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Answers to *Apply What You Know* and *Testing Your Comprehension* Questions

Chapter 1 Answer Key

Apply What You Know

Page 6—The production of useful diagnostic images had to await computer technology that did not exist in 1948.

Page 7—Situs inversus could affect emergency diagnosis (for example, the location of pain from appendicitis) or surgical treatment, so it is advantageous for an emergency medical team to know of this condition before they begin treatment. (It also affects the electrocardiogram, although students would not have a basis for knowing that at this point in their study.)

Testing Your Comprehension

1. Angiography is invasive because it requires the injection of a radiopaque substance into the circulatory system. A PET scan is invasive because it requires the injection of radioisotopes, and angiography is invasive because it requires injection of a contrast medium. MRI is noninvasive because it requires no injection, other breaks in the body surface, or probing of any body cavity. Sonography and CT scans can be either noninvasive or invasive (as when an esophageal, vaginal, or rectal ultrasound probe is used, or a contrast medium is injected for a CT scan).
2. Both internal and external anatomy are variable, so anyone being trained for careers involving patient examination, diagnostic imaging, surgery, and so forth must be well aware of this variability and familiar with the most common variations so that he or she will be less inclined to make false assumptions about a patient.
3. (a) Transverse, (b) sagittal, (c) transverse, (d) frontal, (e) sagittal, (f) frontal.
4. It is a misunderstanding of the word *plantar,* the surface where such warts commonly occur.
5. Eponyms are uninformative; they don't describe anything of the form or function of a structure. Presumably most students would regard noneponymous terms to their advantage. The committee named structures in Latin because it is a static and internationally neutral language, so it is relatively apolitical. Students might object to this, but if everyone in the world had a vote on the language in which to name things, anatomical terms might be in Mandarin Chinese!

Chapter 1: The Study of Human Anatomy

Chapter Overview

Chapter 1 places the study of anatomy within the context of biological sciences. This text emphasizes a functional perspective that addresses the fundamental question of why structures are shaped and arranged as they are in the human body. A functional perspective affords a profound understanding of the human body that goes beyond naming and description of structures.

Our current understanding of anatomy did not spring from thin air but is the product of centuries of effort by many individuals. Greek and Roman scientists laid the foundation for the scientific study of the human body and their observations were the mainstay of anatomical and medical understanding in Europe until the Renaissance. Islamic scientists advanced in knowledge in the Medieval era, while science in general languished in Europe. The modern discipline of anatomy traces its roots to Vesalius, a 16th-century anatomist who ushered in a new era. He combined medical illustration with cadaver demonstrations and lectures, transforming pedagogy—a legacy that remains with us today. The tradition of beautifully illustrated anatomy texts, for example, began with *De Humani Corporis Fabrica* by Vesalius.

There are many approaches to the study of anatomy, including gross anatomy, microscopic anatomy, and comparative anatomy. The word "anatomy" means to cut, and, for many centuries, the only way to visualize what lay beneath the skin was to perform cadaver dissections. Today, cadaver dissection still plays an instructive role in the training of health care professionals, but over the past 100 years or so, new techniques have offered exciting insights into human structure and have expanded the avenues for study of anatomy in living individuals.

Current subdisciplines of anatomy correspond to the expansion of techniques used to study the body. Gross anatomy refers to the study of structures visible to the naked eye and includes dissection, surface anatomy, and radiologic anatomy. Microscopic anatomy (histology) is the study of tissues and the cells that are found in each tissue type. Histology is important for its role in assessing disease processes. Ultrastructure is the study of the subcellular to molecular level.

Systemic and regional anatomy are two different pedagogical approaches to the study of anatomy. Most introductory courses focus on a systemic approach, where one body system at a time is explored. That is the approach of this text. Advanced anatomy courses in medical schools, for example, focus on regional anatomy, where one area of the body is examined with respect to the relationship of the muscles, bones, blood vessels, and connective tissue in a region such as the hand or forearm.

Another subdiscipline of anatomy is comparative anatomy. As humans, we are part of the living world, and our anatomy is best understood in comparison to other living things. We share with all life, from ancient forms which existed billions of years ago to extant forms alive today, certain characteristics that distinguish us from nonliving matter. We are composed of cells, beginning as single-celled organisms. Our cells contain DNA, which underlies our ability to grow, develop, and reproduce and pass genes to future generations. Over generations, the genetic makeup of human populations has changed the basis for evolution. Human anatomy has been shaped over millions of years through the mechanism of natural selection, a concept explained by Charles Darwin. Like other living forms, humans have adapted to changing environmental conditions. The comparative, evolutionary perspective helps us understand that our current anatomy is the result of millions of years of selection pressures. The role this plays in modern health is a focus of Darwinian medicine, which attempts to understand diseases within the context of our evolutionary and cultural history.

Much about the anatomy of a living person can be gleaned by using our senses of sight, touch, and sound to examine the external body. For example, physicians routinely assess anatomy through visual inspection of the skin, eyes, and so on and through manual palpation. They also listen to the sounds of the body (auscultation) often with the help of a stethoscope.

To see more deeply, dissection is required. Indeed, dissection was the main source of anatomical information for centuries. Dissection is still essential for a deep understanding of the body, and cadavers continue to be a source of profound learning experiences for students of health professions.

However, in the past 100 years, new techniques have been developed to visualize internal structures in living patients. The oldest is radiography, which photographs internal structures with X-rays. X-rays are especially useful for seeing pathologies in dense tissues, such as bones and teeth, and can be used to diagnose tumors. Computed tomography (CT) is a more sophisticated application of X-rays that relies on computer analysis to reveal three-dimensional soft tissue anatomy. Sonography relies on sonar technology using ultrasound waves. Sonography is frequently used in obstetrics to assess fetal age and position. Magnetic resonance imaging (MRI) uses magnetic fields to visualize soft tissues and has especially been effective in images of the spinal cord and brain. For example, functional MRI reveals moment-to-moment changes in tissue activity associated with brain function. Positron emission tomography (PET) is used to assess metabolic status of tissues. It produces color images that show which area is using the greatest amount of glucose. PET scans and functional MRI have revolutionized our understanding of brain function because images produced while a person is performing specific tasks, such as movement or cognitive tests, reveal what part of the brain is active during specific activities.

Hundreds of years of anatomical studies have revealed that there is significant anatomical variation among individuals. Variation is due to sex, age, genetic heritage, and experiences during life such as injury and disease. It is important for students to remember that textbooks, atlases, and lectures typically address the most common, average anatomical form, but each human body is unique. This is especially important for clinicians to remember!

Anatomy is best understood in the context of levels of structural complexity, from the most basic level, the atom, all the way up to the complex organism. The molecular biology explosion of recent decades has illuminated the structure and function of DNA, genes, and proteins. It is clear that the tiniest aspects of cell structure and function relate to the structure and function of an entire individual. At every level, structure relates to function or "form follows function." For example, the double-helical nature of DNA enables replication and the elongated shape of muscle fibers makes contraction possible.

The final part of Chapter 1 presents common terms and organizational tools that are essential for the student's understanding of anatomy. The 11 organ systems are introduced. Terms associated with body orientation are presented, beginning with an explanation of the anatomical position. Descriptions of the major body regions, including cavities, are accompanied by vivid illustrations that will be a reference for students as they explore later chapters.

Finally, the chapter ends with a useful discussion of the language of anatomy. Anatomical terms emerged over centuries, and some terms have obscure origins. The chapter provides tools for grappling with Greek and Latin that will help students feel less overwhelmed. The section demonstrates how students may identify roots, prefixes, suffixes, and singular and plural forms to both understand and utilize anatomical terms more effectively. It is important that students learn to use terms correctly because anatomical language forms the basis for effective communication in medical practice.

Key Concepts

- **Functional Morphology**
  Study of the form and function of anatomical structures
- **Gross Anatomy**
  Study of the visible structures traditionally approached through cadaver dissection
- **Microscopic Anatomy**
  Study of the structure of tissues and cells
- **Radiologic Anatomy**
  Study of internal structure using X-rays and other medical imaging techniques
- **Systemic Anatomy**
  Approach to learning anatomy that emphasizes study of one organ system at a time
- **Regional Anatomy**

Approach to learning anatomy by dissecting specific areas of the body and studying the relationship of structures related to multiple organ systems such as blood vessels, nerves, tendons, and so on

- **Comparative Anatomy**
  Study of more than one species to identify and analyze structural similarities and differences
- **Historical Context**
  Modern knowledge rests on centuries of study, dating from Greek and Roman contributions
- **Medical Imaging**
  Methods for viewing structures inside a living person, such as radiographs, CT scans, MRIs, and PET scans
- **Human Variation**
  Each body has unique features, even though the average, typical form (often a single specimen) is presented in atlases
- **Structural Levels**
  Atom, molecule, macromolecule, organelle, cell, tissue, organ, organ system, and organism
- **Organ Systems**
  There are 11 organ systems and an immune system whose function relies on cells rather than organs
  - Integumentary system
  - Skeletal system
  - Muscular system
  - Nervous system
  - Endocrine system
  - Circulatory system
  - Lymphatic system
  - Immune system
  - Respiratory system
  - Urinary system
  - Digestive system
  - Reproductive system
- **Anatomical Position**
  Standing with palms facing forward is the standard reference position. • Location and orientation of structures are from the point of view of the subject. • For example, in an illustration of the heart, the left atrium refers to the subject's left side
- **Anatomical Planes**
  - The **sagittal plane** divides the body or organ into right and left halves
  - The **frontal plane** divides the body or organ into anterior and posterior portions
  - The **transverse plane** divides the body or organ into superior and inferior portions perpendicular to the long axis
- **Directional Terms**

Commonly used terms such as anterior, posterior, and so on are defined in Table 1.1. • Students must learn these in order to understand the terminology in the following chapters

- **Axial Region**
  The axial region consists of the head, neck, and trunk. • The trunk is further divided into the thoracic region and the abdominal region. • For clinical purposes, the abdomen is divided into quadrants or nine regions (e.g., hypochondriac and epigastric, etc.)
- **Appendicular Region**
  The appendicular region consists of the upper and lower limbs (the appendages)
- **Body Cavities and Membranes**
  - **The Cranial Cavity and Vertebral Canal**
  - The cranial cavity is enclosed by the skull and contains the brain. • The vertebral canal is enclosed by the bony vertebrae and contains the spinal cord. • Three membrane layers called the meninges line the cranial cavity and vertebral canal
  - **The Thoracic Cavity**
    The thoracic cavity is separated from the abdominopelvic cavity by the diaphragm. • The thoracic cavity contains the heart and lungs. • The mediastinum is the region between the lungs that contains the heart, great vessels, and other structures. • A two-layered membrane, the pericardium, surrounds the heart • The wall of the thoracic cavity is lined with a serous membrane called the parietal pleura; the visceral pleura adheres to the surface of the lungs
  - **The Abdominopelvic Cavity**
  - The abdominopelvic cavity is divided into a superior abdominal cavity and a pelvic cavity below. • The abdominopelvic cavity wall is lined with parietal peritoneum while visceral peritoneum covers the surface of many organs
  - **Potential Spaces**
  - Often, membranes are so closely pressed together that there is no actual space between them. • Because the membranes are not physically attached, fluid or other material can sometimes create a space. • For example, normally there is no space in the lumen of the uterus but during pregnancy a fetus occupies the space

Learning Strategies/Teaching Tips

- Highlight a particular scientist and their work when discussing functional, comparative anatomy. Anatomy is a dynamic discipline and research about human form is continuous. One example is using comparative anatomy to understand human locomotor anatomy associated with bipedal walking.
- Find studies in journals (including on the internet) that demonstrate the use of functional imaging in current studies. There are many examples that use PET scans for understanding brain function.
- Use forensic science as an example of an application that relies on human variation. For example, forensic anthropologists can gather clues to a person's identity by

assessing stature and sex and can even gain insight into ethnicity, occupation, injuries, and disease by examining unique features of skeletons.

- Use the concept that structure relates to function ("form follows function") as a theme in lectures. Use examples from macromolecules to organelles, to cells, to organs.
- In lab, use skeletons to compare anatomical features of a cat or other quadrupedal mammal, a quadrupedal primate such as a monkey, and a human. In small groups, have the students devise lists of features that are similar and different, and then discuss the functional reasons for the differences. For example, cats have claws versus nails, humans have a broad, bowl-shaped pelvis, and so on.
- Have students assume the anatomical position and use appropriate terminology to describe relationships among common body parts. For example, the elbow is proximal to the wrist.
- Have students work in pairs to practice identifying body regions and directional terms.

Additional Reading

Hayes, B. (2007). *The anatomist: A true story of Gray's anatomy.* Random House.
Human Body 101. (2017). National Geographic. Available on YouTube.
Shubin, N. (2008). *Your inner fish: A journey into the 3.5 billion year history of the human body.* Random House.
The human body: How it works. (2009). Films for Humanities & Science. DVD or Streaming available.
Vance, E. (2008). Truly gross anatomy. *Nature*, *452*, 525–526.
Your Inner Fish Video Series. Available through PBS. https://www.pbs.org/your-inner-fish
Zihlman, A. (2001). *The human evolution coloring book* (2nd ed.). Harper Collins.