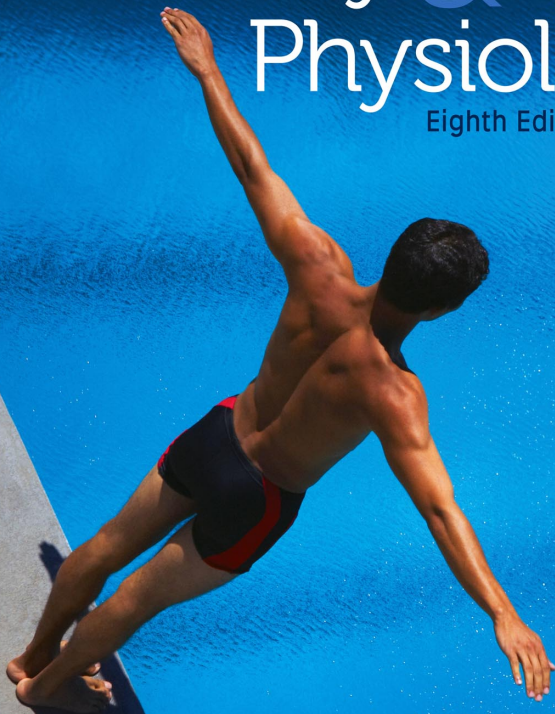


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# ESSENTIALS OF Anatomy & Physiology

Eighth Edition



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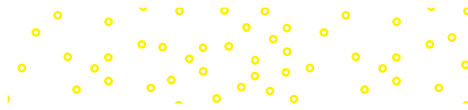
Jason LaPres | Beth Kersten

ESSENTIALS OF  
**Anatomy &  
Physiology**  
Eighth Edition



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Jason LaPres  
Beth Kersten



ESSENTIALS OF ANATOMY & PHYSIOLOGY

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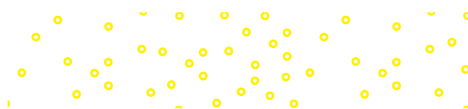
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Jason LaPres received his Master's of Health Science degree with an emphasis in Anatomy and Physiology from Grand Valley State University in Allendale, Michigan.

Over the past 20 years, Jason has had the good fortune to be associated with a number of colleagues who have mentored him, helped increase his skills, and trusted him with the responsibility of teaching students who will be caring for others. Jason began his career in Michigan, where from 2001 to 2003 he taught as an adjunct at Henry Ford Community College, Schoolcraft College, and Wayne County Community College, all in the Detroit area. Additionally, at that time he taught high school chemistry and physics at Detroit Charter High School. Jason is currently Dean of Instruction and Professor of Biology at Lone Star College–CyFair in Houston, Texas. He has been with LSC since 2003. In his capacity with LSC he has served as Faculty Senate President for two of the six LSC campuses. His academic background is diverse and, although his primary teaching load is in the Human Anatomy and Physiology program, he has also taught classes in Pathophysiology and mentored several Honor Projects.

Prior to authoring this textbook, Jason produced dozens of textbook supplements and online resources for many other Anatomy and Physiology textbooks.



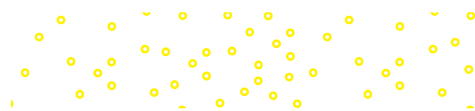
*Beth Kersten/McGraw Hill*

## **Beth Kersten** *State College of Florida*

Beth Ann Kersten is a tenured professor at the State College of Florida (SCF). Though her primary teaching responsibilities are currently focused on Anatomy and Physiology I and II, she has experience teaching comparative anatomy, histology, developmental biology, and nonmajor human biology. She authors a custom A&P I laboratory manual for SCF and sponsors a book scholarship for students enrolled in health science programs. She coordinates a peer tutoring program for A&P and is working to extend SCF's STEM initiative to local elementary and middle schools. Beth employs a learning strength specific approach to guide students in the development of study skills focused on their learning strengths, in addition to improving other student skills such as time management and note taking.

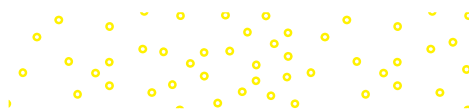
Beth graduated with a PhD from Temple University, where her research focused on neurodevelopment in zebrafish. Her postdoctoral research at the Wadsworth Research Center focused on the response of rat nerve tissue to the implantation of neural prosthetic devices. At Saint Vincent College, she supervised senior research projects on subjects such as the effects of retinoic acid on heart development in zebrafish and the ability of vitamin B12 supplements to regulate PMS symptoms in ovariectomized mice. Beth also maintains a membership in the Human Anatomy & Physiology Society.

Beth currently lives in Venice, Florida, with her husband John and daughter Melanie. As former Northerners, they greatly enjoy the ability to swim almost year round both in their pool and in the Gulf of Mexico.



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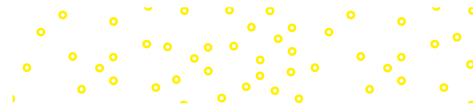
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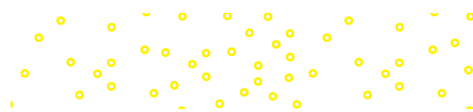
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# PREFACE

*ESSENTIALS OF ANATOMY & PHYSIOLOGY* Eighth Edition is designed for students who are enrolled in a one-semester course in human anatomy and physiology. The scope, organization, writing style, depth of presentation, and pedagogical aspects of the text have been tailored to meet the needs of students preparing for a career in one of the allied health professions, or taking the course as a general education requirement.

## Acknowledgments

The development and production of this eighth edition has been a team effort. Our dedicated and creative teammates at McGraw-Hill Education have contributed greatly to the finished product. We gratefully acknowledge and applaud their efforts, and it has been a pleasure to work with these gifted professionals at each step of the process: Erin DeHeck (Product Developer), Matt Garcia (Senior Portfolio Manager), Vicki Krug (Senior Content Project Manager), and Valerie Kramer (Senior Marketing Manager).

## Student-centric Revision

Students taking a one-semester course in anatomy and physiology have diverse backgrounds, including limited exposure to biology and chemistry, and this presents a formidable challenge to the instructor. To help meet this challenge, this text is written in a clear and concise manner, free from excess jargon, and simplifies the complexities of anatomy and physiology in ways that enhance understanding without diluting the essentials of the subject matter.

In preparation for this eighth edition, we surveyed 50 students (in a variety of majors, including allied health professions) and obtained detailed insight into how they would ideally engage with course materials. Stemming from those results, we adjusted the print and digital delivery of the content to align with student preferences.

Also, we are very pleased to incorporate real student data points and input, derived from thousands of our SmartBook™ users, to help guide our revision. SmartBook™ Heat Maps provided a quick visual snapshot of usage of portions of the text and the relative difficulty students experienced in mastering the content. With these data, we honed not only our text content revision but also the SmartBook™ probes.

## Textbook Themes and Organization

There are two unifying themes in the content presentation: (1) the relationship between structure and function of body parts and (2) the mechanisms of homeostasis. In addition, the interrelationship of organ systems is noted where appropriate and useful.

The sequence of chapters and content within each chapter progresses from simple to complex. Chapters covering an organ system begin with anatomy to ensure that students are well prepared to understand the physiology that follows. Each organ system chapter concludes with a brief consideration of common disorders that the student may encounter in the clinical setting.

## "Careers in" Opener and Learning Objectives

Each chapter begins with a list of major topics discussed in the chapter, along with an opening "Careers" vignette and image that relates the content theme of the chapter to real-world careers. Under each section header within every chapter, the learning objectives are noted. This informs students of the major topics to be covered and their minimum learning responsibilities.

## Key Terms

Several features have been incorporated to assist students in learning the necessary technical terms that often are troublesome for beginning students.

1. Throughout the text, key terms are in bold or italic type for easy recognition, and they are defined at the time of first usage. A phonetic pronunciation follows for students who need help in pronouncing the term. Experience has shown that students learn only terms that they can pronounce.
2. Keys to Medical Terminology in Appendix A explains how technical terms are structured and provides a list of prefixes, suffixes, and root words to further aid an understanding of medical terminology.

## Figures and Tables

Over 350 high-quality, full-color illustrations are coordinated with the text to help students visualize anatomical features and physiological concepts. Tables are used throughout to summarize information in a way that is more easily learned by students.

## Clinical Insight

Numerous boxes containing related clinical information are strategically placed throughout the text. They serve to provide interesting and useful information related to the topic at hand. The Clinical Insight boxes are identified by a medical cross for easy recognition.

## Check My Understanding

Review questions at the end of major sections challenge students to assess their understanding before proceeding.

## Chapter Summary

The chapter summary is conveniently linked by section and briefly states the important facts and concepts covered in each chapter.

## Changes in the Eighth Edition

The eighth edition has been substantially enhanced and improved.

### Global Changes

- Added a “Careers in” section at the start of every chapter to show students how the chapter content relates to careers in the real world.
- Approximately 20 figures and tables were revised or are completely new.
- Revised descriptive language to improve the overall readability of the text. Terminology and phrasing more commonly used by students outside the classroom have been added where appropriate. By making the text easier to read, students will have an easier time grasping more complex anatomical and physiological content.
- Added the course guide of the seventh edition back into the lecture text to facilitate easier student use and completion.
- Updated terminology to align with the *Terminologia Anatomica*, *Terminologia Histologica*, and *Terminologia Embryologica*.

### Chapter 1

- Added common alternative names to some regional terminology.
- Updated figure 1.6 to show the cross-section of the thoracic cavity in the correct standard orientation.

### Chapter 2

- Updated organic molecule terminology for accuracy.
- Corrected the structure of fructose in multiple figures.
- Corrected the structure of the unsaturated fatty acid in figure 2.14.

### Chapter 3

- Added free ribosomes to figure 3.1.
- Updated discussion of cell cycle to include phase names in both text and figures.

### Chapter 4

- Reorganized entire chapter into table format for easier reading and to minimize redundant information.
- Updated terminology to align with the TH.

### Chapter 5

- Updated tissue descriptions for dermis.
- Relabeled figure 5.6.

### Chapter 6

- Rewrote the bone structure section to describe all bones, not just a long bone.
- Reordered figures 6.1 to 6.3 to follow the flow of the new bone structure section.
- Moved table 6.1 closer to figure 6.5 as they both discuss ossification.
- Added coloring legend to figure 6.6 to highlight the axial and appendicular skeletons.
- Relabeled minor updates in several figures.
- Updated mandibular terminology with NEW figure 6.13 added.
- Revised pectoral girdle section.
- Rewrote joint descriptions using matching terminology for clarity.
- Added NEW figure 6.29 to show osteoporosis.
- Revised figure 6.28 on fractures to combine art and text describing fractures.

### Chapter 7

- Updated muscle terminology throughout the text to match TH. Updated terminology is more descriptive to promote student learning.
- Revised figure 7.2 to improve accuracy.
- Replaced old terminology on origins and insertions with updated attachment terminology.
- Updated all tables to match the attachment terminology update.

- Updated actions for some muscles so that all muscle actions describe the body part moved.

## Chapter 8

- Updated terminology throughout chapter to align with the TA and TH.
- Added satellite cells to neuroglia section.
- Revised membrane potentials for clarity.
- Added a NEW figure 8.13 that shows superior, lateral, and median sections of the brain. Previous edition was only a median section.
- Added a NEW figure 8.14 depicting a frontal section of the cerebrum showing white matter and grey matter and highlighting the basal nuclei.
- Included the function of the basal nuclei in the cerebrum section.
- Included the superior colliculi, inferior colliculi, and substantia nigra in the section on the brainstem.
- Added a NEW Clinical Insight on aphasias.
- Added a NEW figure 8.20 that shows the four branches of spinal nerves and how they exit the vertebral canal.
- Updated figure 8.25 to match figure 8.24 color scheme.

## Chapter 9

- Revised the sections on eyes and ears to clearly state that there are two of each and they function the same.
- Revised the flow of an action potential through the retina for accuracy and clarity.

## Chapter 10

- Updated figure 10.2 to include calcitonin.
- Updated multiple figures to match style with figure 10.6. This includes color coding processes for clarity.
- Redesigned figures 10.10 and 10.13 completely to reflect negative-feedback loops.

## Chapter 11

- Revised description of hemoglobin breakdown for accuracy and clarity.
- Updated figure 11.6 to show positive-feedback within coagulation pathway.
- Revised section on hemostasis for clarity regarding negative- vs. positive-feedback mechanisms.
- Added the use of RhoGAM in the prevention of hemolytic disease of the newborn.

## Chapter 12

- Updated figure 12.11 to match color scheme established in chapter 8 for autonomic pathways.
- Added a NEW figure 12.18 that illustrates the factors affecting blood pressure.
- Updated the values and terminology for hypertension to match new American Heart Association recommendations.

## Chapter 13

- Added a description of regulatory T cells.
- Revised figure 13.9 to include regulatory T cells.

## Chapter 14

- Revised chemoreceptor discussion to separate central and peripheral chemoreceptors.
- Added a NEW figure 14.10 that shows the effects of chemoreceptors on ventilation.

## Chapter 15

- Revised the description of dentin so as to not be confused with bone tissue.
- Revised figure 15.7 to updated style.
- Revised figure 15.19 to updated style.

## Chapter 16

- Revised the discussion of collecting ducts and papillary ducts to better clarify their inclusion as parts of the renal tubule according to the TH.
- Retitled table 16.2 to be more accurate.

## Chapter 17

- Clarified the function of the cytoplasmic bridges in spermatogenesis.
- Added cytoplasmic bridges to figure 17.3.
- Updated terminology throughout to align with the TA and TH.
- Redesigned figure 17.8 to better represent ovarian follicular development.

## Chapter 18

- Updated meiosis terminology.
- Added pronucleus as a term.
- Reordered artwork to better flow with text.
- Updated figure 18.7 to new style.
- Revised postnatal cardiovascular changes for clarity.



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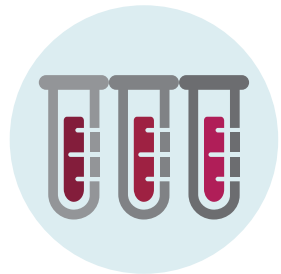
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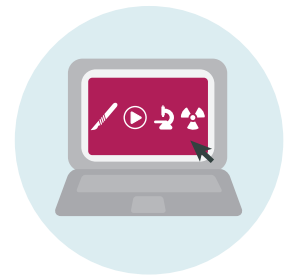
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\*Statistic courtesy of The New England Journal of Higher Education



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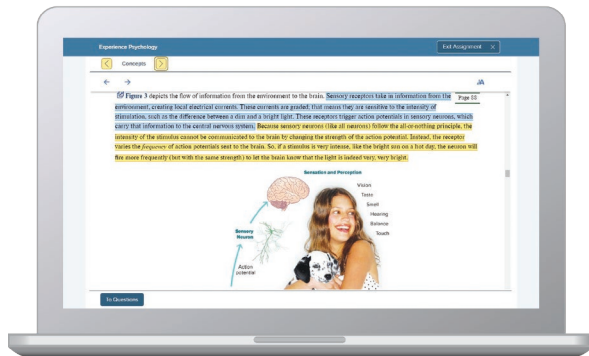
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# CHAPTER

# 1

## Introduction to the Human Body



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### Careers In

Students take a course in anatomy and physiology for a variety of reasons. Some are simply fulfilling a core requirement. Some are taking the course just because they find the human body interesting. Others are taking the course because they seek a career in health care.

The health care field offers many opportunities for individuals with an interest and a passion for helping others. However, many students are not aware of the diversity of options available. The “Careers In . . .” section at the start of each chapter describes health-related careers related to the chapter’s content. Reading about the “Careers In . . .” will not just expose students to a broader range of health-related careers but will also show students how chapter content supports professionals within those fields.

### CHAPTER OUTLINE

- 1.1 Anatomy and Physiology**
- 1.2 Levels of Organization**
  - Chemical Level
  - Cellular Level
  - Tissue Level
  - Organ Level
  - Organ System Level
  - Organismal Level
- 1.3 Directional Terms**
- 1.4 Body Regions**
- 1.5 Body Planes and Sections**
- 1.6 Body Cavities**
  - Membranes of Body Cavities
- 1.7 Abdominopelvic Subdivisions**
- 1.8 Maintenance of Life**
  - Survival Needs
  - Homeostasis

### Chapter Summary



### Module 1

### Body Orientation



**YOU ARE BEGINNING** a fascinating and challenging study—the study of the human body. As you progress through this text, you will begin to understand the complex structures and functions of the human organism.

This first chapter provides an overview of the human body to build a foundation of knowledge that is necessary for your continued study. Like the chapters that follow, this chapter introduces a number of new terms for you to learn. It is important that you start to build a vocabulary of technical terms and continue to develop it throughout your study. This vocabulary will help you reach your goal of understanding human anatomy and physiology.

## 1.1 Anatomy and Physiology

### Learning Objective

1. Define anatomy and physiology.

Knowledge of the human body is obtained primarily from two scientific disciplines—*anatomy* and *physiology*—and each consists of a number of subdisciplines.

Human **anatomy** (ah-nat'-ō-mē) is the study of the structure and organization of the body and the study of the relationships of body parts to one another. There are two major subdivisions of anatomy. *Gross anatomy* involves the dissection and examination of various parts of the body without magnifying lenses. *Microanatomy*, also known as *histology*, consists of the examination of tissues and cells with various magnification techniques.

Human **physiology** (fiz-ē-ol'-ō-jē) is the study of the function of the body and its parts. Physiology involves observation and experimentation, and usually requires the use of specialized equipment and materials.

In your study of the human body, you will see that there is always a definite relationship between the anatomy and physiology of the body and body parts. Just as the structure of a knife is well suited for cutting, the structure (anatomy) of a body part enables it to perform specific functions (physiology). For example, the arrangement of bones, muscles, and nerves in your hands enables the grasping of large objects with considerable force and also the delicate manipulation of small objects. Correlating the relationship between structure and function will make your study of the human body much easier.

## 1.2 Levels of Organization

### Learning Objectives

2. Describe the levels of organization in the human body.
3. List the major organs and functions for each organ system.

The human body is complex, so it is not surprising that there are several levels of structural organization, as shown

in figure 1.1. The levels of organization from simplest to most complex are chemical, cellular, tissue, organ, organ system, and organismal (the body as a whole).

### Chemical Level

The chemical level consists of *atoms*, *molecules*, and *macromolecules*. At the simplest level, the body is composed of chemical substances that are formed of atoms and molecules. Atoms are the fundamental building blocks of chemicals, and atoms combine in specific ways to form molecules. Some molecules are very small, such as water molecules, but others may be very large, such as the macromolecules of proteins. Various small and large molecules are grouped together to form organelles. An **organelle** (or''-ga-nel') is a complex of macromolecules acting like a “mini-organ” that carries out specific functions within a cell. Nuclei, mitochondria, and ribosomes are examples.

### Cellular Level

**Cells** are the basic structural and functional units of the body because all of the processes of life occur within cells. A cell is the lowest level of organization that is alive. The human body is composed of trillions of cells and many different types of cells, such as muscle cells, blood cells, and nerve cells. Each type of cell has a unique structure that enables it to perform specific functions.

### Tissue Level

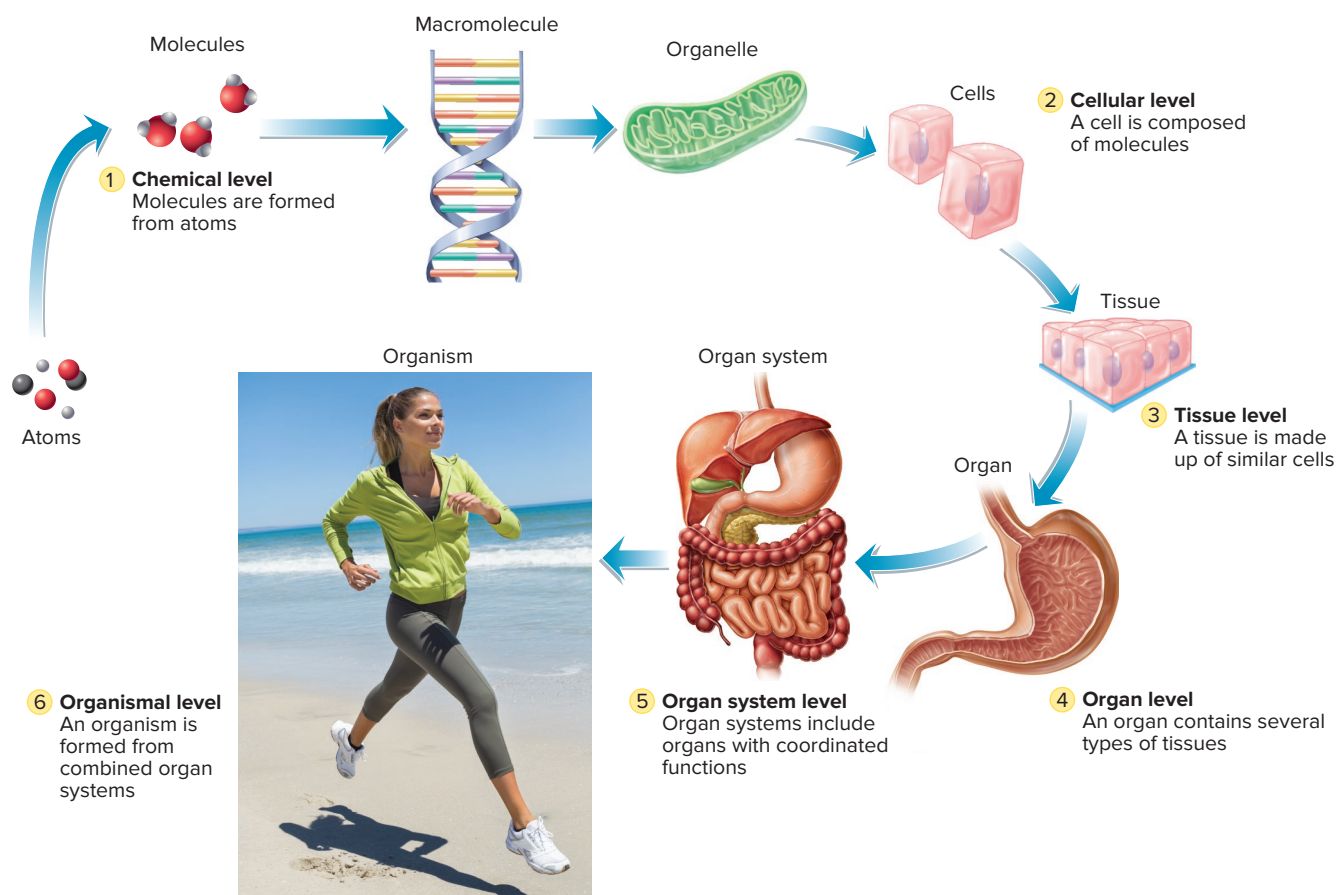
Similar types of cells are usually grouped together in the body to form a tissue. Each body **tissue** consists of an aggregation of similar cells that perform similar functions. There are four major classes of tissues in the body: epithelial, connective, muscle, and nerve tissues.

### Organ Level

Each **organ** of the body is composed of two or more tissues that work together, enabling the organ to perform its specific functions. The body contains numerous organs, and each has a definite structure and function. The stomach, heart, brain, and even bones are examples of organs. Later in this chapter, we will focus our attention on the body cavities. **Body cavities** are spaces within the body that contain organs, collectively referred to as **internal organs**.

### Organ System Level

The organs of the body are arranged in functional groups so that their independent functions are coordinated to perform specific system functions. These coordinated, functional groups are called **organ systems**. The digestive and nervous systems are examples of organ systems. Most organs belong to a single organ system, but a few



**Figure 1.1** Levels of Organization.

Six levels of organization in the human body range from chemical (simplest) to organismal (most complex).

ONOKY - Fabrice LEROUGE/Brand X Pictures/Getty Images

organs are assigned to more than one organ system. For example, the pancreas belongs to both the digestive and endocrine systems.

Figure 1.2 illustrates the 11 organ systems of the human body and lists the major organs and functions for each system. Although each organ system has its own unique functions, all organ systems support one another. For example, all organ systems rely on the cardiovascular system to transport materials to and from their cells. Organ systems work together to enable the functioning of the human body.

## Organismal Level

The highest organizational level dealing with an individual is the *organismal level*, the human organism as a whole. It is composed of all of the interacting organ systems. All of the organizational levels from chemicals to organ systems contribute to the functioning of the entire body.

## Check My Understanding

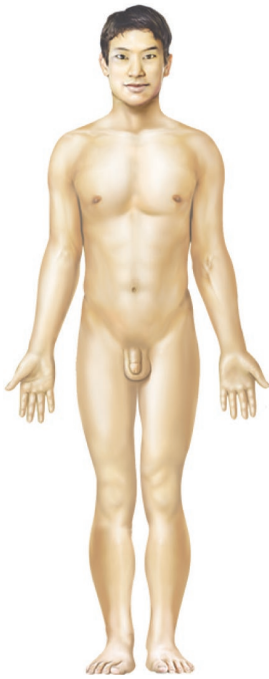
1. What are the organizational levels of the human body?
2. What are the major organs and general functions of each organ system?

## 1.3 Directional Terms

### Learning Objective

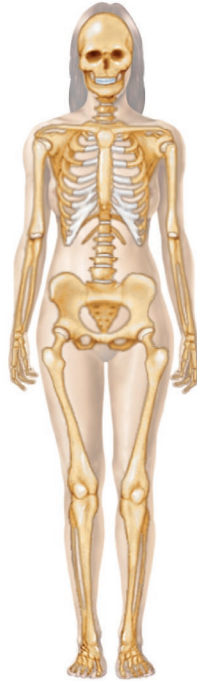
4. Use directional terms to describe the locations of body parts.

**Directional terms** are used to describe the relative position of a body part in relationship to another body part. The use of these terms conveys a precise meaning enabling the listener or reader to locate the body part of interest. It is always assumed that the body is in a standard



**Integumentary system**

*Organs:* skin, hair, nails, and associated glands  
*Functions:* protects underlying tissues and helps regulate body temperature



**Skeletal system**

*Organs:* bones, ligaments, and associated cartilages  
*Functions:* supports the body, protects vital organs, stores minerals, and is the site of blood cell production



**Muscular system**

*Organs:* skeletal muscles and tendons  
*Functions:* moves the body and body parts and produces heat

**Figure 1.2** The 11 Organ Systems of the Body. **APR**

position, the *anatomical position*, in which the body is standing upright with upper limbs at the sides and palms of the hands facing forward, as in figure 1.3. Directional terms occur in pairs, and the members of each pair have opposite meanings, as noted in table 1.1.

## 1.4 Body Regions

### Learning Objective

5. Locate the major body regions on a diagram or anatomical model.

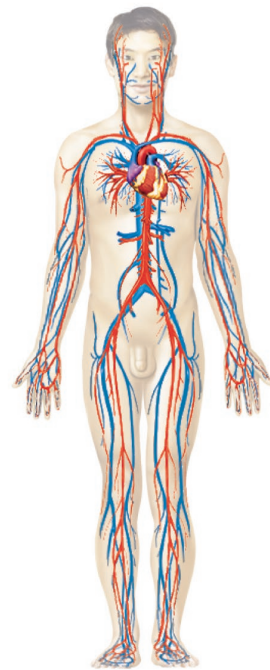
The human body consists of an **axial** (ak'-sē-al) **portion**, the head, neck, and trunk, and an **appendicular** (ap-pendik'-ū-lar) **portion**, the upper and lower limbs and their girdles. Each of these major portions of the body is divided into regions with special names to facilitate communication and to aid in locating body components.

The major **body regions** are listed in tables 1.2 and 1.3 to allow easy correlation with figure 1.4, which shows the locations of the major regions of the body. Take time to learn the names, pronunciations, and locations of the body regions.



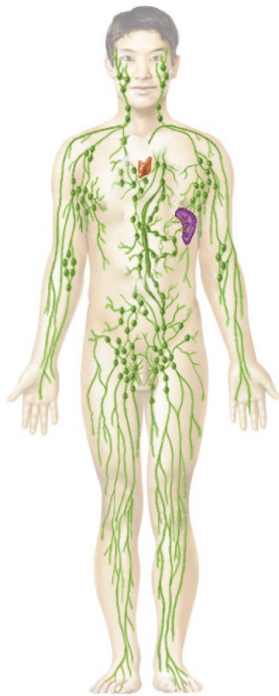
**Respiratory system**

*Organs:* nose, pharynx, larynx, trachea, bronchi, and lungs  
*Functions:* exchanges O<sub>2</sub> and CO<sub>2</sub> between air and blood in the lungs, pH regulation, and sound production



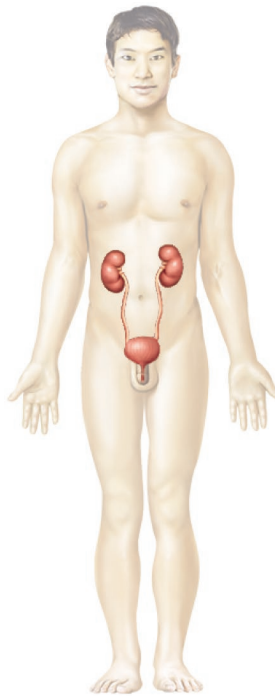
**Cardiovascular system**

*Organs:* blood, heart, arteries, veins, and capillaries  
*Functions:* transports heat and materials to and from the body cells



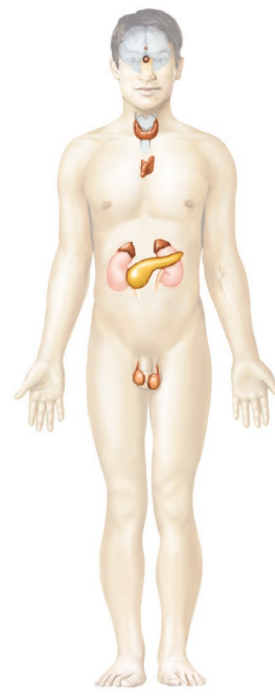
#### Lymphoid system

*Organs:* lymph, lymphatic vessels, and lymphoid organs and tissues  
*Functions:* collects and cleanses interstitial fluid, and returns it to the blood; provides immunity



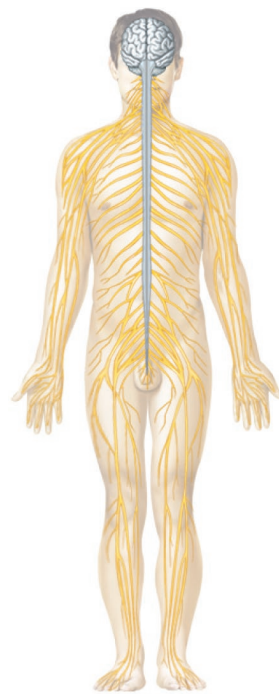
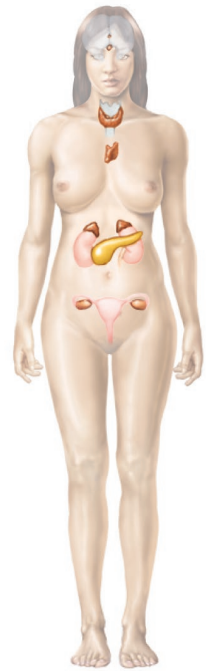
#### Urinary system

*Organs:* kidneys, ureters, urinary bladder, and urethra  
*Functions:* regulates volume and composition of blood by forming and excreting urine



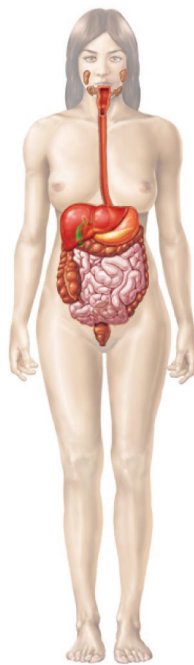
#### Endocrine system

*Organs:* hormone-producing glands, such as the pituitary and thyroid glands  
*Functions:* secretes hormones that regulate body functions



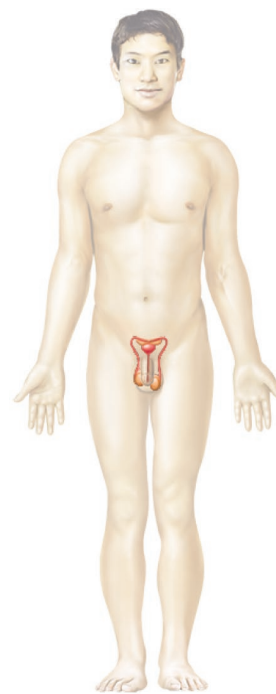
#### Nervous system

*Organs:* brain, spinal cord, nerves, and sensory receptors  
*Functions:* rapidly coordinates body functions and enables learning and memory



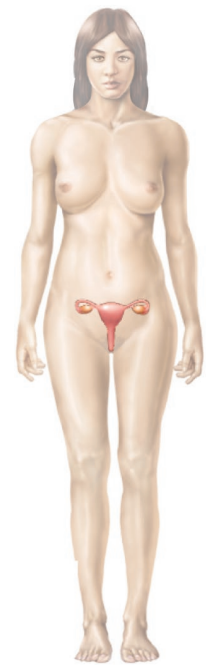
#### Digestive system

*Organs:* mouth, pharynx, esophagus, stomach, intestines, liver, pancreas, gallbladder, and associated structures  
*Functions:* digests food and absorbs nutrients



#### Male reproductive system

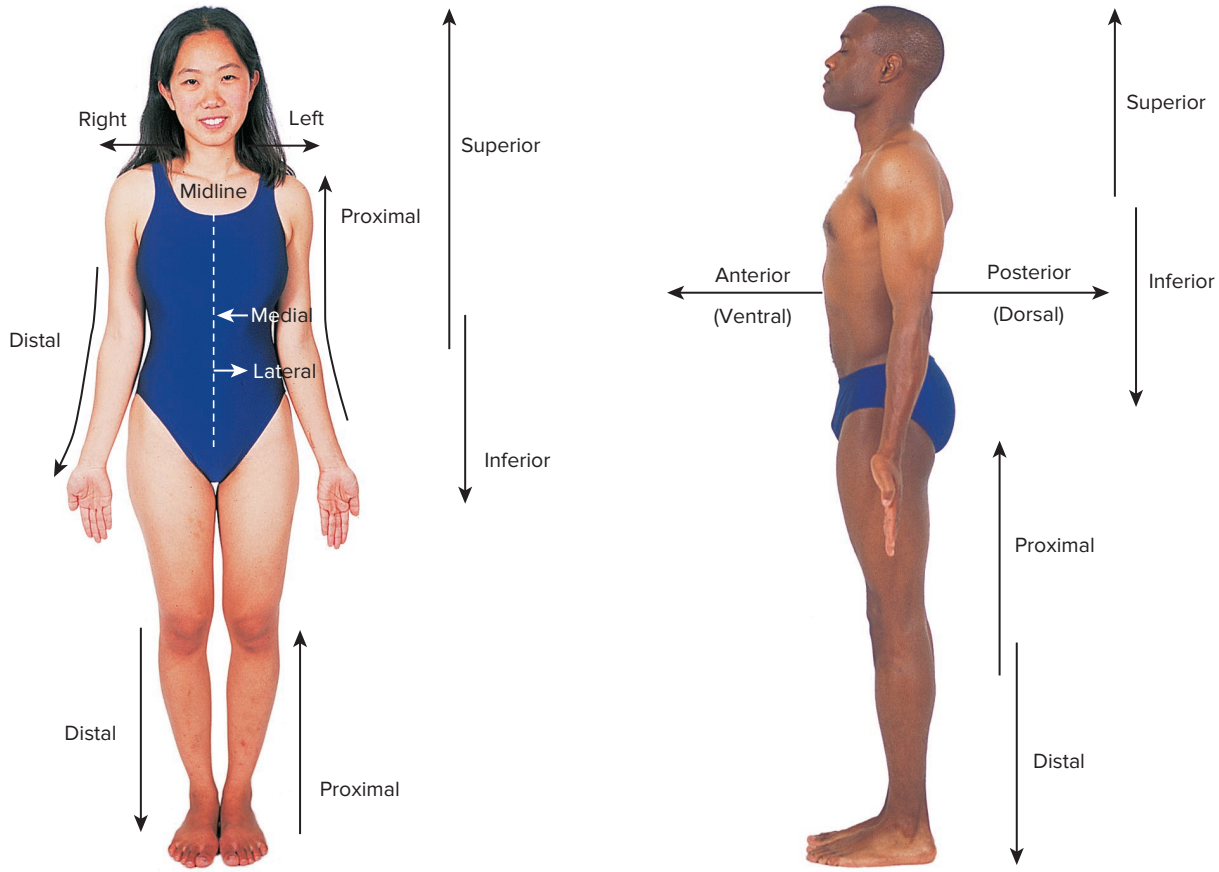
*Organs:* testes, epididymides, vasa deferentia, prostate, bulbo-urethral glands, seminal vesicles, and penis  
*Functions:* produces sperm and transmits them into the female vagina during sexual intercourse



#### Female reproductive system

*Organs:* ovaries, uterine tubes, uterus, vagina, and vulva  
*Functions:* produces oocytes, receives sperm, provides intrauterine development of offspring, and enables birth of an infant

Figure 1.2



**Figure 1.3** Anatomical Position and Directional Terms. **APR**

(a) Eric Wise; (b) Eric Wise

**Table 1.1** Directional Terms

Term	Meaning	Example
Anterior (ventral)	Toward the front or abdominal surface of the body	The abdomen is anterior to the back.
Posterior (dorsal)	Toward the back of the body	The spine is posterior to the face.
Superior (cephalic)	Toward the top/head	The nose is superior to the mouth.
Inferior (caudal)	Away from the top/head	The navel is inferior to the nipples.
Medial	Toward the midline of the body	The breastbone is medial to the nipples.
Lateral	Away from the midline of the body	The ears are lateral to the cheeks.
Parietal	Pertaining to the outer boundary of body cavities	The parietal pleura lines the pleural cavity.
Visceral	Pertaining to the internal organs	The visceral pleura covers the lung.
Superficial (external)	Toward or on the body surface	The skin is superficial to the muscles.
Deep (internal)	Away from the body surface	The intestines are deep to the abdominal muscles.
Proximal	Closer to the beginning	The elbow is proximal to the wrist.
Distal	Farther from the beginning	The hand is distal to the wrist.
Central	At or near the center of the body or organ	The central nervous system is in the middle of the body.
Peripheral	External to or away from the center of the body or organ	The peripheral nervous system extends away from the central nervous system.

**Table 1.2** Major Regions of the Axial Portion

Region			
<b>Head and Neck</b>	<b>Anterior Trunk</b>	<b>Posterior Trunk</b>	<b>Lateral Trunk</b>
Auricular (aw-rik'-yuh-ler)	Abdominal (ab-dom'-i-nal)	Dorsum (dor'-sum)	Axillary (ak'-sil-lary)
Buccal (bu'-kal)	Inguinal (ing'-gwi-nal)	Gluteal (glu'-tē-al)	Coxal (kok'-sal)
Cephalic (se-fal'-ik)	Pectoral (pek'-tōr-al)	Lumbar (lum'-bar)	<b>Inferior Trunk</b>
Cervical (ser'-vi-kal)	Presternal (pre-ster'-nal)	Sacral (sāk'-ral)	Genital (jen'-i-tal)
Cranial (krā'-nē-al)	Pubic (pyoo'-bik)	Scapular (skap'-yuh-ler)	Perineal (per-i-nē'-al)
Facial (fā'-shal)	Sternal (ster'-nal)	Vertebral (ver-tē'-bral)	
Nasal (nā'-zel)	Umbilical (um-bil'-i-kal)		
Oral (or'-al)			
Orbital (or'-bit-al)			
Otic (o'-tic)			

**Table 1.3** Major Regions of the Appendicular Portion

Region		
<b>Upper Limb</b>	Digital (di'-ji-tal)	Patellar (pa-tel'-lar)
Antebrachial (an-tē-brā'-kē-al)	Palmar (pal'-mar)	Pedal (pe'-dal)
Brachial (brā'-kē-al)	<b>Lower Limb</b>	Plantar (plan'-tar)
Carpal (kar'-pal)	Crural (krū'-ral)	Popliteal (pop-li-tē'-al)
Cubital (kū'-bi-tal)	Digital (di'-ji-tal)	Sural (sū'-ral)
Deltoid (del'-toid)	Femoral (fem'-ōr-al)	Tarsal (tahr'-sul)

## 1.5 Body Planes and Sections

### Learning Objective

- Describe the three planes used in making sections of the body or body parts.

In studying the body or organs, you often will be observing the flat surface of a **section** that has been produced by a cut through the body or a body part. Such sections are made along specific **planes**. These well-defined planes—transverse, sagittal, and frontal planes—lie at right angles to each other, as shown in figure 1.5. It is important to understand the nature of the plane along which a section was made in order to understand the three-dimensional structure of an object being observed.

**Transverse**, or horizontal, **planes** divide the body into superior and inferior portions and are perpendicular to the longitudinal axis of the body.

**Sagittal planes** divide the body into right and left portions and are parallel to the longitudinal axis of the body. A **median plane** passes through the midline of the body and divides the body into equal left and right

halves. A **paramedian plane** does not pass through the midline of the body.

**Frontal (coronal) planes** divide the body into anterior and posterior portions. These planes are perpendicular to sagittal planes and parallel to the longitudinal axis of the body.

Cuts made through sagittal and frontal planes, which are parallel to the longitudinal axis of the body, produce longitudinal sections. However, the term *longitudinal section* also refers to a section made through the longitudinal axis of an individual organ, tissue, or other structure. Similarly, cuts made through the transverse plane produce *cross sections* of the body and can also be produced in organs and tissues when cutting at a 90° angle to the longitudinal axis. *Oblique sections* are created when cuts are made in between the longitudinal and cross-sectional axes.



### Check My Understanding

- How do sagittal, transverse, and frontal planes differ from one another?

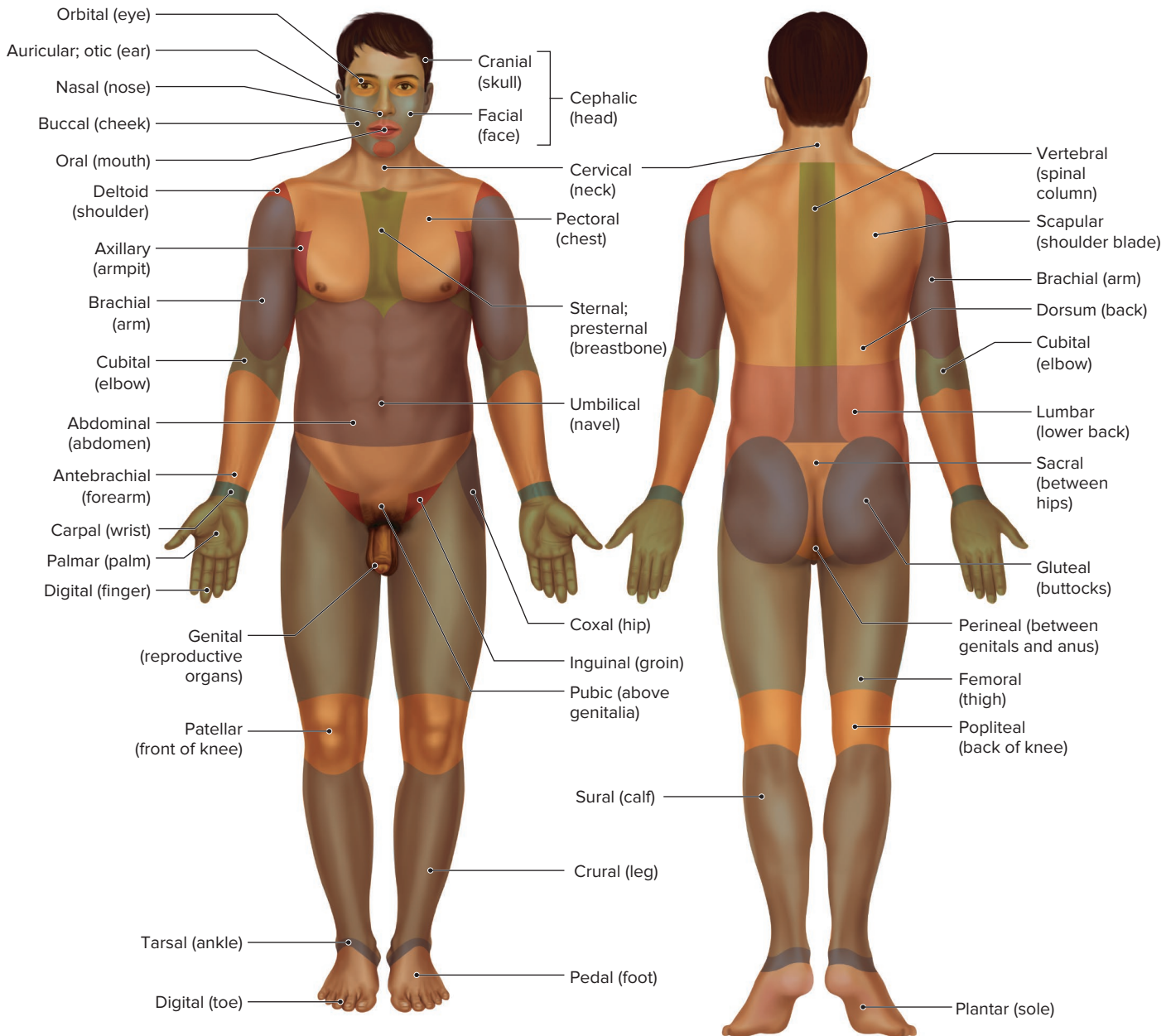


Figure 1.4 Major Regions of the Body. APR

## 1.6 Body Cavities

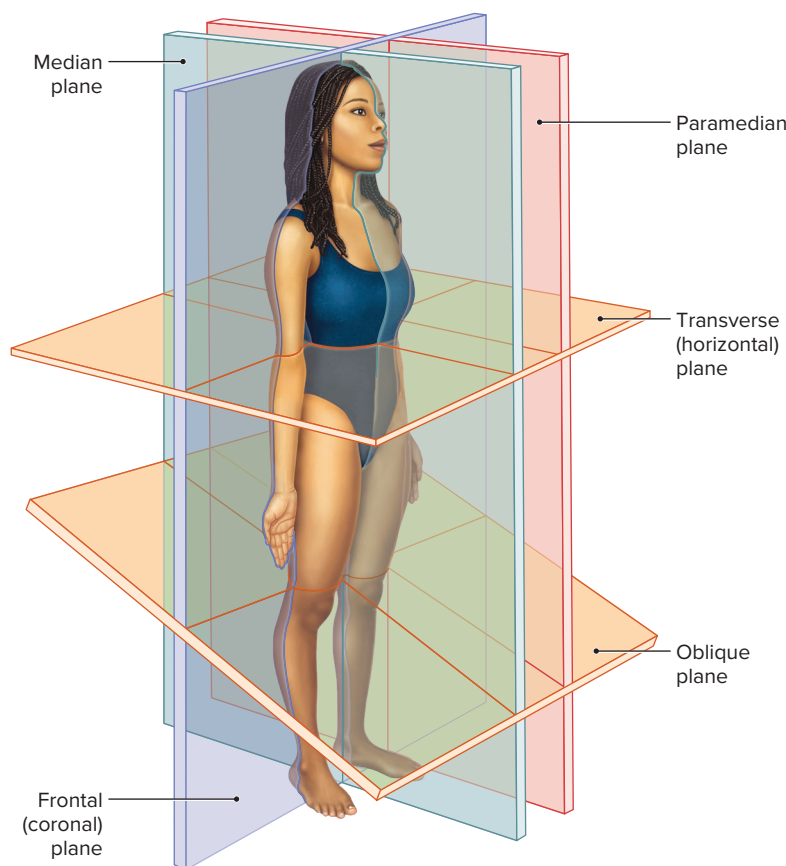
### Learning Objectives

7. Locate the body cavities and their subdivisions and membranes on a diagram.
8. Name the organs located in each body cavity.

The body cavities protect and cushion the contained internal organs and permit changes in their size and shape without impacting surrounding tissues. Note the locations and subdivisions of these cavities in figure 1.6.

The **cranial cavity** is enclosed in the bones of the skull and contains the brain. Within the vertebral column is the **vertebral canal**, which contains the spinal cord. Note in figure 1.6 how the cranial bones and the vertebral column form the walls of these cavities and provide protection for these delicate organs.

The two large body cavities in front of the vertebral column are divided by the *diaphragm*, a thin dome-shaped sheet of muscle. Above the diaphragm is the **thoracic cavity** and below it is the **abdominopelvic cavity**. The thoracic cavity is protected by the *thoracic cage* and contains the heart and lungs. The abdominopelvic



**Figure 1.5** Anatomical Planes of Reference. **APR**

cavity is subdivided into a superior **abdominal cavity** and an inferior **pelvic cavity**, but there is no structural separation between them. To visualize the separation, imagine a transverse plane passing through the body just above the pelvis. The abdominal cavity contains the stomach, intestines, liver, gallbladder, pancreas, spleen, and kidneys. The pelvic cavity contains the urinary bladder, sigmoid colon, rectum, and internal reproductive organs.

### Check My Understanding

4. What organs are located in the cranial cavity and vertebral canal?
5. What organs are located in the thoracic and abdominopelvic cavities?

## Membranes of Body Cavities

The membranes lining body cavities support and protect the internal organs in the cavities.

### Meninges

The cranial cavity and vertebral canal are lined by three layers of protective membranes that are collectively called the **meninges** (me-nin'-jēz; singular, *meninx*). The outer membrane is attached to the wall of the cavity, and the inner membrane tightly envelops the brain and spinal cord. The meninges will be covered in chapter 8.

### Serous Membranes

The thoracic and abdominopelvic cavity organs are supported and protected by **serous membranes**, or **serosae** (singular, *serosa*). The serous membranes are thin layers of tissue that line the body cavity and cover the internal organs. Serous membranes have an outer *parietal* (pah-rī'-e-tal) *layer* that lines the cavity and an inner *visceral* (vis'-er-al) *layer* that covers the organ. The parietal and visceral layers secrete a watery lubricating fluid, generically called *serous fluid*, into the cavity formed between the layers. This arrangement is similar to that of a fist pushed into a balloon (figure 1.7). The serous membranes of the body are the pleura, serous pericardium, and peritoneum.