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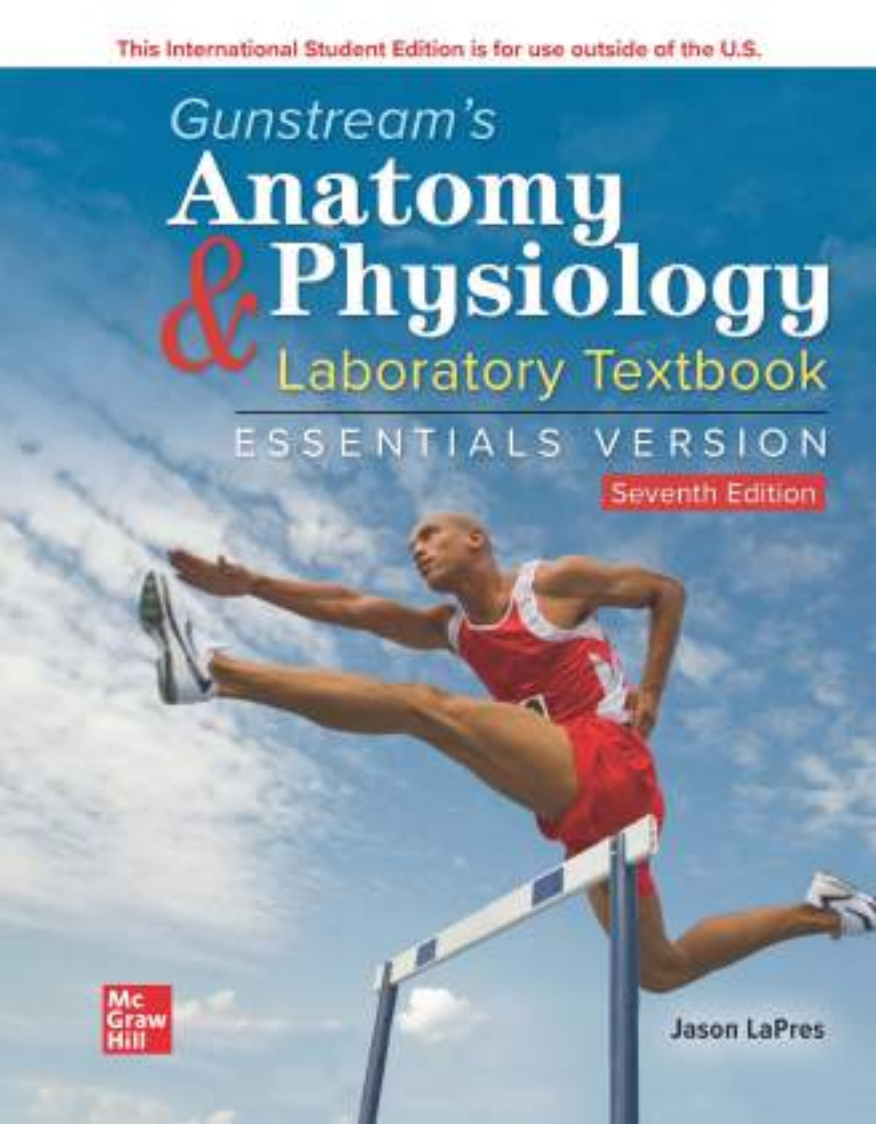
Gunstream's Anatomy & Physiology Laboratory Textbook

ESSENTIALS VERSION

Seventh Edition



Mc Graw Hill

Jason LaPres

Seventh Edition

Anatomy & Physiology

LABORATORY TEXTBOOK • ESSENTIALS VERSION

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ANATOMY & PHYSIOLOGY LABORATORY

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PREFACE

This *Essentials Version* of the *Anatomy & Physiology Laboratory Textbook* presents the fundamentals of human anatomy and physiology in a manner that is appropriate for students in allied health programs such as practical nursing, radiologic technology, medical assisting, and dental assisting. These students usually take a one-semester course in human anatomy and physiology and need a laboratory text that provides coverage of the fundamentals without the clutter of excessive details and unneeded terminology.

Changes to the New Edition

Based on the experience and the thoughtful comments of reviewers, the following overarching changes have been made to the seventh edition:

- Updated terminology throughout the lab manual for more current presentation of material.
- Reordered 38 exercises into a new format of 25 exercises.
- Included cautionary statements to prepare students for working with potentially dangerous materials in the laboratory.
- Moved the appropriate histological photomicrographs out of the atlas at the end of the manual and into each Exercise.
- Improved the organization of histology by presenting all four tissue types together in Exercise 5.

Exercise Format

Each of the 25 exercises begins with a short list of objectives that outline the minimal learning responsibilities for the students. The exercises are basically self-directing, which minimizes the need for lengthy introductions by the instructor.

Instructors will find that the listing of required equipment and materials on the first page of each exercise facilitates laboratory preparation. The exercises use standard equipment and materials that are usually available in most biology departments.

Each exercise topic is covered at a reduced level of difficulty appropriate for the student audience and presented in a direct, concise manner to facilitate student learning. Numerous illustrations and many photomicrographs are correlated with the text to improve understanding.

The necessary key terms are in bold print to aid students in building a vocabulary of anatomical and physiological terms.

Laboratory procedures are distinct from and follow the discussion of the exercise topic. They are presented in a concise, stepwise manner to guide the student. Activities consist of (1) labeling illustrations, (2) dissections, (3) study of specimens and models, (4) physiological experiments, and (5) microscopic studies. A major dissection specimen, such as the cat or fetal pig, is not included. Instead, a rat dissection is used in a single exercise to acquaint students with the basic organization of organ systems in mammals.

Pedagogical Design

The pedagogical design calls for students to develop an understanding of each exercise topic by (1) labeling the illustrations using information presented in the text and (2) completing corresponding portions of the laboratory report. Usually, students should complete these activities *before* coming to the laboratory or proceeding with the other laboratory studies.

The *laboratory reports* are designed to guide and reinforce student learning and provide a convenient site for recording data and making diagrams of observations. They are located at the back of the book to better control the pagination and to keep the book brief. The corresponding laboratory report should be removed from the back of the book whenever students begin working on an exercise. Removing the report prevents page flipping and facilitates completing the laboratory report. Completed laboratory reports should be kept in the student's notebook. Instructors may choose to either post the answer keys from the *Instructor's Manual* so the students can check their work or collect and grade the laboratory reports. The design of the laboratory reports makes them easy to grade.

Students in the target group typically have difficulty in learning the necessary anatomical and physiological terminology, especially the correct spellings. Experience has shown that students learn key terms and their correct spellings more easily if they write the terms. Thus, the laboratory reports are structured so that students are required to write the names of key terms rather than simply provide a matching letter or number.

Microscopic study is another difficult area for these students since they have trouble locating histological structures on slides when using diagrams as a reference. This problem is largely overcome by the inclusion of full-color photomicrographs of common tissues and of selected histological subjects, which have been reorganized to be within each exercise.

Supplements

Instructor's Manual

The accompanying *Instructor's Manual* provides additional aid for the Instructor: (1) a composite list of equipment and supplies, (2) operational suggestions, and (3) answer keys for the laboratory reports.

Adopters are encouraged to contact the author regarding any problems and to submit constructive suggestions that will improve future editions.

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McGraw-Hill Anatomy & Physiology Revealed® is an interactive cadaver dissection tool to enhance lecture and lab, which students can use anytime, anywhere. Detailed cadaver photographs blended together with a state-of-the-art layering technique provide a uniquely interactive dissection experience. Anatomy & Physiology Revealed can now be customized to your course. Choose the specific structures that you require in your course and APR 3.0 does the rest. Once your list is generated, APR 3.0 highlights your selected structures for students. New to this edition are APR icons indicating eBook links to APR to support selected topics.

Acknowledgments

The development and production of this seventh edition has been the result of a team effort. Our dedicated and creative teammates at McGraw-Hill have contributed greatly to the finished product. We gratefully acknowledge the efforts and support of Matt Garcia, Portfolio Manager, Erin DeHeck, Product Developer, Jeni McAtee and Brent dela Cruz, Project Mangers.

The following instructors have served as critical reviewers: Stephanie R. Allen, *University of Louisiana Monroe;* Malene Arnaud, *Delgado Community College;* Barry Bates, *Atlanta Technical College;* Melody Bell, *Vernon College;* Ann M. Findley, *University of Louisiana at Monroe;* Pamela B. Jackson, *Piedmont Technical College;* Sarah Mangum, *Pitt Community College;* Sharon Hall Murff, *Grambling State University;* Susan Rohde, *Triton College;* Nicholas E. Smith, *Mountwest Community and Technical College;* and Adam C. Swolsky, *Mountwest Community and Technical College.*

To the Student

This laboratory textbook has been designed to help you master the fundamentals of human anatomy and physiology, which provide the basis of the health-related professions. An understanding of anatomical structures, physiological processes, terminology, and techniques will give you the basic knowledge that is essential for success in your chosen field.

Each exercise begins with a list of learning objectives to guide your study. The sequence of activities in each exercise is established to facilitate the development of your understanding.

The activities consist of (1) labeling illustrations, (2) dissections, (3) study of specimens and models, (4) physiological experiments, and (5) microscopic study. Follow the directions for each activity with care to enhance your success in the laboratory. Work carefully and thoughtfully. Remember, the objective is to learn the material, not just to complete the exercise.

Each exercise has a *laboratory report,* located in the back of the book, that you are to complete as you work through the exercise. Remove it from the book when you start the exercise so that you can complete it without page flipping. Completed laboratory reports may be kept in your notebook.

Safety

A list of safety guidelines is included in the inside front cover.

Some of the exercises contain a *Before You Proceed* box following the material section. Be sure to check with your instructor about using protective disposable gloves where appropriate.

Labeling Illustrations

Most of the exercises are designed so that you will learn anatomy by labeling illustrations from the information provided in the text. This process helps you to understand the relationships between anatomical features, and it facilitates learning. Correctly labeled illustrations are then used as references when examining specimens and models. Use them for study and review purposes. Usually, the illustrations should be labeled *before* coming to the laboratory session.

Dissections

The dissections will include freshly killed rats and animal parts obtained from a slaughterhouse. The purpose of dissection is to expose anatomical parts for observation and study. Strive to cut as little as possible to achieve this goal. Use the scalpel sparingly. Most dissections can be accomplished with scissors, forceps, and probe.

Experiments

Before performing any experiment, read the directions completely so that you have a good understanding of the experiment. Be sure that you have all of the equipment and materials required to complete the experiment before starting. Then, carefully follow the directions.

Microscopic Study

An examination of prepared slides enables you to visualize and understand the cytological or histological structure of specimens. Correlate your observations with the text, diagrams, and histological photomicrographs. If drawings are required, make them with care and label the structures. In this way, you will understand the microscopic structures more quickly and better prepare yourself for lab practicums.

Laboratory Reports

Complete the laboratory reports independently to maximize your understanding. The laboratory reports are purposely designed so that you must write the key terms involved in the exercise, sometimes more than once. This format is used because writing the terms enables you to learn them more easily, especially their correct spellings.

General Operations

Success in the laboratory can be increased by following a few simple guidelines.

1. Be on time to class so that you will hear the comments and directions given by your instructor.

2. Follow your instructor's directions. Take notes on any changes in the equipment, materials, or procedures.
3. Keep your work area free of clutter. Extraneous items should be located elsewhere during the laboratory session.
4. Bring your textbook to the laboratory for reference.
5. Use equipment and materials with care. Report any problems or accidents to your instructor immediately.
6. Work independently, but be cooperative and helpful in team assignments.
7. Do not eat, drink, or smoke in the laboratory.

Exercise 1

Introduction to Human Anatomy and Body Organization

Objectives

After completing this exercise, you should be able to

1. Correctly use directional and regional terms in describing the location of anatomical structures.
2. Identify the external body regions and body cavities on charts or a torso model.
3. Contrast the types of body sections used in anatomical studies.
4. Describe the organs and membranes of the body cavities.
5. List the organ systems and describe their general functions.
6. List the component organs for each organ system.
7. Locate and identify the organs in the ventral cavity of the rat.

Materials

Human torso model with removable organs
Freshly killed or preserved rat
Dissecting pan with wax bottom
Dissecting instruments and pins
Protective disposable gloves

Before You Proceed

Consult with your instructor about using protective disposable gloves when performing portions of this exercise.

Human anatomy is the study of the structures composing the human body and their interrelationships. The description of anatomical features requires the use of specific *anatomical terminology* that provides precise meaning. It is important that you learn the terminology presented in this exercise as quickly as possible because these terms will be used frequently throughout your study of the human body. In this exercise, you will be introduced to the anatomical terminology that is used to describe (1) relative positions of structures, (2) body planes and sections, (3) body regions, (4) body cavities and their membranes, and (5) body systems.

The human body is composed of a hierarchy of organizational levels. From simplest to most complex, they are chemical, cellular, tissue, organ, and organ system. See Figure 1.1. Components of each organizational level work together at an organismal level to maintain **homeostasis,** the relative constancy of the body's internal environment. Homeostatic mechanisms enable the body to maintain its own stable internal environment.

Directional Terms

The relative position of body structures is communicated through the use of **directional terms.** These terms typically occur as pairs, with the members of each pair having opposite meanings. For example, *anterior (ventral)* means toward the front of the body, and *posterior (dorsal)* means toward the back of the body. Most directional terms apply to organs of the body as well as to the body as a whole. Learn the meanings of the directional terms in Table 1.1.

When directional terms are used to describe the relative positions of body parts, it is assumed that the body is in a standard position called the **anatomical position.** In this position, the body is erect with upper limbs at the sides and with the palms of the hands and the feet facing forward. The anatomical position is shown in Figure 1.2.

Figure 1.1 Levels of organization. (young woman) ONOKY - Fabrice LEROUGE/Brand X Pictures/Getty Images

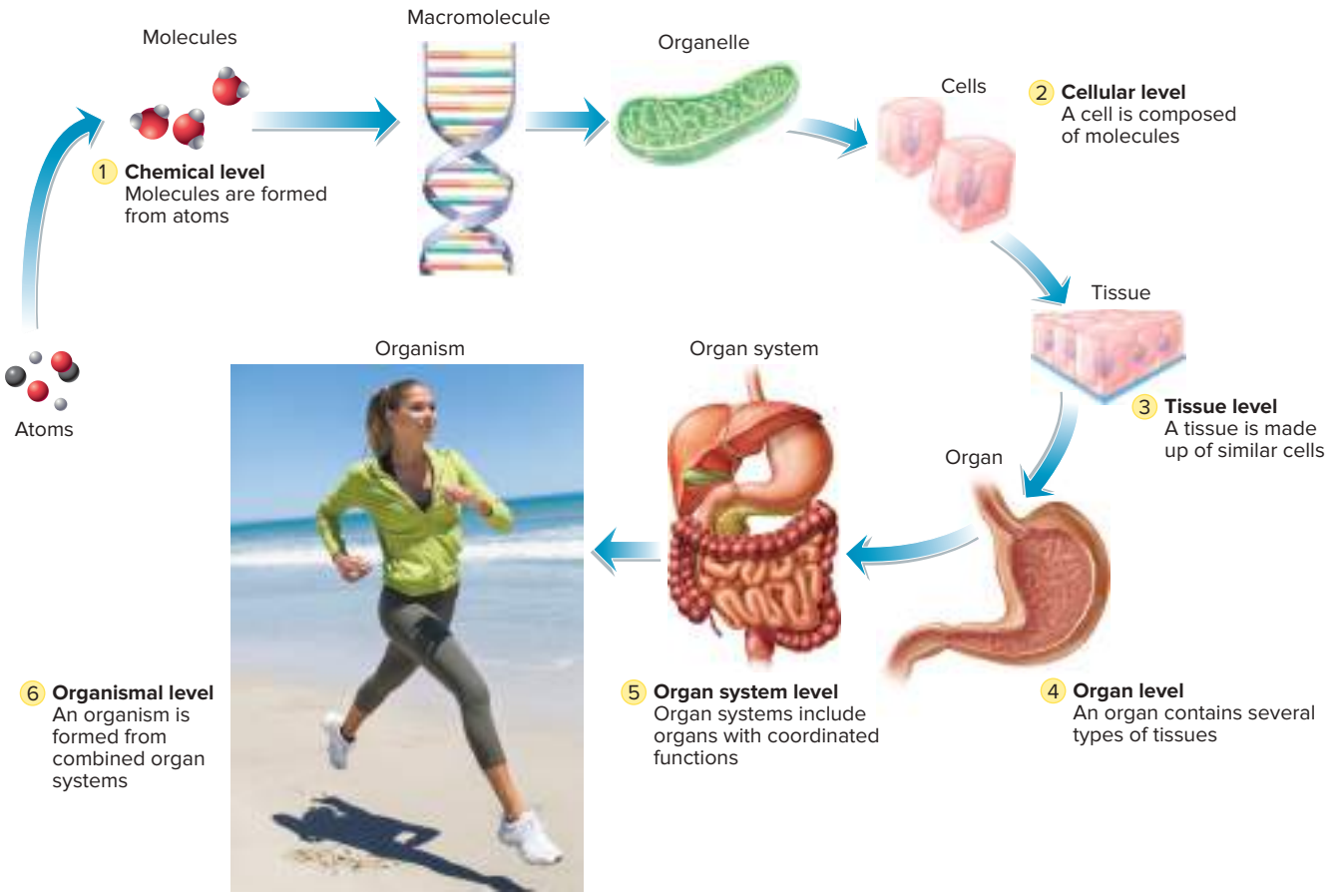


TABLE 1.1

Directional Terms

Term	Meaning
Anterior (ventral)	Toward the front or abdominal surface of the body
Posterior (dorsal)	Toward the back of the body
Superior (cephalic)	Toward the head
Inferior (caudal)	Away from the head
Medial	Toward the midline of the body
Lateral	Away from the midline of the body
Proximal	Closer to the beginning
Distal	Farther from the beginning
Superficial (external)	Toward or on the body surface
Deep (internal)	Away from the body surface
Parietal	Pertaining to the outer boundary of body cavities
Visceral	Pertaining to the internal organs

Body Planes and Sections

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.** See Figure 1.2.

Sagittal planes are parallel to the longitudinal (long) axis of the body and divide the body into left and right portions. A **median plane** is made along the **median line** and divides the body into *equal* left and right halves.

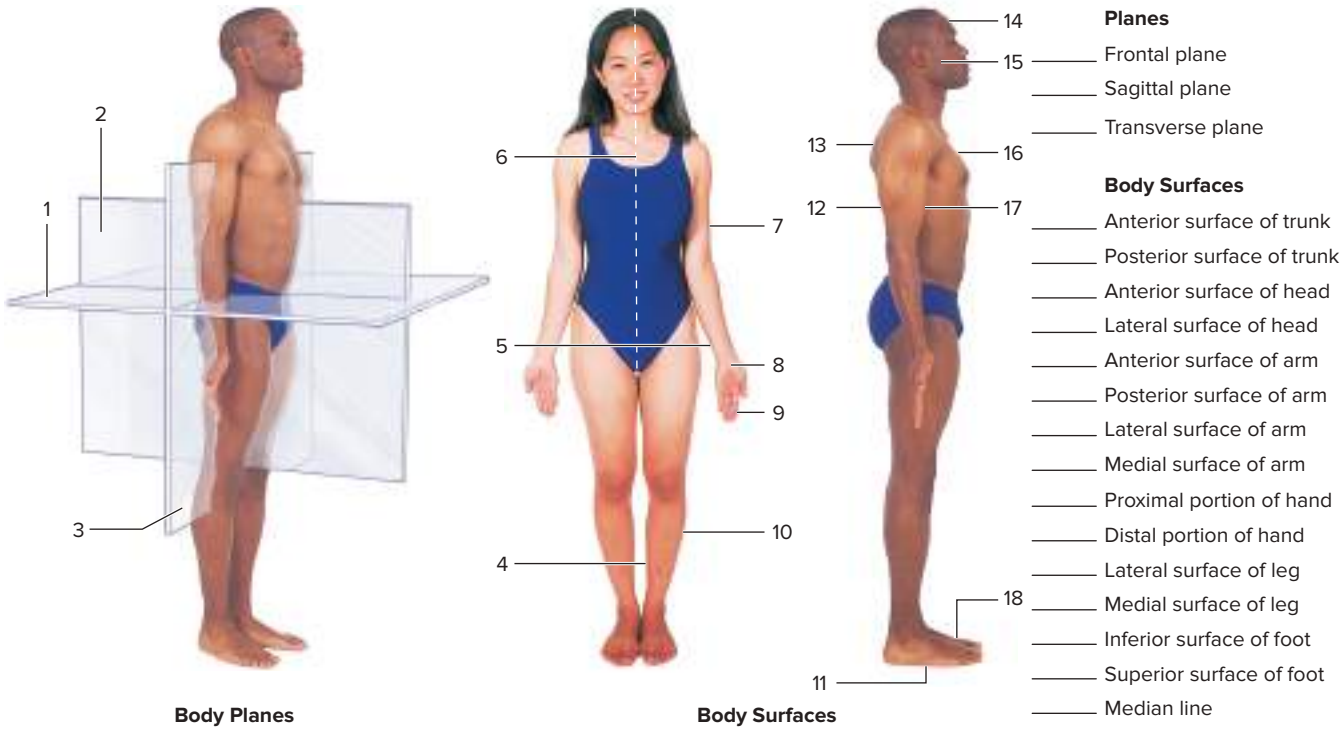
Frontal (coronal) **planes** divide the body into front and back portions and are perpendicular to sagittal sections but parallel to the longitudinal axis.

Transverse (horizontal) **planes** divide the body into top and bottom portions and are perpendicular to the longitudinal axis of the body.

Assignment

Check your understanding of directional terms, body planes, and body surfaces by labeling Figure 1.2. Place the correct number of each plane and surface in the space in front of the labels listed. Record your responses for Figure 1.2 on Laboratory Report 1.

Figure 1.2 Body planes and surfaces. Note that the body is in the anatomical position. Courtesy of Harold Benson



Regional Terminology

The human body consists of an **axial portion,** the head, neck, and trunk, and an **appendicular portion,** the upper and lower limbs and their girdles. These major divisions are subdivided into smaller regions that are identified by specific anatomical terms. Except for the small regions of head and neck, these anatomical regions are shown in Figure 1.3.

Head and Neck

The **head** and **neck** contain several small regions whose names will assist you in learning bones, muscles, and other structures. **Cephalic** simply refers to the entire head. It can be subdivided into the **cranial region,** which refers to the skull, and the **facial region,** or simply the face. The facial region is further subdivided into the **buccal region** (cheeks), **nasal region** (nose), **oral region** (mouth), **orbital region** (eyes), and **otic region** (ears). The anatomical term for the next is the **cervical region.**

Trunk

The front of the trunk consists of an upper **thoracic region** (chest), which is subdivided into two **pectoral regions** separated by a central **sternal region.** The **abdominal region** is below the thoracic region. Two **inguinal** (groin) **regions** lie at the junction of the trunk with the lower limbs. The **pubic region** lies between the inguinal regions. The external reproductive organs in both sexes make up the **genital region.**

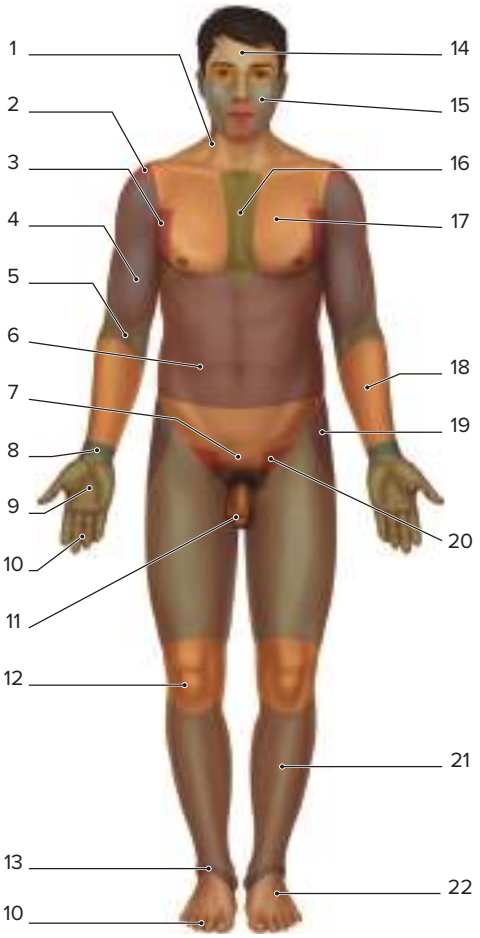
The back of the trunk is the **dorsal region.** It contains two **scapular regions,** which are located over the shoulder blades. An elongated **vertebral region** lies along the vertebral column. The small **sacral region** lies below the vertebral region and between the two **gluteal regions** (buttocks). A **lumbar region** is located on each side of the vertebral region below the ribs.

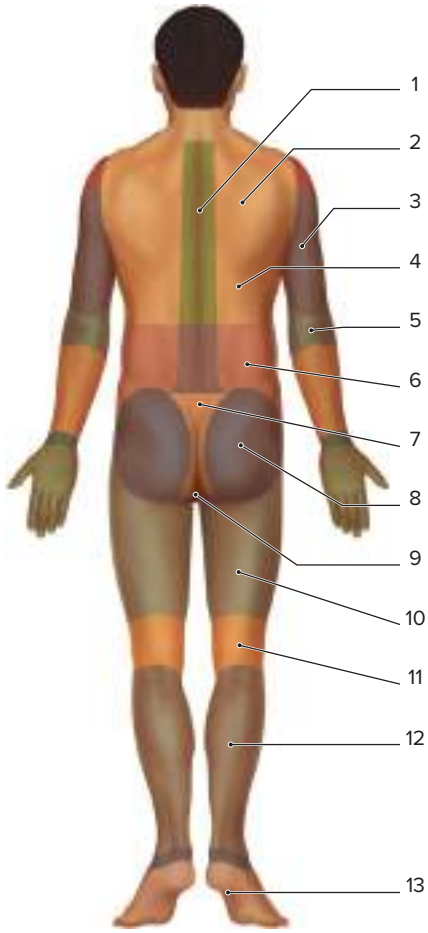
The **axillary regions** (armpits) and the **coxal regions** (hips) lie on the lateral surfaces of the trunk.

Upper Limb

The **deltoid region** (shoulder) is formed by the attachment of each upper limb to the trunk. The arm composes the **brachial region,** and the forearm composes the **antebrachial region.** The elbow forms the **cubital region,** and the front of the elbow is the **antecubital region.** The **carpal region** (wrist), the **manual region** (hand), and the **digital region** (fingers) complete the regions of each upper limb.

Figure 1.3 Regions of the body. Common names are noted in parentheses. A&PR





Anterior View

_____ Abdominal (Abdomen)
_____ Antebrachial (Forearm)
_____ Antecubital (Front of elbow)
_____ Axillary (Armpit)
_____ Brachial (Arm)
_____ Carpal (Wrist)
_____ Cervical (Neck)
_____ Coxal (Hip)
_____ Cranial (Skull)
_____ Crural (Leg)
_____ Deltoid (Shoulder)
_____ Digital (Fingers and toes)
_____ Facial (Face)
_____ Genital (Reproductive organs)
_____ Inguinal (Groin)
_____ Manual (Hand)
_____ Patellar (Kneecap)
_____ Pectoral (Chest)
_____ Pedal (Foot)
_____ Pubic (Above genital)
_____ Sternal (Breastbone)
_____ Tarsal (Ankle)

Posterior View

_____ Brachial (Arm)
_____ Cubital (Elbow)
_____ Dorsal (Back)
_____ Femoral (Thigh)
_____ Gluteal (Buttock)
_____ Lumbar (Loin)
_____ Perineal (Between genitals and anus)
_____ Plantar (Sole)
_____ Popliteal (Back of knee)
_____ Sacral (Between hips)
_____ Scapular (Shoulder blade)
_____ Sural (Calf)
_____ Vertebral (Spinal)

Lower Limb

The proximal part of the lower limb, the thigh, constitutes the **femoral region,** and the leg is the portion between the knee and ankle. The front of the leg, or shin, is the **crural region;** the back of the leg, or calf, is the **sural region.** The front of the knee is the **patellar region,** and the back of the knee is the **popliteal region.** The **tarsal region** (ankle), **pedal region** (foot), **calcaneal region** (heel), and **digital region** (toes) complete the regions of each lower limb. **Plantar region** (sole) refers specifically to the bottom of the foot.

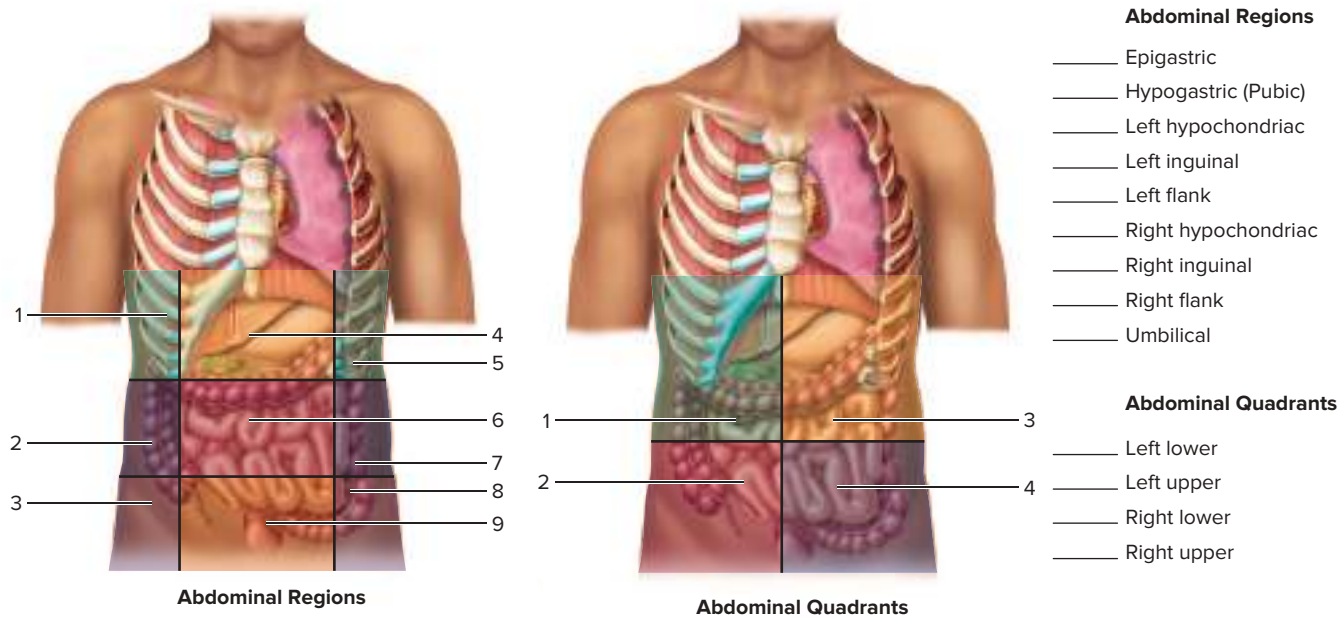
Abdominal Divisions

Underlying internal organs may be located by dividing the abdominal surface into either nine regions or four quadrants. Anatomists prefer to divide the abdominal surface into nine regions formed by the intersecting of two vertical and two transverse planes as shown in Figure 1.4.

The **umbilical region** is the central area that includes the umbilicus (navel). On either side of the umbilical region are the left and right **flank regions.** Just above the umbilical region is the **epigastric region,** which is between the left and right **hypochondriac regions.** Below the umbilical region is the **hypogastric** (pubic) **region,** which is between the left and right **inguinal regions.**

Health-care professionals often use a simpler system to subdivide the abdominal surface into quadrants by perpendicular vertical and transverse planes that intersect at the umbilicus.

Figure 1.4 Abdominal regions and quadrants. APR



See Figure 1.4. This division forms four quadrants: **upper right, upper left, lower right,** and **lower left.**

Assignment

Label Figures 1.3 and 1.4 and record your responses on the laboratory report.

Body Cavities

Internal organs are located within body cavities. There are two major body cavities, the dorsal aspect and the ventral cavity, as shown in Figure 1.5. These cavities are named after the body surface nearest to them.

The **dorsal aspect** consists of the **cranial cavity,** which contains the brain, and the **vertebral canal,** which contains the spinal cord.

The **ventral cavity** consists of the **thoracic cavity,** which houses the lungs, heart, and other thoracic organs, and the **abdominopelvic cavity,** which contains most of the internal organs. A thin, dome-shaped sheet of muscle, the **diaphragm,** separates the thoracic and abdominopelvic cavities.

The thoracic cavity is divided into left and right portions by the **mediastinum,** a membranous partition that contains the heart, trachea, esophagus, and thymus. The **pericardial cavity,** containing the heart, is within the mediastinum. The right and left **pleural cavities** contain the lungs.

The abdominopelvic cavity consists of (1) the **abdominal cavity,** which contains the stomach, intestines, liver, gallbladder, pancreas, spleen, and kidneys, and (2) the **pelvic cavity,** which contains the urinary bladder, sigmoid colon, and rectum. In females, it also contains the uterus, uterine tubes, and ovaries.

Membranes of Body Cavities

The body cavities are lined with membranes that provide protection and support for the internal organs. Refer to Figures 1.6 and 1.7 as you read this section.

Dorsal Aspect Membranes

The dorsal aspect is lined by three membranes that are collectively called the **meninges.** The outermost membrane is tough and fibrous; the other two membranes are more delicate. The thin innermost membrane closely envelops the brain and spinal cord. The meninges will be considered later when you study the nervous system.

Ventral Cavity Membranes

The membranes lining the ventral cavity are **serous membranes** that secrete a watery fluid generically

Figure 1.5 Body cavities. APR

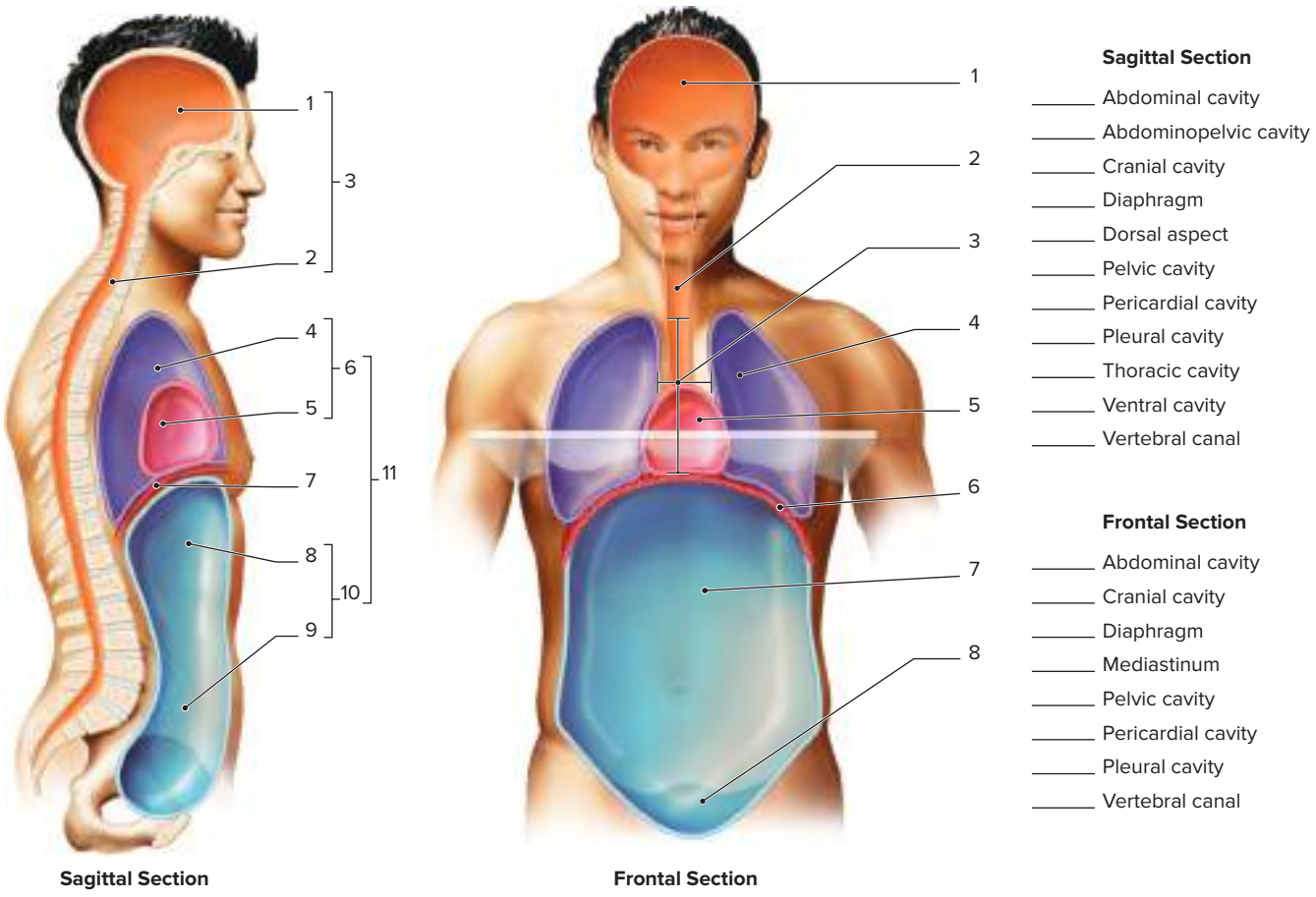
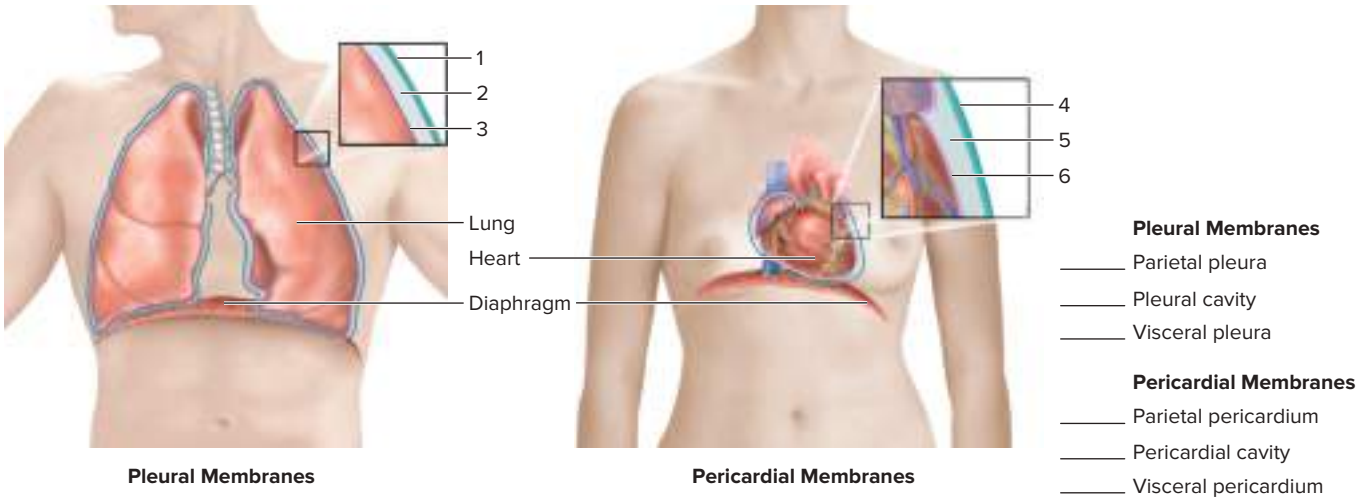


Figure 1.6 Thoracic membranes. APR

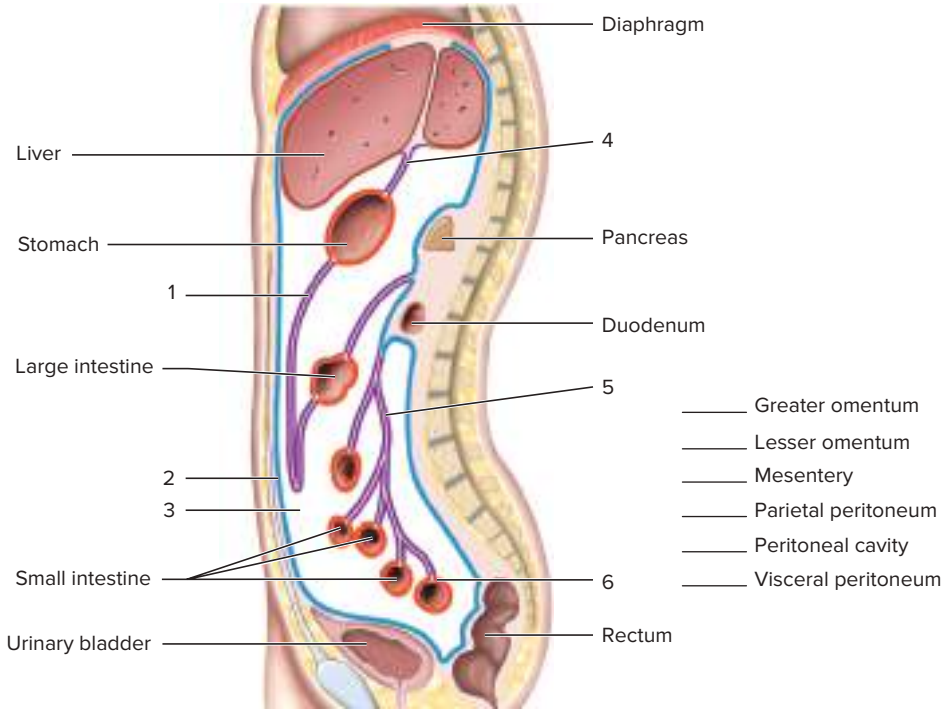


called *serous fluid.* Each cavity's fluid has its own specific name that will be discussed with each membrane next. Their moist, slippery surfaces reduce friction between internal organs and the walls of the ventral cavity as the organs move.

Thoracic Cavity Membranes

The inner walls of the left and right portions of the thoracic cavity are lined by the **parietal pleurae;** the lungs are covered with the **visceral pleurae.** The parietal and visceral pleurae are

Figure 1.7 Membranes of the abdominal cavity.



separated only by a thin layer of **pleural fluid.** This moist space between the pleurae is known as the **pleural cavity.** The parietal pleurae are continuous with the membranes forming the mediastinum.

The heart is enclosed within the **serous pericardium.** The **visceral pericardium,** or **epicardium,** is a thin serous membrane that is tightly attached to the outer surface of the heart. The **parietal pericardium** lines the inside surface of a loosely fitting sac around the heart. The space between the visceral and parietal pericardia is the **pericardial cavity,** and it contains serous fluid, called **pericardial fluid,** that reduces friction as the heart contracts and relaxes.

Abdominal Cavity Membranes

The walls of the abdominal cavity and the surfaces of abdominal organs are covered with the **peritoneum.** The **parietal peritoneum** lines the inner abdominal wall, and the **visceral peritoneum** covers the surface of the abdominal organs. The space between the visceral and parietal peritonea is the **peritoneal cavity,** which contains **peritoneal fluid.** See Figure 1.7. The kidneys, pancreas, and parts of the large intestine are located in the **retroperitoneal region** (behind the peritoneum), so only part of their surfaces is covered with the parietal peritoneum.

Double-layered folds of the peritoneum, called **mesenteries,** extend from the cavity wall to the abdominal organs. The mesenteries support the abdominal organs, and they contain nerves and blood vessels serving the organs. A large mesenteric fold, the **greater omentum,** extends from the bottom of the stomach over the intestines and loops back up to join with the transverse colon (part of the large intestine). A smaller mesenteric fold, the **lesser omentum,** extends between the liver and the stomach.

The parietal peritoneum does not line the pelvic cavity. It only extends far enough to cover the top of the urinary bladder.

Assignment

1. Label Figures 1.5, 1.6, and 1.7 and record the labels on the laboratory report.
2. Using a human torso model, (a) locate the surface features and body cavities, (b) identify the major organs of each cavity, and (c) locate the organs within each of the nine abdominal regions and four abdominal quadrants.

Organ Systems

Most of the functions of the body are performed by organ systems. As illustrated in Figure 1.1, an **organ** is a structure that is (1) composed of two or more tissues, (2) has a definite shape, and (3) performs specific functions. The heart is an example of an organ. An **organ system** is a group of organs that function in a coordinated manner to perform specific functions. The cardiovascular system, which is composed of blood, heart, and blood vessels, is an example of an organ system.

In this exercise, you will study an overview of the components and general functions of the organ systems of the body in order to gain a general understanding of body organization and function. See Figure 1.8. Then you will dissect a freshly killed or preserved rat to observe the mammalian body organization, body cavities, and organs of the ventral cavity.

The Integumentary System

The skin, including hair, nails, associated glands, and sensory receptors, constitutes the integumentary system. The **skin** consists of two layers, an outer **epidermis** and an inner **dermis,** which protect the underlying tissues from mild abrasions, excessive water loss, microorganisms, and ultraviolet radiation. Perspiration secreted by sweat glands contains water and waste materials similar to dilute urine. The evaporation of perspiration cools the body surface, thus aiding in regulating body temperature.

The Skeletal System

The skeletal system forms the framework of the body and provides support and protection for softer organs and tissues. It consists of **bones, cartilages,** and **ligaments.** In conjunction with skeletal muscles, the skeleton forms lever systems that enable movement. In addition, **red bone marrow** produces blood cells.

The Muscular System

The contraction of muscles provides the force that enables movement. **Skeletal muscles** are attached to bones by **tendons** and constitute nearly half of the body weight. Their contractions move body parts during walking, eating, and other activities.

Two other types of muscle tissue are found in the body: smooth and cardiac. *Smooth muscle* is found in the walls of hollow organs. *Cardiac muscle* is found in the walls of the heart.

The Nervous System

The nervous system is a complex, highly organized system consisting of the **brain, spinal cord, cranial** and **spinal nerves,** and **sensory receptors.** These components work together to enable rapid perception and interpretation of the environment and the almost instantaneous coordination of body functions. The human brain is responsible for intelligence, will, self-awareness, and emotions characteristic of humans.

The Endocrine System

The endocrine system consists of small masses of glandular tissue that secrete hormones. **Hormones,** which are chemical messengers, are absorbed by the blood and transported throughout the body, where they bring about the chemical control of body functions. The larger masses of endocrine tissues occur in the **endocrine glands: pituitary, thyroid, parathyroid, thymus, adrenal, pancreas, pineal, ovaries,** and **testes.** Smaller masses of hormone-producing tissues occur in other organs, such as the kidneys, heart, placenta, and in the digestive tract.

The Cardiovascular System

The **heart, arteries, veins, capillaries,** and **blood** constitute the cardiovascular system. These components work together to transport materials such as oxygen, carbon dioxide, nutrients, wastes, and hormones throughout the body. Contractions of the heart circulate the blood through the blood vessels. Blood, consisting of formed elements (cells) and plasma, is the transporting agent and also provides the primary defense against disease organisms. The spleen serves as a blood reservoir and removes worn-out red blood cells from circulation.

The Lymphoid System

The lymphoid system consists of **lymphoid tissue** and a network of **lymphatic vessels** that collect fluid from interstitial spaces (spaces between cells) and return it to large veins under the collarbones. Interstitial fluid is called **lymph** after it enters a lymphatic vessel. En route, lymph passes through **lymph nodes,** nodules of lymphoid tissue, that remove cellular debris and microorganisms. Lymphoid tissue is found in many organs, such as the spleen, thymus, tonsils, adenoids, liver, intestines, and red bone marrow. The lymphoid tissue produces immune cells and plays a central role in the defense against pathogens.

The Respiratory System

The exchange of oxygen and carbon dioxide between the atmosphere and the blood is enabled by the respiratory system. It consists of air passageways and gas-exchange organs. The passageways

Figure 1.8 The 11 organ system of the body.

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

Nervous system

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

Endocrine system

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

Cardiovascular system

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

Figure 1.8 (*Continued*)

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

Respiratory system

Organs: nose, pharynx, larynx, trachea, bronchi, and lungs
Functions: exchanges O_2 and CO_2 between air and blood in the lungs, pH regulation, and sound production

Digestive system

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

Urinary system

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

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

are the **nasal cavity, pharynx, larynx, trachea,** and **bronchi.** Gas exchange occurs in the **lungs.**

The Digestive System

The digestive system converts large, nonabsorbable nutrient molecules into smaller nutrient molecules that can be absorbed into the blood. Digestion involves mechanically breaking food into smaller particles and mixing them with digestive fluids and chemically breaking large molecules into smaller molecules. The digestive tract consists of the **mouth, pharynx, esophagus, stomach, small intestine,** and **large intestine.** Accessory organs of the digestive system include the **salivary glands, gallbladder, liver,** and **pancreas.**

The Urinary System

The nitrogenous wastes of metabolism and excess water and minerals are removed from the blood and body by the urinary system. The **kidneys** remove wastes and excess materials from the blood to form urine, which is carried by two **ureters** to the **urinary bladder** for temporary storage. Subsequently, urine is voided via the **urethra.**

The Reproductive System

Continuity of the species is the function of the male and female reproductive systems. The male reproductive system consists of a pair of sperm-producing **testes** located in the **scrotum;** two tubes, the **vasa deferentia,** which carry sperm to the **urethra; accessory glands** that secrete fluids for sperm transport; and the **penis,** the male copulatory organ. The female reproductive system consists of a pair of **ovaries** that produce ova; two **uterine tubes** that carry the ova to the **uterus; accessory glands** that secrete lubricating fluids; and the **vagina,** the female copulatory organ and birth canal.

Assignment

1. Complete the laboratory report sections E, F, and G.
2. Locate the major organs of the organ systems on the human torso model.

Rat Dissection

You will work in pairs to perform this part of the exercise. Your principal objective in the dissection is to *expose the organs for study, not to simply cut up the animal.* Most cutting will be performed with scissors. The scalpel blade will be used only occasionally, but the flat blunt end of the handle will be used frequently for separating tissues.

Skinning the Ventral Surface

1. Pin the 4 feet to the bottom of the dissecting pan as illustrated in Figure 1.9. Before making any incision, examine the oral cavity. Note the large **incisors** in the front of the mouth, which are used for biting off food particles. Force the mouth open sufficiently to examine the flattened **molars** at the back of the mouth. These teeth are used for grinding food into small particles. Note that the **tongue** is attached near the throat. Lightly scrape the surface of the tongue with a scalpel to determine its texture. Most of the roof of the mouth is the bony **hard palate** and the fleshy portion behind it is the **soft palate.** The throat is called the **pharynx,** which is a component of both the digestive and respiratory systems.
2. Lift the skin in the middle of the abdomen with your forceps and make a small incision with scissors as shown in Figure 1.9. Cut the skin upward to the lower jaw, turn the pan around, and complete this incision to the anus, cutting around both sides of the genital openings. The completed incision should appear as in Figure 1.10.
3. With the handle of the scalpel, separate the skin from the musculature. You may also perform this step by gently inserting closed scissors between the skin and muscles and opening the scissors as shown in Figure 1.11. The connective tissue that lies between the skin and musculature is the **superficial fascia.**

Figure 1.9 Incision is started on the median line with a pair of scissors. unoL/Shutterstock

Figure 1.10 Completed incision from the lower jaw to the anus. unoL/Shutterstock

Figure 1.11 Skin is separated from the musculature using the open-scissors technique. unoL/Shutterstock

4. Skin the limbs down to the "knees" and "elbows" and pin the stretched-out skin to the wax. Examine the surfaces of the **muscles** and note that **tendons,** which consist of tough dense connective tissue, attach the muscles to the skeleton. Covering the surface of each muscle is another thin, gray feltlike layer, the **deep fascia.** Fibers of the deep fascia are continuous with fibers of the superficial fascia, so considerable force with the scalpel handle is necessary to separate the two membranes.
5. At this stage, your specimen should appear as in Figure 1.12. If your specimen is a female, the mammary glands will probably remain attached to the skin.

Opening the Abdominal Wall

1. As shown in Figure 1.12, make an incision through the abdominal wall with a pair of scissors. To make the cut, you must hold the muscle tissue with a pair of forceps. **Caution:** Avoid damaging the underlying viscera as you cut.
2. Cut upward along the median line to the thoracic cage and downward along the median line to the genitalia.
3. To completely expose the abdominal organs, make two lateral cuts near the base of the thoracic cage—one to the left and the other to the right. See Figure 1.13. The cuts should extend all the way to the pinned-back skin.
4. Fold out the flaps of the body wall and pin them to the wax as shown in Figure 1.14. The abdominal organs are now well exposed.
5. Using Figure 1.15 as a reference, identify all of the labeled viscera without moving the organs out of place. Note in particular the position and structure of the **diaphragm.**

Figure 1.12 Incision of musculature is begun on the median line. unoL/Shutterstock

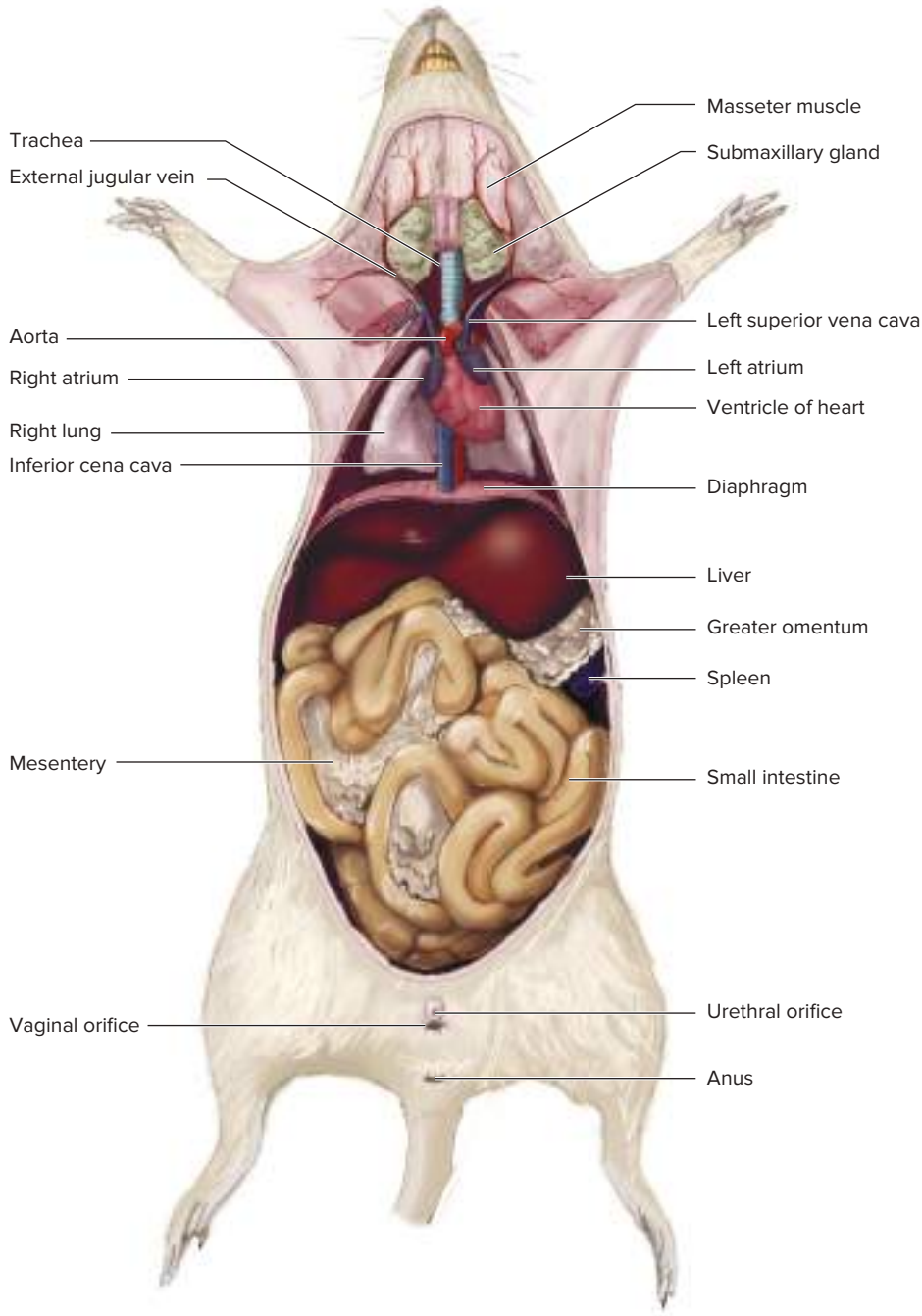
Figure 1.13 Lateral cuts at base of thoracic cage are made in both directions. unoL/Shutterstock

Figure 1.14 Flaps of abdominal wall are pinned back to expose viscera. unoL/Shutterstock

Examination of the Thoracic Cavity

1. Using your scissors, cut along the left side of the thoracic cage. Cut through all of the ribs and connective tissue. Then, cut along the right side of the thoracic cage in a similar manner.
2. Grasp the tip of the sternum with forceps and cut the diaphragm away from the thoracic cage with your scissors. Now you can lift up the thoracic cage and look into the thoracic cavity.
3. With your scissors, complete the removal of the thoracic cage by cutting any remaining attachment tissue.

Figure 1.15 Viscera of a female rat.



4. Now, examine the structures that are exposed in the thoracic cavity. Refer to Figure 1.15 and identify all the structures that are labeled.
5. Note the pale **thymus,** which is located just above the heart. Remove this gland.
6. Carefully remove the thin **pericardial membrane** that encloses the **heart.**
7. Remove the heart by cutting through the major blood vessels attached to it. Gently sponge away pools of blood with Kimwipes or other soft tissues.
8. Locate the **trachea** in the neck region and the **larynx** (voice box) at the proximal end of the trachea. Trace the trachea down to where it divides into two **bronchi** that enter the **lungs.** Squeeze the lungs with your fingers, noting how elastic they are. Remove the lungs.
9. Probe under the trachea to locate the soft tubular **esophagus** that runs from the oral cavity to the stomach. Excise a section of the trachea to reveal the esophagus as illustrated in Figure 1.16.

Deeper Examination of Abdominal Organs

1. Lift up the lobes of the reddish brown liver and examine them. See Figure 1.17. Note that rats lack a **gallbladder.** *Carefully excise the liver* and wash out the abdominal cavity. The stomach and intestines are now clearly visible.
2. Lift out the stomach and a portion of the intestines as shown in Figure 1.18 and identify the membranous **mesentery,** which holds the intestines in place. It contains blood vessels and nerves that supply the digestive tract. If your specimen is a mature

Figure 1.16 Examination of the trachea. unoL/Shutterstock

Figure 1.17 Examination of the liver. unoL/Shutterstock

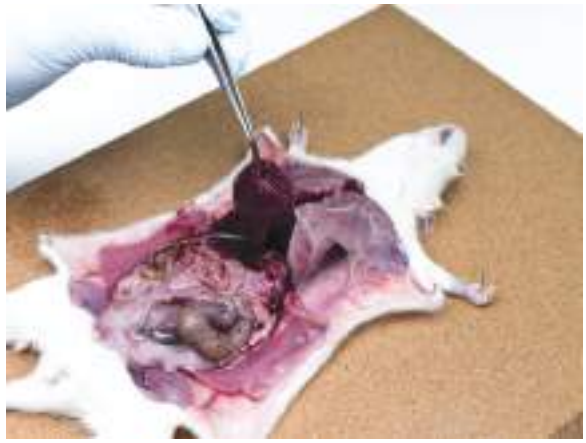


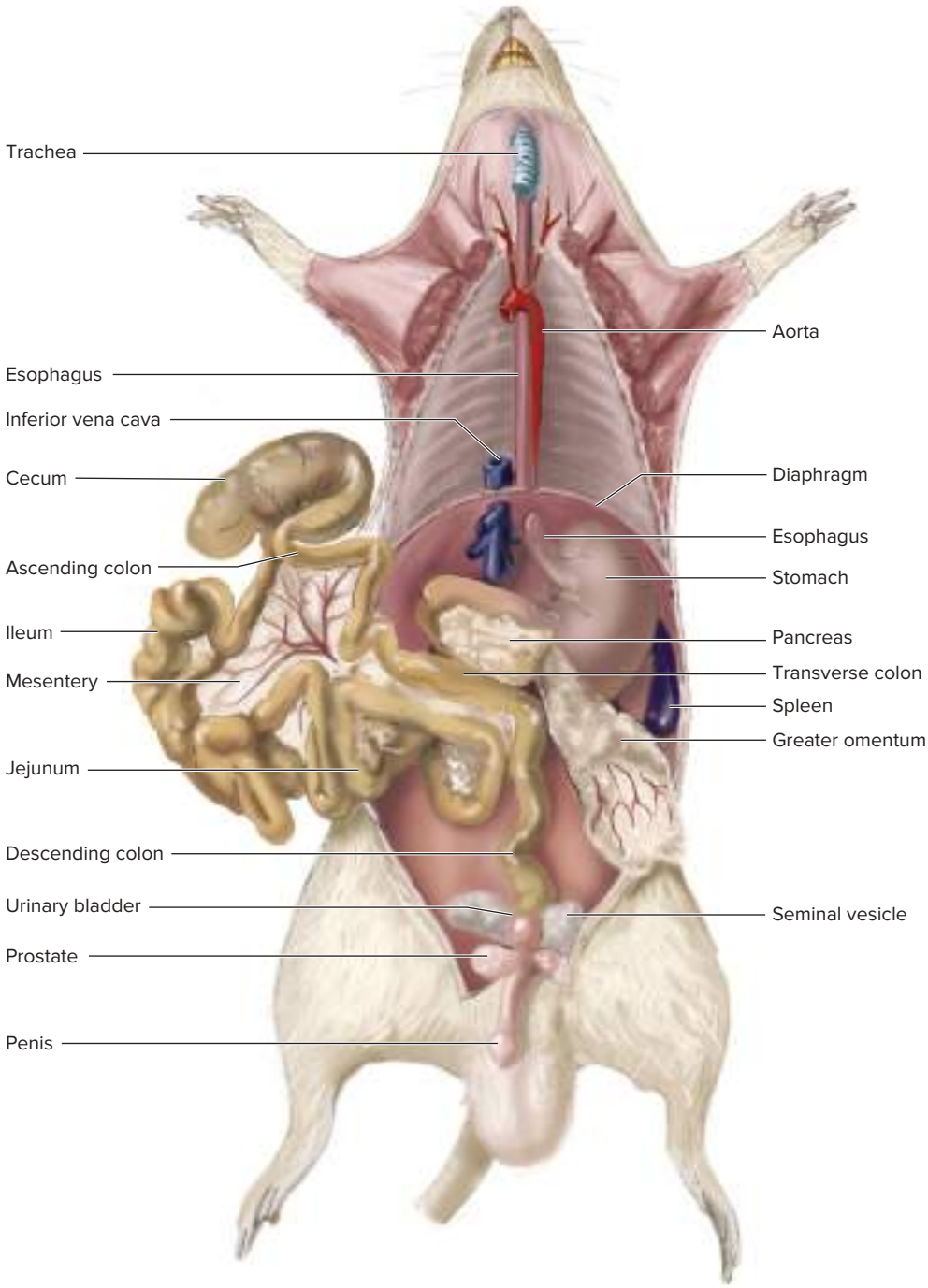
Figure 1.18 Removal of the stomach and examination of the intestines and mesentery. unoL/Shutterstock

Figure 1.19 Retroperitoneal structures. unoL/Shutterstock

healthy animal, the mesenteries will contain considerable fat.

3. Now, lift the intestines out of the abdominal cavity, cutting the mesenteries, as necessary, for a better view of the organs. Note the great length of the small intestine. Its name refers to its diameter, not its length. The first portion of the small intestine, which is connected to the stomach, is called the **duodenum.** At its distal end, the small intestine is connected to a large saclike structure, the **cecum.** The *appendix* in humans is attached to the cecum. The cecum communicates with the **large intestine.** This latter structure consists of the **ascending, transverse, descending,** and **sigmoid** segments. The last of these segments empties into the **rectum.** See Figure 1.20.
4. Try to locate the **pancreas,** which is embedded in the mesentery alongside the duodenum.

Figure 1.20 Viscera of a male rat with heart, lungs, and thymus removed.



It is often difficult to see. Pancreatic enzymes enter the duodenum via the **pancreatic duct.** See if you can locate this tiny tube.

5. Locate the **spleen,** which is situated on the left side of the abdomen near the stomach. It is reddish brown and held in place with mesentery.
6. Remove remainder of the digestive tract by cutting through the esophagus next to the stomach and through the sigmoid colon. You can now see the **descending aorta** and the **inferior vena cava.** See Figures 1.19 and 1.21. The aorta carries blood to the body tissues. The inferior vena cava returns blood from below the diaphragm to the heart.
7. Peel away the peritoneum and fat from the rear wall of the abdominal cavity. *Removal of the fat will require special care to avoid damaging important structures.* The kidneys, blood vessels, and reproductive structures will now be more visible. Locate the two **kidneys** and **urinary bladder.** Trace the two **ureters,** which extend from the kidneys to the bladder. Examine the front of the kidneys and locate the **adrenal glands,** which are important components of the endocrine gland system.
8. **Female.** If your specimen is a female, compare it with Figure 1.21. Locate the two **ovaries,** which lie lateral to the kidneys. From each ovary, a **uterine tube** leads back to join the **uterus.** Note that the uterus is a Y-shaped structure joined to the **vagina.** If your specimen appears to be pregnant, open up the uterus and examine the developing embryos. Note how they are attached to the uterine wall.
9. **Male.** If your specimen is a male, compare it with Figure 1.22. The **urethra** is located in the **penis.** Apply pressure to one of the

Figure 1.21 Abdominopelvic cavity of a female rat with intestines and liver removed.

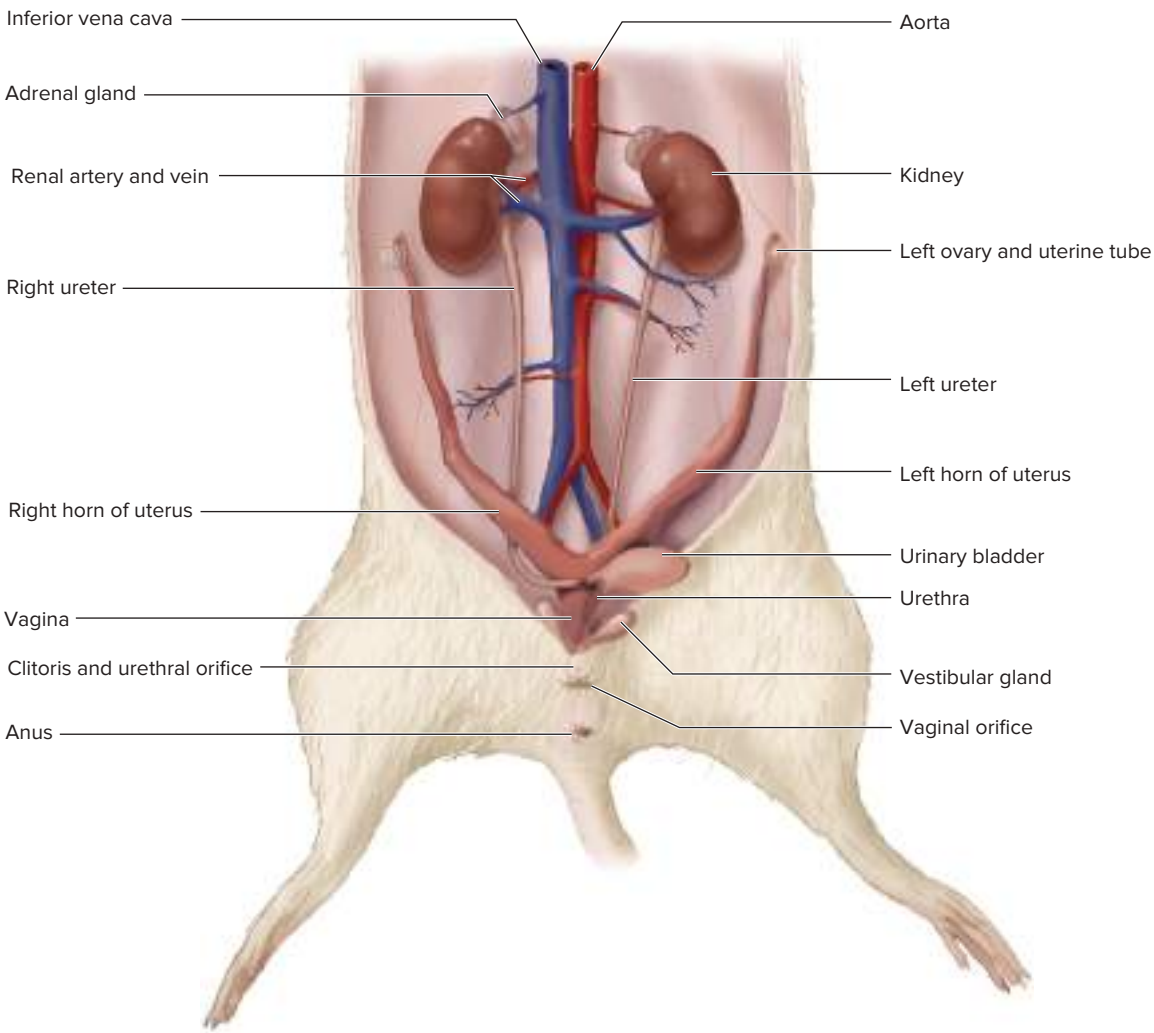
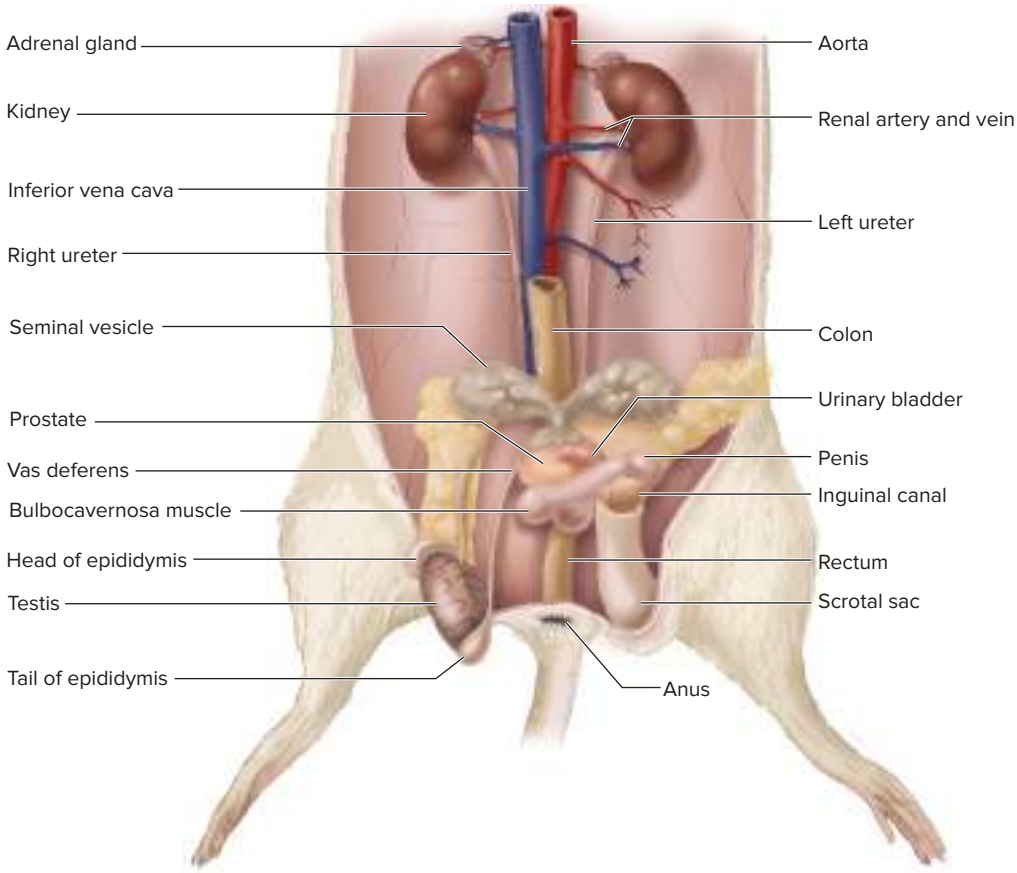


Figure 1.22 Abdominopelvic cavity of a male rat with intestines and liver removed.



testes through the wall of the **scrotum** to see if it can be forced up into the **inguinal canal.** Carefully dissect out a testis, **epididymis,** and **vas deferens** from one side of the scrotum and, if possible, trace the vas deferens over the urinary bladder to where it penetrates the **prostate** to join the urethra.

Conclusion

In this brief dissection, you have become acquainted with the cardiovascular, respiratory, urinary, digestive, and reproductive systems. Portions of the endocrine system have also been observed. If you have done a careful and thoughtful rat dissection, you should have a good general understanding of the basic structural organization of the human body. Much that we see in rat anatomy has its human counterpart.

Cleanup Dispose of the specimen as directed by your instructor. Scrub your instruments with soap and water; rinse and dry them. Wash your hands with soap, rinse, and dry thoroughly.

Exercise 2

MICROSCOPES

Objectives

After completing this exercise, you should be able to

1. Identify the parts of a compound microscope and describe the function of each.
2. Describe and demonstrate the correct way to (a) carry a microscope, (b) clean the lenses, (c) focus with each objective, and (d) calculate the total magnification.
3. Practice microscopic techniques by viewing select prepared slides and making a wet-mount of your own cheek cells.

Materials

- Biohazard container
- Compound microscope
- Microscope slides and cover glasses
- Medicine droppers, toothpicks
- Methylene blue, 0.01%, in dropping bottles
- Prepared slides of
  - letter *e*
  - colored threads
  - human sperm
  - human blood

The effective use of a **compound microscope** is essential for the study of cells and tissues. The term *compound* indicates that multiple lenses are used to view specimens. This exercise will introduce you to the parts, care, and use of a compound microscope.

Parts of the Microscope

Figure 2.1 shows the major parts of a compound microscope. Refer to it as you study this section. Your microscope may be somewhat different from the one illustrated, but you will be able to relate the illustration and the discussion to your microscope without difficulty.

The **base** is the bottom portion of the microscope. It contains the **lamp** and the on/off switch. Ideally, the lamp should have a **light control** to vary the intensity of light. The microscope shown in Figure 2.1 has a rotatable wheel on the right side of the arm to regulate light intensity. The lowest amount of light that provides a good image should be used to extend the life of the lamp.

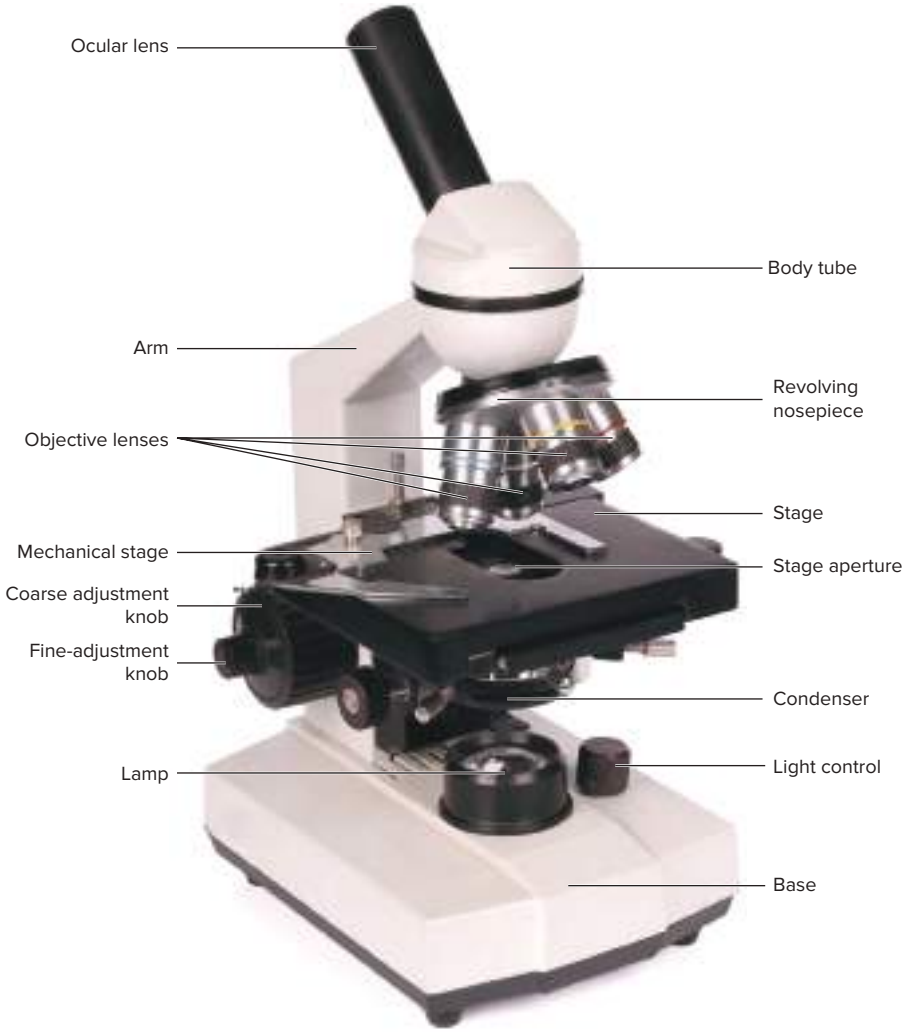
The **arm** rises from the base and supports the rest of the microscope. It serves as a convenient "handle" when carrying a microscope. The **body tube** has an **ocular lens** at the upper end and a **revolving nosepiece,** to which the **objective lenses** are attached, at the lower end. The nosepiece may be rotated to move an objective into viewing position.

The microscope in Figure 2.1 is monocular; however, many microscopes are binocular. The head is rotatable so that the viewing position can be changed. The magnification of the ocular is usually 10×. Student microscopes usually have three objectives attached to the revolving nosepiece. The shortest objective is the **scanning objective,** which has a magnification of 4×. It is used to scan the slide and locate the area of interest for viewing with more powerful objectives. The intermediate-length objective is the **low-power objective,** which has a magnification of 10×. The longest objective is the **high-dry objective,** which typically has a magnification of 40×. Some student microscopes have a fourth objective that is slightly longer than the high-dry objective as shown in Figure 2.1. This is the **oil immersion objective,** and it has a magnification of 100×. You probably will not use the oil immersion objective in this course. The magnifications of the oil immersion and high-dry objectives may vary slightly in different models of microscopes.

The **stage** is the platform on which a microscope slide is placed for viewing. The opening in the center of the stage is the **stage aperture.** The **mechanical stage** is the device on the stage surface that holds the slide and enables precise movement of the slide. It is operated by the **mechanical stage control knobs.**

Below the stage is the **condenser,** which concentrates the light on the microscope slide. It may be raised or lowered by the **condenser control**

Figure 2.1 A compound light microscope. Kovalchuk Oleksandr/Shutterstock



knob located under the stage. Usually, it should be raised to its highest position.

An **iris diaphragm** within the condenser regulates the amount of light that reaches the slide. On the microscope shown in Figure 2.1, the diaphragm is adjusted by turning a ring. Some microscopes have a diaphragm control lever.

Two focusing knobs are used to bring an object into clear focus. The **coarse-adjustment knob** has a larger diameter and is used to bring objects into rough focus. The **fine-adjustment knob** has a smaller diameter and is used to bring objects that are in rough focus into sharp focus.

Magnification

The microscope lens system magnifies specimens so that very small structures can be distinguished. The **total magnification** is determined by the power of the ocular and objective being used. It is calculated by multiplying the power of the ocular by the power of the objective. For example, a 10× ocular and a 40× high-dry objective yield a total magnification of 400×.

Resolution

Magnification without resolution is of little value. **Resolution** is the ability to distinguish tiny adjacent objects as two distinct objects. **Resolving power** is a function of the wavelength of light and the design of the microscope lenses. The shortest wavelengths (blue) of visible light provide maximum resolution. This is why microscopes have a blue light filter over the lamp. Use of the oil immersion objective is required for maximum resolution, and on the best light microscopes, it will enable the distinction of microscopic objects that are 0.2 µm apart. If they are closer together, they will be seen as one object because of a fusion of the images.

Focusing

A microscope is focused by changing the distance between the object on the microscope slide and the objective lens. This change is accomplished by using the coarse- and fine-adjustment knobs. The adjustment knobs raise and lower either the stage *or* the body tube depending on the type of microscope. Both types of focusing procedures are described below. Determine which method is to be used for your microscope.

As a general rule, you should always start focusing with the lowest-power objective (4× or 10×, depending on the microscope). The coarse-adjustment knob is used *only* with the low-power objective. With the high-dry and oil immersion objectives, use *only* the fine-adjustment knob.

Focusing with a Movable Stage

1. Place the scanning (4×) objective into viewing position by rotating the nosepiece.
2. While looking from the side (not through the ocular), raise the stage with the coarse-adjustment knob until either it stops or the slide is about 3 mm from the objective.
3. While looking through the ocular, slowly lower the stage with the coarse-adjustment knob until the object comes into view.
4. Use the fine-adjustment knob to bring the object into sharp focus.

Focusing with a Movable Body Tube

1. Place the scanning objective in viewing position by rotating the nosepiece.
2. While looking from the side (not through the ocular), lower the body tube with the coarse-adjustment knob until either it stops or the slide is about 3 mm from the objective.
3. While looking through the ocular, slowly raise the body tube with the coarse-adjustment knob until the object comes into view.
4. Use the fine-adjustment knob to bring the object into sharp focus.

Switching Objectives

Modern microscopes are usually **parcentric** and **parfocal.** This means that when an object is centered in the field and in sharp focus with one objective, it will be centered and in focus when another objective is rotated into the viewing position. However, it may be necessary to make slight adjustments to re-center the object with the mechanical stage or bring it into sharper focus with the fine-adjustment knob.

Start your observations with the scanning objective, even though you may want to observe the object with the high-dry or oil immersion objective. Once the object is centered and in focus with the scanning objective, it is easy to switch to the low-power and then high-dry objective simply by rotating the nosepiece. Note that the **working distance,** the distance between the objective and the slide, decreases as the power of the objective increases.

The amount of light entering the objective decreases as the power of the objective increases. Thus, you will need to increase the light intensity or open the diaphragm a bit to provide a light intensity that yields the sharpest image with the high-dry objective.

The easiest and safest way to bring the oil immersion objective into position is to progress from low-power to high-dry to oil immersion. Before rotating the oil immersion objective into the viewing position, place a drop of immersion oil on the slide. Also, open the diaphragm to its maximum aperture to increase the amount of light. A *slight turn of the fine-adjustment knob* is all that will be required to bring the object into focus.

Care of the Microscope

You will be responsible for the care of laboratory microscopes. Report any problems or malfunctions to your instructor immediately.

Transport and Placement

Care must be used in transporting the microscope from the storage cabinet to your workstation. Figure 2.2 shows the correct way to carry a microscope. Note that it is carried in front of you, with one hand supporting the base while the other grasps the arm. *Never* carry it with one hand at your side because a microscope in this position is apt to collide with furniture in the lab.

Most modern microscopes have an inclined body tube and a rotatable head that is secured by a set screw. The position can be changed so that either the microscope arm or the mechanical stage is facing the student. In the latter position, the stage is more easily accessible. Care must be taken when changing the position of the microscope. Use the position recommended by your instructor.

Lens Care

Develop the habit of cleaning the lenses with **lens paper** before using the microscope. *Use only lens paper for cleaning the lenses.* If liquid gets on the objectives or stage of the microscope, wipe it off immediately with lens paper. If simply wiping the lenses with lens paper doesn't get them clean,

Figure 2.2 The microscope should be held firmly with both hands while being carried.

it may be necessary to inform your instructor so they may have the microscope properly serviced. *Never try to disassemble any part of the microscope.*

The best way to determine if the ocular is clean is to rotate it between your thumb and forefinger while looking through the microscope. A rotating pattern is evidence of a dirty lens. If cleaning the top lens fails to remove the debris, *inform your instructor. If the ocular is removed to clean the lower lens, it is imperative that a piece of lens paper be placed over the open end of the body tube as shown in Figure 2.3.*

An image that appears cloudy or blurred indicates a dirty objective. If cleaning with lens paper moistened with water fails to clear the image, *consult your instructor* about getting the microscope professionally serviced.

Routinely wipe off the upper surface of the condenser lens with lens paper to remove any accumulated dust.

Cleanup and Storage

When you have finished using the microscope, complete the following steps before returning it to the cabinet.

1. Remove the slide from the stage.
2. Clean the ocular, objective lenses, and the stage.

Figure 2.3 When oculars are removed for cleaning, cover the ocular opening with lens tissue. A blast from an air syringe or gas canister removes dust and lint.

3. Rotate the nosepiece to place the lowest-power objective in the viewing position.
4. Depending on the type of microscope, lower the body tube to its lowest position *or* raise the stage to its highest position.
5. Raise the condenser to its highest position.
6. Adjust the mechanical stage so that it projects minimally from each side of the stage.
7. Place the dustcover over the microscope.

Assignment

Complete Sections A through C of the laboratory report.

Using the Microscope

Obtain the microscope and carry it to your station in the manner just described. Locate on your microscope the parts labeled in Figure 2.1. Manipulate the control knobs and levers to see how they operate. Set up your microscope for viewing as directed by your instructor.

Plug in the cord, turn on the lamp, and look through the ocular. The circle of light that you see is called the **field of view** or just the **field.** If your microscope is binocular, adjust the oculars to match the distance between your eyes.

Clean the lenses with lens paper. Raise the condenser to its highest position. Once you feel comfortable with the microscope controls, proceed with the assignment below.