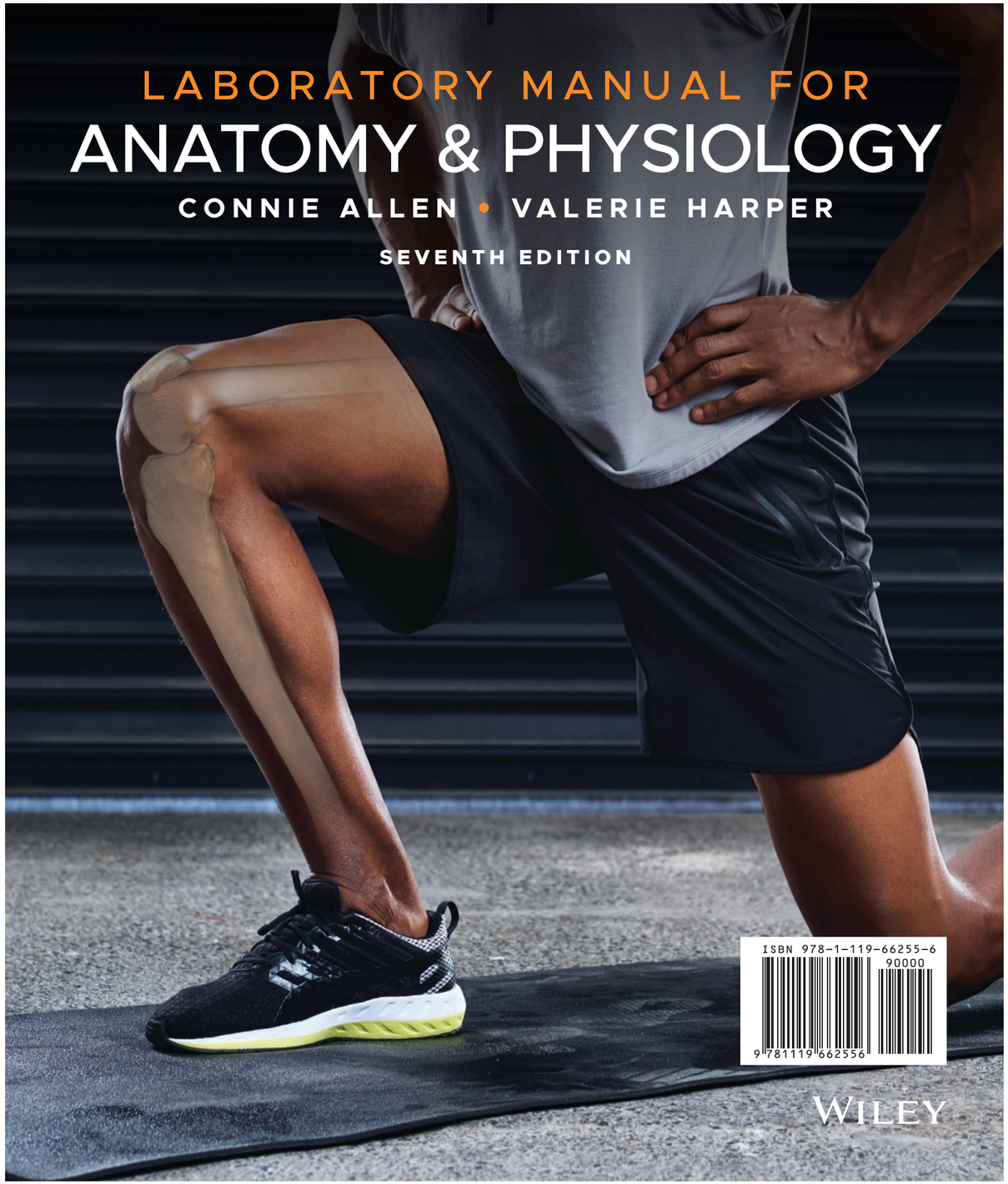
Cover Design: Wiley
Cover Images: © PeopleImages/Getty Images, Mark Nielsen

www.wiley.com

WILEY

Wiley Loose-Leaf Print Edition



7th
EDITION

Laboratory Manual for Anatomy and Physiology

This book is dedicated to my husband Jim, who showed me love, motivation, and patience when I worked long hours; and to our three children Burke, Brittany, and Michaela; and to our six grandchildren Michael, Jaxton, Jaden, Gianna, Taralyn, and Cassidy.

—Connie Allen

To my husband Chuck, thank you for your love, support, and all the dinners you made while I was working. To my children Scott and Kate, thank you for your support and the text messages that made me laugh.

—Valerie Harper

7th EDITION

Laboratory Manual for Anatomy and Physiology

CONNIE ALLEN
Edison State College, Professor Emeritus

VALERIE HARPER
Colorado Mesa University

WILEY

SVP, PUBLISHING STRATEGY AND QUALITY	Elizabeth Widdicombe
EXECUTIVE EDITOR	Natalie Ruffatto
ASSISTANT EDITOR	Georgia Larsen
FREELANCE EXECUTIVE EDITOR	Patrick Farace
SENIOR MARKETING MANAGER	Brittany Hammond
SENIOR MANAGER, COURSE DEVELOPMENT AND PRODUCTION	Svetlana Barskaya
SENIOR COURSE PRODUCTION OPERATIONS SPECIALIST	Lauren Freestone
SENIOR COURSE CONTENT DEVELOPER	Laura Byrnes
EDITORIAL ASSISTANT	Samantha Hart
SENIOR CREATIVE PRODUCT DESIGNER	Thomas Nery
TYPESETTING	Lumina Datamatics, Inc.
COVER DESIGN	Wiley
COVER PHOTO	© PeopleImages/Getty Images

This book was typeset in 10/12 Times LT Std at Lumina Datamatics.

Student Edition: 978-1-119-66255-6
Evaluation Copy: 978-1-119-74062-9

The inside back cover will contain printing identification and country of origin if omitted from this page. In addition, if the ISBN on the back cover differs from the ISBN on this page, the one on the back cover is correct.

Library of Congress Cataloging-in-Publication Data

Names: Allen, Connie, 1945- author. | Harper, Valerie, author.
Title: Laboratory manual for anatomy and physiology / Connie Allen, Edison State College Emeritus, Valerie Harper, Colorado Mesa University.
Description: Seventh edition. | Hoboken : Wiley, [2021] | Includes index.
Identifiers: LCCN 2020043246 (print) | LCCN 2020043247 (ebook) | ISBN 9781119662556 (paperback) | ISBN 9781119740384 (adobe pdf) | ISBN 9781119662617 (epub)
Subjects: LCSH: Human anatomy—Laboratory manuals. | Human physiology—Laboratory manuals.
Classification: LCC QM34 .A396 2021 (print) | LCC QM34 (ebook) | DDC 612—dc23
LC record available at https://lccn.loc.gov/2020043246
LC ebook record available at https://lccn.loc.gov/2020043247

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Preface

Anatomy and physiology is a challenging course, and this laboratory manual is written to help students meet that challenge. It is written for students interested in allied health fields, such as nursing; physical, respiratory, cardiovascular, or occupational therapy; radiology; and dental hygiene. This manual may be used with any two-semester anatomy and physiology textbook.

The design of this laboratory manual is based on the authors' experience as anatomy and physiology instructors and uses three learning preferences: visual, auditory, and kinesthetic.

When students label diagrams, they focus on the structure rather than just the dot at the end of a line. Writing out the structure's name and pronouncing it reinforces learning. Also, having students become subjects of laboratory exercises personalizes the learning process. Animal dissections give students an opportunity to physically manipulate structures, comparing location and texture, and to observe how structures are supported, protected, and attached by connective tissue.

Special Features Incorporated in this Laboratory Manual Include:

- This lab manual can be used for online anatomy and physiology classes. Many lab activities can be performed by students at home or used in the laboratory. Online students can also use the **Real Anatomy** Virtual Dissection program and **PowerPhys** simulated lab activities to enhance their learning.
- Just enough text is provided to introduce concepts in each section and to set up and support the laboratory section. The exercises are written so students do not need their textbooks to complete the laboratory activities.
- New material is divided into small segments, starting with simple diagrams, illustrating the basic concepts and building up to more complex diagrams. Subsequent activities add to the students' knowledge in a stepwise fashion. This is especially noticed in the skeletal and muscular exercises.
- Each exercise contains a list of objectives, materials needed for the exercise, and easily identifiable laboratory activity sections.
- Unlabeled four-color drawings, photographs, and photomicrographs are included for students to label either at home or in the laboratory. Students first write out the name of the structure to help learn it. Then the completed diagrams will be used to identify structures on models.
- Physiology experiments use students as subjects and can be completed with either simple, inexpensive equipment and materials or more complex lab setups.
- Experimental report sections after physiology experiments ask students to make predictions, collect and analyze data, and write simple lab reports.
- Discussion Questions are within the activities to make the students think about the material presented.
- An Answer Key is provided at the end of the laboratory manual for the activities in each exercise. Students receive immediate feedback, and they are not dependent on the instructor for the correct answers.
- "Reviewing Your Knowledge" and "Using Your Knowledge" sections follow the activities at the end of each exercise. "Reviewing Your Knowledge" provides a thorough review of the material in the exercise, whereas "Using Your Knowledge" requires students to apply information learned. Either or both of these sections may be handed in to the instructors for a grade, because neither section has answers in the back of the laboratory manual.
- Biopac Laboratory Guide Experiments are available online for several exercises.

New Features to the Seventh Edition

- Revised Exercise 5: New Osmosis and Diffusion experiment
- Revised Exercises 9 and 10: New bone photos
- Updated drawings in many exercises
- Updated terminology
- 3D interactives where students can manipulate structures, interact with images, and listen to narrated explanations of physiological concepts to dive deeper into complex physiologic processes.

Lastly, our lab manual was written to accompany any textbook, but it has been carefully revised concurrently with Tortora/Derrickson's Principles of Anatomy and Physiology 16th Edition. Tortora and Derrickson's focus on homeostasis has always been our favorite hallmark feature of their book, which is also published by Wiley. The 16th edition contains many new 3D Interactives, updated terminology, and numerous new "Clinical Connections" – which link the relevance of anatomy and physiology to professional, clinical, and everyday life.

Instructor Resources

- Text Illustrations & Tables in JPEG
- Text Illustrations in PowerPoint (Editable)
- Animation Worksheet Answer Keys
- Real Anatomy Worksheet Answer Keys
- PowerPhys Lab Report Answer Keys

- Reviewing Your Knowledge Answer Keys
- Using Your Knowledge Answer Keys
- Anatomy and Physiology Visual Library
- Anatomy Overviews and Animations PowerPoint Slides
- Discussion Questions and Answers
- Differential White Blood Cell Activity
- Study Objectives

For instructor access to these valuable resources, please contact your Wiley sales representative.

Acknowledgments

We deeply appreciate the support, instruction, and encouragement from the members of our editorial, production, and marketing team at Wiley: Natalie Ruffatto, Patrick Farace, Linda Muriello, Trish McFadden, Lauren Freestone, Laura Byrnes, Brittany Hammond, Georgia Larsen, Samantha Hart, and Lumina Datamatics, Inc. We would like to express our special thanks to Amanda Rosenzweig of Delgado Community College for her keen eye, her suggestions that made the lab manual better, and her invaluable assistance during the development and production of this book. We have truly enjoyed working with her! We also wish to thank Gerard Tortora and Bryan Derrickson for producing a wonderful textbook that provided many illustrations and ideas for our laboratory manual. A special thank you to Susan Baxley for reviewing all the exercises and making suggestions and to Bob Clemence for allowing us to use his figure of the Respiratory Volumes and Capacities. A special thanks to Charles Harper for answering many clinical questions.

We also wish to thank Wynne Au Yeung at Imagineering Art for the artwork she provided for our laboratory manual. Thank you to our colleagues at Edison State College: Bob Clemence, Colleen Swanson, Jody Gootkin, Richard McCoy, Jeff Davis, Dick Felden, Lyman O'Neil, Kitty Gronlund, Tony Contino, Cheryl Black, Jed Wolfson, Jay Koepke, and Roy Hepner who encouraged us, answered our questions, and provided critiques of exercises. We also wish to thank Nicole Yarbrough George for her critique of the skeletal muscle chapter. Thank you to Chaim Jay Margolin of Regional Radiology Associates and David Michie of Clinical Physiology Associates for providing images for this manual. Special thanks to SOMSO for providing images for our online Anatomy Drill and Practice: Anatomical Models section. Thanks to contributors Jerri Lindsey, Tarrant County College, and Terry Thompson, Wor-Wic Community College.

Additionally, we are grateful to the following colleagues who provided their valuable feedback by reviewing our 7th edition manuscript:

Pat Clark, Indiana University-Purdue University Indianapolis
Gary Glaser, Genesee Community College
James J. Bolton, Odessa College
Ann Caplea, Walsh University
Zoe Soon, University of British Columbia Okanagan
Victor Alvarez, Delaware Technical Community College
Kristen Hutchins, Howard Payne University
Javanika Moody, Anne Arundel Community College
Jeanine Page, Lock Haven University
Shannon McNew, Southeast Missouri State University
Eric Sun, Middle Georgia State University

Contents

EXERCISE

Anatomical Language

1

OBJECTIVES

1. Describe the anatomical position
2. Use anatomical and directional terms correctly
3. Identify the various body planes and sections

MATERIALS

- human models or anatomical charts
- apples (1 per group) and plastic knives or scalpels
- plastic tubing (eight-inch piece per group) or plastic straw
- 5 sheep brains (for class demonstration)

Anatomical terms describe body positions, body regions, specific body areas, and landmarks. Most of these words are derived from Latin or Greek and are often part of the names of muscles, bones, nerves, and blood vessels. Learning these terms at this time will help you throughout the course.

A. Body Position

The **anatomical position** is the reference position anatomists and people in medical fields use to describe the location of body parts or regions. In the anatomical position, the body is erect (vertical) and facing forward; the arms are straight and at the sides of the body with the palms facing forward; the legs are straight with the feet facing forward and flat (Figure 1.1).

In the **supine position**, the body is horizontal and lying on the back. In the **prone position**, the body is horizontal and lying on the stomach.

B. Body Regions

Body regions refer to specific areas of the body. It is important that you learn the correct boundaries for each region. The main body regions are the head, neck, trunk, upper limbs, and lower limbs. The **head** consists of the **skull** (cranial and facial bones), and **face** (anterior portion of the head comprised of the forehead, eyes, nose, mouth, cheeks, and chin). The **neck** connects the head to the trunk.

The **trunk** consists of the **chest** (area between neck and diaphragm) that contains the heart and lungs, the **abdomen** (area between the diaphragm and hip bones) that contains digestive organs, the **pelvis** (area below abdomen that contains internal reproductive organs and urinary bladder), and the **back** (posterior portion of trunk between neck and buttocks).

The **upper limb** consists of the **shoulder** (curved area where arm attaches to upper border of trunk), **arm** (area between shoulder and elbow), **forearm** (area between elbow and wrist), and **hand** (wrist, palm, fingers).

The **lower limb** consists of **the buttocks** (rounded area on posterior surface where thigh attaches to trunk), **groin** (area on anterior surface where lower limb attaches to pelvis), **thigh** (area of lower limb between the groin anteriorly, buttocks posteriorly, and knee), **leg** (area of lower limb between knee and ankle), and **foot** (includes ankle, sole, toes).

Many anatomical terms have one or more word roots with a prefix and/or a suffix added. For example, in the word *antecubital*, *ante-* is a prefix meaning before or in front of, the word root *cubit-* means elbow, *-al* is a suffix meaning pertaining to. Table 1.1 contains anatomical terms with four different suffixes, all of which mean pertaining to. These suffixes are *-al*, *-ic*, *-ar*, and *-ary.* When suffixes like these are added to word roots they form adjectives, whereas nouns have different endings such as *-um*, *-us*, *-is*,

and *-a.* For example, *stern-* is a word root meaning chest; *sternum* is the noun and *sternal* is the adjective. Anatomical terms and their definitions are found in Table 1.1. Word roots and their definitions are found in Appendix A, as well as nouns and adjectives formed from the word roots.

Before Going to Lab

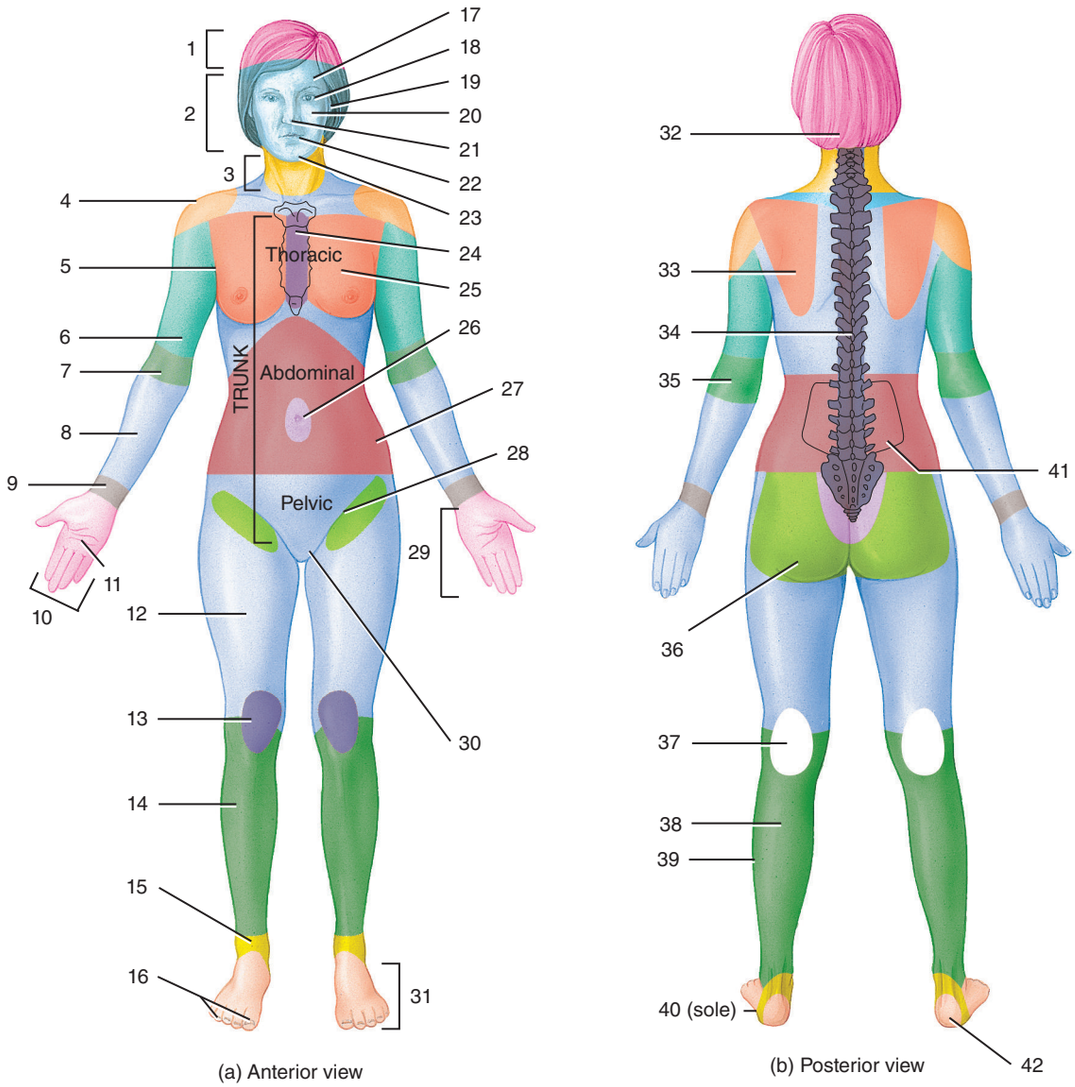
1. Label Figure 1.1 with the appropriate anatomical terms for each body region or area. Refer to Table 1.1.
2. Refer to Appendix A to review how word roots, suffixes, and prefixes are combined to form nouns and adjectives.

LAB ACTIVITY 1 Anatomical Terms

1. Use anatomical and common terms to identify the specific body regions or areas on models, anatomical charts, or yourself.

TABLE 1.1 Anatomical Terms

TERM	DEFINITION	TERM	DEFINITION
AXIAL	Pertaining to the central part of the body, the head and trunk	**APPENDICULAR**	Pertaining to the extremities or limbs
		Upper Limb (Appendage)	
Cephalic (se-FAL-ik)	Pertaining to the head	• Acromial (a-KROM-ee-al)	Pertaining to the highest point of the shoulder
• Cranial	Pertaining to the portion of the skull surrounding the brain	• Axillary (AX-il-ary)	Pertaining to the armpit
		• Brachial (BRAY-key-ul)	Pertaining to the arm
• Facial	Pertaining to the face	• Antecubital (an-teh-KYOO-bi-tul)	Pertaining to the anterior (front) surface of the elbow
• Frontal	Pertaining to the forehead	• Olecranal (oh-LEK-ra-nul)	Pertaining to the posterior (back) surface of the elbow
• Orbital	Pertaining to the eye		
• Otic (OH-tik)	Pertaining to the ear	• Antebrachial	Pertaining to the forearm
• Nasal	Pertaining to the nose	• Carpal	Pertaining to the wrist
• Buccal (BUCK-al)	Pertaining to the cheek	• Manual	Pertaining to the hand
• Oral	Pertaining to the mouth	• Palmar	Pertaining to the palm of the hand
• Mental	Pertaining to the chin		
• Occipital (ox-SIP-i-tal)	Pertaining to the back of head	• Digital	Pertaining to the digits (fingers)
		Lower Limb (Appendage)	
Cervical	Pertaining to the neck	• Inguinal (ING-won-ul)	Pertaining to the groin where the thigh attaches to the pelvis
Thoracic	Pertaining to the chest		
• Sternal	Pertaining to the breast bone	• Gluteal (GLUE-tee-ul)	Pertaining to the buttocks
• Pectoral	Pertaining to the chest	• Femoral (FEM-or-ul)	Pertaining to the thigh
• Mammary	Pertaining to the breast	• Patellar (pa-TEL-ur)	Pertaining to the anterior (front) surface of the knee
Abdominal	Pertaining to the abdomen		
• Umbilical (um-BIL-ih-cal)	Pertaining to the navel	• Popliteal (pop-lih-TEE-ul)	Pertaining to the posterior (back) surface of the knee
• Coxal (COX-al)	Pertaining to the hip		
Pelvic	Pertaining to the pelvis	• Crural (CROO-rul)	Pertaining to the anterior (front) surface of the leg
• Pubic (PYOO-bik)	Pertaining to the genital area		
Dorsal	Pertaining to the back	• Fibular (FIB-you-lur) or peroneal (peh-RONE-ee-ul)	Pertaining to the lateral side of the leg
• Scapular	Pertaining to the shoulder blade region		
		• Sural (SIR-ul)	Pertaining to the posterior (back) surface of the leg
• Vertebral (ver-TEE-brul)	Pertaining to the spinal column		
		• Tarsal (TAR-sul)	Pertaining to the ankle
• Lumbar	Pertaining to the area of the back between the lowest rib and buttocks.	• Pedal	Pertaining to the foot
		• Plantar	Pertaining to the sole of foot
		• Calcaneal (kal-KANE-ee-ul)	Pertaining to the heel
		• Digital	Pertaining to the digits (toes)



(a) Anterior view

(b) Posterior view

(a) Anterior View

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____
11 _____
12 _____
13 _____
14 _____
15 _____
16 _____
17 _____
18 _____
19 _____
20 _____
21 _____
22 _____
23 _____
24 _____
25 _____
26 _____
27 _____
28 _____
29 _____
30 _____
31 _____

(b) Posterior View

32 _____
33 _____
34 _____
35 _____
36 _____
37 _____
38 _____
39 _____
40 _____
41 _____
42 _____

FIGURE 1.1 Anatomical terms.

C. Directional Terms

Directional terms are used to describe the location of body structures relative to other structures. An example of a directional term is *inferior*, which means below. It would be correct to say that the neck is inferior to the head but incorrect to say that the neck is inferior. The directional terms are listed in Table 1.2, along with an example of how they are used. Note that opposite terms are paired.

The directional terms *proximal* and *distal* apply to the point of attachment of a limb to the torso or the point of origin of a structure such as a blood vessel or nerve. These terms refer to the location of structures relative to the point of attachment or point of origin, whether they are closer (proximal) or farther away (distal).

More than one directional term can apply to describe the location of a body structure. For example, the ears are posterior and lateral to the nose.

Before Going to Lab

1 Label Figure 1.2 with the directional terms from the bulleted list by writing the term in the appropriate numbered blank.

LAB ACTIVITY 2 Directional Terms

1 With your partner, complete the sentences using the appropriate directional term from Table 1.2. Refer to the anatomical terms in Table 1.1 and Appendix A as needed.

a. The sternum is _____ to the vertebrae.

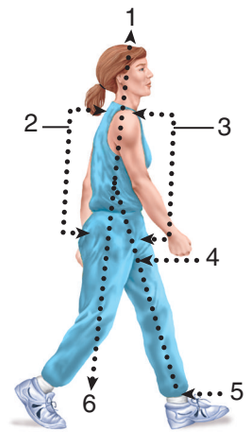
b. The nose is _____ and _____ to the eyes.

c. The heart is _____ to the lungs.

d. The wrist is _____ to the arm.

e. The right lung and right kidney are _____ .

f. The skin is _____ to the bones. ■



- anterior or ventral 1 _____
- distal 2 _____
- inferior 3 _____
- posterior or dorsal 4 _____
- proximal 5 _____
- superior 6 _____

FIGURE 1.2 Directional terms.

TABLE 1.2 Directional Terms

DIRECTIONAL TERM	DEFINITION	EXAMPLE OF USE
Superior	Above	The head is superior to the neck.
Inferior	Below	The neck is inferior to the head.
Anterior (Ventral)	Closer to front of body	The lips are anterior to the teeth.
Posterior (Dorsal)	Closer to back of body	The teeth are posterior to the lips.
Medial	Closer to midline of body	The nose is medial to the eyes.
Lateral	Farther from midline of body	The eyes are lateral to the nose.
Intermediate	Between two structures	The elbow is intermediate between the shoulder and wrist.
Ipsilateral	On same side of body	The right arm and right leg are ipsilateral.
Contralateral	On opposite sides of body	The right arm and left arm are contralateral.
Proximal	Nearer to point of attachment of limb to trunk or nearer to the origin of a structure	The elbow is proximal to the wrist. The small intestine is proximal to the large intestine.
Distal	Farther from point of attachment of limb to trunk or farther from the origin of a structure	The wrist is distal to the elbow. The small intestine is distal to the stomach.
Superficial	Closer to surface of body	The skin is superficial to the muscles.
Deep	Farther from surface of body	The muscles are deep to the skin.

D. Body Planes and Sections

Planes are flat surfaces that divide the body or organs in order to expose internal structures (Figure 1.3). The exposed surfaces produced by planes are called **sections. Sagittal** (*sagitta* = arrow) **planes** pass vertically through the body or organs and divide them into right and left sections **(sagittal sections).**

If a plane passes vertically through the midline and divides the body into equal right and left halves, the plane is a **midsagittal plane,** but if a plane divides the body into unequal right and left portions, it is a **parasagittal plane.**

A **frontal** or **coronal plane** passes vertically through the body or organs and produces anterior and posterior sections **(frontal sections).** A **transverse plane** passes horizontally through the body and produces superior and inferior sections **(transverse sections** or **cross-sections). Oblique planes** pass through the body at an angle forming oblique sections.

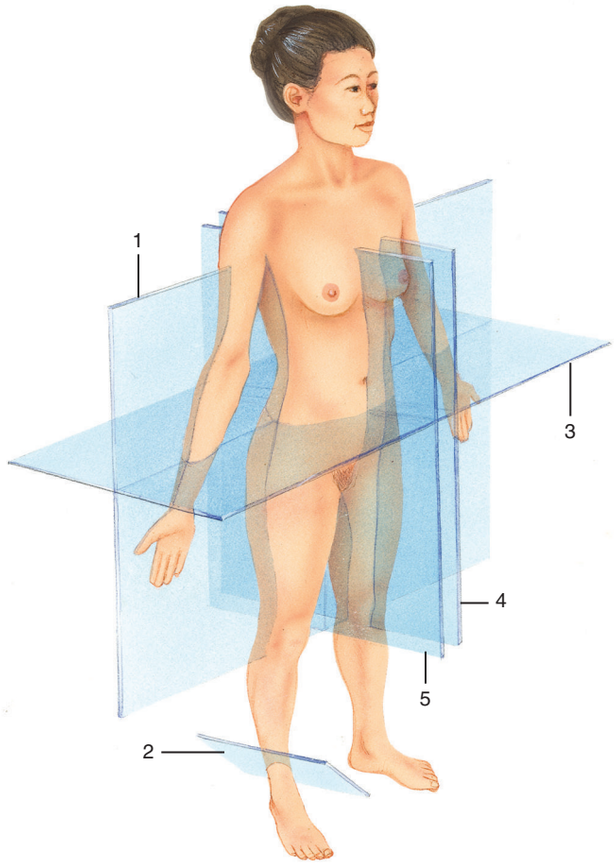
We often look at sections of individual organs, such as blood vessels, intestines, or long bones. Sections that are produced by a plane running along the long axis of a long narrow structure are called **longitudinal sections.** Sections that are produced by a plane running perpendicular to the long axis are called **cross-sections.** Because blood vessels and intestines twist and bend, one body plane may produce longitudinal sections, cross-sections, and oblique sections of these structures.

CLINICAL NOTE: *Transverse sections observed with computed tomography (CT) scans or magnetic resonance imaging (MRIs) are called* ***axial sections****.*

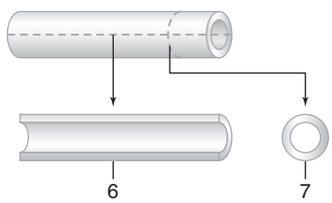
Before Going to Lab

1 Label the planes in Figures 1.3(a) and the sections in Figure 1.3(b) with the terms in the accompanying bulleted list by writing the term in the appropriate numbered blank.

2 Identify the type of sections of the human brain in Figure 1.4.



(a) Right anterolateral view



(b) Longitudinal and cross-sections

- cross-section 1 _____
- frontal plane 2 _____
- longitudinal section 3 _____
- midsagittal plane 4 _____
- oblique plane 5 _____
- parasagittal plane 6 _____
- transverse plane 7 _____

FIGURE 1.3 Body planes and sections.

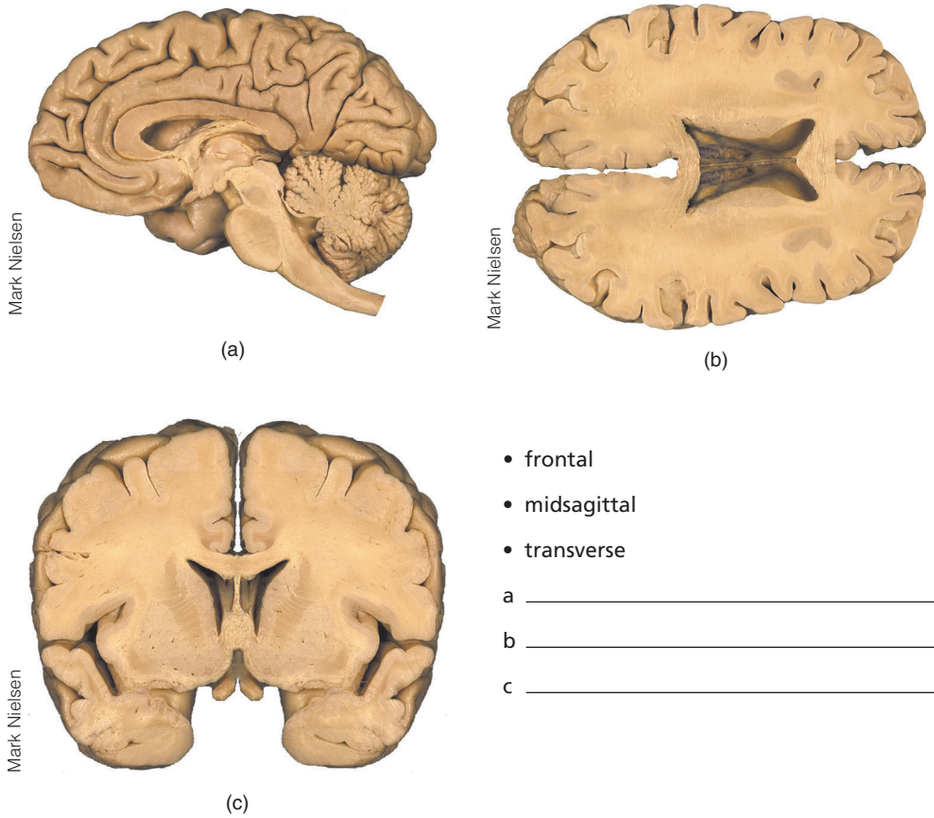


FIGURE 1.4 **Human brain sections.**

LAB ACTIVITY 3 Body Planes and Sections

1 Observe sagittal, frontal, and transverse sections using an apple.
- Working in a group, draw a face on the apple.
- Cut sagittal, frontal, and transverse planes through the apple to make sagittal, frontal, and transverse sections.
- Compare the appearance of the apple core in each section. Describe any difference in shape, size, and number of seed chambers.
- Keep sections together to form a whole apple to show to your instructor.

2 Observe longitudinal sections and cross-sections using plastic tubing or plastic straw.
- Observe a demonstration provided by your instructor of a tube cut along its longitudinal axis to produce a longitudinal section and a tube cut perpendicular to its longitudinal axis to produce a cross-section.
- Obtain an eight-inch piece of plastic tubing or plastic straw and twist it so you can visualize one plane that would simultaneously divide one area of the tube into a longitudinal section and another area into a cross-section.
- Do not cut the tube unless instructed to do so.
- Show your instructor where a cut would produce both a longitudinal section and a cross-section.

3 Identify sagittal, frontal, transverse, and oblique sections on sheep brains.
- Your instructor will display five sheep brains—one whole brain and four brains that have been cut into different sections.
- Determine the anterior, posterior, superior, and inferior surfaces of the brains.
- Decide which brain has been cut into sagittal, frontal, transverse, or oblique sections.
- Compare the appearance of the different sections.

Brain 1—Whole brain

Brain 2 _____ section

Brain 3 _____ section

Brain 4 _____ section

Brain 5 _____ section

Name _____ Date _____ Section _____

Reviewing Your Knowledge

EXERCISE 1

A. Body Regions

Identify the body regions using common terms.

_____ **1.** The area between the groin and knee.

_____ **2.** The area between the shoulder and elbow.

_____ **3.** The area between the elbow and wrist.

_____ **4.** The area between the knee and ankle.

_____ **5.** The area of the trunk between the neck and diaphragm.

_____ **6.** The area of the trunk between the diaphragm and hip bones.

_____ **7.** The area of the trunk inferior to the hip bones.

_____ **8.** Posterior trunk that is located between the neck and buttocks.

_____ **9.** Curved area where upper limb attaches to upper border of trunk.

_____ **10.** Area on anterior surface where lower limb attaches to pelvis.

_____ **11.** Rounded area on posterior surface where lower limb attaches to pelvis.

_____ **12.** Under arm area where upper limb attaches to trunk.

_____ **13.** The leg is to the lower limb as the ____ is to the upper limb.

_____ **14.** The arm is to the upper limb as the ____ is to the lower limb.

_____ **15.** The armpit is to the upper limb as the ____ is to the lower limb.

_____ **16.** The ankle is to the lower limb as the ____ is to the upper limb.

_____ **17.** The elbow is to the upper limb as the ____ is to the lower limb.

_____ **18.** The shoulder is to the upper limb as the ____ is to the lower limb.

_____ **19.** True or False. The hand includes the wrist and fingers and the foot includes the ankles and toes.

_____ **20.** True or False. The bones of the face are also part of the skull.

B. Anatomical Terms

Write the anatomical terms that the phrase or word describes. Phrases or words referring to nouns are indicated. All other phrases refer to adjectives.

_____ **1.** Navel (noun)

_____ **2.** Pertaining to the area between the neck and abdomen

_____ **3.** Pertaining to the ear

_____ **4.** Pertaining to the palm of hand

_____ **5.** Pertaining to the high point of the shoulder

_____ **6.** Pertaining to the anterior surface of the elbow region

_____ **7.** Pertaining to the face; anterior portion of the head

_____ **8.** Pertaining to the nose

_____ **9.** Pertaining to the neck

_____ **10.** Pertaining to the posterior surface of the knee

_____ **11.** Wrist (noun)

_____ **12.** Pertaining to the area between the elbow and wrist

_____ **13.** Back (noun)

_____ **14.** Armpit area (noun)

_____ **15.** Pertaining to the mouth

_____ **16.** Pertaining to the anterior surface of the knee

_____ **17.** Breast bone (noun)

_____ **18.** Pertaining to the hip

_____ **19.** Pertaining to the lateral side of the leg

_____ **20.** Pertaining to the calf

_____ **21.** Pertaining to the area between the shoulder and elbow

_____ **22.** Pertaining to the fingers or toes

_____ **23.** Pertaining to the hand

_____ **24.** Pertaining to the breast

_____ **25.** Pertaining to the cheek

_____ **26.** Pertaining to the heel

_____ **27.** Pertaining to the sole of the foot

_____ **28.** Pertaining to the groin where the thigh attaches to the pelvic region

_____ **29.** Pertaining to the head

_____ **30.** Pertaining to the chin

_____ **31.** Pertaining to the foot

_____ **32.** Pertaining to the eye

_____ **33.** Pertaining to the genital area

_____ **34.** Pertaining to the area between the hip and knee

_____ **35.** Pertaining to the area that includes the bones enclosing the brain

_____ **36.** Pertaining to the forehead

_____ **37.** Pertaining to the spinal column

_____ **38.** Pertaining to the inferior back of the head

_____ **39.** Pertaining to the anterior surface of the leg

_____ **40.** Pertaining to the area of the lower back or loin

_____ **41.** Pertaining to the trunk below the abdomen

_____ **42.** Pertaining to the area of the back that contains the shoulder blades

_____ **43.** Pertaining to the posterior surface of the elbow

_____ **44.** Arm (noun)

_____ **45.** Two terms pertaining to the chest

C. Body Planes and Sections

Write the name of the plane that the phrase describes.

_____ **1.** Divides body or organ into unequal right and left sections

_____ **2.** Divides body or organ into anterior and posterior sections

_____ **3.** Divides body or organ into superior and inferior sections

_____ **4.** Divides body into right and left halves

_____ **5.** Which two planes when passed through the body would result in two sections, with each section containing a piece of the heart and a piece of each lung?

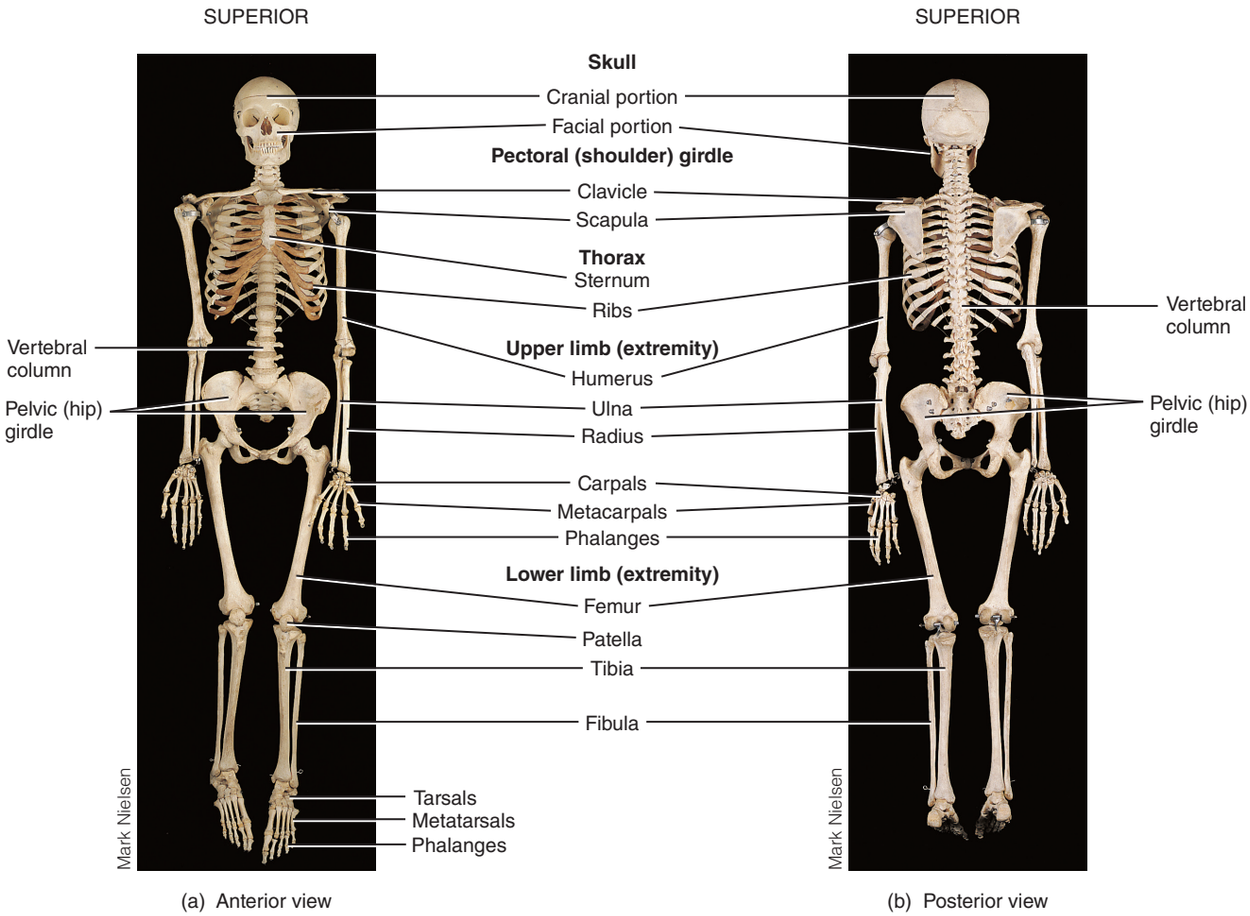


FIGURE 1.5 Human skeleton.

D. Directional Terms

Complete the sentences using directional terms. Use Figure 1.5 for reference.

1. The clavicle is _____ to the ribs.
2. The ribs are _____ to the sternum.
3. The humerus is _____ to the radius.
4. The ulna is _____ to the radius.
5. The tibia is _____ to the femur.
6. The right humerus and the right radius are _____.
7. The pelvic girdle is _____ to the ribs.
8. The sternum is _____ to the vertebral column.
9. The scapula is _____ to the clavicle.
10. The right fibula and left fibula are _____.

Name _____ Date _____ Section _____

Using Your Knowledge

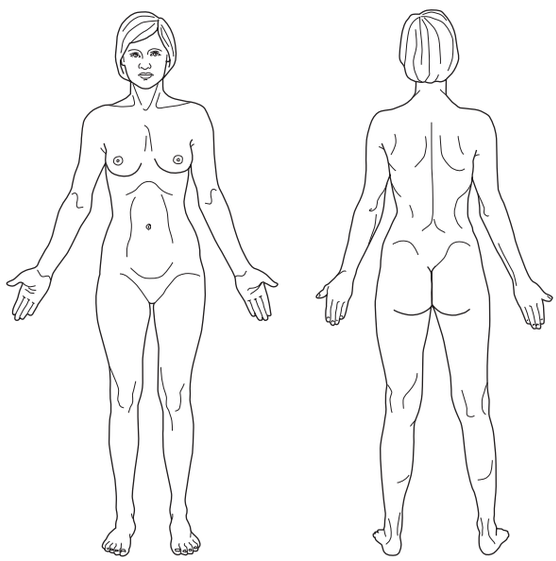
EXERCISE 1

A. Body Regions, Anatomical Terminology, and Directional Terms

1. A 55-year-old male presented with an irregularly shaped and abnormally pigmented mole in the left scapular region, just lateral to the vertebrae. Indicate on Figure 1.6 where this mole is likely to be found.

2. A 37-year-old female presented to the emergency room with a severe burn (3rd degree) on the right brachial region just proximal to the antecubital region. Indicate on Figure 1.6 where the laceration is likely to be found.

3. A 19-year-old female was identified by a tattoo on the fibular surface of the right leg just proximal to the tarsal region. Indicate on Figure 1.6 where the tattoo is likely to be found.



(a) Anterior view (b) Posterior view

FIGURE 1.6 Body regions, anatomical language, and directional terms.

Questions 4-7 each contain an italicized word. These words are derived from the word roots that are also used to form the adjectives in Table 1.1. Using the locations suggested by the italicized words, answer questions 4–7.

4. Is the *popliteal* artery proximal or distal to the *femoral* artery?

5. Is the *pectoralis* major muscle anterior or posterior to the *subscapularis* muscle?

6. Is the *sternocleidomastoid* muscle superior or inferior to the *rectus abdominis* muscle?

7. Are the *thoracic* vertebrae medial or lateral to the *scapulae*?

B. Body Planes and Sections

Figure 1.7 contains three different sections through the thorax. Indicate which section (view a, b, or c) is a

8. Frontal section _____

9. Sagittal section _____

10. Transverse (axial) section _____

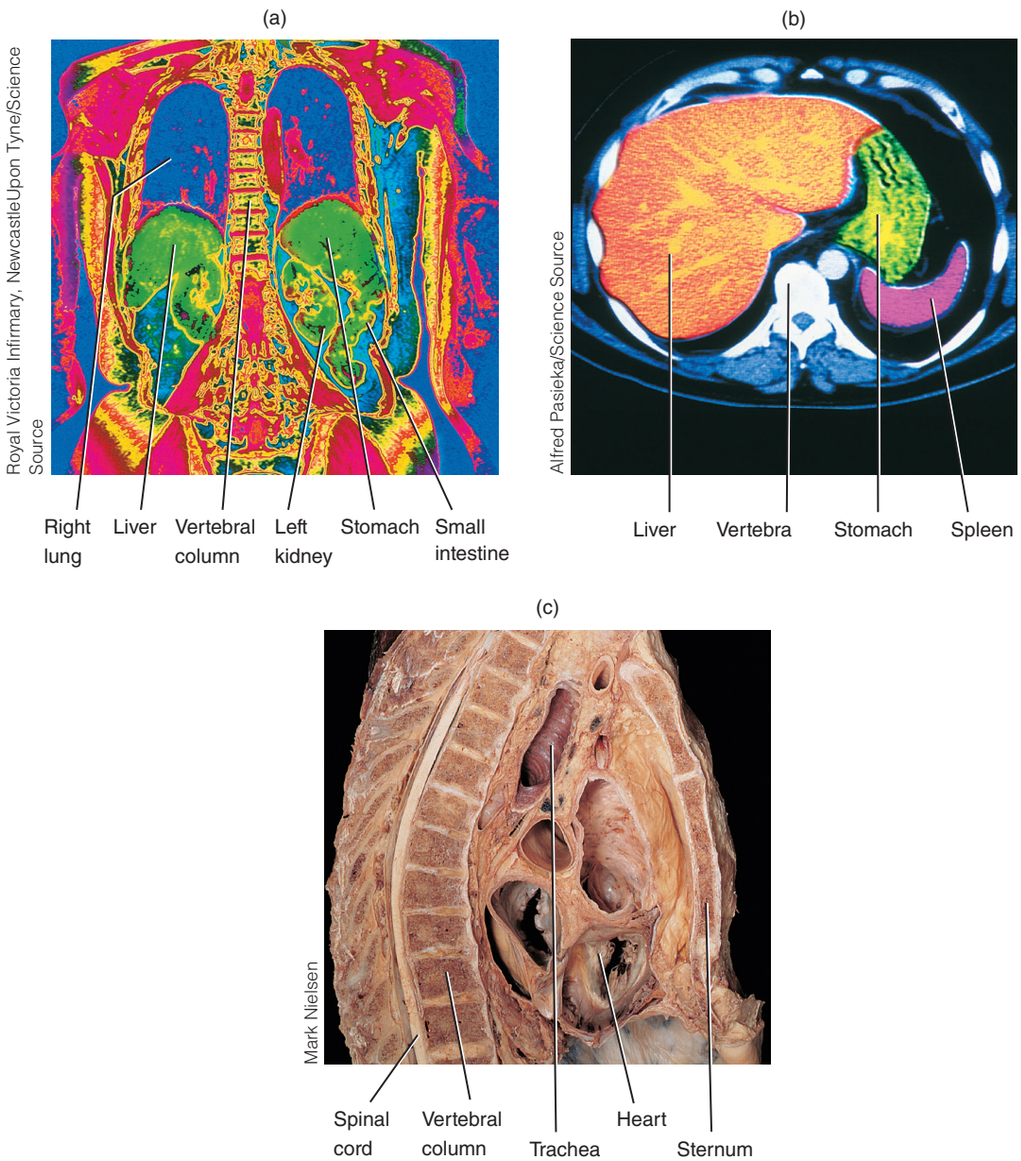


FIGURE 1.7 Sections through the thorax.

EXERCISE

Organ Systems and Body Cavities

2

OBJECTIVES

1. Name the organ systems and describe the functions of each
2. Name and identify the major organs of each organ system
3. Describe the location of the body cavities and name the organs they contain
4. Describe the structure, location, and function of the serous membranes
5. Identify the abdominopelvic quadrants and regions and the major organs found in each

MATERIALS

- human torso models or charts
- male and female human reproductive models or charts
- paper or plastic large enough to outline student torsos, markers
- articulated skeleton
- one-gallon zippered plastic bags (1 per group)
- masking tape
- rat dissection video in the Wiley Student Companion Site

Organ systems are like different departments within a company. Within a company, departments work together to keep the company functioning. Within the body, organ systems work together to keep the body alive. In this exercise, you will learn the basic function and location of each organ system.

Before Going to Lab

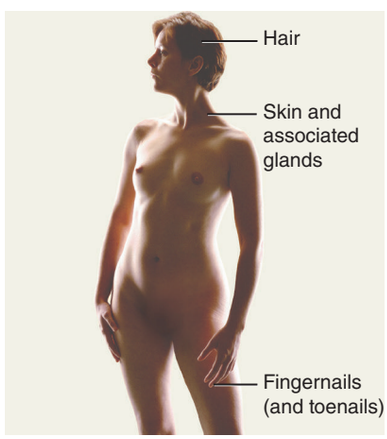
1. Review organ system functions and major organs in Table 2.1
2. Label the organ systems in Figure 2.1. Refer to Table 2.1.

A. Overview of Organ Systems and Major Organs

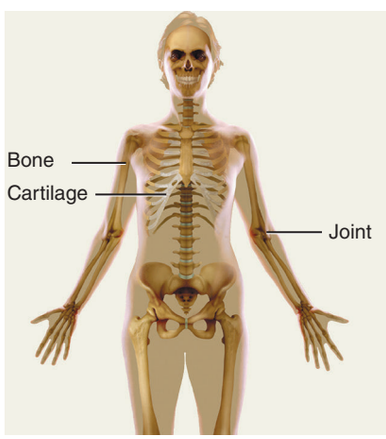
An **organ system** is a group of organs performing a common function. All organ systems cooperate to maintain an optimal environment for body cells through a process called **homeostasis** (*homeo-* = same; *stasis* = standing). Failure to maintain homeostasis results in disorders, disease, and possibly death.

TABLE 2.1 Functions and Major Organs of the Organ Systems

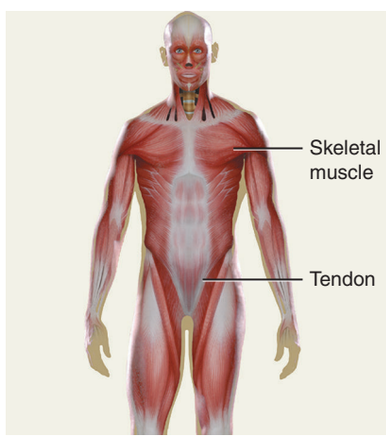
ORGAN SYSTEM	FUNCTION AND MAJOR ORGANS
Cardiovascular	Transports nutrients, chemical messengers, gases, and wastes in blood *Major organs: heart and blood vessels*
Respiratory	Adds oxygen to blood and removes carbon dioxide from blood; produces sound; maintains body fluid pH *Major organs: nose, pharynx (throat), larynx, trachea, bronchi, lungs*
Digestive	Breaks down food into units that can be absorbed into the body, eliminates wastes and non-digestible fiber in food *Major organs: mouth, salivary glands, pharynx, esophagus, stomach, intestines, pancreas, liver, gallbladder*
Urinary	Removes nitrogenous wastes; maintains body fluid volume, pH, and electrolyte levels through urine production *Major organs: kidneys, ureters, urinary bladder, urethra*
Integumentary	Provides a protective barrier for the body and aids in production of vitamin D; eliminates some waste; contains sensory receptors for pain, touch, and temperature; fat provides insulation *Major organs: skin and skin structures (hair, nails, sweat glands, oil glands)*
Lymphatic and Immune	Returns fluid to blood; carries dietary lipids from GI tract to blood; detects and eliminates disease-causing organisms *Major organs: lymphatic vessels, lymph nodes, spleen, thymus, bone marrow, tonsils*
Skeletal	Protects major organs; provides levers and support for body movement; bone marrow contains stem cells that produce blood cells, and is site for maturation of lymphocytes *Major organs: bones and cartilage*
Muscular	Moves bones and maintains posture; major source of body heat *Major organs: skeletal muscles and tendons*
Nervous	Controls cell function with electrical signals; helps control body homeostasis *Major organs: brain, spinal cord, nerves*, and *special sense organs*
Endocrine	Controls cell function with hormones; helps control body homeostasis *Major organs: hypothalamus, pituitary gland, pineal gland, thymus, thyroid gland, pancreas, adrenal glands, ovaries, testes*
Reproductive	Produces gametes and sex hormones; female uterus provides environment for development of fetus *Major organs in male: testes, ductus deferens, penis* *Major organs in female: ovaries, uterine tubes, uterus, vagina*



1 _____

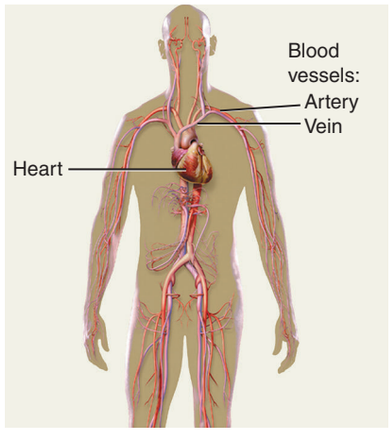


2 _____

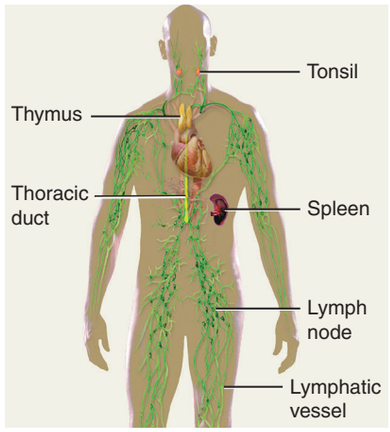


3 _____

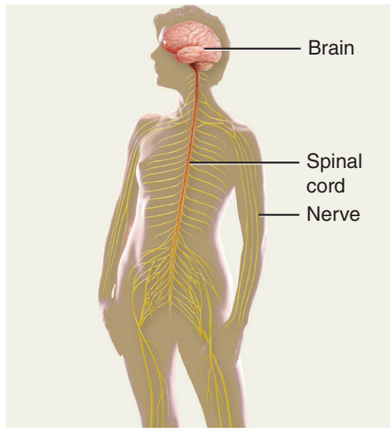
FIGURE 2.1 Selected organs and organ systems.



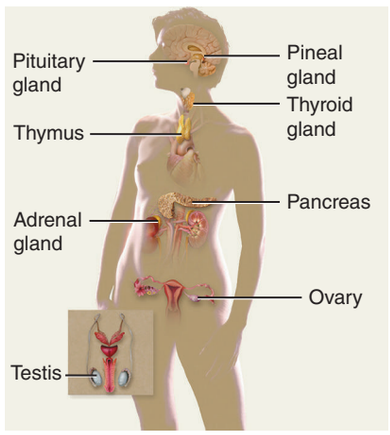
4 _____



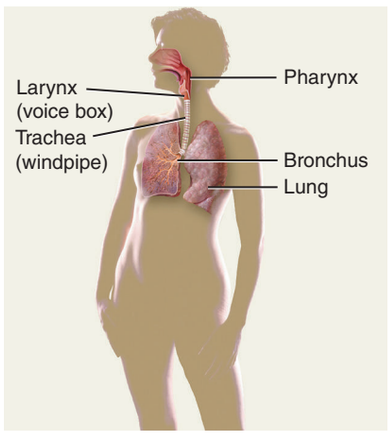
5 _____



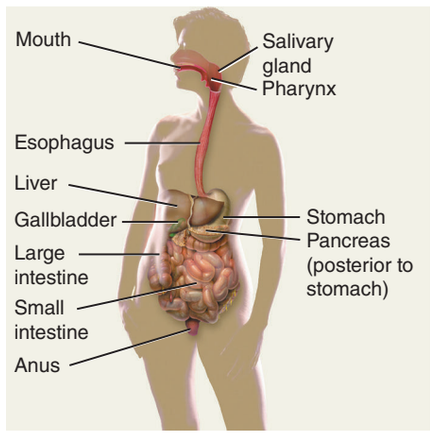
6 _____



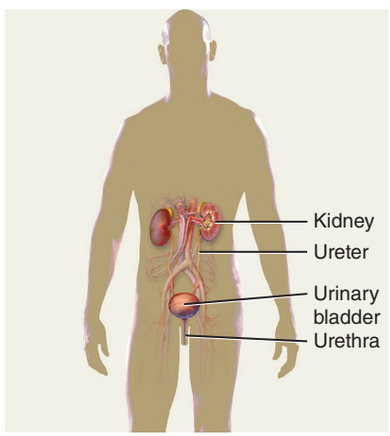
7 _____



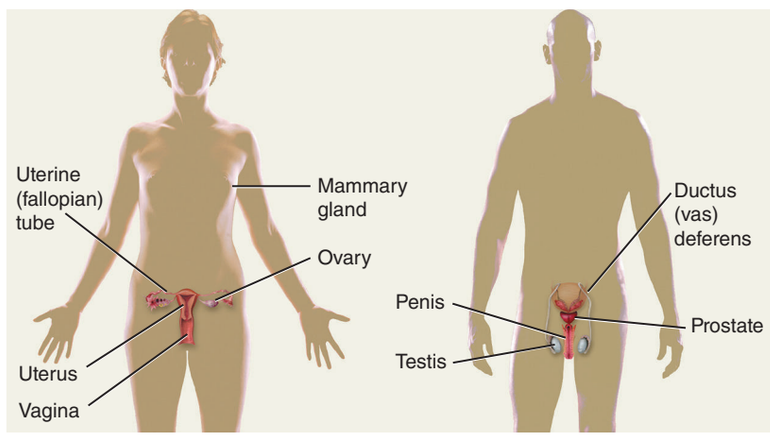
8 _____



9 _____

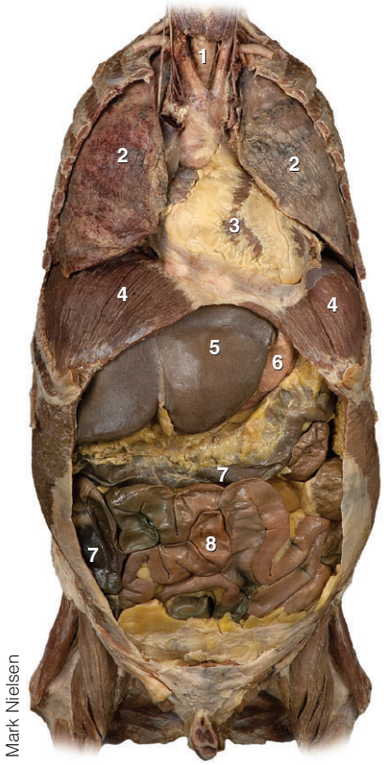


10 _____

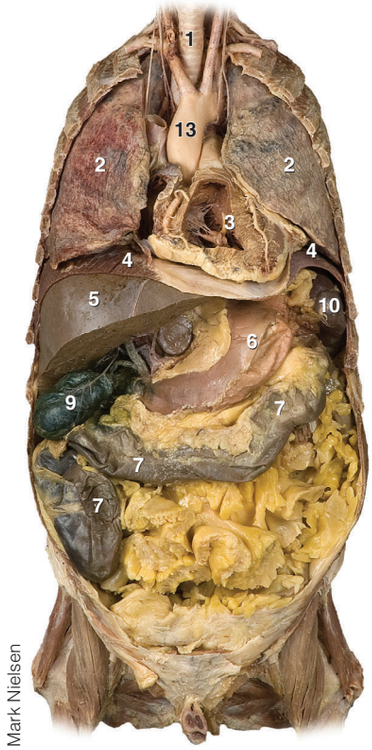


11 _____

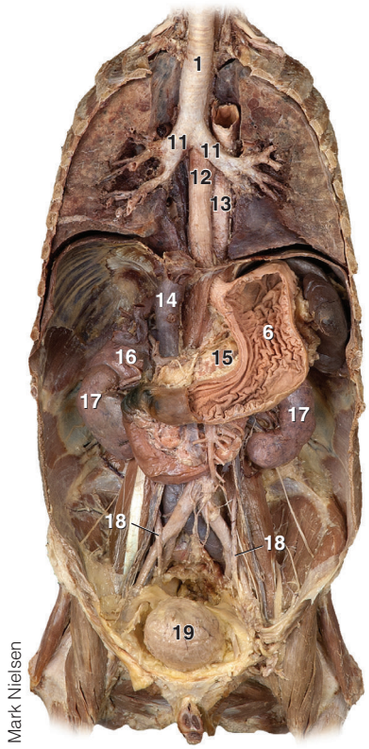
FIGURE 2.1 **Selected organs and organ systems, *continued*.**



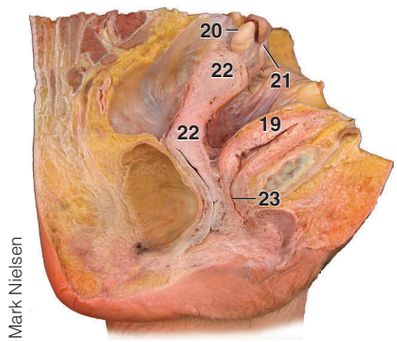
(a) Superficial organs



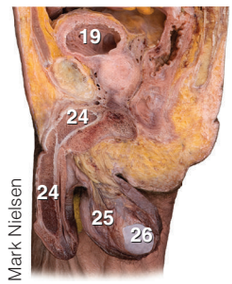
(b) Intermediate organs



(c) Deeper organs



(d) Female pelvis



(e) Male pelvis

FIGURE 2.2 Selected organs in cadaver dissection.

LAB ACTIVITY 1 Identification of Organs on Torso

1 Identify the organs in Figure 2.2. Note which organs must be removed to see deeper organs.

2 Identify the following organs on the anterior surface of a torso model. Identify all the organs without removing any organs from the model.
- trachea
- heart
- lungs
- liver
- stomach (torso's left side)
- small intestine
- large intestine (colon)

3 Remove the lungs, heart, liver, and stomach. Locate the gallbladder on the inferior surface of the liver.

4 Identify the following organs on a torso model:
- esophagus
- bronchi (right and left)
- inferior vena cava
- pancreas (posterior to stomach)
- spleen

5 Remove the small intestine and large intestine. Locate the appendix at the inferior right end of the large intestine.

6 Identify the following organs on a torso model:
- abdominal aorta
- adrenal glands (superior surface of kidneys)
- kidneys
- ureters
- urinary bladder

7 Identify the female reproductive organs on a female reproductive model. Observe the position of the urinary bladder relative to the uterus.
- ovaries
- uterus
- urinary bladder

8 Identify the male reproductive organs on a male reproductive model.
- penis
- scrotum (skin covering testes)
- testes

9 Answer the following questions about the position of each organ on the torso model or in Figure 2.2.

1. The stomach is _____ to the small intestine.
   a. superior b. inferior c. medial d. lateral
2. The liver is _____ to the lungs.
   a. superior b. inferior c. medial d. lateral
3. The lungs are _____ to the heart.
   a. superior b. inferior c. medial d. lateral
4. The trachea is _____ to the esophagus.
   a. medial b. inferior c. anterior d. posterior
5. The pancreas is _____ to the stomach.
   a. superior b. anterior c. lateral d. posterior
6. The large intestine is _____ to the stomach.
   a. superior b. inferior c. posterior d. lateral
7. The stomach is _____ to the spleen.
   a. lateral b. medial c. superior d. inferior
8. The abdominal aorta and inferior vena cava are _____ to the kidneys.
   a. medial b. lateral c. superior d. inferior
9. The kidneys are _____ to the small intestine.
   a. anterior b. posterior c. superior d. inferior
10. The urinary bladder is _____ to the kidneys.
    a. posterior and superior b. medial and inferior
    c. medial and superior d. lateral and posterior ■

LAB ACTIVITY 2 Organ Location

1 Draw the outline of a full-size torso on paper or plastic.

2 Using a marker, draw life-size outlines of all superficial organs in the appropriate place on the paper or plastic torso. ■

Key for Organs in Figure 2.2

1 trachea
2 lungs
3 heart
4 diaphragm
5 liver
6 stomach
7 colon (large intestine)
8 small intestine
9 gallbladder
10 spleen
11 primary bronchi
12 esophagus
13 aorta
14 inferior vena cava
15 pancreas
16 adrenal gland
17 kidney
18 ureters
19 urinary bladder
20 ovary
21 uterine tube
22 uterus
23 urethra
24 penis
25 scrotum
26 testis

B. Body Cavities

Many of the body's organs are found within body cavities. The *cranial cavity* contains the brain, and it is continuous with the *vertebral* (*vertebra* = back) canal that contains the spinal cord.

The **thoracic cavity** is a space enclosed by the ribs, sternum, and vertebral column. This cavity contains three small cavities: the **pericardial cavity** (*peri-* = around; *-cardia* = heart) and two **pleural cavities** (*pleuro-* = side or rib). The pericardial cavity contains the heart, and each pleural cavity contains a lung. The **mediastinum** (*media-* = middle; *-stinum* = partition), a central area within the thoracic cavity, extends from the neck to the diaphragm and from the sternum to the vertebral column. The organs located in the mediastinum are the heart, thymus gland, esophagus, trachea, blood vessels, and bronchi. The pleural cavities are located on either side of the mediastinum. The **diaphragm** separates the thoracic cavity from the abdominopelvic cavity.

The **abdominopelvic cavity** consists of two continuous cavities: the abdominal cavity and the pelvic cavity. The **abdominal cavity** is the superior portion located between the diaphragm and the brim of the pelvis (hip bones). This cavity contains the stomach, liver, gallbladder, pancreas, spleen, small intestine, kidneys, appendix, and part of the large intestine. Within the abdominal cavity is the **peritoneal cavity**, which contains most abdominal organs. A few organs are **retroperitoneal** (*retro* = backward), or located posterior to the peritoneum. These organs are the pancreas, kidneys, adrenal glands, and portions of the large intestine, small intestine, aorta and inferior vena cava. The **pelvic cavity** is the inferior portion of the abdominopelvic cavity. The pelvic cavity contains part of the large intestine, rectum, urinary bladder, female reproductive organs (ovaries, uterine tubes, uterus, vagina), and male reproductive organs (prostate, and part of ductus deferens). It is important to note that the testes and penis are not located in the pelvic cavity but are located inferior to it.

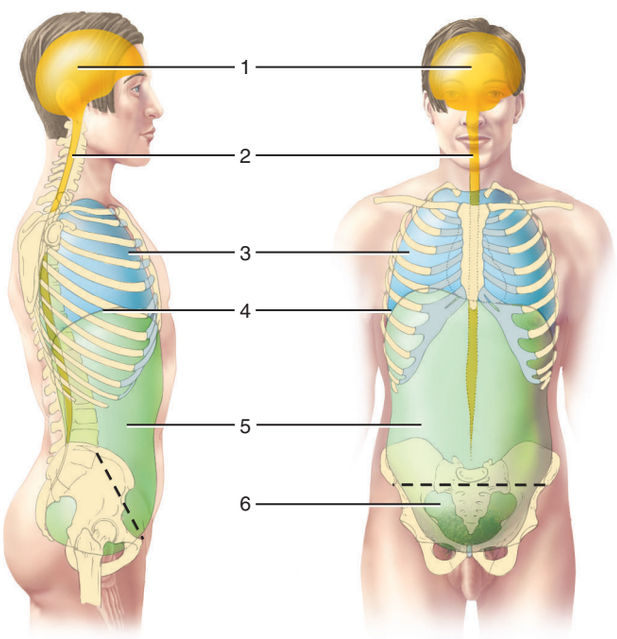
Before Going to Lab

1 Label the major body cavities and the diaphragm on Figure 2.3(a) and (b).

LAB ACTIVITY 3 Body Cavities

1 Locate the major body cavities on a skeleton and torso model. Identify the organs located in each body cavity.

2 Locate the mediastinum (meed-ee-uh-STINE-um) on a torso model or on Figure 2.1. Identify the organs located within the mediastinum. ■



(a) Right lateral view (b) Anterior view

- abdominal cavity
- cranial cavity
- diaphragm
- pelvic cavity
- thoracic cavity
- vertebral canal

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____

FIGURE 2.3 Body cavities.

C. Serous Membranes

Most of the organs in the ventral body cavity are covered with thin **serous** (*serum* = any clear, watery fluid) **membranes,** which are composed of two layers: a visceral layer and a parietal layer. The **visceral** (*viscera* = internal organs) **layer** covers the organ, whereas the **parietal** (*paries* = wall) **layer** attaches to and covers the ventral body wall. These two layers make up one continuous sheet that folds to form a sac. Between the two layers is a potential cavity containing a small amount of serous fluid secreted by the membranes. The clear, watery **serous fluid** prevents friction as the organs move within the ventral body cavity. For example, the heart has movement within the thoracic cavity as it fills with and ejects blood.

Serous membranes are named for the cavities they surround. Thoracic serous membranes include the **pleura,** which covers the lungs, and the **pericardium,** which covers the heart. The serous membrane that covers abdominal organs in the peritoneal cavity is the **peritoneum** (*peri-* = around; *teinein* = to stretch). Although most abdominal organs are positioned within the peritoneal cavity, a few organs are retroperitoneal (*retro-* = backward), or located posterior to the peritoneum.

Before Going to Lab

1 In Figure 2.4, observe how the serous pericardium folds to form a double layer.

2 Label the two layers of the serous pericardium in Figure 2.4.

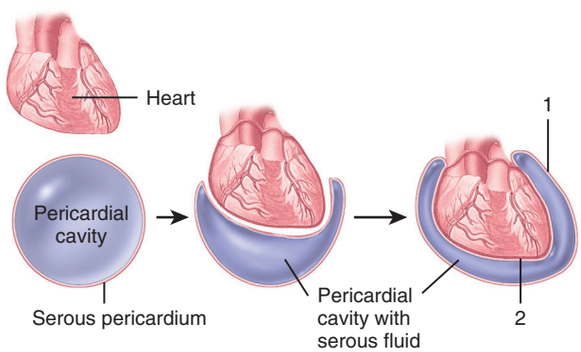


FIGURE 2.4 Serous pericardium folds to surround the heart.

LAB ACTIVITY 4 Serous Membranes

1 Make a replica or model of a serous membrane with your lab group.
- Obtain a 1-gallon zippered plastic bag.
- Push all the air out of the bag and zip the bag.
- Have a lab partner place a fist (simulating an organ) on the bottom edge of the bag and push up into the bag so the bag surrounds the fist.
- Remove the fist, unzip the bag, and add about 40 to 50 mL of water to the bag. Push out the extra air before rezipping the bag.
- Now have the same lab partner place a fist (simulating an organ) on the bottom edge of the bag and push up into the bag so the bag surrounds the fist.

2 Clean up as directed by your instructor.

3 Answer the Discussion Questions with your lab group.

DISCUSSION QUESTIONS
Serous Membranes

1 In the bag with water, what is the name of the simulated serous membrane layer that is touching the fist (organ)?

2 In the same bag, what is the name of the simulated outer serous membrane layer?

3 What does the water represent?

4 Was it easier to push a fist into the bag with no water or into the bag with water?

5 Based on your observations, does the presence of serous fluid make it easier for organs to move? Explain.

D. Organ Systems, Body Cavities, and Serous Membranes in the Rat

The organ systems, body cavities, and serous membranes of the rat are similar to those of humans. The rat dissection will allow you to see the relationship of organs to each other, organ location within body cavities, and serous membranes.

LAB ACTIVITY 5 Rat Dissection Video

Go to the Wiley Student Companion Site to view the rat dissection video.

E. Abdominopelvic Regions and Quadrants

Anatomists divide the abdominopelvic cavity into nine **regions** using two vertical and two horizontal lines in a tic-tac-toe grid so that the location of any organ is simple to describe. The two vertical lines are drawn mid-clavicular (mid-collar bone) and just medial to the nipples, beginning at the diaphragm and extending inferiorly through the pelvic area. The upper horizontal line is drawn across the abdomen, inferior to the ribs and across the inferior portions of the liver and stomach. The lower horizontal line is drawn slightly inferior to the superior portion of the pelvic bones. These nine regions from the top right to the lower left are **right hypochondriac** (*hypo-* = under; *chondro-* = cartilage), **epigastric** (*epi-* = upon; *gastro-* = stomach), **left hypochondriac, right lumbar** (*lumbar* = loin), **umbilical, left lumbar, right inguinal** or **iliac** (*inguinal* = groin), **hypogastric** or **pubic,** and **left inguinal** or **iliac.** Clinicians are more apt to divide this cavity into four **quadrants** that are formed by transverse and sagittal planes running through the umbilicus (navel). These quadrants are useful clinically when one is trying to describe abnormalities or to determine which organ may be the cause of pain. The four quadrants are **right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ),** and **left lower quadrant (LLQ).**

NOTE: *Right and left always refer to the model's or specimen's own right and left.*

Before Going to Lab

1 Draw lines on Figure 2.5(a) separating the abdominopelvic cavity into quadrants and label the quadrants.

2 Draw lines on Figure 2.5(b) separating the abdominopelvic cavity into regions and label the regions.

LAB ACTIVITY 6 Abdominopelvic Quadrants and Regions

1 Using a piece of masking tape, mark the location of the diaphragm on a human torso or on yourself.

2 Using two pieces of masking tape, divide the abdominopelvic cavity into quadrants on a human torso or on yourself.

3 Using the torso model or your textbook, identify in which abdominopelvic quadrant(s) each organ is *primarily* located. Use the abbreviations RUQ, LUQ, RLQ, and LLQ.

a. appendix _____

b. large intestine or colon _____

c. liver _____

d. ovaries _____

e. pancreas _____

f. small intestine _____

g. spleen _____

h. stomach _____

4 Using four pieces of masking tape, divide the abdominopelvic cavity into regions on a human torso or on yourself.

5 Using the torso model or your textbook, identify in which abdominopelvic region each organ is *primarily* located.

a. appendix _____

b. gallbladder _____

c. left ovary _____

d. bifurcation of the abdominal aorta _____

e. spleen _____

f. stomach (majority of) _____

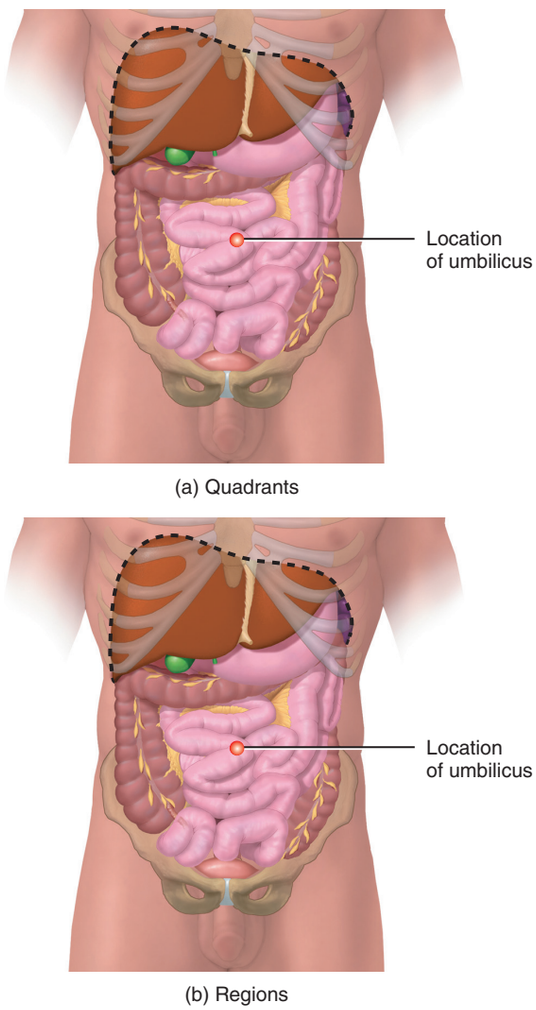


FIGURE 2.5 Abdominopelvic cavity.

Name _____ Date _____ Section _____

Reviewing Your Knowledge

EXERCISE 2

A. Functions and Identification of Organ Systems

Identify the organ system by its function as described below.

_____ **1.** Maintains blood oxygen and carbon dioxide levels

_____ **2.** Controls muscles and glands by electrical impulses; helps control homeostasis

_____ **3.** Causes movement of bones

_____ **4.** Waterproof barrier that blocks the entrance of pathogens into the body and prevents the loss of water from the body

_____ **5.** Transports nutrients, oxygen, and carbon dioxide throughout the body

_____ **6.** Changes food into absorbable nutrients; expels wastes

_____ **7.** Regulates composition of blood by eliminating nitrogenous wastes, excess water, and minerals

_____ **8.** Uses hormones to control cell function; helps control homeostasis

_____ **9.** Provides framework for the body and protects body organs

_____ **10.** Produces gametes (sperm and egg)

_____ **11.** Returns fluid to the bloodstream and provides protection against pathogens that have entered the body

B. Organ System Identification

Identify the correct organ system for the following organs.

_____ **1.** spleen

_____ **2.** liver

_____ **3.** trachea

_____ **4.** blood vessels

_____ **5.** hair

_____ **6.** kidney

_____ **7.** uterus

_____ **8.** pituitary gland

_____ **9.** spinal cord

_____ **10.** testes (2 systems)

_____ **11.** prostate gland

_____ **12.** large intestine

_____ **13.** pancreas (2 systems)

_____ **14.** adrenal gland

_____ **15.** thyroid

C. Body Cavities

Identify all the cavities for each organ as follows: abdominal (A), cranial (C), pelvic (P), pericardial (PC), pleural (PL), peritoneal (PT), thoracic (T), and vertebral (V).

_____ **1.** brain

_____ **2.** small intestine

_____ **3.** heart

_____ **4.** lungs

_____ **5.** bronchi

_____ **6.** stomach

_____ **7.** spinal cord

_____ **8.** liver

_____ **9.** kidneys

_____ **10.** uterus

_____ **11.** urinary bladder

_____ **12.** ovaries

D. Abdominopelvic Quadrants and Regions

Name the quadrant(s) (RUQ, LUQ, RLQ, and LLQ) and region(s) (right hypochondriac, epigastric, left hypochondriac, right lumbar, umbilical, left lumbar, right inguinal or iliac, hypogastric or pubic, and left inguinal or iliac) that the following organs predominantly occupy.

_____ **1.** liver

_____ **2.** stomach

_____ **3.** spleen

_____ **4.** gallbladder

_____ **5.** appendix

_____ **6.** left kidney

_____ **7.** right ovary

_____ **8.** uterus

E. Serous Membranes

Write the term the phrase describes.

_____ **1.** Attaches the heart to the body cavity

_____ **2.** Covers the surface of the lungs

_____ **3.** Covers the surface of abdominal organs

_____ **4.** The lubricating liquid in serous cavities

_____ **5.** Circle the organs that are found within the peritoneal cavity: pancreas, liver, kidney, spleen, adrenal glands, abdominal aorta, inferior portions of vena cava, stomach

Name _____ Date _____ Section _____

Using Your Knowledge

EXERCISE 2

A. Homeostatic Imbalances of Organ Systems

Using your textbook, identify the organ system that is homeostatically imbalanced in the following diseases or disorders.

_____ **1.** muscular dystrophy

_____ **2.** hypothyroidism

_____ **3.** myocardial ischemia

_____ **4.** infectious mononucleosis

B. Body Cavities and Serous Membranes

Identify *all* the cavities entered for each procedure, beginning with the largest cavity and ending with the most specific body cavity. Use these abbreviations for the body cavities: abdominal (A), cranial (C), pelvic (P), pericardial (PC), pleural (PL), peritoneal (PT), thoracic (T), and vertebral (V).

_____ **5.** coronary bypass surgery

_____ **6.** cholecystectomy (gallbladder removal)

_____ **7.** spinal tap

C. Abdominopelvic Quadrants

_____ **8.** A 44-year-old male went to the emergency room complaining of severe pain in his RLQ. The doctor palpated the area and determined that the pain was originating from an organ in that quadrant. Which organ might be involved?

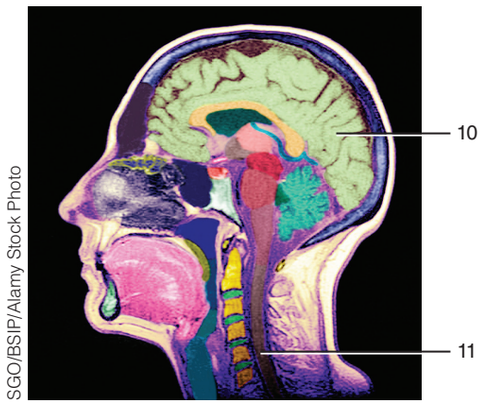
(a) liver (b) appendix (c) gallbladder (d) spleen (e) stomach

_____ **9.** A 23-year-old female went to the doctor with the chief complaint of RLQ pain. Which organ is most likely the cause?

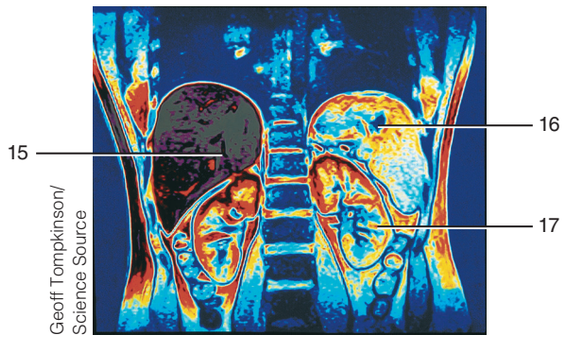
(a) adrenal gland (b) ovary (c) gallbladder (d) pancreas (e) kidney

D. Organ Identification

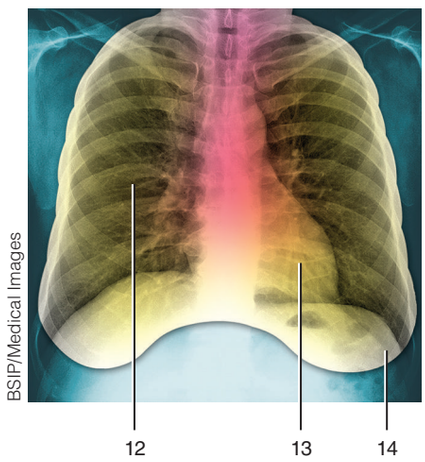
Identify the organs in the color-enhanced medical images in Figure 2.6.



(a) MRI of head and neck, sagittal view



(c) MRI of abdomen, anterior view



(b) Radiograph of thorax, anterior view

(d) Radiograph of abdomen and pelvis, anterior view

10 _____ 14 _____ 18 _____

11 _____ 15 _____ 19 _____

12 _____ 16 _____ 20 _____

13 _____ 17 _____

FIGURE 2.6 Identification of organs on medical images.

EXERCISE

Compound Light Microscope

3

OBJECTIVES

1. Describe and demonstrate how to carry, clean, use, and store a compound light microscope
2. Identify the parts of a compound light microscope and describe their function
3. Calculate total magnification for each objective lens
4. Demonstrate how to view an object with the microscope using all magnifications
5. Demonstrate how to measure the field of view
6. Measure the diameter of a cell
7. Prepare a wet-mount slide

MATERIALS

- compound light microscopes, lens paper, immersion oil
- thin, clear plastic rulers
- prepared microscope slides of the letter "e"
- prepared microscope slides of the trachea (or other organ)
- wet mount of cheek cells; clean microscope slides, coverslips, lens paper, flat toothpicks, and dropper bottle of dilute methylene blue, 0.9% saline solution, 10% bleach solution

A compound light microscope is used to observe small structures such as cells and tissues. The term *compound* refers to the two types of lenses (ocular and objective) that are used simultaneously to magnify the image. The term *light* refers to the necessity of using a light source to view the object. Most human cells must be magnified to be seen by the unaided human eye. The compound light microscope can magnify images up to approximately 1,000 times, depending on the magnifying power of the lenses.

Microscopic examination of cells and tissues allows students to observe how cell and tissue structure determines function. Changes in normal cell and tissue structure cause changes in organ function that lead to a disorder or disease. Tissue biopsies are performed to observe whether normal cellular structure has changed, which would indicate the absence or presence of a disorder or disease.

A. Transporting the Microscope

The compound light microscope is an expensive, precision instrument that must be handled appropriately. Demonstrate care in transporting, cleaning, using, and storing the microscope.

- Pick up the microscope with two hands, one holding the arm and the other supporting the base with the cord in a secure position.
- Carry the microscope upright so that a lens or eyepiece does not fall out, and carefully place the microscope on the lab table in front of you.

B. Parts of the Microscope

- **Base**—The wide bottom part that supports the microscope.
- **Arm**—The straight or curved vertical part that connects the base to the head.
- **Head** (or body tube)—The upper part of the microscope that extends from the arm and contains the ocular lens(es) and the rotating nosepiece with the objective lenses.

NOTE: *All other microscope parts attach to the base, arm, and head—the three basic parts of the framework.*

- **Ocular lens(es)**—Removable eyepieces used to observe the microscope slide. Microscopes with one ocular lens are called **monocular** (*mono-* = one; *ocu-* = eye), and those with two ocular lenses are called **binocular** (*bi-* = two). Typically, these lenses magnify an object tenfold (10×). Look at an ocular lens and record the magnification power. _____ One of the ocular lenses may have a **pointer** used to identify a specific area on the slide. A **micrometer,** used to measure the field of view and object size, may also be present in one ocular lens. State whether your microscope has a pointer and/or a micrometer. If it has a pointer or micrometer, give the ocular lens (right or left) in which each is found.

  Pointer _____

  Micrometer _____
- **Objective lenses**—A microscope will usually have three or four objective lenses mounted on a **revolving nosepiece.** Most microscopes have objective lenses that magnify an object 4× (scanning), 10× (low-power), 40× (high-dry), and 100× (oil immersion). List the magnification powers of the objective lenses on your microscope. _____ As the barrel of the objective lens increases in length, the magnifying power also increases.
- **Stage**—The flat platform located beneath the objective lenses on which the microscope slide is placed. The stage has a hole in the middle, the light aperture, through which light is focused on the slide. The slide may be held onto the stage with either two spring clips or a mechanical stage clamp. Does your microscope have 2 spring clips or a mechanical stage? _____
- **Mechanical stage**—Holds the slide securely in place with a spring clamp for viewing and can be moved with precision by using the **adjuster knobs.** One knob moves the slide side to side, and the other forward and backward.
- **Coarse focus knobs**—On each side of the microscope toward the base is a large knob or dial that may or may not have a smaller knob in the middle. Only one of the large knobs needs to be used, depending on whether one is right- or left-handed. The large knob is used for coarse focusing and either moves the stage up and down quickly or moves the objective lenses up and down quickly. This knob is to be used with scanning or low-power lenses. Does your stage or objective lens move? _____.
- **Fine focus knob**—The smaller knob on each side of the microscope that is used for precision focusing.
- **Condenser**—Located just below the stage is a lens that condenses light through the specimen on the slide above. If the condenser has an **adjustment knob** that raises and lowers the condenser, it usually needs to be in the highest position to focus the most light on the specimen.
- **Iris diaphragm**—Located beneath the condenser, the iris diaphragm works similarly to the iris of the eye. By adjusting its **lever,** the aperture changes diameter and regulates the amount of light that passes through the condenser. Decreasing the aperture size decreases the amount of light on the specimen and increases contrast.
- **Substage light**—The light source is usually built into the base of the microscope and typically has a dial or sliding bar on one side to control the light intensity.

LAB ACTIVITY 1 Parts of the Microscope

1 Identify the parts of your microscope as shown in Figure 3.1.

2 Compare your microscope with the one in Figure 3.1 and identify any differences with your lab group. ■

C. Calculating Magnification

Total magnification is determined by multiplying the ocular lens power times the objective lens power. *Example:* Ocular lens power = 10×; Objective lens power = 4×; Total magnification = 40×.

LAB ACTIVITY 2 Calculating Magnification

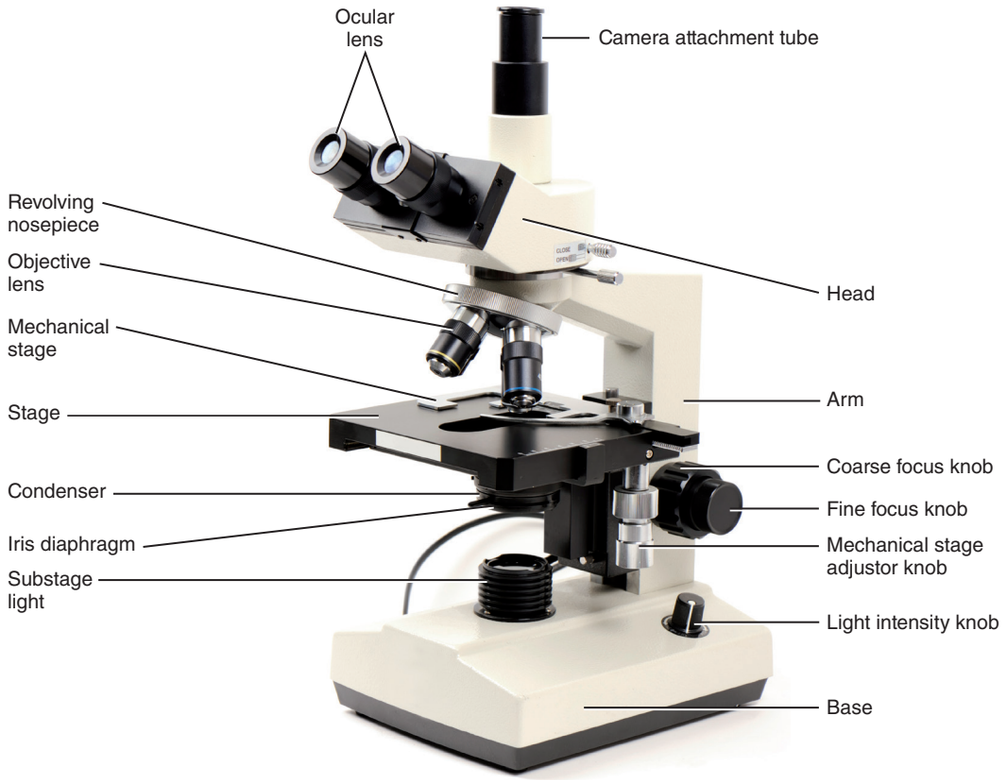
1 Calculate the total magnification by multiplying the magnifying powers of your microscope lenses.

scanning lens ____ × ocular lens _____ = ____ total magnification

low-power lens ____ × ocular lens ____ = ____ total magnification

high-dry lens ____ × ocular lens ____ = ____ total magnification

oil immersion lens ____ × ocular lens ____ = ____ total magnification ■



David_Ahn/iStock.com

FIGURE 3.1 **Parts of the microscope.**

D. Using the Microscope

- Clean up your lab area and put nonessentials away so you will have plenty of room to use the microscope.
- Unwind the cord and plug it in.
- Clean the ocular, objective lenses, and condenser lenses only with the *special lens paper* (optical safe) provided by your instructor. Whenever the image on the slide cannot be focused clearly, it may be that the ocular, objective lens, or slide is dirty and needs additional cleaning. If all else has failed, consult your instructor.
- Turn on the light and adjust it to the lowest light setting feasible for good visibility and color to reduce eye strain. The scanning (4×) and low-power (10×) lenses will not need as much light as the high-dry (40×) and oil immersion (100×) lenses.
- *Trouble-shooting:* If no light comes on initially, check two things before consulting your instructor. (a) Turn the light dial to a higher setting. (b) Check the safety switch on the electrical outlet by pushing in the reset button. If the light still does not work, plug your microscope into an outlet that you know works.

LAB ACTIVITY 3 Using the Microscope

1. Move the **scanning objective lens** into place so it is over the light aperture on the stage. This objective lens has the shortest barrel. Make sure you feel the lens click into position or your field of view will be black.
2. Obtain a prepared slide with the letter "e" from your instructor and place it on the stage, securing it with either the mechanical stage clamps or slide clips. Draw the letter "e" as it appears on the stage without looking in the ocular lens. _____
3. Without looking into the ocular lens, practice moving the slide from side to side in addition to backward and forward using the mechanical stage knobs (or your hands if your stage has slide clips).
4. Using the mechanical stage knobs (or your hands if your stage has slide clips), position the letter "e" over the light hole in the stage.
5. Check to see that the condenser lens is raised completely up to the stage.

6. If your *stage is moveable,* the coarse focus knob will move the stage. Raise the stage as far as it will go. If your *objective is moveable,* use the coarse focus knob to lower the objective lens until it stops. The slide and the scanning objective lens will not actually touch.
7. If you have a binocular microscope, adjust the two ocular lenses as you would a pair of binoculars so that the two lenses are a comfortable distance apart for your eyes.
8. Look through the ocular lens(es) and adjust the light. Use the coarse focus knob to focus in the letter "e." Complete the focusing process by using the fine focus knob.
9. The **working distance** is the distance a specimen is from the bottom of the objective lens. Use a millimeter ruler to measure the distance between the bottom of the scanning objective lens and your specimen. _____ mm
10. Using the mechanical stage knobs, bring the letter "e" directly into the center of the **field of view** (the lighted circular area you see as you look through the ocular lenses).
11. Draw the letter "e" as it appears through the microscope. Compare the appearance to your initial drawing. _____
12. While observing the letter "e" through the ocular lens(es), describe the movement that you observe as you move the slide:
    - to the left _____
    - to the right _____
    - forward _____
    - backward _____
13. Reposition the letter "e" directly in the middle of the field of view and switch to the **low-power objective lens.**
14. Most microscopes are **parfocal** so that when you move to a different magnification the specimen is almost, but not quite, in focus. You will need only the fine focus knob to focus the image. Center the specimen because the previously centered object is usually not in the center.
15. What is the working distance from the bottom of the low-power objective lens to your specimen? _____ mm
16. Use the iris diaphragm lever to adjust the amount of light and improve the contrast of your image.

CAUTION: *Do not use the coarse focus knob with high-dry or oil immersion lenses.*

17. Repeat the above procedure with the **high-dry objective lens.** Be sure to focus *only* with the *fine focus knob.*
18. What is the working distance from the bottom of the high-power objective lens to your specimen? _____ mm
19. Describe the change in diameter of the field of view as one switches from the scanning lens to the low-power lens and then to the high-power lens.

NOTE: Most slides used in anatomy and physiology do not need the magnification of the oil immersion lens. Your instructor will inform you if and when you will use this objective lens. *Only use the oil immersion lens if instructed to do so.*

20. Center the area you want to view and then obtain a container of immersion oil made especially for the oil immersion lens.
21. Focus the slide with the high-power lens. Move the objective lens out of the way and apply a drop of oil directly on the part of the slide you wish to study.
22. Click the *oil immersion lens* into place, open the iris diaphragm as needed, adjust the light, and focus with only the *fine focus knob*.
23. What is the working distance from the bottom of the oil immersion lens to your specimen? _____ mm
24. When you finish, move the scanning power objective lens back into place.
25. Move the stage as far from objectives as possible by either lowering the stage or raising the objectives. Remove the slide and clean the oil from the oil immersion lens with lens paper. (Also clean the high-dry objective lens if you passed it through the oil.) Your instructor may ask you to use an additional cleaner.
26. Clean the slide with a new lens paper. If necessary, clean the stage as well. ■

E. Measuring the Field of View

The **field of view** is the area on the slide that is being observed and is inversely proportional to the magnification (the field of view decreases in size with increasing magnification). Once you know the diameter of the field of view in millimeters (mm) at various magnifications, you will be able to estimate the size of cells or other structures in the field of view. The object being viewed should be in the center of the field of view when you are switching to a higher objective lens (higher magnifying power).

Measuring the field of view at different magnifications demonstrates the advantage of scanning at a lower magnification to find a structure of interest before working up to a higher magnification.

LAB ACTIVITY 4 Measuring the Field of View and Estimating Object Size

1. Move the scanning objective lens in place.
2. Place a clear plastic ruler over the light opening in the stage, or use the micrometer in the ocular lens or grid slide.
3. Look through the ocular lens, and move the ruler or grid slide so that a line touches the left edge of the field and count the number of millimeter intervals that can be seen. Record. _____ mm
4. Switch to the low-power objective lens and repeat this procedure to count the number of millimeter intervals that can be seen. Record. _____ mm
5. Switch to the high-dry objective lens and repeat this procedure to count the number of millimeter intervals that can be seen. Record. _____ mm. The closeness of this lens to the slide may not allow a ruler to be added.
6. Move the scanning power objective lens in place and move the stage as far as possible from the objectives before removing the ruler.
7. Obtain a prepared slide with the letter "e" and place it on the stage. Using the scanning power objective lens, estimate the diameter of the letter e. If it occupies ½ of the field of view, then it is ½ times the measured diameter of the field of view of the scanning objective lens. Record the diameter of the letter "e." _____ mm
8. Move the stage as far as possible from the objectives before removing the ruler. ■

F. Microscopic Structure of an Organ

An organ is composed of a variety of cells and tissues. This activity starts with an observation of a section of a whole organ with the scanning lens to get the "big picture" and then moves to higher magnifying powers to see additional detail.

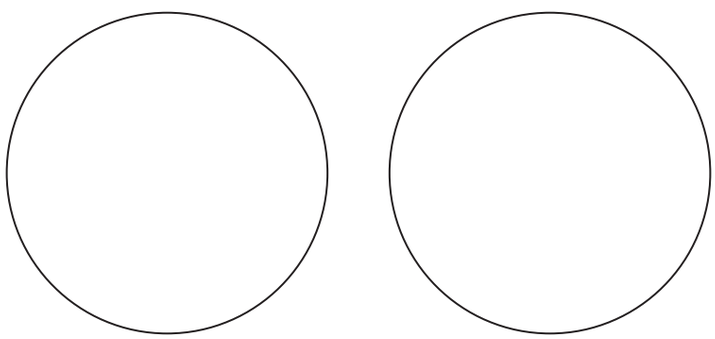
LAB ACTIVITY 5 Observation of an Organ

1. Obtain a prepared slide of the trachea or other organ supplied by your instructor.
2. Begin your observation using the scanning lens. Center and focus the organ, and note that you can see several different tissues (stained different colors) present at this magnifying power.
3. Switch to the low-power lens. Center and focus, and note the additional tissue detail that can be discerned at this magnifying power. Make a drawing of the tissues in Figure 3.2(a).
4. Switch to the high-power lens. Center and focus, and note that you can now observe the cells that constitute the various tissues in this organ. Make a drawing of the cells in Figure 3.2(b).
5. Estimate the diameter of 3 different types of cells.

   _____ mm

   _____ mm

   _____ mm
6. Move the scanning power objective lens into place and move the stage as far as possible from the objectives before removing the slide. ■



(a) Low power (b) High power

FIGURE 3.2 Student drawings of tissues and cells.

G. Wet Mount of Cheek Cells

Cells that line the interior of the mouth fit closely together like floor tiles and form a thick layer of thin cells that protect the underlying tissue from abrasion and microbes (bacteria and viruses). The superficial cells continually slough off and are replaced by underlying cells. Gently scraping the lining of the cheek removes the superficial cells that are about to slough off.

LAB ACTIVITY 6 Wet Mount of Cheek Cells

1 Prepare a cheek smear slide and observe it under the compound microscope.
- Obtain a toothpick, a clean microscope slide, and a coverslip.
- Place a drop of 0.9% saline on the microscope slide.
- Gently scrape the flat end of the toothpick (no blood, please!) on the inner lining of your cheek only one time. Do not scrape hard enough to hurt.
- To apply the cells to the slide, rotate the toothpick between your thumb and forefinger to dislodge the cells into the saline.
- Dispose of the toothpick as your instructor directs.
- Add *one drop* of dilute methylene blue to the cells on your slide.
- Cover the sample with a coverslip as directed by your instructor.
- Using low-power, locate the blue-stained cells. Switch to high-power to observe more cellular detail.

2 Compare the cells on your slide with Figure 3.3(a). Draw a picture of your cells in Figure 3.3(b).

3 Estimate the diameter of the cheek cells. _____ mm

4 Move the scanning power objective lens in place and remove the slide.

5 Place microscope slides in a 10% bleach solution as your instructor directs. Clean your lab top with a 10% bleach solution.

6 Answer Discussion Questions with your lab group.

DISCUSSION QUESTIONS
Cheek Smear

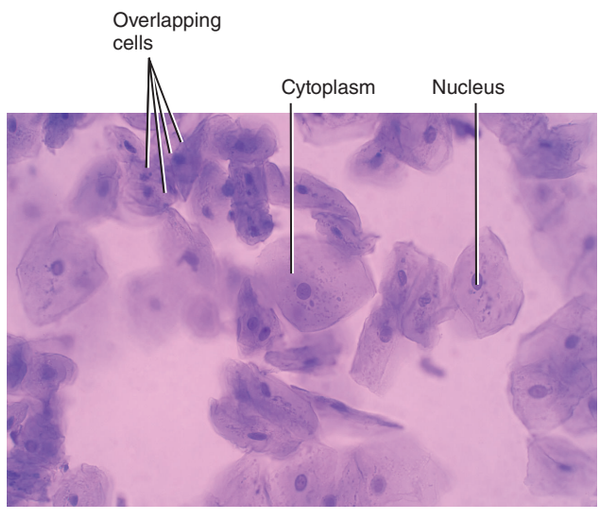
1 Why was stain added to the cheek cells?

2 What cellular structures did you observe?

H. Storing the Microscope

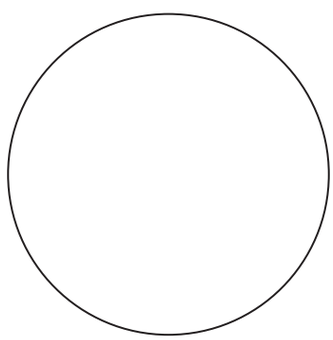
It is important to put the microscope away properly.

- Check that the scanning objective lens is in place and that the slide is removed from the stage.
- Depending on the type of microscope, either lower the stage or raise the objective to put maximum distance between the objective and the stage.
- Center the mechanical stage.
- Turn off the substage light. The bulb life is extended if it cools before moving the microscope.
- Clean the ocular and objective lenses with lens paper.
- Coil the cord neatly according to your instructor's directions.
- Place the dust cover over the microscope.
- Using both hands and the proper carrying technique, return the microscope to the appropriate cabinet.



Choksawatdikorn/Shutterstock.com

(a) Photomicrograph of cheek cells



(b) Student drawing

FIGURE 3.3 Cheek cells.

Name _____ Date _____ Section _____

Reviewing Your Knowledge

EXERCISE 3

A. Care and Use of the Microscope

Correct each statement by crossing out the incorrect word(s) and inserting the correct word(s).

1. One hand is to be used to transport the microscope.

2. Tissue paper can be used to clean the microscope lenses and prepared slides.

3. The microscope should be put away with the high-dry lens in position.

4. The coarse focusing knob should be used when using the high-dry lens.

5. The iris diaphragm should be completely open to obtain maximum contrast.

6. The condenser should be in the lowest position (far from the stage) to focus the most light on the specimen.

B. Parts of the Microscope

Write the term that the phrase describes.

_____ **1.** Large knob that moves the stage or objective lens a great distance. Used with scanning or low-power objective lenses only.

_____ **2.** Flat platform beneath the objective lens on which the microscope slide is placed.

_____ **3.** Removable lenses that you look through to observe the microscope slide.

_____ **4.** Small knob that moves the stage or objective lens a very small distance and is used for precision focusing.

_____ **5.** Extends from the arm and contains the ocular lenses and rotating nosepiece.

_____ **6.** Lens that condenses light through the specimen and is located below the stage.

_____ **7.** Light from specimen passes through these lenses first. These lenses are located in the rotating nosepiece.

_____ **8.** Wide bottom part that supports the microscope.

_____ **9.** Regulates the amount of light passing through the condenser.

_____ **10.** Vertical portion that connects the base to the head.

C. Total Magnification and Field of View

1. Calculate the total magnification of an object viewed with a 10× ocular and a 60× objective lens.

2. Does the size of the field of view increase or decrease when going from a lower- to higher-power objective lens?

EXERCISE 4

Cell Structure and Cell Cycle

OBJECTIVES

1. Identify cellular components on a model or diagram
2. Describe the function of the plasma membrane and cellular organelles
3. Identify cells and observable cellular structures on prepared microscope slides or on photomicrographs
4. Identify the stages of mitosis
5. Describe the events of each stage of mitosis

MATERIALS

- model or diagram of a cell
- compound microscopes and lens paper
- prepared slides of human skeletal muscle cells, pseudostratified ciliated columnar epithelium (trachea), nonciliated simple columnar epithelium with microvilli (small intestine), motor neurons, sperm, and blood or **Real Anatomy** (Histology)
- 3-dimensional models of mitosis
- whitefish blastula slides

The human body contains over a trillion cells. These cells form the organs of the human body and are responsible for organ function. Cells take in nutrients delivered to them by the blood and use these nutrients to make carbohydrates, proteins, lipids, and nucleic acids. Cells use these macromolecules to make cellular and extracellular structures, repair themselves, and perform the tasks required for organ function.

A. Cell Structure

Cells are the smallest structural and functional units of living organisms. They are enclosed by a plasma membrane that controls the movement of substances into and out of the cell. The interior of the cell is filled with cytoplasm that contains cytosol (a viscous fluid) and organelles (little organs). Like an automobile, a cell has different parts or organelles that perform different functions. A "generalized" animal cell is shown in Figure 4.1, and functions of cellular organelles are described in Table 4.1.

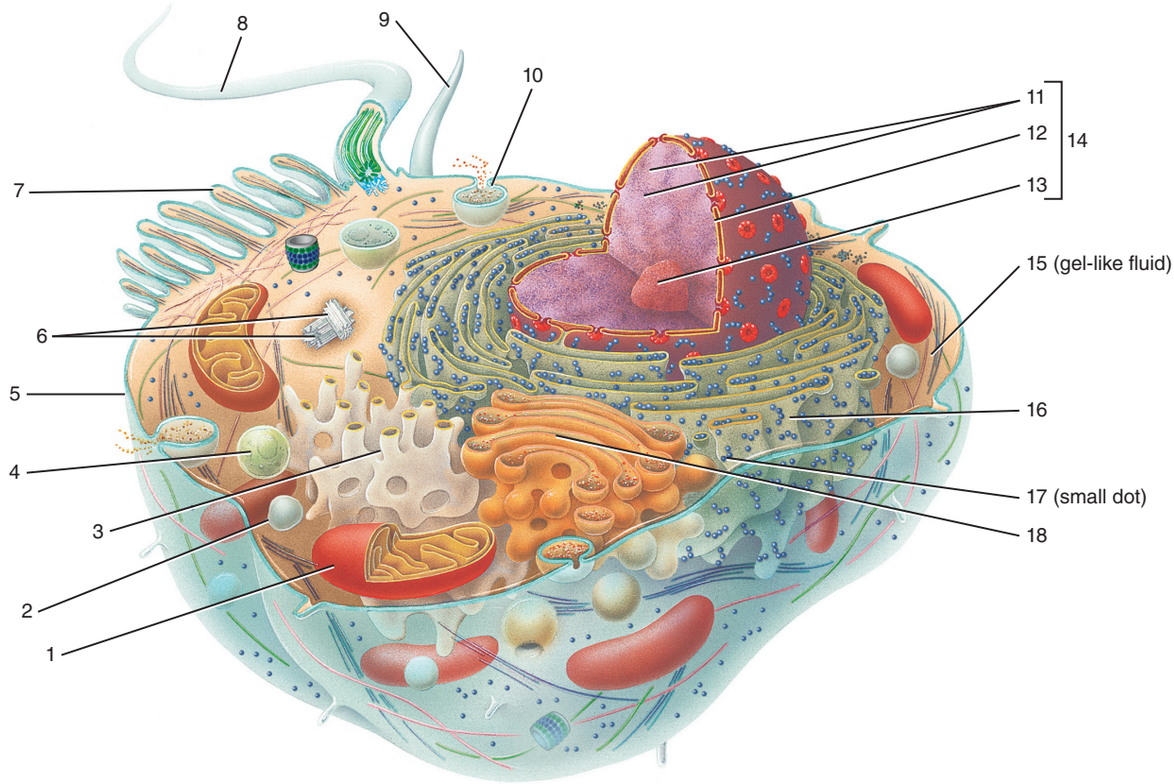
LAB ACTIVITY 1 Cell Structure

1. Point to each cell structure shown in Figure 4.1 on a cell model or chart.
2. Describe the function of each organelle in Figure 4.1(a).
3. Answer the Discussion Question with your lab group.

DISCUSSION QUESTIONS

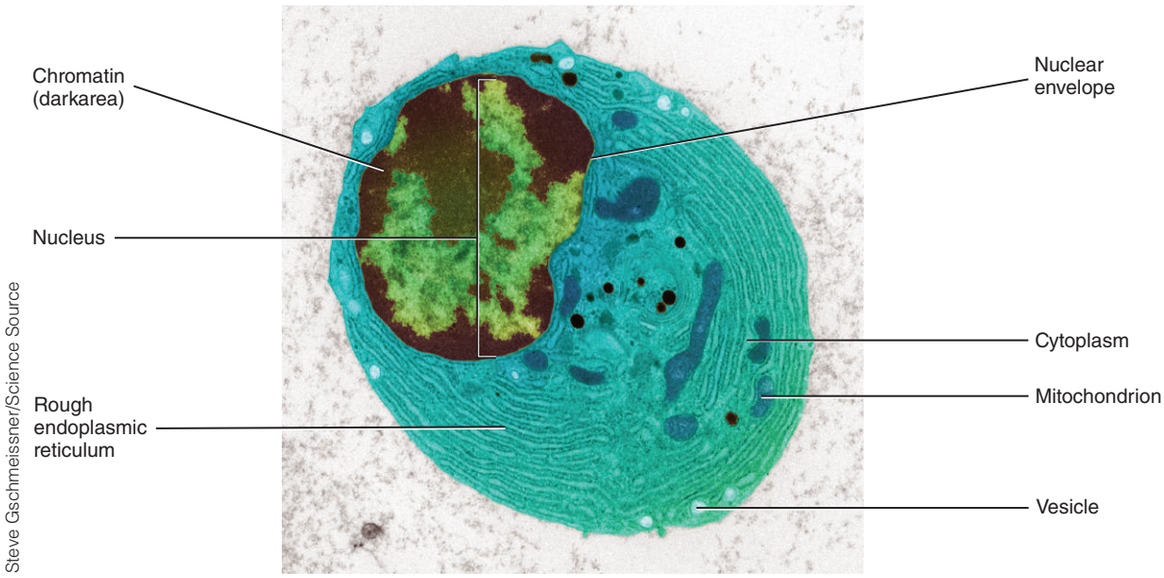
Cell Structures

1. Which cell structures from Table 4.1 are not found in most human cells?



(a) Sectional drawing

1 mitochondrion
2 peroxisome
3 smooth endoplasmic reticulum
4 lysosome
5 plasma membrane
6 centrioles
7 microvillus
8 flagellum
9 cilium
10 secretory vesicle
11 chromatin
12 nuclear membrane
13 nucleolus
14 nucleus
15 cytoplasm
16 rough endoplasmic reticulum
17 ribosome
18 Golgi complex



(b) Transmission electron micrograph 4000×

FIGURE 4.1 Generalized animal cell.

TABLE 4.1 Function of Cell Structures

STRUCTURE	FUNCTION
Plasma Membrane	Controls movement of substances into and out of the cell
Microvilli	Folds of the plasma membrane that increase the surface area of the cell to increase absorption or secretion
Nucleus	Contains DNA molecules and nucleolus
Nucleolus	Assembly site for ribosomes
Chromatin	Long thin strands within nucleus. Each strand composed of one DNA molecule and associated proteins.
Cytoplasm	Area of the cell between plasma membrane and nucleus. Includes cytosol and organelles
Cytosol	Fluid portion of cytoplasm in which many of the cells' chemical reactions occur
Organelles	
• Mitochondria	Makes ATP via aerobic cellular respiration
• Ribosomes	Site of protein synthesis in cytosol and RER
• Rough endoplasmic reticulum (RER)	Synthesize proteins and phospholipids used in the plasma membrane and organelles or secreted via exocytosis
• Smooth endoplasmic reticulum (SER)	Fatty acid and steroid synthesis; detoxifies toxic substances; stores calcium
• Golgi complex	Receives and modifies proteins from RER; sorts and and modifies them for transport
• Secretory vesicles	Secrete substances outside the cell by exocytosis
• Lysosomes	Enzymes digest and recycle worn-out organelles and substances entering the cell; can digest the cell
• Peroxisomes	Produce hydrogen peroxide; detoxify harmful substances
• Cytoskeleton	Three kinds of protein filaments; maintain cell shape and involved in cell movement and movement of organelles
• Centrosomes (centrioles)	Form mitotic spindle; needed to form cilia and flagella
• Cilia	Abundant, hair-like cell projections that move fluids and particles along the cell surface
• Flagella	Long cell projection; whip-like motion moves sperm

B. Cell Specialization

The human body contains over 200 different types of cells with different functions. These differences in function are reflected in cell structure. Cells of the human body differ from the generalized animal cell in shape, size, or number and type of organelles present. In the next activity you will observe cells of skeletal muscle, pseudostratified ciliated columnar epithelium, nonciliated simple columnar epithelium with microvilli, motor neurons, sperm, and blood.

- **Skeletal muscle** cells are long, cylindrical cells that contain specialized proteins (contractile proteins) that enable them to contract (shorten in length) to move bones. The contractile proteins are organized into repeating units that can be observed in the light microscope as striations.
- **Pseudostratified ciliated columnar epithelial cells** have cilia that move substances like mucus along the surface of the cells. Mucus is produced by specialized cells called goblet cells.
- **Nonciliated simple columnar epithelium with microvilli.** Microvilli increase the surface area of the plasma membrane which provides a larger area for absorption of nutrients along the gastrointestinal tract or secretion of product from glands.
- **Motor neurons** are nervous tissue cells with many processes (cell extensions) that receive information from other neurons and send electrical signals to muscle cells causing them to contract.
- **Sperm cells** (sperm) are small, oval cells with a flagellum that propels them through the female reproductive tract.
- **Red blood cells** do not have a nucleus (anucleate) but contain large amounts of hemoglobin, a red pigment that binds oxygen.
- **White blood cells** have nuclei with different shapes and defend the body from pathogens and cancerous cells.

LAB ACTIVITY 2 Cell Specialization

1 Identify the cells and cell components shown in Figure 4.2 on prepared slides (skeletal muscle, pseudostratified ciliated columnar epithelium, motor neuron, sperm, blood cells, and nonciliated simple columnar epithelium with microvilli) or in **Real Anatomy** (Histology).

2 Using Figure 4.2, describe each cell's shape and list the cell structures that can be seen with the light microscope in each cell type.

a. skeletal muscle cell: _____

b. pseudostratified ciliated columnar epithelial cell: _____

c. motor neuron: _____

d. sperm cell: _____

e. red blood cell _____

f. white blood cell _____

g. nonciliated simple columnar epithelium: _____

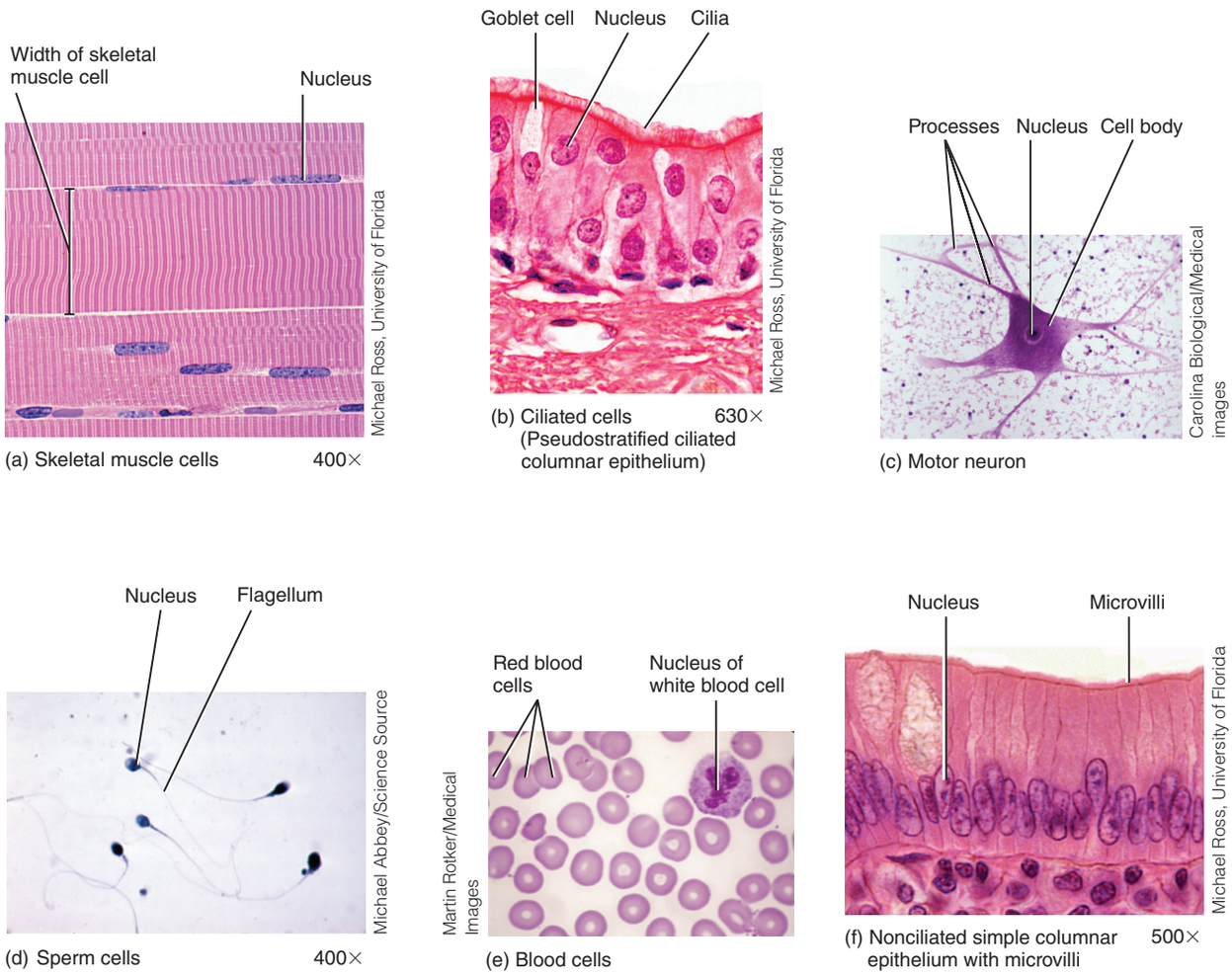


FIGURE 4.2 Cell specialization.

C. Somatic Cell Division

Somatic (*soma-* = body) **cell division** occurs when one cell divides to produce two genetically identical cells. Cell division is needed for growth of the individual, wound healing, and replacement of old and dying cells.

The **cell cycle,** a period during which a cell grows and divides into two genetically identical cells (daughter cells), begins when a cell is produced by cell division and ends when the cell divides (Figure 4.3). The length of the cell cycle differs according to the type of cell, with some cells dividing more frequently than others. The cell cycle can be divided into two basic periods: **interphase,** a long period during which the cell conducts its normal activity, grows, and prepares for cell division; and the **mitotic phase,** when the cell is dividing. The mitotic phase consists of **mitosis,** or nuclear division, and **cytokinesis,** or cytoplasmic division. The four stages of mitosis are prophase, metaphase, anaphase, and telophase (Table 4.2).

To observe interphase and the stages of mitosis, you will examine a prepared microscope slide containing several sections of a whitefish blastula. The **blastula** is an early embryonic stage in which cells are dividing rapidly, providing many cells in different stages of mitosis.

Before Going to Lab

1 Using Table 4.2, identify interphase, each phase of mitosis, and cytokinesis in Figure 4.4(a)–(e).

LAB ACTIVITY 3 Mitotic Phases

1 Observe the 3-dimensional models of the mitotic phases, noting the changes in each phase.

2 Obtain a prepared whitefish blastula slide and hold it up to the light. Notice that there are many blastula sections on each slide. It will be necessary to view several of these sections to find all of the phases.

3 Using a compound microscope, begin looking at your slide with the low-power objective lens. Use the high-power objective lens to identify interphase, the four stages of mitosis, and cytokinesis. ■

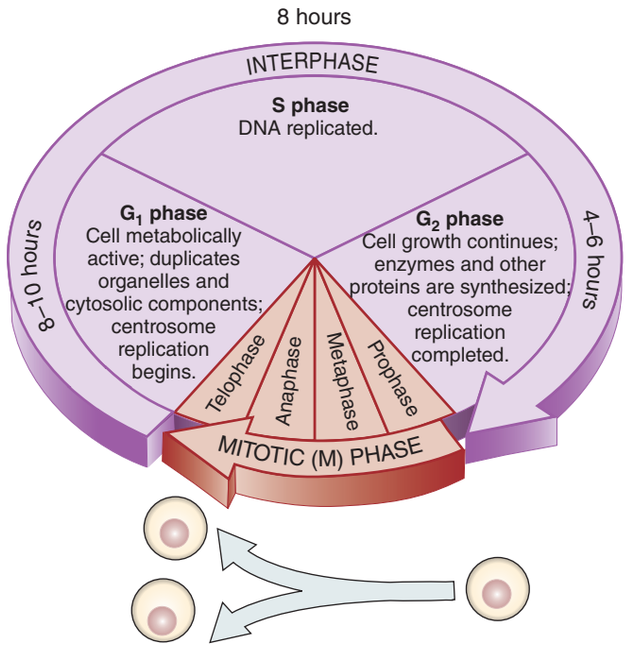
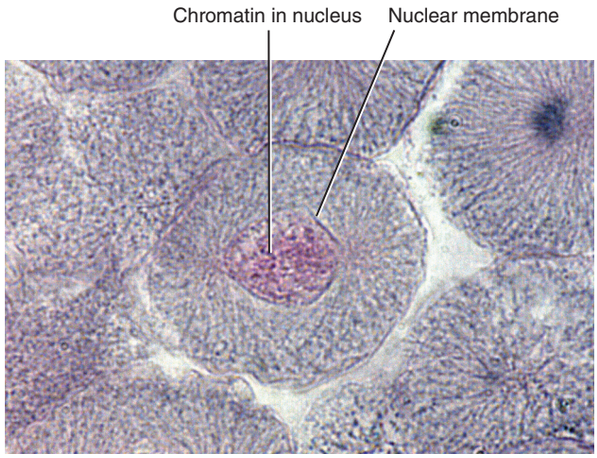


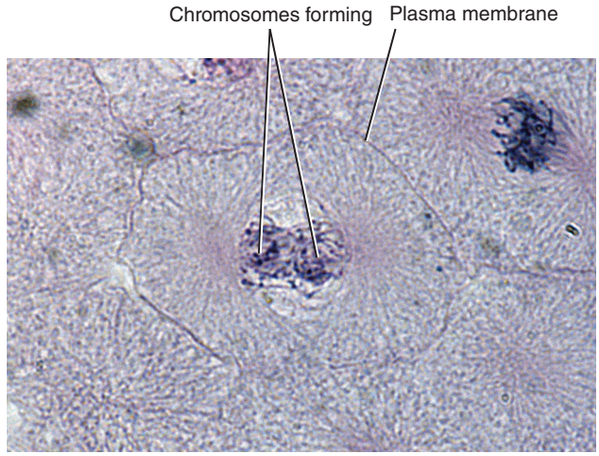
FIGURE 4.3 The cell cycle.

TABLE 4.2 Phases of Somatic Cell Cycle

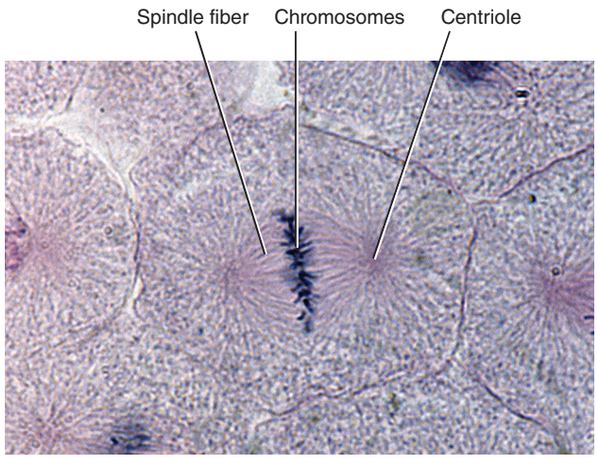
PHASE	DESCRIPTION OF ACTIVITY
Interphase (*inter-* = between)	Period between cell divisions; cells are metabolically active and growing; DNA, organelles, and other cell components replicate; chromosomes cannot be seen with a light microscope
Mitotic Phase	Somatic cell division
Mitosis (*mitos-* = thread)	Nuclear division
• Prophase (*pro-* = first)	Nucleolus and nuclear membrane disappear; chromatin condenses into chromosomes; centrioles move to opposite poles; spindle fibers form
• Metaphase (*meta-* = next)	Chromosomes line up at metaphasal plate; spindle fibers attach to centromeres of chromatids
• Anaphase (*ana-* = apart)	Chromatids of chromosomes separate; move to opposite poles
• Telophase (*telo-* = end)	Cell reverses prophase activities
Cytokinesis (*cyto-* = cell; kinesio- = movement)	Cytoplasmic division into two genetically identical daughter cells; begins during anaphase with formation of cleavage furrow; ends with completion of telophase



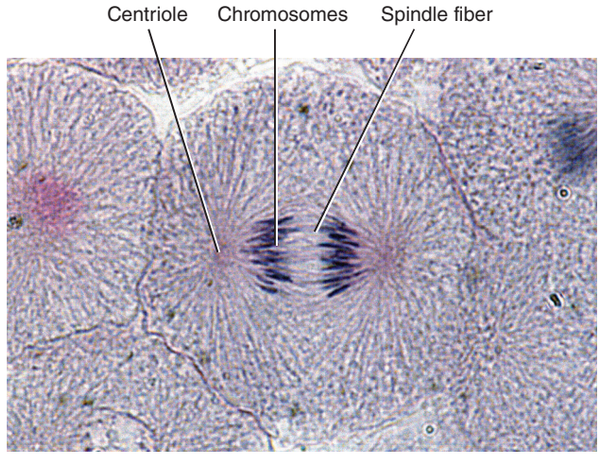
(a)



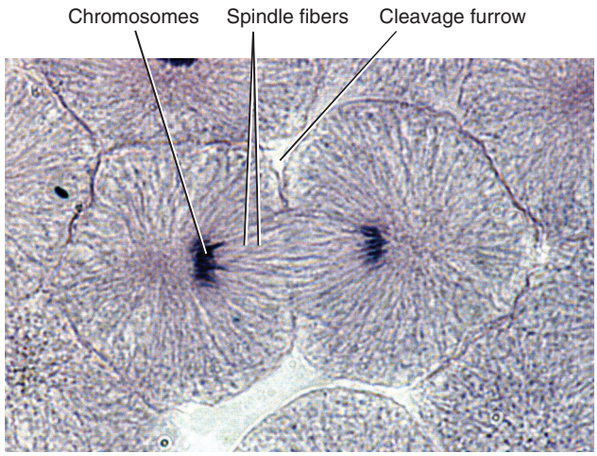
(b)



(c)



(d)



(e)

- anaphase (AN-a-faze) a _____
- interphase (IN-ter-faze) b _____
- metaphase (MEH-ta-faze) c _____
- prophase (PRO-faze) d _____
- telephase and cytokinesis (TELL-o-faze and cyto-kih-NEE-sis) e _____

FIGURE 4.4 Mitotic phases.

Name _____ Date _____ Section _____

Reviewing Your Knowledge

EXERCISE 4

A. Cellular Structure

Fill in the blank with the name of the cell structure that fits the description.

_____ **1.** Short, hair-like projections for movement of substances along cell surface

_____ **2.** Intracellular fluid

_____ **3.** Site of energy production by cellular respiration

_____ **4.** Site of protein synthesis

_____ **5.** Site of steroid and fatty acid synthesis

_____ **6.** Small vesicle with digestive enzymes

_____ **7.** Organelles needed to form cilia and flagella

_____ **8.** Thread-like strand of DNA with associated proteins

_____ **9.** Site of secretory and membrane protein synthesis

_____ **10.** Site where protein products are stored, packaged, and exported

_____ **11.** Contains DNA that control cellular activities

_____ **12.** Site of ribosome synthesis

_____ **13.** Gives the cell shape, support, movement, and holds organelles in position

_____ **14.** Controls movement of substances into or out of the cell

_____ **15.** Folds of the plasma membrane that increase the cell's surface area

_____ **16.** Detoxifies harmful substances, produces hydrogen peroxide, and oxidizes amino acids

_____ **17.** Double membrane that separates the nucleus from the cytoplasm

_____ **18.** A small membranous sac that delivers proteins to the plasma membrane to exit the cell

B. Phases of the Cell Cycle

Write the phase of the cell cycle that the phrase describes.

_____ **1.** Cytoplasmic division

_____ **2.** Cell performing normal functions; longest phase

_____ **3.** Nuclear division

_____ **4.** Chromatid pairs line up at equatorial plate

_____ **5.** Chromatin condenses into chromosomes

_____ **6.** Spindle fibers break up; nucleus reappears

_____ **7.** Centromeres divide; chromosomes move to opposite poles

_____ **8.** Nuclear membrane disassembles and disappears

_____ **9.** Chromosomes unravel to form chromatin

_____ **10.** Mitotic spindle forms

_____ **11.** DNA replicates

Name _____ Date _____ Section _____

Using Your Knowledge

EXERCISE 4

A. Cellular Organelles and Their Function

Write the letter for the correct answer in the blank.

____ **1.** A cell makes and secretes a protein-based hormone. This particular cell would have a great amount of RER and:

(a) SER (b) Golgi complex (c) mitochondria (d) lysosomes

____ **2.** Testes and ovaries that make steroids (lipids) would have a larger amount of:

(a) SER (b) RER (c) mitochondria (d) lysosomes

____ **3.** Muscle cells that need large amounts of ATP would have many:

(a) Golgi complexes (b) ribosomes (c) SER (d) mitochondria

____ **4.** Cells that line the small intestine are specialized for absorption and secretion. The plasma membrane structure they have to accomplish this is:

(a) centrioles (b) cilia (c) flagella (d) microvilli

____ **5.** Immune cells that destroy bacteria with chemicals need an abundance of:

(a) SER (b) ribosomes (c) lysosomes (d) centrioles

B. The Cell Cycle and Mitosis

Answer each question with a short answer.

6. Explain the role of somatic cell division as a person ages from infancy to adulthood.

7. Explain the role of cell division in wound healing.

8. List the cell structures involved in mitosis.

9. Can red blood cells undergo mitosis? Explain.

10. Sperm and eggs have one-half the number of chromosomes of the somatic cells that divided to form them. Are sperm and eggs formed by mitosis? Explain.

11–14. Name four cellular organelles that are membrane bound.

11. _____ **13.** _____

12. _____ **14.** _____

15–17. Which cellular organelles are not membrane bound?

15. _____

16. _____

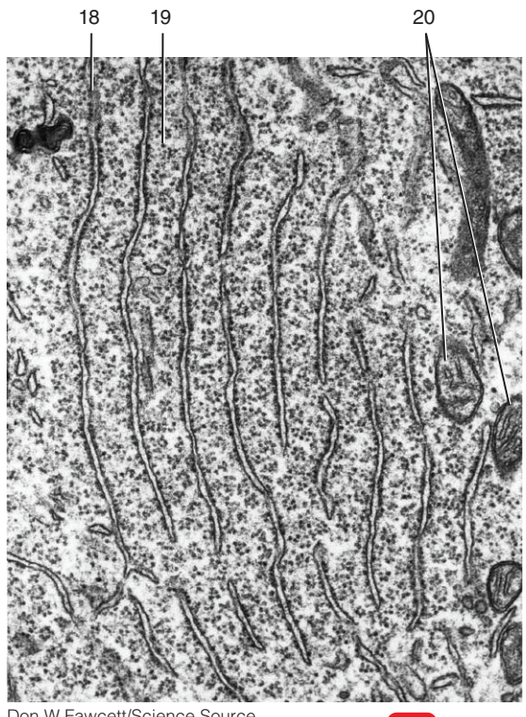
17. _____

18–20. Identify the three structures indicated in Figure 4.5.

18. _____

19. _____

20. _____



Don W.Fawcett/Science Source

TEM 45,000×

FIGURE 4.5 Transmission electron micrograph of a cell section.

EXERCISE

Transport Across the Plasma Membrane

5

OBJECTIVES

1. Describe diffusion and osmosis
2. Compare hypotonic, hypertonic, and isotonic solutions
3. Observe simple diffusion, diffusion and osmosis across a dialysis membrane, osmosis across egg vitelline membrane, and osmosis in living red blood cells

MATERIALS

- **Simple Diffusion:** 2 Petri dishes containing agar per group, small millimeter rulers, forceps, methylene blue crystals, potassium permanganate crystals
- **Diffusion and Osmosis Across a Dialysis Membrane (per group):** dialysis tubing 15 cm long, 2 dialysis clips, 1% starch/ 40% glucose solution, glucose test strips, Lugol's iodine, two 5 mL pipettes, 250 mL beaker, distilled water, gram scale
- **Osmosis Across the Egg Vitelline Membrane:** uncooked egg, vinegar, Karo syrup or 25% sucrose solution, water, 500-mL beaker or glass container with lid, gram scale
- **Osmosis in Living Red Blood Cells:** blood (uncoagulated), disposable gloves, safety glasses, clean microscope slides and coverslips, 4 medicine droppers per group, compound microscope, filter paper

The plasma membrane with its unique design is responsible for discriminately allowing substances into and out of a living cell. **Active processes** require cellular energy (ATP) to transport substances from an area of lower concentration to an area of higher concentration. **Passive processes** do not require the cell to expend energy because the kinetic energy of the particles causes them to move from an area of higher concentration to an area of lower concentration. Passive processes include simple diffusion, facilitated diffusion, and osmosis. In this exercise, we will look at the passive processes of diffusion and osmosis.

A. Simple Diffusion

Diffusion can occur in solids, liquids, or gas, and across the plasma membrane. The net movement of substances from a region of greater concentration to a region of lesser concentration is called moving substances "down the concentration gradient," while moving substances from an area of lesser concentration to an area of higher concentration is called moving substances "against their concentration gradient". A **concentration gradient** indicates there is a difference in the concentration of molecules or ions inside the cell (intracellular) compared to outside the cell (extracellular).

In the following activity, diffusion of two substances through a solid (agar) will be studied. Methylene blue has a molecular weight of 320, and potassium permanganate has a molecular weight of 158. The two substances move at different rates through the agar, which is made up mostly of water.

LAB ACTIVITY 1 Experiment: Simple Diffusion

1. **Prediction:** With your lab group, predict which substance will move faster. (*Hint: Use the molecular weights.*) Circle your answer: *methylene blue* or *potassium permanganate*.
2. **Materials:** Obtain the materials for simple diffusion.
3. **Data Collection:** Measure the diffusion rates of methylene blue and potassium permanganate.
   - Decide who will set up the experiment, who will time, who will measure, and who will record.
   - Carefully using forceps, place a large crystal of methylene blue on the surface of an agar Petri dish (Figure 5.1). Be careful not to drop any extra crystals on the agar surface.
   - Using the same technique, place a similar size crystal of potassium permanganate on the other side of the Petri dish.
   - Using a millimeter (mm) ruler, measure each substance's diameter of diffusion at 15-minute intervals for at least 1 hour (or longer if desired).
   - After each observation, record the diffusion diameter of each substance in millimeters (mm) in Table 5.1.
4. Clean up as directed by your instructor.

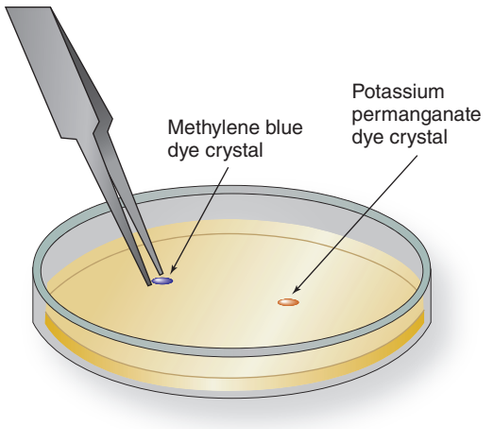


FIGURE 5.1 Diffusion in agar plate setup.

5. **Data Analysis:** Calculate the diffusion rates for each time period for the two substances using Table 5.1.
6. Complete the Experimental Report with your lab group.

EXPERIMENTAL REPORT
Simple Diffusion

Results: Which substance moved faster?

Discussion: Discuss why the diffusion rates of the two substances differed.

Conclusion: State how molecular weight affects diffusion rate.

TABLE 5.1 Simple Diffusion Results

	DIFFUSION OF METHYLENE BLUE		DIFFUSION OF POTASSIUM PERMANGANATE	
TIME (min)	DIFFUSION DIAMETER (mm)	DIFFUSION RATE (mm/min)	DIFFUSION DIAMETER (mm)	DIFFUSION RATE (mm/min)
15				
30				
45				
60				
75				

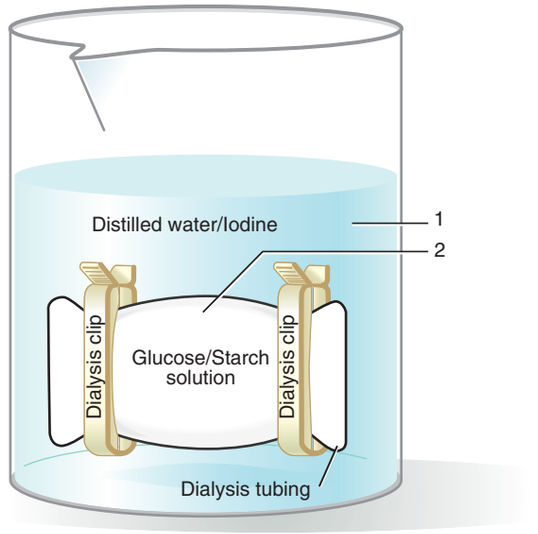
B. Diffusion and Osmosis Across a Dialysis Membrane

Osmosis is the diffusion of a solvent (dissolving medium, which is water in living organisms) across a selectively permeable membrane that occurs in response to differences in solute (substance dissolved in solvent) concentrations. Water diffuses from an area of higher water concentration but lower solute concentration **(hypotonic solution)** to an area of lower water concentration but higher solute concentration **(hypertonic solution)**. The terms hypotonic (*hypo-* = deficient; *-tonos* = stretching) solution or hypertonic solution are used only when two solutions are compared. A solution's *tonicity* is a measure of the solution's ability to change the volume of a cell by changing water content. Water will move into the hypertonic solution until the solute concentrations of the two solutions equalize to become **isotonic solutions** (*iso-* = same) or if enough pressure is applied to stop the flow of water.

In the following activity, a solution containing glucose and starch is added to a dialysis membrane bag (semipermeable membrane), which is placed in distilled water. Iodine is added to the distilled water at the end of the experiment. Dialysis membranes contain small pores that allow water and small solutes to cross. If water enters the bag, the weight of the bag will increase, and if water leaves the bag, its weight will decrease.

Before Going to Lab

1 Label Figure 5.2.



- hypertonic solution 1 _____
- hypotonic solution 2 _____

FIGURE 5.2 Dialysis bag setup.

LAB ACTIVITY 2 Experiment: Diffusion and Osmosis Across a Dialysis Membrane

NOTE: *This experiment should be set up at the beginning of class so that changes can be observed and recorded throughout the lab time. The results become more dramatic the longer this experiment runs.*

1 Prediction: With your lab group, predict the direction of each of the following substances: water, glucose, iodine, and starch in Figure 5.2 by circling the correct italicized choice.

- The net movement of water (measurable by weight) will be *into* or *out of* the dialysis bag.
- Glucose *will* or *will not* move out of the dialysis bag.
- Starch *will* or *will not* move out of the dialysis bag.
- Iodine *will* or *will not* move into the dialysis bag.

2 Materials: Obtain materials for osmosis and diffusion across a dialysis membrane.

3 Data Collection:

- Decide who will set up the experiment, who will time, and who will weigh and record.
- Obtain a 15-cm piece of dialysis tubing and soak the bag in distilled water for 3 minutes to make it easier to open.
- Fold over one end of the dialysis tubing and secure it with a dialysis clip or tie it.
- Rub the open end of the dialysis tubing between your thumb and finger to separate the sides and fill the dialysis tubing with 5 mL of the 1% starch/ 40% glucose solution. Gently push air out of bag and close end with a dialysis clip.
- Rinse the bag to remove any starch/glucose solution on the outside of the bag, blot it dry, and weigh it. Record the beginning weight in Table 5.2
- Submerge the dialysis bag in a beaker containing 100 mL of distilled water.
- Dry and weigh the dialysis bag after 15-minutes, 30-minutes, and 45-minutes. If your lab lasts longer, you may also do a 60-minute measurement.
- Record each measurement in Table 5.2. Do not put dialysis bag back into the beaker water until later.
- Dip a glucose test stick into the beaker water to determine if glucose is present. Glucose present: Yes or No

TABLE 5.2 Dialysis Bag Results

TIME (min)	WEIGHT OF DIALYSIS BAG (grams)
0 min	Start weight:
15 min	
30 min	
45 min	
60 min	

- Add 2 mL of Lugol's iodine to the beaker water to see if starch is present. If starch is present, the Lugol's iodine solution will turn blue. Starch present: Yes or No
- Place the dialysis bag back into the beaker water. If iodine can diffuse across the dialysis membrane, the glucose/starch solution in the dialysis bag will turn blue. Iodine enters dialysis bag: Yes or No
- Clean up as directed by your instructor.
- Complete the Experimental Report with your lab group.

EXPERIMENTAL REPORT

Results:

- Describe how the weight of the bag changed over time.

- Did glucose and/or starch diffuse across the dialysis membrane and into the beaker water?

- Did iodine diffuse across the dialysis membrane and into the dialysis bag?

Discussion:

- Identify the solutes and solvents in this experiment.

- Which direction did osmosis occur?

- What determined whether glucose, starch, and iodine were able to diffuse across the dialysis membrane?

- In this experiment, what represented the plasma membrane, intracellular fluid, and extracellular fluid?

Conclusion: State what drives osmosis and diffusion across the dialysis membrane. When would osmosis and diffusion stop?

C. Osmosis Across the Egg Vitelline Membrane

The vitelline membrane of the egg is a thin, semipermeable membrane found on the underside of the shell in a raw egg. The chicken egg is not a single cell, and the vitelline membrane is not equivalent to the cell plasma membrane. In this activity, a raw egg is soaked in vinegar for 24–48 hours to dissolve the eggshell and leave the vitelline membrane. The egg surrounded by the vitelline membrane is then placed in different solutions to observe osmosis.

LAB ACTIVITY 3 Experiment: Osmosis Across the Egg Vitelline Membrane

1. **Prediction:** With your lab group, predict the direction of water movement by circling the correct italicized choice.
   - When the egg is placed in distilled water, the net movement of water will be *into* or *out of* the egg.
   - When the egg is placed in 25% sucrose solution (or Karo syrup), the net movement of water will be *into* or *out of* the egg.
2. **Materials:** Obtain materials for osmosis across the egg vitelline membrane. The eggs used in this experiment are raw eggs that have been soaked in vinegar for 24–48 hours.
3. **Data Collection:** Observe osmosis across the vitelline membrane of the egg and record your results in Table 5.3.
   - Decide who will set up the experiment, who will time, who will weigh, and who will record.
   - Remove two eggs from the vinegar solution and gently rinse the eggs in water. Blot water off the eggs and then weigh the eggs. Record the weight in Table 5.3.
   - Place one egg in a 25% sucrose solution (Karo syrup or maple syrup can also be used) and the other egg in distilled water.
   - Dry and weigh the eggs after 15-minutes, 30-minutes, 45-minutes, and 60-minutes. Observe any change in appearance of the eggs over time.
   - Record each measurement in Table 5.3.
   - Break the vitelline membrane and observe the appearance of the egg. Is it similar to a raw egg or a cooked egg?
4. Clean up as directed by your instructor.
5. Complete the Experimental Report with your lab group.

TABLE 5.3 Osmosis Across the Vitelline Membrane

TIME (min)	WEIGHT OF EGG IN SUCROSE SOLUTION (grams)	WEIGHT OF EGG IN WATER (grams)
0 min	Start weight:	Start weight:
15 min		
30 min		
45 min		
60 min		
Change in Appearance of Egg over Time		
Egg in sucrose solution		
Egg in water		