

MARTINI
TALLITSCH
NATH

HUMAN ANATOMY

NINTH EDITION

Contents in Brief

BODY SYSTEM	CHAPTER		
FOUNDATIONS	1	An Introduction to Anatomy	1
	2	The Cell	27
	3	Tissues and Early Embryology	49
THE INTEGUMENTARY SYSTEM	4	The Integumentary System	86
THE SKELETAL SYSTEM	5	Osseous Tissue and Bone Structure	107
	6	Axial Division	131
	7	Appendicular Division	172
	8	Joints	203
THE MUSCULAR SYSTEM	9	Skeletal Muscle Tissue and Muscle Organization	235
	10	Axial Musculature	259
	11	Appendicular Musculature	282
SURFACE ANATOMY AND CROSS-SECTIONAL ANATOMY	12	Surface Anatomy and Cross-Sectional Anatomy	325
THE NERVOUS SYSTEM	13	Nervous Tissue	338
	14	The Spinal Cord and Spinal Nerves	360
	15	Sensory and Motor Tracts of the Spinal Cord	387
	16	The Brain and Cranial Nerves	403
	17	Autonomic Nervous System	449
	18	General and Special Senses	471
THE ENDOCRINE SYSTEM	19	The Endocrine System	506
THE CARDIOVASCULAR SYSTEM	20	Blood	528
	21	The Heart	545
	22	Vessels and Circulation	567
THE LYMPHATIC SYSTEM	23	The Lymphatic System	603
THE RESPIRATORY SYSTEM	24	The Respiratory System	624
THE DIGESTIVE SYSTEM	25	The Digestive System	650
THE URINARY SYSTEM	26	The Urinary System	687
THE REPRODUCTIVE SYSTEM	27	The Reproductive System	707
	28	Embryology and Human Development	739



CLINICAL CASES

Using Anatomy to Save a Life	1
Inheritance from Mom	27
The Tallest in the School	49
Flesh-Eating Bacteria	86
Pushing Beyond Her Limits	107
The Last Lap	131
Double Jeopardy	172
Why Does My Knee Hurt So Much?	203
A Case of Asymmetrical Development	235
Waking with a Crooked Smile	259
Hamstrung	282
Breathing Through Your Neck	325
When Nerves Become Demyelinated	338
A Case of the Bends	360
Amyotrophic Lateral Sclerosis	387
A Neuroanatomist's Stroke of Insight	403
First Day of Anatomy Lab	449
Why Am I So Dizzy?	471
Why Am I So Cold and Tired?	506
A Surplus of WBCs	528
A Broken Heart	545
In the Absence of Capillaries	567
Fighting a Zoonotic Disease	603
How Long Should This Cough Last?	624
An Unusual Transplant	650
This Too Shall Pass	687
A Serious Game of Twister	707
The Least-Alike Twins	739

SPOTLIGHT FIGURES

2.4 Membrane Permeability: Passive and Active Processes	32
2.13 Functions of the Golgi Apparatus	41
2.17 Mitosis	45
3.10 Mechanisms of Glandular Secretion	60
5.6 Intramembranous Ossification	115
5.7 Endochondral Ossification	116
8.2 Joint Motion	208
9.7 Sliding Filament Theory	244
9.13 Levers and Pulleys	254
11.2 Factors Affecting Appendicular Muscle Function	284
13.9 Myelination	346
14.8 The Cervical and Brachial Plexuses	370
14.10 The Lumbar and Sacral Plexuses	376
15.2 Organization of Spinal Cord Tracts	390
17.2 An Introduction to the Autonomic Nervous System	452
17.3 A Review of the Sympathetic Nervous System	454
19.2 Neuroendocrine Integration: The Hypothalamus and Pituitary Gland	510
21.11 The Conducting System and the Cardiac Cycle	560
22.1 The Structure of Blood Vessels	570
23.6 Lymphocyte Formation and Immunity	609
24.16 Respiratory Muscles and Pulmonary Ventilation	644
25.10 Anatomy of the Stomach	664
26.9 The Renal Corpuscle	696

HUMAN ANATOMY

NINTH EDITION

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Claire E. Ober, R.N., B.A., practiced family, pediatric, and obstetric nursing before turning to medical illustration as a full-time career. She returned to school at Mary Baldwin

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Dr. O'Keefe did her undergraduate studies at Marquette University, attended graduate school at the University of Wisconsin, and received her M.D. from George Washington

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Mr. Hutchings was associated with The Royal College of Surgeons of England for 20 years. An engineer by training, he has focused for years on photographing the structure of

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Preface

Welcome to the ninth edition of *Human Anatomy*! This edition marks a significant change to the author team with the retirement of Michael Timmons and the addition of a fine colleague and excellent writer, Judi Nath.

We have made significant changes to *every* chapter of the text. As a result, this book—which was already highly visual—is now even more visual and engaging. These changes will enhance students’ understanding of the chapters and the intricacies of the human body. Our new and revised visuals will promote student involvement with the figures.

In addition, the author team has revised the chapter narratives to be even more “student friendly” with a lively writing style. We have repositioned figure callouts and tried to place all graphics on the same two-page spread with their anatomical descriptions.

New to the Ninth Edition

Our goal is to build on the strengths of previous editions while meeting the needs of today’s students. The author team has paid significant attention to the latest research on the science of teaching and learning. Our reading of this research has informed the revision of both the art program and text narratives in this edition. As a result, we believe this edition will prove even more effective for attracting students’ attention, enhancing their understanding, and promoting their retention of anatomical concepts.

- **EVERY ILLUSTRATION** has been revised, either partially or totally.
- **EVERY CHAPTER** has been extensively rewritten to
 - Engage students with an informal, friendly approach
 - Reposition figure callouts for easy reading and understanding
 - Place figures in a logical design that is both attractive and effective
 - Place figures as close to their anatomical descriptions as possible
 - Increase the number of bullet lists and numbered lists to better facilitate student learning
 - Use standardized terminology of the latest editions of *Terminologia Anatomica*, *Terminologia Histologica*, *Terminologia Embryologica*, and *Stedman’s Medical Dictionary*
- **NEW Chapter Opener Clinical Cases** have been added to every chapter. These clinical cases increase student interest in the topics and vividly demonstrate the importance of anatomical concepts in the health professions. In addition, all of the existing Clinical Notes features, found within the chapters, have been updated or replaced to reflect current topics and the latest research.
- **NEW Tips & Tools** boxes are concise, catchy memory devices to help students easily remember anatomical facts and concepts.
- **NEW Key Points** boxes give students a quick summary of the material discussed in the upcoming section of the chapter.
- **Improved text-art integration** throughout enhances the readability of figures with the text.
- **NEW MasteringA&P features** include the following:
 - Ready to Go Teaching Modules, created by teachers for teachers, are organized around eight of the toughest topics in human anatomy. They provide suggestions to instructors on which assets in MasteringA&P can best be used before, during, and after class to effectively teach the topic.
 - A Coaching Activity for the new Spotlight Figure in Chapter 17 on the sympathetic nervous system.
 - Revised and updated Dynamic Study Modules.

Chapter-by-Chapter Revisions

In addition to a significant rewriting of every chapter within the text, as outlined above, the following changes have been made in each chapter of the ninth edition of *Human Anatomy*:

1 Foundations: An Introduction to Anatomy

- Nine illustrations either are new or have been significantly revised.
- All Clinical Notes within this chapter have been revised.
- One new Tips & Tools box was added to this chapter.
- The section dealing with sectional anatomy was extensively revised to better facilitate student learning.

2 Foundations: The Cell

- Eight illustrations either are new or have been significantly revised.
- The sections dealing with the plasma membrane, cellular cytoskeleton and intercellular attachments were reorganized and revised to better facilitate student learning.

3 Foundations: Tissues and Early Embryology

- Sixteen illustrations either are new or have been significantly revised.
- Four new Tips & Tools boxes were added to this chapter.

4 The Integumentary System

- Nine illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

5 The Skeletal System: Osseous Tissue and Bone Structure

- Nine illustrations either are new or have been significantly revised.
- The sections dealing with blood and nerve supply to bones and factors regulating growth were reorganized and revised to better facilitate student learning.

6 The Skeletal System: Axial Division

- Twenty-nine illustrations either are new or have been significantly revised.
- Two new Tips & Tools boxes were added to this chapter.

7 The Skeletal System: Appendicular Division

- Twenty-four illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

8 The Skeletal System: Joints

- The chapter title has been changed from Articulations to Joints.
- Twenty-one illustrations either are new or have been significantly revised.
- The sections dealing with diarthroses (freely movable synovial joints) and the elbow and radio-ulnar joints were reorganized and revised.

9 The Muscular System: Skeletal Muscle Tissue and Muscle Organization

- Thirteen illustrations either are new or have been significantly revised.
- All sections dealing with the microanatomy and the physiology of skeletal muscle contraction were extensively revised.
- One new Tips & Tools box was added to this chapter.

10 The Muscular System: Axial Musculature

- Fourteen illustrations either are new or have been significantly revised.
- The organization of the sections dealing with muscles of the vertebral column and muscles of the perineum and the pelvic diaphragm was changed to better facilitate student learning.
- One new Tips & Tools box was added to this chapter.

11 The Muscular System: Appendicular Musculature

- Thirty illustrations either are new or have been significantly revised.
- Five new Tips & Tools boxes were added to this chapter.

12 Surface Anatomy and Cross-Sectional Anatomy

- Eighteen illustrations either are new or have been significantly revised.
- Four Clinical Note illustrations have been added to this chapter.

13 The Nervous System: Nervous Tissue

- The chapter title has been changed from Neural Tissue to Nervous Tissue.
- Sixteen illustrations either are new or have been significantly revised.
- The section dealing with synaptic transmission was reorganized and revised to better facilitate student learning.

14 The Nervous System: The Spinal Cord and Spinal Nerves

- Seventeen illustrations either are new or have been significantly revised.
- The sections dealing with the spinal meninges and the peripheral distribution of spinal nerves were reorganized and revised to better facilitate student learning.

15 The Nervous System: Sensory and Motor Tracts of the Spinal Cord

- Seven illustrations either are new or have been significantly revised.
- The entire chapter was significantly revised to better facilitate student learning.

16 The Nervous System: The Brain and Cranial Nerves

- Thirty-four illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

17 The Nervous System: Autonomic Nervous System

- Eleven illustrations either are new or have been significantly revised.
- All material describing the anatomy of the sympathetic nervous system was revised to better facilitate student learning
- A new Spotlight Figure on the sympathetic nervous system has been added.
- New material was added to clarify the anatomy of the sympathetic ganglia

18 The Nervous System: General and Special Senses

- Twenty-eight illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the general and special senses were extensively revised.

19 The Endocrine System

- Eleven illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the endocrine glands were extensively revised.
- All material describing the anatomy of the pituitary gland was reorganized and revised to better facilitate student learning.

20 The Cardiovascular System: Blood

- Eight illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

21 The Cardiovascular System: The Heart

- Twelve illustrations either are new or have been significantly revised.
- All material describing the anatomy of the pericardium and the surface anatomy of the heart were revised to better facilitate student learning.

22 The Cardiovascular System: Vessels and Circulation

- Twenty-six illustrations either are new or have been significantly revised.
- One new Tips & Tools box was added to this chapter.

23 The Lymphatic System

- Seventeen illustrations either are new or have been significantly revised.
- All sections dealing with the development and immunological functions of the lymphatic cells, lymphatic vessels, and lymph nodes were extensively revised.

24 The Respiratory System

- Eighteen illustrations either are new or have been significantly revised.
- The organization of several sections was changed to better facilitate student learning.

25 The Digestive System

- Twenty-three illustrations either are new or have been significantly revised.

26 The Urinary System

- Thirteen illustrations either are new or have been significantly revised.
- All sections dealing with the anatomy of the nephron were revised to better facilitate student learning
- All sections dealing with the physiology of the urinary system were extensively revised.

27 The Reproductive System

- Twenty-two illustrations either are new or have been significantly revised.
- All sections dealing with the physiology of the male and female reproductive systems were extensively revised

28 The Reproductive System: Embryology and Human Development

- All of the Embryology Summaries have been revised.

Acknowledgments

Once again, the creative talents and patience brought to this project by our artist team, William Ober, M.D., Claire E. Ober, R.N., and Anita Impagliazzo, M.F.A., are inspiring and valuable beyond expression. Bill, Claire, and Anita worked intimately and tirelessly with us, imparting a unity of vision to the book while making each illustration clear and beautiful. Their superb art program is greatly enhanced by the incomparable bone and cadaver photographs of Ralph T. Hutchings, formerly of The Royal College of Surgeons of England. In addition, Dr. Pietro Motta, Professor of Anatomy, University of Roma, La Sapienza, provided several superb SEM images for use in the text. Thanks also to Dr. Ruth Anne O’Keefe for her excellent work on the clinical material, and to Colonel (ret) Michael Yard of Indiana University – Purdue University Indianapolis, for his additional feedback on clinical cases and notes. We are grateful to Elise Lansdon of Elise Lansdon Design for her excellent work on the design of the ninth edition of *Human Anatomy*.

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We would like to acknowledge the many users and reviewers whose advice, comments, and collective wisdom helped shape this text into its final form. Their passion for the subject, their concern for accuracy and method of presentation, and their experience with students of widely varying abilities and backgrounds have made the revision process interesting and educating.

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We are very grateful to Adam Jaworski, Vice President, and Serina Beauparlant, Editor in Chief, for their continued enthusiasm and support of this project. We appreciate the contributions of Derek Perrigo, Senior Anatomy and Physiology Specialist, and Allison Rona, Executive Marketing Manager, who keep their fingers on the pulse of the market and help us meet the needs of our customers. Thanks also to the remarkable and tireless Pearson Science sales reps.

We are also grateful that the contributions of all the aforementioned people have led to this text receiving the following awards: the Association of Medical Illustrators Award, the Text and Academic Authors Award, the New York International Book Fair Award, the 35th Annual Bookbuilders West Award, and the 2010 Text and Academic Authors Association “Texty” Textbook Excellence Award.

Finally, we would like to thank our families for their love, patience, and support during the revision process. We could not have accomplished this without the help of our spouses—Kitty, Mary, and Mike.

In an effort to improve future editions, we ask that readers with pertinent information, suggestions, or comments concerning the organization or content of this textbook send their remarks to Robert Tallitsch directly, by the email address below, or care of Publisher, Applied Sciences, Pearson Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.

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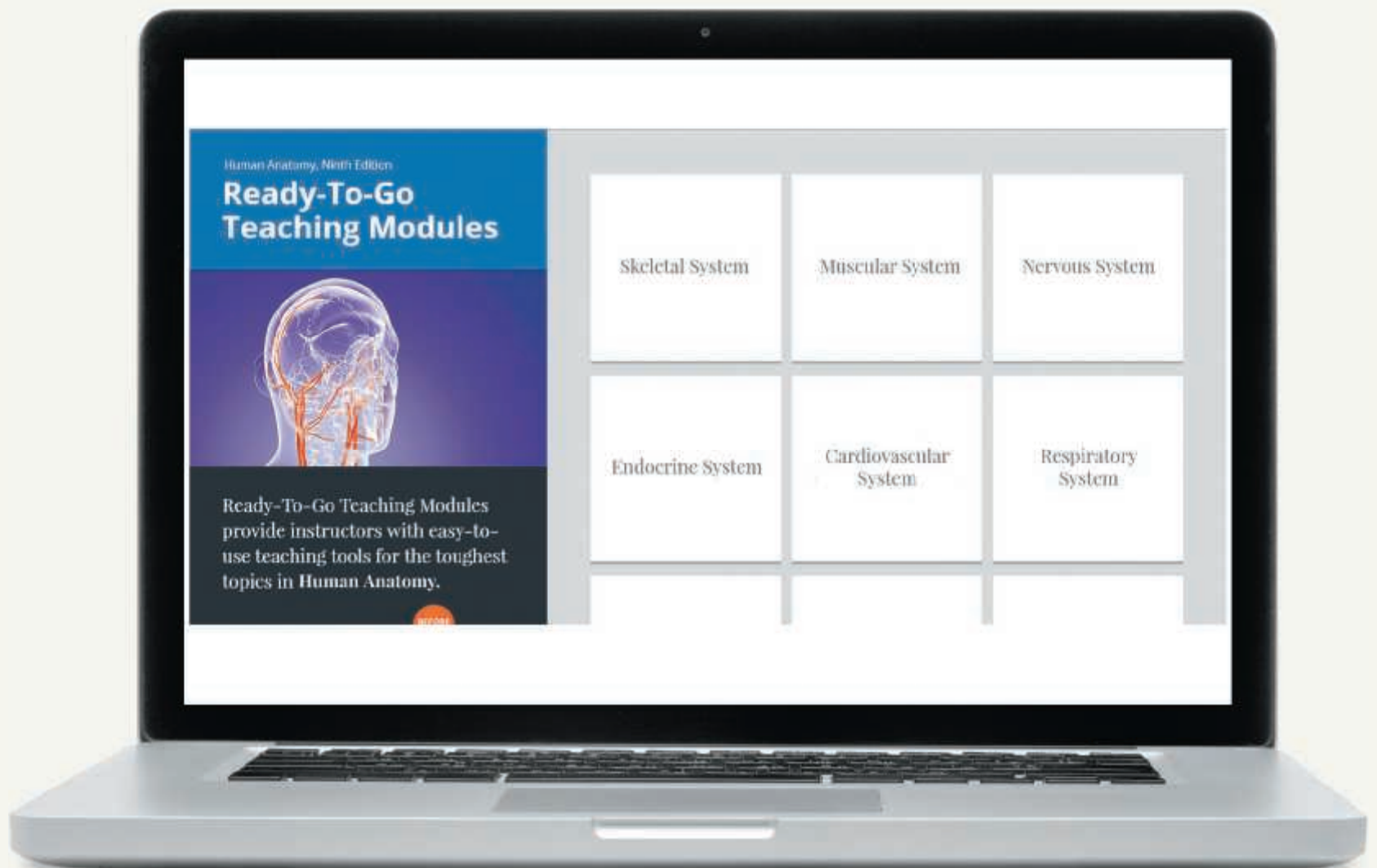
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Judi L. Nath

Get Ready for a Whole New Human Anatomy Experience

Celebrated author Judi Nath (*Fundamentals of Anatomy & Physiology* and *Visual Anatomy & Physiology*) brings a fresh voice and a clear, engaging writing style to the **Ninth Edition** of **Human Anatomy**. The Ninth Edition continues the Martini legacy of a visually stunning presentation with exceptionally clear photographs, detailed illustrations, and captivating clinical content.

NEW! Ready-to-Go Teaching Modules help instructors find the best assets to use before, during, and after class to teach the toughest topics in Human Anatomy. Created by teachers for teachers, these curated sets of teaching tools save you time by highlighting the most effective and engaging animations, videos, quizzing, coaching and active learning activities from MasteringA&P.



Prepare for the Classroom

New Study Tools

throughout each chapter help students understand and navigate the content.

NEW! Summary Boxes

at the beginning of each section outline the key points from that reading.

► **KEY POINT** Dermal ridges form friction ridges, ensuring a secure grip on objects. Dermal ridges also form fingerprints, a unique genetic identifier of an individual.

► **KEY POINT** The position of the wrist affects the functioning of the hand. Many muscles of the forearm, therefore, affect the actions of the wrist because (1) all of the muscles that flex or extend the wrist originate on the humerus, radius, and/or ulna and (2) many muscles that flex or extend the fingers originate on the radius and/or ulna.

TIPS & TOOLS

Remembering the names of the epidermal layers of thick skin

A mnemonic to help you remember the names of the epidermal layers of thick skin, from deep to superficial, is "Brent Spiner gained Lieutenant Commander" (basale, spinosum, granulosum, lucidum, corneum).

NEW! Tips & Tools

offer advice on how to approach some of the toughest topics.

TIPS & TOOLS

Here is a simple trick to remember the four anterior superficial forearm muscles originating from the medial epicondyle of the humerus. Hold both arms out, palms touching. Then slide your right hand proximally until your palm reaches your elbow with your fingers pointing toward your wrist. With each finger representing one of the four muscles, think PFPF: **P**ronator teres (index finger), **F**lexor carpi radialis (middle finger), **P**almaris longus (ring finger), and **F**lexor carpi ulnaris (little finger).

and Future Careers

NEW! Clinical Cases

help motivate students for their future careers. Each chapter opens with a story-based Clinical Case related to the chapter content and ends with a Clinical Case Wrap-Up.



CLINICAL NOTE

Skin Cancer

SKIN CANCER, the abnormal growth of skin cells, is often caused by exposure to UV radiation, primarily sunlight. **Basal cell carcinoma** originates in the stratum basale. This is the most common skin cancer and the slowest growing, and it most often arises in areas that receive UV exposure. Although basal cell carcinomas almost never metastasize, they should be treated quickly to prevent local spread.



Squamous cell carcinoma

Squamous cell carcinoma, the second most common skin cancer, is an uncontrolled growth of abnormal squamous cells in the epidermis. They most often occur in UV-exposed areas of skin, but tobacco can also be a trigger. They can metastasize to tissues, bones, and nearby lymph nodes, and they often cause local disfigurement.

Malignant melanoma develops in melanocytes in the basal layer. These cancerous melanocytes multiply rapidly and metastasize to distant sites. Malignant melanomas cause the most deaths from skin cancer.

Clinical Notes appear within every chapter, expand upon topics just discussed, and present diseases and pathologies along with their relationship to normal function.



CLINICAL CASE

A Neuroanatomist's Stroke of Insight

Dr. Jill Taylor, a neuroanatomist, is 37 and at the top of her field. One morning she develops a throbbing headache behind her left eye. She then notices that her thoughts and movements are slowing down. Soon she realizes her right arm is paralyzed, and she is barely able to call for help. When she arrives at the hospital, she cannot walk, talk, read, write, or recall anything. She feels her spirit surrender and braces for death.

Dr. Taylor awakes later that day, shocked to be alive. She still cannot speak or understand speech, or recognize or use numbers. She can, however, appreciate the irony of her situation: a neuroscientist (scientist who studies the brain) witnessing her very own brain emergency, an evolving cerebrovascular accident (CVA) or stroke. Doctors perform open brain surgery to remove a large blood clot that was pressing on the left side of her brain near her language area.

Will Dr. Taylor return to the Clinical Case Wrap-Up on p. 448.

A Neuroanatomist's Stroke of Insight

While her stroke affected the left side of Dr. Taylor's brain, the right side continued functioning. Because language and thoughts are typically controlled in the left hemisphere (the dominant hemisphere of a right-handed person), Dr. Taylor "sat in an absolutely silent mind" for the first month. Since the center for mathematical calculation is situated in the left hemisphere, she had to learn to use numbers all over again. And because the primary motor cortex governing the right side of the body resides in the precentral gyrus of the left hemisphere, she had to learn to use her right arm again. Full recovery took 8 years.

The stroke destroyed some brain cells, but others were able to form new neuronal connections. Neuroplasticity, this ability of nerve cells to make new connections, allows the brain to reorganize itself after injury.

Dr. Taylor wants anatomy students to know two things. First, "If you study the brain, you will never be bored." Second, "if you treat stroke patients like they will recover, they are more likely to recover." She has written a best-selling memoir about her experience, *My Stroke of Insight: A Brain Scientist's Personal Journey*.



1. How would you know, based on signs and symptoms, which side of Dr. Taylor's brain was injured by the stroke?
2. What is neuroplasticity, and why was it important in Dr. Taylor's recovery?

See the *View Answers* on the back of the book.

Clinical Terms end every chapter with a list of relevant clinical terms and definitions.

Related Clinical Terms

aphasia: A neurological condition caused by damage to the portions of the brain that are responsible for language.

ataxia: Loss of muscle coordination in the arms or legs due to cerebellar dysfunction.

chronic traumatic encephalopathy (CTE): A traumatic brain injury resulting from repeated sports-related head trauma.

concussion: A mild traumatic brain injury that may be accompanied by a period of unconsciousness.

dementia: A chronic or persistent disorder of the mental processes caused by brain disease or injury and marked by memory

disorders, personality changes, and impaired reasoning.

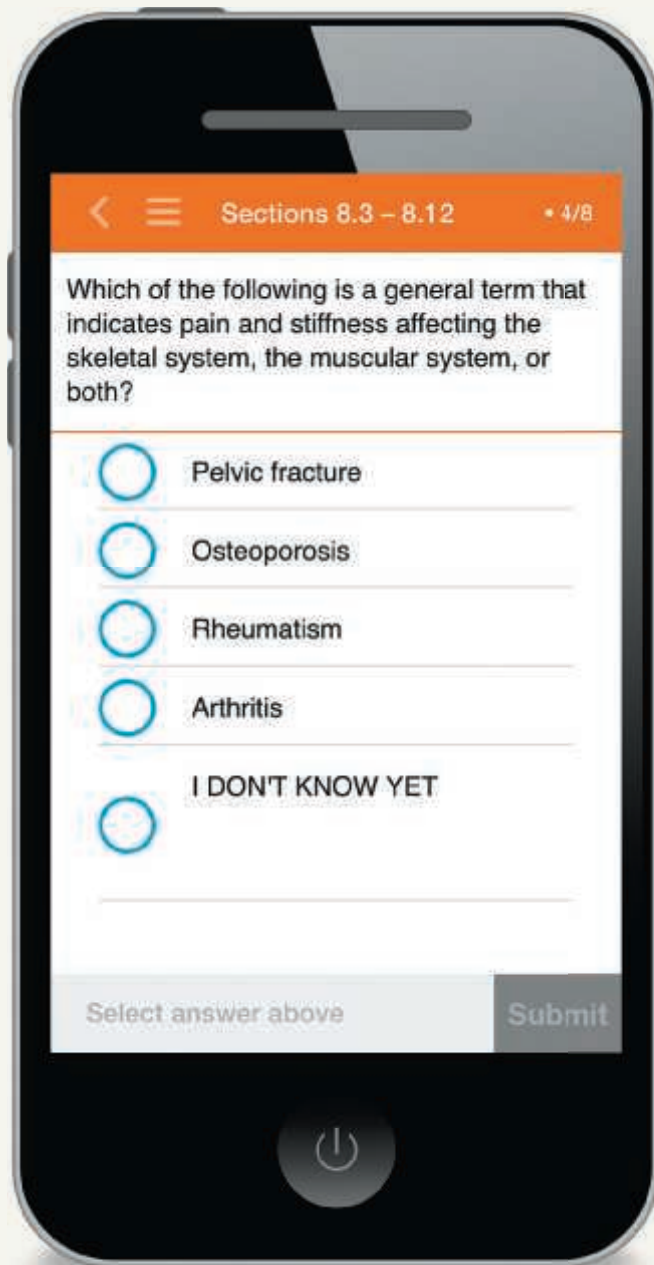
epidural hematoma: The accumulation of blood between the inner table of the skull and the dura mater.

hydrocephalus: A condition marked by an excessive accumulation of cerebrospinal fluid within the brain ventricles.

microcephaly: A birth defect in which the head circumference is much smaller than expected for the age and sex of the child.

Parkinson's disease: A neurological disorder resulting from a degeneration of the dopaminergic neurons in the substantia nigra.

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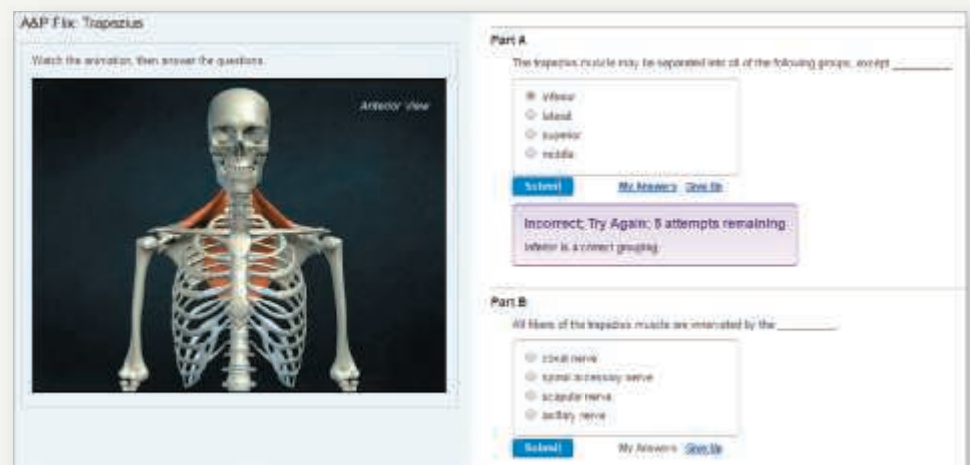
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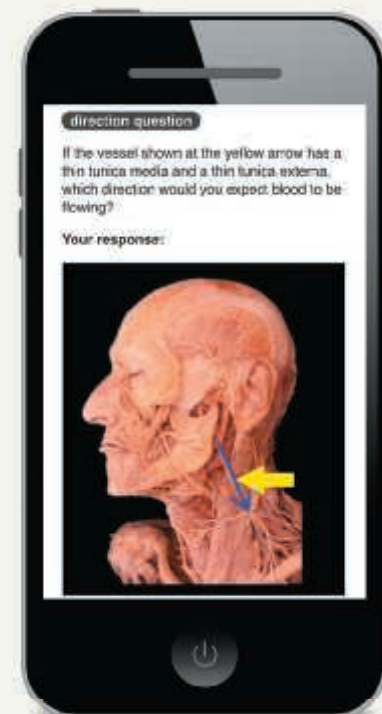
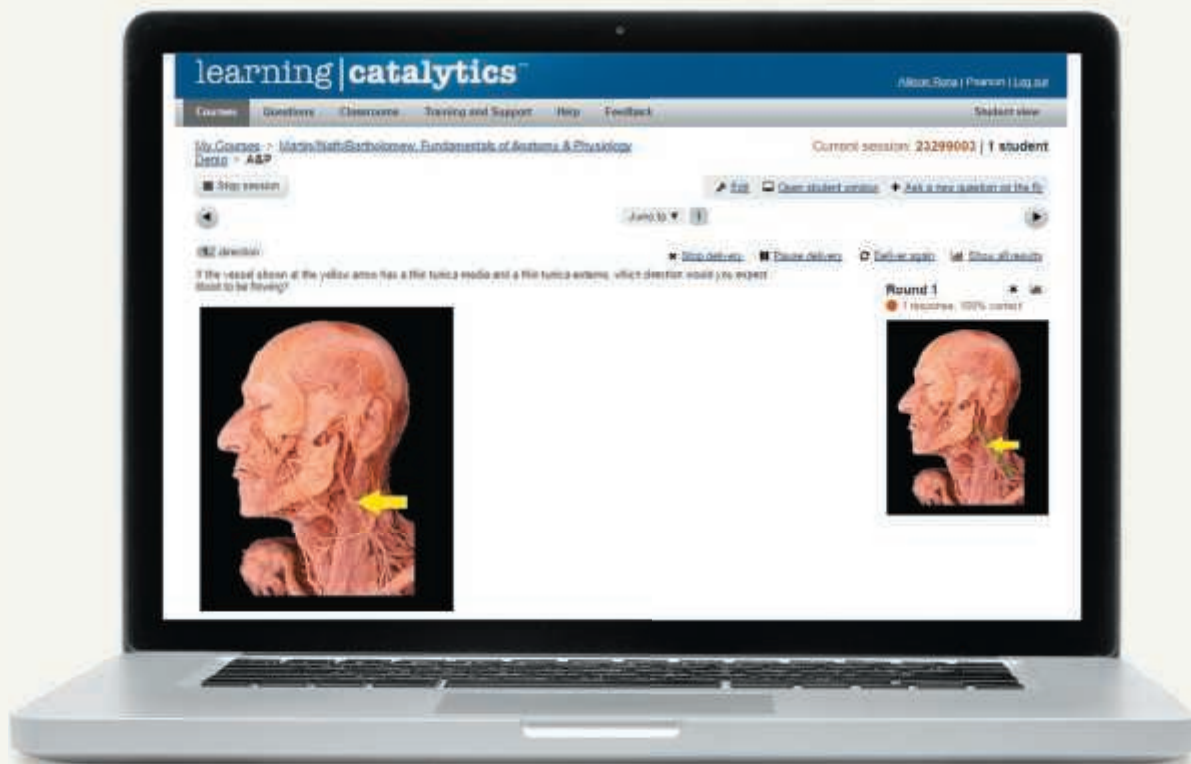
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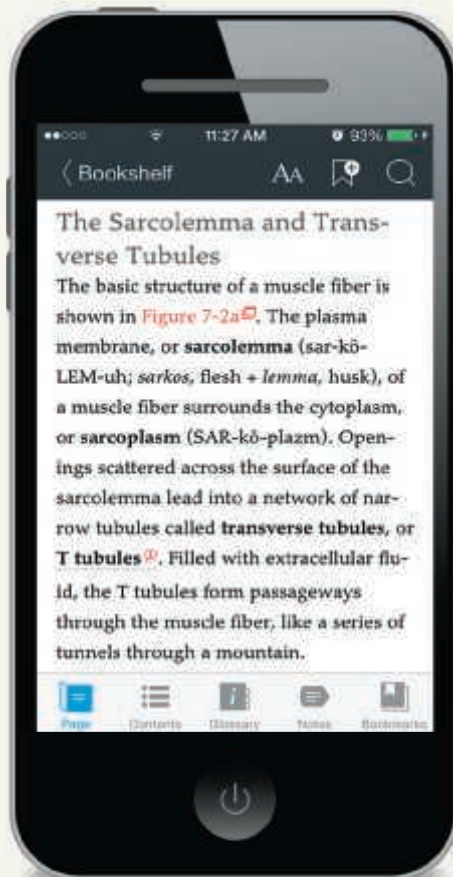
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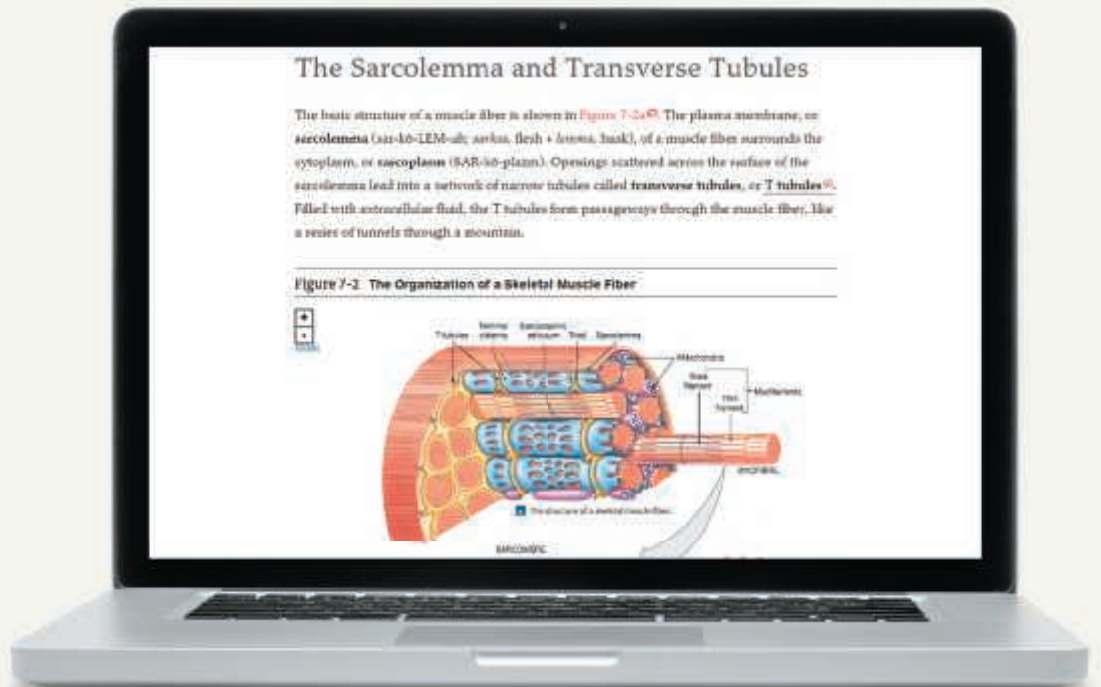
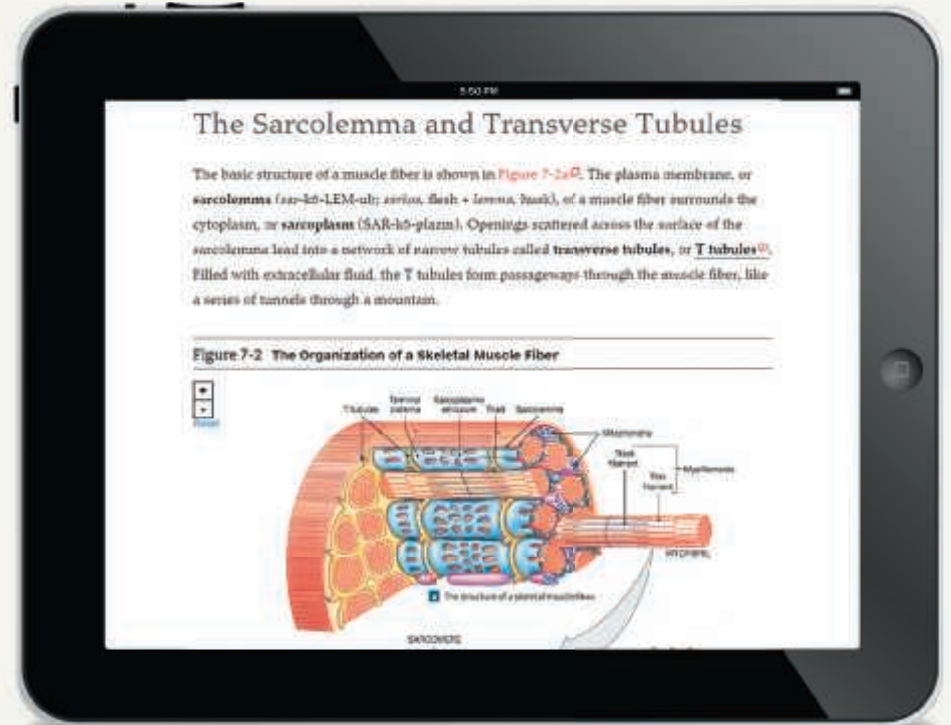
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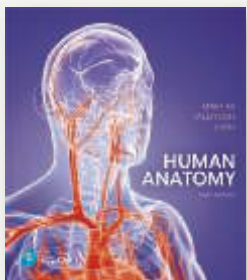


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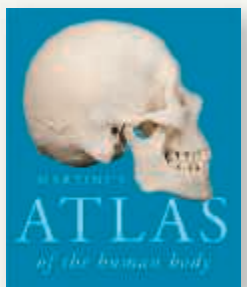
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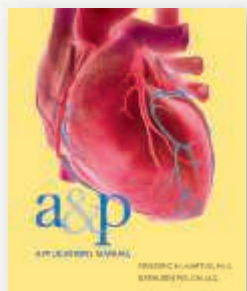
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Contents

1 FOUNDATIONS An Introduction to Anatomy 1

CLINICAL CASE | Using Anatomy to Save a Life 1

- 1.1 Microscopic Anatomy 2
- 1.2 Gross Anatomy 2
- 1.3 Other Types of Anatomical Studies 2
- 1.4 Levels of Organization 5
- 1.5 An Introduction to Organ Systems 7
- 1.6 The Language of Anatomy 14
 - Superficial Anatomy 14
 - Anatomical Landmarks 14
 - Anatomical Regions 16
 - Anatomical Directions 16
 - Sectional Anatomy 18
 - Planes and Sections 18
 - Body Cavities 18

CLINICAL NOTES

- The Diagnosis of Disease 4
- Disease, Pathology, and Diagnosis 7
- Pericarditis and Peritonitis 19
- Clinical Anatomy and Technology 20
- Study Outline 22
- Chapter Review 24
- Related Clinical Terms 26

2 FOUNDATIONS The Cell 27

CLINICAL CASE | Inheritance from Mom 27

- 2.1 Cellular Anatomy 28
 - The Plasma Membrane 30
 - Components of the Plasma Membrane 30
 - Membrane Permeability: Passive and Active Processes 30
 - Extensions of the Plasma Membrane: Microvilli 31
 - The Cytoplasm 31
 - The Cytosol 31
 - Organelles 34
 - Nonmembranous Organelles 34
 - The Cytoskeleton 34
 - Centrioles, Cilia, and Flagella 36
 - Ribosomes 36
 - Membranous Organelles 36
 - Mitochondria 37
 - The Nucleus 37
 - The Endoplasmic Reticulum 39

- The Golgi Apparatus 40
- Lysosomes 40
- Peroxisomes 42
- Membrane Flow 42

2.2 Intercellular Attachments 42

2.3 The Cell Life Cycle 42

- Interphase 43
- DNA Replication 43
- Mitosis 44

SPOTLIGHTS

- Membrane Permeability: Passive and Active Processes 32
- Functions of the Golgi Apparatus 41
- Mitosis 45

CLINICAL NOTE

- Bodybuilding 36
- Study Outline 46
- Chapter Review 47
- Related Clinical Terms 48

3 FOUNDATIONS Tissues and Early Embryology 49

CLINICAL CASE | The Tallest in the School 49

3.1 Epithelial Tissue 50

- Functions of Epithelial Tissue 50
- Specializations of Epithelial Cells 50
- Maintaining the Integrity of the Epithelium 52
 - Intercellular Connections 52
 - Attachment to the Basement Membrane 52
 - Epithelial Maintenance and Renewal 53
- Classification of Epithelia 53
 - Squamous Epithelia 53
 - Cuboidal Epithelia 54
 - Columnar Epithelia 54
 - Pseudostratified and Transitional Epithelia 54
- Glandular Epithelia 54
 - Type of Secretions 55
 - Structure of the Gland 56
 - Method of Secretion 58

3.2 Connective Tissues 59

- Classification of Connective Tissues 59
- Connective Tissue Proper 61
 - Cells of Connective Tissue Proper 61
 - Fibers of Connective Tissue Proper 62
 - Ground Substance of Connective Tissue Proper 63
 - Loose Connective Tissues 63
 - Dense Connective Tissues 65

Fluid Connective Tissues 65
Supporting Connective Tissues 67
Cartilage 67
Bone 68

3.3 Membranes 70

Mucous Membranes 71
Serous Membranes 71
The Cutaneous Membrane (Skin) 72
Synovial Membranes 72
Embryonic Connective Tissues 72

3.4 The Connective Tissue Framework of the Body 73

3.5 Muscle Tissue 74

Skeletal Muscle Tissue 74
Cardiac Muscle Tissue 74
Smooth Muscle Tissue 74

3.6 Nervous Tissue 76

3.7 Tissues and Aging 76

3.8 Summary of Early Embryology 78

■ SPOTLIGHT

Mechanisms of Glandular Secretion 60

■ CLINICAL NOTES

Liposuction 63

Do Chondroitin and Glucosamine Help Arthritis Pain? 73

Cell Division, Tumor Formation, and Cancer 77

Study Outline 82

Chapter Review 84

Related Clinical Terms 85

4 | The Integumentary System 86

■ CLINICAL CASE | Flesh-Eating Bacteria 86

4.1 Structure and Function of the Integumentary System 87

4.2 The Epidermis 88

Layers of the Epidermis 88
Stratum Basale 88
Stratum Spinosum 89
Stratum Granulosum 89
Stratum Lucidum 90
Stratum Corneum 90

Thick and Thin Skin 90

Dermal Ridges 91

Skin Color 91

Dermal Blood Supply 91

Epidermal Pigments 91

4.3 The Dermis 92

Dermal Organization 92

Wrinkles, Stretch Marks, and Tension Lines 92

Other Dermal Components 93

Blood Supply to the Skin 93

Nerve Supply to the Skin 94

4.4 The Subcutaneous Layer 94

4.5 Accessory Structures 95

Hair Follicles and Hair 95

Hair Production 96

Follicle Structure 96

Functions of Hair 96

Types of Hairs 96

Hair Color 96

Growth and Replacement of Hair 96

Glands in the Skin 96

Sebaceous Glands 96

Sweat Glands 98

Control of Glandular Secretions 100

Other Integumentary Glands 100

Nails 102

4.6 Local Control of Integumentary Function 102

4.7 Aging and the Integumentary System 102

■ CLINICAL NOTES

Skin Cancer 94

Acne and Seborrheic Dermatitis 98

Repairing Injuries to the Skin 101

Study Outline 103

Chapter Review 105

Related Clinical Terms 106

5 | THE SKELETAL SYSTEM

Osseous Tissue and Bone Structure 107

■ CLINICAL CASE | Pushing Beyond Her Limits 107

5.1 Structure and Function of Bone 108

The Histological Organization of Mature Bone 108

The Matrix of Bone 108

The Cells of Mature Bone 108

Compact and Spongy Bone 109

Structural Differences between Compact and Spongy Bone 110

Functional Differences between Compact and Spongy Bone 111

The Periosteum and Endosteum 112

5.2 Bone Development and Growth 113

Intramembranous Ossification 113

Endochondral Ossification 113

Epiphyseal Closure 113

Increasing the Diameter of a Developing Bone 113

Blood and Nerve Supply to Bones 114

Factors Regulating Bone Growth 114

5.3 Bone Maintenance, Remodeling, and Repair 118

Remodeling of Bone 119

Injury and Repair 120

Aging and the Skeletal System 120

5.4 Anatomy of Skeletal Elements 120

Classification of Bone Shapes 121

Bone Markings 121

5.5 Integration with Other Systems 125

■ SPOTLIGHTS

Intramembranous Ossification 115

Endochondral Ossification 116

■ CLINICAL NOTES

Fractures and Their Repair 122

Osteoporosis 125

Congenital Disorders of the Skeleton 126

Examination of the Skeletal System 127

Study Outline 127

Chapter Review 129

Related Clinical Terms 130

6 | THE SKELETAL SYSTEM

Axial Division 131

■ CLINICAL CASE | The Last Lap 131

6.1 The Skull and Associated Bones 133

6.2 Sutures of the Skull 140

6.3 Bones of the Cranium 140

Occipital Bone 140

Parietal Bones 145

Frontal Bone 145

Temporal Bones 145

Sphenoid 148

Ethmoid 149

Cranial Fossae 149

6.4 Bones of the Face 150

The Maxillae 150

The Palatine Bones 150

The Nasal Bones 152

The Inferior Nasal Conchae 153

The Zygomatic Bones 153

The Lacrimal Bones 153

The Vomer 153

The Mandible 153

6.5 The Orbits, Nasal Complex and the Hyoid Bone 154

The Orbits 154

The Nasal Complex 154

The Paranasal Sinuses 154

The Hyoid Bone 156

6.6 The Skulls of Infants, Children, and Adults 156

6.7 The Vertebral Column 158

Spinal Curves 158

Vertebral Anatomy 158

The Vertebral Body 158

The Vertebral Arch 158

The Articular Processes 158

Vertebral Articulation 158

Vertebral Regions 158

Cervical Vertebrae 160

The Atlas (C₁) 162

The Axis (C₂) 162

Vertebra Prominens (C₇) 162

Thoracic Vertebrae 162

Lumbar Vertebrae 162

The Sacrum 162

The Coccyx 165

6.8 The Thoracic Cage 167

The Ribs 167

The Sternum 168

■ CLINICAL NOTES

Coccygeal Fractures 157

Spina Bifida 161

Kyphosis, Lordosis, and Scoliosis 166

Study Outline 168

Chapter Review 170

Related Clinical Terms 171

7 | THE SKELETAL SYSTEM

Appendicular Division 172

■ CLINICAL CASE | Double Jeopardy 172

7.1 The Pectoral Girdle and Upper Limb 174

The Pectoral Girdle 174

The Clavicle 174

The Scapula 174

The Upper Limb 177

The Humerus 177

The Ulna 177

The Radius 177

The Carpal Bones 182

The Proximal Carpal Bones 182

The Distal Carpal Bones 182

The Metacarpals and Phalanges 182

7.2 The Pelvic Girdle and Lower Limb 184

The Pelvic Girdle 185

The Hip Bones 185

The Pelvis 185

The Lower Limb 185

The Femur 190

The Patella 193

The Tibia 193

The Fibula 193

The Tarsal Bones 196

The Metatarsals and Phalanges 196

7.3 Individual Variation in the Skeletal System 197

■ CLINICAL NOTES

Scaphoid Fractures 184

Hip Dysplasia 198

Women and Sports Injuries 199

Study Outline 200

Chapter Review 201

Related Clinical Terms 202

8 THE SKELETAL SYSTEM

Joints 203

CLINICAL CASE | Why Does My Knee Hurt So Much? 203

8.1 Joint Classification 204

- Synarthroses (Immovable Joints) 204
- Amphiarthroses (Slightly Movable Joints) 204
- Diarthroses (Freely Movable Synovial Joints) 204
 - Synovial Fluid 204
 - Accessory Structures 205
 - Strength versus Mobility 206

8.2 Articular Form and Function 207

- Describing Dynamic Motion and the Structural Classification of Synovial Joints 207
- Types of Movements 207
 - Angular Motion 207
 - Rotation 207
 - Special Movements 207

8.3 The Temporomandibular Joint 212

8.4 Intervertebral Joints 212

- Zygapophysial Joints 212
- The Intervertebral Discs 213
- Intervertebral Ligaments 215
- Vertebral Movements 215

8.5 The Shoulder Complex 216

- The Sternoclavicular Joint 216
- The Shoulder Joint 217
 - Ligaments 217
 - Skeletal Muscles and Tendons 217
 - Bursae 217

8.6 The Elbow and Radio-ulnar Joints 219

- The Elbow Joint 219
- The Radio-ulnar Joints 221

8.7 The Joints of the Wrist and Hand 221

- The Joints of the Wrist 221
 - Wrist Stability 221
- The Joints of the Hand 221

8.8 The Hip Joint 222

- The Articular Capsule 223
- Hip Stabilization 223

8.9 The Knee Joint 224

- The Articular Capsule 225
- Supporting Ligaments 225
- Locking of the Knee 225

8.10 The Joints of the Ankle and Foot 228

- The Ankle Joint 228
- The Joints of the Foot 228

8.11 Aging and Joints 231

SPOTLIGHT

Joint Motion 208

CLINICAL NOTES

- Dislocation of a Synovial Joint 206
- Problems with Intervertebral Discs 214
- Ankylosing Spondylitis 215
- Shoulder Injuries 219
- Ankle Injuries 229
- Study Outline 231
- Chapter Review 233
- Related Clinical Terms 234

9 THE MUSCULAR SYSTEM

Skeletal Muscle Tissue and Muscle Organization 235

CLINICAL CASE | A Case of Asymmetrical Development 235

9.1 Functions of Skeletal Muscle 236

9.2 Anatomy of Skeletal Muscles 236

- Gross Anatomy 236
- Connective Tissue 236
- Nerves and Blood Vessels 237
- Microanatomy of Skeletal Muscle Fibers 238
- Myofibrils and Myofilaments 238
- Sarcomere Organization 241

9.3 Muscle Contraction 243

- The Sliding Filament Theory 243
- Neural Control of Muscle Fiber Contraction 243
- Muscle Contraction: A Summary 243

9.4 Motor Units and Muscle Control 247

- Muscle Tone 247
- Muscle Hypertrophy 247
- Muscle Atrophy 248

9.5 Types of Skeletal Muscle Fibers 248

- Distribution of Fast, Slow, and Intermediate Fibers 249

9.6 Organization of Skeletal Muscle Fibers 249

- Parallel Muscles 250
- Convergent Muscles 251
- Pennate Muscles 251
- Circular Muscles 251

9.7 Muscle Terminology 251

- Origins and Insertions 251
- Actions 251
- Names of Skeletal Muscles 252

9.8 Levers and Pulleys: A System Designed for Movement 253

9.9 Aging and the Muscular System 253

■ SPOTLIGHTS

Sliding Filament Theory 244
Levers and Pulleys 254

■ CLINICAL NOTES

Fibromyalgia 238
Delayed-Onset Muscle Soreness 242
Rigor Mortis 243

Study Outline 256
Chapter Review 257
Related Clinical Terms 258

10 | THE MUSCULAR SYSTEM

Axial Musculature 259

■ CLINICAL CASE | Waking with a Crooked Smile 259

10.1 The Four Groups of Axial Muscles 260

10.2 Muscles of the Head and Neck 262

Muscles of Facial Expression 262

Extra-ocular Muscles 264

Muscles of Mastication 266

Muscles of the Tongue 267

Muscles of the Pharynx 267

Anterior Muscles of the Neck 269

10.3 Muscles of the Vertebral Column 270

The Superficial Layer of the Intrinsic Back Muscles 270

The Intermediate Layer of the Intrinsic Back Muscles 270

The Deep Layer of the Intrinsic Back Muscles 270

Spinal Flexors 272

10.4 Oblique and Rectus Muscles 273

The Diaphragm 275

10.5 Muscles of the Perineal Region and the Pelvic Diaphragm 277

■ CLINICAL NOTE

Botox 266

Study Outline 279
Chapter Review 280
Related Clinical Terms 281

11 | THE MUSCULAR SYSTEM

Appendicular Musculature 282

■ CLINICAL CASE | Hamstrung 282

11.1 Factors Affecting Appendicular Muscle Function 283

11.2 Muscles of the Pectoral Girdle and Upper Limb 286

Muscles That Position the Pectoral Girdle 286

Muscles That Move the Arm 288

Muscles That Move the Forearm and Hand 292

Muscles That Move the Hand and Fingers 294

Extrinsic Muscles of the Hand 296

Intrinsic Muscles of the Hand 298

11.3 Compartments and Sectional Anatomy of the Arm and Forearm 301

11.4 Muscles of the Pelvic Girdle and Lower Limb 303

Muscles That Move the Thigh 304

Muscles That Move the Leg 306

Muscles That Move the Foot and Toes 309

Extrinsic Muscles of the Foot 309

Intrinsic Muscles of the Foot 315

11.5 Compartments and Sectional Anatomy of the Thigh and Leg 319

■ SPOTLIGHT

Factors Affecting Appendicular Muscle Function 284

■ CLINICAL NOTES

Sports Injuries 294

Carpal Tunnel Syndrome 296

Calcaneal Tendon Rupture 316

Compartment Syndrome 319

Study Outline 321

Chapter Review 323

Related Clinical Terms 324

12 | Surface Anatomy and Cross-Sectional Anatomy 325

■ CLINICAL CASE | Breathing Through Your Neck 325

12.1 Surface Anatomy: A Regional Approach 326

Head and Neck 326

Thorax 328

Abdomen 329

Shoulder and Arm 330

Arm, Forearm, and Wrist 331

Pelvis and Thigh 332

Leg and Foot 333

12.2 Cross-Sectional Anatomy 334

Cross Section at the Level of the Optic Chiasm 334

Cross Section at the Level of Vertebra C₂ 335

Cross Section at the Level of Vertebra T₂ 335

Cross Section at the Level of Vertebra T₈ 336

Cross Section at the Level of Vertebra T₁₀ 336

Cross Section at the Level of Vertebra T₁₂ 337

Cross Section at the Level of Vertebra L₅ 337

■ CLINICAL NOTES

Heart Sounds 328

Lumbar Puncture 328

Venipuncture 331

Femoral Artery 332

Breathing Through Your Neck 337

13 THE NERVOUS SYSTEM

Nervous Tissue 338

CLINICAL CASE | When Nerves Become Demyelinated 338

13.1 An Overview of the Nervous System 339

13.2 Cellular Organization in Nervous Tissue 340

13.3 Neuroglia 342

Neuroglia of the CNS 342

Astrocytes 342

Oligodendrocytes 342

Microglia 343

Ependymal Cells 343

Neuroglia of the PNS 343

Satellite Cells 343

Schwann Cells 344

13.4 Neurons 348

Neuron Classification 348

Structural Classification of Neurons 348

Functional Classification of Neurons 348

13.5 Regeneration of Nervous Tissue 350

13.6 The Nerve Impulse 350

13.7 Synaptic Communication 351

Chemical Synapses 351

Electrical Synapses 352

13.8 Neuron Organization and Processing 353

13.9 Anatomical Organization of the Nervous System 354

SPOTLIGHT

Myelination 346

CLINICAL NOTE

Myasthenia Gravis 355

Study Outline 355

Chapter Review 357

Related Clinical Terms 359

14 THE NERVOUS SYSTEM

The Spinal Cord and Spinal Nerves 360

CLINICAL CASE | A Case of the Bends 360

14.1 Gross Anatomy of the Spinal Cord 361

14.2 Spinal Meninges 361

The Dura Mater 361

The Arachnoid Mater 364

The Pia Mater 364

14.3 Sectional Anatomy of the Spinal Cord 364

Organization of Gray Matter 364

Organization of White Matter 364

14.4 Spinal Nerves 366

Peripheral Distribution of Spinal Nerves 367

14.5 Nerve Plexuses 367

The Cervical Plexus 368

The Brachial Plexus 374

The Lumbar and Sacral Plexuses 374

14.6 Reflexes 374

Classification of Reflexes 380

Spinal Reflexes 380

Higher Centers and Integration of Reflexes 380

SPOTLIGHTS

The Cervical and Brachial Plexuses 370

The Lumbar and Sacral Plexuses 376

CLINICAL NOTES

Spinal Cord Injuries 366

Testing Sensory Nerves 372

Localized Peripheral Neuropathies 375

Lumbar Puncture and Spinal Anesthesia 375

Study Outline 382

Chapter Review 384

Related Clinical Terms 386

15 THE NERVOUS SYSTEM

Sensory and Motor Tracts of the Spinal Cord 387

CLINICAL CASE | Amyotrophic Lateral Sclerosis 387

15.1 Organization and Patterns of Spinal Cord Tracts 388

15.2 Sensory Tracts 388

The Posterior Columns 388

The Spinothalamic Tracts 394

The Spinocerebellar Tracts 394

15.3 Motor Tracts 394

The Corticospinal Tracts 394

The Corticobulbar Tracts 394

The Lateral and Anterior Corticospinal Tracts 394

The Motor Homunculus 396

The Subconscious Motor Pathways 396

The Vestibulospinal Tracts 396

The Tectospinal Tracts 396

The Medial Reticulospinal Tracts 396

The Rubrospinal Tracts 398

15.4 Levels of Somatic Motor Control 398

SPOTLIGHT

Organization of Spinal Cord Tracts 390

CLINICAL NOTE

Multiple Sclerosis 397

Study Outline 400

Chapter Review 401

Related Clinical Terms 402

16 | THE NERVOUS SYSTEM

The Brain and Cranial Nerves 403

CLINICAL CASE | A Neuroanatomist's Stroke of Insight 403

16.1 An Introduction to the Organization of the Brain 404

Embryology of the Brain 404

Major Regions and Landmarks 404

The Medulla Oblongata 404

The Pons 404

The Mesencephalon (Midbrain) 404

The Diencephalon 404

The Cerebellum 406

The Cerebrum 406

Gray Matter and White Matter Organization 406

The Ventricular System of the Brain 406

16.2 Protection and Support of the Brain 406

The Cranial Meninges 406

The Dura Mater 408

The Arachnoid Mater 409

The Pia Mater 409

The Blood Brain Barrier 409

Cerebrospinal Fluid 410

Formation of CSF 410

Circulation of CSF 410

The Blood Supply to the Brain 412

16.3 The Medulla Oblongata 413

16.4 The Pons 414

16.5 The Mesencephalon (Midbrain) 415

16.6 The Diencephalon 417

The Epithalamus 417

The Thalamus 417

Functions of Thalamic Nuclei 417

The Hypothalamus 418

Functions of the Hypothalamus 418

16.7 The Cerebellum 422

16.8 The Cerebrum 422

The Cerebral Hemispheres 424

The Cerebral Lobes 424

Motor and Sensory Areas of the Cerebral Cortex 425

Association Areas 425

Higher-Order Functions 425

Integrative Centers of the Cerebral Cortex 427

The Specialized Language Areas in the Brain 427

The Prefrontal Cortex 428

Hemispheric Lateralization 428

The Central White Matter 428

The Basal Nuclei 429

Functions of the Basal Nuclei 429

The Limbic System 431

16.9 The Cranial Nerves 434

The Olfactory Nerves (I) 434

The Optic Nerves (II) 435

The Oculomotor Nerves (III) 436

The Trochlear Nerves (IV) 436

The Trigeminal Nerves (V) 437

The Abducens Nerves (VI) 438

The Facial Nerves (VII) 438

The Vestibulocochlear Nerves (VIII) 439

The Glossopharyngeal Nerves (IX) 440

The Vagus Nerves (X) 440

The Accessory Nerves (XI) 441

The Hypoglossal Nerves (XII) 442

CLINICAL NOTES

Traumatic Brain Injuries 411

Cerebellar Dysfunction 422

Microcephaly and Hydrocephalus 427

Damage to the Specialized Language Areas 428

Alzheimer's Disease 432

Tic Douloureux 438

Bell's Palsy 439

Dementia and Alzheimer's Disease 443

Cranial Reflexes 444

Study Outline 445

Chapter Review 447

Related Clinical Terms 448

17 | THE NERVOUS SYSTEM

Autonomic Nervous System 449

CLINICAL CASE | First Day of Anatomy Lab 449

17.1 A Comparison of the Somatic and Autonomic Nervous Systems 450

Sympathetic and Parasympathetic Subdivisions of the ANS 450

17.2 The Sympathetic Division 450

Sympathetic Chain Ganglia 450

Collateral Ganglia 451

Anatomy of the Collateral Ganglia 451

Adrenal Medullae 457

Effects of Sympathetic Stimulation 457

Sympathetic Activation and Neurotransmitter Release 458

Membrane Receptors and Sympathetic Function 458

A Summary of the Sympathetic Division 458

17.3 The Parasympathetic Division 459

Organization and Anatomy of the Parasympathetic Division 459

General Functions of the Parasympathetic Division 460

Parasympathetic Activation and Neurotransmitter Release 462

Plasma Membrane Receptors and Responses 462

Summary: Parasympathetic Division 462

17.4 Relationship between the Sympathetic and Parasympathetic Divisions 462

Anatomy of Dual Innervation 462

Visceral Reflexes 463

■ SPOTLIGHTS

An Introduction to the Autonomic Nervous System 452

A Review of the Sympathetic Nervous System 454

■ CLINICAL NOTES

Sympathetic Function: Too Little, Too Much 459

Urinary Bladder Dysfunction Following Spinal Cord Injury 465

Sexual Dysfunction After Spinal Cord Injury 466

Dysautonomia 466

Study Outline 466

Chapter Review 468

Related Clinical Terms 470

18 | THE NERVOUS SYSTEM

General and Special Senses 471

■ CLINICAL CASE | Why Am I So Dizzy? 471

18.1 Receptors 472

Interpretation of Sensory Information 472

Central Processing and Adaptation 472

Sensory Limitations 473

18.2 The General Senses 473

Nociceptors 473

Thermoreceptors 474

Mechanoreceptors 474

Tactile Receptors 474

Baroreceptors 474

Proprioceptors 476

Chemoreceptors 476

18.3 Olfaction (Smell) 476

Olfactory Sensory Neurons 477

Olfactory Pathways 477

Olfactory Discrimination 477

18.4 Gustation (Taste) 478

Gustatory Epithelial Cells (Taste Receptors) 479

Gustatory Pathways 479

Gustatory Discrimination 479

18.5 Equilibrium and Hearing 480

The External Ear 480

The Middle Ear 480

The Auditory Ossicles 482

The Internal Ear 482

The Cochlear Duct and Hearing 482

The Vestibular Complex and Equilibrium 483

Hearing 485

The Cochlea 485

Sound Detection 486

Auditory Pathways 487

18.6 Vision 491

Accessory Structures of the Eye 491

Eyelids 491

The Lacrimal Apparatus 492

The Eye 492

The Fibrous Layer 495

The Vascular Layer 496

The Inner Layer (Retina) 496

The Chambers of the Eye 498

The Lens 499

Visual Pathways 499

Cortical Integration 500

The Brainstem and Visual Processing 500

■ CLINICAL NOTES

Hearing Loss 487

Disorders of the Eye 493

Nystagmus 499

Study Outline 501

Chapter Review 503

Related Clinical Terms 505

19 | The Endocrine System 506

■ CLINICAL CASE | Why Am I So Cold and Tired? 506

19.1 An Overview of the Endocrine System 507

19.2 Hypothalamus and the Pituitary Gland 508

Hypophyseal Portal System 508

The Anterior Lobe of the Pituitary Gland 508

The Posterior Lobe of the Pituitary Gland 509

19.3 The Thyroid Gland 509

Thyroid Follicles and Thyroid Hormones 512

The C Thyrocytes of the Thyroid Gland 514

19.4 The Parathyroid Glands 515

19.5 The Thymus 516

19.6 The Adrenal Glands 516

The Adrenal Cortex 516

The Zona Glomerulosa 516

The Zona Fasciculata 516

The Zona Reticularis 516

The Adrenal Medulla 518

19.7 Endocrine Functions of the Kidneys and Heart 518

19.8 The Pancreas and Other Endocrine Tissues of the Digestive System 518

The Pancreas 518

19.9 Endocrine Tissues of the Reproductive System 520

Testes 520

Ovaries 521

19.10 The Pineal Gland 521

19.11 Hormones and Aging 524

■ SPOTLIGHT

Neuroendocrine Integration: The Hypothalamus and Pituitary Gland 510

■ CLINICAL NOTES

Diabetes Insipidus 509

Diabetes Mellitus 520

Endocrine Disorders 522

Study Outline 524

Chapter Review 526

Related Clinical Terms 527

20 | THE CARDIOVASCULAR SYSTEM

Blood 528

CLINICAL CASE | A Surplus of WBCs 528

20.1 Functions and Composition of the Blood 529

Plasma 529

Differences between Plasma and Interstitial Fluid 529

The Plasma Proteins 531

20.2 Formed Elements 531

Red Blood Cells (RBCs) 531

Structure of RBCs 532

RBC Life Span and Circulation 532

RBCs and Hemoglobin 532

Blood Types 533

White Blood Cells (WBCs) 534

Granular Leukocytes 535

Neutrophils 535

Eosinophils 535

Basophils 535

Agranular Leukocytes 536

Monocytes 536

Lymphocytes 536

Platelets 536

20.3 Hemopoiesis 539

Erythropoiesis 539

Leukopoiesis 541

CLINICAL NOTES

Disorders of the Blood, Blood Doping, and Treatments for Blood Disorders 538

Study Outline 541

Chapter Review 543

Related Clinical Terms 544

21 | THE CARDIOVASCULAR SYSTEM

The Heart 545

CLINICAL CASE | A Broken Heart 545

21.1 An Overview of the Cardiovascular System 546

21.2 The Pericardium 546

21.3 Structure of the Heart Wall 548

Cardiac Muscle Tissue 548

The Intercalated Discs 548

The Cardiac Skeleton 548

21.4 Orientation and Superficial Anatomy of the Heart 550

21.5 Internal Anatomy and Organization of the Heart 553

The Right Atrium 553

The Right Ventricle 554

The Left Atrium 554

The Left Ventricle 554

Structural Differences between the Right and Left Ventricles 554

The Structure and Function of Heart Valves 555

21.6 Coronary Blood Vessels 555

The Right Coronary Artery 555

The Left Coronary Artery 559

The Coronary Veins 559

21.7 The Coordination of Cardiac Contractions 559

21.8 The Cardiac Cycle 562

21.9 Autonomic Control of Heart Rate 562

SPOTLIGHT

The Conducting System and the Cardiac Cycle 560

CLINICAL NOTES

Pericarditis, Myocarditis, and Epicarditis 552

Heart Murmurs 555

Coronary Artery Disease and Myocardial Infarction 558

Study Outline 563

Chapter Review 565

Related Clinical Terms 566

22 | THE CARDIOVASCULAR SYSTEM

Vessels and Circulation 567

CLINICAL CASE | In the Absence of Capillaries 567

22.1 Histological Organization of Blood Vessels 568

Distinguishing Arteries from Veins 568

Arteries 568

Elastic Arteries 568

Muscular Arteries 569

Arterioles 569

Capillaries 569

Capillary Beds 572

Veins 572

Venules 572

Medium-Sized Veins 572

Venous Valves 574

Large Veins 574

22.2 The Distribution of Blood 574

22.3 Blood Vessel Distribution 575

22.4 The Pulmonary Circuit 576

22.5 Systemic Arteries 576

The Aorta 579

The Ascending Aorta and the Aortic Arch 579

The Subclavian Arteries 579

The Carotid Arteries and the Blood Supply to the Brain 582

The Descending Aorta 585

The Thoracic Aorta 585

The Abdominal Aorta 585

Arteries of the Pelvis and Lower Limbs 587

22.6 Systemic Veins 590

The Superior Vena Cava 590

Venous Return from the Cranium 590

Venous Return from the Upper Limb 593

The Formation of the Superior Vena Cava 594

The Inferior Vena Cava 594
Veins Draining the Lower Limb 594
Veins Draining the Pelvis 594
Veins Draining the Abdomen 594
The Hepatic Portal System 594

22.7 Cardiovascular Changes at Birth 596

22.8 Aging and the Cardiovascular System 598

■ SPOTLIGHT

The Structure of Blood Vessels 570

■ CLINICAL NOTES

Arteriosclerosis 569

Repair of an Aortic Aneurysm 585

Congenital Cardiovascular Problems 598

Study Outline 599

Chapter Review 600

Related Clinical Terms 602

23 | The Lymphatic System 603

■ CLINICAL CASE | Fighting a Zoonotic Disease 603

23.1 An Overview of the Lymphatic System 604

Functions of the Lymphatic System 604

23.2 Structure of Lymphatic Vessels 605

Lymphatic Capillaries 605

Larger Lymphatic Vessels 606

23.3 Major Lymph-Collecting Vessels 606

The Thoracic Duct 607

The Right Lymphatic Duct 607

23.4 Lymphocytes 607

Types of Lymphocytes 607

T Cells 608

B Cells 608

NK Cells 610

Lymphocytes and the Immune Response 610

Distribution and Life Span of Lymphocytes 610

Lymphocytopoiesis: Lymphocyte Production 610

23.5 Lymphatic Tissues 610

23.6 Lymphatic Organs 612

Lymph Nodes 612

Distribution of Lymphatic Tissues and Lymph Nodes 613

The Thymus 616

The Spleen 618

Surfaces of the Spleen 618

Histology of the Spleen 618

23.7 Aging and the Lymphatic System 619

■ SPOTLIGHT

Lymphocyte Formation and Immunity 609

■ CLINICAL NOTES

Infected Lymphatic Nodules 611

HIV/AIDS 614

Lymphatic Vessels and Metastatic Cancer 617

Lymphoma 619

Study Outline 620

Chapter Review 621

Related Clinical Terms 623

24 | The Respiratory System 624

■ CLINICAL CASE | How Long Should This Cough Last? 624

24.1 An Overview of the Respiratory System and Respiratory Tract 625

Functions of the Respiratory System 626

The Respiratory Epithelium 626

24.2 The Upper Respiratory System 627

The Nose and Nasal Cavity 627

The Pharynx 629

The Nasopharynx 629

The Oropharynx 629

The Laryngopharynx 629

24.3 The Lower Respiratory System 630

The Larynx 630

Cartilages of the Larynx 630

Laryngeal Ligaments 631

The Laryngeal Musculature 631

24.4 The Trachea 632

24.5 The Main Bronchi 632

24.6 The Lungs 633

Lobes and Fissures of the Lungs 633

Lung Surfaces 633

The Main Bronchi 635

Branches of the Right Main Bronchus 635

Branches of the Left Main Bronchus 635

Branches of the Lobar Bronchi 635

The Bronchopulmonary Segments 635

The Bronchioles 635

Alveolar Ducts and Alveoli 638

The Alveolus and the Blood–Air Barrier 638

The Blood Supply to the Lungs 638

24.7 The Pleural Cavities and Pleural Membranes 642

24.8 Respiratory Muscles and Pulmonary Ventilation 643

Respiratory Muscles 643

Respiratory Movements 643

24.9 Respiratory Changes at Birth 643

24.10 Respiratory Centers of the Brain 643

24.11 Aging and the Respiratory System 645

■ SPOTLIGHT

Respiratory Muscles and Pulmonary Ventilation 644

■ CLINICAL NOTES

Cystic Fibrosis 627

Tracheal Blockage 638

Lung Cancer 638

Chronic Obstructive Pulmonary Disease (COPD) 641

Respiratory Distress Syndrome (RDS) 642

Study Outline 646
Chapter Review 647
Related Clinical Terms 649

25 | The Digestive System 650

■ CLINICAL CASE | An Unusual Transplant 650

25.1 An Overview of the Digestive System 651

Histological Organization of the Digestive Tract 651

The Mucosa 651
The Submucosa 651
The Muscular Layer 651
The Serosa 652

Muscular Layers and the Movement of Digestive Materials 652

Peristalsis and Segmentation 653

The Peritoneum 654

Mesenteries 655

25.2 The Oral Cavity 655

Anatomy of the Oral Cavity 655

The Tongue 657
Salivary Glands 658
Regulation of Salivary Secretion 658
The Teeth 659

25.3 The Pharynx 661

The Swallowing Process 661

25.4 The Esophagus 661

Histology of the Esophageal Wall 663

25.5 The Stomach 663

Anatomy of the Stomach 663

Blood Supply to the Stomach 663
Musculature of the Stomach 666

Histology of the Stomach 666

Gastric Secretory Cells 666

Regulation of Gastric Activity 668

25.6 The Small Intestine 668

Regions of the Small Intestine 669

The Duodenum 669
The Jejunum 669
The Ileum 669

Support of the Small Intestine 669

Histology of the Small Intestine 669

The Intestinal Epithelium 671
Intestinal Glands 671
The Lamina Propria 671
Regional Specializations 672

Regulation of the Small Intestine 672

25.7 The Large Intestine 672

The Cecum and Appendix 672

The Colon 672
Regions of the Colon 674

The Rectum 674

Histology of the Large Intestine 674

Regulation of the Large Intestine 675

25.8 Accessory Digestive Organs 675

The Liver 675

Anatomy of the Liver 677
Histology of the Liver 678

The Gallbladder 678

Histological Organization of the Gallbladder 679

The Pancreas 679

Histological Organization of the Pancreas 680
Pancreatic Enzymes 681
The Regulation of Pancreatic Secretion 681

25.9 Aging and the Digestive System 682

■ SPOTLIGHT

Anatomy of the Stomach 664

■ CLINICAL NOTES

Ascites 655

Mumps 659

Esophagitis, GERD, and Hiatal Hernia 662

Endoscopy 665

Gastritis and Peptic Ulcers 668

Study Outline 682

Chapter Review 685

Related Clinical Terms 686

26 | The Urinary System 687

■ CLINICAL CASE | This Too Shall Pass 687

26.1 The Kidneys 688

Superficial Anatomy of the Kidney 688

Sectional Anatomy of the Kidney 689

The Blood Supply to the Kidneys 689

Innervation of the Kidneys 690

Histology of the Kidney 690

The Nephron and Collecting System 690

The Renal Corpuscle 692

The Proximal Convoluted Tubule 693

The Nephron Loop 694

The Distal Convoluted Tubule 697

The Collecting System 697

26.2 Structures for Urine Transport, Storage, and Elimination 697

The Ureters 697

Histology of the Ureters 699

The Urinary Bladder 699

Histology of the Urinary Bladder 701

The Urethra 701

Histology of the Urethra 702

Urinary Reflexes: Urine Storage and Urine Voiding 702

Urine Storage Reflex 702

Urine Voiding Reflex 702

26.3 Aging and the Urinary System 702

■ SPOTLIGHT

The Renal Corpuscle 696

■ CLINICAL NOTES

Treatment of Renal Failure 699

Transitional Cell Carcinoma 702

Urinary Tract Infections 703

Study Outline 703

Chapter Review 705

Related Clinical Terms 706

27 | The Reproductive System 707

■ CLINICAL CASE | A Serious Game of Twister 707

27.1 Organization of the Reproductive System 708

27.2 Anatomy of the Male Reproductive System 708

The Testes 708

Descent of the Testes 708

The Spermatic Cords 708

Structure of the Testes 711

Histology of the Testes 711

Spermatogenesis and Meiosis 711

Spermiogenesis 712

Nurse Cells 712

Anatomy of a Sperm 714

The Male Reproductive Tract 714

The Epididymis 714

The Ductus Deferens 716

The Urethra 716

The Accessory Glands 716

The Seminal Glands 716

The Prostate 716

The Bulbo-urethral Glands 716

Semen 719

The Penis 719

27.3 Anatomy of the Female Reproductive System 719

The Ovaries 721

The Ovarian Cycle and Oogenesis 721

The Uterine Tubes 724

Histology of the Uterine Tube 725

The Uterus 725

Suspensory Ligaments of the Uterus 725

Gross Anatomy of the Uterus 725

The Uterine Wall 726

Blood Supply to the Uterus 727

Histology of the Uterus 727

The Uterine Cycle 727

The Vagina 730

Histology of the Vagina 730

The External Genitalia 730

The Breasts 730

Development of the Mammary Glands During Pregnancy 732

27.4 Aging and the Reproductive System 733

Menopause 733

The Male Climacteric 733

■ CLINICAL NOTES

Testicular Cancer 716

Ovarian Cancer 721

Uterine Fibroids and Cancers 728

Breast Cancer 733

Study Outline 734

Chapter Review 736

Related Clinical Terms 738

28 | THE REPRODUCTIVE SYSTEM Embryology and Human Development 739

■ CLINICAL CASE | The Least-Alike Twins 739

28.1 An Overview of Development 740

28.2 Fertilization 740

The Oocyte at Ovulation 740

Pronucleus Formation and Amphimixis 740

28.3 Prenatal Development 742

The First Trimester 742

Cleavage and Blastocyst Formation 742

Implantation 743

Placentation 745

Embryogenesis 746

The Second and Third Trimesters 746

28.4 Labor and Delivery 752

Stages of Labor 752

The Dilation Stage 752

The Expulsion Stage 752

The Placental Stage 754

Premature Labor 754

28.5 The Neonatal Period 755

28.6 Embryology of Organ Systems 756

■ CLINICAL NOTES

Congenital Malformations 742

Teratogens and Abnormal Development 744

Common Complications of Parturition 755

Study Outline 788

Chapter Review 789

Related Clinical Terms 790

Answers to Concept Checks, Chapter Reviews, and Clinical Case Wrap-Ups 791

Appendices 808

Foreign Word Roots, Prefixes, Suffixes, and Combining Forms 809

Eponyms in Common Use 810

Glossary 812

Credits 826

Index 830

1

Foundations

An Introduction to Anatomy

Learning Outcomes

These Learning Outcomes correspond by number to this chapter's sections and indicate what you should be able to do after completing the chapter.

- 1.1** Define the limits of microscopic anatomy and compare and contrast cytology and histology. p. 2
- 1.2** Compare and contrast the various ways to approach gross anatomy. p. 2
- 1.3** Define the various subspecialties of anatomy. p. 2
- 1.4** Explain the major levels of organization in a living organism. p. 5
- 1.5** Identify the organ systems of the human body and compare and contrast their functions. p. 7
- 1.6** Understand and correctly apply descriptive anatomical and directional terminology. p. 14



CLINICAL CASE

Using Anatomy to Save a Life

Zach, a 20-year-old college sophomore, is late for his anatomy class, so he decides to ride his bike to class instead of walking. As he enters an intersection, he is struck by a speeding pickup truck. The impact throws him 50 feet, and he lands on his head and left side.

Emergency medical technicians (EMTs) arrive within minutes. They roll the unconscious Zach onto his back for initial assessment. He has an obvious open skull fracture (bone break with pierced skin), open fractures of his left upper and lower extremities, and multiple rib fractures on his left side, and he exhibits rapid, shallow breathing. Assuming he has neck and back injuries, the EMTs splint him carefully for transport to the nearest Level I (highest designation) trauma center.

En route, an EMT calls the triage nurse in the emergency room (who assigns medical priority) and reports that he is arriving with a young male trauma victim with an Injury Severity Score (ISS) of 57. The nurse tells him to immediately report to the trauma room and sounds the alert for the trauma team.

With an ISS of 57, what are Zach's chances of survival? To find out, turn to the Clinical Case Wrap-Up on p. 26.

WE ALL USE our knowledge of human anatomy in our daily lives: We remember specific anatomical features to identify friends and family, and we observe changes in body movements and facial expressions for clues to what others are thinking. **Anatomy** is the study of the external and internal structures of the body and the physical relationships between body parts. In practical terms, anatomy is the careful observation of the human body.

Anatomical information provides clues about probable functions. **Physiology** is the study of the function of bodily structures, and we explain physiological mechanisms in terms of the underlying anatomy. *All specific physiological functions are performed by specific anatomical structures.* For instance, functions of the nasal cavity include filtering, warming, and humidifying inhaled air. The shapes of the bones projecting into the nasal cavity cause turbulence in the inhaled air. As the air swirls, it contacts the moist lining of the nasal cavity, which warms and humidifies the air, and any suspended particles stick to the moist surfaces. In this way, the air is conditioned and filtered before it reaches the lungs.

This text discusses the anatomical structures and functions that make human life possible. Our goals are to help you

- 1 develop a three-dimensional understanding of anatomical relationships,
- 2 prepare for more advanced courses in anatomy, physiology, and related subjects, and
- 3 make informed decisions about your personal health.

1.1 Microscopic Anatomy

► **KEY POINT** Microscopic anatomy—the study of structures too small to be seen by the naked eye—includes the specialties of cytology and histology.

Microscopic anatomy is the study of structures that cannot be seen without magnification. The boundaries of microscopic anatomy are established by the limits of the equipment used (**Figure 1.1**). A simple hand lens shows details that barely escape the naked eye, while an electron microscope shows structural details that are more than a million times smaller. As we proceed through the text, we will consider details at various size levels.

Microscopic anatomy is subdivided into two specialties that consider features within a characteristic range of sizes:

- **Cytology** (sī-TOL-ō-jē) analyzes the internal structure of **cells**, the smallest units of life. Living cells are composed of complex chemicals in various combinations, and our lives depend on the chemical processes occurring in the trillions of cells that form our body.
- **Histology** (his-TOL-ō-jē) takes a broader perspective and examines **tissues**, groups of specialized cells and cell products that work together and perform specific functions. The human body has four basic tissue types: epithelial tissue, connective tissue, muscle tissue, and neural tissue (which will be described in Chapter 3).

Tissues combine to form organs such as the heart, kidney, liver, and brain. An **organ** is an anatomical structure that has multiple functions. Many tissues and most organs are examined easily without a microscope, and at this point we cross the boundary from microscopic anatomy into gross anatomy.

1.1 CONCEPT CHECK



- 1 Histologists study what structures?
- 2 Define an organ.

See the blue Answers tab at the back of the book.

1.2 Gross Anatomy

► **KEY POINT** We study gross anatomy—the study of structures visible to the naked eye—by examining surface anatomy, regional anatomy, or systemic anatomy.

Gross anatomy (*macroscopic anatomy*) is the study of structures and features that are visible to the unaided (naked) eye. There are several ways to approach gross anatomy:

- **Surface anatomy** is the study of general anatomical form, or **morphology**, and how superficial (surface) anatomical markings relate to deeper anatomical structures.
- **Regional anatomy** is the study of the superficial and internal features in a specific area of the body, such as the head, neck, or trunk. Advanced courses in anatomy often stress a regional approach because it emphasizes the relationships among structures.
- **Systemic anatomy** is the study of anatomy based upon the body's organ systems. An **organ system** is a group of organs that function together to produce coordinated effects. For example, the heart, blood, and blood vessels form the cardiovascular system, which distributes oxygen and nutrients throughout the body. There are 11 organ systems in the human body, which we will introduce later in the chapter. Introductory anatomy texts, including this one, usually use a systemic approach to organize information about important structural and functional patterns.

1.2 CONCEPT CHECK



- 3 How does the work of a gross anatomist differ from that of a histologist?
- 4 What is an organ system, and how does it apply to systemic anatomy?

See the blue Answers tab at the back of the book.

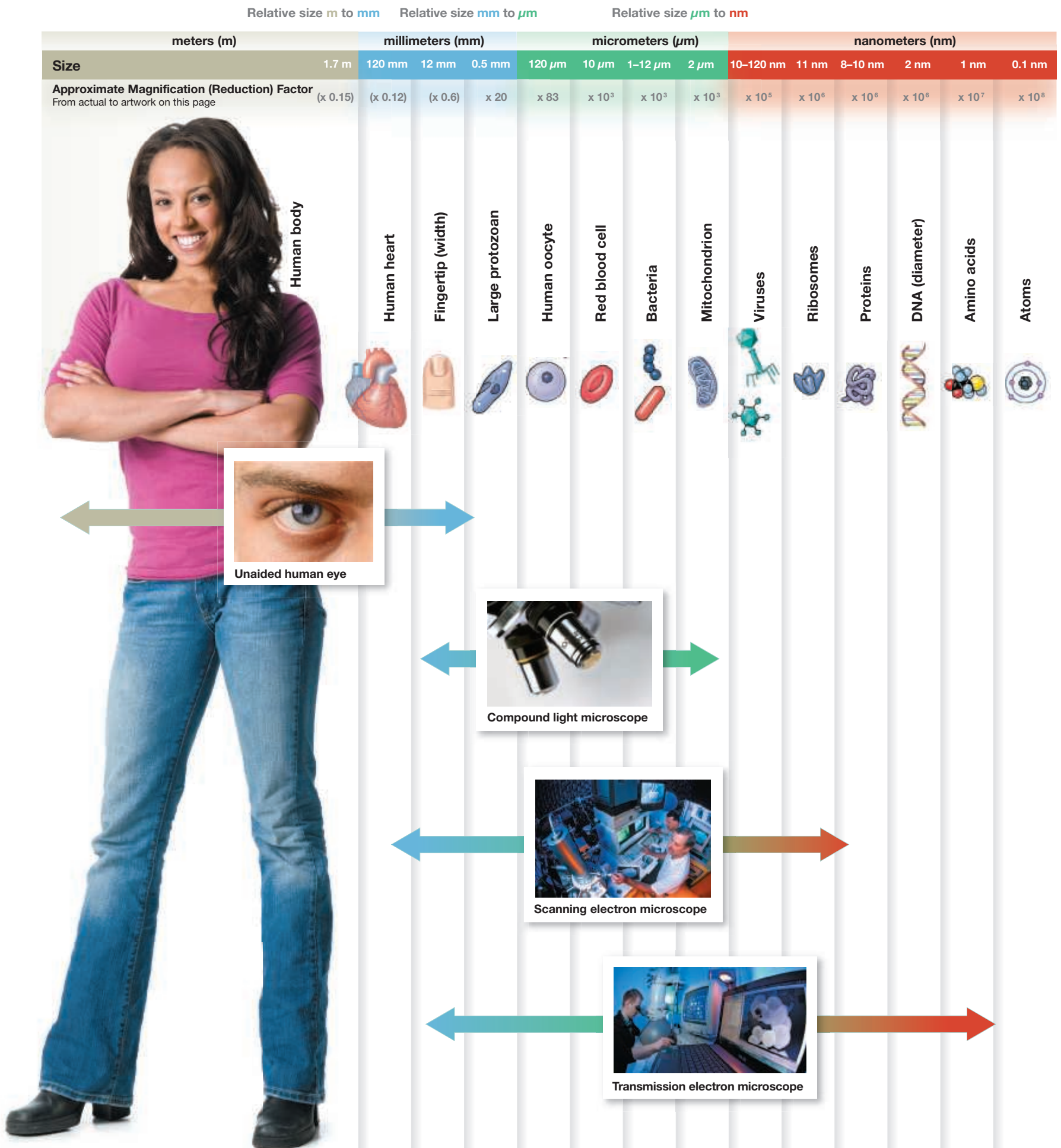
1.3 Other Types of Anatomical Studies

► **KEY POINT** Other anatomical specialties that are important in the understanding of the human body are developmental, comparative, clinical, surgical, radiographic, and cross-sectional anatomy.

Other anatomical specialties you will read about in this text include the following:

- **Developmental anatomy** studies the changes in form that take place between conception and physical maturity. Because it considers anatomical structures with a broad range of sizes (from a single cell to an adult human), developmental anatomy involves both microscopic and gross anatomy. Developmental anatomy is important in medicine because many structural abnormalities result from errors that occur during development. The most extensive structural changes occur during the first two months of development; **embryology** (em-brē-OL-ō-jē) is the study of these early developmental processes.
- **Comparative anatomy** studies the anatomical organization of different types of animals. Observed similarities may reflect evolutionary relationships. For example, humans, chickens, and salmon are all called vertebrates because they share a combination of anatomical features not found in any other group of animals, including a spinal column composed of individual structures called vertebrae (**Figure 1.2a**). Comparative anatomy uses the techniques of gross, microscopic, and developmental anatomy.

Figure 1.1 The Study of Anatomy at Different Scales. The amount of detail recognized depends on the method of study and the degree of magnification.



Research shows that related animals typically go through similar developmental stages (Figure 1.2b,c).

Several other gross anatomical specialties are important in medical diagnosis:

- **Clinical anatomy** focuses on anatomical features that may undergo recognizable pathological changes during illness.
- **Surgical anatomy** studies anatomical landmarks important for surgical procedures.
- **Radiographic anatomy** utilizes x-rays, ultrasound scans, or other specialized procedures performed on an intact body to visualize and study anatomical structures.
- **Cross-sectional anatomy** has emerged due to advances in radiographic anatomy, such as computerized tomography (CT) and spiral CT scans.

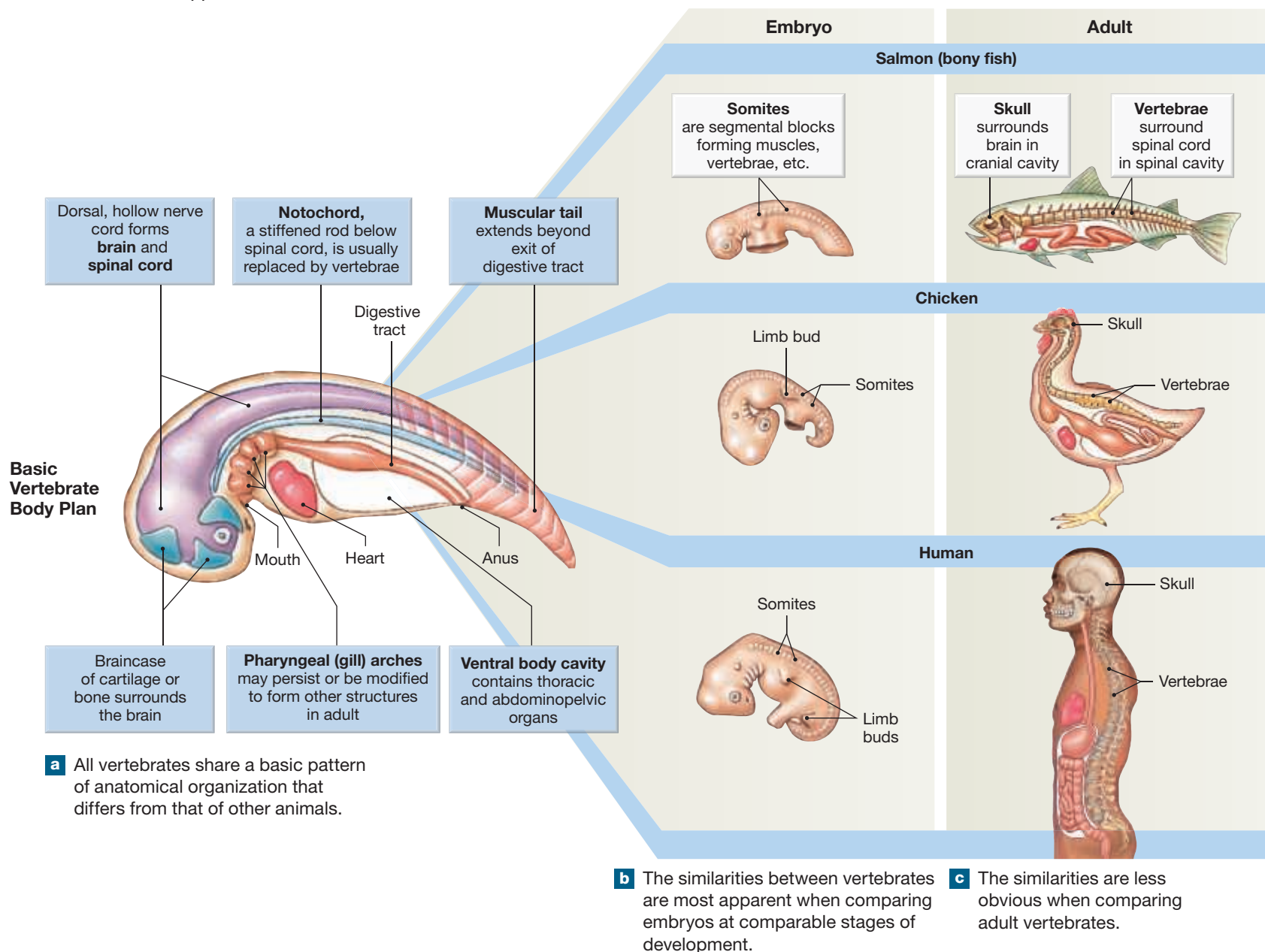


CLINICAL NOTE

The Diagnosis of Disease

Homeostasis is the maintenance of a relatively constant internal environment suitable for the survival of cells, tissues, and organs. It is achieved by a system of control mechanisms activated by negative feedback. **Disease** is the failure to maintain homeostatic conditions. The disease process may affect any aspect of physiology from the cellular to the organismic level. The body's defenses can overcome some diseases, but others require medical intervention.

Figure 1.2 Comparative Anatomy. Humans are classified as vertebrates, a group that also includes animals as different in appearance as salmon and chickens.



1.3 CONCEPT CHECK



- 5 How does surgical anatomy differ from clinical anatomy?
- 6 Cross-sectional anatomy is a subspecialty of which anatomical specialty?

See the blue Answers tab at the back of the book.

1.4 Levels of Organization

► **KEY POINT** The levels of structural organization in the human body range from the chemical/molecular level (the simplest level) to the entire organism (the most complex level).

Our study of the human body begins at the chemical, or molecular, level of organization. The human body consists of more than a dozen different elements, but four of them (hydrogen, oxygen, carbon, and nitrogen) account for more than 99 percent of the total number of atoms (Figure 1.3a). At the chemical level, atoms interact to form three-dimensional molecules with distinctive properties. The major classes of molecules in the human body are indicated in Figure 1.3b.

The next level of organization, the cellular level, includes cells, the smallest living units in the body (Figure 1.4). Cells contain internal structures called organelles. Cells and their organelles are made of complex chemicals. (Cell structure and the function of the major organelles found within cells are presented in Chapter 2.) As shown in Figure 1.4, chemical interactions produce complex proteins within a muscle cell in the heart. Muscle cells are unusual because they can contract powerfully, shortening along their longitudinal axis.

Heart muscle cells are connected to form a distinctive muscle tissue, an example of the tissue level of organization. Layers of muscle tissue form most

of the wall of the heart, a hollow, three-dimensional organ. We are now at the organ level of organization (Figure 1.4).

Normal functioning of the heart depends on interrelated events at the chemical, cellular, tissue, and organ levels of organization. Coordinated contractions in the muscle cells of cardiac muscle tissue produce a heartbeat. When that beat occurs, the internal anatomy of the organ enables it to function as a pump. With each contraction, the heart pushes blood into the vascular system, a network of blood vessels. Together, the heart, blood, and vascular system form an organ system: the cardiovascular system (CVS).

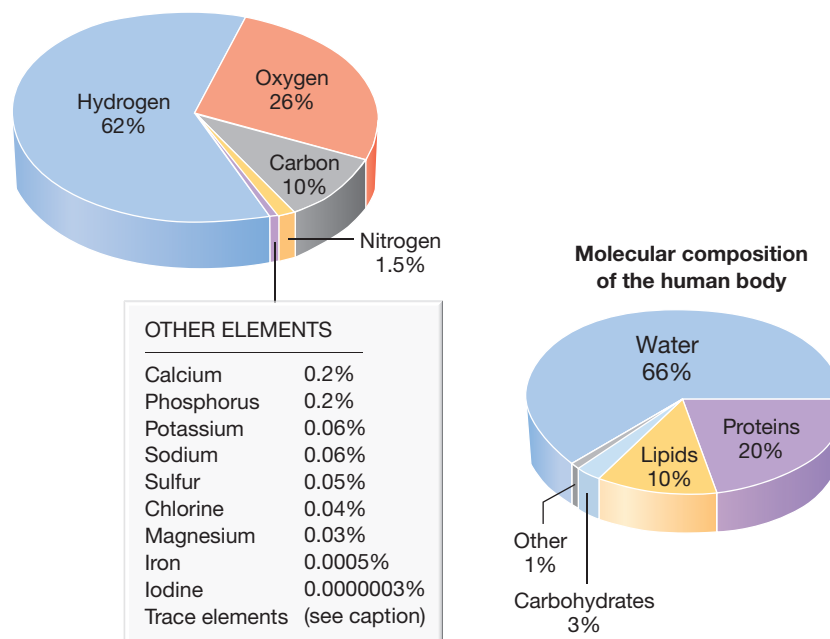
Each level of organization is dependent on the others. Damage at any level may affect the entire system. A chemical change in heart muscle cells may cause abnormal contractions or even stop the heartbeat. Physical damage to muscle tissue, such as a chest wound, can make the heart ineffective even when most of the heart muscle cells are intact. An inherited abnormality in heart structure can make it an ineffective pump even if muscle cells and tissues are normal.

Note that anything affecting a system ultimately affects all the components of that system. For example, damage to a major blood vessel somewhere else in the body can cause the heart to lose the ability to pump blood effectively. If the heart cannot pump and blood cannot flow, oxygen and nutrients cannot be distributed to tissues. In a very short time, the tissue breaks down as heart muscle cells die from oxygen and nutrient starvation.

Of course, the changes that occur when the heart is not pumping effectively are not limited to the cardiovascular system; all the cells, tissues, and organs in the body will be damaged. This observation brings us to the highest level of organization, an organism—in this case, a human. The organism level reflects the interactions among organ systems (Figure 1.4). All are vital; every system must be working properly and in harmony with every other system, or survival will be impossible.

When all systems are functioning normally, the characteristics of the internal environment are relatively stable at all levels. This tendency toward stability, called **homeostasis** (hō-mē-ō-STĀ-sis; *homeo*, unchanging, + *stasis*, standing), is maintained by physiological processes.

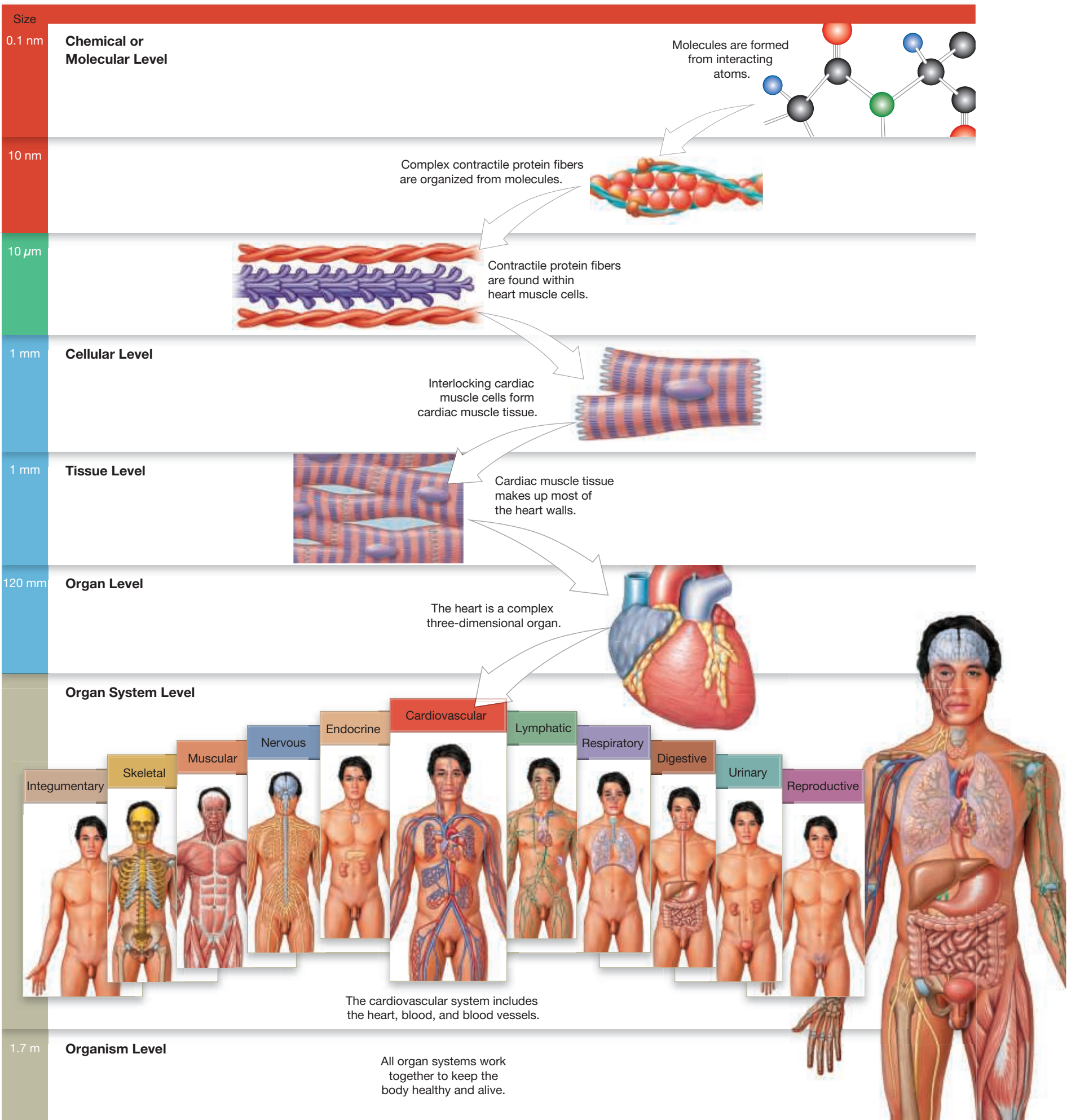
Figure 1.3 Composition of the Body at the Chemical Level of Organization.



a Elemental composition of the body. Trace elements include silicon, fluorine, copper, manganese, zinc, selenium, cobalt, molybdenum, cadmium, chromium, tin, aluminum, and boron.

b Molecular composition of the body.

Figure 1.4 Levels of Organization



1.4 CONCEPT CHECK



- 7 Cyanosis is a medical condition in which a person's lips and fingertips turn blue due to the inadequate delivery of oxygen to tissues. If a patient is exhibiting cyanosis, why should the patient's heart be examined *in addition to* the patient's lungs?

See the blue Answers tab at the back of the book.



CLINICAL NOTE

Disease, Pathology, and Diagnosis

Pathology is the study of disease. Diseases produce **signs** (objective evidence that the health provider can detect, such as fever or limited motion) and **symptoms** (subjective indications that the patient perceives, such as pain or fatigue). A **diagnosis** is an identification of the nature of an illness based on its signs and symptoms.

The World Health Organization (WHO) developed the International Classification of Diseases (ICD) as an international diagnostic standard. The ICD is important for health management and epidemiology (the study of disease occurrence, distribution, and cause). The current ICD-10 contains 69,823 diseases.

1.5 An Introduction to Organ Systems

► **KEY POINT** The 11 organ systems of the human body enable us to carry out vital life functions such as responsiveness, growth and differentiation, reproduction, movement, and metabolism and excretion.

Figure 1.5 summarizes the functions of the 11 organ systems of the human body. **Figure 1.6** details the components and primary functions of each organ system. Like all living organisms, humans share vital characteristics and processes:

- **Responsiveness:** The ability of an organism to respond to changes in its immediate environment is termed **responsiveness**. Examples include you jerking your hand away from a hot stove, your dog barking at approaching strangers, and amoebas gliding toward potential prey. Organisms also make longer-lasting responses as they adjust to their environments. For example, as winter approaches, an animal grows a heavier coat or migrates to a warmer climate. Adaptability is the capacity to make longer-lasting adjustments.
- **Growth and Differentiation:** Over a lifetime, organisms grow larger, increasing in size by increasing the size or number of their cells. In multicellular organisms, the individual cells become specialized to perform particular functions. This specialization is called **differentiation**. Growth and differentiation in cells and organisms produce changes in form and function. For example, the anatomical proportions and physiological capabilities of an adult human are quite different from those of an infant.
- **Reproduction:** Organisms reproduce, creating subsequent generations of their own kind, whether unicellular or multicellular.
- **Movement:** Organisms produce movement, which may be internal (transporting food, blood, or other materials inside the body) or external (moving through the environment).

Figure 1.5 An Introduction to Organ Systems. An overview of the 11 organ systems and their major functions.

ORGAN SYSTEM		MAJOR FUNCTIONS
	Integumentary	Protects against environmental hazards; controls temperature
	Skeletal	Supports and protects soft tissues; stores minerals; forms blood
	Muscular	Provides movement and support; generates heat
	Nervous	Directs immediate responses to stimuli, usually by coordinating the activities of other organ systems
	Endocrine	Directs long-term changes in the activities of other organ systems
	Cardiovascular	Distributes cells and dissolved materials, including nutrients, wastes, and gases
	Lymphatic	Defends against infection and disease
	Respiratory	Delivers air to sites where gas exchange occurs between the air and circulating blood
	Digestive	Processes and digests food; absorbs nutrients; stores energy reserves
	Urinary	Eliminates excess water, salts, and wastes; controls pH; regulates blood pressure
	Reproductive	Produces sex cells and hormones

- **Metabolism and Excretion:** Organisms rely on chemical reactions to provide energy for responsiveness, growth, reproduction, and movement. They also synthesize complex chemicals, such as proteins. The term **metabolism** refers to *all* the chemical operations under way in the body. Types of metabolic reactions include **catabolism** (the *breakdown* of complex molecules into simple ones) and **anabolism** (the *synthesis* of complex molecules from simple ones). Normal metabolic operations require the **absorption** (*taking in*) of materials from the environment. To generate energy efficiently, cells require various nutrients, as well as oxygen, an atmospheric gas. The term **respiration** refers to cells' absorption, transport, and use of oxygen. Metabolic operations generate potentially harmful wastes that must be removed through the process of **excretion**.

Figure 1.6 The Organ Systems of the Body

The Integumentary System

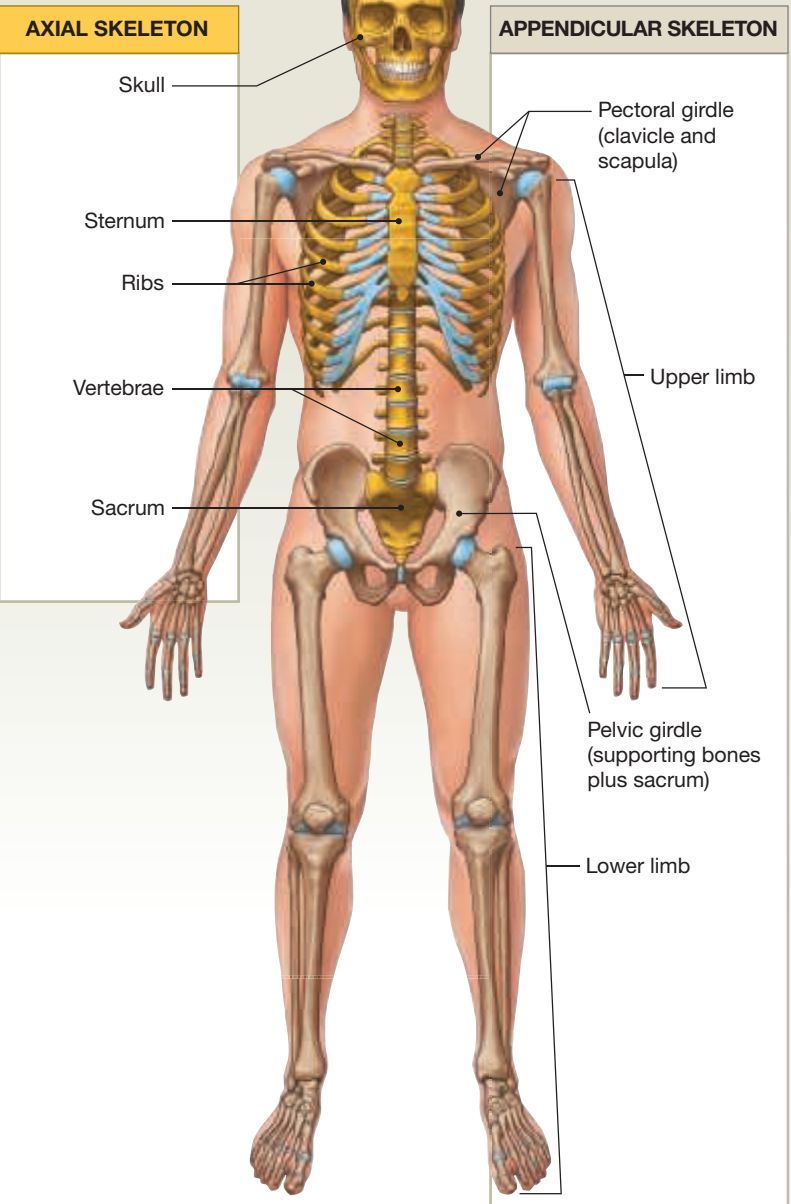
Protects against environmental hazards; helps control body temperature



Organ/Component	Primary Functions
Skin (Cutaneous Membrane) Epidermis Dermis	Covers surface; protects deeper tissues Nourishes epidermis; provides strength; contains glands
Hair Follicles Hairs Sebaceous glands	Produce hair; innervation provides sensation Provide protection for head Secrete lipid coating that lubricates hair shaft and epidermis
Sweat Glands	Produce perspiration for evaporative cooling
Nails	Protect and stiffen distal tips of digits
Sensory Receptors	Provide sensations of touch, pressure, temperature, and pain
Subcutaneous Layer	Stores lipids; attaches skin to deeper structures

The Skeletal System

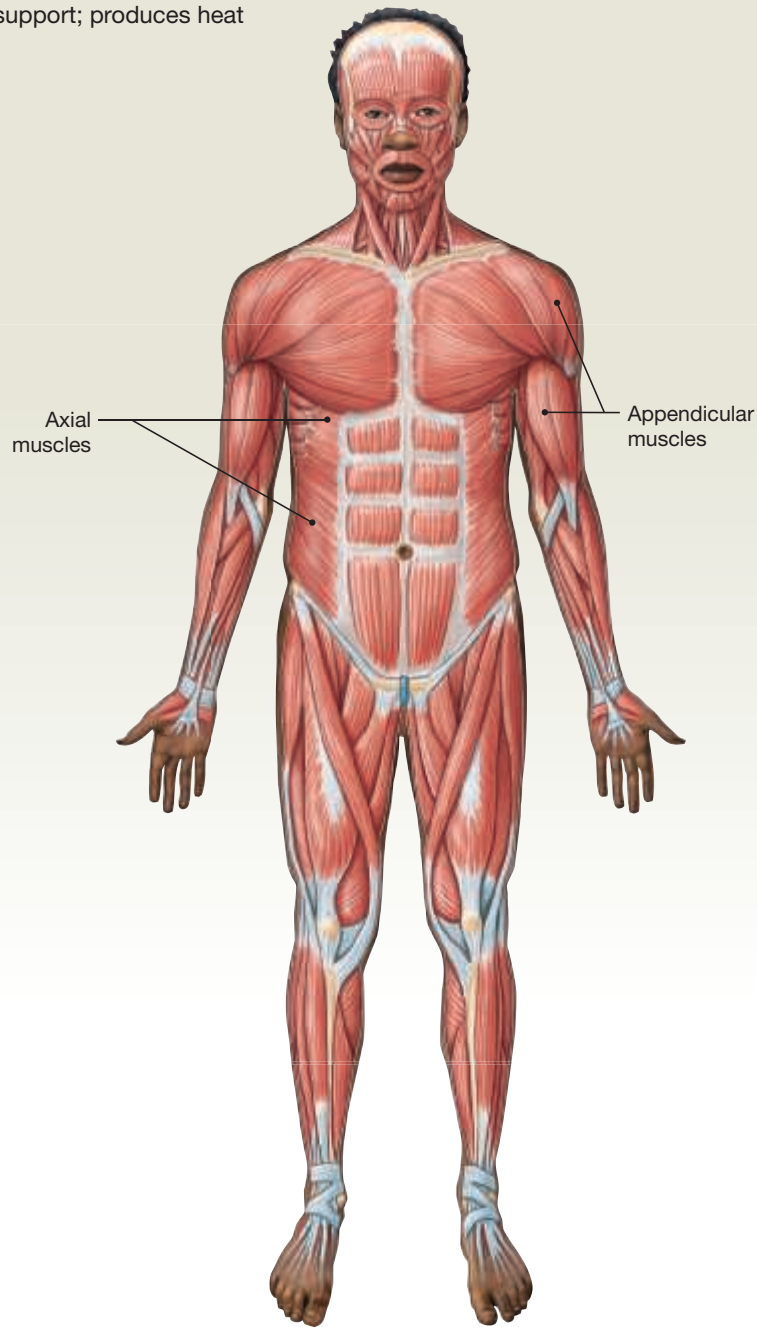
Supports and protects tissues; stores minerals; forms blood cells



Organ/Component	Primary Functions
Bones, Cartilages, and Joints Axial skeleton (skull, vertebrae, sacrum, coccyx, sternum, supporting cartilages and ligaments) Appendicular skeleton (limbs and supporting bones and ligaments)	Support and protect soft tissues; bones store minerals Protects brain, spinal cord, sense organs, and soft tissues of thoracic cavity; supports the body weight over lower limbs Provides internal support and positioning of the limbs; supports and moves axial skeleton
Ligaments	Connect bone to bone, bone to cartilage, or cartilage to cartilage
Bone Marrow	Primary site of blood cell production (red bone marrow); storage of energy reserves in fat cells (yellow bone marrow)

The Muscular System

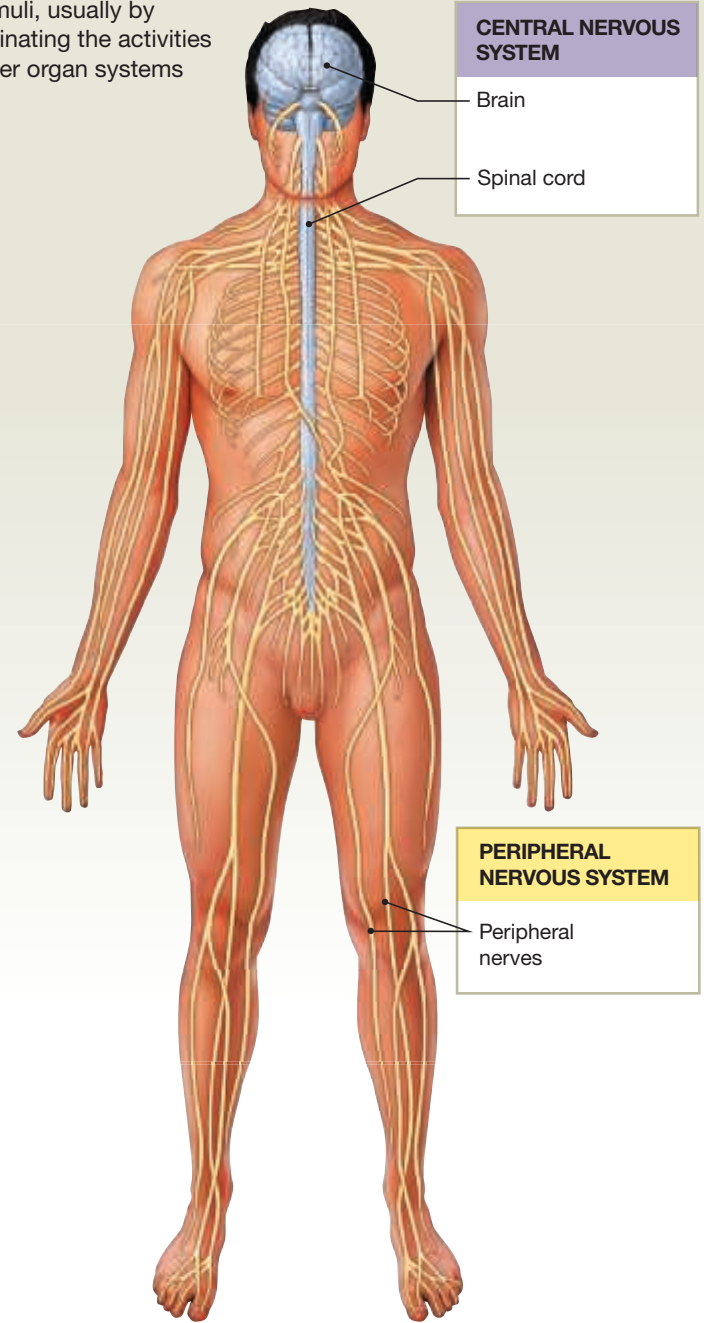
Allows for locomotion; provides support; produces heat



Organ/Component	Primary Functions
Skeletal Muscles	Provide skeletal movement; control entrances to digestive and respiratory tracts and exits to digestive and urinary tracts; produce heat; support skeleton; protect soft tissues
Axial muscles	Support and position axial skeleton
Appendicular muscles	Support, move, and brace limbs
Tendons and Aponeuroses	Transmit the contractile forces of skeletal muscle to bone in order to move

The Nervous System

Directs immediate responses to stimuli, usually by coordinating the activities of other organ systems

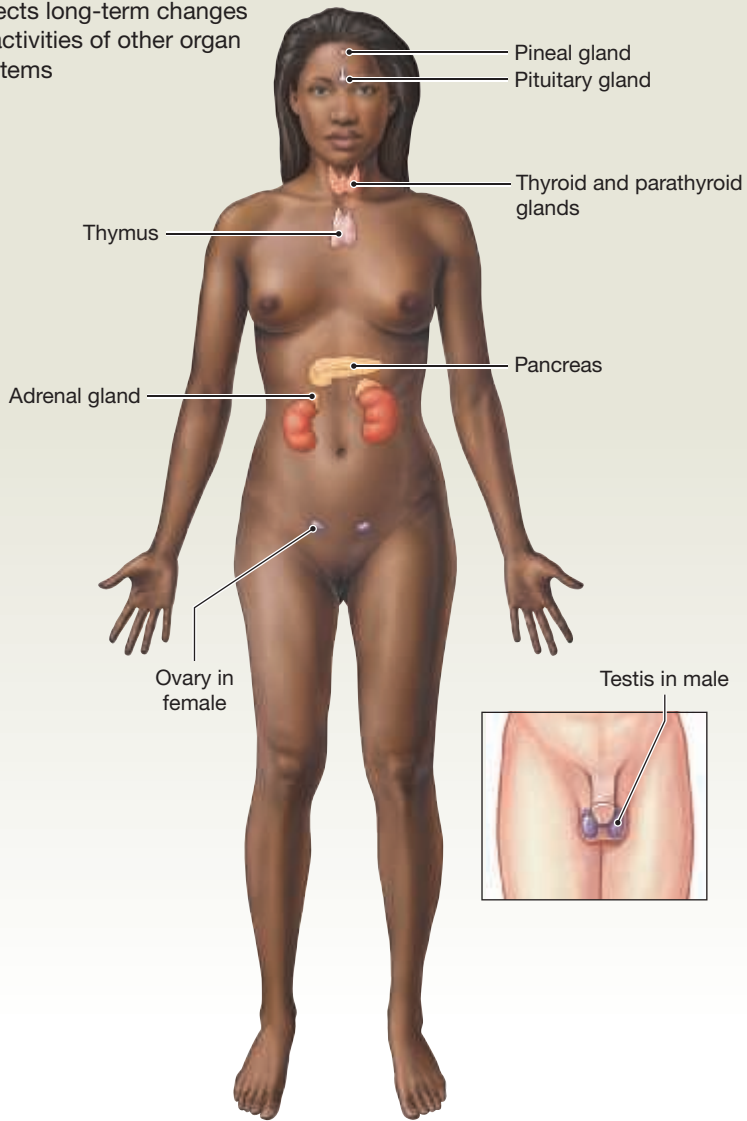


Organ/Component	Primary Functions
Central Nervous System (CNS)	Control center for nervous system; processes information; short-term control over activities of other systems
Brain	Performs complex integrative functions; controls both voluntary and autonomic activities
Spinal cord	Relays information to and from brain; performs less-complex integrative activities
Special senses	Provide sensory input to the brain relating to sight, hearing, smell, taste, and equilibrium
Peripheral Nervous System (PNS)	Links CNS with other systems and with sense organs

Figure 1.6 (continued)

The Endocrine System

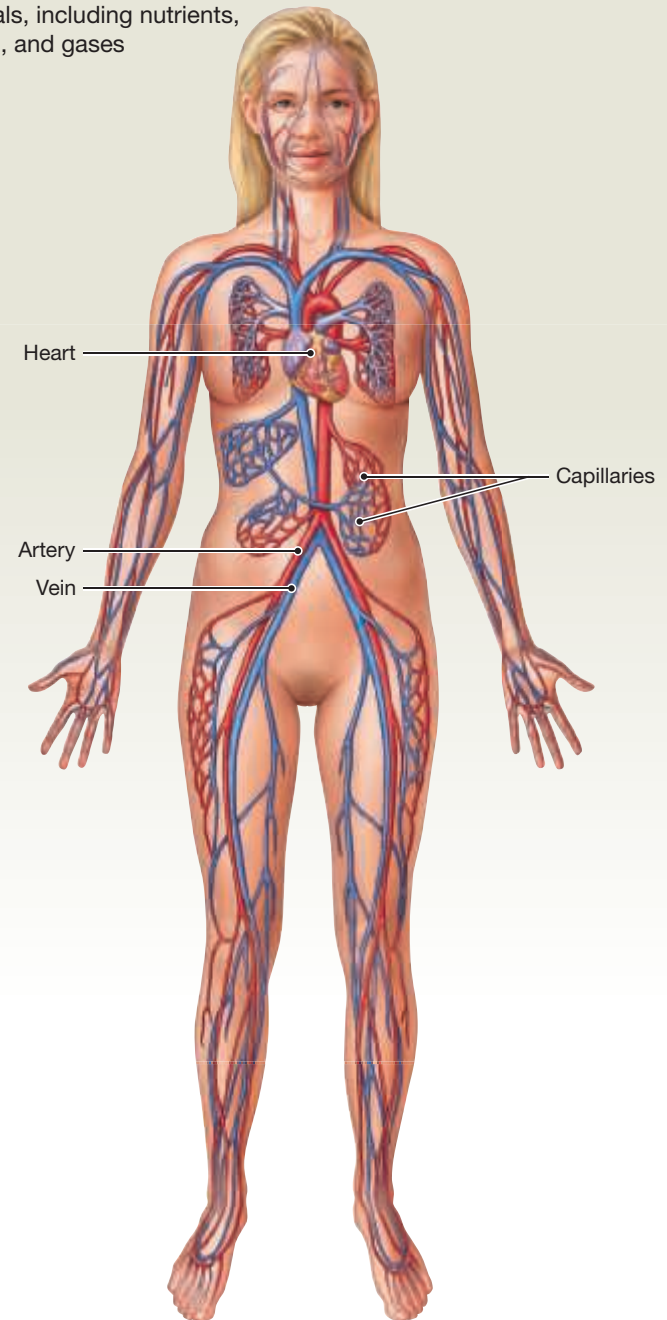
Directs long-term changes in activities of other organ systems



Organ/Component	Primary Functions
Pineal Gland	May control timing of reproduction and set day-night rhythms
Pituitary Gland	Controls other endocrine glands; regulates growth and fluid balance
Thyroid Gland	Controls tissue metabolic rate; regulates calcium levels
Parathyroid Glands	Regulate calcium levels (with thyroid)
Thymus	Controls maturation of lymphocytes
Adrenal Glands	Regulate water balance, tissue metabolism, and cardiovascular and respiratory activity
Kidneys	Control red blood cell production and elevate blood pressure
Pancreas	Regulates blood glucose levels
Gonads	
Testes	Support male sexual characteristics and reproductive functions
Ovaries	Support female sexual characteristics and reproductive functions

The Cardiovascular System

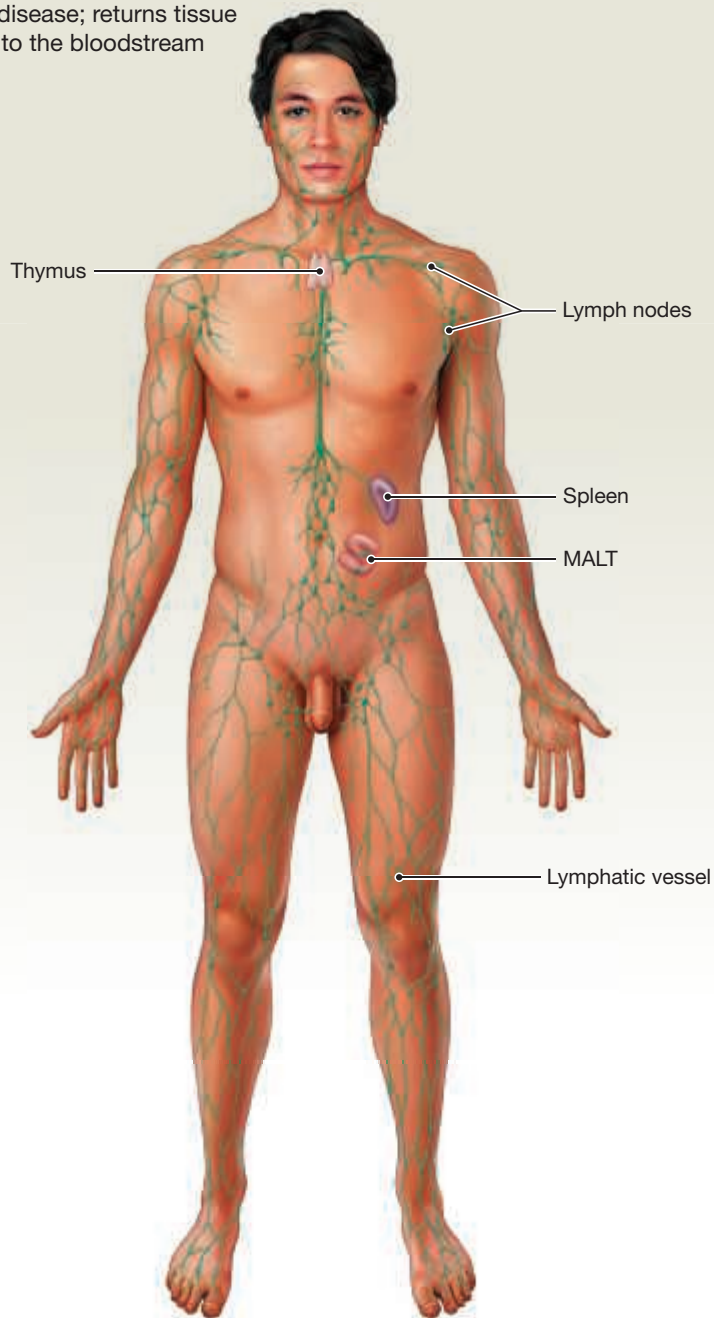
Transports cells and dissolved materials, including nutrients, wastes, and gases



Organ/Component	Primary Functions
Heart	Propels blood; maintains blood pressure
Blood Vessels	
Arteries	Distribute blood around the body
Capillaries	Carry blood from the heart to capillaries Permit diffusion between blood and interstitial fluids
Veins	Return blood from capillaries to the heart
Blood	Transports oxygen, carbon dioxide, and blood cells; delivers nutrients and hormones; removes wastes; assists in temperature regulation and defense against disease

The Lymphatic System

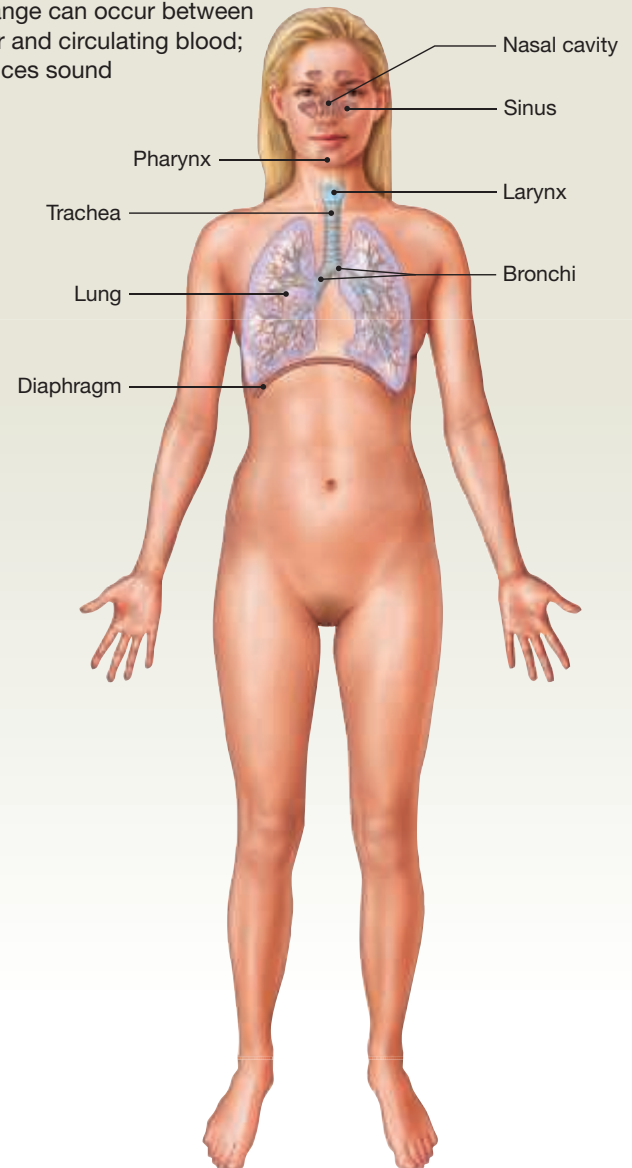
Defends against infection and disease; returns tissue fluid to the bloodstream



Organ/Component	Primary Functions
Lymphatic Vessels	Carry lymph (fluid with cells and proteins) and lymphocytes from peripheral tissues to veins of the cardiovascular system
Lymph Nodes	Monitor the composition of lymph; engulf pathogens; stimulate immune response
Spleen	Monitors circulating blood; engulfs pathogens and recycles red blood cells; stimulates immune response
Thymus	Controls development and maintenance of one class of lymphocytes (T cells)

The Respiratory System

Delivers air to sites where gas exchange can occur between the air and circulating blood; produces sound

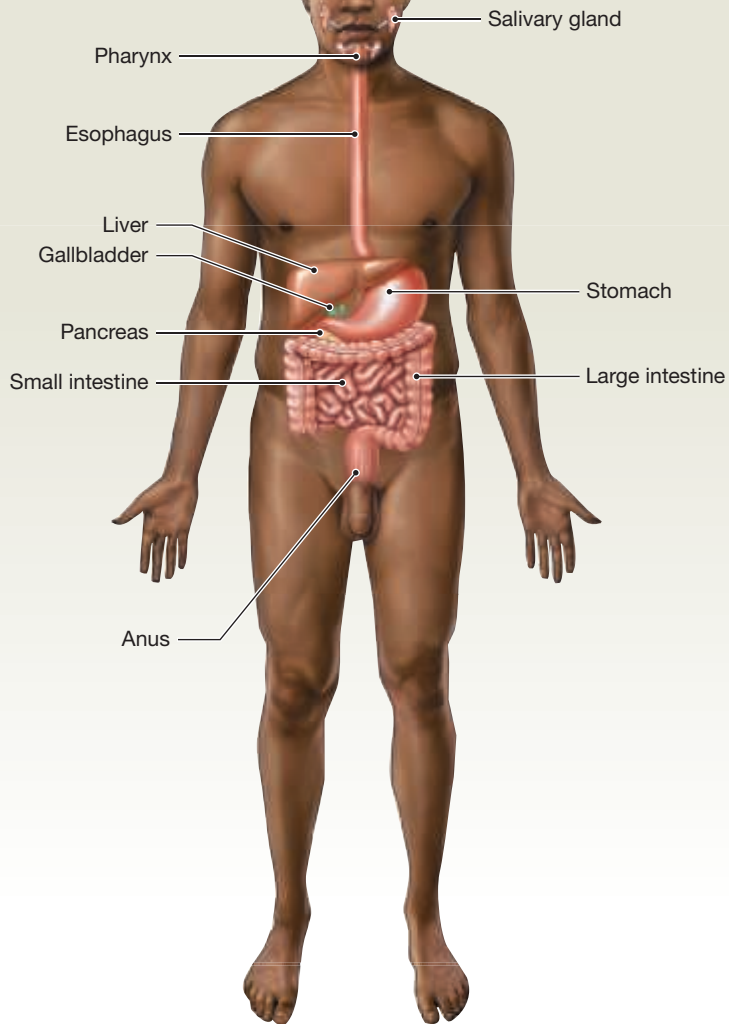


Organ/Component	Primary Functions
Nasal Cavities and Paranasal Sinuses	Filter, warm, humidify air; detect smells
Pharynx	Conducts air to larynx, a chamber shared with the digestive tract
Larynx	Protects opening to trachea and contains vocal cords
Trachea	Filters air, traps particles in mucus, conducts air to lungs; cartilages keep airway open
Bronchi	Same functions as trachea; diameter decreases as branching occurs
Lungs	Responsible for air movement during movement of ribs and diaphragm; include airways and alveoli
Alveoli	Blind pockets at the end of the smallest branches of the bronchioles; sites of gas exchange between air and blood

Figure 1.6 (continued)

The Digestive System

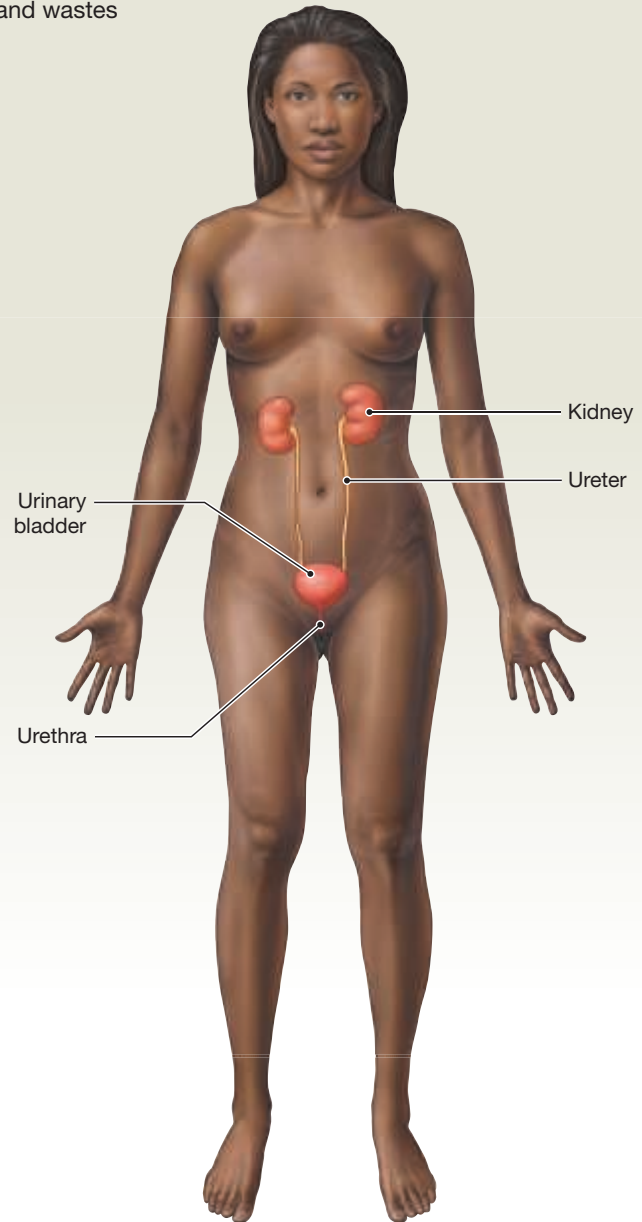
Processes food and absorbs nutrients



Organ/Component	Primary Functions
Oral Cavity	Receptacle for food; works with associated structures (teeth, tongue) to break up food and pass food and liquids to pharynx
Salivary Glands	Provide buffers and lubrication; produce enzymes that begin digestion
Pharynx	Conducts solid food and liquids to esophagus; chamber shared with respiratory tract
Esophagus	Delivers food to stomach
Stomach	Secretes acids and enzymes
Small Intestine	Secretes digestive enzymes, buffers, and hormones; absorbs nutrients
Liver	Secretes bile; regulates nutrient composition of blood
Gallbladder	Stores and concentrates bile for release into small intestine
Pancreas	Secretes digestive enzymes and buffers; contains endocrine cells
Large Intestine	Removes water from fecal material; stores wastes

The Urinary System

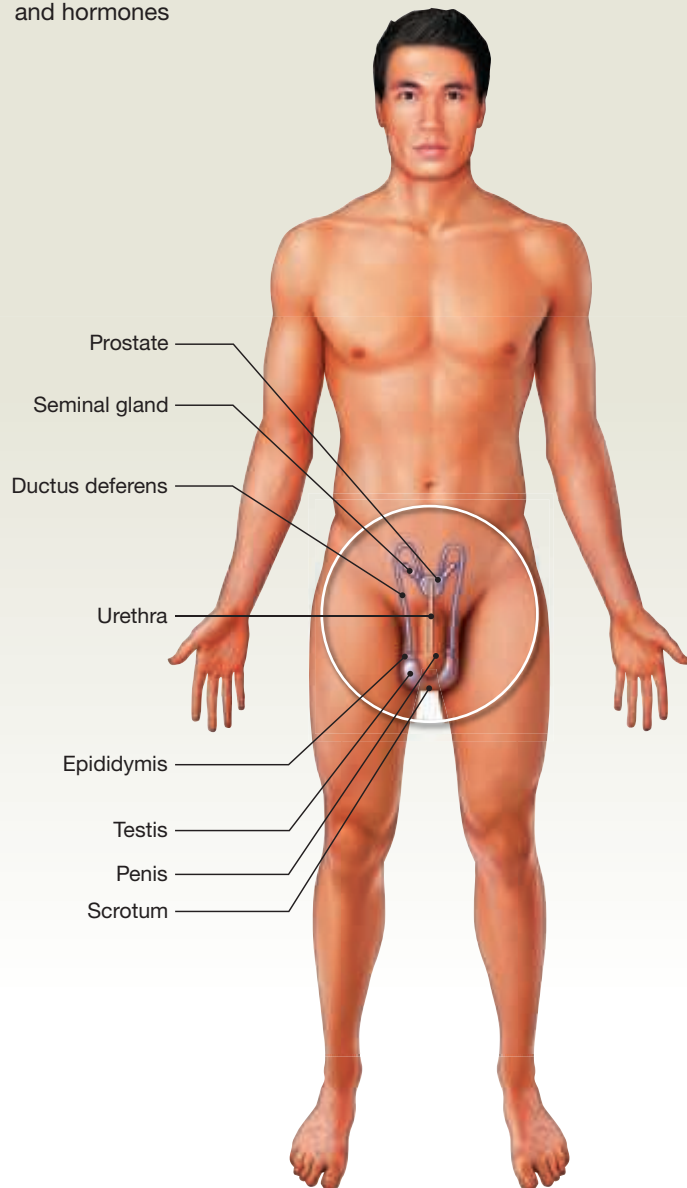
Eliminates excess water, salts, and wastes



Organ/Component	Primary Functions
Kidneys	Form and concentrate urine; regulate blood pH, ion concentrations, blood pressure; perform endocrine functions
Ureters	Conduct urine from kidneys to urinary bladder
Urinary Bladder	Stores urine for eventual elimination
Urethra	Conducts urine to exterior

The Male Reproductive System

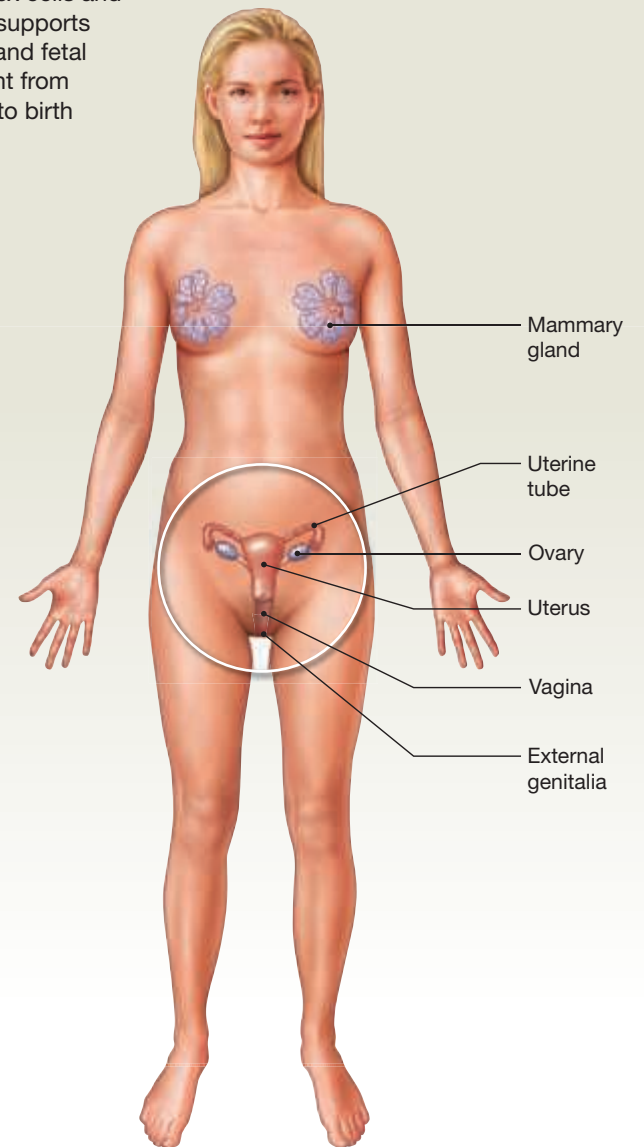
Produces sex cells and hormones



Organ/Component	Primary Functions
Testes	Produce sperm and hormones
Accessory Organs	
Epididymis	Site of sperm maturation
Ductus deferens	Conducts sperm from the epididymis and merges with the duct of the seminal gland
Seminal glands	Secrete fluid that makes up much of the volume of semen
Prostate	Secretes fluid and enzymes
Urethra	Conducts semen to exterior
External Genitalia	
Penis	Contains erectile tissue; deposits sperm in vagina of female; produces pleasurable sensations during sexual activities
Scrotum	Surrounds the testes and controls their temperature

The Female Reproductive System

Produces sex cells and hormones; supports embryonic and fetal development from fertilization to birth



Organ/Component	Primary Functions
Ovaries	Produce oocytes and hormones
Uterine Tubes	Deliver oocyte or embryo to uterus; normal site of fertilization
Uterus	Site of embryonic and fetal development; site of exchange between maternal and fetal bloodstreams
Vagina	Site of sperm deposition; birth canal during delivery; provides passageway for fluids during menstruation
External Genitalia	
Clitoris	Contains erectile tissue; provides pleasurable sensations during sexual activities
Labia	Contain glands that lubricate entrance to vagina
Mammary Glands	Produce milk that nourishes newborn infant

For very small organisms, absorption, respiration, and excretion involve the movement of materials across exposed surfaces. But creatures larger than a few millimeters seldom absorb nutrients directly from their environment. For example, we cannot absorb steaks, apples, or ice cream directly—our bodies must first alter the foods' chemical structure. That processing, called **digestion**, occurs in specialized areas where complex foods are broken down into simpler components that are absorbed easily. Respiration and excretion are also more complicated for large organisms, so we have specialized organs responsible for gas exchange (the lungs) and waste excretion (the kidneys). Finally, because absorption, respiration, and excretion are performed in different portions of the body, we have an internal transportation system, or **cardiovascular system**.

1.5 CONCEPT CHECK



8 What is differentiation?

9 Which organ system includes the following components: sweat glands, nails, and hair follicles?

See the blue Answers tab at the back of the book.

1.6 The Language of Anatomy

► **KEY POINT** Learning the specialized terminology of human anatomy will make it easier to understand anatomical concepts.

If you discovered and then fully explored a new continent, how would you describe it to others in a way that everyone would understand? One method would be to construct a specific, detailed map of the territory. Your map would identify prominent landmarks, such as mountains, valleys, and rivers; the distance between these landmarks; and the direction you would need to travel to get from one landmark to another using compass bearings (north, south, northeast, southwest, and so on). With such a map, anyone could find a specific location on that continent.

Early anatomists faced a similar challenge when trying to communicate their findings. Identifying a particular location on the human body proved to be difficult. Stating that a bump is “on the back,” for instance, does not specify its exact location. So anatomists created maps of the human body. The landmarks are the prominent anatomical structures, and distances are measured in centimeters or inches.

Anatomy uses a special language that you must learn at the start. It will take some time and effort, but it is absolutely essential if you want to avoid a situation like that shown in **Figure 1.7**.

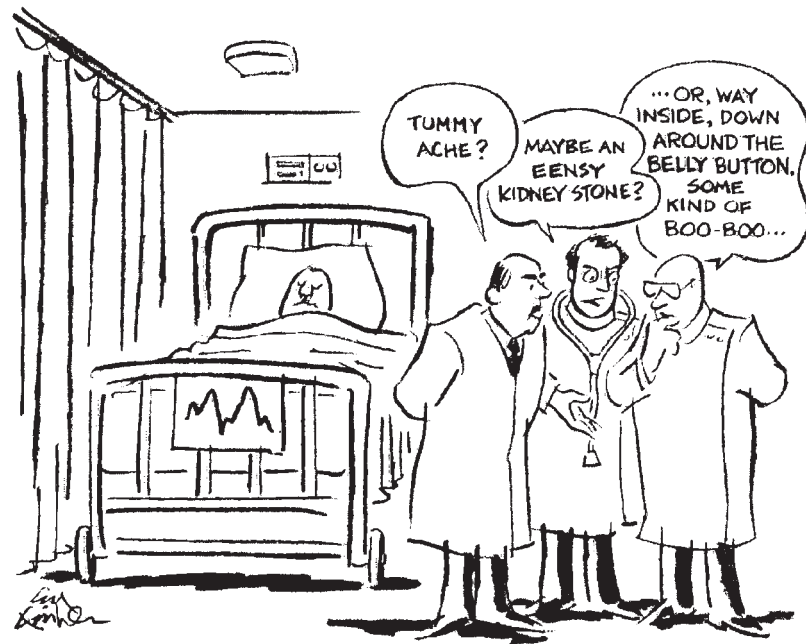
New anatomical terms are introduced as technology advances, but many older words and phrases persist. Latin and Greek words form the basis for an impressive number of anatomical terms. Many Latin names assigned to specific structures 2000 years ago are still in use today. (For more information, see the Appendix “Foreign Word Roots, Prefixes, Suffixes, and Combining Forms.”)

Some anatomical structures and clinical conditions were named after the discoverer or, in the case of diseases, after the most famous victim. Over time, most of these commemorative names, or *eponyms*, have been replaced by more descriptive terms. (For information about commemorative names still being used today, see the Appendix “Eponyms in Common Use.”)

Superficial Anatomy

► **KEY POINT** Learning anatomical landmarks, regions, and directions will help you create “mental maps” of internal structures.

Figure 1.7 The Importance of Precise Vocabulary. Would you want to be this patient? [© The New Yorker Collection 1990 Ed Fisher from cartoonbank.com. All Rights Reserved.]



Except for the skin, hair, and nails (which are parts of the integumentary system), you cannot see any of the organ systems from the body surface. To understand structures that are deep to (internal to) the integument, it is important to create your own mental maps based on the illustrations and discussions throughout this text. The following sections discuss anatomical landmarks and regions that will help you create these mental maps.

Anatomical Landmarks

Figure 1.8 presents important anatomical landmarks. Become familiar with both the anatomical term (for instance, *nasus*) and its adjective form (*nasal*). Learning these terms will help you remember the location of a particular structure as well as its name. For example, the term **brachium** refers to the arm, and in later chapters you will learn about the brachialis muscle and the brachial artery, both of which are located in the arm.

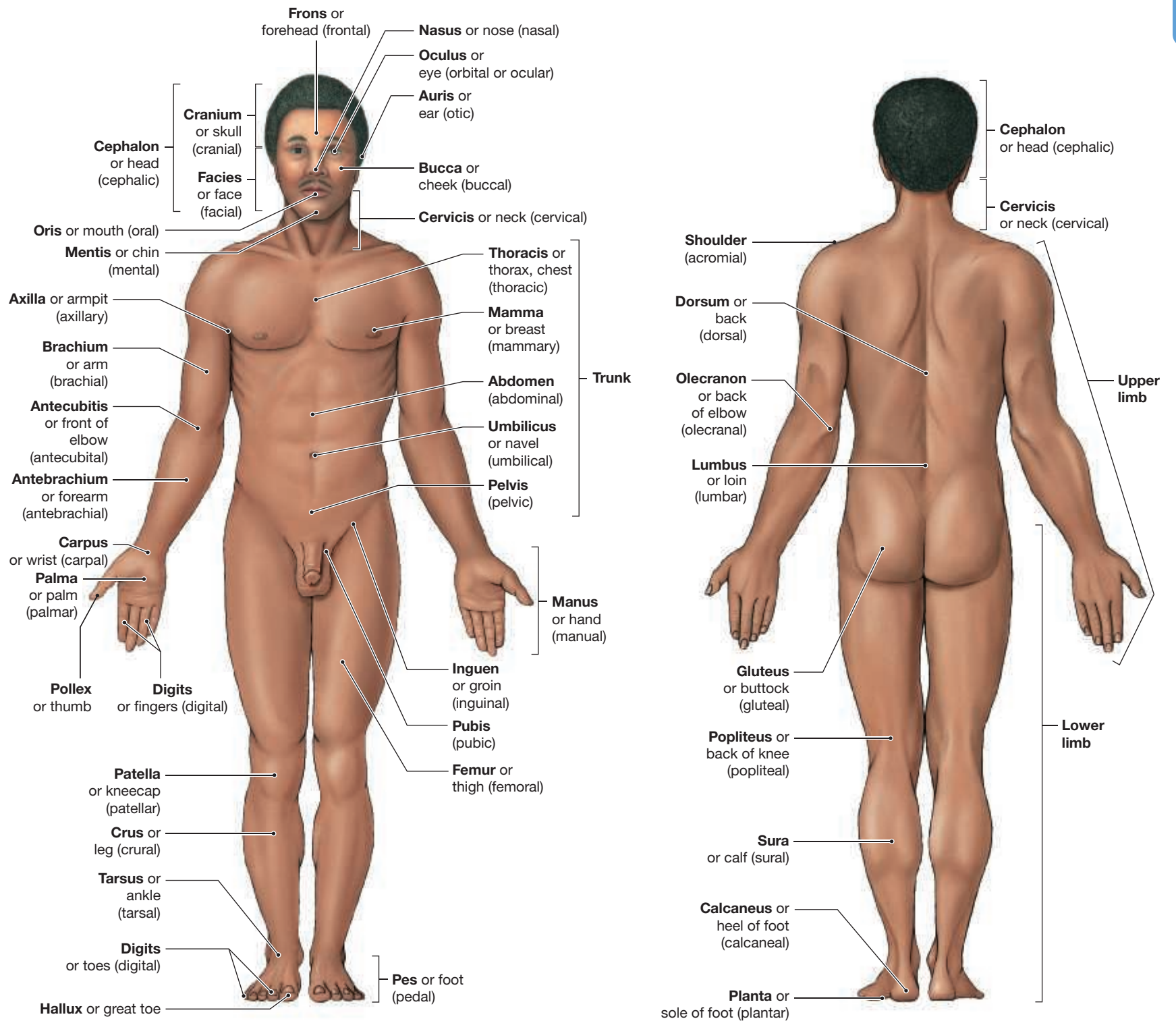
Standard anatomical illustrations show a human figure in the **anatomical position**: standing with legs together, feet flat on the floor, with hands at the sides and palms facing forward. **Figure 1.8a** shows the anatomical position from the anterior (front) view, and **Figure 1.8b** shows it from the posterior (back) view. The anatomical position is the standard by which the language of anatomy is communicated. *Therefore, unless otherwise noted, all the descriptions in this text refer to the body in the anatomical position.* A person lying down in the anatomical position is said to be **supine** (sū -PĪN) when lying face up and **prone** when lying face down.

TIPS & TOOLS

Remembering Supine Position

When you are in the supine position, you can hold a bowl of soup in the palm of your hand or on your navel without spilling it.

Figure 1.8 Anatomical Landmarks. Anatomical terms are shown in boldface type, common names are in plain type, and anatomical adjectives are in parentheses.



a Anatomical position: anterior view

b Anatomical position: posterior view

Table 1.1 | Regions of the Human Body*

Anatomical Name	Anatomical Region	Area Indicated
Cephalon	Cephalic	Head
Cervicis	Cervical	Neck
Thoracis	Thoracic	Chest
Brachium	Brachial	Segment of the upper limb closest to the trunk; the arm
Antebrachium	Antebrachial	Forearm
Carpus	Carpal	Wrist
Manus	Manual	Hand
Abdomen	Abdominal	Abdomen
Pelvis	Pelvic	Pelvis (in general)
Pubis	Pubic	Anterior pelvis
Inguen	Inguinal	Groin (crease between thigh and trunk)
Lumbus	Lumbar	Lower back
Gluteus	Gluteal	Buttock
Femur	Femoral	Thigh
Patella	Patellar	Kneecap
Crus	Crural	Leg, from knee to ankle
Sura	Sural	Calf
Tarsus	Tarsal	Ankle
Pes	Pedal	Foot
Planta	Plantar	Sole region of foot

* See [Figure 1.8](#).

Anatomical Regions

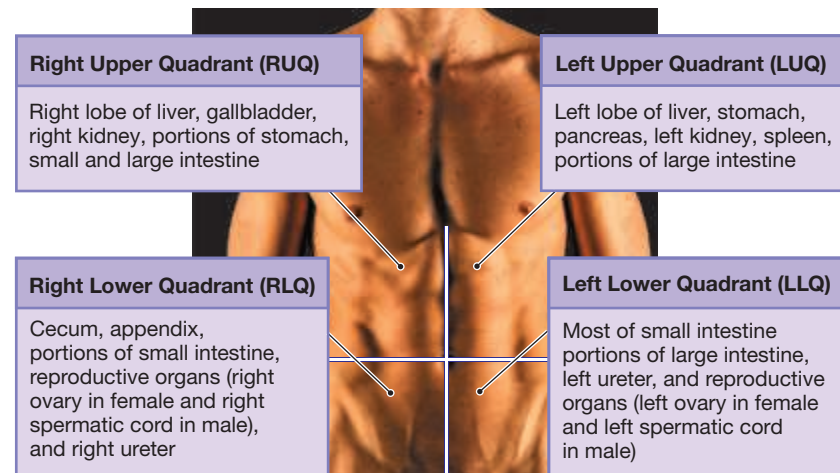
Table 1.1 summarizes the major regions of the body, and **Figure 1.9** labels these regions (additional regions and anatomical landmarks are noted in [Figure 1.8](#)). Anatomists and clinicians use special terminology to describe specific areas of the abdominal and pelvic regions. There are two different methods in use. In the first, the abdominopelvic surface is divided into four sections, called the **abdominopelvic quadrants**, using a pair of imaginary lines (one horizontal and one vertical) that intersect at the umbilicus (navel) ([Figure 1.9a](#)). This simple method is useful for describing pain and injuries. Knowing the location of an ache or pain helps a clinician determine the possible cause; for example, tenderness in the right lower quadrant (RLQ) is a symptom of appendicitis, whereas tenderness in the right upper quadrant (RUQ) may indicate gallbladder or liver problems.

In the second method, nine **abdominopelvic regions** are used to more precisely describe the location and orientation of internal organs ([Figure 1.9b](#)). [Figure 1.9c](#) shows the relationship between abdominopelvic quadrants, regions, and internal organs.

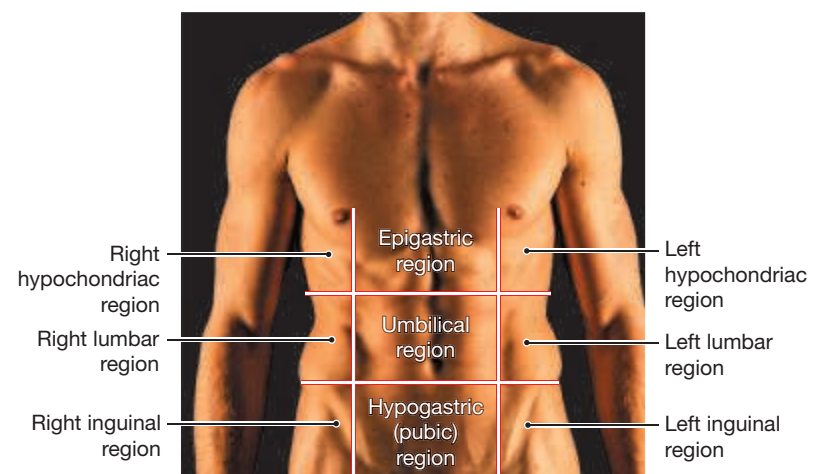
Anatomical Directions

Figure 1.10 shows the principal directional terms used in anatomy and examples of their use. There are many different directional terms, and some can be used interchangeably. As you learn these terms, it is important to remember that all anatomical directions use the anatomical position as the standard point of reference. When following anatomical descriptions, it is useful to remember that the terms left and right refer to the left and right sides of the subject, not the observer. You should also note that although some reference terms are equivalent, such as posterior and dorsal and anterior and ventral, anatomical descriptions do not mix the terms of the opposing pairs. For example, a discussion would reference either posterior versus anterior or dorsal versus ventral; it would not reference posterior versus ventral.

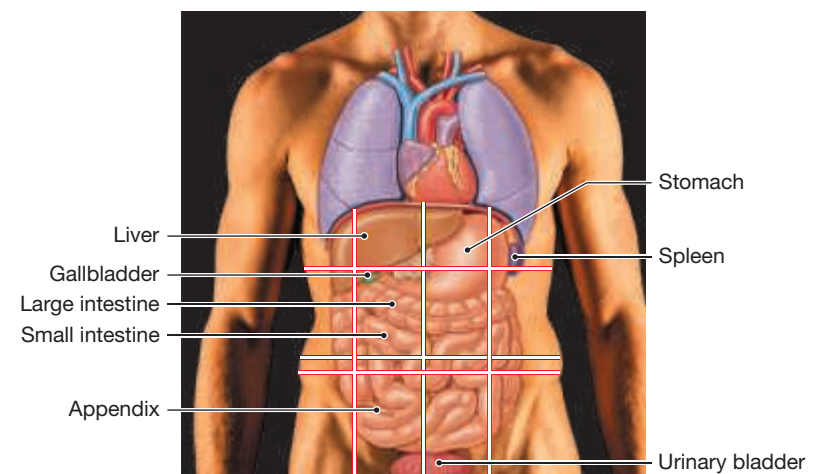
Figure 1.9 **Abdominopelvic Quadrants and Regions.** The abdominopelvic surface is separated into sections to identify anatomical landmarks more clearly and to define the location of contained organs more precisely.



a Abdominopelvic quadrants divide the area into four sections.

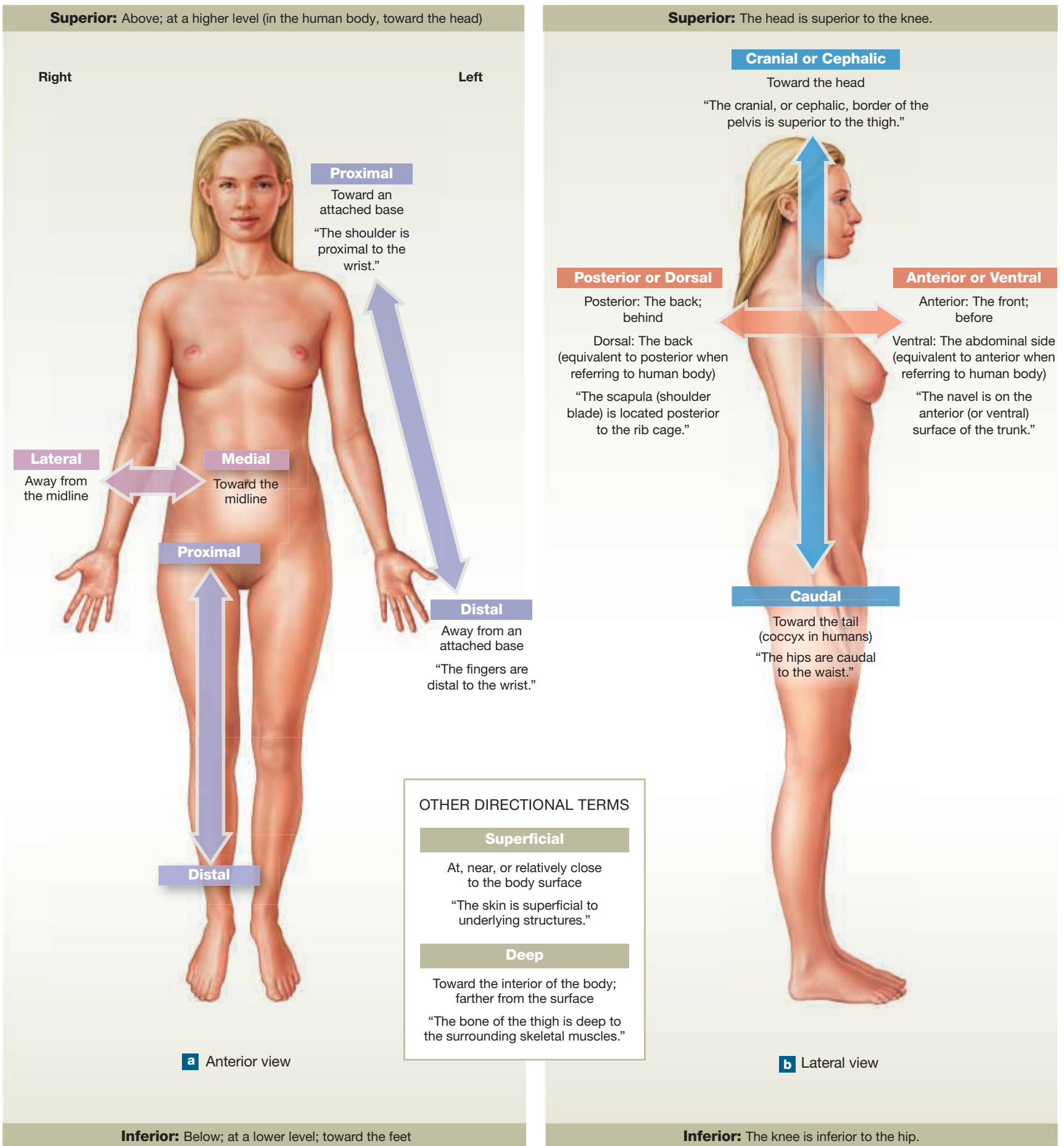


b More precise anatomical descriptions are provided by reference to the appropriate abdominopelvic region.



c Dividing the abdominal/pelvic area into quadrants or regions is useful because there is a known relationship between superficial anatomical landmarks and the underlying organs.

Figure 1.10 Directional References. The arrows indicate important directional references used in this text.



Sectional Anatomy

► **KEY POINT** The word anatomy comes from a Greek word meaning “to cut apart.” To fully understand anatomy, you must understand how the plane of section—how something is cut apart—changes the appearance of a structure.

The development of electronic imaging techniques that enable us to see inside the living body without resorting to surgery makes it important to understand sectional anatomy. A sectional view is sometimes the only way to illustrate the relationships between the parts of a three-dimensional object.

Planes and Sections

You can describe a slice through a three-dimensional object by referencing one of three **sectional planes**: frontal, sagittal, or transverse (**Figure 1.11**).

- The **frontal plane**, or *coronal plane*, parallels the longitudinal axis of the body. The frontal plane extends from side to side, dividing the body into **anterior** and **posterior** sections.
- The **sagittal plane** also parallels the longitudinal axis of the body. The sagittal plane extends from anterior to posterior, dividing the body into left and right sections. A section passing along the midline that divides the body into roughly equal left and right halves is a **midsagittal section**, or a *median sagittal section*. A section that runs parallel to the midsagittal line is a **parasagittal section**.
- The **transverse plane**, or *horizontal* or *cross-sectional plane*, lies at right angles to the longitudinal axis of the part of the body being studied. A division along this plane is a **transverse section**, or *horizontal* or *cross section*.

Each sectional plane gives a different perspective on the structure of the body. When combined with observations of external anatomy, they create a reasonably complete picture. You could develop an even more complete picture by choosing one sectional plane and making a series of sections at small intervals. This process, called **serial reconstruction**, allows us to analyze complex structures. **Figure 1.12** shows the serial reconstruction of a simple bent tube, such as a piece of elbow macaroni. This procedure can show the path of a small blood vessel or follow a loop of the intestine. Serial reconstruction is an important method for studying histological structure and analyzing the images produced by sophisticated clinical procedures (see the Clinical Note on pp. 20–21).

Body Cavities

The human body is not a solid object; many organs are suspended in internal chambers called **body cavities*** that protect and cushion them. The **ventral body cavity** contains organs of the respiratory, cardiovascular, digestive, urinary, and reproductive systems (**Figure 1.13**). The ventral body cavity is subdivided into the thoracic cavity and the abdominopelvic cavity; the **diaphragm** (DĪ-a-fram) is a dome-shaped sheet of skeletal muscle that separates them (**Figure 1.13**). The internal organs that project into these cavities are called **viscera** (VIS-er-a). Many of the organs within these cavities change size and shape as they perform their

*In the human adult, the thoracic, abdominal, and pelvic cavities share a common embryological origin. The term *dorsal body cavity* is sometimes used to refer to the internal chamber of the skull and the space enclosed by the vertebral arches. These chambers, which are defined by bony structures, are anatomically and embryologically distinct from true body cavities, and the term dorsal body cavity is not encountered in either clinical anatomy or comparative anatomy.

Figure 1.11 Sectional Planes. The three primary planes of section are frontal, sagittal, and transverse.

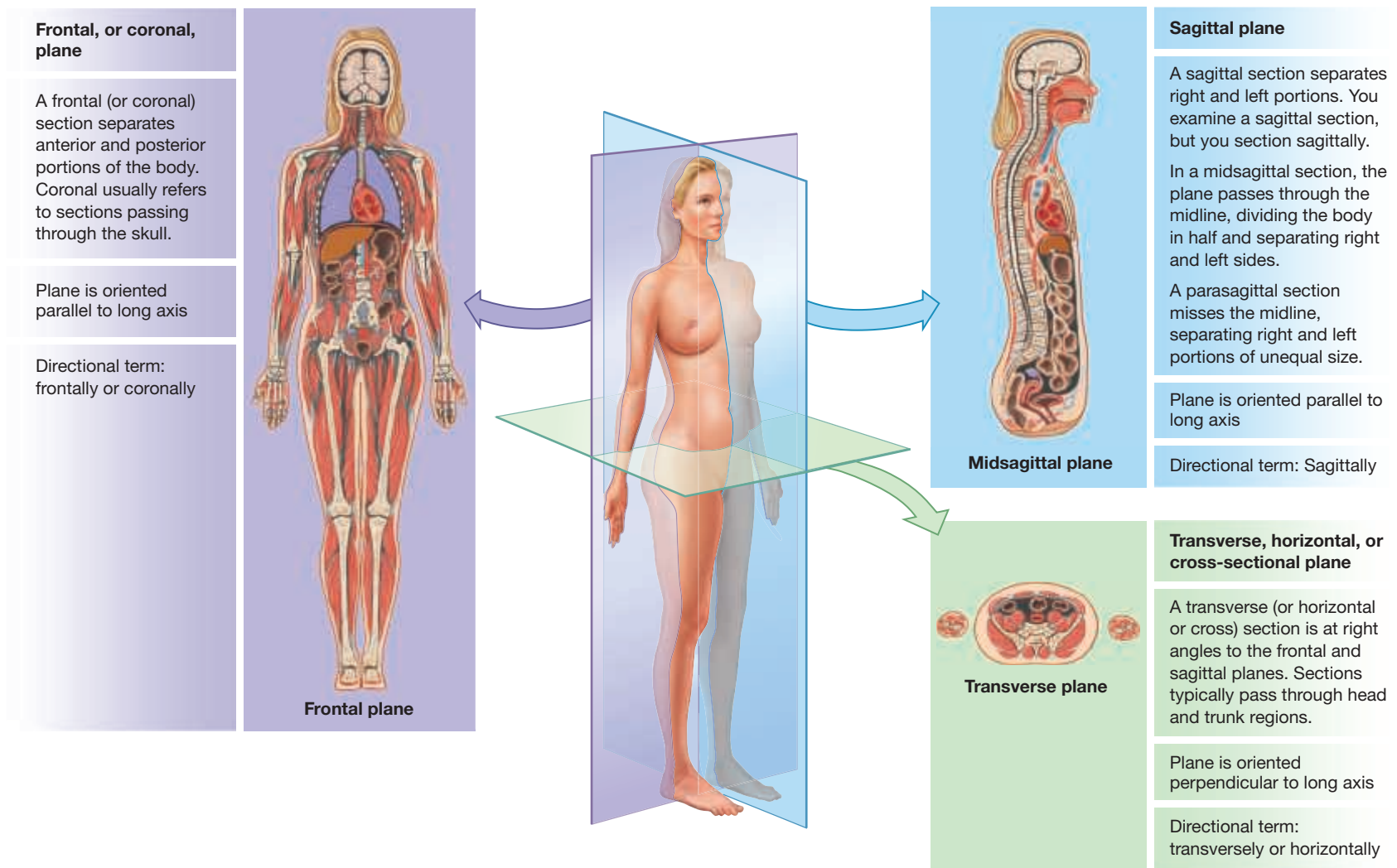
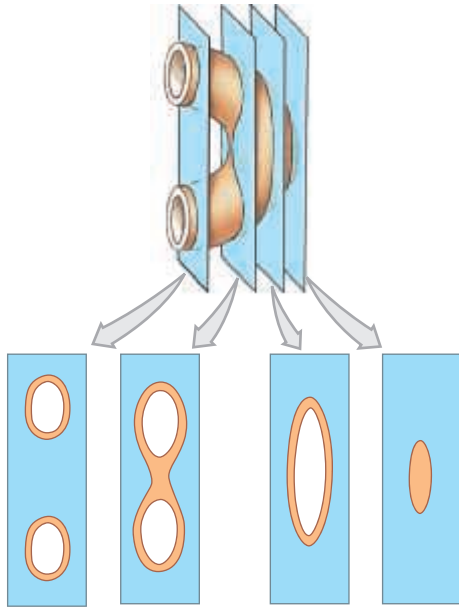


Figure 1.12 Sectional Planes and Visualization. This diagram shows the serial reconstruction of a bent tube (like a piece of elbow macaroni). Notice how the sectional views change as the plane approaches the curve. Keep the effects of sectioning in mind when looking at slides under the microscope. Sectional views of internal organs, such as those taken via a CT or MRI scan (see pp. 20–21), can vary widely. For example, although it is a simple tube, the small intestine can look like a pair of tubes, a dumbbell, an oval, or a solid, depending on where the section was taken.



functions. For example, the stomach swells at each meal, and the heart contracts and expands with each beat. These organs project into moist internal chambers that allow expansion and limited movement, but prevent friction.

The Thoracic Cavity The **thoracic cavity** contains organs of the respiratory, cardiovascular, and lymphatic systems, as well as the thymus and inferior portions of the esophagus. The muscles and bones of the chest wall and the diaphragm form the boundaries of the thoracic cavity. The thoracic cavity is subdivided into the left and right pleural cavities, which are separated by the mediastinum (Look ahead to **Figure 1.13a–c**).

Each **pleural cavity** contains a lung. A shiny, slippery serous membrane called a **pleura** (plūr-ah) lines each pleural cavity and reduces friction as the lung expands and recoils during breathing. The **visceral pleura** covers the outer surfaces of each lung, and the **parietal pleura** covers the opposing mediastinal surface and the inner body wall.

The **mediastinum** (mē-dē-as-tī-num) is connective tissue that surrounds, stabilizes, and supports the esophagus, trachea, thymus, and major blood vessels that originate or end at the heart. The mediastinum also contains the **pericardial cavity**, a small chamber that surrounds the heart. The serous membrane covering the heart is called the **pericardium** (*peri*, around, + *kardia*, heart). To visualize the relationship between the heart and pericardial cavity, think of a fist pushing into a balloon (**Figure 1.13d**): The wrist corresponds to the base (attached portion) of the heart, and the balloon corresponds to the pericardium.

The pericardium is composed of two parts: an outer sac of tough, fibrous connective tissue termed the **parietal layer of the serous pericardium** an inner **visceral layer of the serous pericardium**. During each beat, the heart changes in size and shape. The pericardial cavity permits these changes, and the slippery pericardial lining prevents friction between the heart and adjacent structures in the mediastinum.

The Abdominopelvic Cavity The **abdominopelvic cavity** is divided into (1) a superior abdominal cavity, (2) an inferior pelvic cavity, and (3) an internal chamber called the **peritoneal** (per-i-tō-NĒ-al) **cavity** (**Figure 1.13a,c**).

The peritoneal cavity is lined by a serous membrane called the **peritoneum** (per-i-tō-NĒ-um). The **parietal peritoneum** lines the body wall. A narrow, fluid-filled space separates the parietal peritoneum from the **visceral peritoneum**, which covers the enclosed organs. Double sheets of peritoneum, called **mesenteries** (MES-en-ter-ēs), suspend organs such as the stomach, small intestine, and portions of the large intestine within the peritoneal cavity. Mesenteries provide blood supply, support, lubrication, and stability while permitting limited movement.

The **abdominal cavity** extends from the inferior surface of the diaphragm to an imaginary plane extending from the inferior surface of the lowest spinal vertebra to the anterior and superior margins of the pelvic girdle (**Figure 1.13a,c**). The abdominal cavity contains the liver, stomach, spleen, kidneys, pancreas, and small intestine, and most of the large intestine. (Refer to **Figure 1.9a,c** on page 16 for the positions of many of these organs.) These organs project partially or completely into the peritoneal cavity, much as the heart and lungs project into the pericardial and pleural cavities, respectively.

The inferior portion of the abdominopelvic cavity is the **pelvic cavity** (**Figure 1.13a,c**). The pelvic cavity is enclosed by the bones of the pelvis and contains the last segments of the large intestine, the urinary bladder, and various reproductive organs: The pelvic cavity of a female contains the ovaries, uterine tubes, and uterus; in a male, it contains the prostate and seminal glands. The inferior portion of the peritoneal cavity extends into the pelvic cavity. The peritoneum covers the uterine tubes, the ovaries, and the superior portion of the uterus in females, as well as the superior portion of the urinary bladder in both males and females.

The Clinical Note on pp. 20–21 summarizes modern methods of visualizing anatomical structures in living people. A true understanding of anatomy involves integrating the information provided by sectional images, interpretive artwork based on sections and dissections, and direct observation. It is up to you to integrate these views and develop your ability to observe and visualize anatomical structures. Remember that every structure you encounter has a specific function. The goal of anatomy isn't simply to identify structural details, but to understand the three-dimensional relationships between bodily structures and how those structures interact to perform the varied functions of the human body.



CLINICAL NOTE

Pericarditis and Peritonitis

The suffix *-itis* means “inflammation.” Thus, pericarditis means inflammation of the pericardium. Pericarditis can be caused by any disease-causing agent or trauma, and it can severely restrict the function of the heart. Peritonitis is an inflammation of the peritoneum (the serous membrane lining the abdomen). It may be due to bacterial infection, liver failure, kidney failure, or many other causes. Peritonitis affects all the organs within the peritoneal cavity.

1.6 CONCEPT CHECK



- 10 You fall and break your antebrachium. What part of your body is affected?
- 11 What is the anatomical name for each of the following areas: groin, buttock, and hand?
- 12 What type of section would separate the two eyes?
- 13 What is the general function of the mesenteries?
- 14 If a surgeon makes an incision just inferior to the diaphragm, which body cavity will be opened?

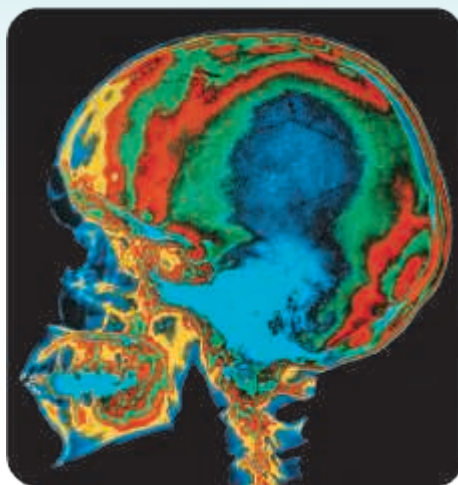
See the blue Answers tab at the back of the book.



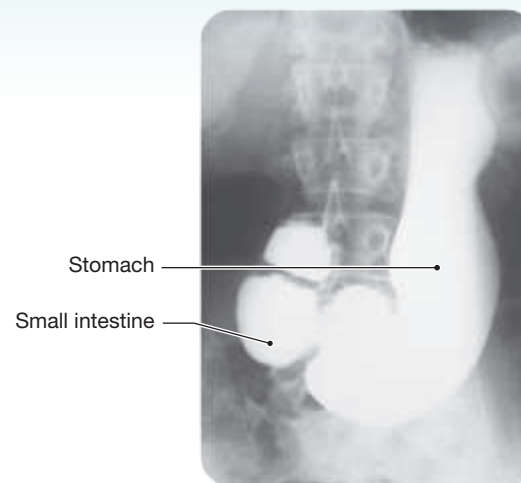
Clinical Anatomy and Technology



X-ray



Color-enhanced x-ray



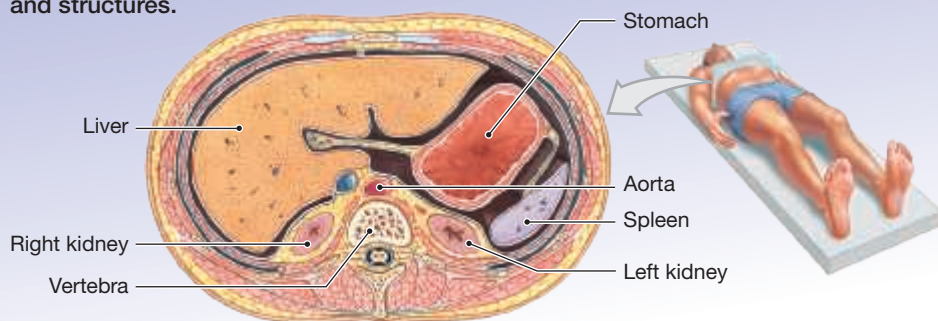
Barium-contrast x-ray

Radiological procedures

include various noninvasive techniques that use radioisotopes, radiation, and magnetic fields to produce images of internal structures. Physicians who specialize in the performance and analysis of these diagnostic images are called radiologists. Radiological procedures can provide detailed information about internal systems and structures.

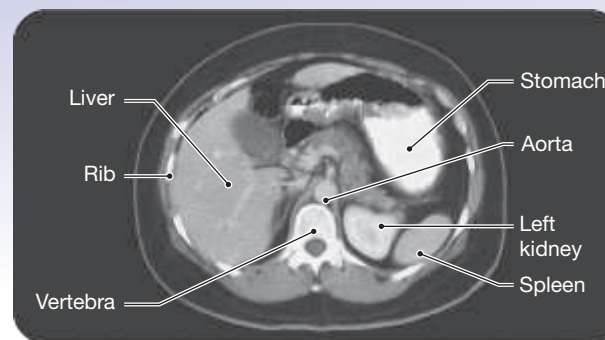
X-rays are a form of high-energy radiation that can penetrate living tissues. In the most familiar procedure, a beam of x-rays travels through the body and strikes a photographic plate. Not all of the projected x-rays arrive at the film; some are absorbed or deflected as they pass through the body. The resistance to x-ray penetration is called radiodensity. In the human body, the order of increasing radiodensity is as follows: air, fat, liver, blood, muscle, bone. The result is an image with radiodense tissues, such as bone, appearing white, while less dense tissues are seen in shades of gray to black.

A **barium-contrast x-ray** of the upper digestive tract. Barium is very radiodense, and the contours of the gastric and intestinal lining can be seen outlined against the white of the barium solution.



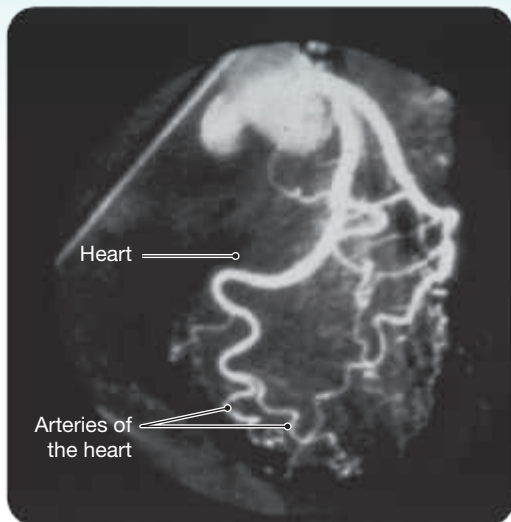
The relative position and orientation of the scans shown to the right.

Note that when anatomical diagrams or scans present cross-sectional views, the sections are presented as though the observer were standing at the feet of a person in the supine position and looking toward the head of the subject.

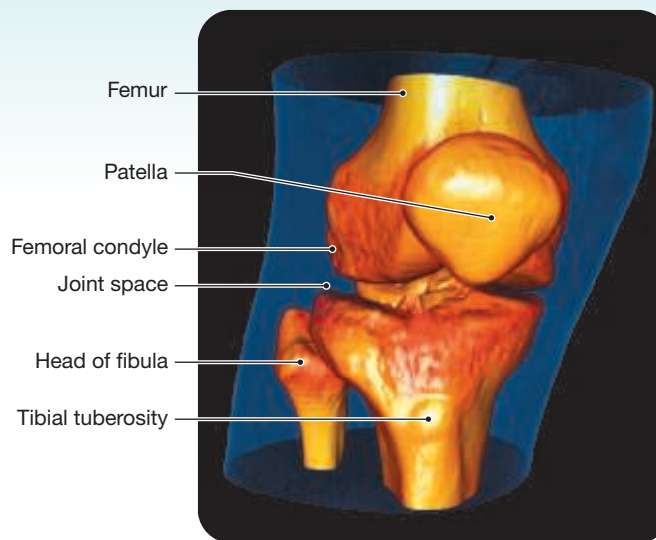


CT scan of the abdomen

CT scans, formerly called CAT (computerized axial tomography), use a single x-ray source rotating around the body. The x-ray beam strikes a sensor monitored by a computer. The source completes one revolution around the body every few seconds; it then moves a short distance and repeats the process. By comparing the information obtained at each point in the rotation, the computer reconstructs the three-dimensional structure of the body. The result is usually displayed as a sectional view in black and white, but it can be colorized.



Digital subtraction angiography

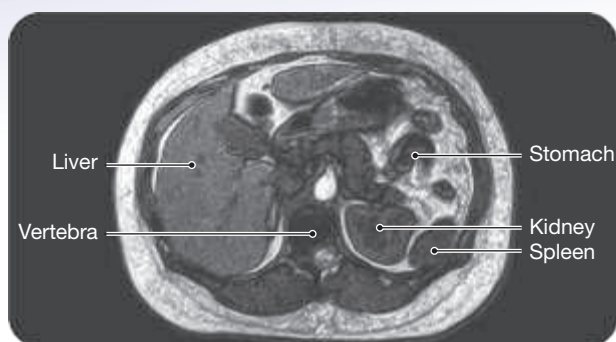


Spiral scan



Digital subtraction angiography (DSA) is used to monitor blood flow through specific organs, such as the brain, heart, lungs, and kidneys. X-rays are taken before and after radiopaque dye is administered, and a computer “subtracts” details common to both images. The result is a high-contrast image showing the distribution of the dye.

A **spiral CT scan** (also termed a helical CT scan) is a new form of three-dimensional imaging technology that is becoming increasingly important in clinical settings. With a spiral CT scan the patient is placed on a platform that advances at a steady pace through the scanner while the imaging source, usually x-rays, rotates continuously around the patient. Because the x-ray detector gathers data quickly and continuously, a higher quality image is generated, and the patient is exposed to less radiation as compared to a standard CT scanner, which collects data more slowly and only one slice of the body at a time.



MRI scan of the abdomen

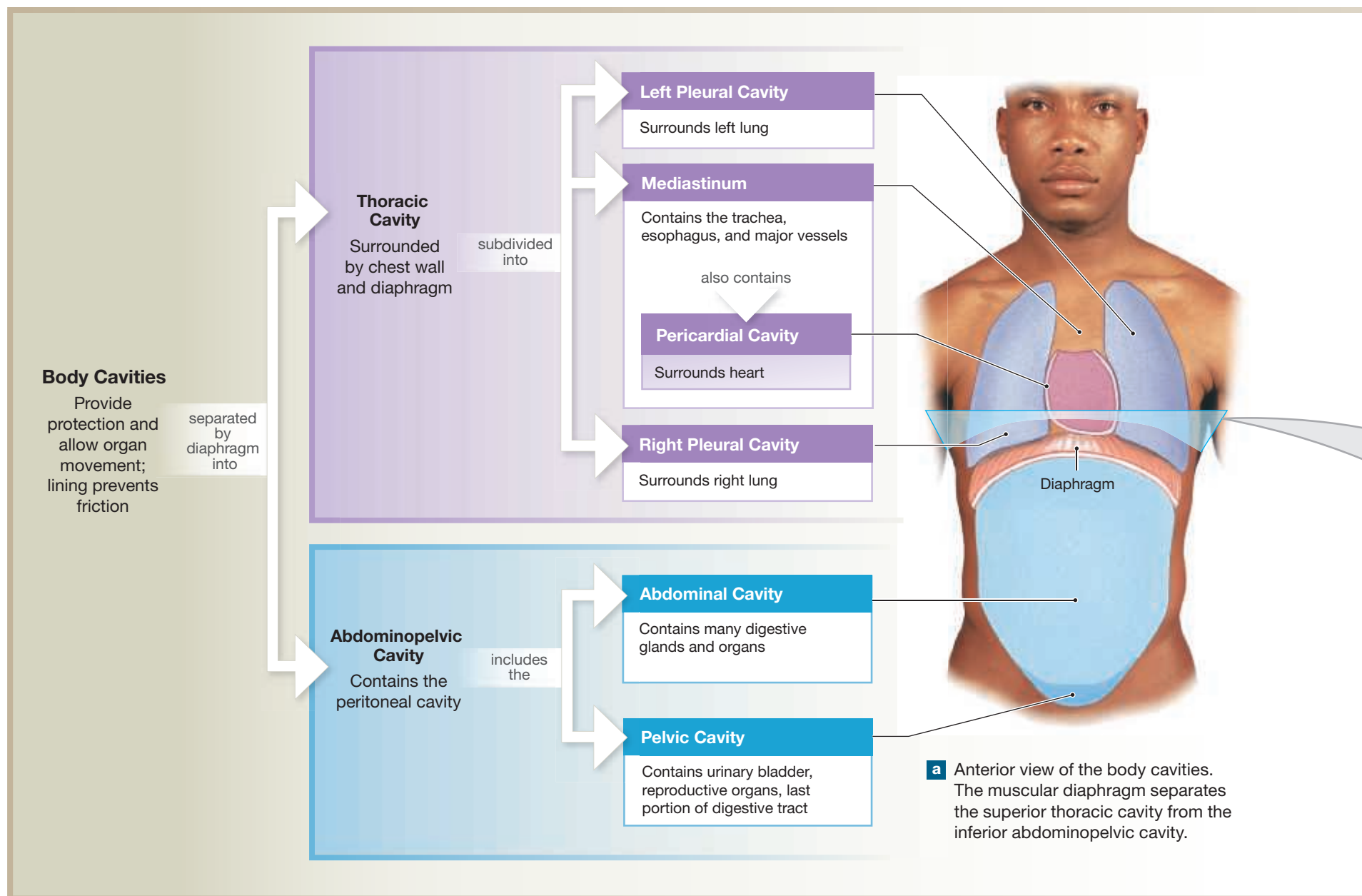


Ultrasound scan of the abdomen

An **MRI (magnetic resonance imaging)** scan surrounds part or all of the body with a magnetic field about 3000 times as strong as that of Earth. This field affects protons within atomic nuclei throughout the body, which line up along the magnetic lines of force like compass needles in Earth’s magnetic field. When struck by a radio wave of the proper frequency, a proton will absorb energy. When the pulse ends, that energy is released, and the energy source of the radiation is detected by the MRI computers.

In **ultrasound** procedures, a small transmitter contacting the skin broadcasts a brief, narrow burst of high-frequency sound and then picks up the echoes. The sound waves are reflected by internal structures, and a picture, or echogram, can be assembled from the pattern of echoes. These images lack the clarity of other procedures, but no adverse effects have been attributed to the sound waves, and fetal development can be monitored without a significant risk of birth defects.

Figure 1.13 Body Cavities. Relationships, contents, and selected functions of the subdivisions of the thoracic and abdominopelvic body cavities.



Study Outline

Introduction p. 2

- **Anatomy** is the study of internal and external structures and the physical relationships between body parts. Specific anatomical structures perform specific functions.

1.1 | Microscopic Anatomy p. 2

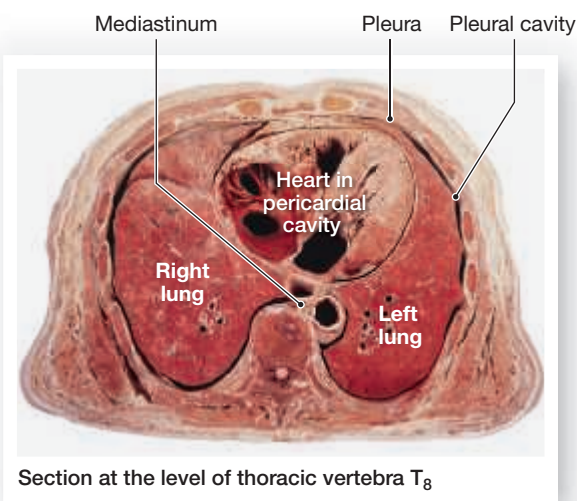
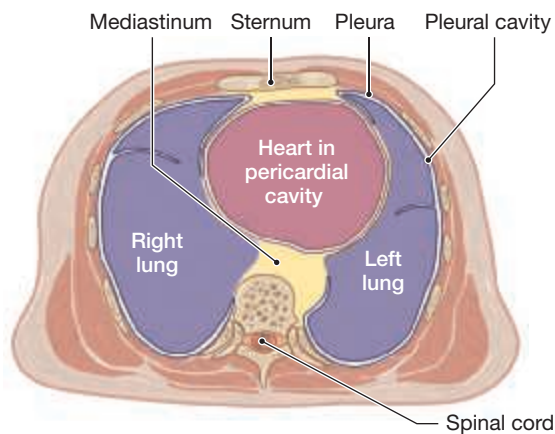
- The boundaries of **microscopic anatomy** are established by the limits of the equipment used. **Cytology** is the study of the internal structure of individual **cells**, the smallest units of life. **Histology** examines **tissues**, groups of cells that work together to perform specific functions. Specific arrangements of tissues form an **organ**, an anatomical unit with multiple functions. A group of organs that function together forms an **organ system**. (See Figure 1.1.)

1.2 | Gross Anatomy p. 2

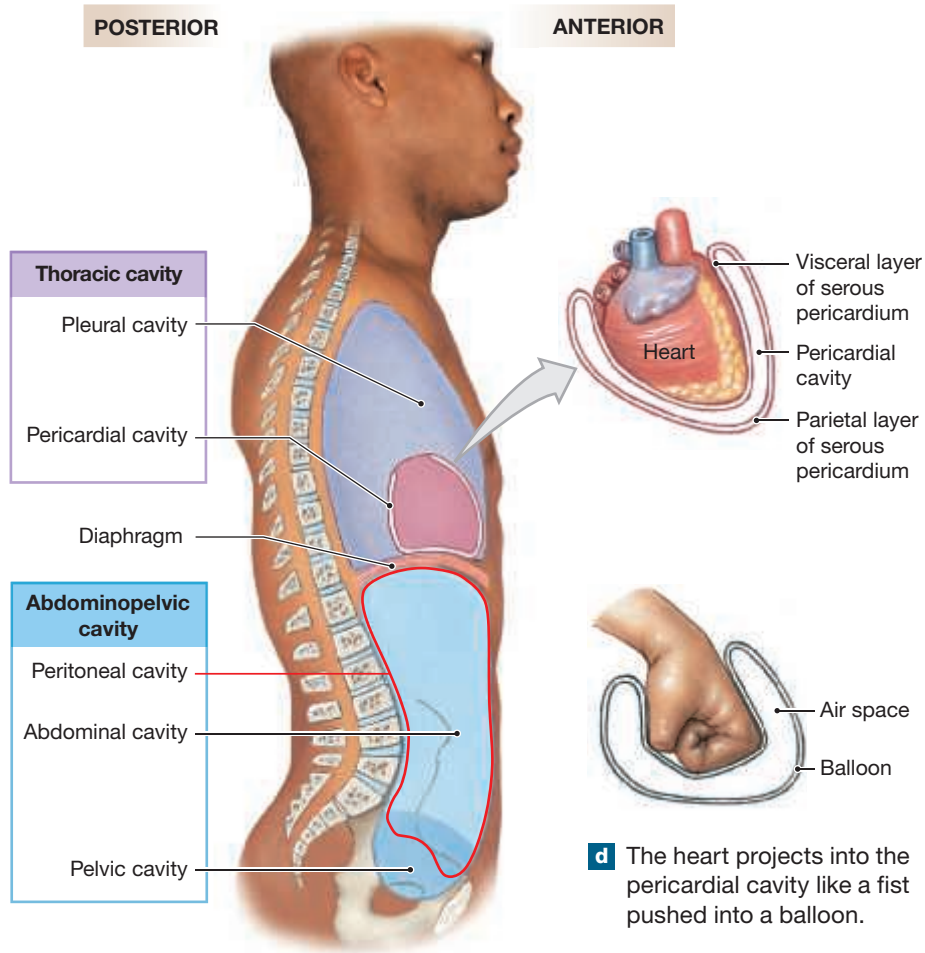
- **Gross** (macroscopic) **anatomy** considers features visible without a microscope. It includes **surface anatomy** (general form and superficial markings), **regional anatomy** (superficial and internal features in a specific area of the body), and **systemic anatomy** (structure of major organ systems).

1.3 | Other Types of Anatomical Studies p. 2

- **Developmental anatomy** examines the changes in form that occur between conception and physical maturity. **Embryology** studies the processes that occur during the first two months of development.
- **Comparative anatomy** considers the similarities and relationships in anatomical organization of different animals. (See Figure 1.2.)



b Sectional view of the thoracic cavity. Unless otherwise noted, all sectional views are presented in inferior view. (See Clinical Note on pp. 20–21 for more details.)



c Lateral view of the subdivisions of the body cavities.

- Anatomical specialties important to clinical practice include **clinical anatomy** (anatomical features that undergo characteristic changes during illness), **surgical anatomy** (landmarks important for surgical procedures), **radiographic anatomy** (anatomical structures that are visualized by specialized procedures performed on an intact body), and **cross-sectional anatomy**. (See *Clinical Note* on pp. 20–21.)

1.4 | Levels of Organization p. 5

- Anatomical structures are arranged in a series of interacting levels of organization ranging from the chemical/molecular level, through cell/tissue levels, to the organ/organ system/organism levels. (See *Figures 1.3 and 1.4*.)
- When the body's internal environment is relatively stable, this is called **homeostasis**.

1.5 | An Introduction to Organ Systems p. 7

- All living organisms share a set of vital properties and processes: **responsiveness** to changes in their environment, growth and **differentiation**, reproduction, movement, and **metabolism** and **excretion**. Organisms absorb and consume oxygen during **respiration** and discharge waste products during excretion. **Digestion** breaks down complex foods for use by the body. The **cardiovascular system** forms an internal transportation system between areas of the body. (See *Figures 1.5 and 1.6*.)
- The 11 organ systems of the human body perform these vital functions. (See *Figure 1.5*.)

1.6 | The Language of Anatomy p. 14

- Anatomy uses a specialized language. (See *Figures 1.7 to 1.13*.)

Superficial Anatomy p. 14

- Standard anatomical illustrations show the body in the **anatomical position**. (See Figures 1.8 and 1.10.)
- A person lying down in the anatomical position may be **supine** (face up) or **prone** (face down).
- Specific terms identify specific anatomical regions. (See Figure 1.8 and Table 1.1.)
- Abdominopelvic quadrants** and **abdominopelvic regions** represent two different approaches to describing locations in the abdominal and pelvic areas of the body. (See Figure 1.9.)
- Specific directional terms are used to indicate relative location on the body. (See Figure 1.10.)

Sectional Anatomy p. 18

- There are three **sectional planes**: **frontal plane** or *coronal plane* (anterior versus posterior), **sagittal plane** (right versus left sides), and **transverse plane** (superior versus inferior). These sectional planes and related reference terms describe relationships between the parts of the three-dimensional human body. (See Figure 1.11.)
- Serial reconstruction** is an important technique for studying histological structure and analyzing images produced by radiological procedures. (See Figure 1.12.)

- Body cavities** protect delicate organs and permit changes in the size and shape of visceral organs.
- The **diaphragm** separates the superior **thoracic cavity** from the inferior **abdominopelvic cavity**. (See Figure 1.13.)
- The **abdominal cavity** extends from the inferior surface of the diaphragm to an imaginary line drawn from the inferior surface of the most inferior spinal vertebra to the anterior and superior margin of the pelvic girdle. Inferior to this imaginary line is the **pelvic cavity**. (See Figure 1.13.)
- The thoracic and abdominopelvic cavities contain narrow, fluid-filled spaces lined by a serous membrane. The thoracic cavity contains two **pleural cavities** (each surrounding a lung) separated by the **mediastinum**. (See Figure 1.13.)
- The mediastinum contains the thymus, trachea, esophagus, blood vessels, and the **pericardial cavity**, which surrounds the heart. The membrane lining the pleural cavities is called the **pleura**; the membrane lining the pericardial cavity is called the **serous pericardium**. (See Figure 1.13.)
- The **abdominopelvic cavity** contains the **peritoneal cavity**, which is lined by the **peritoneum**. Many digestive organs are supported and stabilized by **mesenteries**. (See Figure 1.13.)
- Important **radiological procedures**, which can provide detailed information about internal systems, include **x-rays**, **CT scans**, **MRI**, and **ultrasound**. Physicians who perform and analyze these procedures are called radiologists. (See Clinical Note on pp. 20–21.)

Chapter Review

For answers, see the blue Answers tab at the back of the book.

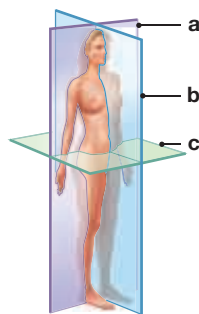
Level 1 Reviewing Facts and Terms

Match each numbered item with the most closely related lettered item.

- | | |
|----------------------|--------------------------|
| 1. supine | <input type="checkbox"/> |
| 2. cytology | <input type="checkbox"/> |
| 3. homeostasis | <input type="checkbox"/> |
| 4. lumbar | <input type="checkbox"/> |
| 5. prone | <input type="checkbox"/> |
| 6. metabolism | <input type="checkbox"/> |
| 7. histology | <input type="checkbox"/> |

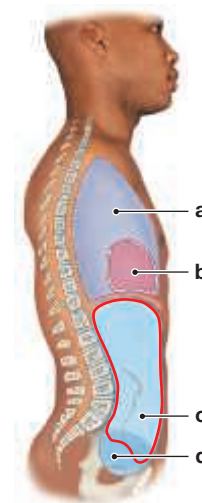
- a. study of tissues
 b. face down
 c. all chemical activity in body
 d. study of cells
 e. face up
 f. constant internal environment
 g. lower back

8. Label the planes on the diagram below.



- (a) _____
 (b) _____
 (c) _____

9. Label the abdominal, pleural, pelvic, and pericardial cavities on the diagram below.



- (a) _____
 (b) _____
 (c) _____
 (d) _____