CAT VERSION

THIRTEENTH EDITION

Human Anatomy & Physiology Laboratory Manual

Elaine N. Marieb
Lori A. Smith

Anatomy and Physiology Laboratory Safety Guidelines*

1. Upon entering the laboratory, locate exits, fire extinguisher, fire blanket, chemical shower, eyewash station, first aid kit, containers for broken glass, and materials for cleaning up spills.
2. Do not eat, drink, smoke, handle contact lenses, store food, or apply cosmetics or lip balm in the laboratory. Restrain long hair, loose clothing, and dangling jewelry.
3. Students who are pregnant, are taking immunosuppressive drugs, or have any other medical conditions (e.g., diabetes, immunological defect) that might necessitate special precautions in the laboratory must inform the instructor immediately.
4. Wearing contact lenses in the laboratory is inadvisable because they do not provide eye protection and may trap material on the surface of the eye. Soft contact lenses may absorb volatile chemicals. If possible, wear regular eyeglasses instead.
5. Use safety glasses in all experiments involving liquids, aerosols, vapors, and gases.
6. Decontaminate work surfaces at the beginning and end of every lab period, using a commercially prepared disinfectant or 10% bleach solution. After labs involving dissection of preserved material, use hot soapy water or disinfectant.
7. Keep all liquids away from the edge of the lab bench to avoid spills. Clean up spills of viable materials using disinfectant or 10% bleach solution.
8. Properly label glassware and slides.
9. Use mechanical pipetting devices; mouth pipetting is prohibited.
10. Wear disposable gloves when handling blood and other body fluids, mucous membranes, and nonintact skin, and when touching items or surfaces soiled with blood or other body fluids. Change gloves between procedures. Wash hands immediately after removing gloves. (**Note:** Cover open cuts or scrapes with a sterile bandage before donning gloves.)
11. Place glassware and plasticware contaminated by blood and other body fluids in a disposable autoclave bag for decontamination by autoclaving, or place them directly into a 10% bleach solution before reuse or disposal. Place disposable materials such as gloves, mouthpieces, swabs, and toothpicks that have come into contact with body fluids into a disposable autoclave bag, and decontaminate before disposal.
12. To help prevent contamination by needlestick injuries, use only disposable needles and lancets. Do not bend the needles and lancets. Needles and lancets should be placed promptly in a labeled, puncture-resistant, leakproof container and decontaminated, preferably by autoclaving.
13. Do not leave heat sources unattended.
14. Report all spills or accidents, no matter how minor, to the instructor.
15. Never work alone in the laboratory.
16. Remove protective clothing before leaving the laboratory.

---

*Adapted from:

Biosafety in Microbiological and Biomedical Laboratories (BMBL), Fifth Edition. 2007. U.S. Government Printing Office. Washington, D.C. www.cdc.gov/od/OHS/biosfty/bmbl5/bmbl5toc.htm

Centers for Disease Control. 1996. "Universal Precautions for Prevention of Transmission of HIV and Other Bloodborne Infections." Washington, D.C. www.cdc.gov/ncidod/dhqp/bp_universal_precautions.html

Johnson, Ted, and Christine Case. 2010. *Laboratory Experiments in Microbiology,* Ninth Edition. San Francisco: Pearson Benjamin Cummings.

School Chemistry Laboratory Safety Guide. 2006. U.S. Consumer Product Safety Commission. Bethesda, MD. www.cpsc.gov/CPSCPUB/PUBS/NIOSH2007107.pdf

This page intentionally left blank

Your time is valuable. Make the most of your time *inside and outside* the lab.

To help you manage your time inside and outside the A&P lab classroom, this best-selling manual works hand-in-hand with **Mastering A&P**, the leading online homework and learning program for A&P. This edition features dozens of new, full-color figures and photos, revamped Clinical Application questions, an expanded set of pre-lab videos, dissection videos, and more.

EXERCISE 9

The Axial Skeleton

Learning Outcomes

- Name the three parts of the axial skeleton.
- Identify the bones of the axial skeleton, either by examining disarticulated bones or by pointing them out on an articulated skeleton or skull, and name the important bone markings on each.
- Name and describe the different types of vertebrae.
- Discuss the importance of intervertebral discs and spinal curvatures.
- Identify three abnormal spinal curvatures.
- List the components of the thoracic cage.
- Identify the bones of the fetal skull by examining an articulated skull or image.
- Define *fontanelle*, and discuss the function and fate of fontanelles.
- Discuss important differences between the fetal and adult skulls.

Pre-Lab Quiz

Instructors may assign these and other Pre-Lab Quiz questions using Mastering A&P™

1. The axial skeleton can be divided into the skull, the vertebral column, and the:
   a. thoracic cage **c.** hip bones
   b. femur **d.** humerus
2. Eight bones make up the _____, which encloses and protects the brain.
   a. cranium **b.** face **c.** skull
3. The _____ vertebrae articulate with the corresponding ribs.
   a. cervical **c.** spinal
   b. lumbar **d.** thoracic
4. The _____, commonly referred to as the breastbone, is a flat bone formed by the fusion of three bones: the manubrium, the body, and the xiphoid process.
   a. coccyx **b.** sacrum **c.** sternum
5. A fontanelle:
   a. is found only in the fetal skull
   b. is a fibrous membrane
   c. allows for compression of the skull during birth
   d. all of the above

The **axial skeleton** (the green portion of Figure 8.1 on p. 104) can be divided into three parts: the skull, the vertebral column, and the thoracic cage. This division of the skeleton forms the longitudinal axis of the body and protects the brain, spinal cord, heart, and lungs.

Go to Mastering A&P™ > Study Area to improve your performance in A&P Lab.

> Lab Tools > Bone & Dissection Videos

Instructors may assign new Building Vocabulary coaching activities, Pre-Lab Quiz questions, Art Labeling activities, related bone videos and coaching activities, Practice Anatomy Lab Practical questions (PAL), and more using the Mastering A&P™ Item Library.

Materials

- Intact skull and Beauchene skull
- X-ray images of individuals with scoliosis, lordosis, and kyphosis (if available)
- Articulated skeleton, articulated vertebral column, removable intervertebral discs
- Isolated cervical, thoracic, and lumbar vertebrae, sacrum, and coccyx
- Isolated fetal skull

115

See p. 115

NEW! Mastering A&P study tools are highlighted on the first page of each lab exercise, along with a photo preview of a related pre-lab video, image from Practice Anatomy Lab 3.1 (PAL), or animation.

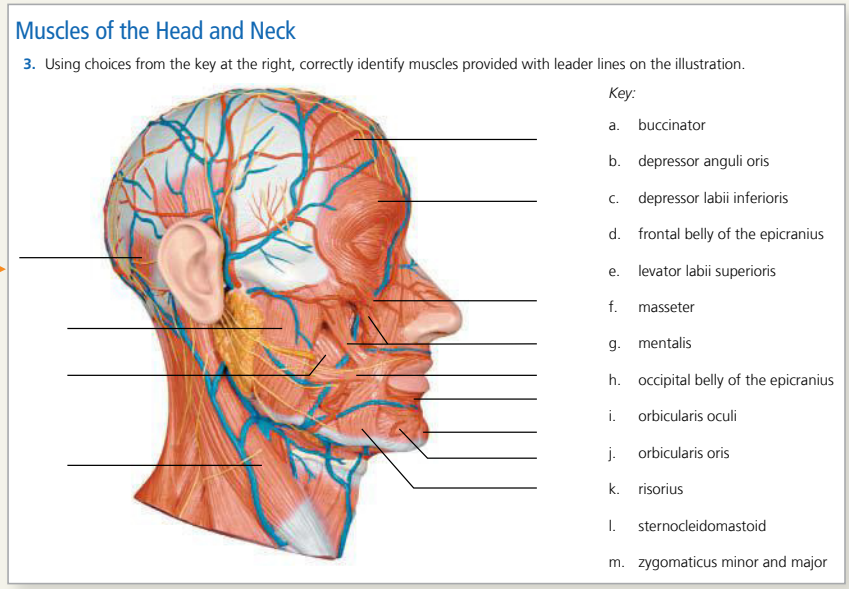
NEW! Mastering A&P assignments, including NEW Building Vocabulary Coaching Activities, are signaled at appropriate points throughout the manual to help you connect the exercises to relevant assignments that can be auto-graded in Mastering A&P.

Be Prepared: Learning in A&P Lab is an *Active* Process.

Before going into the lab, read the **background information** for the exercise, connect your reading to the figures and photos, complete the **pre-lab quiz**, and preview the questions in the tear-out **Exercise Review Sheet**. After lab, review your lab notes to remember important concepts. To improve your performance on lab practical exams, log into **Mastering A&P**, where you can watch related videos, practice with customized flashcards, and more.

NEW! Dozens of full-color figures and photos have been added to the Exercise Review Sheets, replacing black-and-white line drawings. Selected labeling questions are available as **new Art-Labeling assignments in Mastering A&P**.

See p. 224



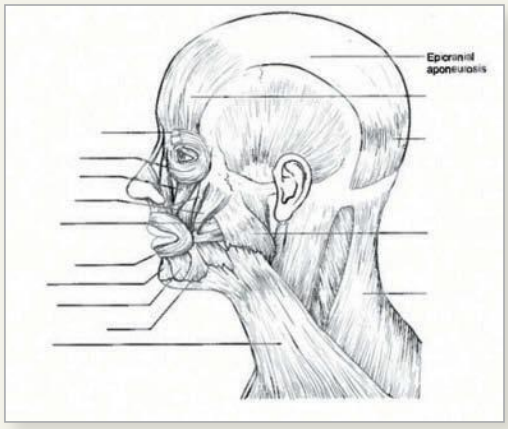
Muscles of the Head and Neck

3. Using choices from the key at the right, correctly identify muscles provided with leader lines on the illustration.

Key:

a. buccinator
b. depressor anguli oris
c. depressor labii inferioris
d. frontal belly of the epicranius
e. levator labii superioris
f. masseter
g. mentalis
h. occipital belly of the epicranius
i. orbicularis oculi
j. orbicularis oris
k. risorius
l. sternocleidomastoid
m. zygomaticus minor and major

Compare to Previous Edition



NEW! Clinical Application Questions have been added to the Exercise Review Sheets to help you connect lab concepts with real-world clinical scenarios.

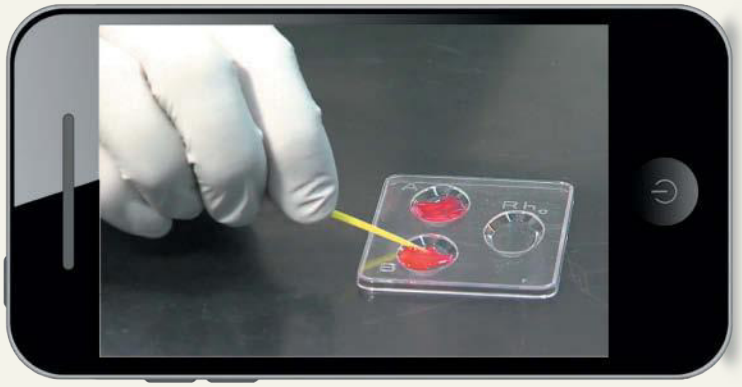
27. As we age, we often become shorter. Explain why this might occur.

See p. 141

NEW! Building Vocabulary Coaching Activities are a fun way to learn word roots and A&P terminology while building and practicing important language skills.

Get 24/7 videos, coaching, and practice with Mastering A&P.

EXPANDED! 8 new Pre-Lab Video Coaching Activities in Mastering A&P (for a total of 18) focus on key concepts in the lab activity and walk you through important procedures. New pre-lab video topics include Preparing and Observing a Wet Mount, Examining a Long Bone, Initiating Pupillary Reflexes, Palpating Superficial Pulse Points, Auscultating Heart Sounds, and more.



NEW! Cat and Fetal Pig Dissection Video Coaching Activities help you prepare for dissection by previewing key anatomical structures. Each video includes one to two comparisons to human structures.

NEW! Customizable Practice Anatomy Lab (PAL) Flashcards allow you to create a personalized, mobile-friendly deck of flashcards and quizzes using images from PAL 3.1. You can generate flashcards using only the structures that your instructor has emphasized in lecture or lab.

IMPROVED! The Pearson eText mobile app allows you to access the complete lab manual online or offline, along with all of the videos described above.

Additional Support for Students & Instructors

Mastering A&P offers thousands of tutorials, activities, and questions that can be assigned for homework and practice. Highlights of popular assignment options include the following:

PhysioEx™ 9.1 is an easy-to-use lab simulation program that consists of 12 exercises containing 63 physiology lab activities that can be used to supplement or substitute for wet labs.

IMPROVED! Practice Anatomy Lab 3.1 is now accessible on all mobile devices to give students 24/7 access to the most widely used lab specimens, including human cadaver, anatomical models, histology slides, cat, and fetal pig.

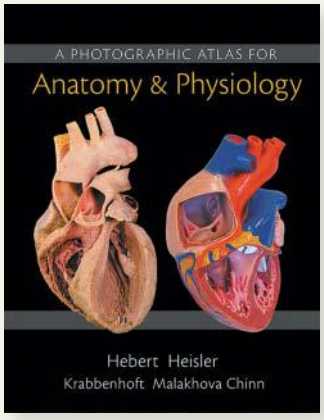
Dynamic Study Modules are manageable, mobile-friendly sets of questions with extensive feedback for students to test, learn, and retest until they master basic concepts.

- **NEW!** Instructors can select or deselect specific questions to customize assignments.
- **EXPANDED!** The Lab Manual Mastering A&P course now offers over 3,000 Dynamic Study Module questions, shared with the Marieb/Hoehn texbook ***Human Anatomy & Physiology*** **11th Edition**.

The Mastering A&P Instructor Resources Area includes the following downloadable tools:

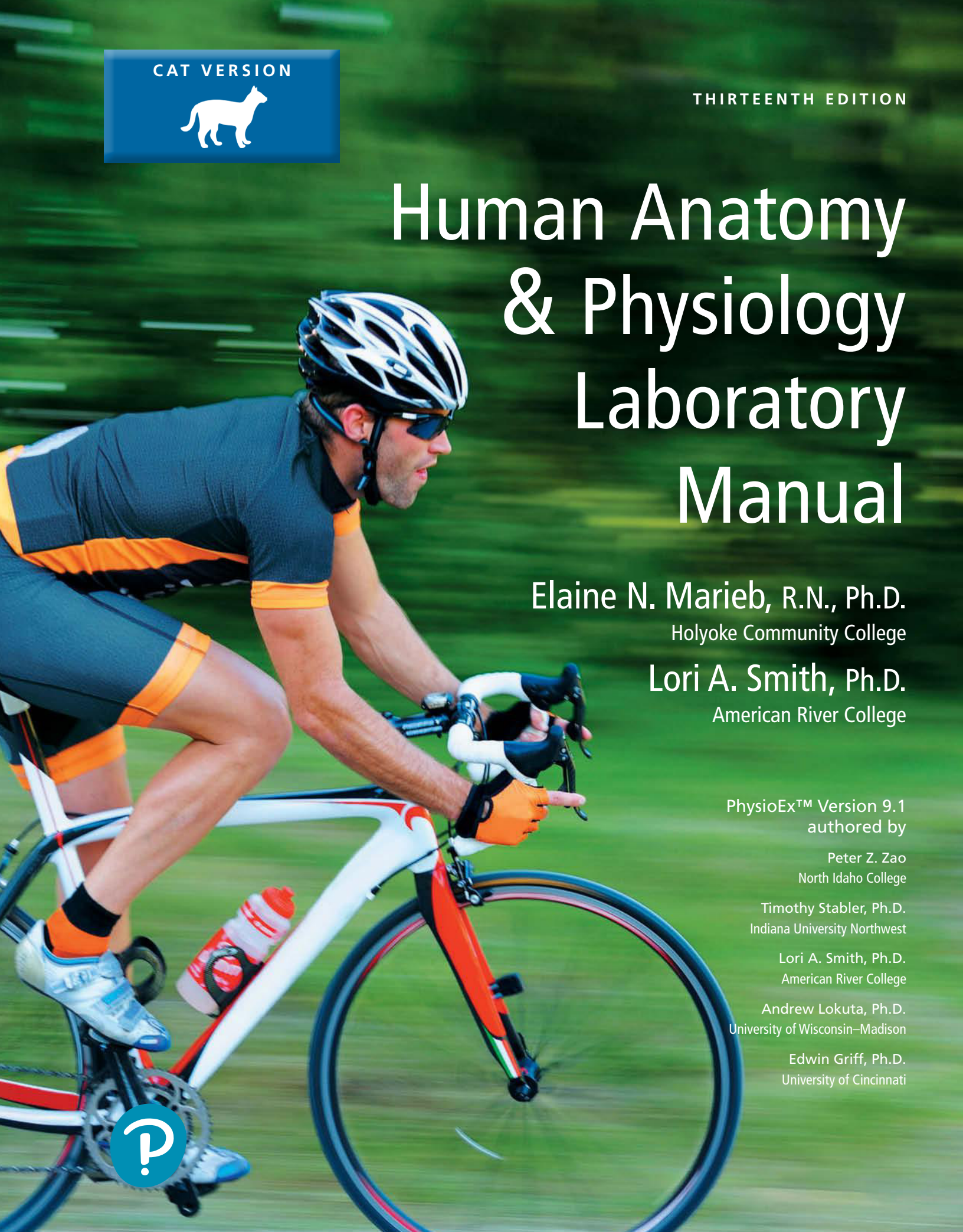
- **Customizable PowerPoint® lecture outlines** include customizable images and provide a springboard for lab prep.
- **All of the figures, photos, and tables from the manual** are available in JPEG and PowerPoint® formats, in labeled and unlabeled versions, and with customizable labels and leader lines.
- **Test bank** provides thousands of customizable questions across Bloom's taxonomy levels and includes all lab practical and quiz questions from Practice Anatomy Lab 3.1. Each question is tagged to chapter learning outcomes that can also be tracked within Mastering A&P assessments. Available in Microsoft® Word and TestGen® formats.
- **Animations and videos** bring A&P concepts to life and include pre-lab videos, bone videos, and dissection videos.
- **A comprehensive Instructor's Guide**, co-authored by Elaine Marieb and Lori Smith, includes prep instructions for each exercise, along with answer keys for all of the Exercise Review Sheets.

A Photographic Atlas for Anatomy & Physiology
By Nora Hebert, Ruth E. Heisler, et al.
ISBN 9780321869258



Instructor Resource DVD with PowerPoint Lecture Outlines
ISBN 9780134777092

Instructor's Guide for Human Anatomy & Physiology Lab Manual 13/e
ISBN 9780134778839



THIRTEENTH EDITION

Human Anatomy & Physiology Laboratory Manual

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

Lori A. Smith, Ph.D.
American River College

PhysioEx™ Version 9.1
authored by

Peter Z. Zao
North Idaho College

Timothy Stabler, Ph.D.
Indiana University Northwest

Lori A. Smith, Ph.D.
American River College

Andrew Lokuta, Ph.D.
University of Wisconsin–Madison

Edwin Griff, Ph.D.
University of Cincinnati

Editor-in-Chief: Serina Beauparlant
Senior Courseware Portfolio Manager: Lauren Harp
Managing Producer: Nancy Tabor
Content & Design Manager: Michele Mangelli, Mangelli Productions, LLC
Courseware Editorial Assistant: Dapinder Dosanjh
Rich Media Content Producer: Kimberly Twardochleb
Mastering Content Developer: Cheryl Chi
Production Supervisor: Janet Vail
Copyeditor: Sally Peyrefitte
Proofreader: Betsy Dietrich
Compositor: iEnergizer Aptara®, Ltd.
Art Coordinator: David Novak
Interior & Cover Designer: Hespenheide Design
Illustrator: Imagineering STA Media Services, Inc.
Rights & Permissions Management: Ben Ferrini
Rights & Permissions Project Manager: Cenveo © Publishing Services, Matt Perry
Photo Researcher: Kristin Piljay
Manufacturing Buyer: Stacey Weinberger
Director of Product Marketing: Allison Rona
Senior Anatomy & Physiology Specialist: Derek Perrigo

Cover Photo Credit: technotr/Getty Images

Acknowledgments of third-party content appear on page C-1, which constitutes an extension of this copyright page.

1 17

www.pearson.com

ISBN 10: 0-13-463233-8 (Student edition)
ISBN 13: 978-0-13-463233-9 (Student edition)
ISBN 10: 0-13-477708-5 (Instructor's Review Copy)
ISBN 13: 978-0-13-477708-5 (Instructor's Review Copy)

About the Authors

Elaine N. Marieb

After receiving her Ph.D. in zoology from the University of Massachusetts at Amherst, Elaine N. Marieb joined the faculty of the Biological Science Division of Holyoke Community College. While teaching at Holyoke Community College, where many of her students were pursuing nursing degrees, she developed a desire to better understand the relationship between the scientific study of the human body and the clinical aspects of the nursing practice. To that end, while continuing to teach full time, Dr. Marieb pursued her nursing education, which culminated in a Master of Science degree with a clinical specialization in gerontology from the University of Massachusetts. It is this experience that has informed the development of the unique perspective and accessibility for which her publications are known.

Dr. Marieb has given generously to provide opportunities for students to further their education. She funds the E. N. Marieb Science Research Awards at Mount Holyoke College, which promotes research by undergraduate science majors, and has underwritten renovation of the biology labs in Clapp Laboratory at that college. Dr. Marieb also contributes to the University of Massachusetts at Amherst, where she provided funding for reconstruction and instrumentation of a cutting-edge cytology research laboratory. Recognizing the severe national shortage of nursing faculty, she underwrites the Nursing Scholars of the Future Grant Program at the university.

In 2012 and 2017, Dr. Marieb gave generous philanthropic support to Florida Gulf Coast University as a long-term investment in education, research, and training for healthcare and human services professionals in the local community. In honor of her contributions, the university is now home to the Elaine Nicpon Marieb College of Health and Human Services.

Lori A. Smith

Lori A. Smith received her Ph.D. in biochemistry from the University of California at Davis. Before discovering her passion for teaching, she worked as a research scientist and project leader in the medical diagnostics industry. In 1999, she joined the faculty at American River College in the Biology Department, where she teaches anatomy and physiology and microbiology to students preparing for nursing or other allied health careers. Since 2005, she has coauthored Pearson's PhysioEx™: Laboratory Simulations in Physiology and has continued to coauthor several Pearson lab manuals. Dr. Smith has been named Instructor of the Year by the American River College Associated Student Body, and she is a member of the Human Anatomy and Physiology Society (HAPS) and California Academy of Sciences. When not teaching or writing, she enjoys spending time with her family: hiking, cycling, and kayaking.

Preface to the Instructor

The philosophy behind the revision of this manual mirrors that of all earlier editions. It reflects a still developing sensibility for the way teachers teach and students learn, informed by years of teaching the subject and by collecting suggestions from other instructors as well as from students enrolled in multifaceted healthcare programs. *Human Anatomy & Physiology Laboratory Manual* was originally developed to facilitate and enrich the laboratory experience for both teachers and students. This edition retains those same goals.

This manual, intended for students in introductory human anatomy and physiology courses, presents a wide range of laboratory experiences for students concentrating in nursing, physical therapy, pharmacology, respiratory therapy, and exercise science, as well as biology and premedical programs. The manual's coverage is intentionally broad, allowing it to serve both one- and two-semester courses, and it is available in versions that contain detailed guidelines for dissecting a cat or fetal pig laboratory specimen.

Basic Approach and Features

The generous variety of experiments in this manual provides flexibility that enables instructors to gear their laboratory approach to specific academic programs or to their own teaching preferences. The manual remains independent of any textbook, so it contains the background discussions and terminology necessary to perform all experiments. Such a self-contained learning aid eliminates the need for students to bring a textbook into the laboratory.

Each of the 46 exercises leads 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 together provide the necessary tools for studying the various body systems. The exercises that follow reflect the dual focus of the manual—both anatomical and physiological aspects receive considerable attention. As the various organ systems of the body are introduced, the initial exercises focus on organization, from the cellular to the organ system level. As indicated by the table of contents, the anatomical exercises are usually followed by physiological experiments that familiarize students with various aspects of body functioning and promote the critical understanding that function follows structure. The numerous physiological experiments for each organ system range from simple experiments that can be performed without specialized tools to more complex experiments using laboratory equipment, computers, and instrumentation techniques.

Features

The dissection scissors icon appears at the beginning of activities that entail the dissection of isolated animal organs. In addition to the figures, isolated animal organs, such as the sheep heart and pig kidney, are employed to study anatomy because of their exceptional similarity to human organs.

Homeostasis is continually emphasized as a requirement for optimal health. Pathological conditions are viewed as a loss of homeostasis; these discussions can be recognized by the homeostatic imbalance logo within the descriptive material of each exercise. This holistic approach encourages an integrated understanding of the human body. The homeostatic imbalance icon directs the student's attention to conditions representing a loss of homeostasis.

A safety icon notifies students that specific safety precautions must be observed when using certain equipment or conducting particular lab procedures. For example, when working with ether, students are to use a hood; and when handling body fluids such as blood, urine, or saliva, students are to wear gloves. All exercises involving body fluids (blood, urine, saliva) incorporate current Centers for Disease Control and Prevention (CDC) guidelines for handling human body fluids. Because it is important that nursing students in particular learn how to safely handle bloodstained articles, the manual has retained the option to use human blood in the laboratory. However, the decision to allow testing of human (student) blood or to use animal blood in the laboratory is left to the discretion of the instructor in accordance with institutional guidelines. The CDC guidelines for handling body fluids are reinforced by the laboratory safety procedures described on the inside front cover of this text, in Exercise 29: Blood, and in the *Instructor's Guide*. You can photocopy the inside front cover and post it in the lab to help students become well versed in laboratory safety.

Group Challenge activities are designed to enhance collaborative group learning and to challenge students to think critically, identify relationships between anatomical structures and physiological functions, and achieve a deeper understanding of anatomy and physiology concepts.

The BIOPAC® icon in a relevant exercise materials list signals the use of the BIOPAC® Student Lab System and alerts you to the equipment needed. BIOPAC® is used in Exercises 14, 18, 20, 21, 31, 33, 34, and 37. The instructions in the lab manual are for use with the BIOPAC® MP36/35 and MP45 data acquisition unit. Note that some exercises are not compatible with the MP45 data acquisition unit. For those exercises, the MP45 will not be listed in the Materials section. In this edition, the lab manual instructions are for use with BSL software 4.0.1 and above for Windows 10/8.x/7 or Mac OS X10.9–10.12. Refer to the Materials section in each exercise for the applicable software version. The Instructor Resources area of Mastering A&P provides the following additional support for alternative data acquisitions systems, including exercises that can be distributed to students:

- *BIOPAC® Instructions for the MP36 (or MP35/30) data acquisition unit* using BSL software versions earlier than 4.0.1 (for Windows and Mac) for Exercises 14, 18, 20, 21, 31, and 34
- *Powerlab®* Instructions for Exercises 14, 21, 31, 33, 34, and 37
- *iWorx®* Instructions for Exercises 14, 18, 21, 31, 33, 34, and 37
- *Intelitool®* Instructions for Exercises 14i, 21i, 31i, and 37i

- **Exercise Review Sheets** follow each laboratory exercise and provide space for recording and interpreting experimental results and require students to label diagrams and answer matching and short-answer questions. Selected questions can be assigned and automatically graded in Mastering A&P.
- **PhysioEx™ 9.1 Exercises**, located in the back of the lab manual and accessible through a subscription to Mastering A&P, are easy-to-use computer simulations that supplement or take the place of traditional wet labs safely and cost-effectively. These 12 exercises contain a total of 63 physiology laboratory activities that allow learners to change variables and test out various hypotheses for the experiments. PhysioEx™ allows students to repeat labs as often as they like, perform experiments without harming live animals, and conduct experiments that are difficult to perform because of time, cost, or safety concerns.

Updated Content in This Edition of the Lab Manual

Throughout the manual, the narrative text has been streamlined and updated to make the language more understandable and to better meet the needs of today's students. Additional highlights include the following:

- **Dozens of new full-color figures and photos** replace black-and-white line drawings in the Exercise Review Sheets. Selected labeling questions in the manual can be assigned in Mastering A&P.
- **New Clinical Application questions** have been added to the Exercise Review Sheets and challenge students to apply lab concepts and critical-thinking skills to real-world clinical scenarios.
- **Updated BIOPAC® procedures** are included in the manual for eight lab exercises for the BIOPAC® 4.0 software upgrade. Procedures for Intelitool®, PowerLab®, and iWorx® remain available in the Instructor Resources area of Mastering A&P.
- **New Mastering A&P visual previews** appear on the first page of each lab exercise, highlighting a recommended pre-lab video, a related image from Practice Anatomy Lab 3.1 (PAL 3.1), or a helpful animation.
- **New Mastering A&P assignment recommendations** are signaled at appropriate points throughout the manual to help instructors assign related auto-graded activities and assessments.
- **Extensive updates and improvements** have been made to each of the 46 laboratory exercises in the manual to increase clarity and reduce ambiguity for students. Art within the exercises, the narrative, as well as the questions and figures within the Review Sheets have been updated. For a complete list of content updates, please refer to the *Instructor's Guide for Human Anatomy & Physiology Laboratory Manual* 13/e (ISBN 9780134778839 or in the Instructor Resources area of Mastering A&P).

Highlights of Updated Content in Mastering A&P

Mastering A&P, the leading online homework, tutorial, and assessment system is designed to engage students and improve results by helping them stay on track in the course and quickly master challenging anatomy and physiology concepts. Mastering A&P assignments support interactive features in the lab manual, including pre-lab video coaching activities; bone, muscle, and dissection videos; Dynamic Study Modules; *Get Ready for A&P*; plus a variety of Art Labeling questions, Clinical Application questions, and more. Highlights for this edition include the following:

- **8 new Pre-Lab Video Coaching Activities in Mastering A&P** (for a total of 18) focus on key concepts in the lab activity and walk students through important procedures. New pre-lab video titles include Preparing and Observing a Wet Mount, Examining a Long Bone, Initiating Pupillary Reflexes, Palpating Superficial Pulse Points, Auscultating Heart Sounds, and more.
- **New Cat and Fetal Pig Dissection Video Coaching Activities** help students prepare for dissection by previewing key anatomical structures. Each video includes one to two comparisons to human structures.
- **IMPROVED! Practice Anatomy Lab™ (PAL™ 3.1) is now fully accessible on all mobile devices**, including smartphones, tablets, and laptops. PAL is an indispensable virtual anatomy study and practice tool that gives students 24/7 access to the most widely used lab specimens, including human cadaver; anatomical models from leading manufacturers such as 3B Scientific, SOMSO, Denoyer-Geppert, Frey Scientific/Nystrom, Altay Scientific, and Ward's; histology; cat; and fetal pig. PAL 3.1 is easy to use and includes built-in audio pronunciations, rotatable bones, and simulated fill-in-the-blank lab practical exams.
- **New Customizable Practice Anatomy Lab (PAL) Flashcards** enable students to create a personalized, mobile-friendly deck of flashcards and quizzes using images from PAL 3.1. Students can generate flashcards using only the structures that their instructor emphasizes in lecture or lab.
- **New Building Vocabulary Coaching Activities** are a fun way for students to learn word roots and A&P terminology while building and practicing important language skills.
- **Expanded Dynamic Study Modules** help students study effectively on their own by continuously assessing their activity and performance in real time. Students complete a set of questions and indicate their level of confidence in their answer. Questions repeat until the student can answer them all correctly and confidently. These are available as graded assignments prior to class and are accessible on smartphones, tablets, and computers.
  - The Lab Manual Mastering A&P course now offers over 3000 Dynamic Study Module questions, shared with Marieb/Hoehn *Human Anatomy & Physiology*, 11th Edition.
  - Instructors can now remove questions from Dynamic Study Modules to better fit their course.
- **Expanded Drag-and-Drop Art Labeling Questions** allow students to assess their knowledge of terms and structures in the lab manual. Selected Exercise Review Sheet labeling activities in the manual are now assignable.

Please refer to the preceding pages for additional information about Mastering A&P and other resources for instructors and students.

Acknowledgments

Continued thanks to our colleagues and friends at Pearson who collaborated with us on this edition, especially Editor-in-Chief Serina Beauparlant, Acquisitions Editor Lauren Harp, Editorial Assistant Dapinder Dosanjh, and Rich Content Media Producers Kimberly Twardochleb and Lauren Chen. We also thank the Pearson Sales and Marketing team for their work in supporting instructors and students, especially Senior A&P Specialist Derek Perrigo and Director of Product Marketing Allison Rona.

Special thanks go out to Amanda Kaufmann for her leadership and expertise in producing the 18 pre-lab videos that support this edition, and to Mike Mullins of BIOPAC®, who helped us update the instructions for consistency with the upgraded software.

We're also grateful to Michele Mangelli and her superb production team, who continue to cross every hurdle with uncommon grace and skill, including Janet Vail, production coordinator; David Novak, art and photo coordinator; Kristin Piljay, photo researcher; Gary Hespenheide, interior and cover designer; and Sally Peyrefitte, copyeditor.

Last but not least, we wish to extend our sincere thanks to the many A&P students who have circulated through our lab classrooms and have used this lab manual over the years—you continue to inspire us every day! As always, we welcome your feedback and suggestions for future editions.

Elaine N. Marieb & Lori A. Smith

THIRTEENTH EDITION REVIEWERS

We wish to thank the following reviewers, who provided thoughtful feedback and helped us make informed decisions for this edition of both the lab manual and Mastering A&P resources:

Matthew Abbott, *Des Moines Area Community College*
Lynne Anderson, *Meridian Community College*
Penny Antley, *University of Louisiana, Lafayette*
Marianne Baricevic, *Raritan Valley Community College*
Christopher W. Brooks, *Central Piedmont Community College*
Jocelyn Cash, *Central Piedmont Community College*
Christopher D'Arcy, *Cayuga Community College*
Mary E. Dawson, *Kingsborough Community College*
Karen Eastman, *Chattanooga State Community College*
Jamal Fakhoury, *College of Central Florida*
Lisa Flick, *Monroe Community College*
Michele Finn, *Monroe Community College*
Juanita Forrester, *Chattahoochee Technical College*
Larry Frolich, *Miami Dade College*
Michelle Gaston, *Northern Virginia Community College, Alexandria*
Tejendra Gill, *University of Houston*
Abigail M. Goosie, *Walters State Community College*
Karen Gordon, *Rowan Cabarrus Community College*
Jennifer Hatchel, *College of Coastal Georgia*
Clare Hays, *Metropolitan State University*
Nathanael Heyman, *California Baptist University*
Samuel Hirt, *Auburn University*
Alexander Ibe, *Weatherford College*
Shahdi Jalilvand, *Tarrant County College–Southeast*
Marian Leal, *Sacred Heart University*
Geoffrey Lee, *Milwaukee Area Technical College*
Tara Leszczewiz, *College of Dupage*
Mary Katherine Lockwood, *University of New Hampshire*
Francisco J. Martinez, *Hunter College of CUNY*
Bruce Maring, *Daytona State College*
Geri Mayer, *Florida Atlantic University*
Tiffany B. McFalls-Smith, *Elizabethtown Community & Technical College*
Melinda A. Miller, *Pearl River Community College*
Todd Miller, *Hunter College of CUNY*
Susan Mitchell, *Onondaga Community College*
Erin Morrey, *Georgia Perimeter College*
Jill O'Malley, *Erie Community College*
Suzanne Oppenheimer, *College of Western Idaho*
Lori Paul, *University of Missouri - St. Louis*
Stacy Pugh-Towe, *Crowder College*
Suzanne Pundt, *The University of Texas at Tyler*
Jackie Reynolds, *Richland College*
Anthony Rizzo, *Polk State College*
Jo Rogers, *University of Cincinnati*
James Royston, *Pearl River Community College*
Connie E. Rye, *East Mississippi Community College*
Mark Schmidt, *Clark State Community College*
Jennifer Showalter, *Waubonsee Community College*
Teresa Stegall-Faulk, *Middle Tennessee State University*
Melissa Ann Storm, *University of South Carolina–Upstate*
Bonnie J. Tarricone, *Ivy Tech Community College*
Raymond Thompson, *University of South Carolina*
Anna Tiffany Tindall-McKee, *East Mississippi Community College*
Allen Tratt, *Cayuga Community College*
Khursheed Wankadiya, *Central Piedmont Community College*
Diane L. Wood, *Southeast Missouri State University*

Contents

A Pre-Lab video is available in Mastering A&P™ for selected activities.

THE SKELETAL SYSTEM

THE MUSCULAR SYSTEM

THE NERVOUS SYSTEM

Instructors may download two additional lab activities: Inhibiting the Nerve and Visualizing the Compound Action Potential with an Oscilloscope. Instructors, please go to Mastering A&P™ > Instructor Resources > Additional Resources > Additional Exercises

THE ENDOCRINE SYSTEM

THE CIRCULATORY SYSTEM

THE RESPIRATORY SYSTEM

THE DIGESTIVE SYSTEM

THE URINARY SYSTEM

THE REPRODUCTIVE SYSTEM, DEVELOPMENT, AND HEREDITY

EXERCISE 1

The Language of Anatomy

Learning Outcomes

- Describe the anatomical position, and explain its importance.
- Use proper anatomical terminology to describe body regions, orientation and direction, and body planes.
- Name the body cavities, and indicate the important organs in each.
- Name and describe the serous membranes of the ventral body cavities.
- Identify the abdominopelvic quadrants and regions on a torso model or image.

Pre-Lab Quiz

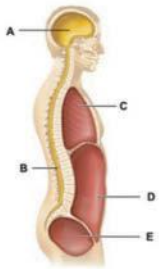
Instructors may assign these and other Pre-Lab Quiz questions using Mastering A&P™

1. Circle True or False. In anatomical position, the body is lying down.
2. Circle the correct underlined term. With regard to surface anatomy, abdominal / axial refers to the structures along the center line of the body.
3. The term *superficial* refers to a structure that is:
   a. attached near the trunk of the body
   b. toward or at the body surface
   c. toward the head
   d. toward the midline
4. The _____ plane runs longitudinally and divides the body into right and left sides.
   a. frontal
   b. sagittal
   c. transverse
   d. ventral
5. Circle the correct underlined terms. The dorsal body cavity can be divided into the cranial / thoracic cavity, which contains the brain, and the sural / vertebral cavity, which contains the spinal cord.

A student new to any science is often overwhelmed at first by the terminology used in that subject. The study of anatomy is no exception. But without specialized terminology, confusion is inevitable. For example, what do *over*, *on top of*, *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 precisely with a minimum of words.

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

Go to Mastering A&P™ > Study Area to improve your performance in A&P Lab.



Instructors may assign new Building Vocabulary coaching activities, Pre-Lab Quiz questions, Art Labeling activities, and more using the Mastering A&P™ Item Library.

Materials

- Human torso model (dissectible)
- Human skeleton
- Demonstration: sectioned and labeled kidneys (three separate kidneys uncut or cut so that [a] entire, [b] transverse sectional, and [c] longitudinal sectional views are visible)
- Gelatin-spaghetti molds
- Scalpel

Anatomical Position

When anatomists or doctors refer to specific areas of the human body, the picture they keep in mind is a universally accepted standard position called the **anatomical position**. In the anatomical position, the human body is erect, with the feet only slightly apart, head and toes pointed forward, and arms hanging at the sides with palms facing forward (Figure 1.1a). It is also important to remember that "left" and "right" refer to the sides of the individual, not the observer.

☐ Assume the anatomical position. The hands are held unnaturally forward rather than hanging with palms toward the thighs.

Check the box when you have completed this task.

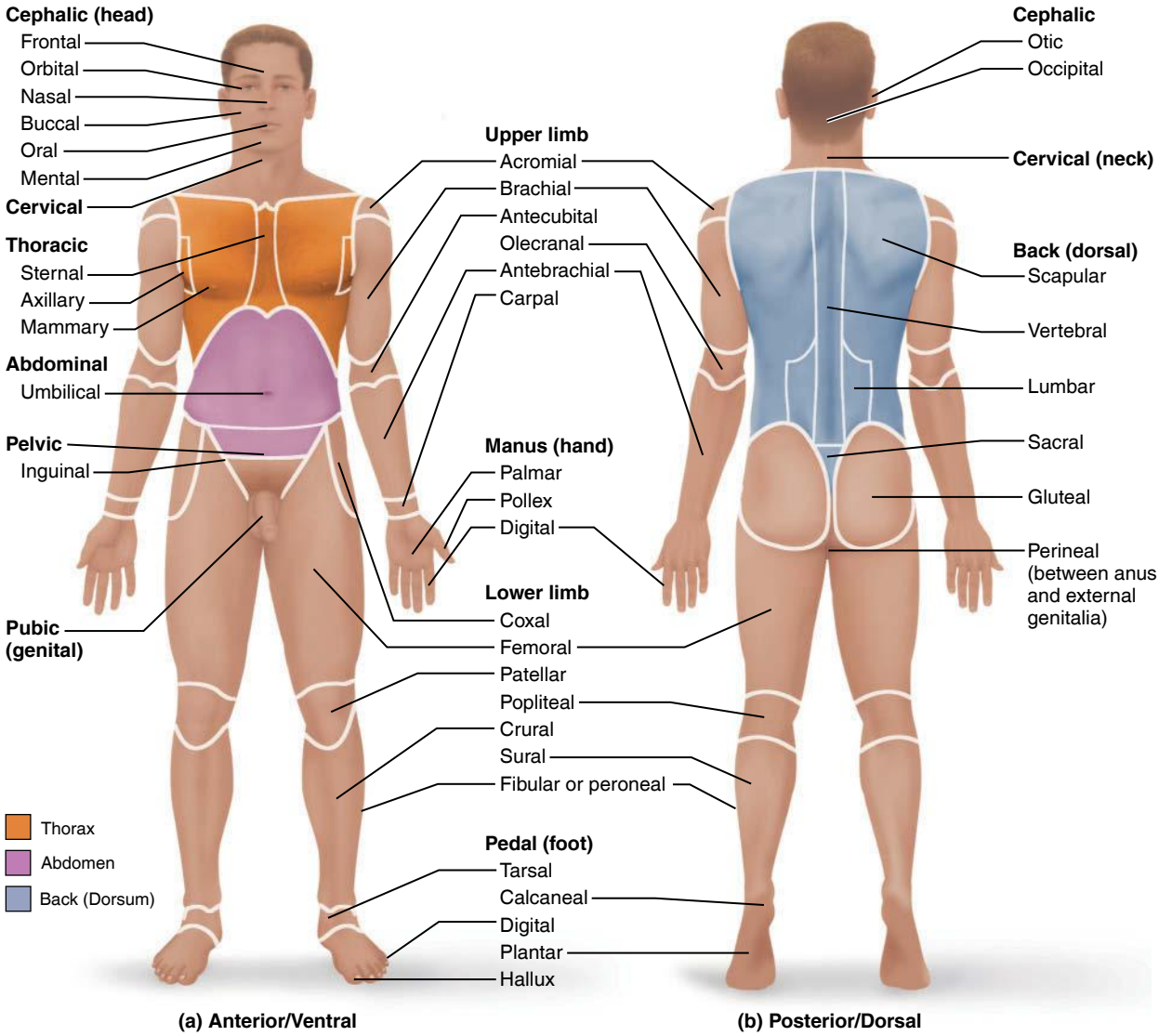


Figure 1.1 Anatomical position and regional terms. Heels are raised to illustrate the plantar surface of the foot, which is actually on the inferior surface of the body.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

Regional Anatomy

The body is divided into two main regions, the axial and appendicular regions. The **axial region** includes the head, neck, and trunk; it runs along the vertical axis of the body. The **appendicular region** includes the limbs, which are also called the appendages or extremities. The body is also divided up into smaller regions within those two main divisions. Table 1.1 summarizes the body regions that are illustrated in Figure 1.1.

Table 1.1 Regions of the Human Body (Figure 1.1)

Region	Description	Region	Description
Abdominal	Located below the ribs and above the hips	Nasal	Nose
Acromial	Point of the shoulder	Occipital	Back of the head
Antebrachial	Forearm	Olecranal	Back of the elbow
Antecubital	Anterior surface of the elbow	Oral	Mouth
Axillary	Armpit	Orbital	Bony eye socket
Brachial	Arm (upper portion of the upper limb)	Otic	Ear
Buccal	Cheek	Palmar	Palm of the hand
Calcaneal	Heel of the foot	Patellar	Kneecap
Carpal	Wrist	Pedal	Foot
Cephalic	Head	Pelvic	Pelvis
Cervical	Neck	Perineal	Between the anus and the external genitalia
Coxal	Hip	Plantar	Sole of the foot
Crural	Leg	Pollex	Thumb
Digital	Fingers or toes	Popliteal	Back of the knee
Femoral	Thigh	Pubic	Genital
Fibular (peroneal)	Side of the leg	Sacral	Posterior region between the hip bones
Frontal	Forehead	Scapular	Shoulder blade
Gluteal	Buttocks	Sternal	Breastbone
Hallux	Great toe	Sural	Calf
Inguinal	Groin	Tarsal	Ankle
Lumbar	Lower back	Thoracic	Chest
Mammary	Breast	Umbilical	Naval
Manus	Hand	Vertebral	Spine
Mental	Chin		

Activity 1

Locating Body Regions

Locate the anterior and posterior body regions on yourself, your lab partner, and a human torso model.

Directional Terms

Study the terms below, referring to **Figure 1.2** for a visual aid. Notice that certain terms have different meanings, depending on whether they refer to a four-legged animal (quadruped) or to a human (biped).

Superior/inferior *(above/below):* These terms refer to placement of a structure along the long axis of the body. The nose, for example, is superior to the mouth, and the abdomen is inferior to the chest.

Anterior/posterior *(front/back):* In humans, the most anterior structures are those that are most forward—the face, chest, and abdomen. Posterior structures are those toward the backside of the body. For instance, the spine is posterior to the heart.

Medial/lateral *(toward the midline/away from the midline or median plane):* The sternum (breastbone) is medial to the ribs; the ear is lateral to the nose.

The terms of position just described assume the person is in the anatomical position. The next four term pairs are more absolute. They apply in any body position, and they consistently have the same meaning in all vertebrate animals.

Cephalad (cranial)/caudal *(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*, respectively.

Ventral/dorsal *(belly side/backside):* These terms are used chiefly in discussing the comparative anatomy of animals, assuming the animal is standing. In humans, the terms *ventral* and *dorsal* are used interchangeably with the terms *anterior* and *posterior*, but in four-legged animals, *ventral* and *dorsal* are synonymous with *inferior* and *superior*, respectively.

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 body limbs. For example, the fingers are distal to the elbow; the knee is proximal to the toes. However, these terms may also be used to indicate regions (closer to or farther from the head) of internal tubular organs.

Superficial (external)/deep (internal) *(toward or at the body surface/away from the body surface):* For example, the skin is superficial to the skeletal muscles, and the lungs are deep to the rib cage.

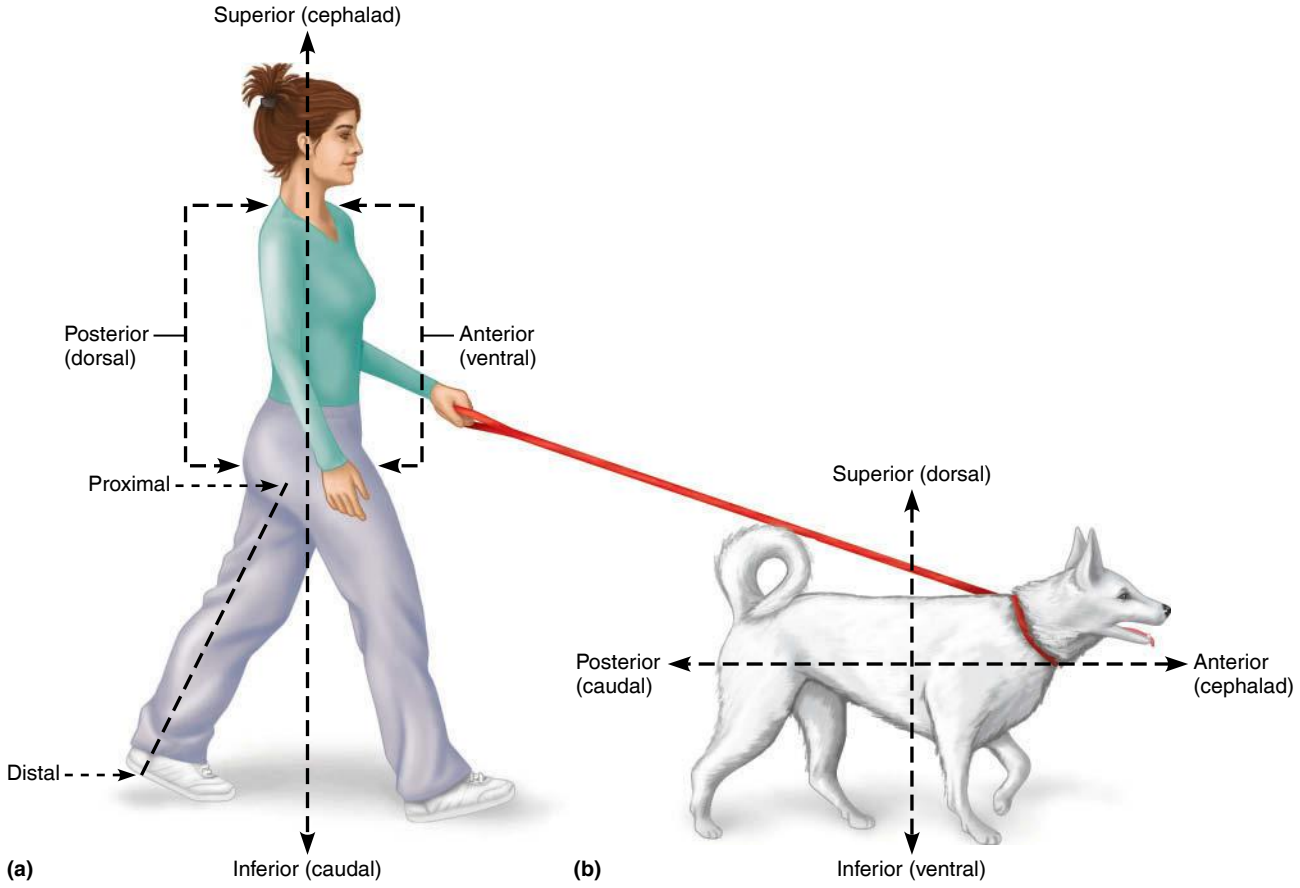


Figure 1.2 Directional terms. (a) With reference to a human. **(b)** With reference to a four-legged animal.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

Activity 2

Practicing Using Correct Anatomical Terminology

Use a human torso model, a human skeleton, or your own body to practice using the regional and directional terminology.

1. The popliteal region is _____. (anterior or posterior)

2. The acromial region is _____ to the otic region. (medial or lateral)

3. The femoral region is _____ to the tarsal region. (proximal or distal)

4. The bones are _____ to the skin. (superficial or deep)

Body Planes and Sections

The body is three-dimensional, and in order to observe its internal structures, it is often necessary to make a **section**, or cut. When the section is made through the body wall or through an organ, it is made along an imaginary surface or line called a **plane**. A section is named for the plane along which it is cut. Anatomists commonly refer to three planes (Figure 1.3), or sections, that lie at right angles to one another.

Figure 1.3 Planes of the body with corresponding magnetic resonance imaging (MRI) scans. Note the transverse section is an inferior view.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

Sagittal plane: A sagittal plane runs longitudinally and divides the body into right and left parts. If it divides the body into equal parts, right down the midline of the body, it is called a **median**, or **midsagittal**, **plane**.

Frontal plane: Sometimes called a **coronal plane**, the frontal plane is a longitudinal plane that divides the body (or an organ) into anterior and posterior parts.

Transverse plane: A transverse plane runs horizontally, dividing the body into superior and inferior parts. When organs are sectioned along the transverse plane, the sections are commonly called **cross sections**.

On microscope slides, the abbreviation for a longitudinal section (sagittal or frontal) is l.s. Cross sections are abbreviated x.s. or c.s.

A median or frontal plane section of any nonspherical object, be it a banana or a body organ, provides quite a different view from a cross section (Figure 1.4).

Activity 3

Observing Sectioned Specimens

1. Go to the demonstration area and observe the transversely and longitudinally cut organ specimens (kidneys).

2. After completing instruction 1, obtain a gelatin-spaghetti mold and a scalpel, and take them to your laboratory bench. (Essentially, this is just cooked spaghetti added to warm gelatin, which is then allowed to gel.)

3. Cut through the gelatin-spaghetti mold along any plane, and examine the cut surfaces. You should see spaghetti strands that have been cut transversely (x.s.) and some cut longitudinally (a median section).

4. Draw the appearance of each of these spaghetti sections below, and verify the accuracy of your section identifications with your instructor.

Transverse section

Median section

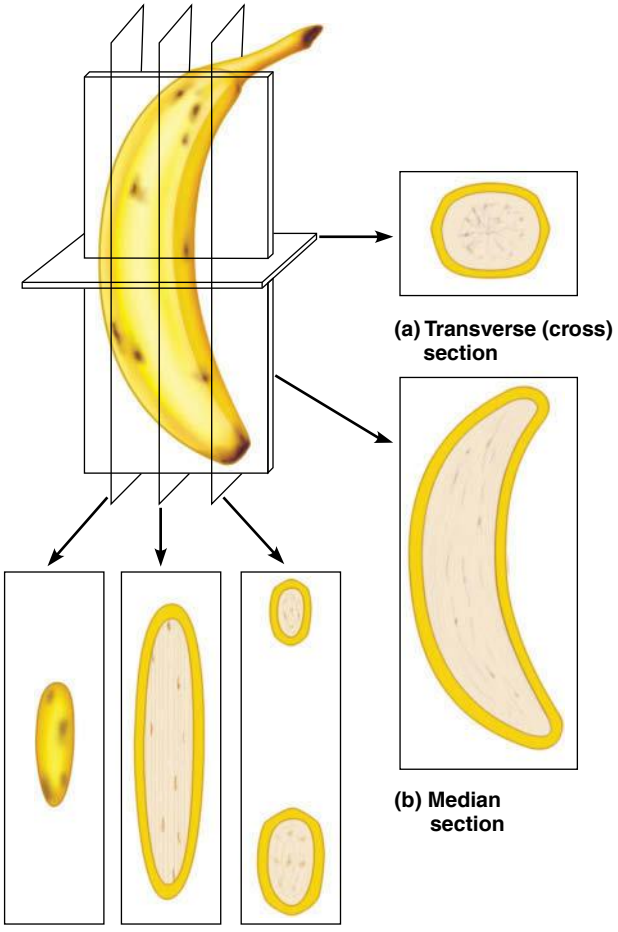


Figure 1.4 Objects can look odd when viewed in section. This banana has been sectioned in three different planes **(a–c)**, and only in one of these planes **(b)** is it easily recognized as a banana. If one cannot recognize a sectioned organ, it is possible to reconstruct its shape from a series of successive cuts, as from the three serial sections in **(c)**.

Body Cavities

The axial region of the body has two large cavities that provide different degrees of protection to the organs within them (Figure 1.5).

Dorsal Body Cavity

The dorsal body cavity can be subdivided into the **cranial cavity**, which lies within the rigid skull and encases the brain, and the **vertebral** (or **spinal**) **cavity**, which runs through the bony vertebral column to enclose the delicate spinal cord.

Ventral Body Cavity

Like the dorsal cavity, the ventral body 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 protected by the bony rib cage. The cavity inferior to the diaphragm is referred to as the **abdominopelvic cavity**. Although there is no further physical separation of the ventral cavity, some describe the abdominopelvic cavity as two areas: a superior **abdominal cavity**, the area that houses the stomach, intestines, liver, and other organs, and an inferior **pelvic cavity**, the region that is partially enclosed by the bony pelvis and contains the reproductive organs, bladder, and rectum.

Serous Membranes of the Ventral Body Cavity

The walls of the ventral body cavity and the outer surfaces of the organs it contains are covered with a very thin, double-layered membrane called the **serosa**, or **serous membrane**. The part of the membrane lining the cavity walls is referred to as the **parietal serosa**, and it is continuous with a similar membrane, the **visceral serosa**, covering the external surface of the organs within the cavity. These membranes produce a thin lubricating fluid that allows the visceral organs to slide over one another or to rub against the body wall with minimal

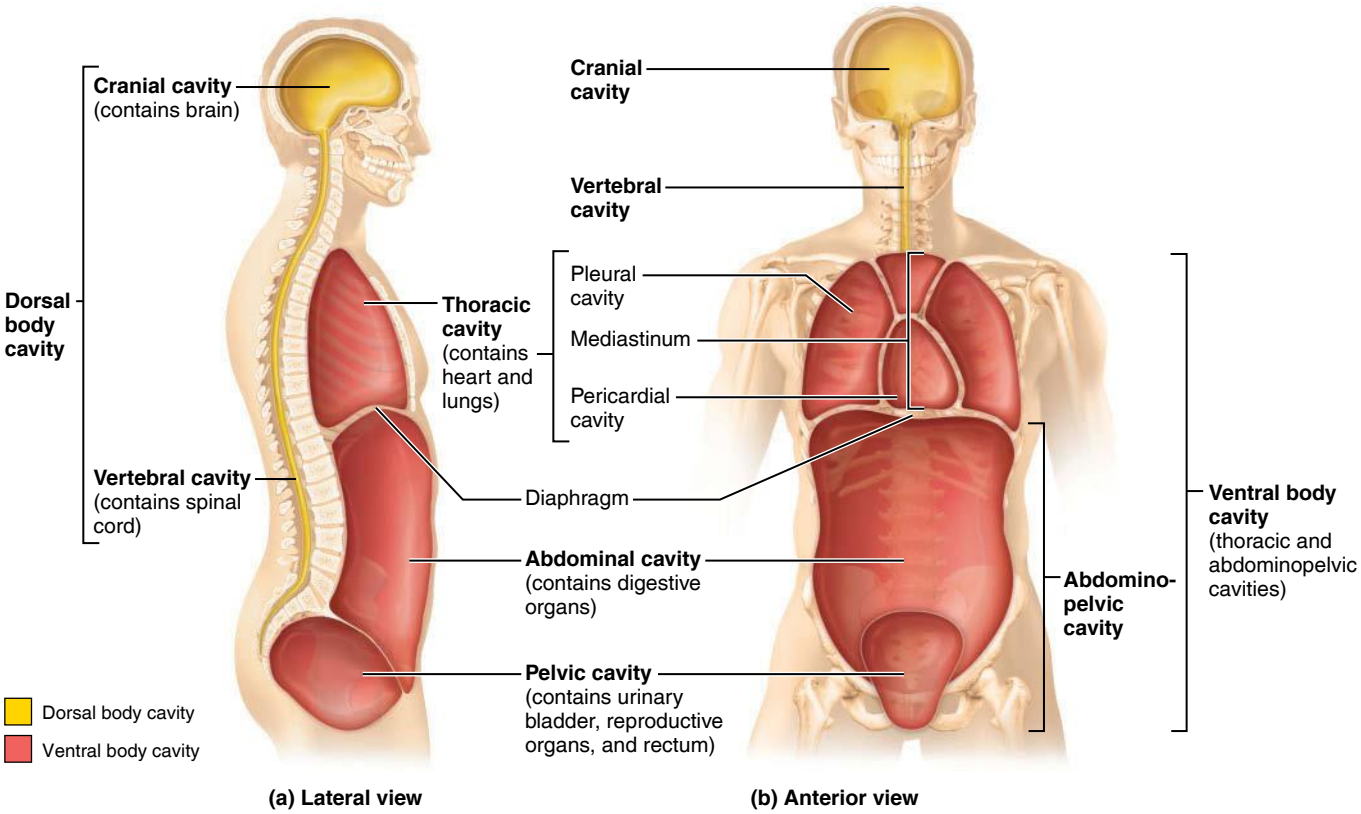
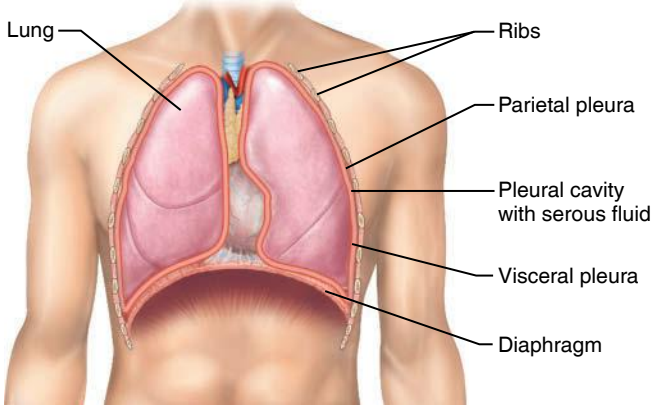
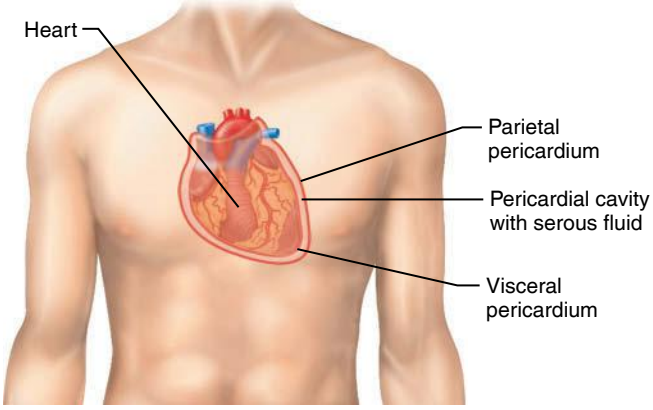


Figure 1.5 Dorsal and ventral body cavities and their subdivisions.

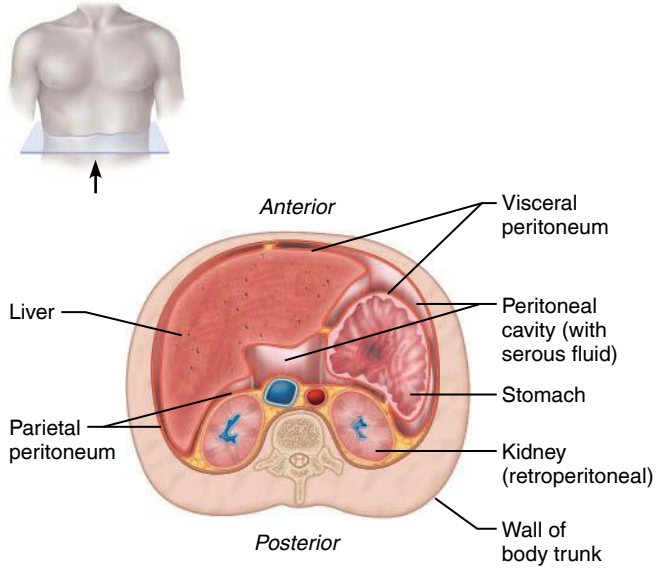
Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™



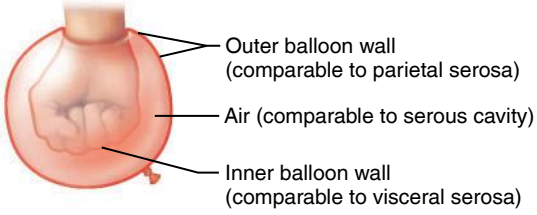
(a) Serosae associated with the lungs: pleura



(b) Serosae associated with the heart: pericardium



(c) Serosae associated with the abdominal viscera: peritoneum



(d) Model of the serous membranes and serous cavity

Figure 1.6 Serous membranes of the ventral body cavities.

friction. Serous membranes also compartmentalize the various organs to prevent infection in one organ from spreading to others.

The specific names of the serous membranes depend on the structures they surround. The serosa lining the abdominal cavity and covering its organs is the **peritoneum**, the serosa enclosing the lungs is the **pleura**, and the serosa around the heart is the **pericardium** (Figure 1.6). A fist pushed into a limp balloon demonstrates the relationship between the visceral and parietal serosae (Figure 1.6d).

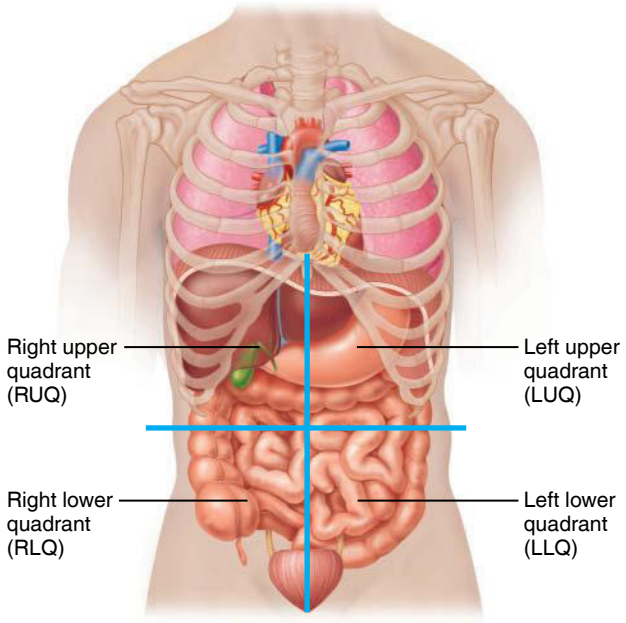


Figure 1.7 Abdominopelvic quadrants. Superficial organs are shown in each quadrant.

Activity 4

Identifying Organs in the Abdominopelvic Cavity

Examine the human torso model to respond to the following questions.

Name two organs found in the left upper quadrant.

_____ and _____

Name two organs found in the right lower quadrant.

_____ and _____

What organ (Figure 1.7) is divided into identical halves by the median plane? _____

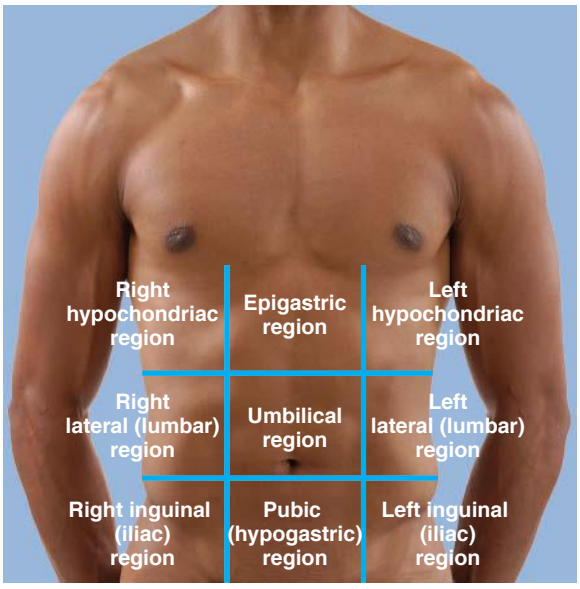
1

Abdominopelvic Quadrants and Regions

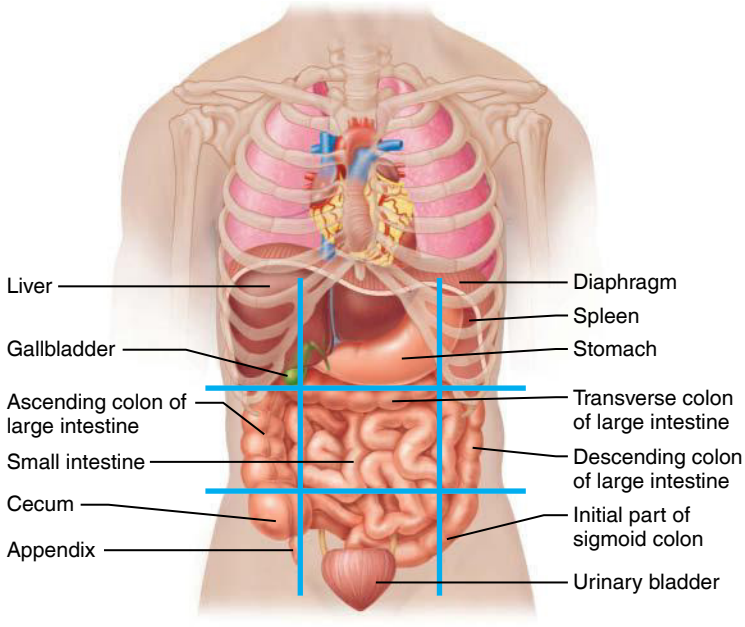
Because the abdominopelvic cavity is quite large and contains many organs, it is helpful to divide it up into smaller areas for discussion or study.

Most physicians and nurses use a scheme that divides the abdominal surface and the abdominopelvic cavity into four approximately equal regions called **quadrants**. These quadrants are named according to their relative position—that is, *right upper quadrant*, *right lower quadrant*, *left upper quadrant*, and *left lower quadrant* (Figure 1.7). Note that the terms *left* and *right* refer to the left and right side of the body in the figure, not the left and right side of the art on the page.

A different scheme commonly used by anatomists divides the abdominal surface and abdominopelvic cavity into nine separate regions by four planes (Figure 1.8). As you read



(a)



(b)

Figure 1.8 Abdominopelvic regions. Nine regions delineated by four planes. **(a)** The superior horizontal plane is just inferior to the ribs; the inferior horizontal plane is at the superior aspect of the hip bones. The vertical planes are just medial to the nipples. **(b)** Superficial organs are shown in each region.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

through the descriptions of these nine regions, locate them in Figure 1.8, and note the organs contained in each region.

Umbilical region: The centermost region, which includes the umbilicus (navel)

Epigastric region: Immediately superior to the umbilical region; overlies most of the stomach

Pubic (hypogastric) region: Immediately inferior to the umbilical region; encompasses the pubic area

Inguinal, or iliac, regions: Lateral to the hypogastric region and overlying the superior parts of the hip bones

Lateral (lumbar) regions: Between the ribs and the flaring portions of the hip bones; lateral to the umbilical region

Hypochondriac regions: Flanking the epigastric region laterally and overlying the lower ribs

Activity 5

Locating Abdominopelvic Surface Regions

Locate the regions of the abdominopelvic surface on a human torso model.

Other Body Cavities

Besides the large, closed body cavities, there are several types of smaller body cavities (Figure 1.9). Many of these are in the head, and most open to the body exterior.

Oral cavity: The oral cavity, commonly called the *mouth*, contains the tongue and teeth. It is continuous with the rest of the digestive tube, which opens to the exterior at the anus.

Nasal cavity: Located within and posterior to the nose, the nasal cavity is part of the passages of the respiratory system.

Orbital cavities: The orbital cavities (orbits) in the skull house the eyes and present them in an anterior position.

Middle ear cavities: Each middle ear cavity lies just medial to an eardrum and is carved into the bony skull. These cavities contain tiny bones that transmit sound vibrations to the hearing receptors in the inner ears.

Synovial cavities: Synovial cavities are joint cavities—they are enclosed within fibrous capsules that surround the freely movable joints of the body, such as those between the vertebrae and the knee and hip joints. Like the serous membranes of the ventral body cavity, membranes lining the synovial cavities secrete a lubricating fluid that reduces friction as the enclosed structures move across one another.

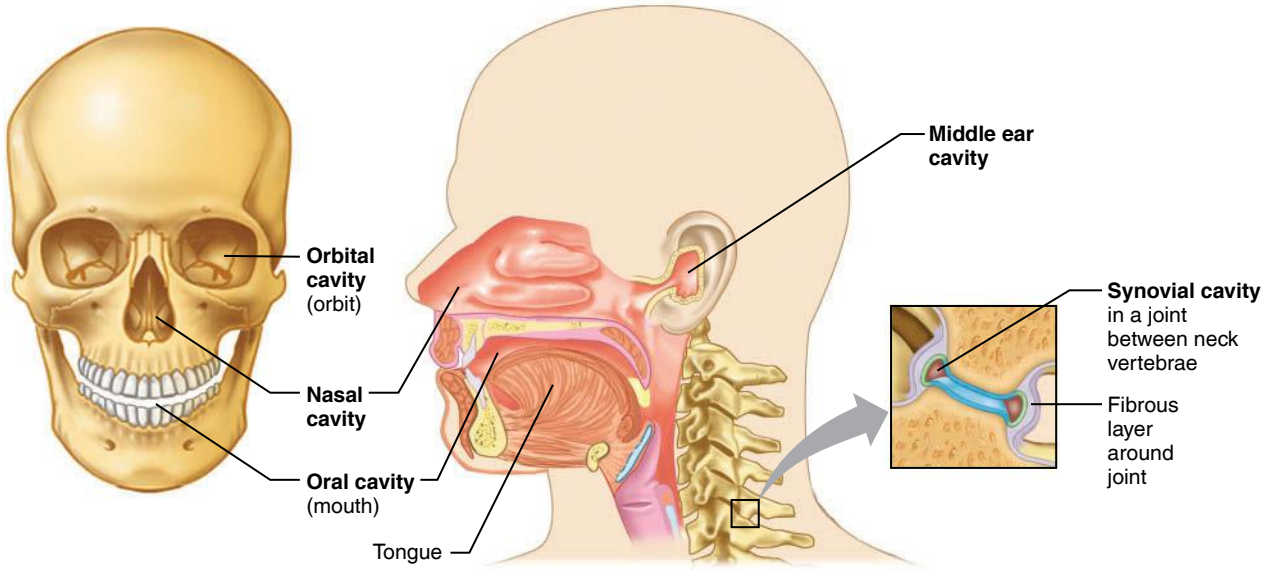


Figure 1.9 Other body cavities. The oral, nasal, orbital, and middle ear cavities are located in the head and open to the body exterior. Synovial cavities are found in joints between bones, such as the vertebrae of the spine, and at the knee, shoulder, and hip.

Instructors may assign a portion of the Review Sheet questions using Mastering A&P™

EXERCISE 1

REVIEW SHEET

The Language of Anatomy

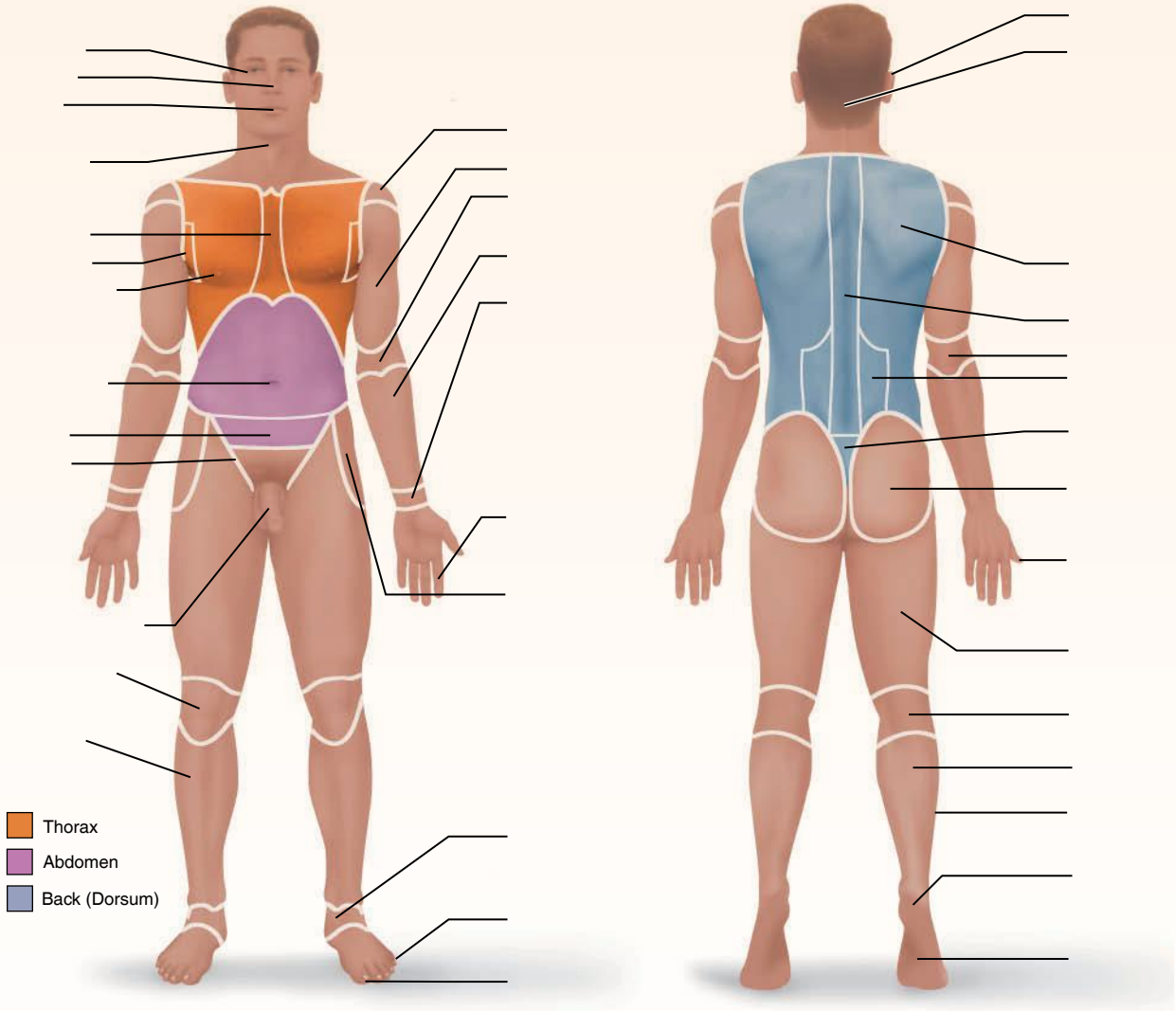
Name _____ Lab Time/Date _____

Regional Terms

1. Describe completely the standard human anatomical position. _____

_____

2. Use the regional terms to correctly label the body regions indicated on the figures below.



(a) Anterior/Ventral (b) Posterior/Dorsal

Directional Terms, Planes, and Sections

3. Define *plane*. _____

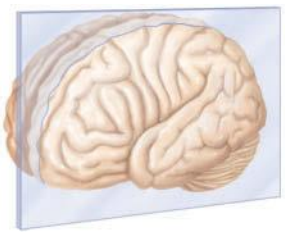
4. Several incomplete statements appear below. Correctly complete each statement by choosing the appropriate anatomical term from the choices. Use each term only once.

anterior	inferior	posterior	superior
distal	lateral	proximal	transverse
frontal	medial	sagittal	

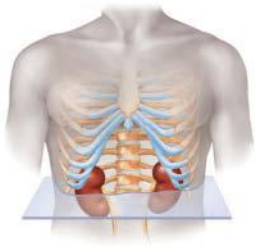
1. The thoracic cavity is _____ to the abdominopelvic cavity.
2. The trachea (windpipe) is _____ to the vertebral column.
3. The wrist is _____ to the hand.
4. If an incision cuts the heart into left and right parts, a _____ plane of section was used.
5. The nose is _____ to the cheekbones.
6. The thumb is _____ to the ring finger.
7. The vertebral cavity is _____ to the cranial cavity.
8. The knee is _____ to the thigh.
9. The plane that separates the head from the neck is the _____ plane.
10. The popliteal region is _____ to the patellar region.
11. The plane that separates the anterior body surface from the posterior body surface is the _____ plane.

5. Correctly identify each of the body planes by writing the appropriate term on the answer line below the drawing.

(a) _____



(b) _____



(c) _____

Body Cavities

6. Name the muscle that subdivides the ventral body cavity. _____

7. Which body cavity provides the least protection to its internal structures? _____

8. For the body cavities listed, name one organ located in each cavity.

1. cranial cavity _____.
2. vertebral cavity _____.

3. thoracic cavity _____.

4. abdominal cavity _____.

5. pelvic cavity _____.

6. mediastinum _____.

9. Name the abdominopelvic region where each of the listed organs is located.

1. spleen _____

2. urinary bladder _____

3. stomach (largest portion) _____

4. cecum _____

10. Explain how serous membranes protect organs from infection. _____

_____

11. Which serous membrane(s) is/are found in the thoracic cavity? _____

_____

12. Which serous membrane(s) is/are found in the abdominopelvic cavity? _____

_____

13. Using the key choices, identify the small body cavities described below.

Key: a. middle ear cavity e. oral cavity e. synovial cavity
b. nasal cavity d. orbital cavity

_____ 1. holds the eyes in an anterior-facing position

_____ 2. houses three tiny bones involved in hearing

_____ 3. contained within the nose

_____ 4. contains the tongue

_____ 5. surrounds a joint

14. Name the body region that blood is usually drawn from. _____

15. A patient has been diagnosed with appendicitis. Use anatomical terminology to describe the location of the person's pain.

Assume that the pain is referred to the surface of the body above the organ. _____

16. Which body cavity would be opened to perform a hysterectomy? _____

_____

17. Which smaller body cavity would be opened to perform a total knee joint replacement? _____

_____

18. An abdominal hernia results when weakened muscles allow the protrusion of abdominal structures. In the case of an umbilical hernia, parts of a serous membrane and the small intestine form the bulge. Which serous membrane is involved?

_____

This page intentionally left blank

EXERCISE 2

Organ Systems Overview

Learning Outcomes

- Name the human organ systems, and indicate the major functions of each.
- List several major organs of each system, and identify them in a dissected rat, human cadaver or cadaver image, or a dissectible human torso model.
- Name the correct organ system for each organ when presented with a list of organs.

Pre-Lab Quiz

Instructors may assign these and other Pre-Lab Quiz questions using Mastering A&P™

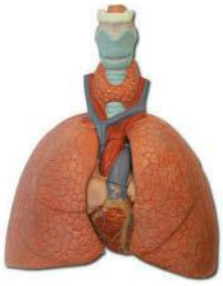
1. Name the structural and functional unit of all living things. _____
2. The small intestine is an example of a(n) _____, because it is composed of two or more tissue types that perform a particular function for the body.
   a. epithelial tissue
   b. muscular tissue
   c. organ
   d. organ system
3. The _____ system is responsible for maintaining homeostasis of the body via rapid transmission of electrical signals.
4. The kidneys are part of the _____ system.
5. The thin muscle that separates the thoracic and abdominal cavities is the _____.

The basic unit of life is the **cell**. Cells fall into four different categories according to their structures and functions. These categories correspond to the four primary tissue types: epithelial, muscular, nervous, and connective. A **tissue** is a group of cells that are similar in structure and function. An **organ** is a structure composed of two or more tissue types that performs a specific function for the body.

An **organ system** is a group of organs that act together to perform a particular body function. For example, the organs of the digestive system work together to break down foods and absorb the end products into the bloodstream in order to provide nutrients and fuel for all the body's cells. In all, there are 11 organ systems, described in Table 2.1 on p. 16.

Read through this summary of the body's organ systems (Table 2.1) before beginning your rat dissection or examination of the predissected human cadaver. If a human cadaver is not available, Figures 2.3 to 2.6 will serve as a partial replacement.

Go to Mastering A&P™ > Study Area to improve your performance in A&P Lab.



> Lab Tools > Practice Anatomy Lab > Anatomical Models

Instructors may assign new Building Vocabulary coaching activities, Pre-Lab Quiz questions, Art Labeling activities, Practice Anatomy Lab Practical questions (PAL), and more using the Mastering A&P™ Item Library.

Materials

- Freshly killed or preserved rat (predissected by instructor as a demonstration or for student dissection [one rat for every two to four students]) or predissected human cadaver
- Dissection trays
- Twine or large dissecting pins
- Scissors
- Probes
- Forceps
- Disposable gloves
- Human torso model (dissectible)

Table 2.1 Overview of Organ Systems of the Body

Organ system	Major component organs	Function
Integumentary	Skin, hair, and nails; cutaneous sense organs and glands	• Protects deeper organs from mechanical, chemical, and bacterial injury, and from drying out • Excretes salts and urea • Aids in regulation of body temperature • Produces vitamin D
Skeletal	Bones, cartilages, tendons, ligaments, and joints	• Body support and protection of internal organs • Provides levers for muscular action • Cavities provide a site for blood cell formation • Bones store minerals
Muscular	Muscles attached to the skeleton	• Primary function is to contract or shorten; in doing so, skeletal muscles allow locomotion (running, walking, etc.), grasping and manipulation of the environment, and facial expression • Generates heat
Nervous	Brain, spinal cord, nerves, and sensory receptors	• Allows body to detect changes in its internal and external environment and to respond to such information by activating appropriate muscles or glands • Helps maintain homeostasis of the body via rapid transmission of electrical signals
Endocrine	Pituitary, thymus, thyroid, parathyroid, adrenal, and pineal glands; ovaries, testes, and pancreas	• Helps maintain body homeostasis, promotes growth and development; produces chemical messengers called hormones that travel in the blood to exert their effect(s) on various target organs of the body
Cardiovascular	Heart and blood vessels	• Primarily a transport system that carries blood containing oxygen, carbon dioxide, nutrients, wastes, ions, hormones, and other substances to and from the tissue cells where exchanges are made; blood is propelled through the blood vessels by the pumping action of the heart • Antibodies and other protein molecules in the blood protect the body
Lymphatic	Lymphatic vessels, lymph nodes, spleen, and thymus	• Picks up fluid leaked from the blood vessels and returns it to the blood • Cleanses blood of pathogens and other debris • Houses lymphocytes that act via the immune response to protect the body from foreign substances
Respiratory	Nasal cavity, pharynx, larynx, trachea, bronchi, and lungs	• Keeps the blood continuously supplied with oxygen while removing carbon dioxide • Contributes to the acid-base balance of the blood
Digestive	Oral cavity, pharynx, esophagus, stomach, small and large intestines, and accessory structures including teeth, salivary glands, liver, and pancreas	• Breaks down ingested foods to smaller particles, which can be absorbed into the blood for delivery to the body cells • Undigested residue removed from the body as feces
Urinary	Kidneys, ureters, bladder, and urethra	• Rids the body of nitrogen-containing wastes including urea, uric acid, and ammonia, which result from the breakdown of proteins and nucleic acids • Maintains water, electrolyte, and acid-base balance of blood
Reproductive	Male: testes, prostate gland, scrotum, penis, and duct system, which carries sperm to the body exterior	• Provides gametes called sperm for perpetuation of the species
	Female: ovaries, uterine tubes, uterus, mammary glands, and vagina	• Provides gametes called eggs; the uterus houses the developing fetus until birth; mammary glands provide nutrition for the infant

DISSECTION AND IDENTIFICATION

The Organ Systems of the Rat

Many of the external and internal structures of the rat are quite similar in structure and function to those of the human. So, a study of the gross anatomy of the rat should help you understand our anatomy. The following instructions include directions for dissecting and observing a rat. In addition, the descriptions of the organs (**Activity 4, Examining the Ventral Body Cavity**, which begins on p. 18) also apply to superficial observations of a previously dissected human cadaver. The general instructions for observing external structures also apply to human cadaver observations. The photographs in Figures 2.3 to 2.6 will provide visual aids.

Note that four organ systems (integumentary, skeletal, muscular, and nervous) will not be studied at this time, because they require microscopic study or more detailed dissection.

Activity 1

Observing External Structures

1. If your instructor has provided a predissected rat, go to the demonstration area to make your observations. Alternatively, if you and/or members of your group will be dissecting the specimen, obtain a preserved or freshly killed rat, a dissecting tray, dissecting pins or twine, scissors, probe, forceps, and disposable gloves, and bring them to your laboratory bench.

If a predissected human cadaver is available, obtain a probe, forceps, and disposable gloves before going to the demonstration area.

2. Don the gloves before beginning your observations. This precaution is particularly important when handling freshly killed animals, which may harbor pathogens.

3. Observe the major divisions of the body—head, trunk, and extremities. If you are examining a rat, compare these divisions to those of humans.

Activity 2

Examining the Oral Cavity

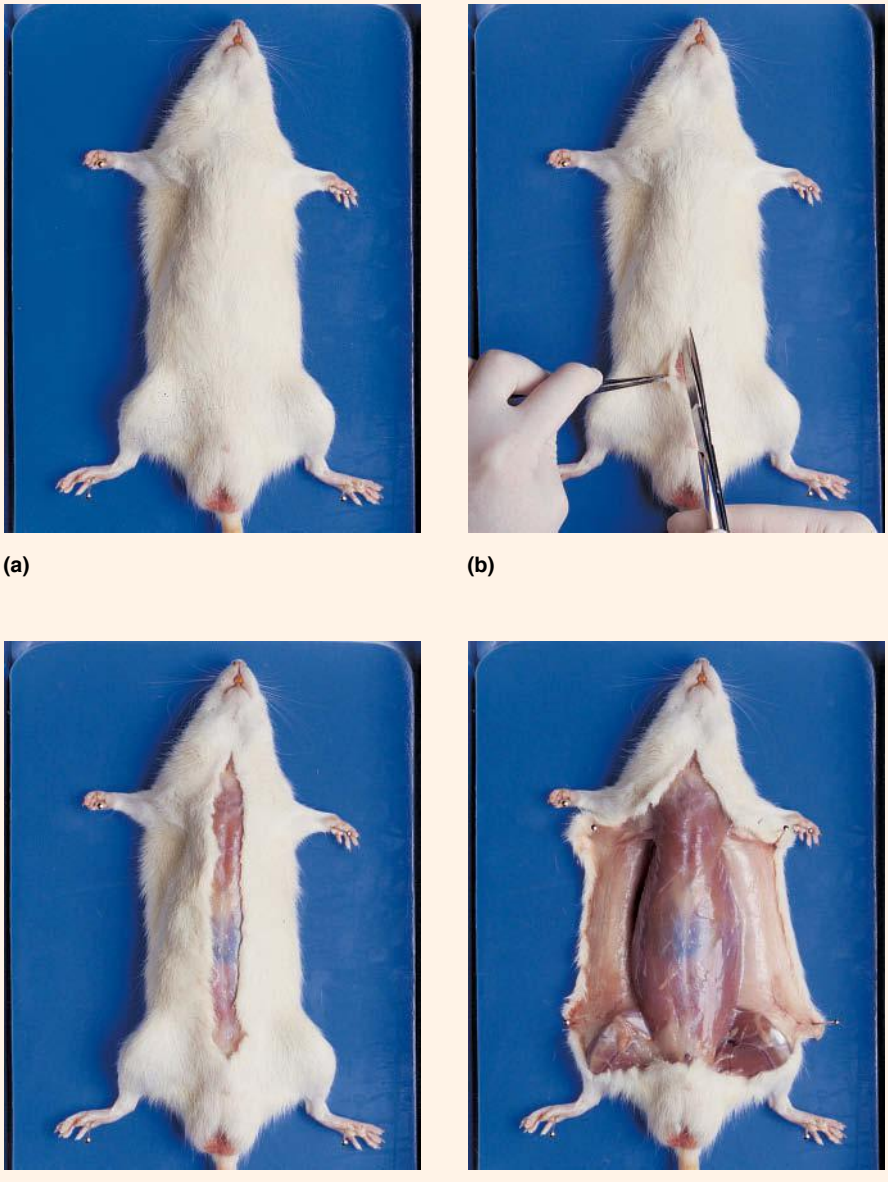
Examine the structures of the oral cavity. Identify the teeth and tongue. Observe the extent of the hard palate (the portion underlain by bone) and the soft palate (immediately posterior to the hard palate, with no bony support). Notice that the posterior end of the oral cavity leads into the throat, or pharynx, a passageway used by both the digestive and respiratory systems.

Activity 3

Opening the Ventral Body Cavity

1. Pin the animal to the wax of the dissecting tray by placing its dorsal side down and securing its extremities to the wax with large dissecting pins as shown in **Figure 2.1a**.

Text continues on next page ➔



(a) **(b)** **(c)** **(d)**

Figure 2.1 Rat dissection: Securing for dissection and the initial incision. **(a)** Securing the rat to the dissection tray with dissecting pins. **(b)** Using scissors to make the incision on the median line of the abdominal region. **(c)** Completed incision from the pelvic region to the lower jaw. **(d)** Reflection (folding back) of the skin to expose the underlying muscles.

2. Lift the abdominal skin with a forceps, and cut through it with the scissors (Figure 2.1b). Close the scissor blades, and insert them flat under the cut skin. Moving in a cephalad direction, open and close the blades to loosen the skin from the underlying connective tissue and muscle. Now, cut the skin along the body midline, from the pubic region to the lower jaw (Figure 2.1c). Finally, make a lateral cut about halfway down the ventral surface of each limb. Complete the job of freeing the skin with the scissor tips, and pin the flaps to the tray (Figure 2.1d). The underlying tissue that is now exposed is the skeletal musculature of the body wall and limbs. Notice that the muscles are packaged in sheets of pearly white connective tissue (fascia), which protect the muscles and bind them together.

3. Carefully cut through the muscles of the abdominal wall in the pubic region, avoiding the underlying organs. Now, hold and lift the muscle layer with a forceps and cut through the muscle layer from the pubic region to the bottom of the rib cage. Make two lateral cuts at the base of the rib cage (**Figure 2.2**). A thin membrane attached to the inferior boundary of the rib cage should be obvious; this is the **diaphragm**, which separates the thoracic and abdominal cavities. Cut the diaphragm where it attaches to the ventral ribs to loosen the rib cage. Cut through the rib cage on either side. You can now lift the ribs to view the contents of the thoracic cavity. Cut across the flap, at the level of the neck, and remove the rib cage.

Figure 2.2 Rat dissection. Making lateral cuts at the base of the rib cage.

Activity 4

Examining the Ventral Body Cavity

1. Starting with the most superficial structures and working deeper, examine the structures of the thoracic cavity. Refer to **Figure 2.3** as you work. Choose the appropriate view depending on whether you are examining a rat (a) or a human cadaver (b).

Thymus: An irregular mass of glandular tissue overlying the heart (not illustrated in the human cadaver photograph).

With the probe, push the thymus to the side to view the heart.

Heart: Medial oval structure enclosed within the pericardium (serous membrane).

Lungs: Lateral to the heart on either side.

Now observe the throat region to identify the trachea.

Trachea: Tubelike "windpipe" running medially down the throat; part of the respiratory system.

Follow the trachea into the thoracic cavity; notice where it divides into two branches. These are the bronchi.

Bronchi: Two passageways that plunge laterally into the tissue of the two lungs.

To expose the esophagus, push the trachea to one side.

Esophagus: A food chute; the part of the digestive system that transports food from the pharynx (throat) to the stomach.

Diaphragm: A thin muscle attached to the inferior boundary of the rib cage.

Follow the esophagus through the diaphragm to its junction with the stomach.

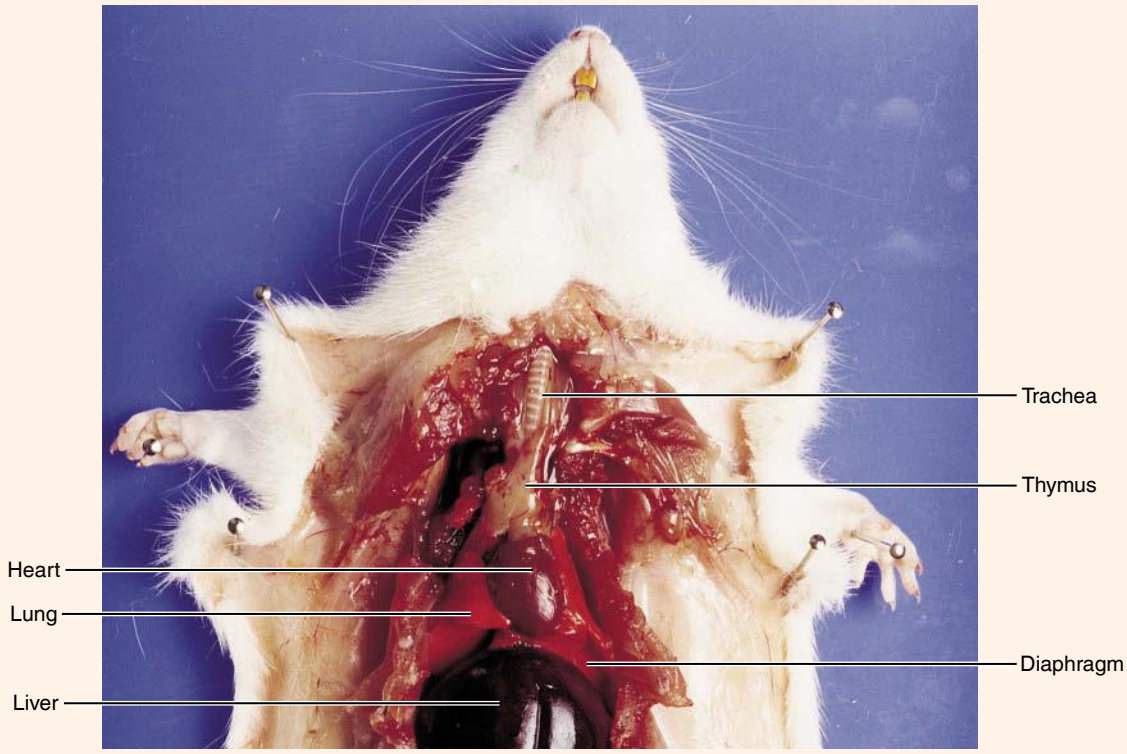
Stomach: A curved organ important in food digestion and temporary food storage.

2. Examine the superficial structures of the abdominopelvic cavity. Lift the **greater omentum**, an extension of the peritoneum (serous membrane) that covers the abdominal viscera. Continuing from the stomach, trace the rest of the digestive tract (**Figure 2.4**, p. 20).

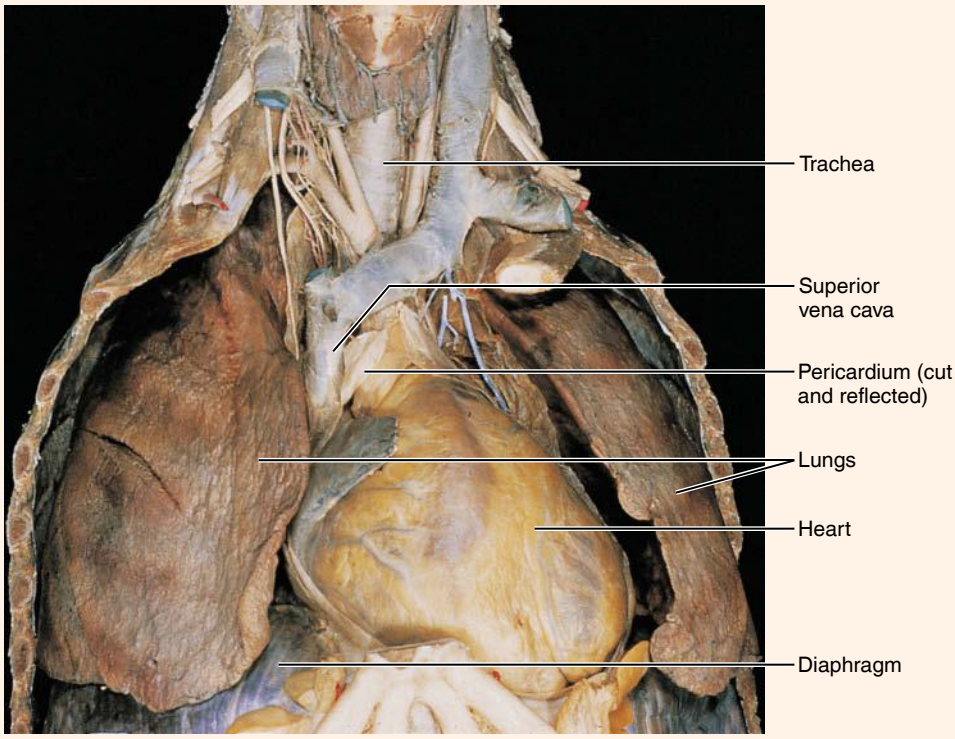
Small intestine: Connected to the stomach and ending just before the saclike cecum.

Large intestine: A large muscular tube connected to the small intestine and ending at the anus.

Text continues on page 20. ➔



(a)



(b)

Figure 2.3 Superficial organs of the thoracic cavity. (a) Dissected rat. **(b)** Human cadaver.

Instructors may assign this figure as an Art Labeling Activity using Mastering **A&P™**

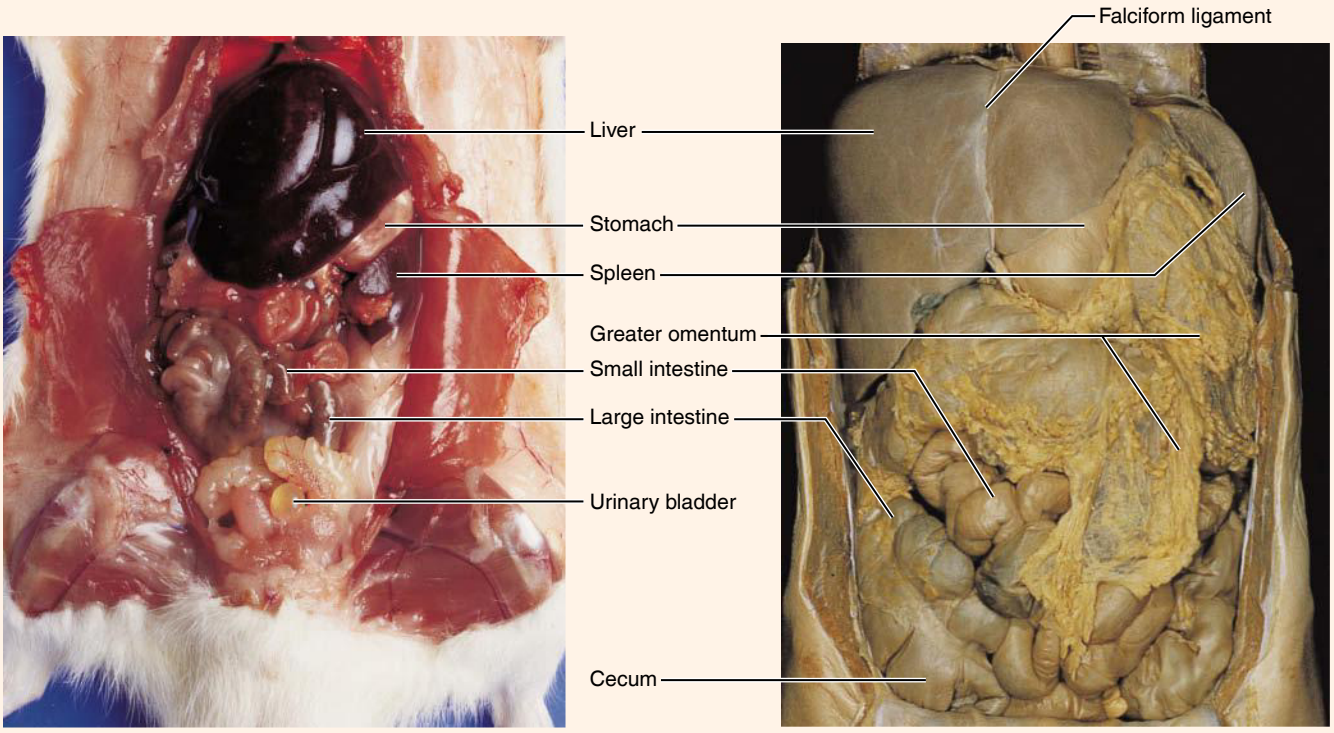


Figure 2.4 Abdominal organs. (a) Dissected rat, superficial view. **(b)** Human cadaver, superficial view.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

Cecum: The initial portion of the large intestine.

Follow the course of the large intestine to the rectum, which is partially covered by the urinary bladder (**Figure 2.5**).

Rectum: Terminal part of the large intestine; continuous with the anal canal.

Anus: The opening of the digestive tract (through the anal canal) to the exterior.

Now lift the small intestine with the forceps to view the mesentery.

Mesentery: An apronlike serous membrane; suspends many of the digestive organs in the abdominal cavity. Notice that it is heavily invested with blood vessels and, more likely than not, riddled with large fat deposits.

Locate the remaining abdominal structures.

Pancreas: A diffuse gland; rests dorsal to and in the mesentery between the first portion of the small intestine and the stomach. You will need to lift the stomach to view the pancreas.

Spleen: A dark red organ curving around the left lateral side of the stomach; an organ of the lymphatic system, it is often called the red blood cell "graveyard."

Liver: Large and brownish red; the most superior organ in the abdominal cavity, directly beneath the diaphragm.

3. To locate the deeper structures of the abdominopelvic cavity, move the stomach and the intestines to one side with the probe.

Examine the posterior wall of the abdominal cavity to locate the two kidneys (Figure 2.5).

Kidneys: Bean-shaped organs; retroperitoneal (behind the peritoneum).

Adrenal glands: Large endocrine glands that sit on top of each kidney; considered part of the endocrine system.

Carefully strip away part of the peritoneum with forceps and attempt to follow the course of one of the ureters to the bladder.

Ureter: Tube running from the indented region of a kidney to the urinary bladder.

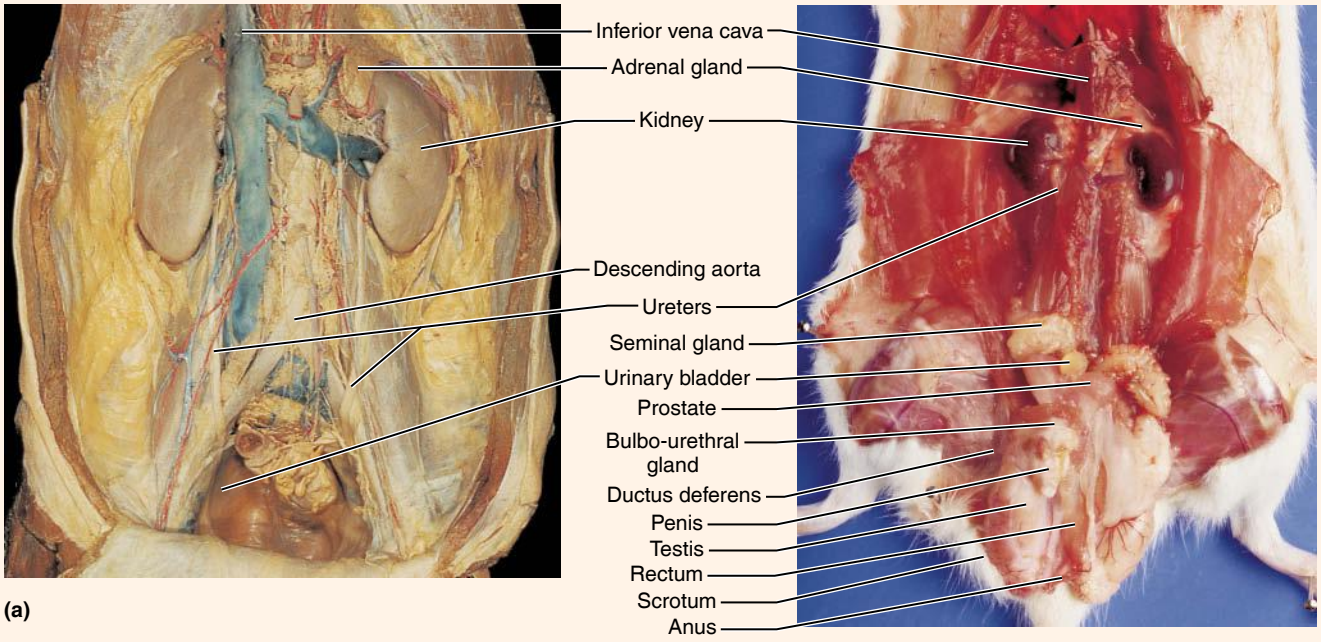
Urinary bladder: The sac that serves as a reservoir for urine.

4. In the midline of the body cavity lying between the kidneys are the two principal abdominal blood vessels:

Inferior vena cava: The large vein that returns blood to the heart from the lower body regions.

Descending aorta: Deep to the inferior vena cava; the largest artery of the body; carries blood away from the heart.

5. You will perform only a brief examination of reproductive organs. If you are working with a rat, first determine if the animal is a male or female. Observe the ventral body surface beneath the tail. If a saclike scrotum and an opening for the anus are visible, the animal is a male. If three body openings—urethral, vaginal, and anal—are present, it is a female.



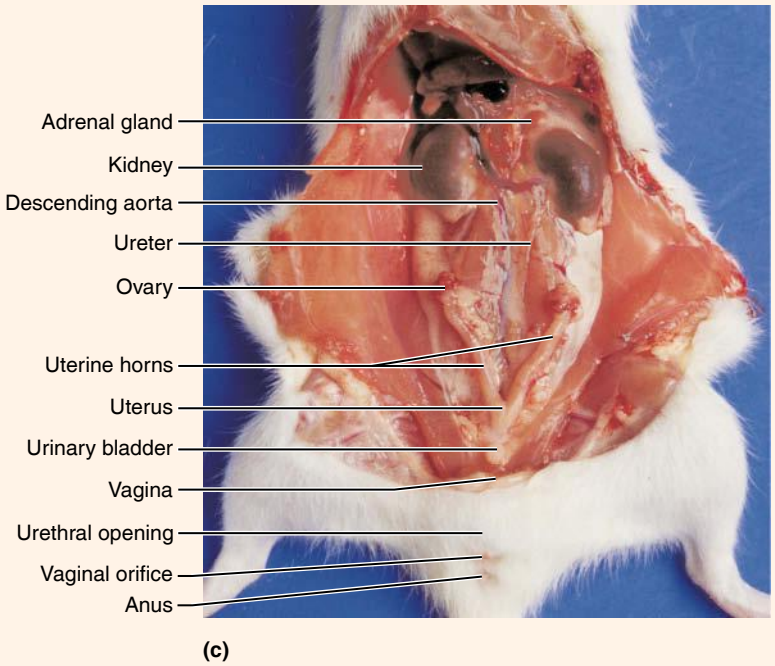


Figure 2.5 Deep structures of the abdominopelvic cavity. (a) Human cadaver. **(b)** Dissected male rat. (Some reproductive structures also shown.) **(c)** Dissected female rat. (Some reproductive structures also shown.)

Male Rat

Make a shallow incision into the **scrotum**. Loosen and lift out one oval **testis**. Exert a gentle pull on the testis to identify the slender **ductus deferens**, or **vas deferens**, which carries sperm from the testis superiorly into the abdominal cavity and joins with the urethra. The urethra runs through the penis and carries both urine and sperm out of the body. Identify the **penis**, extending from the bladder to the ventral body wall. Figure 2.5b indicates other glands of the male rat's reproductive system, but they need not be identified at this time.

Female Rat

Inspect the pelvic cavity to identify the Y-shaped **uterus** lying against the dorsal body wall and superior to the bladder (Figure 2.5c). Follow one of the uterine horns superiorly to identify an **ovary**, a small oval structure at the end of the uterine horn. (The rat uterus is quite different from the uterus of a human female, which is a single-chambered organ about the size and shape of a pear.) The inferior undivided part of the rat uterus is continuous with the **vagina**, which leads to the body exterior. Identify the **vaginal orifice** (external vaginal opening).

Text continues on next page ➔

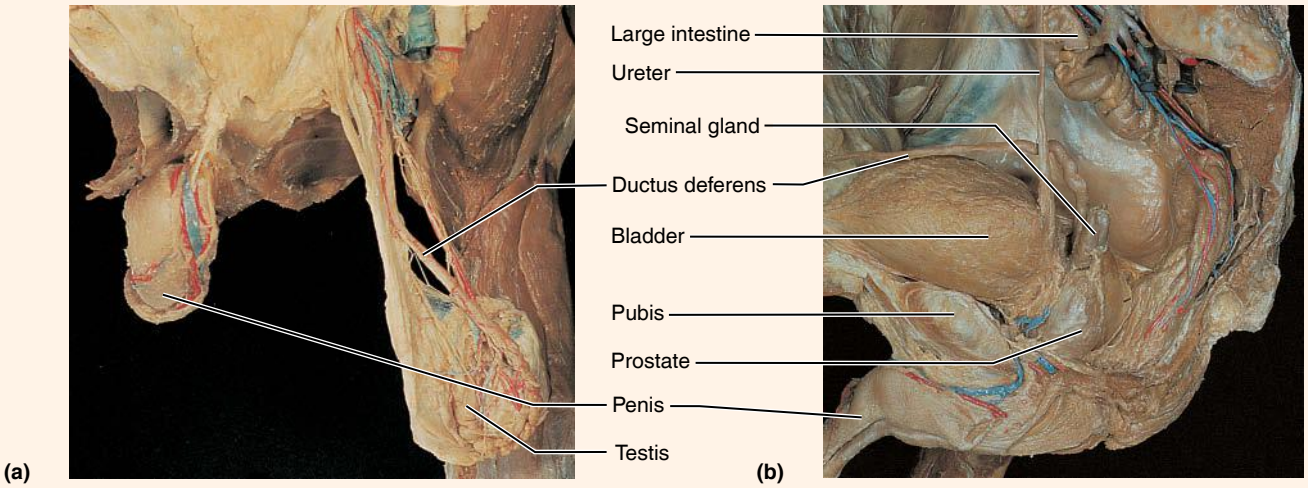
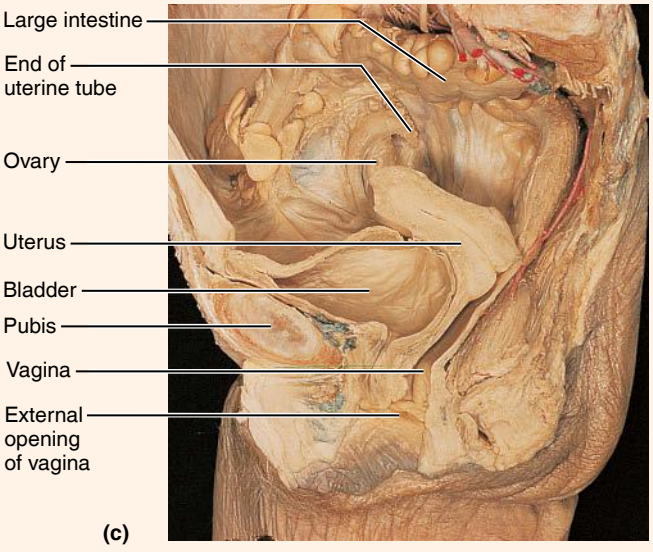


Figure 2.6 Human reproductive organs. (a) Male external genitalia. **(b)** Sagittal section of the male pelvis. **(c)** Sagittal section of the female pelvis.



Male Cadaver

Make a shallow incision into the **scrotum** (Figure 2.6a). Loosen and lift out the oval **testis**. Exert a gentle pull on the testis to identify the slender **ductus (vas) deferens**, which carries sperm from the testis superiorly into the abdominopelvic cavity and joins with the urethra (Figure 2.6b). The urethra runs through the penis and carries both urine and sperm out of the body. Identify the **penis**, extending from the bladder to the ventral body wall.

Female Cadaver

Inspect the pelvic cavity to identify the pear-shaped **uterus** lying against the dorsal body wall and superior to the bladder. Follow one of the **uterine tubes** superiorly to identify an **ovary**, a small oval structure at the end of the uterine tube (Figure 2.6c). The inferior part of the uterus is continuous with the **vagina**, which leads to the body exterior. Identify the **vaginal orifice** (external vaginal opening).

6. When you have finished your observations, rewrap or store the dissection animal or cadaver according to your instructor's directions. Wash the dissecting tools and equipment with laboratory detergent. Dispose of the gloves as instructed.

Activity 5

Examining the Human Torso Model

Examine a human torso model to identify the organs listed. Check off the boxes as you locate the organs. Some model organs will have to be removed to see the deeper organs.

- ☐ Adrenal gland
- ☐ Aortic arch
- ☐ Brain
- ☐ Diaphragm
- ☐ Esophagus
- ☐ Heart
- ☐ Inferior vena cava
- ☐ Kidneys
- ☐ Large intestine
- ☐ Liver
- ☐ Lungs
- ☐ Mesentery
- ☐ Pancreas
- ☐ Small intestine
- ☐ Spleen
- ☐ Stomach
- ☐ Thyroid gland
- ☐ Trachea
- ☐ Ureters
- ☐ Urinary bladder

Instructors may assign a portion of the Review Sheet questions using Mastering A&P™

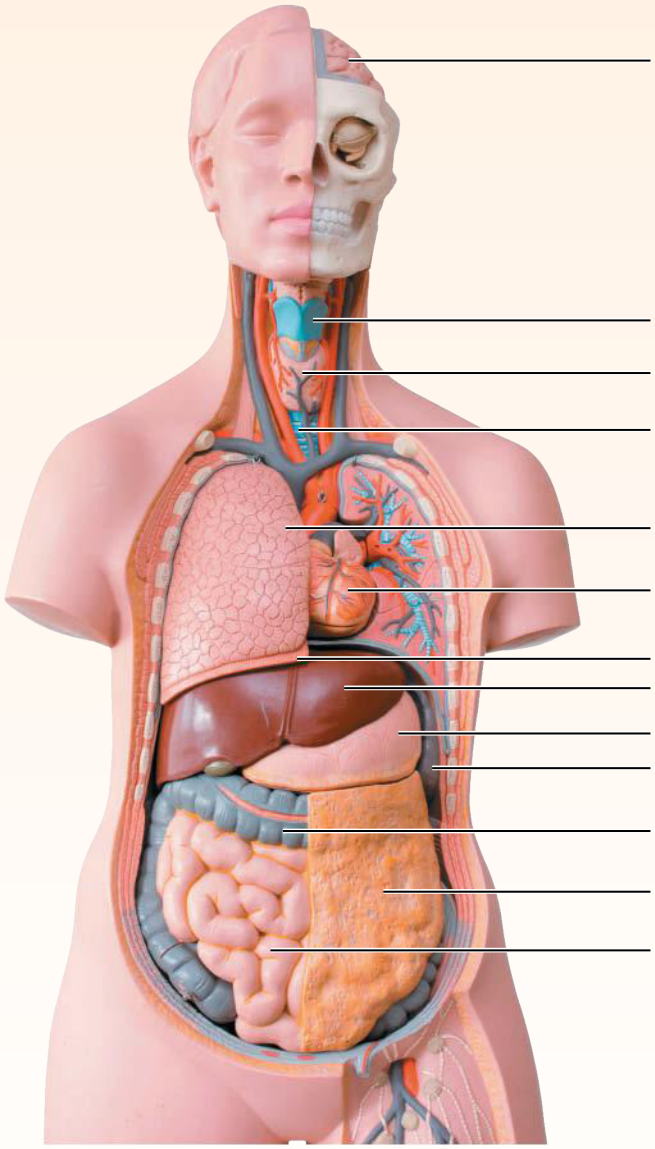
EXERCISE 2

REVIEW SHEET

Organ Systems Overview

Name _____ Lab Time/Date _____

1. Label each of the organs at the end of the supplied leader lines.



2. Name the *organ system* to which each of the following sets of organs or body structures belongs.

_____ 1. thymus, spleen, lymphatic vessels

_____ 2. bones, cartilages, tendons

_____ 3. pancreas, pituitary gland

_____ 4. trachea, bronchi, lungs

_____ 5. epidermis, dermis, cutaneous sense organs

_____ 6. testis, prostate

_____ 7. liver, large intestine, rectum

_____ 8. kidneys, ureter, urethra

3. Name the cells that are produced by the testes and ovaries. _____

_____

4. List the four primary tissue types. _____

_____

5. Explain why an artery is an organ. _____

_____

6. Name the two main organ systems that communicate within the body to maintain homeostasis. Briefly explain their different control mechanisms. _____

_____

_____

7. Explain the role that the skeletal system plays in facilitating cardiovascular system function. _____

_____

8. Untreated diabetes mellitus can lead to a condition in which the blood is more acidic than normal. Name two organ systems that play the largest role in compensating for acid-base imbalances. _____

_____

9. The mother of a child scheduled to receive a thymectomy (removal of the thymus gland) asks you whether there will be any side effects from the removal of the gland. Which two organ systems would you mention in your explanation?

_____

_____

10. Individuals with asplenia are missing their spleen or have a spleen that doesn't function well. It is recommended that these patients talk to their doctor about vaccines that are indicated for their health condition. Explain how this recommendation correlates to their chronic health condition. _____

_____

_____

EXERCISE 3

The Microscope

Learning Outcomes

- Identify the parts of the microscope, and list the function of each.
- Describe and demonstrate the proper techniques for care of the microscope.
- Demonstrate proper focusing technique.
- Define *total magnification*, *resolution*, *parfocal*, *field*, *depth of field*, and *working distance*.
- Measure the field diameter for one objective lens, calculate it for all the other objective lenses, and estimate the size of objects in each field.
- Discuss the general relationships between magnification, working distance, and field diameter.

Pre-Lab Quiz

Instructors may assign these and other Pre-Lab Quiz questions using Mastering **A&P™**

1. The microscope slide rests on the _____ while being viewed.
   a. base **c.** iris
   b. condenser **d.** stage
2. Your lab microscope is *parfocal*. What does this mean?
   a. The specimen is clearly in focus at this depth.
   b. The slide should be almost in focus when changing to higher magnifications.
   c. You can easily discriminate two close objects as separate.
3. If the ocular lens magnifies a specimen 10×, and the objective lens used magnifies the specimen 35×, what is the total magnification being used to observe the specimen? _____
4. How do you clean the lenses of your microscope?
   a. with a paper towel
   b. with soap and water
   c. with special lens paper and cleaner
5. Circle True or False. You should always begin observation of specimens with the oil immersion lens.

With the invention of the microscope, biologists gained a valuable tool to observe and study structures, such as cells, that are too small to be seen by the unaided eye. This exercise will familiarize you with the workhorse of microscopes—the compound microscope—and provide you with the necessary instructions for its proper use.

***Note to the Instructor:** The slides and coverslips used for viewing cheek cells are to be soaked for 2 hours (or longer) in 10% bleach solution and then drained. The slides and disposable autoclave bag containing coverslips, lens paper, and used toothpicks are to be autoclaved for 15 min at 121°C and 15 pounds pressure to ensure sterility. After autoclaving, the disposable autoclave bag may be discarded in any disposal facility, and the slides and glassware washed with laboratory detergent and prepared for use. These instructions apply as well to any bloodstained glassware or disposable items used in other experimental procedures.*

Go to Mastering A&P™ > Study Area to improve your performance in A&P Lab.

> Lab Tools > Pre-Lab Videos > Compound Microscope

Instructors may assign new Building Vocabulary coaching activities, Pre-Lab Quiz questions, Art Labeling activities, Pre-Lab Video Coaching Activities for The Compound Microscope, and more using the Mastering **A&P™** Item Library.

Materials*

- Compound microscope
- Millimeter ruler
- Prepared slides of the letter *e* or newsprint
- Immersion oil
- Lens paper
- Prepared slide of grid ruled in millimeters
- Prepared slide of three crossed colored threads
- Clean microscope slide and coverslip
- Toothpicks (flat-tipped)
- Physiological saline in a dropper bottle
- Iodine or dilute methylene blue stain in a dropper bottle
- Filter paper or paper towels
- Beaker containing fresh 10% household bleach solution for wet mount disposal
- Disposable autoclave bag
- Prepared slide of cheek epithelial cells

Care and Structure of the Compound Microscope

The **compound microscope** is a precision instrument and should always be handled with care. *At all times you must observe the following rules for its transport, cleaning, use, and storage:*

- When transporting the microscope, hold it in an upright position, with one hand on its arm and the other supporting its base. Do not swing the instrument during its transport or jar the instrument when setting it down.
- Use only special grit-free lens paper to clean the lenses. Use a circular motion to wipe the lenses, and clean all lenses before and after use.
- Always begin the focusing process with the scanning objective lens in position, changing to the higher-power lenses as necessary.
- Use the coarse adjustment knob only with the scanning objective lens.
- Always use a coverslip with wet mount preparations.
- Before putting the microscope in the storage cabinet, remove the slide from the stage, rotate the scanning objective lens into position, wrap the cord as directed, and replace the dust cover or return the microscope to the appropriate storage area.
- Never remove any parts from the microscope; inform your instructor of any mechanical problems that arise.

Activity 1

Identifying the Parts of a Microscope

1. Using the proper transport technique, obtain a microscope and bring it to the laboratory bench.

☐ Record the number of your microscope in the **Summary chart** (p. 28).

Compare your microscope with **Figure 3.1**, and identify the microscope parts described in **Table 3.1** on p. 29.

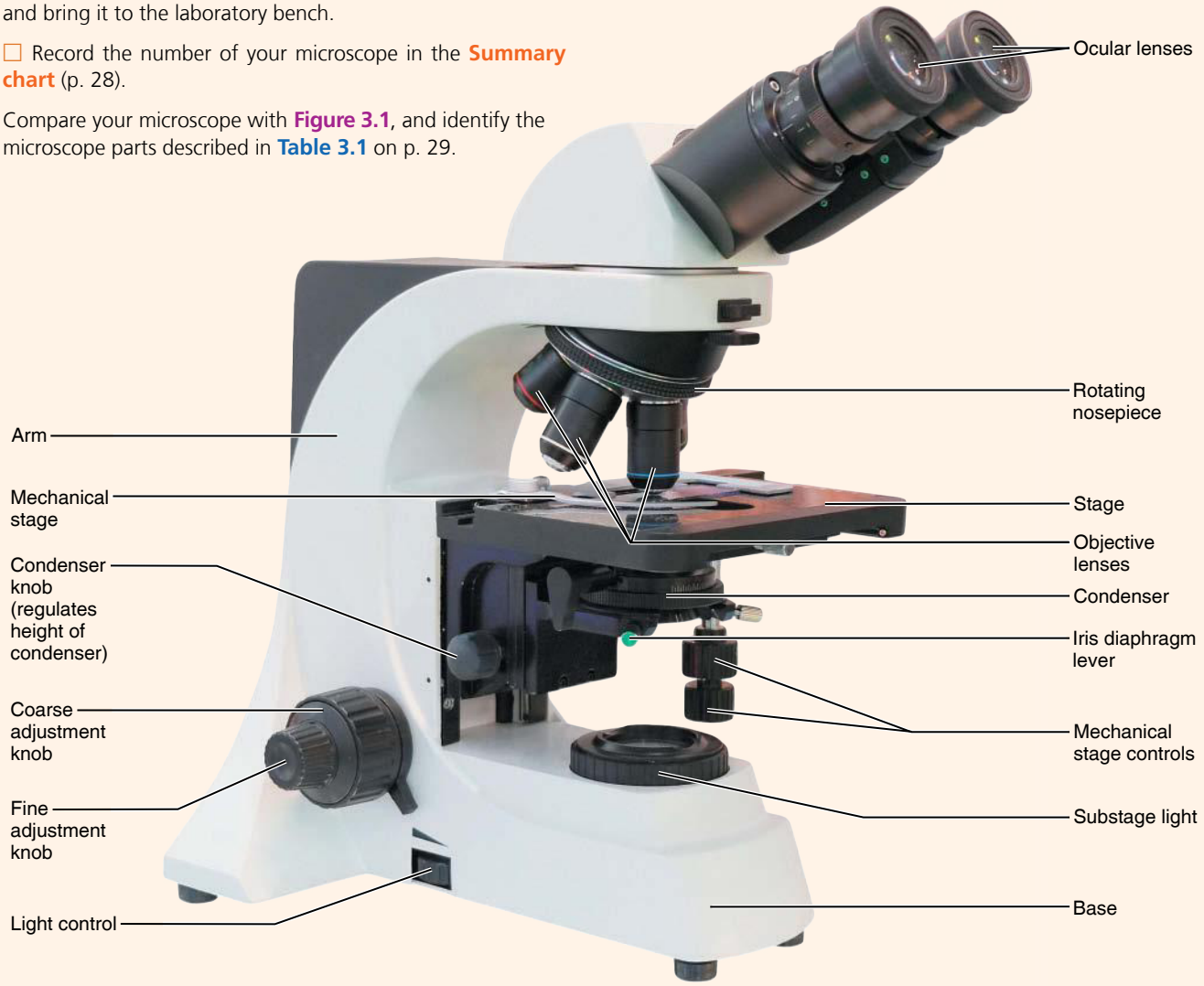


Figure 3.1 Compound microscope and its parts.

Instructors may assign this figure as an Art Labeling Activity using Mastering A&P™

2. Examine the objective lenses carefully; note their relative lengths and the numbers inscribed on their sides. On many microscopes, the scanning lens, with a magnification of 4×, is the shortest lens. The low-power objective lens typically has a magnification of 10×. The high-power objective lens is of intermediate length and has a magnification range from 40× to 50×. The oil immersion objective lens is usually the longest of the objective lenses and has a magnifying power of 100×. Some microscopes lack the oil immersion lens.

☐ Record the magnification of each objective lens of your microscope in the first row of the Summary chart (p. 28). Also, cross out any column relating to a lens that your microscope does not have.

Magnification and Resolution

The microscope is an instrument of magnification. With the compound microscope, magnification is achieved through the interplay of two lenses—the ocular lens and the objective lens. The objective lens magnifies the specimen to produce a **real image** that is projected to the ocular. This real image is magnified by the ocular lens to produce the **virtual image** that your eye sees (Figure 3.2).

The **total magnification** (TM) of any specimen being viewed is equal to the power of the ocular lens multiplied by the power of the objective lens used. For example, if the ocular lens magnifies 10× and the objective lens being used magnifies 45×, the total magnification is 450× (or 10 × 45).

- Determine the total magnification for each of the objectives on your microscope, and record the figures on the third row of the Summary chart.

The compound light microscope has certain limitations. Although the level of magnification is almost limitless, the **resolution** (or resolving power), that is, the ability to discriminate two close objects as separate, is not. The human eye can resolve objects about 100 µm apart, but the compound microscope has a resolution of 0.2 µm under ideal conditions. Objects closer than 0.2 µm are seen as a single fused image.

Resolution is determined by the amount and physical properties of the visible light that enters the microscope. In general, the more light delivered to the objective lens, the greater the resolution. The size of the objective lens aperture (opening) decreases with increasing magnification, allowing less light to enter the objective. Thus, you will probably find it necessary to increase the light intensity at the higher magnifications.

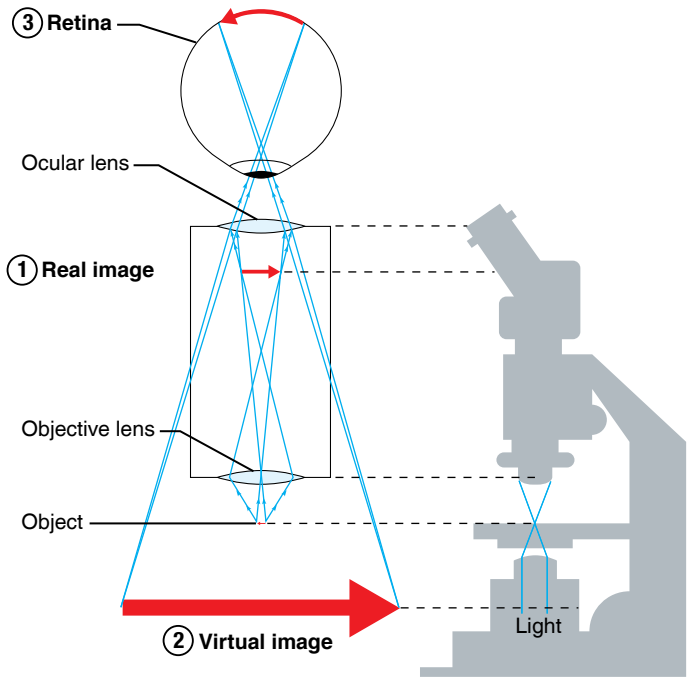


Figure 3.2 Image formation in light microscopy.
Step ① The objective lens magnifies the object, forming the real image. **Step** ② The ocular lens magnifies the real image, forming the virtual image. **Step** ③ The virtual image passes through the lens of the eye and is focused on the retina.

Activity 2

Instructors may assign a related Pre-Lab Video Coaching Activity using Mastering A&P™

Viewing Objects Through the Microscope

1. Obtain a millimeter ruler, a prepared slide of the letter *e* or newsprint, a dropper bottle of immersion oil, and some lens paper. Adjust the condenser to its highest position, and switch on the light source of your microscope.

2. Secure the slide on the stage so that you can read the slide label and the letter *e* is centered over the light beam passing through the stage. On the mechanical stage of your microscope, open the jaws of its slide holder by using the control lever, typically located at the rear left corner of the mechanical stage. Insert the slide squarely within the confines of the slide holder.

3. With your scanning objective lens in position over the stage, use the coarse adjustment knob to bring the objective lens and stage as close together as possible.

4. Look through the ocular lens and adjust the light for comfort using the iris diaphragm lever. Now use the coarse adjustment knob to focus slowly away from the *e* until it is as clearly focused as possible. Complete the focusing with the fine adjustment knob.

5. Sketch the letter *e* in the circle on the Summary chart (p. 28) just as it appears in the **field**—the area you see through the microscope.

How far is the bottom of the objective lens from the surface of the slide? In other words, what is the **working distance**? (See Figure 3.3.) Use a millimeter ruler to measure the working distance.

Record the working distance in the Summary chart.

Text continues on next page. →

How has the apparent orientation of the *e* changed top to bottom, right to left, and so on?

_____

_____

6. Move the slide slowly away from you on the stage as you view it through the ocular lens. In what direction does the image move?

_____

Move the slide to the left. In what direction does the image move?

_____

7. Today, most good laboratory microscopes are **parfocal**; that is, the slide should be in focus (or nearly so) at the higher magnifications once you have properly focused at the lower magnification. *Without touching the focusing knobs*, increase the magnification by rotating the next higher magnification lens into position over the stage. Make sure it clicks into position. Using the fine adjustment only, sharpen the focus. If you are unable to focus with a new lens, your microscope is not parfocal. Do not try to force the lens into position. Consult your instructor. Note the decrease in working distance. As you can see, focusing with the coarse adjustment knob could drive the objective lens through the slide, breaking the slide and possibly damaging the lens. Sketch the letter *e* in the Summary chart. What new details become clear?

_____

_____

As best you can, measure the distance between the objective and the slide.

Record the working distance in the Summary chart.

Is the image larger or smaller? _____

Approximately how much of the letter *e* is visible now?

_____

Is the field diameter larger or smaller? _____

Why is it necessary to center your object (or the portion of the slide you wish to view) before changing to a higher power?

_____

Move the iris diaphragm lever while observing the field. What happens?

_____

Is it better to increase *or* to decrease the light when changing to a higher magnification?

_____ Why? _____

_____

8. If you have just been using the low-power objective, repeat the steps given in direction 7 using the high-power objective lens. What new details become clear?

_____

_____

Record the working distance in the Summary chart.

Summary Chart for Microscope #____

	Scanning	Low power	High power	Oil immersion
Magnification of objective lens	_____ ×	_____ ×	_____ ×	_____ ×
Magnification of ocular lens	10 ×	10 ×	10 ×	10 ×
Total magnification	_____ ×	_____ ×	_____ ×	_____ ×
Working distance	_____ mm	_____ mm	_____ mm	_____ mm
Detail observed letter *e*	◯	◯	◯	◯
Field diameter	_____ mm _____ µm	_____ mm _____ µm	_____ mm _____ µm	_____ mm _____ µm

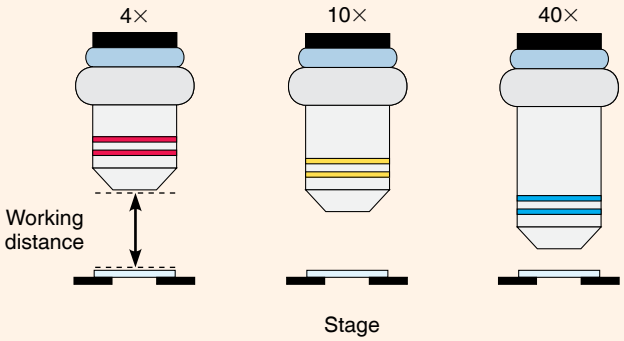


Figure 3.3 Relative working distances of the 4×, 10×, and 40× objectives.

9. Without touching the focusing knob, rotate the high-power lens out of position so that the area of the slide over the opening in the stage is unobstructed. Place a drop of immersion oil over the *e* on the slide and rotate the oil immersion lens into position. Set the condenser at its highest point (closest to the stage), and open the diaphragm fully. Adjust the fine focus and fine-tune the light for the best possible resolution.

Note: *If for some reason the specimen does not come into view after adjusting the fine focus, do not go back to the 40× lens to recenter. You do not want oil from the oil immersion lens to cloud the 40× lens. Turn the revolving nosepiece in the other direction to the low-power lens, and recenter and refocus the object. Then move the immersion lens back into position, again avoiding the 40× lens. Sketch the letter* e *in the Summary chart. What new details become clear?*

_____

_____

Is the field diameter again decreased in size? _____

As best you can, estimate the working distance, and record it in the Summary chart. Is the working distance less *or* greater than it was when the high-power lens was focused?

_____

Compare your observations on the relative working distances of the objective lenses with the illustration in **Figure 3.3**. Explain why it is desirable to begin the focusing process at the lowest power.

_____

_____

10. Rotate the oil immersion lens slightly to the side, and remove the slide. Clean the oil immersion lens carefully with lens paper, and then clean the slide in the same manner with a fresh piece of lens paper.

Table 3.1 Parts of the Microscope

Microscope part	Description and function
Base	The bottom of the microscope. Provides a sturdy flat surface to support and steady the microscope.
Substage light	Located in the base. The light from the lamp passes directly upward through the microscope.
Light control	Located on the base or arm. This dial allows you to adjust the intensity of the light passing through the specimen.
Stage	The platform that the slide rests on while being viewed. The stage has a hole in it to allow light to pass through the stage and through the specimen.
Mechanical stage	Holds the slide in position for viewing and has two adjustable knobs that control the precise movement of the slide.
Condenser	Small nonmagnifying lens located beneath the stage that concentrates the light on the specimen. The condenser may have a knob that raises and lowers the condenser to vary the light delivery. Generally, the best position is close to the inferior surface of the stage.
Iris diaphragm lever	The iris diaphragm is a shutter within the condenser that can be controlled by a lever to adjust the amount of light passing through the condenser. The lever can be moved to close the diaphragm and improve contrast. If your field of view is too dark, you can open the diaphragm to let in more light.
Coarse adjustment knob	This knob allows you to make large adjustments to the height of the stage to initially focus your specimen.
Fine adjustment knob	This knob is used for precise focusing once the initial coarse focusing has been completed.
Head	Attaches to the nosepiece to support the objective lens system. It also provides for attachment of the eyepieces which house the ocular lenses.
Arm	Vertical portion of the microscope that connects the base and the head.
Nosepiece	Rotating mechanism connected to the head. Generally, it carries three or four objective lenses and permits positioning of these lenses over the hole in the stage.
Objective lenses	These lenses are attached to the nosepiece. Usually, a compound microscope has four objective lenses: scanning (4×), low-power (10×), high-power (40×), and oil immersion (100×) lenses. Typical magnifying powers for the objectives are listed in parentheses.
Ocular lens(es)	Binocular microscopes will have two lenses located in the eyepieces at the superior end of the head. Most ocular lenses have a magnification power of 10×. Some microscopes will have a pointer and/or reticle (micrometer), which can be positioned by rotating the ocular lens.

The Microscope Field

The microscope field decreases with increasing magnification. Measuring the diameter of each of the microscope fields will allow you to estimate the size of the objects you view in any field. For example, if you have calculated the field diameter to be 4 mm and the object being observed extends across half this diameter, you can estimate that the length of the object is approximately 2 mm.

Microscopic specimens are usually measured in micrometers and millimeters, both units of the metric system. You can get an idea of the relationship and meaning of these units from Table 3.2. A more detailed treatment appears in the appendix.

Table 3.2 Comparison of Metric Units of Length

Metric unit	Abbreviation	Equivalent
Meter	m	(about 39.37 in.)
Centimeter	cm	10^{-2} m
Millimeter	mm	10^{-3} m
Micrometer (or micron)	µm (µ)	10^{-6} m
Nanometer	nm (mµ)	10^{-9} m

(Refer to the Getting Started exercise on MasteringA&P for tips on metric conversions.)

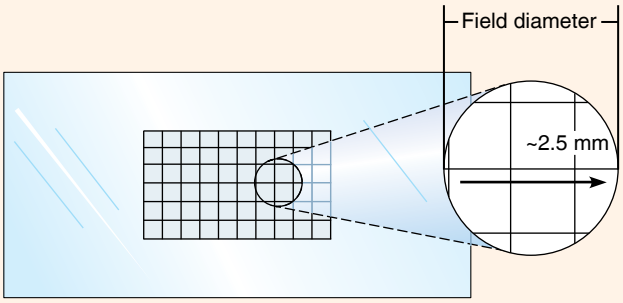
Activity 3

Instructors may assign a related Pre-Lab Video Coaching Activity using Mastering A&P™

Estimating the Diameter of the Microscope Field

1. Obtain a grid slide, which is a slide prepared with graph paper ruled in millimeters. Each of the squares in the grid is 1 mm on each side. Use your scanning objective lens to bring the grid lines into focus.

2. Move the slide so that one grid line touches the edge of the field on one side, and then count the number of squares you can see across the diameter of the field. If you can see only part of a square, as in the accompanying diagram, estimate the part of a millimeter that the partial square represents.



Record this figure in the appropriate space marked "field diameter" on the Summary chart (p. 28). (If you have been using the scanning lens, repeat the procedure with the low-power objective lens.)

Complete the chart by computing the approximate diameter of the high-power and oil immersion fields. The general formula for calculating the unknown field diameter is:

Diameter of field *A* × total magnification of field *A* = diameter of field *B* × total magnification of field *B*

where *A* represents the known or measured field and *B* represents the unknown field. This can be simplified to

$$\text{Diameter of field } B = \frac{\text{diameter of field } A \times \text{total magnification of field } A}{\text{total magnification of field } B}$$

For example, if the diameter of the low-power field (field *A*) is 2 mm and the total magnification is 50×, you would compute the diameter of the high-power field (field *B*) with a total magnification of 100× as follows:

Field diameter *B* = (2 mm × 50)/100

Field diameter *B* = 1 mm

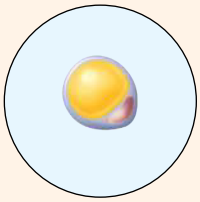
3. Estimate the length (longest dimension) of the following drawings of microscopic objects. *Base your calculations on the field diameters you have determined for your microscope and the approximate percentage of the diameter that the object occupies.* The first one is done for you.

Fat cell seen in 400× (total magnification, TM) field:

Field diameter = 0.4 mm = 400 µm

Portion of the field diameter occupied by the object = 1/3

Approximate length = 133 µm

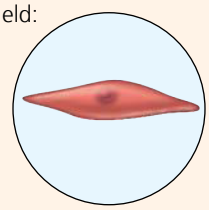


Smooth muscle cell seen in 400× (TM) field:

approximate length:

_____ mm

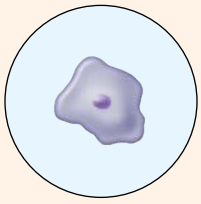
or _____ µm



Cheek cell seen in oil immersion field:

approximate length:

_____ µm



Perceiving Depth

Any microscopic specimen has depth as well as length and width; it is rare indeed to view a tissue slide with just one layer of cells. Normally you can see two or three cell thicknesses. Therefore, it is important to learn how to determine relative depth with your microscope. In microscope work, the **depth of field** (the thickness of the plane that is clearly in focus) is greater at lower magnifications. As magnification increases, depth of field decreases.

Activity 4

Perceiving Depth

1. Obtain a slide with colored crossed threads. Focusing at low magnification, locate the point where the three threads cross each other.

2. Use the iris diaphragm lever to greatly reduce the light, thus increasing the contrast. Focus down with the coarse adjustment until the threads are out of focus, then slowly focus upward again, noting which thread comes into clear focus first. Observe: As you rotate the adjustment knob forward (away from you), does the stage rise or fall? If the stage rises, then the first clearly focused thread is the top one; the last clearly focused thread is the bottom one.

If the stage descends, how is the order affected?_____

_____

Record your observations, relative to which color of thread is uppermost, middle, or lowest:

Top thread _____

Middle thread _____

Bottom thread _____

Viewing Cells Under the Microscope

There are various ways to prepare cells for viewing under a microscope. One method is to mix the cells in physiological saline (called a *wet mount*) and stain them.

If you are not instructed to prepare your own wet mount, obtain a prepared slide of epithelial cells to make the observations in step 10 of Activity 5.

Activity 5

Instructors may assign a related Pre-Lab Video Coaching Activity using Mastering A&P™

Preparing and Observing a Wet Mount

1. Obtain the following: a clean microscope slide and coverslip, two flat-tipped toothpicks, a dropper bottle of physiological saline, a dropper bottle of iodine or methylene blue stain, and filter paper (or paper towels). Handle only your own slides throughout the procedure.

2. Place a drop of physiological saline in the center of the slide. Using the flat end of the toothpick, *gently* scrape the inner lining of your cheek. Transfer your cheek scrapings to the slide by agitating the end of the toothpick in the drop of saline (**Figure 3.4a** on p. 32).

Immediately discard the used toothpick in the disposable autoclave bag provided.

3. Add a tiny drop of the iodine or methylene blue stain to the preparation. (These epithelial cells are nearly transparent and thus difficult to see without the stain, which colors the nuclei of the cells.) Stir again, using a second toothpick.

Immediately discard the used toothpicks in the disposable autoclave bag provided.

4. Hold the coverslip with your fingertips so that its bottom edge touches one side of the drop (Figure 3.4b), then *slowly* lower the coverslip onto the preparation (Figure 3.4c). *Do not just drop the coverslip*, or you will trap large air bubbles under it, which will obscure the cells. *Always use a coverslip with a wet mount* to protect the lens.

5. Examine your preparation carefully. The coverslip should be tight against the slide. If there is excess fluid around its edges, you will need to remove it. Obtain a piece of filter paper, fold it in half, and use the folded edge to absorb the excess fluid.

Text continues on next page. →

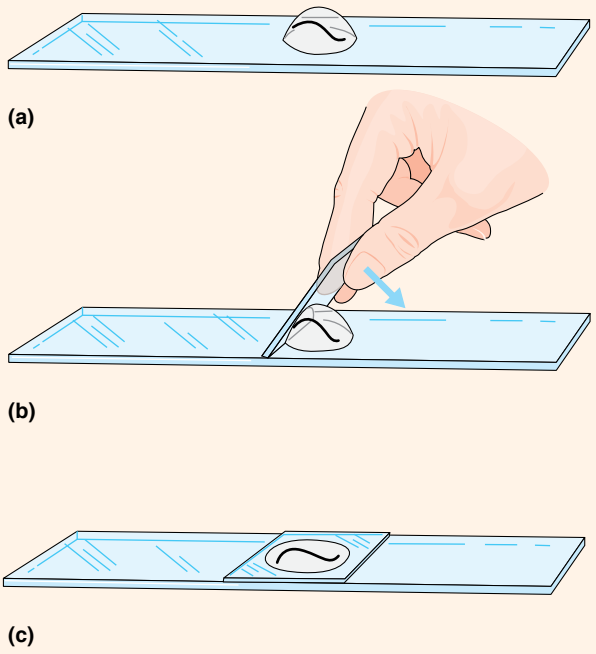


Figure 3.4 Procedure for preparation of a wet mount. **(a)** Place the object in a drop of water (or saline) on a clean slide; **(b)** hold a coverslip at a 45° angle with the fingertips; and **(c)** lower the coverslip slowly.

Before continuing, discard the filter paper or paper towel in the disposable autoclave bag.

6. Place the slide on the stage, and locate the cells at the lowest power. You will probably want to dim the light to provide more contrast for viewing the lightly stained cells.

7. Cheek epithelial cells are very thin, flat cells. In the cheek, they provide a smooth, tilelike lining (**Figure 3.5**). Move to high power to examine the cells more closely.

8. Make a sketch of the epithelial cells that you observe.

Use information on your Summary chart (p. 28) to estimate the diameter of cheek epithelial cells. Record the total magnification (TM) used.

_____ µm _____ × (TM)

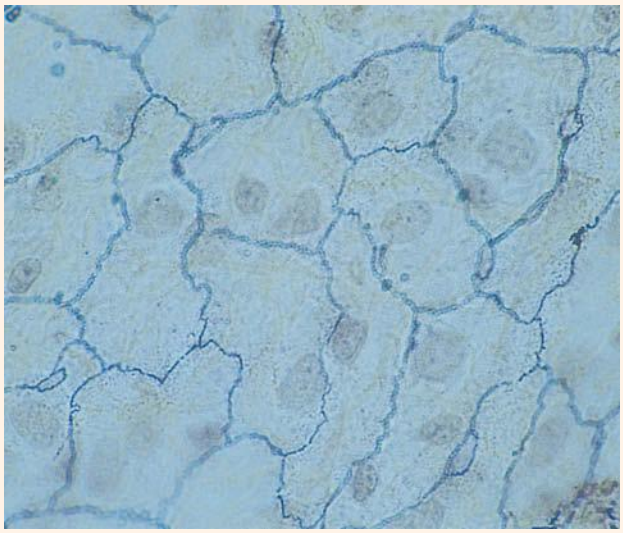


Figure 3.5 Epithelial cells of the cheek cavity (surface view, 600×).

Why do *your* cheek cells look different from those in Figure 3.5? (Hint: What did you have to *do* to your cheek to obtain them?)

_____

_____

9. When you complete your observations of the wet mount, dispose of your wet mount preparation in the beaker of bleach solution, and put the coverslips in an autoclave bag.

10. Obtain a prepared slide of cheek epithelial cells, and view them under the microscope.

Estimate the diameter of one of these cheek epithelial cells using information from the Summary chart (p. 28).

_____ µm _____ × (TM)

Why are these cells more similar to those in Figure 3.5 and easier to measure than those of the wet mount?

_____

_____

_____

11. Before leaving the laboratory, make sure all other materials are properly discarded or returned to the appropriate laboratory station. Clean the microscope lenses, and return the microscope to the storage cabinet.

Instructors may assign a portion of the Review Sheet questions using Mastering A&P™

EXERCISE 3

REVIEW SHEET
The Microscope

Name _____ Lab Time/Date _____

Care and Structure of the Compound Microscope

1. Label all indicated parts of the microscope.

2. Explain the proper technique for transporting the microscope.

_____

3. Each of the following statements is either true or false. If true, write *T* on the answer blank. If false, correct the statement by writing on the blank the proper word or phrase to replace the one that is underlined.

_____ 1. The microscope lens may be cleaned <u>with any soft tissue</u>.

_____ 2. The microscope should be stored with the <u>oil immersion</u> lens in position over the stage.

_____ 3. When beginning to focus, use the <u>scanning objective</u> lens.

_____ 4. When focusing on high power, always use the <u>coarse</u> adjustment knob to focus.

_____ 5. A coverslip should always be used <u>with wet mounts</u>.

4. Match the microscope structures in column B with the statements in column A that identify or describe them.

Column A

_____ 1. platform on which the slide rests for viewing

_____ 2. used to adjust the amount of light passing through the specimen

_____ 3. controls the movement of the slide on the stage

_____ 4. delivers a concentrated beam of light to the specimen

_____ 5. used for precise focusing once initial focusing has been done

_____ 6. carries the objective lenses; rotates so that the different objective lenses can be brought into position over the specimena.

Column B

a. coarse adjustment knob
b. condenser
c. fine adjustment knob
d. iris diaphragm lever
e. mechanical stage
f. nosepiece
g. objective lenses
h. ocular lens
i. stage

5. Define the following terms.

total magnification: _____

_____

resolution: _____

Viewing Objects Through the Microscope

6. Complete, or respond to, the following statements:

_____ 1. The distance from the bottom of the objective lens to the surface of the slide is called the _____.

_____ 2. Assume there is an object on the left side of the field that you want to bring to the center (that is, toward the apparent right). In what direction would you move your slide? _____.

_____ 3. The area of the slide seen when looking through the microscope is the _____.

_____ 4. If a microscope has a 10× ocular lens and the total magnification is 950×, the objective lens in use at that time is _____ ×.

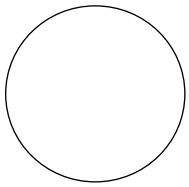
_____ 5. Why should the light be dimmed when looking at living (nearly transparent) cells?

_____ 6. If, after focusing in low power, you need to use only the fine adjustment to focus the specimen at the higher powers, the microscope is said to be _____.

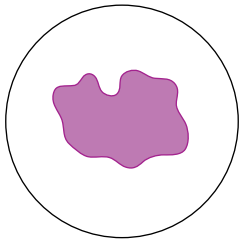
_____ 7. You are using a 10× ocular and a 15× objective, and the field diameter is 1.5 mm. The approximate field size with a 30× objective is _____ mm.

_____ 8. If the diameter of the low-power field is 1.5 mm, an object that occupies approximately a third of that field has an estimated diameter of _____ mm.

7. You have been asked to prepare a slide with the letter *F* on it (as shown below). In the circle below, draw the *F* as seen in the low-power field.



8. Estimate the length (longest dimension) of the object in µm:



Total magnification = 100×

Field diameter = 1.6 mm

Length of object = _____ µm

9. Say you are observing an object in the low-power field. When you switch to high power, it is no longer in your field of view.

Why might this occur? _____

_____

What should you do initially to prevent this from happening? _____

_____

10. Do the following factors increase or decrease as one moves to higher magnifications with the microscope?

resolution: _____ amount of light needed: _____

working distance: _____ depth of field: _____

11. A student has the high-power lens in position and appears to be intently observing the specimen. The instructor, noting a working distance of about 1 cm, knows the student isn't actually seeing the specimen.

How so? _____

12. Describe the proper procedure for preparing a wet mount.

_____

_____

_____

13. Indicate the probable cause of the following situations during use of a microscope.

a. Only half of the field is illuminated: _____

_____

b. The visible field does not change as the mechanical stage is moved: _____

_____

14. A blood smear is used to diagnose malaria. In patients with malaria, the protozoa can be found near and inside red blood cells. Explain why a microscope capable of high magnification and high resolution would be needed to diagnose malaria.

_____

_____

15. Histopathology is the use of microscopes to view tissues to diagnose and track the progression of diseases. Why are thin slices of tissue ideal for this procedure? _____

_____