CHAPTER

1 The Human Body

An Orientation

Chapter Summary

Chapter 1 emphasizes the relevance of anatomy and physiology in explaining the phenomena that occur in the body every day. It introduces and establishes the framework upon which all the other chapters are built. This chapter provides the necessary terminology so that instructor and students are all "speaking the same language." It begins by defining the key terms *anatomy* and *physiology*, and then continues to describe the ways in which these key terms are interrelated. It is important that students understand the concept of complementarity of structure and function in the body. Structure determines function; the various body structures in their form are most efficient for the particular function that the structure performs. This concept will help students to master the more difficult material in future chapters. It is also important to emphasize to students that this course is similar to a language class in that new, unfamiliar terminology will be introduced; this course requires students to begin to learn the language of medicine. This language is a universal one shared by medical professionals across various specializations, and it is one that the students will repeatedly "speak" in their future allied health careers.

Levels of hierarchical structural/anatomical organization in the body are presented next, beginning with the atomic building block level and progressing through to the highest level of organization, the human body. A brief overview of each organ system follows, with a focus on the ways in which all the organ systems are interconnected into a working whole. This concept is presented through the discussion of the eight necessary life functions, since it is important for students to understand that each of the organ systems has several functions and that any given function is actually carried out by several organ systems working together. For example, excretion is not only overseen by the urinary system; it is also carried out and/or monitored by the endocrine, integumentary, respiratory, and cardiovascular systems. The five survival needs of the body to accomplish the necessary life functions are then discussed. The next section then provides the basic terminology that will be used and expanded upon throughout the text. Instructors should emphasize anatomical position and the midline of the body as an axis point. To that end, directional terms referencing trunk attachment points, such as *proximal* and *distal*, or midline reference points, such as *medial* and *lateral*, are introduced. Regional terms are then discussed to address anterior and posterior body landmarks. Terminology for body sections and planes, as well as classification of body cavities and their respective components, round out the introduction of medical terminology.

The final section of this chapter ends with a discussion of homeostasis, the ability of the organ systems to cohesively function to respond to the ever-changing environment, as well as consequent disease states that occur when homeostasis cannot be achieved or resolved. Students appreciate the image of the dynamic body continually striving to maintain balance and equilibrium.

Suggested Lecture Outline

I. An Overview of Anatomy and Physiology (pp. 1–2)

A. Anatomy (pp. 1–2)

B. Physiology (p. 2)

C. Relationship between Anatomy and Physiology (p. 2)

II. Levels of Structural Organization (pp. 2–7)

A. From Atoms to Organisms (pp. 2–3)

B. Organ System Overview (pp. 3–7)

1. Integumentary System
2. Skeletal System
3. Muscular System
4. Nervous System
5. Endocrine System
6. Cardiovascular System
7. Lymphatic System
8. Respiratory System
9. Digestive System
10. Urinary System
11. Reproductive System

III. Maintaining Life (pp. 7–12)

A. Necessary Life Functions (pp. 7–9)

1. Maintaining Boundaries
2. Movement
3. Responsiveness
4. Digestion
5. Metabolism
6. Excretion
7. Reproduction
8. Growth

B. Survival Needs (pp. 9, 12)

IV. The Language of Anatomy (pp. 12–19)

A. Anatomical Position (p. 12)

B. Directional Terms (p. 12)

C. Regional Terms (pp. 12, 15)

1. Anterior Body Landmarks
2. Posterior Body Landmarks

D. Body Planes and Sections (p. 15)

E. Body Cavities (pp. 15–19)

1. Dorsal Body Cavity

TEACHING TIP

Build a language of biology. Use commonly used words to help students decipher the meanings of anatomic terminology. For example, for *hypergastric*, break the word down to *hyper* (use a word like *hyperactive* to lead the students to understand *hyper* means "more than") and *gastric* (similarly, use the term *gastric bypass surgery*, from which the students will derive the word *stomach*). Have students make flash cards of commonly encountered A&P word roots, prefixes, and suffixes, then have students combine the word parts in different ways to create new terms. In discussing medical conditions, point out the use of these same word parts to form medical terms. Students are usually excited to see how quickly their vocabulary expands with their increasing knowledge of word parts.

MEDIA TIP

NOVA: Inside the Human Body(PBS; 240 min., 2004). Using microphotography, NOVA presents the microworld of the human body. ***Inside the Human Body*** (National Geographic; 50 min., 2007). The development of the human body from birth to old age is viewed through microscopic videography.

2. Ventral Body Cavity
3. Other Body Cavities

V. Homeostasis (pp. 19-20)

A. Components of Homeostatic Control Systems (p. 19)

B. Feedback Mechanisms (pp.19-20)

Note: For a list of Key Terms for this chapter, please see the Instructor Resource DVD, or visit the Instructor Resource Center for this title online, at www.pearsonhighered.com.

Learning Objectives

1-1 Define anatomy and physiology.

1-2 Explain how anatomy and physiology are related.

1-3 Name the six levels of structural organization that make up the human body, and explain how they are related.

1-4 Name the organ systems of the body, and briefly state the major functions of each system.

1-5 Identify and classify by organ system all organs discussed.

1-6 List eight functions that humans must perform to maintain life.

1-7 List the five survival needs of the human body.

1-8 Verbally describe or demonstrate the anatomical position.

1-9 Use proper anatomical terminology to describe body directions, surfaces, and body planes.

1-10 Locate the major body cavities, and list the chief organs in each cavity.

1-11 Define homeostasis, and explain its importance.

1-12 Define negative feedback, and describe its role in maintaining homeostasis and normal body function.

Resources for Teaching Online

Discussion Board Topic: Homeostatic Imbalance – Aging

In the textbook on page 20, the Homeostatic Imbalance section explains that most disease results from the disturbance of homeostasis. Engage your students by using the following discussion question in lecture or by posting it to the discussion board on your course management system.

Discussion Question

The textbook cites aging as a cause of homeostatic imbalance, where body processes become inefficient, thus leading to changes in the body, including higher incidences of illness. One aging-related disease is osteoarthritis. Why is osteoarthritis common in elderly populations? What is the age of onset? How can osteoarthritis be caused in non-elderly populations?

Which medical imaging techniques are used to diagnose osteoarthritis? What are the current treatment options for osteoarthritis?

Potential Student Responses:

1. Osteoarthritis is also known as the "wear and tear" arthritis. Over time, the articular cartilage will erode, tendons and ligaments can stretch, and bones can generate friction against each other. Most people over 60 years of age will have some degree of osteoarthritis. Osteoarthritis can also be a secondary result of a trauma or repetitive occupational/sports-related joint stress from overuse, which can occur even as early as in the 20s. Since osteoarthritis often affects weight-bearing joints, obesity can prematurely cause osteoarthritis as well. The conventional diagnostic imaging technique is radiography, which will allow visualization of localized narrowing of the joint spaces, sclerosis, and/or bone spurs in the joint, which are all hallmark symptoms of osteoarthritis. In addition, other diagnostic techniques can be used. MRIs can detect reactive bone edema, soft tissue swelling, or cartilage and bone fragments in the joint; CTs can determine the degree of bone spur formation; and ultrasound can detect synovial cysts that may be found in association with osteoarthritis. Although there are no procedures to cure osteoarthritis, there are treatments to alleviate the pain associated with the disease. NSAIDs, acetaminophen, cortisone injections, physical therapy, synovial fluid injections, osteotomies, and joint replacement surgeries are some treatment options, depending on the degree of damage caused by osteoarthritis.

Investigate Online

Take learning a step further by searching for relevant research articles on the web. Visit science websites, such as those listed below, and begin by searching for key terms such as *accident* and *trauma*, *abdominal cavity*, *abdominopelvic organs*, and *solid organinjury* and see how what you're learning in the course applies to science and medicine today.

www.sciencedaily.com

www.scientificamerican.com

www.the-scientist.com

https://www.ncbi.nlm.nih.gov/pubmed

www.aaos.org

Lecture Hints

1. To illustrate the basic concept of *anatomy = structure and physiology = function*, micrographs or models of organs or various cells of the body can be shown. An effective organ system to use as an illustration for structure dictating function is the respiratory system, where macroscopic structures such as the nasal passages and trachea are specialized for conduction of air, and structural characteristics to aid respiratory function can continue to be described down to the level of the alveoli, which are composed of simple squamous cells; the one-layer thickness allows simple diffusion of O_2 and CO_2. Other microscopic-level examples are cells, such as macrophages that look and function similar to amoebas with their phagocytosis, as well as neurons that have extensive processes to facilitate cellular communication.

Key point: Physiology, or function, is dependent on anatomy. Use the analogy that the body is really a well-designed machine for optimal function of life processes. A slight change in anatomy can have a significant effect on physiology. For example, in sickle cell anemia, the normal biconcave structure of the red blood cell is altered to a crescent/sickle shape, which causes the reduction of the oxygen-carrying capacity of the red blood cells.

2. Discuss the differences between microscopic and macroscopic (gross) anatomy, where microscopic is at the level of cells and tissues, and macroscopic is at the organ level. Reference the relevance to such specialties as pathology and microbiology.

   Key point: Point out to students that dissection is aimed at helping us to understand the functions of each of the various levels of organization, but that the body works as a whole and is consequently more complex than the simple sum of its component parts.

3. Starting with the concept of atoms joining to form molecules, have the students "build" a single organ system that then combines with other organs to form the living body.

   Key point: Every level of the system relies on the smooth workings of the level preceding it, and a malfunction at any level may have life-threatening consequences to the levels built upon it.

4. Discuss each of the fundamental life functions (e.g., digestion, metabolism) and have students list all of the organ systems that contribute to this single function. Also point out secondary functions of organs; for example, the kidney is important for creating urine primarily, but it also has an endocrine role of producing and secreting erythropoetin to stimulate red blood cell production in the bone marrow.

   Key point: It is important for students to understand that organ systems often have an obvious primary function, but that all the systems are closely interrelated and impact one another in numerous ways, including ways not yet identified.

5. Ask the students to describe the physiological effects of being outside for an extended period of time on a hot, summer day (sweating, feeling thirsty), and compare that to being outside on a cold, winter day (shivering). Outline the ways in which the body compensates for such variations in temperature and identify these mechanisms as homeostasis at work.

   Key point: Point out to students that the body is still in a constant state of flux, balancing between a range of "normal" values that is rarely static.

6. A simple, clear method of demonstrating negative feedback is to discuss the thermostat in the classroom. Students can easily understand the negative feedback system of the HVAC system at work.

   Key point: Negative feedback loops are the chief regulators of homeostasis under normal healthy conditions. A rise in any given value (e.g., blood pH, heart rate, blood pressure) precipitates a reaction to lower it, until such time as it becomes too low, causing negative feedback to initiate responses to raise it again.

7. Positive feedback is more difficult to understand than negative feedback. An effective example is to set up a domino cascade, where one domino hits two dominoes that each in turn hit two more dominoes, and so on. Also give a real-world example, such as how wet nurses were able to nurse multiple children over a period of time.

Key point: Negative feedback loops are more commonly used in homeostasis in the body rather than positive feedback loops. Nevertheless, positive feedback mechanisms are equally important for maintaining homeostasis. Some examples include childbirth, blood clotting, breast-feeding, and hormone cascades (CRH to ACTH to cortisol secretion, for instance), which involve an ever-increasing buildup of responses that trigger the next response until they bring about the culmination of a major event. Like a nuclear reaction, positive feedback involves a series of chain reactions of ever-increasing magnitude.

8. Directional terms are best presented as opposites, with appropriate demonstrations for each. For example, *anterior* is easily distinguished from *posterior*, *superior* from *inferior*, and so on. The most difficult set to distinguish seems to be *proximal* and *distal*. Use a set of examples that demonstrate their relationship, such as elbow to wrist (the elbow is *proximal* in this instance) compared with elbow to shoulder (the elbow is *distal* in this instance), to help clarify the concept.

   Key point: It is important for students to understand that proximal and distal terminology is used to describe the comparative distances of two limb structures from the point of attachment on the trunk of the body.

9. Point out to students how the terms *ventral* (*anterior*)/*dorsal* (*posterior*) and *superior*/*inferior* refer to different areas for bipeds and quadrupeds. In particular for ventral/dorsal, relate the dorsal fin of the shark. Show also the similarity of embryonic forms of various animals versus human to emphasize the derivation of this terminology. Also point out that words are often combined to more accurately identify the relative position of a single structure.

   Key point: Just as more than one adjective can be used to describe a single noun, so can more than one directional term be used to describe a single structure.

10. Draw or show slides of various cells of the body, such as a smooth muscle cell, neuron, pseudostratified ciliated columnar cell of the trachea, and red blood cell without identifying the function or location of the cells. Have students hypothesize the function of the cell by analyzing its structure.

    Key point: There is complimentarity of structure and function; structure is driven by function. For example, neurons have processes that function to receive and convey information, and red blood cells are flattened to increase the ratio of surface area to volume and ease of diffusion of oxygen for maximal transport.

11. Provide students with opportunities to verbalize material and use appropriate terminology that you have covered in your lecture. The unfamiliar terms students are introduced to will have more meaning if they pronounce them out loud. Encourage students to study verbally while practicing vocabulary and explaining concepts. Encourage students to explain processes or mechanisms in their own words whenever possible.

    Key point: Science has its own language, as complex as English or any other language, and it takes time and concentrated effort to master. As with any new language, practice and repetition are the keys to development and long-term retention.

12. Have students use sticky notes with regional and directional terminology and put them on a classmate in class, or a friend or family member during their studies at home, and then use the book to double-check placement of terms. Have them take photographs or create

a video and upload them into the learning management system or a class-assigned Google drive as an assignment.

Key point: Devise fun and creative exercises that will make the terminology more relevant and less intimidating to tackle.

13. With an articulated skeleton present, ask students to identify and locate body cavities. Have students discuss the organs found within each cavity, and how protection to those organs is conferred (whether there is bony protection, skeletal muscle protection, fluid protection, etc.).

    Key point: Explain that *potential space* is a space that exists but may be filled, such as the abdominal cavity, which is filled with organs; an uninflated balloon also has a potential space that can be filled with air or fluid. Students may need to be guided to certain cavities that are not as evident visually, such as to the middle ear cavity that houses the ossicles or to the paranasal sinuses.

Classroom Demonstrations and Student Activities

Classroom Demonstrations

1. Dissect a small preserved animal (e.g., a fetal pig) to demonstrate the various organ systems of the body. Point out at least two organs from each organ system and discuss their function. If dissection is not an option, there are several films that can be substituted (see Multimedia section) or computer programs that offer virtual dissection experiences. In addition, Carolina Biological Supply Company and other supply companies offer plastinated dissected specimens that can be passed around the classroom.
2. Use a human torso model to point out the dorsal and ventral body cavities and the organs in each cavity. Use this opportunity to also compare a quadruped animal with the biped human to illustrate the use of dorsal/ventral versus anterior/posterior at the level of the head.
3. Use a skeleton and human torso model to show directional terms in action. With a dissectible human torso model, first have students point out, for example, an organ that is superior to the liver. Then, once students are familiar with the gross anatomy, the various organs except for the one under discussion, such as the liver, can be laid out on a table and students can be asked to pick up an organ (or even all organs) superior to the one under discussion and replace them within the model. A skeletal model can be used to demonstrate the distinction between directional terms associated with point of attachment to the trunk (*proximal* and *distal*) versus on the trunk (*superior* and *inferior*).
4. Demonstrate various pulse points, some of which the students will already be familiar with. Relating these pulse points to regional terminology will help the students understand their usage.
5. Arrange for the class to attend an autopsy or take a tour of the anatomy lab at the local medical school (preferably after the material of Chapter 1 has been covered).
6. Thin, plastinated sections of the human body can be circulated for view in the classroom, allowing students to view the orientation and position of organs, as well as different body section views.

7. Circulate photographic atlases of the human body in class or use cadaver images from software or from Internet resources. Compare these images with the idealized textbook illustrations.
8. Bring in a two-arm balance and demonstrate with weights how negative feedback works to maintain homeostasis or "balance." Positive feedback can also be demonstrated with the balance. If a two-arm balance is not readily available, create a simple balance using a stick, string, and weighing boats.
9. Create emergency room scenarios using terminology from Chapter 1. Have the students determine the location of the illness or injury using regional and directional terms. Extend the exercise by either relating to homeostatic feedback mechanisms and/or challenging the students to brainstorm which body functions could be impacted by the illness or injury to those specific areas of the body.

Student Activities

1. Have students stand and assume the anatomical position. Ask the students to comment on how that position differs from the "usual" standing position and to explain why knowing this position is important to precisely identify anatomical terms and physiological processes.
2. Remove all the organs from the ventral and dorsal body cavities of a human torso model. Ask for volunteers or assign students to return the organs to their proper anatomical location. As each organ is properly repositioned, have other students call out its name and organ system relationship.
3. Place a human torso model at center stage. Ask for a volunteer to come up and show how the torso model would be cut along the sagittal, frontal, and transverse planes. Have students come up with medical situations for which visualizations along each respective plane would elucidate diagnosis or function of specific organs/areas.
4. To initiate a class discussion on the relative degree of protection of organs in the dorsal versus the ventral body cavity, ask the class a question such as "Why do you think a dog instinctively curls over and protects its abdomen when that body region is approached (threatened by a blow, etc.) even playfully?" or "Two people have rapidly growing tumors. The tumor is in the dorsal cavity in one of these individuals and in the ventral cavity of the other. Which of these people will develop symptoms first, and why?"
5. Call out anatomical terms (*buccal*, *femoral*, etc.) and have the students (as a group) point out the named regions on their own bodies. Alternatively, organize students into small groups/teams for a quiz with a game show format with cards that have body landmarks they must demonstrate on their bodies or draw out. The key terms in each chapter are provided in the Instructor Resource DVD for your use.
6. Have students find a series of landmarks on their own bodies, providing a list of landmarks for the students to locate. Use real-life examples to help the students better understand the terminology. For example, the list could include items such as "the location where a necktie is worn," "the location of a belly button piercing," and so on. Have the students do this in small groups so they can discuss the terms with each other and begin to develop camaraderie among the group.

7. Have students play a game of Simon Says with regional terms and directional terms. The leader can use instruction cards provided by the instructor; for more advanced play, the students can take turns coming up with their own commands using a combination of regional and directional terms.
8. Demonstrate the location of the radial, brachial, carotid, femoral, popliteal, and pedal pulses. Have students try to locate several pulse points on themselves and their fellow students.
9. Have students get into groups of four or five. List five root words on the board and have the student groups come up with as many terms as they can think of that incorporate those roots. The terms can be common English, biological, or medical in nature, as long as a root word is found in each. Allow them 15 minutes to compile their lists, then compare the terms of the various groups. Point out their increased vocabulary based on the knowledge of a relatively small number of roots.
10. To help the students understand negative feedback, have them do a balancing exercise: bring in a bicycle or attach a slackline, for example, to show the compensations and adjustments done to maintain balance. Students should be able to articulate their compensating actions and able to understand that their actions are examples of negative feedback.
11. To encourage an understanding of organ system interrelationships, ask the students to comment on the functional relationships between muscles and bones, and between the respiratory and cardiovascular systems.
12. Use a simple battery-operated clock as an example to indicate the importance of relatively constant conditions on optimal functioning of any system. Ask the class to indicate what would happen if it was (a) immersed in water, (b) hit with a hammer, (c) heated until it was red-hot, and (d) had its battery removed. Then ask them what conditions would be best suited for the clock to operate properly, and ask them to provide a single term that describes those conditions (*homeostasis*).
13. Have students go up to the board and create a hierarchy chart, first listing the survival needs essential to sustain life, then listing which necessary life functions are needed to carry out each survival need, and finally listing what organ systems are involved to carry out the necessary life functions.
14. Student assignment for class discussion: Bring in an article from a popular magazine or newspaper describing an environmental problem(s), such as toxic waste disposal, pollution of the ocean, and so on, that threatens their homeostasis or even survival. Be prepared to describe the problem and how it represents a threat to the body.
15. Discuss current medical technology that is being used to treat various disorders such as pacemakers, prosthetics, or gene therapy. Have students speculate on what new technologies could emerge in the next decade, or even in the next century.

Multimedia

See page 164 for a listing of media distributors.

1. *Homeostasis* (FHS: 20 min., 1995, DVD, 3-year streaming webcast). From *The New Living Body* series, live-action video, advanced imaging technology, and 3-D computer graphics show homeostatic mechanisms in the human body at work during a marathon.

2. *Human Biology* (FHS: 58 min., 1995, VHS, DVD). Live-action video sequences (21) provide an overview of human biology.
3. *Human Body: The Ultimate Machine* (CBS: 27 min., 2005, DVD). The body's major systems are described through footage of surgical procedures, microphotography, and 3-D animation.
4. *Introduction to the Body: Landscapes and Interiors* (FHS: 28 min., 1984, VHS, DVD, 3-year streaming webcast). Introduction to the award-winning *The Living Body* series, which shows the body's adaptability to diverse climates and other homeostatic triggers.
5. *Incredible Human Machine* (National Geographic, 90 min., 2007, DVD). Tour of the human body describing organ systems through microphotography and CGI.
6. *Human Anatomy and Physiology* (Khan Academy website). Tutorial website on introduction of organ systems. https://www.khanacademy.org/science/health-and-medicine/human-anatomy-and-physiology
7. *Organ Systems* (Khan Academy, web education). Video of organ functions within an organ system and how organ systems interact with one another. https://lol.khanacademy.org/science/biology/principles-of-physiology/body-structure-and-homeostasis/v/organ-systems-bozeman

Software

1. *Practice Anatomy Lab 3.0 (PAL)* (Pearson, DVD, Website). An interactive study and lab assessment tool available to students in the Study Area of Mastering A&P, with assessments available for assignment in the Mastering A&P Item Library.
2. *Essentials of Interactive Physiology* (Pearson, CD). This brief version of the award-winning Interactive Physiology10-System Suite is specifically adapted for the Marieb *Essentials of Interactive Physiology* textbook, and includes animations and videos explaining difficult topics in A&P. *Essentials of IP* covers the following body systems: cardiovascular, digestive, endocrine, immune, muscular, nervous, respiratory, and urinary, plus fluids and electrolytes.

