

Essentials of Human Anatomy & Physiology

TWELFTH EDITION

Elaine N. Marieb Suzanne M. Keller





ห้องสมุดวพบ.นครราชสีมา



Contents

The Human Body: An Orientation 27

An Overview of Anatomy and Physiology 27

Anatomy 27

Physiology 28

Relationship between Anatomy and Physiology 28

Levels of Structural Organization 28

From Atoms to Organisms 28

Organ System Overview 29

Integumentary System • Skeletal System • Muscular System • Nervous System • Endocrine System

- Cardiovascular System Lymphatic System
- Respiratory System Digestive System
- Urinary System Reproductive System

Maintaining Life 33

Necessary Life Functions 33

Maintaining Boundaries • Movement • Responsiveness

- Digestion Metabolism Excretion Reproduction
- Growth

Survival Needs 35

The Language of Anatomy 38

Anatomical Position 38

Directional Terms 38

Regional Terms 38

Anterior Body Landmarks • Posterior Body Landmarks

Body Planes and Sections 41

Body Cavities 41

Dorsal Body Cavity • Ventral Body Cavity • Other Body Cavities

Homeostasis 45

Components of Homeostatic Control Systems 45

Feedback Mechanisms 45

SUMMARY 47

REVIEW QUESTIONS 48

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 49

A CLOSER LOOK Medical Imaging: Illuminating the Body 36

2 Basic Chemistry 50

Concepts of Matter and Energy 50

Matter 50

Energy 51

Forms of Energy • Energy Form Conversions

Composition of Matter 52

Elements and Atoms 52

Atomic Structure 52

The Basic Atomic Subparticles • Planetary and Orbital Models of an Atom

Identifying Elements 54

Atomic Number • Atomic Mass Number • Atomic Weight and Isotopes

Molecules and Compounds 57

Chemical Bonds and Chemical Reactions 58

Bond Formation 58

Role of Electrons • Types of Chemical Bonds

Patterns of Chemical Reactions 62

Synthesis Reactions • Decomposition Reactions

• Exchange Reactions • Factors Influencing the Rate of Chemical Reactions

Biochemistry: The Chemical Composition of Living Matter 64

Inorganic Compounds 65

Water • Salts • Acids and Bases

Chapter 2, continued

Organic Compounds 68

Carbohydrates • Lipids • Proteins • Nucleic Acids

• Adenosine Triphosphate (ATP)

SUMMARY 83

REVIEW QUESTIONS 85

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 87

FOCUS ON CAREERS Pharmacy Technician 82

3 Cells and Tissues 88

PART I: CELLS 88

Overview of the Cellular Basis of Life 88

Anatomy of a Generalized Cell 89

The Nucleus 89

Nuclear Envelope • Nucleolus • Chromatin

The Plasma Membrane 90

The Fluid Mosaic Model • Cell Membrane Junctions

The Cytoplasm 93

Cytosol and Inclusions • Organelles

Cell Extensions 97

Cilia and Flagella • Microvilli

Cell Diversity 100

Cell Physiology 102

Membrane Transport 102

Passive Processes: Diffusion and Filtration

Active Processes

Cell Division 108

Preparations: DNA Replication • Events of Cell Division

Protein Synthesis 111

Genes: The Blueprint for Protein Structure • The Role of RNA • The Process of Protein Synthesis

PART II: BODY TISSUES 114

Epithelial Tissue 114

Hallmarks of Epithelium 114

Classification of Epithelia 115

Simple Epithelia • Stratified Epithelia • Glandular Epithelium

Connective Tissue 119

Hallmarks of Connective Tissue 119

Extracellular Matrix 120

Types of Connective Tissue 120

Bone • Cartilage • Dense Connective Tissue • Loose Connective Tissue • Blood

Muscle Tissue 124

Skeletal Muscle 124

Cardiac Muscle 124

Smooth Muscle 126

Nervous Tissue 126

Tissue Repair (Wound Healing) 126

PART III: DEVELOPMENTAL ASPECTS OF CELLS AND TISSUES 128

SUMMARY 130

REVIEW QUESTIONS 133

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 134

A CLOSER LOOK IV Therapy and Cellular "Tonics" 105

A CLOSER LOOK Cancer—An Intimate Enemy 130

4 Skin and Body Membranes 135

Classification of Body Membranes 135

Epithelial Membranes 136

Cutaneous Membrane • Mucous Membranes

Serous Membranes

Connective Tissue Membranes 136

The Integumentary System (Skin) 138

Functions of the Integumentary System 138

Structure of the Skin 139

Epidermis • Dermis

Skin Color 144

Appendages of the Skin 145

Cutaneous Glands • Hair and Hair Follicles • Nails

Homeostatic Imbalances of Skin 149

Infections and Allergies • Burns • Skin Cancer

Developmental Aspects of Skin and Body Membranes 153

SUMMARY 156

REVIEW QUESTIONS 157

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 158

A CLOSER LOOK A Wrinkle Out of

Time 143

FOCUS ON CAREERS Medical Transcriptionist 154

SYSTEMS IN SYNC 155

The Skeletal System 160

Bones: An Overview 160

Functions of the Bones 161

Classification of Bones 161

Structure of Bone 163

Gross Anatomy of a Long Bone • Microscopic Anatomy

Bone Formation, Growth, and

Remodeling 167

Bone Formation and Growth • Bone Remodeling

Bone Fractures 170

Axial Skeleton 172

Skull 172

Cranium • Facial Bones • The Hyoid Bone

Vertebral Column (Spine) 178

Cervical Vertebrae • Thoracic Vertebrae

• Lumbar Vertebrae • Sacrum • Coccyx

Thoracic Cage 182

Sternum • Ribs

Appendicular Skeleton 184

Bones of the Shoulder Girdle 184

Bones of the Upper Limbs 184

Arm • Forearm • Hand

Bones of the Pelvic Girdle 188

Bones of the Lower Limbs 190

Thigh • Leg • Foot

Joints 192

Fibrous Joints 195

Cartilaginous Joints 195

Synovial Joints 195

Types of Synovial Joints Based on Shape 196

ipe 13

Developmental Aspects of the Skeleton 199

Birth to Adulthood 199 Older Adults 201

SUMMARY 203

REVIEW QUESTIONS 204

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 206

FOCUS ON CAREERS Radiologic Technologist 169

A CLOSER LOOK Joint Ventures 192

SYSTEMS IN SYNC 202

6 The Muscular System 207

Overview of Muscle Tissues 207

Muscle Types 207

Skeletal Muscle • Smooth Muscle • Cardiac Muscle

Muscle Functions 211

Produce Movement • Maintain Posture and Body Position • Stabilize Joints • Generate Heat

Position • Stabilize Joints • Generate ne

Additional Functions

Chapter 6, continued

Microscopic Anatomy of Skeletal Muscle 211

Skeletal Muscle Activity 213

Stimulation and Contraction of Single Skeletal Muscle Fibers 213

The Nerve Stimulus and the Action Potential

• Mechanism of Muscle Contraction: The Sliding Filament Theory

Contraction of a Skeletal Muscle as a Whole 217

Graded Responses • Providing Energy for Muscle Contraction • Muscle Fatigue and Oxygen Deficit

• Types of Muscle Contractions—Isotonic and Isometric • Muscle Tone • Effect of Exercise on Muscles

Muscle Movements, Roles, and Names 222

Types of Body Movements 222

Special Movements

Interactions of Skeletal Muscles

in the Body 226

Naming Skeletal Muscles 228

Arrangement of Fascicles 228

Gross Anatomy of Skeletal Muscles 229

Head and Neck Muscles 229

Facial Muscles • Neck Muscles

Trunk Muscles 232

Anterior Muscles • Posterior Muscles

Muscles of the Upper Limb 235

Muscles Causing Movement at the Elbow Joint

Muscles of the Lower Limb 235

Muscles Causing Movement at the Hip Joint • Muscles Causing Movement at the Knee Joint • Muscles Causing Movement at the Ankle and Foot

Developmental Aspects of the Muscular System 244

SUMMARY 245

REVIEW OUESTIONS 248

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 249

A CLOSER LOOK Anabolic Steroids: Dying to Win? 231

SYSTEMS IN SYNC 246

7 The Nervous System 251

Organization of the Nervous System 252

Structural Classification 253

Functional Classification 253

Nervous Tissue: Structure and Function 253

Supporting Cells 253

Neurons 255

Anatomy • Classification • Physiology: Nerve Impulses

Physiology: Reflexes

Central Nervous System 265

Functional Anatomy of the Brain 265

Cerebral Hemispheres • Diencephalon • Brain Stem

Cerebellum

Protection of the Central Nervous System 273

Meninges • Cerebrospinal Fluid • The Blood-Brain Barrier

Brain Dysfunctions 277

Spinal Cord 278

Grav Matter of the Spinal Cord and Spinal Roots

• White Matter of the Spinal Cord

Peripheral Nervous System 281

Structure of a Nerve 281

Cranial Nerves 283

Spinal Nerves and Nerve Plexuses 283

Autonomic Nervous System 290

Somatic and Autonomic Nervous Systems Compared

• Anatomy of the Parasympathetic Division • Anatomy of the Sympathetic Division • Autonomic Functioning

Developmental Aspects of the Nervous System 295

SUMMARY 299

REVIEW QUESTIONS 301

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 303

A CLOSER LOOK The "Terrible Three" 278

A CLOSER LOOK Tracking Down CNS

Problems 296

SYSTEMS IN SYNC 298

Special Senses 304

PART I: THE EYE AND VISION 305

Anatomy of the Eye 305

External and Accessory Structures 305
Internal Structures: The Eyeball 307
Layers Forming the Wall of the Eyeball • Lens

Physiology of Vision 313

Pathway of Light through the Eye and Light Refraction 313 Visual Fields and Visual Pathways to the Brain 314 Eye Reflexes 316

PART II: THE EAR: HEARING AND BALANCE 316

Anatomy of the Ear 317

External (Outer) Ear 317 Middle Ear 318 Internal (Inner) Ear 318

Equilibrium 318

Static Equilibrium 319

Dynamic Equilibrium 319

Hearing 322

Hearing and Equilibrium Deficits 323

PART III: CHEMICAL SENSES: SMELL AND TASTE 324

Olfactory Receptors and the Sense of Smell 324

Taste Buds and the Sense of Taste 326

PART IV: DEVELOPMENTAL ASPECTS OF THE SPECIAL SENSES 327

SUMMARY 329

REVIEW QUESTIONS 331

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 332

A CLOSER LOOK Visual Pigments—The Actual Photoreceptors 311

A CLOSER LOOK Bringing Things into Focus 315

FOCUS ON CAREERS Physical Therapy Assistant 321

The Endocrine System 334

The Endocrine System and Hormone Function—An Overview 335

The Chemistry of Hormones 335

Hormone Action 335

Direct Gene Activation • Second-Messenger System

Stimuli for Control of Hormone

Release 337

Hormonal Stimuli • Humoral Stimuli • Neural Stimuli

The Major Endocrine Organs 338

Pituitary Gland and Hypothalamus 339
Pituitary-Hypothalamus Relationships
Pineal Gland 343
Thyroid Gland 343
Parathyroid Glands 345
Thymus 346

Chapter 9, continued

Adrenal Glands 346

Hormones of the Adrenal Cortex • Hormones of the Adrenal Medulla

Pancreatic Islets 349

Gonads 353

Hormones of the Ovaries • Hormones of the Testes

Other Hormone-Producing Tissues and Organs 353

Developmental Aspects of the Endocrine System 357

SUMMARY 359

REVIEW QUESTIONS 361

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 362

A CLOSER LOOK Potential Uses for Growth Hormone 342

SYSTEMS IN SYNC 358

10 Blood 363

Composition and Functions of Blood 363

Components 364

Physical Characteristics and Volume 364

Plasma 364

Formed Elements 366

Erythrocytes • Leukocytes • Platelets

Hematopoiesis (Blood Cell Formation) 371

Formation of Red Blood Cells • Formation of White Blood Cells and Platelets

Hemostasis 373

Phases of Hemostasis 373

Disorders of Hemostasis 374

Blood Groups and Transfusions 375

Human Blood Groups 375 Blood Typing 378

Developmental Aspects of Blood 378

SUMMARY 379

REVIEW QUESTIONS 380

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 381

FOCUS ON CAREERS Phlebotomy
Technician 376

1 1 The Cardiovascular System 382

The Heart 383

Anatomy of the Heart 383

Size, Location, and Orientation • Coverings and Walls of the Heart

Chambers and Associated Great Vessels 384

Heart Valves 387

Cardiac Circulation

Physiology of the Heart 390

Intrinsic Conduction System of the Heart: Setting the Basic Rhythm • Cardiac Cycle and Heart Sounds • Cardiac Output

caraiac oacpac

Blood Vessels 396

Microscopic Anatomy of Blood Vessels 396

Tunics • Structural Differences in Arteries, Veins, and Capillaries

Gross Anatomy of Blood Vessels 399

Major Arteries of the Systemic Circulation • Major Veins of the Systemic Circulation • Special Circulations

Physiology of Circulation 406

Arterial Pulse • Blood Pressure • Capillary Exchange of Gases and Nutrients • Fluid Movements at Capillary Beds

Developmental Aspects of the Cardiovascular System 415

SUMMARY 418

REVIEW QUESTIONS 420

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 422

A CLOSER LOOK Electrocardiography: (Don't) Be Still My Heart 393

A CLOSER LOOK Atherosclerosis? Get Out the Cardiovascular Drāno! 412

SYSTEMS IN SYNC 417

1 The Lymphatic System and Body Defenses 424

PART I: THE LYMPHATIC SYSTEM 424

Lymphatic Vessels 425

Lymph Nodes 426

Other Lymphoid Organs 428

PART II: BODY DEFENSES 429

Innate Body Defenses 430

Surface Membrane Barriers 430

Internal Defenses: Cells and Chemicals 432

Natural Killer Cells • Inflammatory Response

• Phagocytes • Antimicrobial Proteins • Fever

Adaptive Body Defenses 436

Antigens 438

Cells of the Adaptive Defense System: An Overview 438

Lymphocytes • Antigen-Presenting Cells

Humoral (Antibody-Mediated) Immune Response 441

Active and Passive Humoral Immunity • Antibodies

Cellular (Cell-Mediated) Immune Response 446

Organ Transplants and Rejection 448

Disorders of Immunity 451

PART III: DEVELOPMENTAL ASPECTS OF THE LYMPHATIC SYSTEM AND BODY DEFENSES 455

SUMMARY 457

REVIEW QUESTIONS 459

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 461

A CLOSER LOOK AIDS: An Ongoing

Pandemic 454

SYSTEMS IN SYNC 456

13 The Respiratory System 462

Functional Anatomy of the Respiratory System 462

The Nose 463

The Pharynx 464

The Larynx 465

The Trachea 466

The Main Bronchi 466

The Lungs 467

The Bronchial Tree • Respiratory Zone Structures and the Respiratory Membrane

Respiratory Physiology 471

Mechanics of Breathing 471

Inspiration • Expiration

Respiratory Volumes and Capacities 474

Nonrespiratory Air Movements 475

Respiratory Sounds 475

External Respiration, Gas Transport, and Internal Respiration 475

External Respiration • Gas Transport in the Blood

Internal Respiration

Control of Respiration 478

Neural Regulation: Setting the Basic Rhythm

• Nonneural Factors Influencing Respiratory Rate and Depth

Respiratory Disorders 480

Developmental Aspects of the Respiratory System 483

SUMMARY 485

Chapter 13, continued

REVIEW QUESTIONS 487

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 488

A CLOSER LOOK Too Clean for Our Own Good? 482

SYSTEMS IN SYNC 484

14 The Digestive System and Body Metabolism 489

PART I: ANATOMY AND PHYSIOLOGY OF THE DIGESTIVE SYSTEM 489

Anatomy of the Digestive System 489

Organs of the Alimentary Canal 490

Mouth • Pharynx • Esophagus • Stomach • Small Intestine • Large Intestine

Accessory Digestive Organs 500

Teeth • Salivary Glands • Pancreas • Liver and Gallbladder

Functions of the Digestive System 502

Overview of Gastrointestinal Processes and Controls 503

Activities Occurring in the Mouth, Pharynx, and Esophagus 506

Food Ingestion and Breakdown • Food Propulsion— Swallowing and Peristalsis

Activities of the Stomach 507

Food Breakdown • Food Propulsion

Activities of the Small Intestine 509

Chyme Breakdown and Absorption • Chyme Propulsion

Activities of the Large Intestine 511

Nutrient Breakdown and Absorption • Propulsion of Food Residue and Defecation

PART II: NUTRITION AND METABOLISM 513

Nutrition 513

Dietary Recommendations 513

Dietary Sources of the Major Nutrients 514

Carbohydrates • Lipids • Proteins • Vitamins

Minerals

Metabolism 516

Carbohydrate, Fat, and Protein Metabolism in Body Cells 516

Carbohydrate Metabolism • Fat Metabolism • Protein Metabolism

The Central Role of the Liver

in Metabolism 520

General Metabolic Functions • Cholesterol Metabolism and Transport

Body Energy Balance 523

Regulation of Food Intake • Metabolic Rate and Body Heat Production • Body Temperature Regulation

PART III: DEVELOPMENTAL ASPECTS OF THE DIGESTIVE SYSTEM AND METABOLISM 527

SUMMARY 532

REVIEW QUESTIONS 534

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 536

A CLOSER LOOK Peptic Ulcers: "Something

Is Eating at Me" 512

A CLOSER LOOK Obesity: Magical

Solution Wanted 529

SYSTEMS IN SYNC 531

15 The Urinary System 537

Kidneys 538

Location and Structure 538
Kidney Structure • Blood Supply
Nephrons 539

ห้องสมค

วิทยาลัยพยาบาลบรมราชชนนี นครราชสีมา

Urine Formation and Characteristics 542

Glomerular Filtration • Tubular Reabsorption • Tubular Secretion • Nitrogenous Wastes • Characteristics of Urine

Ureters, Urinary Bladder, and Urethra 546

Ureters 546
Urinary Bladder 547
Urethra 548
Micturition 548

Fluid, Electrolyte, and Acid-Base Balance 550

Maintaining Water Balance of Blood 550

Body Fluids and Fluid Compartments • The Link between Water and Electrolytes • Regulation of Water Intake and Output

Maintaining Electrolyte Balance 553

Maintaining Acid-Base Balance of Blood 555
Blood Buffers • Respiratory Mechanisms • Renal
Mechanisms

Developmental Aspects of the Urinary System 557

SUMMARY 561

REVIEW QUESTIONS 562

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 563

A CLOSER LOOK Renal Failure and the Artificial Kidney 549

FOCUS ON CAREERS Licensed Practical Nurse (LPN) 558

SYSTEMS IN SYNC 560

16 The Reproductive System 564

Anatomy of the Male Reproductive System 565

Testes 565

Duct System 565

Epididymis • Ductus Deferens • Urethra

Accessory Glands and Semen 567

Seminal Vesicles • Prostate • Bulbo-urethral Glands

Semen

External Genitalia 568

Male Reproductive Functions 569

Spermatogenesis 569
Testosterone Production 571

Anatomy of the Female Reproductive System 573

Ovaries 573

Duct System 573

Uterine Tubes • Uterus • Vagina

External Genitalia and Female Perineum 576

Female Reproductive Functions and Cycles 577

Oogenesis and the Ovarian Cycle 577 Hormone Production by the Ovaries 579 Uterine (Menstrual) Cycle 580

Mammary Glands 580

Pregnancy and Embryonic Development 583

Accomplishing Fertilization 584 Events of Embryonic and Fetal Development 585

Effects of Pregnancy on the Mother 589
Anatomical Changes • Physiological Changes
Childbirth 591

Initiation of Labor • Stages of Labor

Developmental Aspects of the Reproductive System 593

SUMMARY 598

REVIEW OUESTIONS 600

CRITICAL THINKING AND CLINICAL APPLICATION QUESTIONS 602

A CLOSER LOOK Contraception: Preventing

Pregnancy 594

SYSTEMS IN SYNC 597

Review Questions 603

Appendix B: Word Roots, Prefixes, and

Suffixes 610

Appendix C: Periodic Table of the

Elements 612

Credits 630

Subject Index 631