CAT EDITION

Human Anatomy and Physiology Laboratory Manual

Elaine Nicpon-Marieb, Ph.D., R.N.

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Elaine Nicpon-Marieb, Ph.D., R.N.
Holyoke Community College

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PREFACE

Human Anatomy and Physiology Laboratory Manual is a self-contained learning aid designed for introductory courses in human anatomy and physiology. It presents a wide range of laboratory experiences for students concentrating in nursing, physical therapy, occupational therapy, respiratory therapy, dental hygiene, pharmacology, health and physical education, as well as biology and pre-medical programs.

ORGANIZATION

The organization and scope of this manual lend themselves to use in both one- and two-term courses. The variety of both anatomical studies and physiological experiments enables instructors to gear their courses to specific academic programs, or to their own teaching preferences. The manual is independent of any textbook, and contains all the background discussion and terminology necessary to perform all experiments. This eliminates the need for students to bring a textbook into the laboratory.

Many anatomy and physiology textbooks were consulted during the writing of this manual to ensure consistency of terminology. Spence and Mason's *Human Anatomy and Physiology* was particularly helpful in this regard, and I gratefully acknowledge the permission of the publisher and authors to borrow and adapt many of the outstanding illustrations from that book.

Each of the 15 units contains two or more exercises leading students toward a coherent understanding of the structure and function of the human body. The manual begins with anatomical terminology and an orientation to the body, which provides the necessary tools for studying the various body systems. The book focuses on organization of each body system, from the cellular to the organ level. Each unit includes physiological experiments familiarizing students with the scientific method, important laboratory skills, and an appreciation of the concept of homeostasis. This holistic approach ultimately gives students an integrated understanding of the human body.

Most exercises can be completed in a two-hour lab session, although some exercises, such as those on blood, cardiovascular physiology, and muscle physiology may require more time. In such exercises, generally requiring animal dissection or elaborate equipment setups, students can work in teams or can conduct selected portions of the exercises and share their results with the others. Instructor demonstrations have been kept to a minimum in the interest of maximizing student involvement in the learning process.

THE DISSECTION ANIMAL

Although this manual emphasizes the study of the human body, the cat is the major dissection animal. The cat was chosen for this edition because market research from the publisher indicates that the majority of laboratory courses in anatomy and physiology use cats as dissection animals. The fetal pig is the next most common animal of dissection. Given the ever-increasing price of cats, many courses may begin using fetal pigs in the future. In response to this trend, and in order to minimize the amount of supplemental material necessary to adapt this manual to courses using the fetal pig, an alternate Fetal Pig Edition of this manual is available (ISBN 0-8053-6725-X). The only differences between this manual and the Fetal Pig Edition are in the instructions and artwork for the dissections.

SPECIAL FEATURES

The following features will be appreciated by students and instructors:

- Each unit begins with an introductory overview of the organ system under study.

- Learning objectives precede each exercise.
- Key terminology appears in boldface print, and each term is defined when introduced.
- Illustrations are plentiful, large, and of exceptional quality. Structures are consistently shown in their natural anatomical positions within the body.
- Exercises are balanced between histological, gross anatomical, and physiological topics.
- There are numerous physiological experiments for each organ system, ranging from simple experiments that can be performed without specialized tools to more complex experiments using laboratory equipment or instrumentation techniques.
- Tear-out Laboratory Review-Study Sections, keyed to the exercises, require students to label diagrams and answer multiple-choice, short-answer, and review questions. Space is provided for recording and interpreting experimental results.
- A set of 68 overhead transparencies is available gratis to adopters on request of the publisher.
- A Solutions Manual is available to instructors free, on request from the publisher.

ACKNOWLEDGMENTS

I wish to express my appreciation for the help and guidance of David Smith (San Antonio College), Gail Jacobson (Clackamas Community College), Ron Gaines (Kansas State University), L. Jack Pierce (Mountain View College), Michael L. Hain (Riverside City College), Betsy Peitz (California State University, Los Angeles), and Micheline H. Carr (Los Angeles Valley College). These instructors reviewed the manuscript during various stages of development and provided invaluable help.

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UNIT 1

THE HUMAN BODY: AN ORIENTATION

Most of us have a natural curiosity about our bodies. This fact is amply demonstrated by infants, who early in life become fascinated with their own waving hands or their mother's nose. The study of the gross anatomy of the human body elaborates on this fascination. Unlike the infant, however, the student of anatomy must learn to identify and observe the dissectible body structures formally. The purpose of any gross-anatomy experience is to examine the three-dimensional relationships of body structures—a goal that can never completely be achieved by using illustrations and models, regardless of their excellence.

When beginning the study of any science, the student is often initially overcome by the jargon unique to the subject. The study of anatomy is no exception. But without this specialized terminology, confusion is inevitable. For example, what do *over, on top of, superficial to, above*, and *behind* mean in reference to the human body? Anatomists have an accepted set of reference terms that are universally understood. These allow body structures to be located and identified with a minimum of words and a high degree of clarity.

This unit presents some of the most important anatomical terminology used to describe the body and introduces you to the basic concepts of **gross anatomy**, the study of body structures visible to the naked eye.

EXERCISE 1

The Language of Anatomy

Objectives

1. To describe the anatomical position verbally or by demonstration.
2. To use proper anatomical terminology to describe body directions, planes, and surfaces.
3. To describe the body cavities and note the important organs of each.

Materials

human torso model
human skeleton
related film: *Man: The Incredible Machine* (color, sound, 16 mm, 28 minutes, National Geographic Educational Services)

ANATOMICAL TERMINOLOGY

When anatomists or doctors discuss the human body, they refer to specific areas in relation to other body parts. This is done in accordance with a universally accepted standard position called the **anatomical position**. It is essential to understand this position, because all body terminology employed in this book refers to this body positioning, regardless of the position the body happens to be in. In the anatomical position the human body is erect, with feet together, head and toes pointed forward, and arms hanging at the sides with palms facing forward (Figure 1-1).

Assume the anatomical position, and note that it is not particularly comfortable. The hands are held unnaturally forward rather than hanging partially cupped toward the thighs.

Body Orientation and Direction

Study the terms below, referring to Figure 1-2. Note that certain terms have a different connotation for a four-legged animal than they do for a human.

Superior/inferior *(above/below):* These terms refer to placement of a body structure along a vertical axis—that is, with the long axis of the body. Thus superior structures always appear above other structures. For example, the nose is superior to the mouth, and the abdomen is inferior to the chest region.

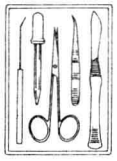
Cephalad/caudad *(toward the head/toward the tail):* In humans these terms are used interchangeably with *superior* and *inferior*. But in four-legged animals they are synonymous with *anterior* and *posterior*.

Anterior/posterior *(front/back):* In humans the most anterior surfaces are those that are most forward—the face, chest, and abdomen. Posterior surfaces are those on the backside of the body—the back and buttocks.

Dorsal/ventral *(backside/belly side):* These terms are used chiefly in discussing the comparative anatomy of animals, assuming the animal is on all fours. *Dorsum* is a Latin word meaning "back"; thus *dorsal* refers to the backside of the animal's body or of any other structures. For instance, the posterior surface of the leg is its dorsal surface. The term *ventral* derives from the Latin term *venter*, meaning "belly," and thus always refers to the belly side of animals. In humans the terms *ventral* and *dorsal* may be used interchangeably with the terms *anterior* and *posterior*, but in four-legged animals *ventral* and *dorsal* are synonymous with inferior and superior.

Medial/lateral *(toward the midline/away from the midline or median plane):* For example, the ear is lateral to the eye; the breastbone is medial to the ribs.

Proximal/distal *(nearer the trunk or attached end/farther from the trunk or point of attachment):* These terms are used primarily to locate various areas of the appendages or limbs of the body. For example, the fingers are distal to the elbow; the knee is proximal to the toes.



Before continuing, use a human torso model, a skeleton, or your own body to specify the relationship between the following structures using the correct anatomical terminology:

The wrist is _____ to the hand.

The trachea is _____ to the spine.

The brain is _____ to the spinal cord.

The kidneys are _____ to the liver.

The bridge of the nose is _____ to the eyes.

Body Planes and Sections

In order to observe internal structures, it is often helpful and necessary to make use of a **section**, or cut. When the section is made through the body wall or

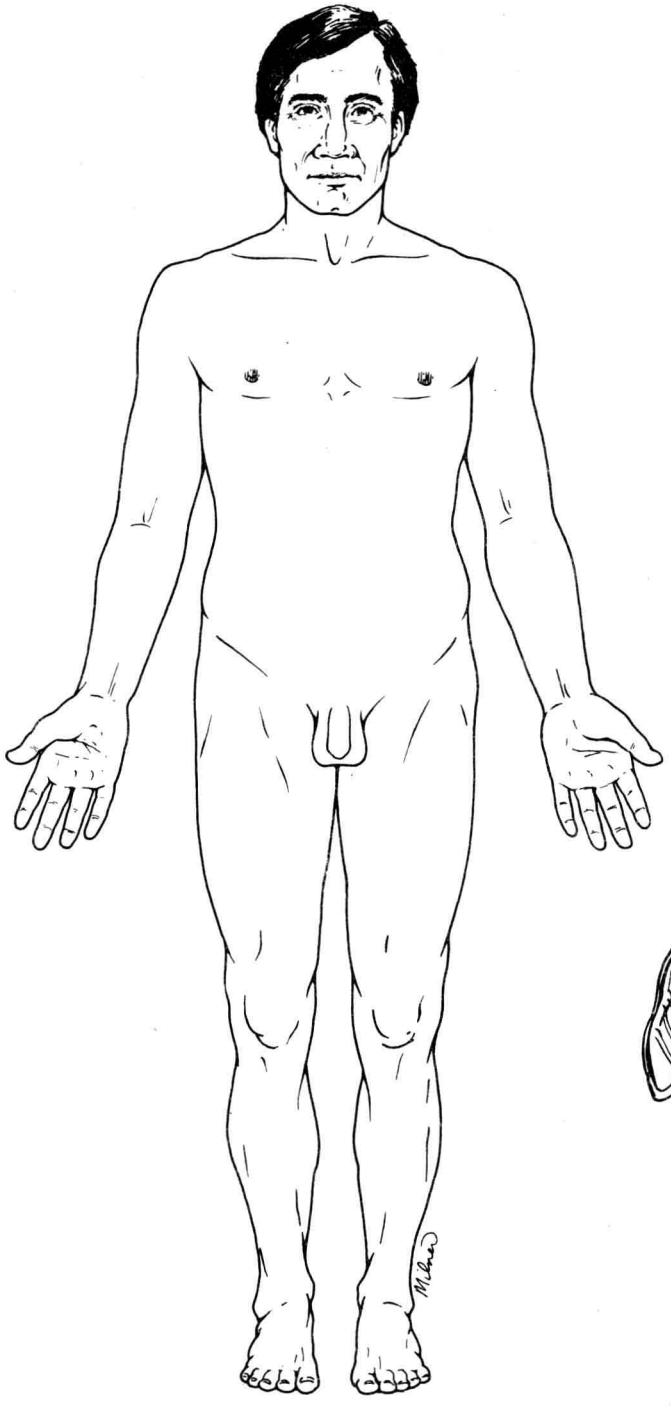
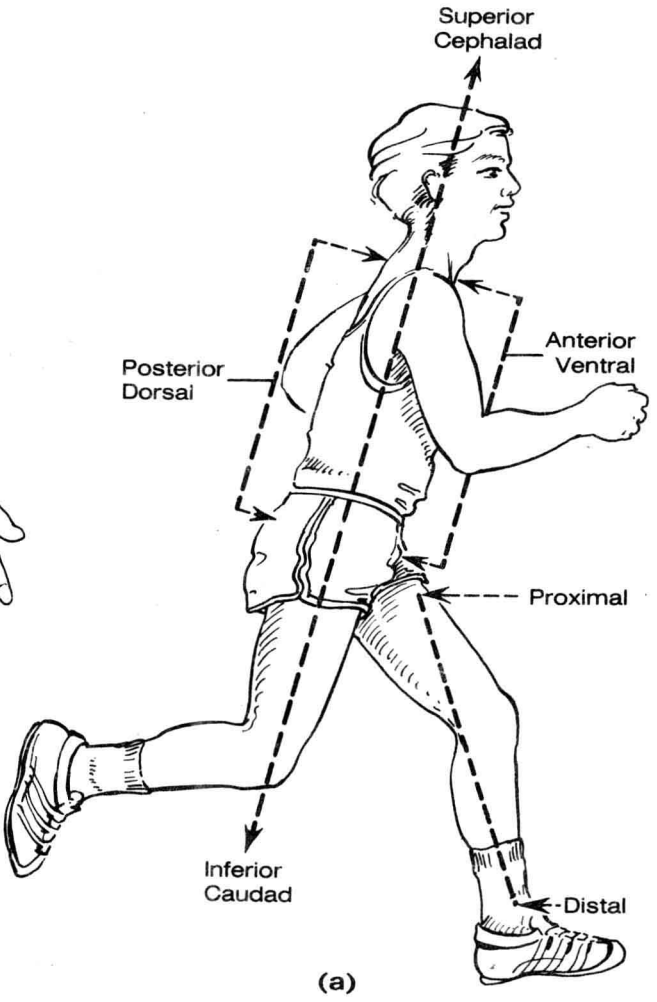


Figure 1-1. Anatomical position.



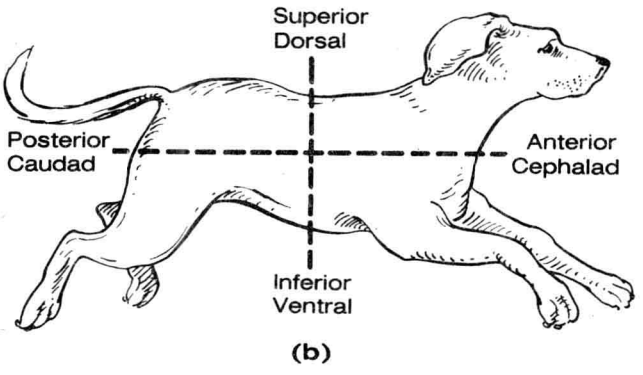


Figure 1-2. Anatomical terminology describing body orientation and direction (a) with reference to a human and (b) with reference to a four-legged animal.

through an organ, it is made along an imaginary line called a **plane**. Anatomists commonly refer to three planes (Figure 1-3) or sections, which lie at right angles to one another:

Sagittal section: When the cut is made along a longitudinal plane, dividing the body into right and left parts, it is referred to as a sagittal section. If it divides the body into equal parts, right down the median plane of the body, it is called a **midsagittal section**.

Frontal section: Sometimes called a coronal section, this cut is made along a longitudinal plane that divides the body into anterior and posterior parts.

Transverse section: A cut made along a transverse or horizontal plane, dividing the body into superior and inferior parts, may also be called a cross section.

These terms can also be used to describe the way organs are cut for observation. Thus an organ cut along the sagittal plane provides quite a different view from one cut along the transverse plane (Figure 1-4).

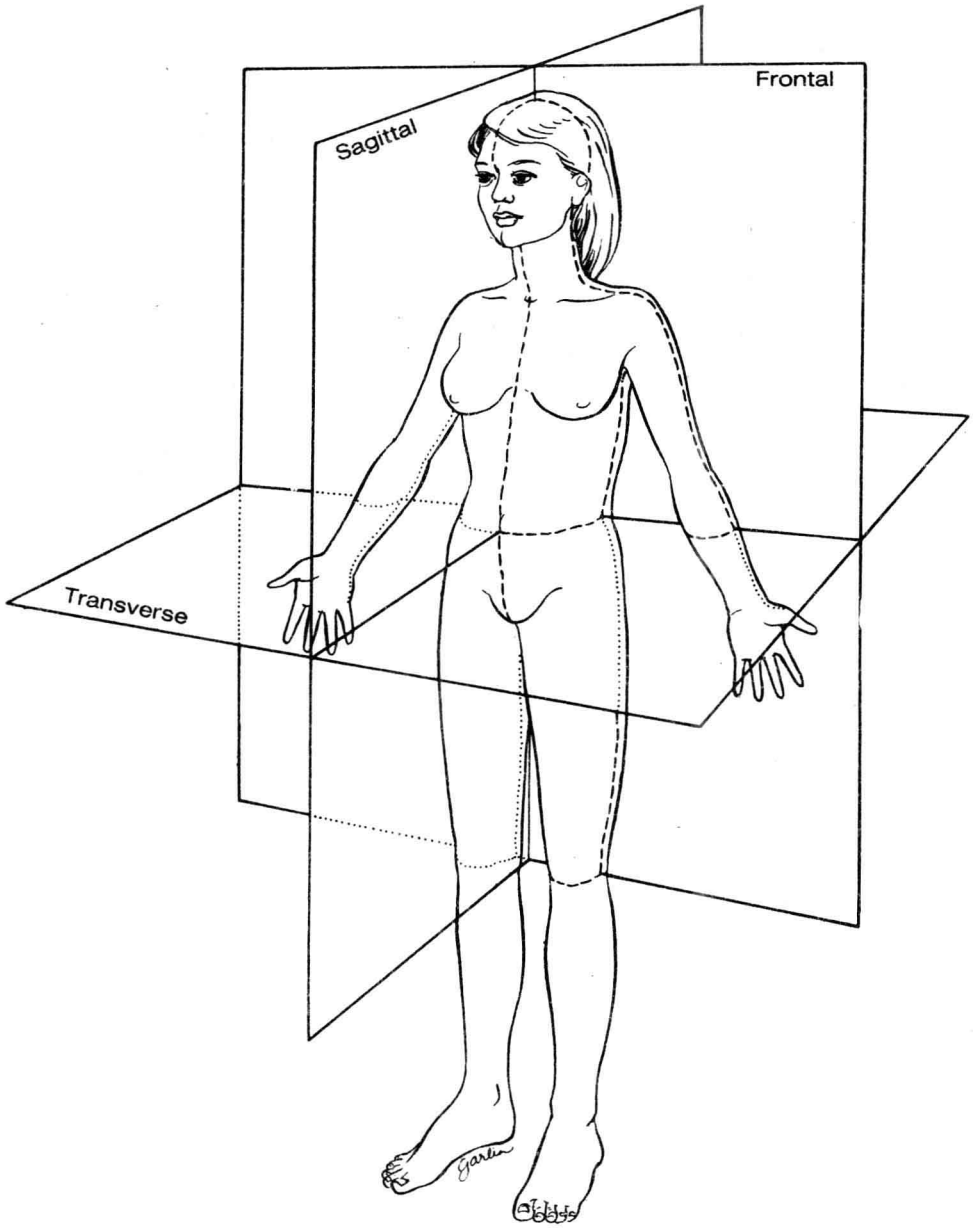


Figure 1-3. Planes of the body.

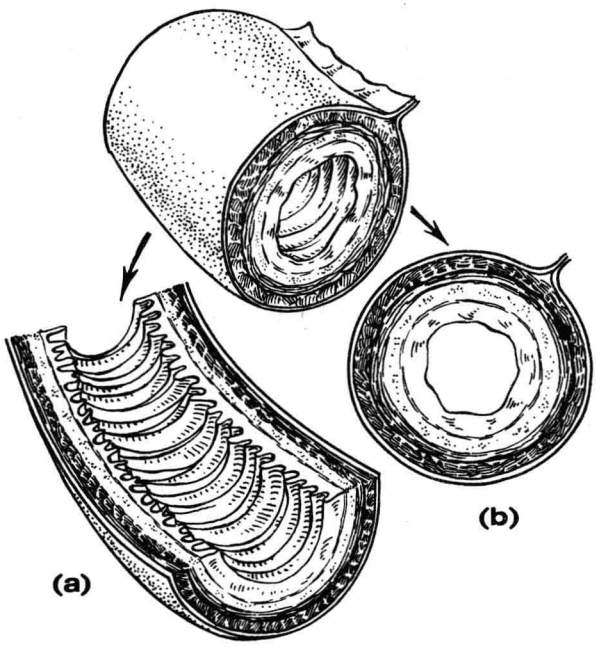


Figure 1-4. Segment of the small intestine (a) cut sagittally and (b) cut transversely.

SURFACE ANATOMY

Anatomists commonly refer to several body surfaces, and these provide visible landmarks for study of the body.

Anterior Body Landmarks

Note the following body regions in Figure 1-5a.

Orbital: pertaining to the eye.
Buccal: pertaining to the mouth
Cervical: pertaining to the neck region
Thoracic: pertaining to the chest
Axillary: pertaining to the armpit
Brachial: pertaining to the arm
Umbilical: pertaining to the navel
Abdominal: pertaining to the anterior body trunk
Cubital: pertaining to the anterior surface of the elbow
Groin: pertaining to the area where the thigh meets the body trunk
Femoral: pertaining to the thigh
Flank: pertaining to the lateral surface of the body from the rib cage to the hip
Pubic: pertaining to the genital region

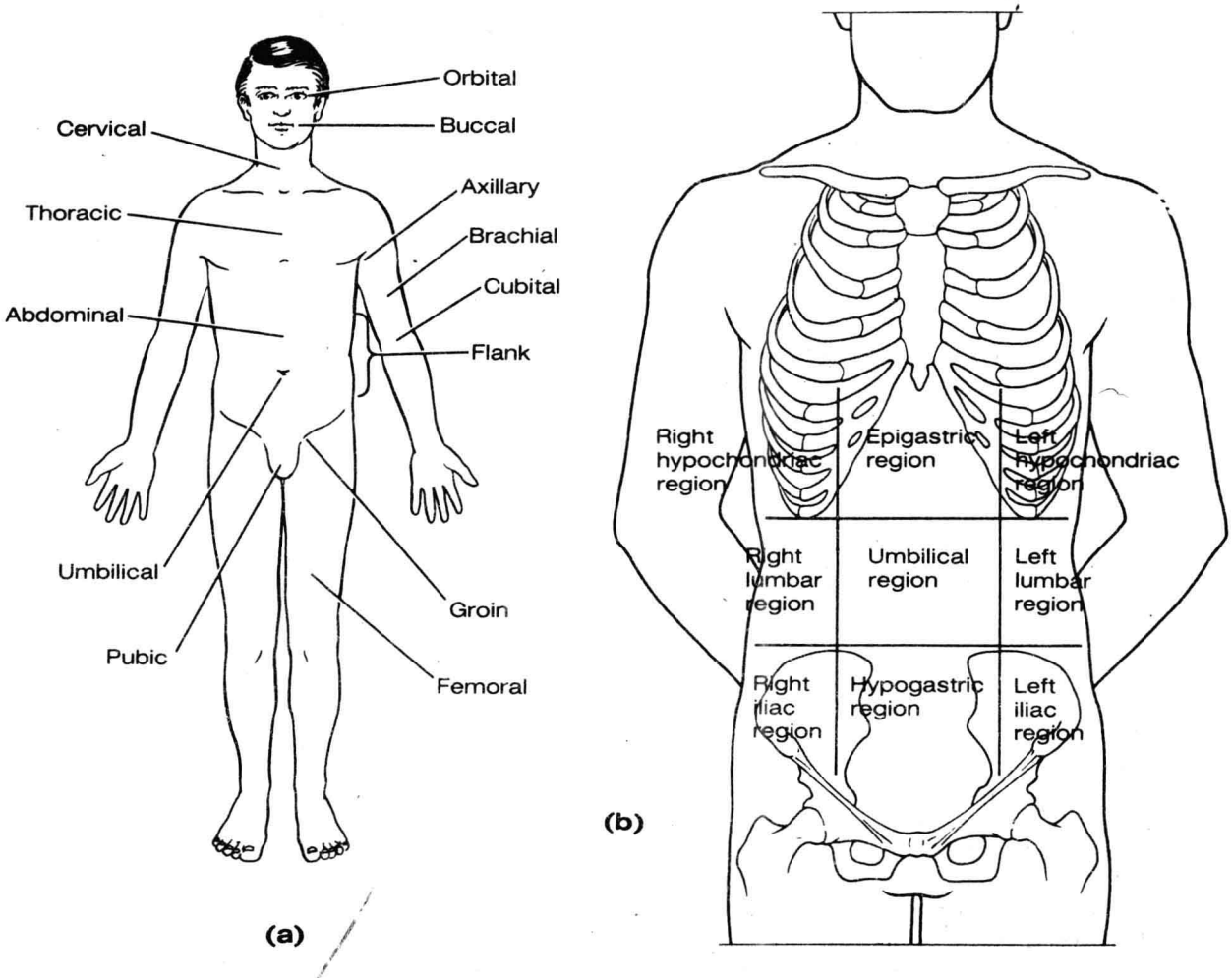


Figure 1-5. Anterior surface anatomy: (a) anterior body landmarks; (b) abdominal surface.

Doctors and nurses discuss the abdominal surface as if it were divided into nine regions or areas by four planes, as shown in Figure 1–5b.

Umbilical region: the centermost region, which includes the umbilicus
Epigastric region: immediately above the umbilical region; overlies most of the stomach
Hypogastric region: immediately below the umbilical region; encompasses the pubic area
Iliac regions: lateral to the hypogastric region and overlying the inferior portion of the hip bones
Lumbar regions: overlying the flaring portions of the hip bones
Hypochondriac regions: flanking the epigastric region and overlying the lower ribs

Locate the anterior body landmarks, including the regions of the abdominal surface, on a torso model and on yourself.

Posterior Body Landmarks

Note the following body regions in Figure 1–6:

Scapular: pertaining to the scapula or shoulder blade area
Lumbar: pertaining to the area of the back between the ribs and hips
Gluteal: pertaining to the buttocks or rump
Popliteal: pertaining to the knee region
Calf: pertaining to the posterior surface of the lower leg
Occipital: pertaining to the posterior surface of the head
Deltoid: pertaining to the curve of the shoulder formed by the large deltoid muscle

BODY CAVITIES

The body has two sets of cavities, which offer quite different degrees of protection to the organs within them (Figure 1–7a).

Dorsal Body Cavity

The dorsal body cavity can be subdivided into the **cranial cavity**, in which the brain is enclosed within the rigid skull, and the **spinal cavity**, in which the delicate spinal cord is protected within a bony vertebral column. Since the cord is a continuation of the brain, these cavities are continuous with each other.

Ventral Body Cavity

The ventral cavity is much larger than the dorsal cavity. It contains all the structures within the chest and abdomen. Like the dorsal cavity, the ventral cavity is subdivided. The superior **thoracic cavity** is separated from the rest of the ventral cavity by the dome-shaped diaphragm. The heart and lungs, located in the thoracic cavity, are afforded some measure of protection by the bony rib cage. The cavity below the diaphragm is often referred to as the **abdominopelvic cavity**, since there is no further physical separation of the ventral cavity. Some prefer to subdivide the abdominopelvic cavity into a superior **abdominal cavity**, which houses the stomach, intestines, liver, and other organs, and an inferior **pelvic cavity**, containing the reproductive organs, bladder, and rectum. Note in Figure 1–7b that the abdominal and pelvic cavities are not continuous with each other in a straight plane but that the pelvic cavity is tipped away from the perpendicular.

The inner body wall of the ventral cavity is lined with a smooth serous membrane, the **parietal serosa**, which is continuous with a similar membrane, the **visceral serosa**, covering the external surfaces of the organs within the cavity (Figure 1–8). These membranes produce a thin lubricating fluid that allows the organs to slide over one another or to rub against the body wall without friction.

The specific names of the serous membranes depend on the structures they envelop. Thus the serosa lining the abdominal cavity and covering its organs is the **peritoneum**, that enclosing the lungs is the **pleura**, and that around the heart is the **pericardium**.

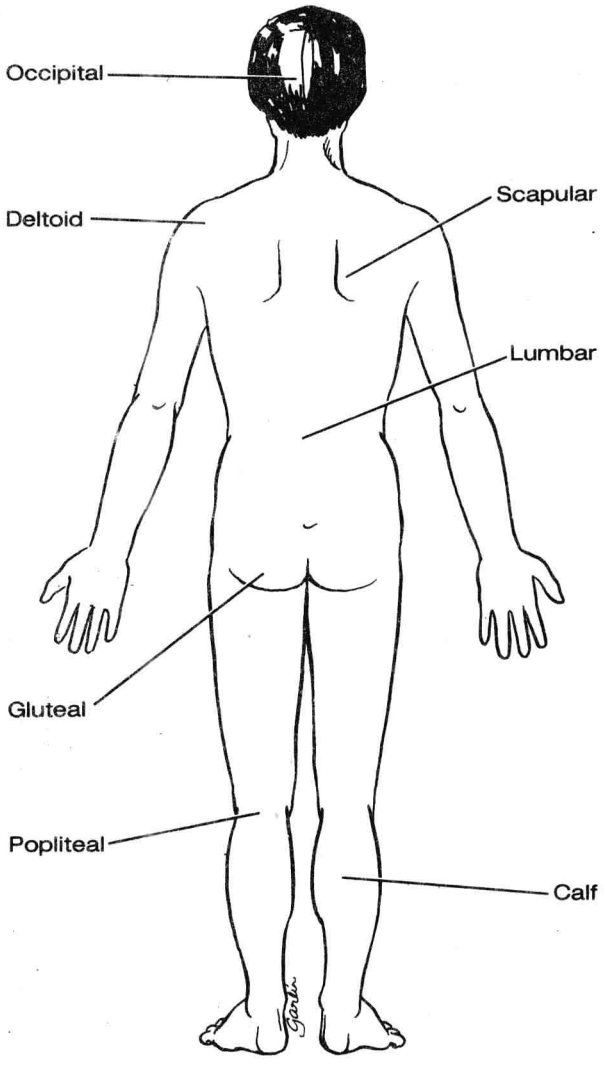


Figure 1–6. Posterior body landmarks.

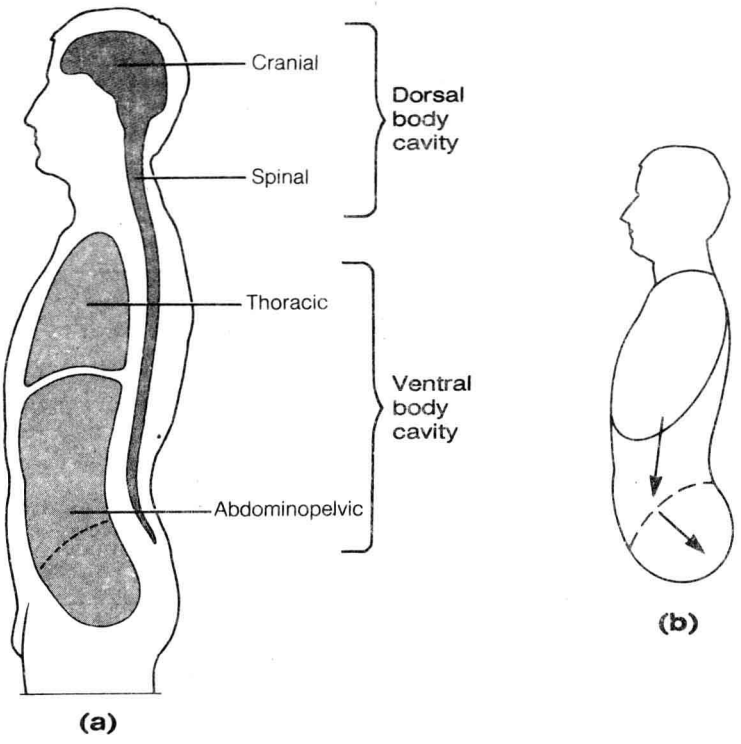


Figure 1-7. Body cavities: (a) dorsal and ventral cavities (lateral view); (b) angle of the relationship between the abdominal and pelvic cavities.

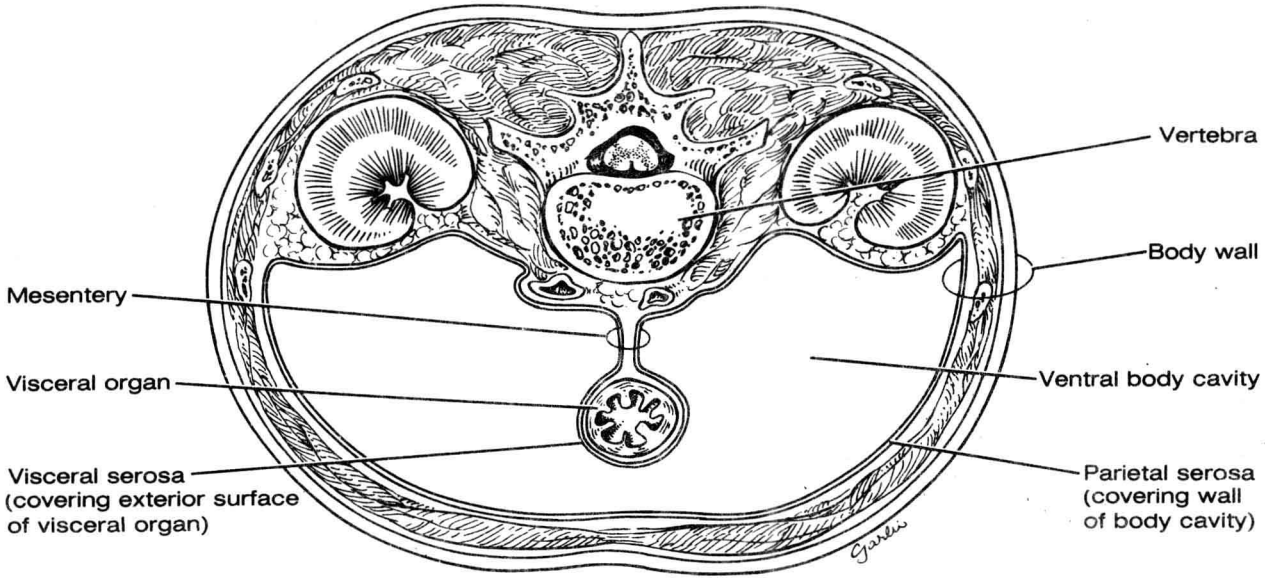


Figure 1-8. Parietal and visceral serosa (transverse section through body wall).

EXERCISE 2

Organ System Overview

Objectives

1. To name the major human organ systems and state the major functions of each.
2. To list two or three organs of each system and to categorize the various organs by organ system.
3. To identify these organs in a dissected rat or on a dissectible torso.

Materials

freshly killed or preserved rat for dissection (1 for every 2 to 4 students) or a previously dissected rat for demonstration
dissecting pans and pins
scissors
forceps
dissectible human torso model

ORGAN SYSTEMS

The basic unit or building block of all living things is the cell. The cells in the human body fall into four different categories according to their functions. Each of these corresponds to one of the four **tissue** types: epithelial (lining and glandular function), muscular, nervous, and connective (support and packaging function).

An **organ** is a structure composed of two or more of these tissue types that performs a specific function for the body. For example, the small intestine, which digests and absorbs nutrients, is composed of all four tissue types. An **organ system** is a group of organs that act together to perform a particular body function. For example, the digestive system is made up of the salivary glands, esophagus, stomach, and small and large intestines, to name a few. These organs work together to assure that food moving through the digestive system is properly broken down by mechanical and chemical processes and that the end products are absorbed into the bloodstream to provide nutrients and fuel for all the body's cells. In all, there are ten organ systems.

Integumentary System

The integumentary system is the external covering of the body, or the integument. It consists of two major regions, the epidermis (epithelial tissue) and the dermis (connective tissue), which together constitute the skin. The integument waterproofs the body (rather like a raincoat) and cushions and protects the deeper tissues from injury through mechanical, chemical, and bacterial damage. It also functions as an avenue of excretion (salts and urea are lost in perspiration) and aids in the regulation of body temperature.

Skeletal System

The skeletal system consists of the bones and the cartilages, tendons, and joints that bind the bones together. Its major roles are to support the body and to provide a framework of levers that the skeletal muscles can act on to cause movement. Obviously it also has a protective function (for example, the skull). Hemopoiesis, or formation of blood cells, goes on within the cavities of the skeletal system.

Muscular System

The muscles of the body have only one function: to contract or shorten. When they do so, movement occurs. Thus the heart, composed of cardiac muscle, contracts; as it contracts, it pumps blood through the blood vessels. When the large, fleshy muscles attached to your bones (the skeletal muscles) contract, you are able to walk, run, grasp, and smile. When the smooth muscle in the walls of hollow organs contracts, the organs change shape; thus substances are moved through an organ along a predetermined pathway, as in the movement of food through the digestive tract organs or the passage of urine from the bladder down the urethra to the outside of the body.

Nervous System

The nervous system is the body's fast-acting control system. It consists of the brain, spinal cord, nerves, and sensory receptors. The body must be able to respond to stimuli from external sources (such as light, sound, pressure, and changes in temperature) and from internal sources (such as decreases in oxygen in a particular body tissue). The sensory receptors detect these changes and relay the information to the central nervous system (the brain and spinal cord). The central nervous system then assesses this

information and brings about an appropriate response by activating the appropriate body muscles or glands.

Endocrine System

Like the nervous system, the endocrine system controls body activities and maintains homeostasis. Instead of employing rapid electrochemical impulses as messengers (as in the nervous system), the endocrine glands produce chemical molecules called hormones. The endocrine glands release the hormones into the blood to travel to relatively distant target organs. Comparing the speed of the nervous system and the endocrine system is rather like comparing jet travel and the pony express. Although the messengers of the endocrine system (the hormones) reach their target organs much more slowly, their effects are of much longer duration.

The endocrine glands consist of the pituitary, thyroid, parathyroids, adrenals, thymus, pancreas, pineal, ovaries (in the female), and testes (in the male). Certain cells in the lining of the organs of the digestive system also make and release hormones that affect the digestive process. The endocrine glands are not connected anatomically the way parts of the other organ systems are. Their common characteristic is that they all secrete hormones that regulate other structures.

The body functions controlled by hormones are many and varied, affecting virtually every cell in the body. Two hormonally regulated functions are the control of skeletal growth and sexual maturation.

Circulatory System

The circulatory system, or cardiovascular system, functions as a transport and delivery system. It consists primarily of the heart, blood vessels, and blood and acts to carry oxygen, carbon dioxide, nutrients, metal ions, hormones, and other substances to and from the tissue cells, where exchanges are made. White blood cells and antibodies in the blood protect the body from such "foreign invaders" as bacteria, toxins, and tumor cells. The blood is propelled through the blood vessels (arteries, veins, and capillaries) by the pumping action of the heart.

Respiratory System

The sole role of the respiratory system is to keep the body constantly supplied with oxygen while removing carbon dioxide. The respiratory system consists of the nasal passages, pharynx, larynx, trachea, bronchi, and lungs. Within the lungs are minute branches of the bronchi called bronchioles, which terminate in alveoli (air sacs). It is through the thin walls of the alveoli that gas exchanges are made, to and from the blood.

Digestive System

The digestive system is essentially a tube running through the body from mouth to anus. The organs of the digestive system include the mouth (with its teeth and salivary glands), esophagus, stomach, small intestine, large intestine, and rectum. Their role is to break down food and assure that the products get into the blood for delivery elsewhere. Thus the digestive system prepares food for absorption into the body. The undigested food that remains in the tract at the rectum leaves the body through the anus as feces.

Mechanical food breakdown (chewing, churning, and the like) occurs in the mouth and the stomach; chemical digestion (which employs enzymes) begins in the mouth with the enzymes contained in saliva, continues in the stomach, and is completed in the small intestine. From that point on, the major function of the digestive system is to remove water.

The liver is also considered a digestive organ, because the bile it produces aids in the breakdown of fats in the small intestine; its other functions are discussed in greater depth in Unit 13. The pancreas, which delivers a broad array of digestive enzymes to the small intestine, is also functionally a digestive organ.

Urinary System

As it functions, the body produces various wastes that must be discarded. Carbon dioxide is one of these wastes; its disposal is handled by the respiratory system. Another type of waste is nitrogenous waste (primarily in the form of urea, uric acid, and ammonia), which results from the breakdown of proteins and nucleic acids by the body cells.

The urinary system, often called the excretory system, is composed of the kidneys, ureters, bladder, and urethra. It removes the nitrogenous wastes from the blood and eliminates them from the body in urine. Other important functions of this system include maintenance of the body's water balance and the blood's proper pH and ionic composition.

Reproductive System

The reproductive system exists primarily to provide germ cells (eggs and sperm) for the perpetuation of the species. Sperm are produced by the testes of the male. Other structures of the male reproductive system include the scrotum, penis, accessory glands, and the duct system that carries sperm to the body exterior. The ovary of the female produces the eggs, or ova; the female duct system consists of the fallopian tubes, uterus, and vagina.

RAT DISSECTION

Now you will have a chance to observe the size, shape, location, and distribution of the organs and organ systems. Many of the external and internal