humans, 11 **organ systems** are commonly denoted, each composed of interrelated organs that work in concert to perform specific functions (**figure 1.3**). A person maintains a healthy body through the intricate interworkings of all of its organ systems. Subsequent chapters examine each of these organ systems in detail.



WHAT DID YOU LEARN?

8

Which organ system is responsible for filtering the blood and removing the waste products of the blood in the form of urine?

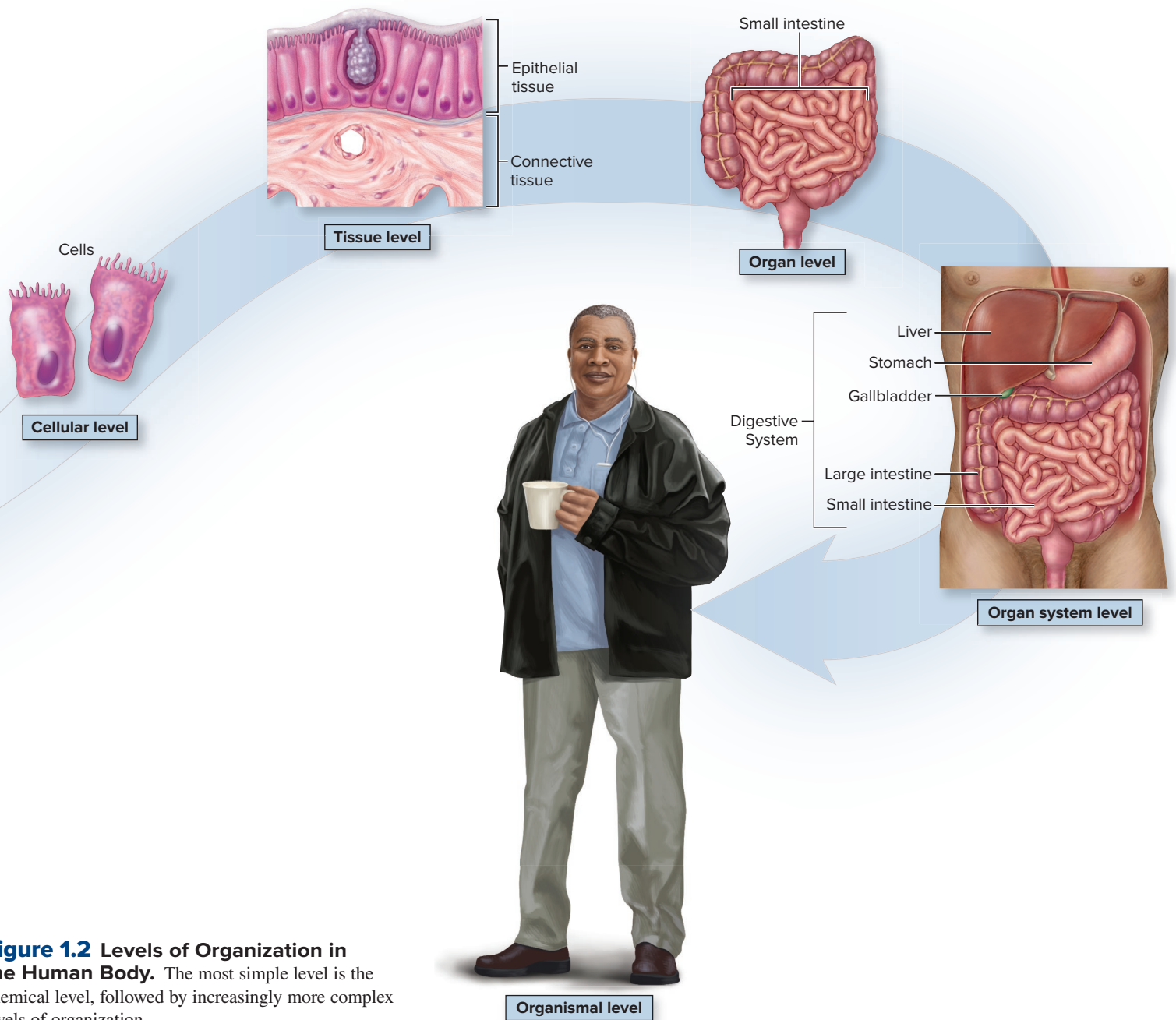


Figure 1.2 Levels of Organization in the Human Body. The most simple level is the chemical level, followed by increasingly more complex levels of organization.

1.5 The Precise Language of Anatomy and Physiology

Clinicians and researchers in anatomy and physiology require a precise language to ensure that they are all discussing the same features and functions. A technical terminology has been developed that describes body position, direction, regions, and body cavities. These technical terms are different from those used in everyday conversation, because the more conversational terms often do not accurately describe location and position or identify structures. For example, the term *arm* in everyday conversation refers to the entire upper limb, but in anatomy the specific portions of the upper limb are named, and the term *arm* or *brachium* refers only to that part of the upper limb between the shoulder and the elbow.

Most anatomic and physiologic terms are derived from Greek or Latin, and we frequently provide word origins, pronunciations, and definitions of terms where appropriate throughout this text. We've used *Stedman's Medical Dictionary* (which defines all medical terms) and *Terminologia Anatomica* (which lists and categorizes the

modern, proper anatomic terms) as references. If you actively practice the vocabulary and descriptive terminology presented here, your understanding and appreciation of body structure and function will be enhanced significantly.

INTEGRATE

LEARNING STRATEGY

Breaking a word into smaller parts can help you understand and remember its meaning. In this book, we provide word derivations for new terms following their pronunciations. For example, in the case of *histology*, the study of tissues, we provide the following: (*histos* = web, tissue, *logos* = study).

Many biological terms share some of the same prefixes, suffixes, and word roots, so learning the meanings of these common terms can help you figure out the meanings of unfamiliar terms.

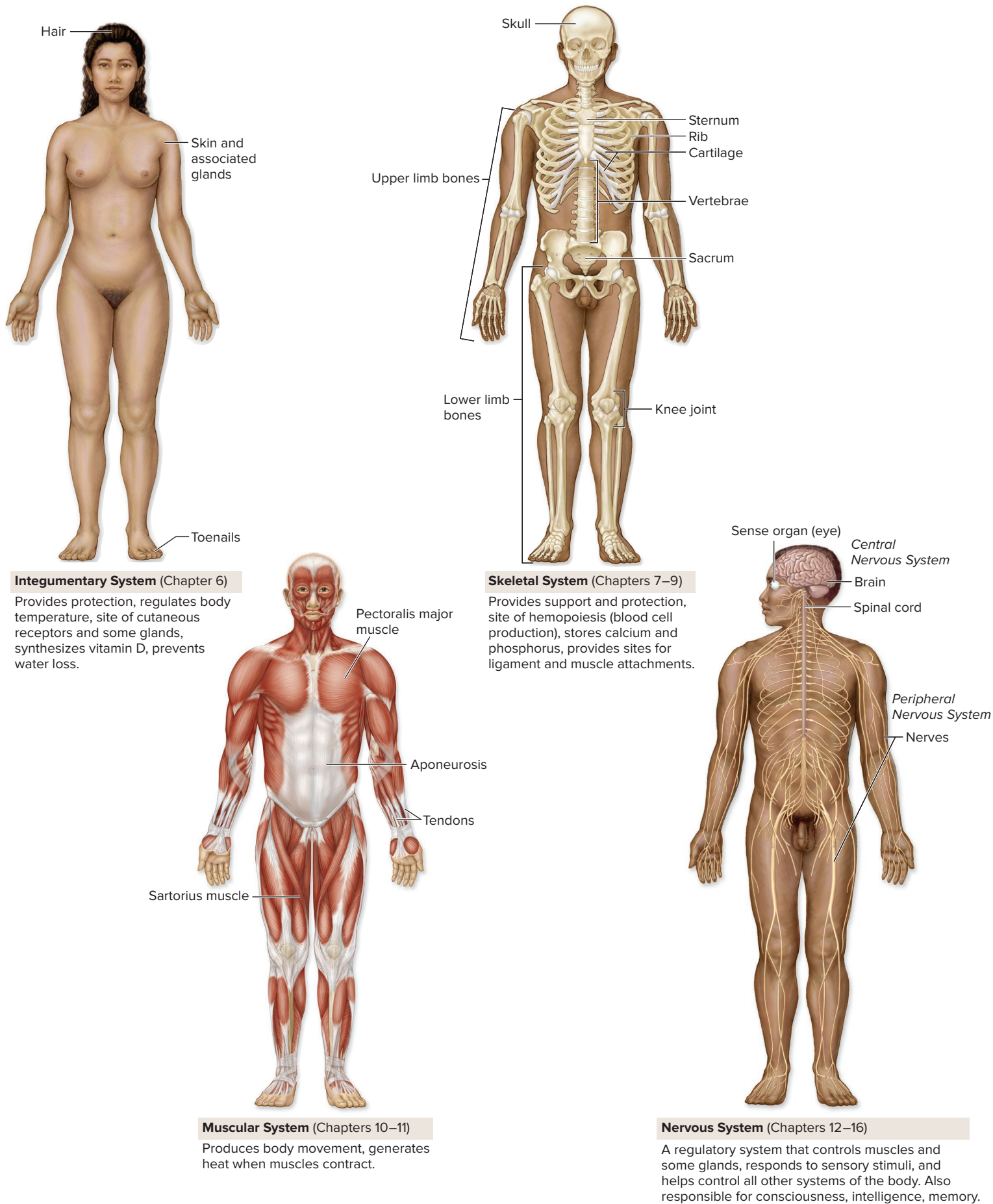
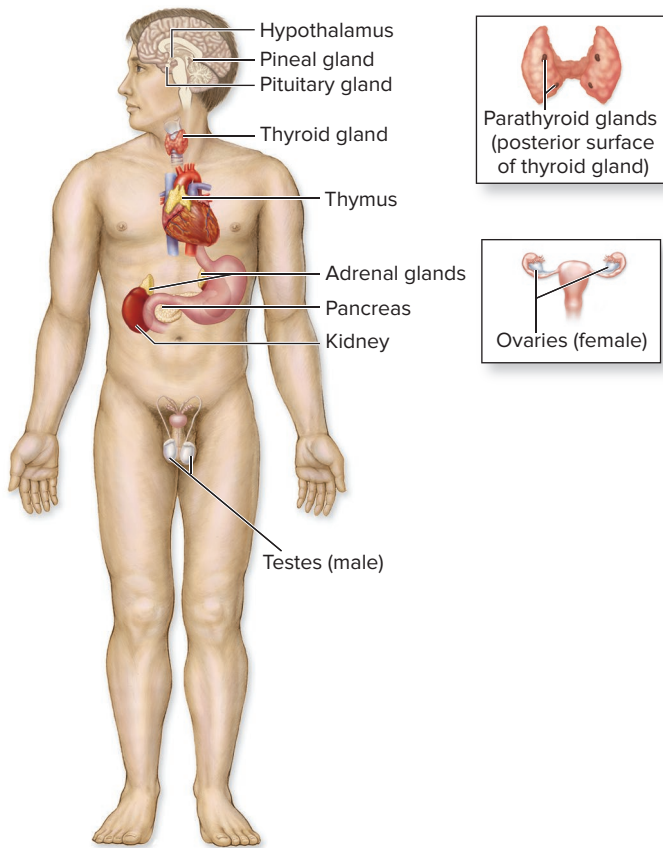
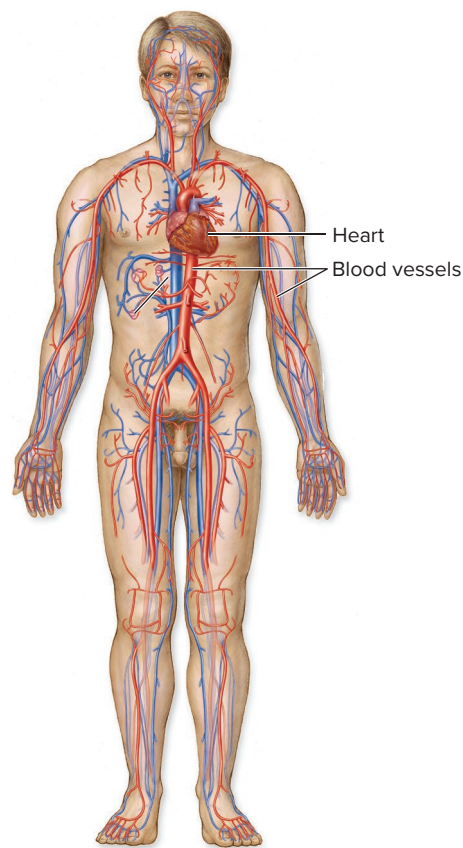


Figure 1.3 Organ Systems. Major components and characteristics of the 11 organ systems of the human body are presented. **AP|R**



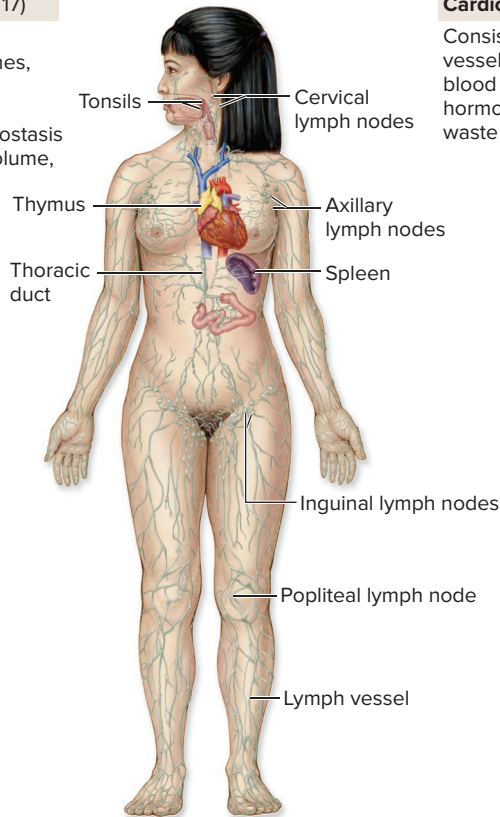
Endocrine System (Chapter 17)

Consists of glands and cell clusters that secrete hormones, (some of which regulate development, growth and metabolism); maintain homeostasis of blood composition and volume, control digestive processes, and control reproductive functions.



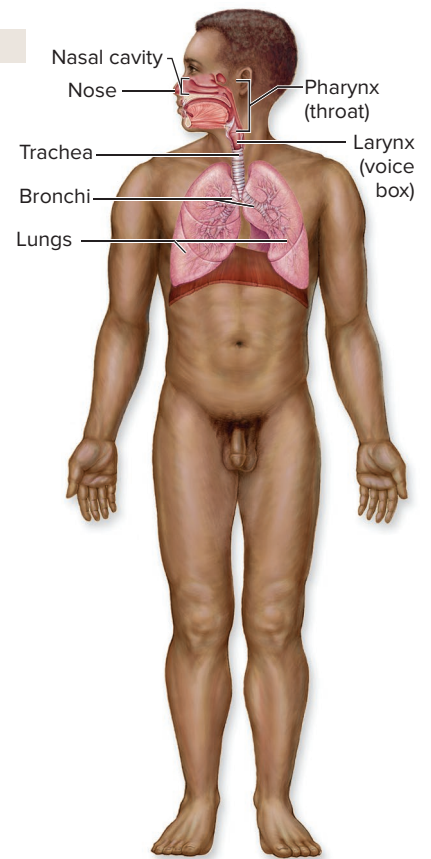
Cardiovascular System (Chapters 18–20)

Consists of the heart (a pump) and blood vessels; the heart moves blood through blood vessels in order to distribute hormones, nutrients, gases, and pick up waste products.



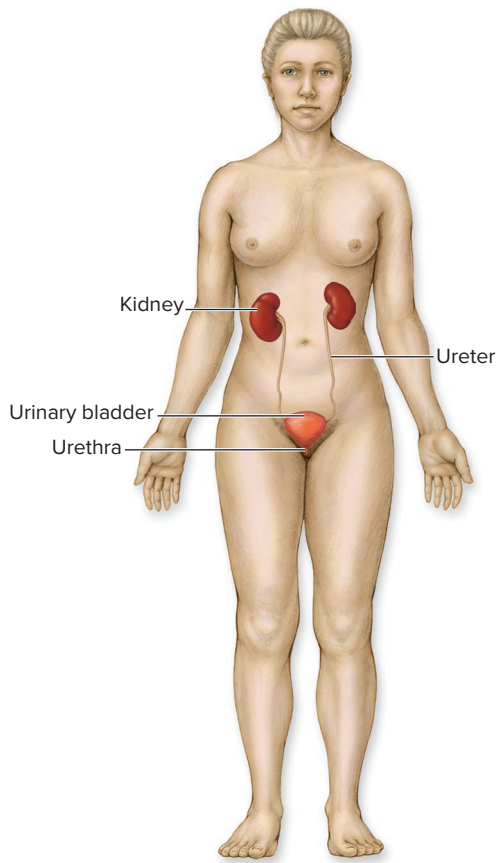
Lymphatic System (Chapters 21–22)

Transports and filters lymph (interstitial fluid that is collected in and transported through lymph vessels) and may participate in an immune response.



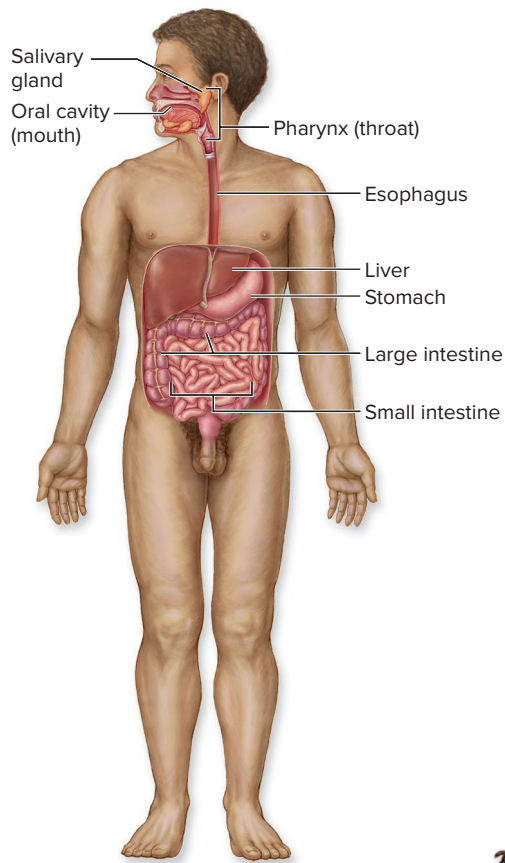
Respiratory System (Chapter 23)

Responsible for exchange of gases (oxygen and carbon dioxide) between blood and the air in the lungs.



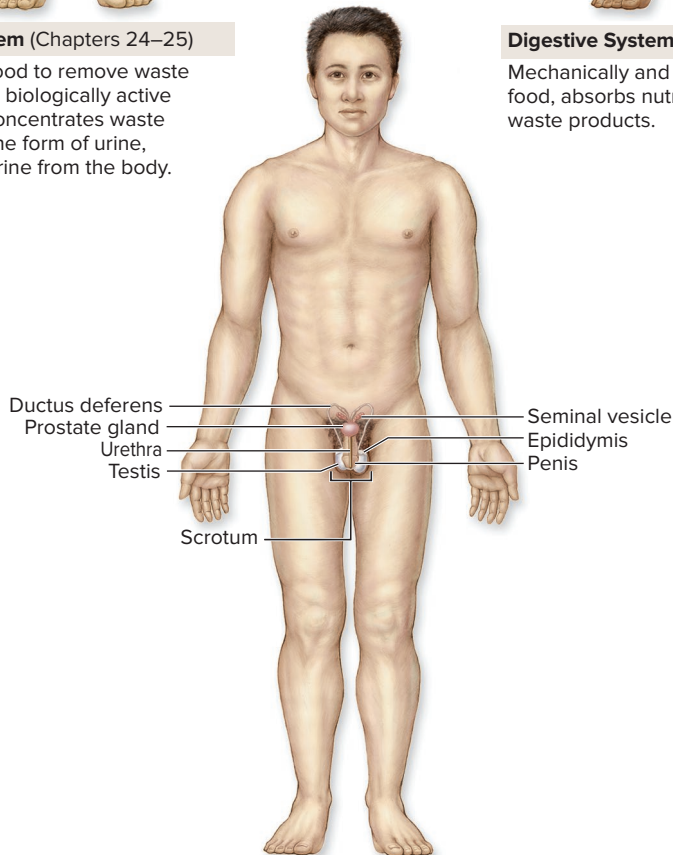
Urinary System (Chapters 24–25)

Filters the blood to remove waste products and biologically active molecules, concentrates waste products in the form of urine, and expels urine from the body.



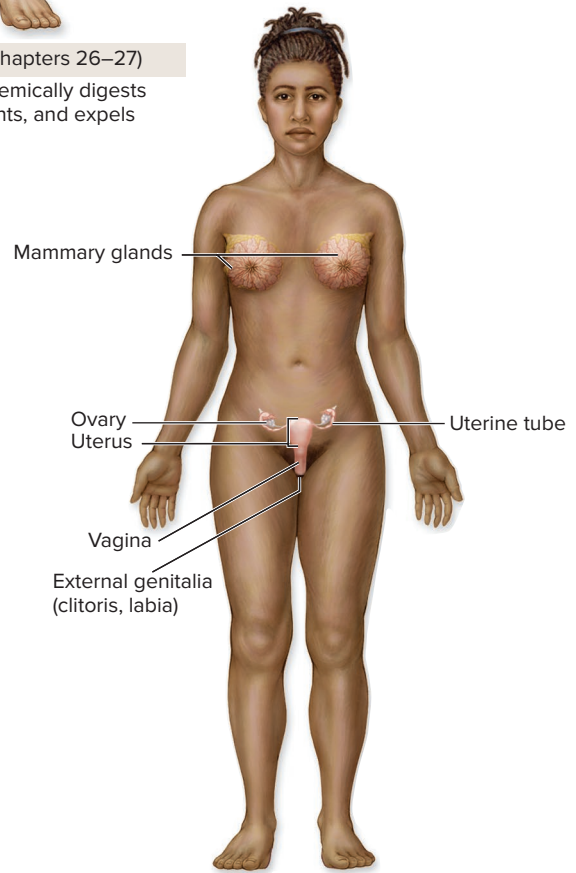
Digestive System (Chapters 26–27)

Mechanically and chemically digests food, absorbs nutrients, and expels waste products.



Male Reproductive System (Chapter 28)

Produces male sex cells (sperm) and male hormones (e.g., testosterone), transfers sperm to the female.



Female Reproductive System (Chapters 28–29)

Produces female sex cells (oocytes) and female hormones (e.g., estrogen and progesterone), receives sperm from male, site of fertilization of oocyte, site of growth and development of embryo and fetus, produces and secretes breast milk for nourishment of newborn.

Figure 1.3 Organ Systems. (*continued*) **AP|R**

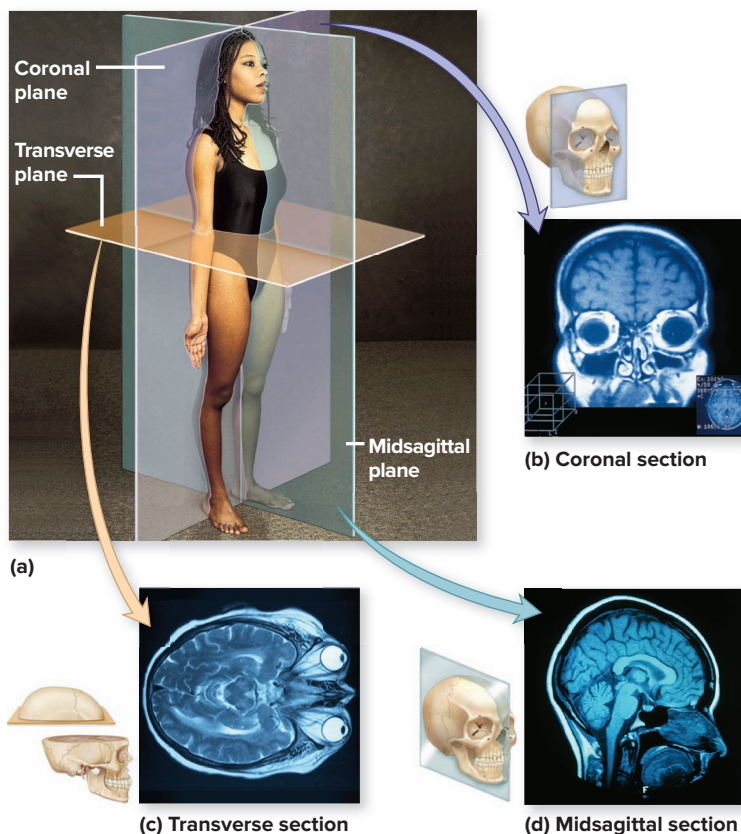


Figure 1.4 Anatomic Position and Body Planes. (a) In the anatomic position, the body is upright, and the forearms are positioned so the palms are facing anteriorly. A plane is an imaginary surface that slices the body into specific sections. Sections are shown from each of the three major anatomic planes of reference: (b) coronal, (c) transverse, and (d) midsagittal planes. **AP|R**

(a) ©McGraw-Hill Education/Joe DeGrandis; (b) ©James Cavallini/Science Source; (c) ©Trevor Lush/Getty Images; (d) ©Stevie Grand/Science Source

1.5a Anatomic Position

✓ LEARNING OBJECTIVE

10. Describe the anatomic position and its importance in the study of anatomy.

Descriptions of any body region or part require a common initial point of reference. Note that terms such as *superior* and *inferior* can be relative terms. For example, when a person is standing it would be accurate to say “the heart is superior to the stomach,” yet if that person were in a **supine** (lying down, face upward) position, this statement would seem not to be true. For accuracy and clarity, anatomists and physiologists describe these parts based on the premise that the body is in what is termed the **anatomic position**, which is then the point of common reference. An individual in the **anatomic position** stands upright with the feet parallel and flat on the floor, the upper limbs are at the sides of the body, and the palms face anteriorly (toward the front); the head is level, and the eyes look forward toward the observer (**figure 1.4**). All of the anatomic and directional terms used in this book refer to the body in anatomic position.

1.5b Sections and Planes

✓ LEARNING OBJECTIVE

11. Describe the anatomic sections and planes through the body.

Anatomists and physiologists refer to real or imaginary “slices” of the body, called sections or planes, to examine the internal anatomy and

describe the position of one body part relative to another. The term **section** implies an actual cut or slice to expose the internal anatomy, whereas the word **plane** implies an imaginary flat surface passing through the body. The three major anatomic planes are the coronal, transverse, and midsagittal planes (**figure 1.4**).

A **coronal** (kōr’o-nāl; *korone* = crown) **plane**, also called a *frontal plane*, is a vertical plane that divides the body or organ into *anterior* (front) and *posterior* (back) parts. When a coronal plane is taken through the trunk, the anterior portion contains the chest and the posterior portion contains the back and buttocks.

A **transverse plane**, also called a *horizontal plane* or *cross-sectional plane*, divides the body or organ into *superior* (top) and *inferior* (bottom) parts. If a transverse plane is taken through the middle of the trunk, the superior portion contains the chest and the inferior portion contains the abdomen.

A **midsagittal** (mid-saj’ī-tāl; *sagitta* = arrow) **plane**, or *median plane*, is a vertical plane and divides the body or organ into equal *left* and *right halves*. A midsagittal plane through the head will split it into a left half and a right half (each containing one eye, one ear, and half of the nose and mouth). A plane that is parallel to the midsagittal plane, but either to the left or right of the midsagittal plane, is termed a **sagittal plane**. A sagittal plane divides a structure into left and right portions that are not equal. Although there is only one midsagittal plane, an infinite number of sagittal planes are possible.

In addition to these major planes, there are numerous minor planes called **oblique** (ob-lēk’) **planes** that pass through a structure at an angle (**figure 1.5**).

Interpreting body sections has become increasingly important for health-care professionals. Technical advances in medical imaging have produced sectional images of internal body structures (**figures 1.4b-d**). To determine the shape of any object within a section, we must be able to reconstruct its three-dimensional shape by observing many serial sections.

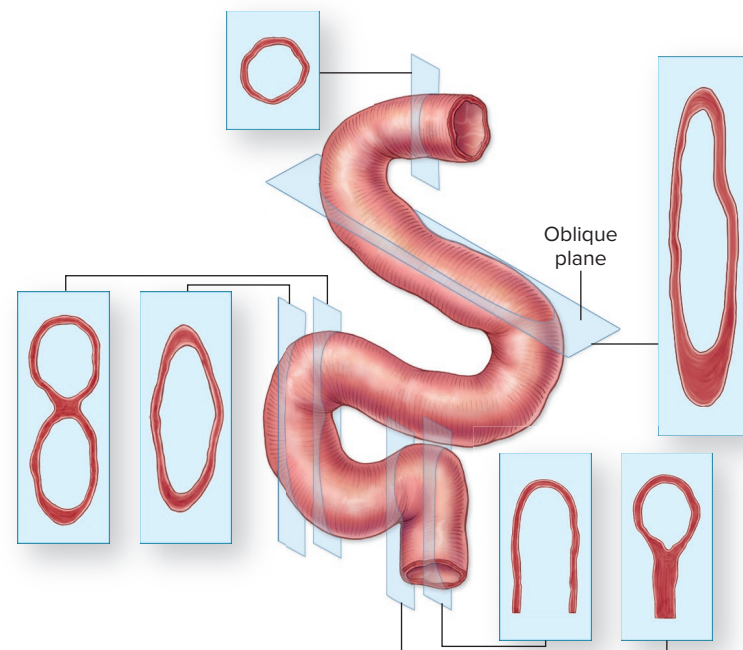


Figure 1.5 Sections from a Three-Dimensional Structure. Serial sections through an object are used to reconstruct its three-dimensional structure, as in these sections of the small intestine. Often a single section, such as the plane at the lower part of this figure, misrepresents the complete structure of the object. An oblique plane is labeled for reference.

Sectioning the body or an organ along different planes often results in very different views of that organ or region. For example, different sections through the abdominal cavity exhibit multiple profiles of the long, twisted tube that is the small intestine. These sections may appear as circles, ovals, a figure eight, or maybe a long tube with parallel sides, depending on where the section was taken (figure 1.5). Being able to convert and interpret two-dimensional images into three-dimensional structures is especially important when comparing and understanding histologic and gross anatomic views of the same organ.

WHAT DID YOU LEARN?

- 9 What type of plane would separate the nose and mouth into superior and inferior structures?

1.5c Anatomic Directions

LEARNING OBJECTIVE

12. Define the different anatomic directional terms.

When the body is in the anatomic position, we can precisely describe the relative positions of structures by using specific directional terms. These directional terms are precise and usually presented in opposing pairs. Examples include **anterior** (in front of) and **posterior** (in back of), and **proximal** (nearer to the trunk) and **distal** (farther from the trunk). **Table 1.1** and **figure 1.6** describe some commonly used directional terms. Studying the table and figure together, and referring back to them as needed, will maximize your understanding of anatomic directions and aid your study of anatomy throughout the rest of this book.

WHAT DID YOU LEARN?

- 10 Which directional term would be most appropriate in the sentence “The elbow is _____ to the wrist”?

1.5d Regional Anatomy

LEARNING OBJECTIVE

13. Identify the major regions of the body, using proper anatomic terminology.

The human body is partitioned into two main regions, the axial and appendicular regions. The **axial** (ak'sē-āl) **region** includes the head, neck, and trunk; it forms the main vertical axis of the body. The **appendicular** (ap'en-dik'ū-lăr) **region** is composed of the upper and lower limbs, which attach to the axial region. Several more specific regions are located within these two main ones, and they are identified by proper anatomic terminology. **Figure 1.7** and **table 1.2** identify the major regional terms and some additional minor ones. Not all regions are shown in figure 1.7.

WHAT DID YOU LEARN?

- 11 The term *antebrachial* refers to which body region?

1.5e Body Cavities and Membranes

LEARNING OBJECTIVES

14. Describe the body cavities and their subdivisions.
15. Explain the role of serous membranes in the ventral cavities.

Direction	Term	Meaning	Example
Relative to front (belly side) or back of the body	Anterior	In front of; toward the front surface	The stomach is <i>anterior</i> to the spinal cord.
	Posterior	In back of; toward the back surface	The heart is <i>posterior</i> to the sternum.
	Dorsal	Toward the back side of the human body	The spinal cord is on the <i>dorsal</i> side of the body.
	Ventral	Toward the belly side of the human body	The umbilicus (navel, belly button) is on the <i>ventral</i> side of the body.
Relative to the head or bottom of the body	Superior	Closer to the head	The chest is <i>superior</i> to the pelvis.
	Inferior	Closer to the feet	The stomach is <i>inferior</i> to the heart.
	Cranial (cephalic)	Toward the head end	The shoulders are <i>cranial</i> to the feet.
	Caudal	Toward the rear or tail end	The buttocks are <i>caudal</i> to the head.
	Rostral	Toward the nose or mouth	The frontal lobe of the brain is <i>rostral</i> to the back of the head.
Relative to the midline or center of the body	Medial	Toward the midline of the body	The lungs are <i>medial</i> to the shoulders.
	Lateral	Away from the midline of the body	The arms are <i>lateral</i> to the heart.
	Ipsilateral	On the same side	The right arm is <i>ipsilateral</i> to the right leg.
	Contralateral	On the opposite side	The right arm is <i>contralateral</i> to the left leg.
	Deep	Closer to the inside, internal to another structure	The heart is <i>deep</i> to the rib cage.
	Superficial	Closer to the outside, external to another structure	The skin is <i>superficial</i> to the biceps brachii muscle.
	Relative to point of attachment of appendage	Proximal	Closer to point of attachment to trunk
Distal		Farther away from point of attachment to trunk	The wrist is <i>distal</i> to the elbow.

Internal organs and organ systems are housed within enclosed spaces, or cavities. These body cavities are named according to either the bones that surround them or the organs they contain. For purposes of discussion, these body cavities are grouped into a posterior aspect and a ventral cavity.

Posterior Aspect

The **posterior aspect** of the body is different from the ventral cavity, in that the posterior aspect contains cavities that are completely encased in bone and are physically and developmentally different

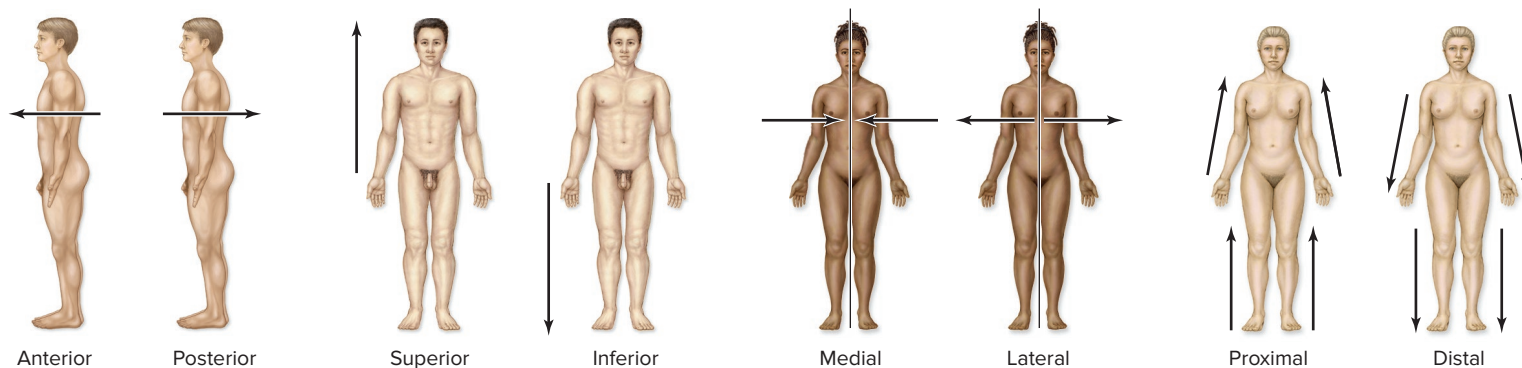


Figure 1.6 Directional Terms in Anatomy. Directional terms precisely describe the location and relative relationships of body parts. (See also table 1.1.) **AP|R**

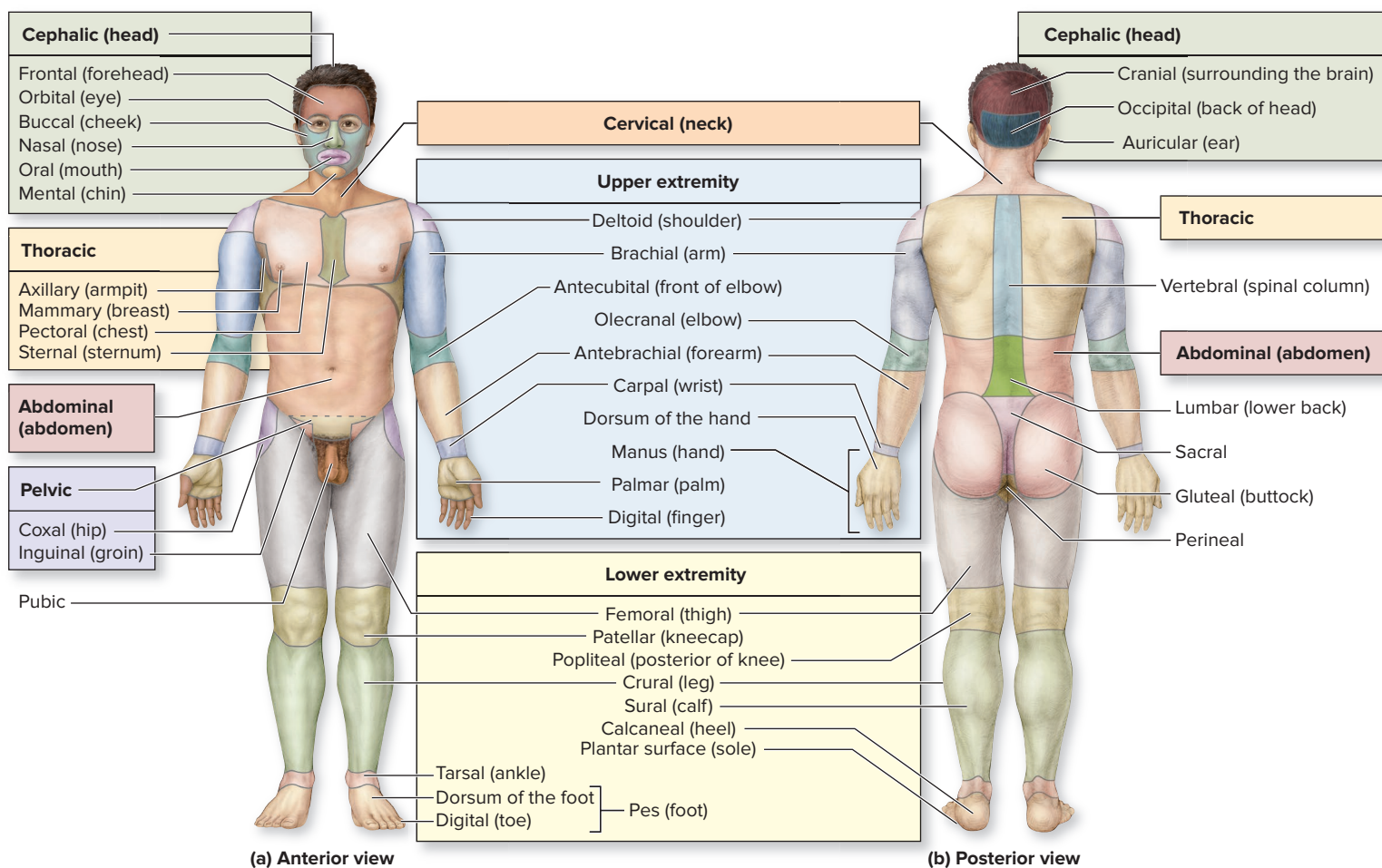


Figure 1.7 Regional Terms. (a) Anterior and (b) posterior views show key regions of the body. Their common names appear in parentheses. **AP|R**

from the ventral cavity. The term *dorsal body cavity* has been used by others to describe this posterior aspect but is not used here because of these differences between the ventral cavity and posterior aspect.

The posterior aspect is subdivided into two enclosed cavities (figure 1.8a). A **cranial cavity** is formed by the bones of the cranium, and so it also goes by the name *endocranium*. The cranial cavity houses the brain. The second cavity is the **vertebral canal**, which is formed by the bones of the vertebral column. The vertebral canal houses the spinal cord.

Ventral Cavity

The **ventral cavity** is the larger, anteriorly placed cavity in the body (figure 1.8). Unlike the posterior aspect, the ventral cavity and its subdivisions do not completely encase their organs in bone. The ventral cavity is partitioned by the **thoracic diaphragm** into a superior **thoracic** (thō-ras'ik) **cavity** and an inferior **abdominopelvic** (ab-dom'i-nō-pel'vik) **cavity**.

Another significant difference between the posterior aspect and the ventral cavity is that the subdivisions of the ventral cavity are

Table 1.2**Human Body Regions¹**

Region Name	Description	Region Name	Description
Abdominal	Region inferior to the thorax (chest) and superior to the pelvic brim of the hip bones	Manus	Hand
Antebrachial	Forearm (the portion of the upper limb between the elbow and the wrist)	Mental	Chin
Antecubital	Region anterior to the elbow; also known as the cubital region	Nasal	Nose
Auricular	Visible surface structures of the ear	Occipital	Posterior aspect of the head
Axillary	Armpit	Olecranal	Posterior aspect of the elbow
Brachial	Arm (the portion of the upper limb between the shoulder and the elbow)	Oral	Mouth
Buccal	Cheek	Orbital	Eye
Calcaneal	Heel of the foot	Palmar	Palm (anterior surface) of the hand
Carpal	Wrist	Patellar	Kneecap
Cephalic	Head	Pectoral	Chest, includes mammary region
Cervical	Neck	Pelvic	Pelvis; region inferior to the pelvic brim of the hip bones
Coxal	Hip	Perineal	Diamond-shaped region between the thighs that contains the anus and external reproductive organs
Cranial	Skull	Pes	Foot
Crural	Leg (the portion of the lower limb between the knee and the ankle)	Plantar	Sole of the foot
Deltoid	Shoulder	Pollex	Thumb
Digital	Fingers or toes (also called phalangeal)	Popliteal	Area posterior to the knee
Dorsal/ Dorsum	Back	Pubic	Anterior region of the pelvis
Facial	Face	Radial	Lateral aspect (thumb side) of forearm
Femoral	Thigh	Sacral	Posterior region between the hip bones
Fibular	Lateral aspect of the leg	Scapular	Shoulder blade
Frontal	Forehead	Sternal	Anterior middle region of the thorax
Gluteal	Buttock	Sural	Calf (posterior part of the leg)
Hallux	Great toe	Tarsal	Proximal part of the foot and ankle
Inguinal	Groin (sometimes used to indicate the crease or junction of the thigh with the trunk)	Thoracic	Part of torso superior to thoracic diaphragm; contains the pectoral, axillary, and sternal regions
Lumbar	The “small of the back”: the inferior part of the back between the ribs and the pelvis	Tibial	Medial aspect of leg
Mammary	Breast	Ulnar	Medial aspect (pinkie side) of the forearm
		Umbilical	Navel
		Vertebral	Spinal column

1. The word *region* should follow each region name listed in the table (e.g., femoral region).

lined with thin **serous membranes**. (Posterior aspect cavities have no serous membranes.) In this usage, a *membrane* is a continuous layer of cells, as compared to the plasma membrane that surrounds a single cell (see section 4.1c). Serous membranes form two layers: (1) a **parietal** (pă-rĭ'ě-tăĭ) **layer** that typically lines the internal surface of the body wall and (2) a **visceral** (vis'er-ăĭ) **layer** that covers the external surface of the organs (**viscera**) within that cavity. Between the parietal and visceral serous membrane layers is a potential space called the **serous cavity**. (Note: A potential space is capable of becoming a larger opening under certain physiological or pathological conditions.) Serous membranes secrete a liquid called **serous fluid** within a serous cavity. Serous fluid has the consistency of oil and serves as a lubricant. In a living person, organs (e.g., heart, lungs, intestines) move and rub against each other and the body wall. Friction caused by this movement is reduced by the serous

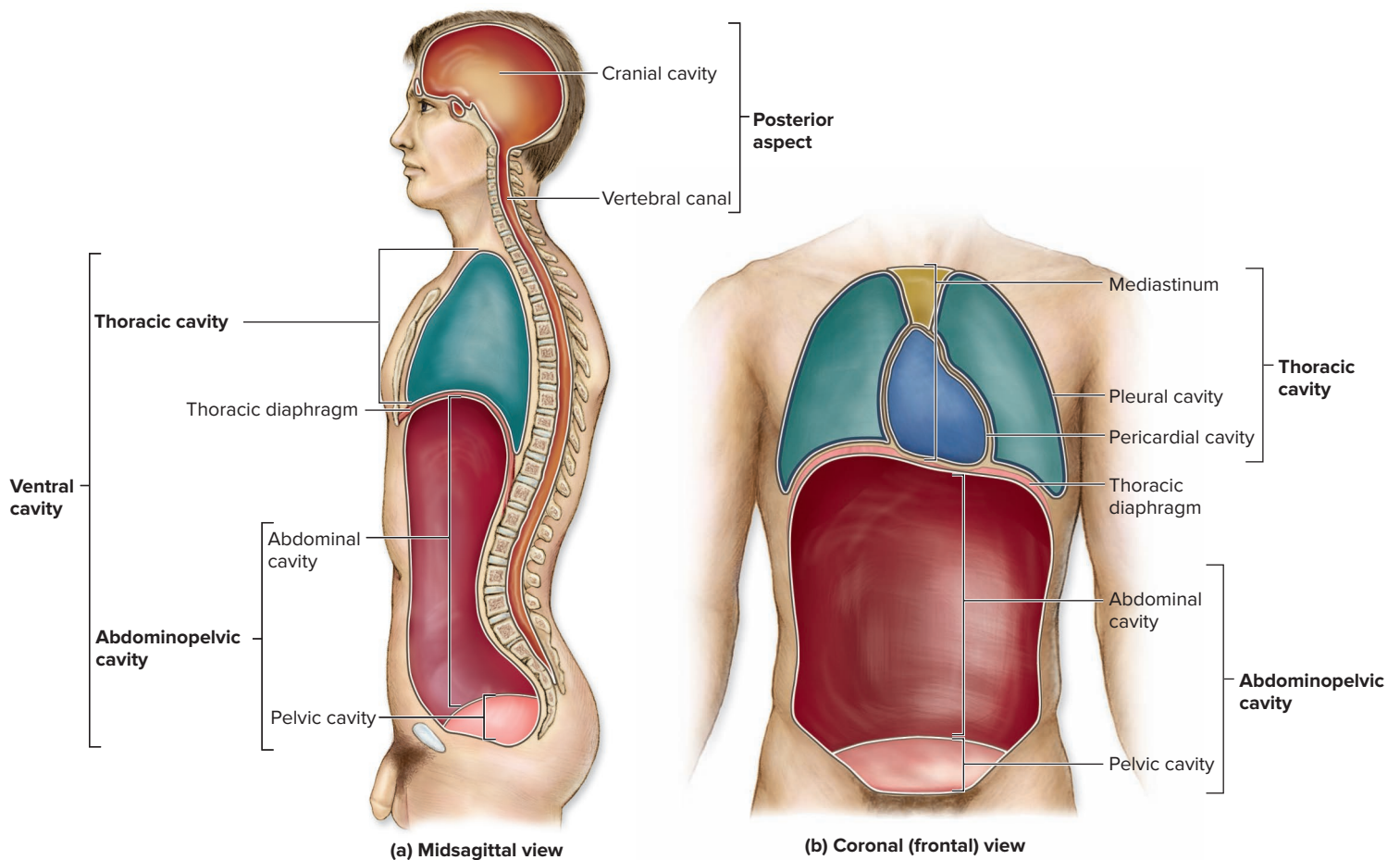


Figure 1.8 Body Cavities. The body is composed of two main spaces: the posterior aspect and the ventral cavity. Many vital organs are housed within these spaces. (a) A midsagittal view shows both the posterior aspect and the ventral cavity. (b) A coronal view shows the relationship between the thoracic and abdominopelvic cavities within the ventral cavity. **APR**

fluid so the organs move more smoothly against one another and the body walls. Serous membranes will be discussed again in section 5.5b.

WHAT DO YOU THINK?

- What do you think would happen to your body organs if there were no serous fluid between the parietal and visceral layers?

Figure 1.9a provides a helpful analogy for visualizing the serous membrane layers. The closed fist is comparable to an organ, and the balloon is comparable to a serous membrane. When a fist is pushed against the wall of the balloon, the inner balloon wall that surrounds the fist is comparable to the visceral layer of the serous membrane. The outer balloon wall is comparable to the parietal layer of the serous membrane. The thin, air-filled space within the balloon, between the two “walls,” is comparable to the serous cavity. Note that the organ is not *inside* the serous cavity; it is actually *outside* the cavity and merely covered by the serous membrane.

Thoracic Cavity Within the thoracic cavity, the median space between the lungs is called the **mediastinum** (mē-dē-as-tī-nŭm; *medius* = middle) (figure 1.8b). It contains the heart, thymus, esophagus, trachea, and major blood vessels that connect to the heart.

Within the mediastinum, the heart is enclosed by a two-layered serous membrane called the serous **pericardium** (per-ī-kar’dē-ŭm; *peri* = around, *kardia* = heart). The **parietal pericardium** is the outermost layer of the serous membrane and forms the sac around the heart, whereas the **visceral pericardium** forms the heart’s external surface (figure 1.9b). The **pericardial cavity** is the serous cavity between the parietal and visceral layers of the pericardium, and it contains serous fluid. (see section 19.2b).

The right and left sides of the thoracic cavity house the lungs, which are associated with a two-layered serous membrane called the **pleura** (plūr’ă; a rib) (figure 1.9c).