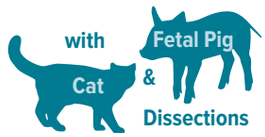

LABORATORY MANUAL FOR

HUMAN ANATOMY & PHYSIOLOGY

FIFTH EDITION

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Mc Graw Hill

LABORATORY MANUAL FOR HUMAN ANATOMY & PHYSIOLOGY, FIFTH EDITION

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CONTENTS

Surface Anatomy

Nervous System

General and Special Senses

Endocrine System

Cardiovascular System

Lymphatic System

Respiratory System

Digestive System

Urinary System

Reproductive System and Development

Cat Dissection

Fetal Pig Dissection

Supplemental Laboratory Exercises*

*These supplemental exercises are available in the eBook via Connect Anatomy & Physiology and also online for instructor distribution; see Instructor Resources via Connect Library tab.

PREFACE

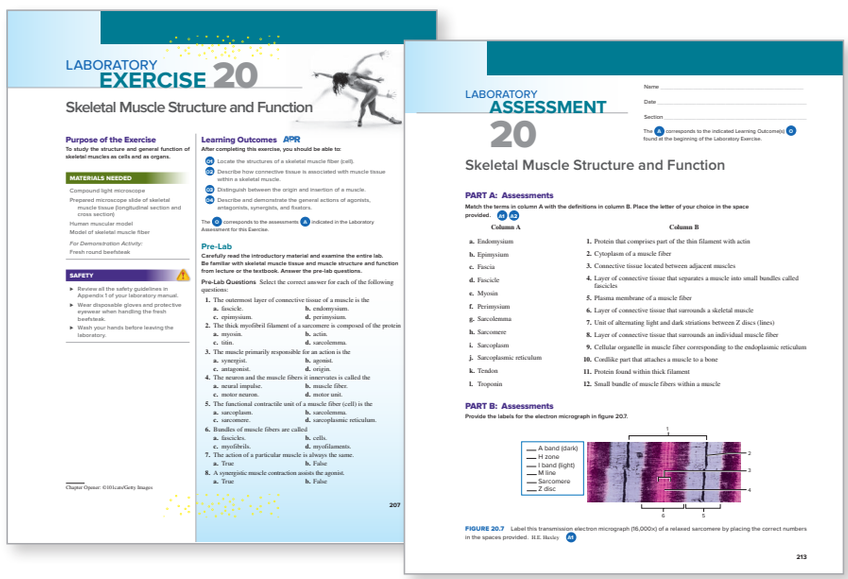
In TOUCH | WITH Anatomy & Physiology Lab Courses

Author Cynthia Prentice-Craver's twenty-seven years of passion for and experience in teaching human anatomy and physiology, and her commitment to developing curriculum that stimulates student curiosity and enthusiasm, steered her cultivation of this fifth edition laboratory manual. Terry, the original author of this laboratory manual, had forty-year experience teaching anatomy and physiology courses, authored three different laboratory manuals, and was actively involved in the Human Anatomy and Physiology Society (HAPS) which drove his determination to create a laboratory manual with an innovative approach that would benefit students. Cynthia is honored to have had Terry Martin as her mentor and coauthor on previous editions, and she has worked to uphold the reputation and brand while developing this fifth edition laboratory manual. The *Laboratory Manual for Human Anatomy & Physiology* includes sixty-three laboratory exercises, three supplemental labs found online, six cat dissection labs, six fetal pig dissection labs, forty-six Virtual Lab lessons, and thirteen Physiology Interactive Lab Simulations (Ph.I.L.S) lessons. This laboratory manual is written to work well with any anatomy and physiology text.

Martin Lab Manual Series . . .

In TOUCH WITH Anatomy & Physiology Lab Courses

- Anatomy and Physiology REVEALED® icons are found in figure legends. These icons indicate that there is a direct link to APR available in the eBook provided with Connect® for this title.
- Incorporates **learning outcomes and assessments** to help students master important material.
- **Pre-Lab** assignments are printed in the lab manual. They will help students be more prepared for lab and save instructors time during lab.
- **Clear, concise** writing style facilitates more thorough understanding of lab exercises.
- **BIOPAC®** exercises use hardware and software for data acquisition, analysis, and recording.



- **NEW! Virtual Labs,** with lessons available in Appendix 4, are simulations that correspond well to many of the laboratory activities in this 5e laboratory manual. The virtual lab lessons can be completed as pre-lab preparation, in-lab or on-line assignments, or post-lab review.
- **NEW!** Cadaver and anatomical models **(APR)** are incorporated throughout the lab manual. These anatomical model images correspond with typical models seen in a laboratory classroom and help students make an association with the cadaver.
- **Ph.I.L.S.** physiology lab simulations, with lessons available in Appendix 4, make otherwise difficult and expensive experiments a breeze through digital simulations.
- **Micrographs** incorporated throughout the lab aid students' visual understanding of difficult topics.
- **Instructor's Guide** is available online for quick and easy use by instructors.

FEATURES OF THIS LABORATORY MANUAL

InTOUCH WITH Student Needs

- The procedures are clear, concise, and easy to follow. Relevant lists and summary tables present the contents efficiently. Histology micrographs and anatomical model and cadaver photos are incorporated in the appropriate locations within the associated labs.
- The pre-lab section includes quiz questions. It also directs the student to carefully read the introductory material and the entire lab to become familiar with its contents. If necessary, a textbook or lecture notes might be needed to supplement the concepts.
- **Terminologia Anatomica** is used as the source for universal terminology in this laboratory manual. Alternative names are included when a term is introduced for the first time.
- Laboratory assessments immediately follow each laboratory exercise.
- Histology photos (micrographs) are placed within the appropriate laboratory exercise.
- A section called "Study Skills for Anatomy and Physiology" is located in the front of this laboratory manual. This section was written by students enrolled in a Human Anatomy and Physiology course.
- Critical Thinking Activities and Assessments are incorporated within most of the laboratory exercises to enhance valuable critical thinking skills that students need throughout their lives.
- Cadaver images are incorporated with dissection labs.
- Images of anatomical models are included within certain laboratory exercises.

InTOUCH WITH Instructor Needs

- The instructor will find digital assets for use in creating customized lectures, visually enhanced tests and quizzes, and other printed support material.
- Some unique labs included are "Scientific Method and Measurements," "Chemistry of Life," "Fetal Skeleton," "Surface Anatomy," "Diabetic Physiology," "Metabolism," and "Genetics."
- The instructor's guide for *Laboratory Manual for Human Anatomy and Physiology, 5e* provides the answers to the pre-lab and assessment questions, as well as an estimated average time schedule.
- One or more laboratory exercise can be completed during a single laboratory session.

InTOUCH WITH Educational Needs

- Learning outcomes with icons O have matching assessments with icons A so students can be sure they have accomplished the laboratory exercise content. Outcomes and assessments include all levels of learning skills: remember, understand, apply, analyze, evaluate, and create.
- Assessment rubrics for entire laboratory assessments are included in Appendix 3.

InTOUCH WITH Technology

- Anatomy & Physiology Revealed® 4.0

  Detailed cadaver photographs blended together with a state-of-the-art layering technique provide a uniquely interactive dissection experience. Certain animations can be viewed to enhance student learning. Cat and fetal pig versions are also available.

- Virtual Labs Virtual Labs are included with Connect for this laboratory manual. There are forty-six Virtual Lab lessons located in Appendix 4, including a correlation guide.

- PhILS Physiology Interactive Lab Simulations (Ph.I.L.S.) is included with Connect for this laboratory manual. Thirteen lab simulation lessons are located in Appendix 4, including a correlation guide.

- BIOPAC Systems, Inc. BIOPAC® exercises are included on four different body systems. BIOPAC® systems use hardware and software for data acquisition, analysis, and recording of information for an individual.

- Practice ATLAS Practice Atlas is included with Connect for this laboratory manual. It is an interactive tool that pairs images of anatomical models with cadaver photographs, allowing students to practice naming structures on both models and human bodies. New to this edition are additional labeling exercises that feature anatomical models and cadaver images from Practice Atlas.

(hand): 4FR/E+/Getty Images

GUIDED TOUR THROUGH AN EXERCISE

The laboratory exercises include a variety of special features that are designed to stimulate interest in the subject matter, to involve students in the learning process, and to guide them through the planned activities. These features include the following:

Purpose of the Exercise The purpose provides a statement about the intent of the exercise—that is, what will be accomplished.

Learning Outcomes The learning outcomes list what a student should be able to do after completing the exercise. Each learning outcome will have matching assessments indicated by the corresponding icon A in the laboratory assessment.

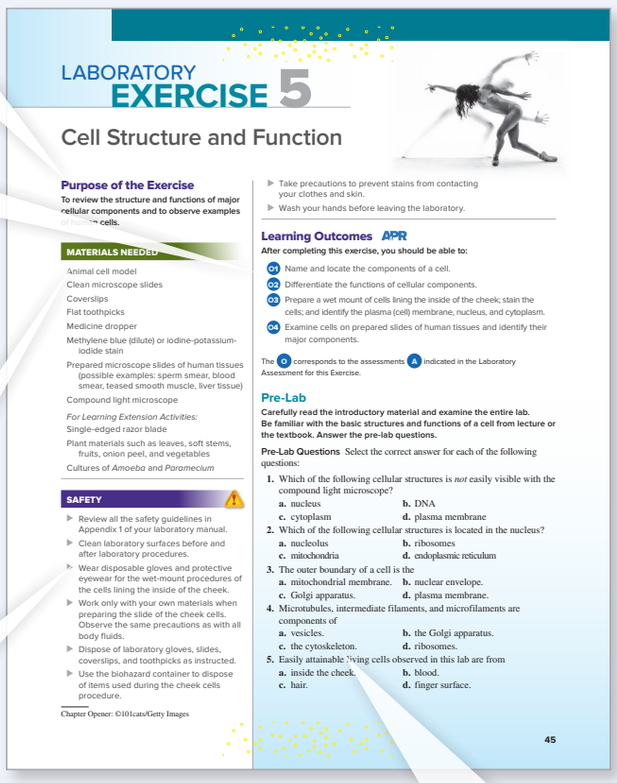
Materials Needed This section lists the laboratory materials that are required to complete the exercise and to perform the demonstrations and learning extensions.

Safety A list of laboratory safety guidelines is located in Appendix 1 of your laboratory manual. Each lab session that requires special safety guidelines has a safety section. Your instructor might require some modifications of these guidelines.

Introduction The introduction describes the subject of the exercise or the ideas that will be investigated. It includes all of the information needed to perform the laboratory exercise.

Procedure The procedure provides a set of detailed instructions for accomplishing the planned laboratory activities. Usually these instructions are presented in outline form so that a student can proceed efficiently through the exercise in stepwise fashion.

The procedures, often presented in parts, include a wide variety of laboratory activities and, from time to time, direct the student to complete various tasks in the laboratory assessments.



LABORATORY EXERCISE 5

Cell Structure and Function

Purpose of the Exercise

To review the structure and functions of major cellular components and to observe examples of human cells.

MATERIALS NEEDED

Animal cell model
Clean microscope slides
Coverslips
Flat toothpicks
Medicine dropper
Methylene blue (dilute) or iodine-potassium-iodide stain
Prepared microscope slides of human tissues (possible examples: sperm smear, blood smear, teased smooth muscle, liver tissue)
Compound light microscope

For Learning Extension Activities:
Single-edged razor blade
Plant materials such as leaves, soft stems, fruits, onion peel, and vegetables
Cultures of *Amoeba* and *Paramecium*

SAFETY

- Review all the safety guidelines in Appendix 1 of your laboratory manual.
- Clean laboratory surfaces before and after laboratory procedures.
- Wear disposable gloves and protective eyewear for the wet-mount procedures of the cells lining the inside of the cheek.
- Work only with your own materials when preparing the slide of the cheek cells. Observe the same precautions as with all body fluids.
- Dispose of laboratory gloves, slides, coverslips, and toothpicks as instructed.
- Use the biohazard container to dispose of items used during the cheek cells procedure.
- Take precautions to prevent stains from contacting your clothes and skin.
- Wash your hands before leaving the laboratory.

Learning Outcomes APR

After completing this exercise, you should be able to:

- LO1 Name and locate the components of a cell.
- LO2 Differentiate the functions of cellular components.
- LO3 Prepare a wet mount of cells lining the inside of the cheek; stain the cells; and identify the plasma (cell) membrane, nucleus, and cytoplasm.
- LO4 Examine cells on prepared slides of human tissues and identify their major components.

The LO corresponds to the assessments A indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Be familiar with the basic structures and functions of a cell from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. Which of the following cellular structures is *not* easily visible with the compound light microscope?
   a. nucleus **b.** DNA
   c. cytoplasm **d.** plasma membrane
2. Which of the following cellular structures is located in the nucleus?
   a. nucleolus **b.** ribosomes
   c. mitochondria **d.** endoplasmic reticulum
3. The outer boundary of a cell is the
   a. mitochondrial membrane. **b.** nuclear envelope.
   c. Golgi apparatus. **d.** plasma membrane.
4. Microtubules, intermediate filaments, and microfilaments are components of
   a. vesicles. **b.** the Golgi apparatus.
   c. the cytoskeleton. **d.** ribosomes.
5. Easily attainable living cells observed in this lab are from
   a. inside the cheek. **b.** blood.
   c. hair. **d.** finger surface.

Chapter Opener: ©101cats/Getty Images

45

Pre-Lab The pre-lab includes quiz questions and directs the student to carefully read introductory material and examine the entire laboratory contents after becoming familiar with the topics from a textbook or lecture. After successfully answering the pre-lab questions, the student is prepared to become involved in the laboratory exercise.

The vertebral column and thoracic cage are part of the axial skeleton, in addition to the skull. The vertebral column, consisting of twenty-six bones, extends from the skull to the pelvis and forms the vertical axis of the human skeleton. The *vertebral column* includes seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, one sacrum of five fused vertebrae, and one coccyx of usually four fused vertebrae. To help you remember the number of cervical, thoracic, and lumbar vertebrae from superior to inferior, consider this saying: breakfast at 7, lunch at 12, and dinner at 5. These vertebrae are separated from one another by cartilaginous *intervertebral discs* and are held together by ligaments.

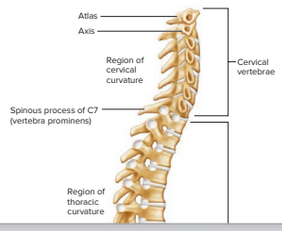
The *thoracic cage* surrounds the thoracic and upper abdominal cavities. It includes the ribs, the thoracic vertebrae, the sternum, and the costal cartilages. The thoracic cage provides protection for the heart and lungs.

PROCEDURE A: Vertebral Column

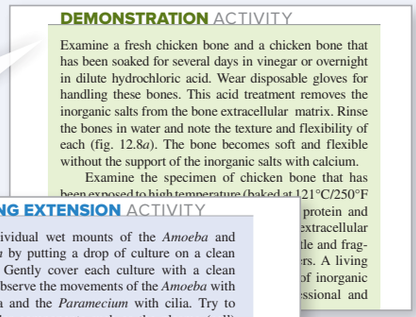
The vertebral column extends from the first cervical vertebra adjacent to the skull to the inferior tip of the coccyx. The first cervical vertebra (C1) is also known as the *atlas* and has a posterior tubercle instead of a more pronounced spinous process. The second cervical vertebra (C2), known as the *axis*, has a superior projection, the dens (odontoid process) that serves as a pivot point for some rotational movements. The seventh cervical vertebra (C7) is often referred to as the *vertebra prominens* because the spinous process is elongated and easily palpated as a surface feature. The seven cervical vertebrae have the distinctive feature of transverse foramina for passageways of blood vessels serving the brain.

The four curvatures of the vertebral column develop either before or after birth. The *thoracic* and *sacral curvatures* (primary curvatures) form by the time of birth. The *cervical curvature* develops by the time a baby is able to hold the head erect and crawl, while the *lumbar curvature* forms by the time the child is able to walk. The cervical and lumbar curvatures represent the secondary curvatures. The four curvatures allow for flexibility and resiliency of the vertebral column and for it to function somewhat like a spring instead of a rigid rod.

1. Examine figure 15.1 and the vertebral column of the human skeleton. Locate the following bones and features. At the same time, locate as many of the corresponding bones and features in the skeleton as possible.



Demonstration Activities Demonstration activities appear in separate boxes. They describe specimens, specialized laboratory equipment, or other materials of interest that an instructor may want to display to enrich the student's laboratory experience.

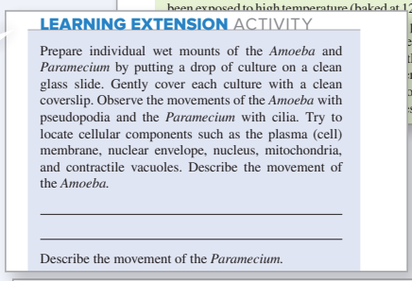


DEMONSTRATION ACTIVITY

Examine a fresh chicken bone and a chicken bone that has been soaked for several days in vinegar or overnight in dilute hydrochloric acid. Wear disposable gloves for handling these bones. This acid treatment removes the inorganic salts from the bone extracellular matrix. Rinse the bones in water and note the texture and flexibility of each (fig. 12.8*a*). The bone becomes soft and flexible without the support of the inorganic salts with calcium.

Examine the specimen of chicken bone that has been exposed to high temperature (baked at 121°C/250°F protein and extracellular le and frag- rs. A living of inorganic ssional and

Learning Extension Activities Learning extension activities also appear in separate boxes. They encourage students to extend their laboratory experiences. Some of these activities are open-ended in that they suggest the student plan an investigation or experiment and carry it out after receiving approval from the laboratory instructor. Some of the figures are illustrated as line art or in grayscale. This will allow colored pencils to be used as a visual learning activity to distinguish various structures.

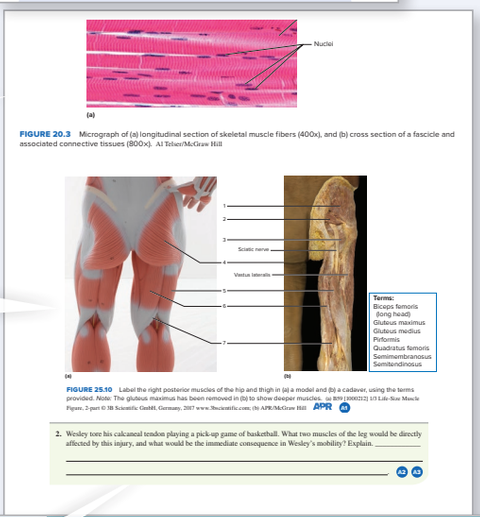


LEARNING EXTENSION ACTIVITY

Prepare individual wet mounts of the *Amoeba* and *Paramecium* by putting a drop of culture on a clean glass slide. Gently cover each culture with a clean coverslip. Observe the movements of the *Amoeba* with pseudopodia and the *Paramecium* with cilia. Try to locate cellular components such as the plasma (cell) membrane, nuclear envelope, nucleus, mitochondria, and contractile vacuoles. Describe the movement of the *Amoeba.*

Describe the movement of the *Paramecium.*

Histology Histology photos (micrographs) are placed within the appropriate exercise.



Nuclei

(a)

FIGURE 20.3 Micrograph of (a) longitudinal section of skeletal muscle fibers (400x), and (b) cross section of a fascicle and associated connective tissues (800x). A) Telser/McGraw Hill

Illustrations Diagrams similar to those in a textbook often are used as aids for reviewing subject matter. Other illustrations provide visual instructions for performing steps in procedures or are used to identify parts of instruments or specimens. Micrographs are included to help students identify microscopic structures or to evaluate student understanding of tissues.

1
2
3
Sciatic nerve
4
Vastus lateralis
5
6
7

Terms:
Biceps femoris (long head)
Gluteus maximus
Gluteus medius
Piriformis
Quadratus femoris
Semimembranosus
Semitendinosus

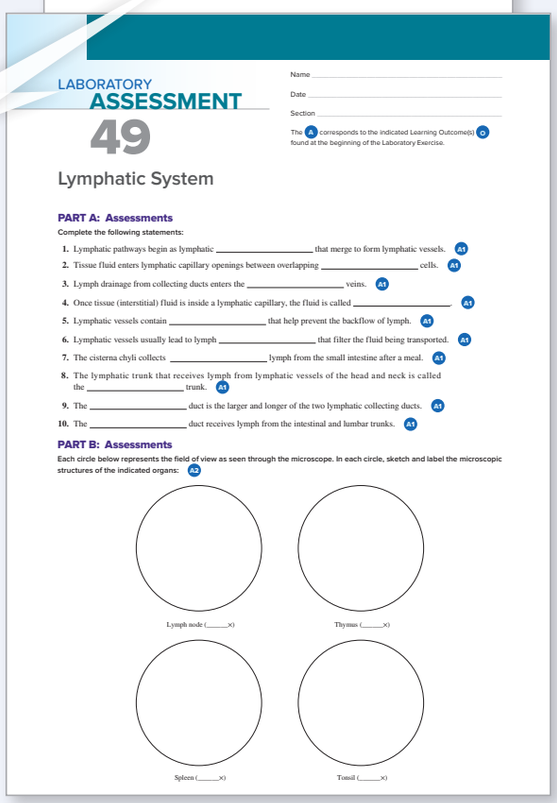
(a) (b)

FIGURE 25.10 Label the right posterior muscles of the hip and thigh in (a) a model and (b) a cadaver, using the terms provided. *Note:* The gluteus maximus has been removed in (b) to show deeper muscles. (a) BSN [380522] 1/3 Life-Size Muscle Figure, 2-part © 3B Scientific GmbH, Germany, 2017 www.3bscientific.com; (b) APR/McGraw Hill APR A1

2. Wesley tore his calcaneal tendon playing a pick-up game of basketball. What two muscles of the leg would be directly affected by this injury, and what would be the immediate consequence in Wesley's mobility? Explain. _____ A2 A3

Laboratory Assessments A laboratory assessment form to be completed by the student immediately follows each exercise. These assessments include various types of review activities, spaces for sketches of microscopic specimens, tables for recording observations and experimental results, and questions dealing with the analysis of such data. Critical Thinking Assessments enhance higher-order thinking skills.

As a result of these activities, students will develop a better understanding of the structural and functional characteristics of their bodies and will increase their skills in gathering information by observation and experimentation. By completing all of the assessments, students will be able to determine if they were able to accomplish all of the learning outcomes.



LABORATORY
ASSESSMENT
49

Name _____
Date _____
Section _____

The A corresponds to the indicated Learning Outcome(s) O found at the beginning of the Laboratory Exercise.

Lymphatic System

PART A: Assessments

Complete the following statements:

1. Lymphatic pathways begin as lymphatic _____ that merge to form lymphatic vessels. A1
2. Tissue fluid enters lymphatic capillary openings between overlapping _____ cells. A1
3. Lymph drainage from collecting ducts enters the _____ veins. A1
4. Once tissue (interstitial) fluid is inside a lymphatic capillary, the fluid is called _____ A1
5. Lymphatic vessels contain _____ that help prevent the backflow of lymph. A1
6. Lymphatic vessels usually lead to lymph _____ that filter the fluid being transported. A1
7. The cisterna chyli collects _____ lymph from the small intestine after a meal. A1
8. The lymphatic trunk that receives lymph from lymphatic vessels of the head and neck is called the _____ trunk. A1
9. The _____ duct is the larger and longer of the two lymphatic collecting ducts. A1
10. The _____ duct receives lymph from the intestinal and lumbar trunks. A1

PART B: Assessments

Each circle below represents the field of view as seen through the microscope. In each circle, sketch and label the microscopic structures of the indicated organs: A2

Lymph node (_____×)
Thymus (_____×)
Spleen (_____×)
Tonsil (_____×)

CHANGES TO THIS FIFTH EDITION

Global Changes

- Consolidated the MAIN, CAT, and FETAL PIG dissection versions into a single version of the laboratory manual.
- NEW Virtual Lab lessons added; forty-six lessons located in appendices.
- Ph.I.L.S. laboratory lessons revised and updated; thirteen lessons located in appendices.
- New photos added of micrographs, Practice Atlas anatomical models, and cadaver images from APR to enhance visuals for student learning. APR icons.
- Moved location of figure number and caption to below the illustration or image.
- Critical Thinking Assessment questions have added to their title the assessment Part in which they are located.

LABORATORY EXERCISE	TOPIC	CHANGE
2	Introductory material Procedure A (body cavities and membranes) Fig. 2.2*a* and 2.2*b* (thoracic serous membranes) Fig. 2.3 (abdominal serous membranes) Table 2.1 (directional terms meaning) Fig. 2.7 (planes) Fig. 2.9 (body surface regions) Fig. 2.11 (body cavities of head) Fig. 2.12 (serous membranes of heart) Fig. 2.13 (abdominal cavity serous membrane) Assessments: Part C Fig. 2.14 (planes) Fig. 2.15 (regions)	Revised components and improved depth Removed content from labels and added them to text Removed content from labels and added them to text Removed content from labels and added them to text Added terms Changed/revised figure Changed location of labels New figure Changed figure New figure Added questions Changed/revised figure New figure
3	Pre-Lab	Added question
4	Learning Outcomes Fig. 4.1 (microscope) Table 4.1 (microscope parts and their function) Fig. 4.5 (focus on objectives) Assessments: Part A Fig. 4.8 (microscope) Assessments: Part D Matching	Revised Learning Outcome 01 Changed/revised figure Revised table Cropped figure Added letter *e* directions to step 9 text Changed/revised figure Edited certain terms in Column A
5	Introductory material Fig. 5.4*b* (cell model) Fig. 5.5 (cellular components)	Provided examples of membranous and nonmembranous organelles New figure Changed/revised figure
6	Introductory material Procedure B (osmosis)	Revised part on filtration Revised components
7	Learning Outcomes Fig. 7.4 (anaphase) Fig. 7.6 (onion root tip cells) Fig. 7.7 (human chromosomes) Assessments: Part D	Revised Learning Outcome 01 Added (b) micrograph Replaced images; revised legend Replaced (b) image New CTA question
8	Fig. 8.1 (epithelial tissues histology) Assessments: Part B Assessments: Part C	Replaced (i) micrograph Revised questions; added question New CTA question Revised leader lines Revised field of view circles for drawings Added questions
9	Fig. 9.1 (connective tissues histology) Procedure (connective tissues) Assessments: Part B	Replaced (d) micrograph Expanded directions in steps 3 and 4 Added question
10	Introductory material Assessments: Part B	Revised components New CTA question

LABORATORY EXERCISE	TOPIC	CHANGE
11	Introductory material Fig. 11.2 (skin and hypodermis) Table 11.1 (layers of epidermis) Procedure (integumentary system) Fig. 11.6 (glands) Fig. 11.8 (strata of thick skin) Assessments: Part A	Revised components Added hair matrix label Added components Expanded directions in step 7 New figure with micrographs (a) and (b) New figure with model and micrograph images New CTA question
12	Introductory material Assessments: Part A Assessments: Part C	Improved depth of cells Added question New CTA question
13	Fig. 13.3 (major bones of skeleton) Assessments: Part A Assessments: Part C Assessments: Part D	Replaced illustrations Added question Added term and definition to number 1; new CTA question Renumbered 9-14
14	Learning Outcome 04 Procedure (skull) Fig. 14.9 (paranasal sinuses) Assessments: Part B Assessments: Part C Fig. 14.14 (paranasal sinuses) Fig. 14.15 (orbital bones)	Revised for clarity Added bone feature to number 3 Replaced illustrations Added bone feature Rearranged questions; added question to number 1; added a number 2 New figure with radiograph image New figure
15	Learning Outcomes 01 and 04 Procedure A (vertebral column) Fig. 15.8 (vertebral column)	Changed wording Modified components Replaced illustration with image; revised/added features to terms
16	Pre-Lab Introductory material Procedure A (pectoral girdle) Procedure B (upper limb) Fig. 16.9 (left shoulder radiograph) Assessments: Part D	Added question Revised components Revised and expanded components Added components; new CTA question Replaced radiograph image New CTA question
17	Introductory material Procedure A (pelvic girdle) Fig. 17.1 (bones of the pelvis) Procedure B (lower limb) Fig. 17.3 (femur and patella) Fig. 17.4 (tibia and fibula) Fig. 17.6 (male and female pelves) Fig. 17.7 (radiograph of pelvic region) Fig. 17.10 (features of coxal bone)	Expanded components Added components Added (a) anterolateral view; revised (b) anterosuperior view Added components Added label Added label New figure Added term to label Replaced illustrations with images; moved position of figure
19	Purpose of this Exercise Fig. 19.8 (knee joint) Assessments: Part E	Revised and expanded components New figure New CTA question
20	Pre-Lab Introductory material Fig. 20.3 (skeletal muscle) Procedure (skeletal muscle structure and function)	Added question Expanded components Added (a) longitudinal section micrograph Revised components
21	Introductory material and procedures	Updated branding and equipment terms
22	Pre-Lab Fig. 27.7 (anterior head and neck muscles)	Added question Added terms to (a); added new image of model as (b)
23	Pre-Lab Fig. 23.9 (posterior muscles) Fig. 23.11 (forearm muscles)	Added questions Modified legend; added new image of model as (b) Added new image of posterior muscles as (b)

LABORATORY EXERCISE	TOPIC	CHANGE
24	Pre-Lab Procedure B (muscles of the pelvic floor) Table 24.3 (pelvic floor) Fig. 24.5 (deep back) Assessments: Part B Fig. 24.7 (pelvic floor) Assessments: Part C	Added question Organized muscles Expanded components Added label; renumbered Improved clarity to numbers 2 and 9 New figure Added questions
25	Pre-Lab Introductory material Fig. 25.9 (anterior hip and thigh) Fig. 25.10 (posterior hip and thigh) Assessments: Part B Fig. 25.11 (lateral leg)	Added question Revised components Added new cadaver image as (b); added new terms box Added new image of model in (a) Added muscle and action Added new image of model in (b)
26	Fig. 26.2 (anterior head and neck) Fig. 26.3 (anterior upper torso) Fig. 26.4 (lateral upper shoulder and upper limb) Fig. 26.5 (anterior and posterior upper limb) Fig. 26.7 (plantar foot) Fig. 26.8 (lower limb) Table 26.1 (bony and soft tissue surface)	Replaced image of (a) Replaced image of (a); moved and removed some labels Replaced image Replaced images of (a) and (b) Replaced image Replaced images of (a), (b), and (c) Added three terms
27	Pre-Lab Fig. 27.8 Assessments: Part A Assessments: Part D	Added question Replaced image Added term and description New CTA question
28	Pre-Lab Introductory material Fig. 28.5 (spinal cord) Table 28.1 (nerve plexuses) Fig. 28.11 (lumbar and sacral plexuses) Fig. 28.15 (spinal cord cross-section model) Fig. 28.16 (nerves and plexi of arm and leg models) Assessments: Part D	Added question Revised components Added image of cadaver as (b) Removed and expanded components Added labels New figure New figure Added question
29	Pre-Lab	Added question
30	Pre-Lab Introductory material Procedure A: Meninges and brain Fig. 30.2 (cadaver brain) Fig. 30.12 (facial cranial nerve) Fig. 30.13 (median section brain) Fig. 30.14 (median section brain model)	Added question Expanded components Changed title; expanded components in steps 3, 4, and 5 Added image as (b) Replaced (b) with line art Added terms and renumbered New figure
31A	Introductory material and procedures	Updated branding and equipment terms
31B	Introductory material and procedures	Updated branding and equipment terms
32	Pre-Lab Fig. 32.5 (median section sheep brain) Assessments: Part A Fig. 32.8 (dorsal view sheep brain); Fig. 32.9 (midbrain and pineal gland); Fig. 32.10 (ventral view sheep brain)	Added question Revised labels Removed question; new CTA question New figures
34	Pre-Lab Assessments: Part C Assessments: Part D	Added question Added questions New CTA question
35	Introductory material Procedure A (structure and function of the eye) Fig. 35.12 (sagittal section of eye) Fig. 35.13 (eye model) Fig. 35.14 (sagittal section eye micrograph) Fig. 35.15 (tunics of eye micrograph) Assessments: Part B Fig. 35.16 (cow eye internal structures) and Fig. 35.17 (cow eye tunics)	Expanded components Expanded components in step 3 Added label New figures (a) and (b) Replaced image New figure New CTA question New figures

LABORATORY EXERCISE	TOPIC	CHANGE
36	Purpose of the Exercise Introductory material	Revised components Expanded components
37	Procedure A (structure and function of the ear) Fig. 37.3 (middle and inner ear) Fig. 37.10 (ear model) Assessments: Part C	Expanded components in step 2 Added label New figure New CTA question
38	Pre-Lab Assessments: Part A	Added question Added questions
39	Purpose of the Exercise Pre-Lab Table 39.1 (hypothalamic hormones) Table 39.2 Procedure (endocrine gland and histology) Fig. 39.8 (parathyroid gland) Fig. 39.3 (ovary) Assessments: Part B Fig. 39.16 (major endocrine organs) Assessments: Part C Assessments: Part D	Revised components Added questions New table Expanded components Revised components of pituitary gland (c), thyroid gland (b), parathyroid gland (b), adrenal gland (a), and ovary (b) Replaced micrograph Added antral label to tertiary Added question New figure Added questions New CTA question
40	Pre-Lab	Added question
41	Introductory material Table 41.1 (cellular components of blood) Table 41.2 (differential WBC count) Assessment: Part C	Revised components Expanded component Revised component New CTA question
42	Pre-Lab	Added questions
43	Pre-Lab Introductory material Fig. 43.3 (agglutinated RBCs) Fig. 43.5 (possible results of ABO test) Assessments: Part B Assessments: Part D Assessments: Part E	Added question Revised components Replaced micrograph Replaced image Added ABO blood testing results table Added Rh blood testing results table Moved Fig. 43.7 and results in separate assessment part; new CTA question
44	Pre-Lab Procedure A (the human heart) Procedure B (dissection of a sheep heart) Fig. 44.11 (frontal section of sheep heart) Fig. 44.13 (anterior heart region of cadaver) Fig. 44.14 (frontal section of heart model) Fig. 44.15 (exterior and interior features of heart model) Assessments: Part B	Revised question number 6 and added a question Revised and expanded components of steps 4 and 5 Revised and expanded components of steps 2, 9, and 10 Revised and added labels Revised and added labels Added label New figure New CTA questions
45	Pre-Lab Introductory material Table 45.1 (ECG components) Assessments: Part A and Part C Fig. 45.7 (heart chambers and conduction system)	Revised question numbers 3 and 5; added question Revised components Revised and expanded components Added questions Revised components
46	Materials Needed and Procedure A (setup) Introductory material	Updated branding and equipment terms Revised components
47	Learning Outcome 02 Pre-Lab Fig. 47.2 (neurovascular bundle) Fig. 47.9 (arteries chest and neck) Fig. 47.10 (arteries of shoulder and arm); fig. 47.15 (veins of shoulder and arm) Fig. 47.17 (veins of pelvis and lower limb) Assessments: Part C Assessments: Part D Fig. 47.20 (blood vessels of models)	Revised wording Revised question number 3; added questions Added new micrograph as (b) New figure Replaced illustrations Revised illustration Added question Added question; new CTA question New figure

LABORATORY EXERCISE	TOPIC	CHANGE
48	Pre-Lab Introductory material	Added questions Revised components
49	Learning Outcomes Pre-Lab Introductory material Fig. 49.9 (thymus) Assessments: Part A, Part C, and Part D	Revised Learning Outcomes 01 and 03 Added question Revised and added components Replaced micrograph Added questions
50	Fig. 50.6 (trachea and surrounding organs and tissues) Fig. 50.7 (tracheal wall) Fig. 50.11 (respiratory system) Fig. 50.12 (upper respiratory) Assessments: Part B	New figure Revised to form (a) and (b) micrographs Added image of model as (b) Replaced illustration with image of model as (a) and cadaver as (b) New CTA question
51	Introductory material Assessments: Part A Assessments: Part B	Revised components Added questions; new CTA question Revised test results table expected values
52	Materials Needed and Procedure A (setup)	Updated branding and equipment terms
53	Pre-Lab Assessments: Part A	Added question Added question
54	Pre-Lab Fig. 54.5 (esophagus) Procedure B (pharynx and esophagus) Fig. 54.6 (stomach features) Fig. 54.7 (stomach mucosa) Fig. 54.11 (microscopic liver) Procedure E (small and large intestines) Fig. 54.15 (small intestine histology) Fig. 54.16 (large intestine histology) Fig. 54.19 (abdominal digestive organs); Fig. 54.21 (villi of small intestine) Fig. 54.22 (large intestine)	Added question Replaced and added micrographs as (a) and (b) Revised and added components of step 4 Added label Added new micrograph of chief and parietal cells as (b) Added new micrograph of hepatic triad as (c) Revised components in step number 1; added components in step number 2 Added label in (a); added new micrograph of villus as (b) Added new micrograph of mucous gland as (b) New figures Added label
55	Pre-Lab	Added question
56	Pre-Lab Introductory material Assessments: Part C	Revised question number 1; added questions Revised and added components Revised questions 1, 3, and 4
57	Learning Outcomes Pre-Lab Introductory material Procedure A (kidney) Procedure C (ureter, urinary bladder, urethra) Fig. 57.8 (urinary bladder histology) Fig. 57.11 (parts of a nephron); Fig. 57.12 (blood vessels of kidney model); Fig. 57.13 (urinary organs and associated blood vessels model)	Revised Learning Outcomes 01, 02, and 05 Added question; revised question numbers 3 and 6 Revised and added components Revised and added components in step 2 Revised components Added new micrograph as (b) New figures
58	Pre-Lab Assessments: Part A	Added questions New CTA question
59	Pre-Lab Procedure A (male reproductive organs) Fig. 59.8 (male reproductive system)	Added question Revised components of step 2 Added new image of model as (b)
60	Introductory material Procedure B (microscopic anatomy) Fig. 60.7 (ovarian cortex histology) Fig. 60.10 (female reproductive system) Fig. 60.11 (female reproductive structures) Assessments: Part A Fig. 60.12 (ovary) Fig. 60.13 (ovary histology)	Revised and expanded components Revised and expanded components in steps 3 and 8 Added label Added new image of model as (b) Added labels; renumbering Added questions to number 2; new CTA question Revised illustration New figure

LABORATORY EXERCISE	TOPIC	CHANGE
61	Pre-Lab Introductory material Fig. 61.3 (sea urchin stages) Procedure C (human early development) Assessments: Part A Assessments: Part C	Revised question numbers 3 and 6; added questions Revised and expanded components Replaced blastula and gastrula images Revised components in step 2 Revised question numbers 7 and 12; added questions Revised question numbers 8 and 9; new CTA question
62	Purpose of the Exercise Learning Outcome Pre-Lab Introductory material Table 62.1 (examples of common human phenotypes); fig. 62.1 (representative genetic traits) Procedure C (genetics problems) Assessments: Part A Assessments: Part C	Revised component Revised Learning Outcome 03 Added question Revised and expanded components Removed tongue roller Added new steps 3 and 4 Revised test results table Added new question
63	Learning Outcomes Assessments: Part E Assessments: Part F Fig. 63.25 (ventral thorax muscles) Fig. 63.26 (dorsal muscles) Fig. 63.27 (medial hindlimb muscles) Fig. 63.28 (superficial hip and hindlimb muscles) Assessments: Part G	Revised Learning Outcome 01 Added questions in new Part Changed Part letter New figure New figure as (a) New figure New figure as (a) Changed Part letter
64	Fig. 64.14 (cardiovascular structures) Fig. 64.17 (cardiovascular structures) Fig. 64.18 (cadaver arteries and veins)	New figure as (a) Replaced figure Added term; renumbering
65	Fig. 65.3 (lower respiratory tract) Fig. 65.6 (lungs and respiratory structure)	Added labels New figure
66	Fig. 66.5 (digestive features)	Added label and renumbering in (a); replaced figure (b)
67	Fig. 67.7 (urinary features and associated blood vessels)	New figure
68	Fig. 68.7 (female reproductive structures) Fig. 68.8 (male reproductive structures)	Added new figure as (b) Added new figure as (b)
69	Learning Outcome Fig. 69.12 (head, neck, thorax, medial arm) Fig. 69.16 (hindlimb)	Revised Learning Outcome 01 New figure New figure
70	Fig. 70.4 (abdominal arteries and veins) Fig. 70.5 (trunk and neck veins)	Replaced figure as (b) Added new figure as (b)
71	Assessments: Part B Fig. 71.6 (lungs and respiratory tubes) Assessments: Part C	Added questions in new Part New figure Changed Part letter
72	Fig. 72.5 (salivary glands)	New figure
73	Assessments: Part B Fig. 73.3 (urinary features) Assessments: Part C	Added questions in new Part New figure Changed Part letter

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I would like to express my sincere gratitude to all reviewers of the laboratory manual who provided suggestions for its improvement. Their thoughtful comments and valuable suggestions are greatly appreciated. They include the following:

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CYNTHIA PRENTICE-CRAVER, author of this fifth-edition laboratory manual, has been teaching anatomy and physiology at Chemeketa Community College for twenty-seven years. Her experience as a contributing author of the third edition, coauthor of the fourth edition, as well as her observations and engagement with students who use this laboratory manual, continually reinforce her excitement and passion for authoring. Her M.S. in Curriculum and Instruction, B.S. in Exercise Science, and extended undergraduate and graduate coursework in biological sciences have been instrumental in achieving the effective results in the online and on-campus courses she teaches. Teaching anatomy and physiology in these different formats has allowed Cynthia to explore and use different methods of content delivery that promote student involvement, learning, and confidence building. She is thrilled to be using the human cadaver lab at Chemeketa Community College in her teaching. Cynthia was a contributing author of the *Hole's Essentials Human Anatomy and Physiology, Fourteenth Edition* and coauthor with Charles Welsh of the *Hole's Human Anatomy and Physiology, Sixteenth Edition.* She is a member of the Human Anatomy and Physiology Society (HAPS) and the Textbook & Academic Authors Association (TAA). Her professional experiences include serving as program chair in the Life Sciences for eight years, serving on committees, and being a reviewer and advisor of textbooks and digital products. Beyond her professional pursuits, Cynthia's passions include reading and listening to books, attending exercise classes, hiking/walking outdoors, attending concerts, traveling, and spending time with her family and friends.

J and J Photography

This laboratory manual series was created by now-coauthor **TERRY R. MARTIN** of Kishwaukee College. Terry's teaching experience of over forty years, his interest in students and love for college instruction, and his innovative attitude and use of technology-based learning enhance the solid tradition of his other well-established laboratory manuals. Among Terry's awards are the Kishwaukee College Outstanding Educator, Kishwaukee College ICCTA Outstanding Educator Award, Kishwaukee College Faculty Board of Trustees Award of Excellence, Continued Excellence Award for Phi Theta Kappa Advisors, and John C. Roberts Community Service Award. Terry's professional memberships include the National Association of Biology Teachers (NABT), Human Anatomy and Physiology Society (HAPS), and The Nature Conservancy. Terry coauthored with Phillip Snider the *Laboratory Manual to Accompany Hole's Human Anatomy and Physiology,* Sixteenth Edition and the *Laboratory Manual to Accompany Hole's Essentials of Human Anatomy and Physiology,* Fourteenth Edition. Terry taught lecture and cadaver portions of EMT and paramedic classes. He has also been a faculty exchange member in Ireland. Terry locally supports historical preservation, natural areas, scouting, and scholarship. Through an established endowment to the Kishwaukee College Foundation, the "Terry & Sherrie Martin Health Careers Wing" was designated in 2014.

Laura Chiavini, Creative Communication Specialist, Kishwaukee College

TO THE STUDENT

The exercises in this laboratory manual will provide you with opportunities to observe various anatomical structures and to investigate certain physiological phenomena. Such experiences should help you relate specimens, models, microscope slides, and your body to what you have learned in the lecture and read about in the textbook.

Frequent variations exist in anatomical structures among humans. The illustrations in the laboratory manual represent normal (normal means the most common variation) anatomy. Variations from normal anatomy do not represent abnormal anatomy unless some function is impaired.

The following list of suggestions and study skills may make your laboratory activities more effective and profitable.

1. Prepare yourself before attending the laboratory session by reading the assigned exercise and reviewing the related sections of the textbook and lecture notes as indicated in the pre-lab section of the laboratory exercise. Answer the pre-lab questions. It is important to have some understanding of what will be done in the lab before you come to class.
2. Be on time. During the first few minutes of the laboratory meeting, the instructor often will provide verbal instructions. Make special note of any changes in materials to be used or procedures to be followed. Also listen carefully for information about special techniques to be used and precautions to be taken.
3. Keep your work area clean and your materials neatly arranged so that you can locate needed items. This will enable you to proceed efficiently and will reduce the chances of making mistakes.
4. Pay particular attention to the purpose of the exercise, which states what you are to accomplish in general terms, and to the learning outcomes, which list what you should be able to do as a result of the laboratory experience. Then, before you leave the class, review the outcomes and make sure that you can perform all of the assessments.
5. Precisely follow the directions in the procedure and proceed only when you understand them clearly. Do not improvise procedures unless you have the approval of the laboratory instructor. Ask questions if you do not understand exactly what you are supposed to do and why you are doing it.
6. Handle all laboratory materials with care. Some of the materials are fragile and expensive to replace. Whenever you have questions about the proper treatment of equipment, ask the instructor.
7. Treat all living specimens humanely and try to minimize any discomfort they might experience.
8. Although at times you might work with a laboratory partner or a small group, try to remain independent when you are making observations, drawing conclusions, and completing the activities in the laboratory reports.
9. Record your observations immediately after making them. In most cases, such data can be entered in spaces provided in the laboratory assessments.
10. Read the instructions for each section of the laboratory assessment before you begin to complete it. Think about the questions before you answer them. Your responses should be based on logical reasoning and phrased in clear and concise language.
11. At the end of each laboratory period, clean your work area and the instruments you have used. Return all materials to their proper places and dispose of wastes, including glassware or microscope slides that have become contaminated with human blood or body fluids, as directed by the laboratory instructor. Wash your hands thoroughly before leaving the laboratory.

Study Skills for Anatomy and Physiology

Students have found that certain study skills worked well for them while enrolled in Human Anatomy and Physiology. Although everyone has his or her learning style, there are techniques that work well for most students. Using some of the skills listed here can make your course more enjoyable and rewarding.

1. **Time management:** Prepare monthly, weekly, and daily schedules. Include dates of quizzes, exams, and projects on the calendar. On your daily schedule, budget several short study periods. Daily repetition alleviates cramming. Prioritize your tasks so that you still have time for work and leisure activities. Find an appropriate study atmosphere with minimum distractions.
2. **Note taking:** Look for the main ideas and briefly express them in your own words. Organize, edit, and review your notes soon after the lecture. Add textbook information to your notes as you reorganize them. Underline or highlight with different colors the important points, major headings, and key terms. Create concept maps and flow charts to show relationships and interconnections. Study your notes daily, as they provide sequential building blocks of the course content.
3. **Chunking:** Organize information into logical groups or categories. Study and master one chunk of information at

a time. For example, study the bones of the upper limb, lower limb, trunk, and head as separate study tasks.

4. **Mnemonic devices:** An *acrostic* is a combination of association and imagery to aid your memory. It is often in the form of a poem, rhyme, or jingle in which the first letter of each word corresponds to the first letters of the words you need to remember. **S**o **L**ong **T**op **P**art, **H**ere **C**omes **T**he **T**humb is an example of such a mnemonic device for remembering the eight carpals in a correct sequence. *Acronyms* are words formed by the first letters of the items to remember. *IPMAT* is an example of this type of mnemonic device to help you remember the phases of the cell cycle in the correct sequence. Try to create some of your own.
5. **Note cards/flash cards:** Make your own. Add labels and colors to enhance the material. Keep them with you; study them often and for short periods. Concentrate on a small number of cards at one time. Shuffle your cards and have someone quiz you on their content. As you become familiar with the material, you can set aside cards that don't require additional mastery.
6. **Recording and recitation:** An auditory learner can benefit by recording lectures and review sessions using a recording device. Many students listen to the taped sessions as they drive or just before going to bed. Reading your notes aloud can help also. Explain the material to anyone (even if there are no listeners) as if you are teaching. Talk about anatomy and physiology in everyday conversations.
7. **Study groups:** Small study groups that meet periodically to review course material and compare notes have helped and encouraged many students. However, keep the group on the task at hand. Work as a team and alternate leaders. This group often becomes a support group.

Practice sound study skills during your anatomy and physiology endeavor.

The Use of Animals in Biology Education*

The National Association of Biology Teachers (NABT) believes that the study of organisms, including nonhuman animals, is essential to the understanding of life on Earth. NABT recommends the prudent and responsible use of animals in the life science classroom. NABT believes that biology teachers should foster a respect for life. Biology teachers also should teach about the interrelationship and interdependency of all things.

Classroom experiences that involve nonhuman animals range from observation to dissection. NABT supports these experiences so long as they are conducted within the long-established guidelines of proper care and use of animals, as developed by the scientific and educational community.

As with any instructional activity, the use of nonhuman animals in the biology classroom must have sound educational objectives. Any use of animals, whether for observation or dissection, must convey substantive knowledge of biology. NABT believes that biology teachers are in the best position to make this determination for their students.

NABT acknowledges that no alternative can substitute for the actual experience of dissection or other use of animals and urges teachers to be aware of the limitations of alternatives. When the teacher determines that the most effective means to meet the objectives of the class do not require dissection, NABT accepts the use of alternatives to dissection, including models and the various forms of multimedia. The Association encourages teachers to be sensitive to substantive student objections to dissection and to consider providing appropriate lessons for those students where necessary.

To implement this policy, NABT endorses and adopts the "Principles and Guidelines for the Use of Animals in Precollege Education" of the Institute of Laboratory Animals Resources (National Research Council). Copies of the "Principles and Guidelines" may be obtained from the ILAR (2101 Constitution Avenue, NW, Washington, DC 20418; 202-334-2590).

*Adopted by the Board of Directors in October 1995. This policy supersedes and replaces all previous NABT statements regarding animals in biology education.

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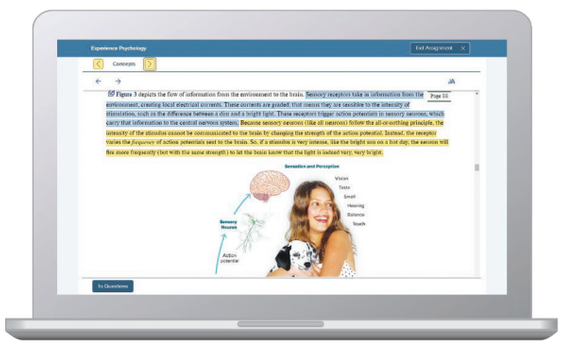

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*Statistic courtesy of The New England Journal of Higher Education

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LABORATORY
EXERCISE 1

Scientific Method and Measurements

Purpose of the Exercise

To become familiar with the scientific method of investigation, learn how to formulate sound conclusions, and provide opportunities to use the metric system of measurements.

MATERIALS NEEDED

Meterstick
Calculator
Human skeleton

Learning Outcomes APR

After completing this exercise, you should be able to:

- O1 Convert English measurements to the metric system, and vice versa.
- O2 Calculate expected upper limb length and actual percentage of height from recorded upper limb lengths and heights.
- O3 Apply the scientific method to test the validity of a hypothesis concerning the direct, linear relationship between human upper limb length and height.
- O4 Design an experiment, formulate a hypothesis, and test it using the scientific method.

The O corresponds to the assessments A indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Be familiar with the scientific method from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. To explain biological phenomena, scientists use a technique called
   a. the scientific method. **b.** the scientific law.
   c. conclusions. **d.** measurements.
2. Which of the following represents the correct sequence of the scientific method?
   a. analysis of data, conclusions, observations, experiment, hypothesis
   b. conclusions, experiment, hypothesis, analysis of data, observations
   c. observations, hypothesis, experiment, analysis of data, conclusions
   d. hypothesis, observations, experiment, analysis of data, conclusions
3. A hypothesis, verified continuously from experiments by many investigators, can become known as a
   a. control. **b.** variable.
   c. valid result. **d.** theory.
4. The most likely scientific unit for measuring the height of a person would be
   a. feet. **b.** centimeters.
   c. inches. **d.** kilometers.
5. Which of the following is *not* a unit of the metric system of measurements?
   a. centimeters **b.** liters
   c. inches **d.** millimeters

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6. The variable that can be changed and is determined before the experiment starts is the
   a. dependent variable. **b.** hypothesis.
   c. independent variable. **d.** analysis.
7. The hypothesis is formulated from the results of the experiment.
   a. True **b.** False
8. A centimeter represents an example of a metric unit of length.
   a. True **b.** False

Scientific investigation involves a series of logical steps to arrive at explanations for various biological phenomena. It reflects a long history of asking questions and searching for knowledge. This technique, called the *scientific method,* is used in all disciplines of science. It allows scientists to draw logical and reliable conclusions.

The scientific method begins with making *observations* related to the topic under investigation. This step commonly involves the accumulation of previously acquired information and/or your observations of the phenomenon. These observations are used to formulate a tentative explanation known as the *hypothesis.* An important attribute of a hypothesis is that it must be testable. The testing of the proposed hypothesis involves designing and performing a carefully controlled *experiment* to obtain data that can be used to support, reject, or modify the hypothesis. During the experiment to test the proposed hypothesis, it is important to be able to examine only a single changeable factor, known as a *variable.* An *independent variable* is one that can be changed, but is determined before the experiment occurs; a *dependent variable* is determined from the results of the experiment.

An *analysis of data* is conducted using sufficient information collected during the experiment. Data analysis may include organization and presentation of data as tables, graphs, and drawings. From the interpretation of the data analysis, *conclusions* are drawn. (If the data do not support the hypothesis, you must reexamine the experimental design and the data, and if needed develop a new hypothesis.) The final presentation of the information is made from the conclusions. Results and conclusions are presented to the scientific community for evaluation through peer reviews, presentations at professional meetings, and published articles. If many investigators working independently can validate the hypothesis by arriving at the same conclusions, the explanation can become a *theory.* A theory serves as the explanation from a summary of known experiments and supporting evidence unless it is disproved by new information. The five components of the scientific method are summarized as

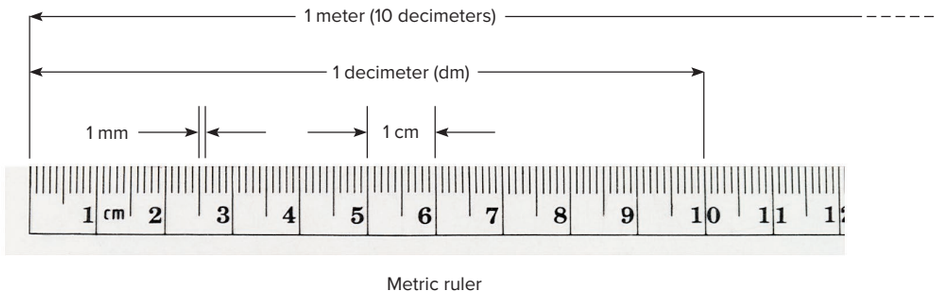
Observations
↓
Hypothesis
↓
Experiment
↓
Analysis of data
↓
Conclusions

Metric measurements are characteristic tools of scientific investigations. The English system of measurements is often used in the United States, so the investigator must make conversions from the English system to the metric system. Table 1.1 provides the conversion factors necessary to change from English to metric units.

PROCEDURE A: Using the Steps of the Scientific Method

This procedure represents a specific example of the order of the steps utilized in the scientific method. Each of the steps for this procedure will guide you through the proper sequence in an efficient pathway.

1. A correlation exists between the length of the upper and lower limbs and the height (stature) of an individual. For example, a person who has long upper limbs (the arm, forearm, and hand combined) tends to be tall. Make some visual observations of other people around you to observe a possible correlation.
2. From such observations, the following hypothesis can be formulated: The length of a person's upper limb is equal to 0.4 (40%) of the height of the person. To test this hypothesis, perform the following experiment.
3. Use a meterstick (fig. 1.1) to measure an upper limb length of ten subjects. Place the meterstick in the axilla (armpit) and record the length in centimeters to the end of the longest finger (fig. 1.2). Obtain the height of



Metric ruler

FIGURE 1.1 Metric ruler with metric lengths indicated. A meterstick length would be 100 cm (10 dm). (The image size is approximately to scale.)

Table 1.1 Metric Measurement System and Conversions

Measurement	Unit and Abbreviation	Metric Equivalent	Conversion Factor Metric to English (approximate)	Conversion Factor English to Metric (approximate)
Length	1 kilometer (km)	1,000 (10^3) m	1 km = 0.62 mile	1 mile = 1.61 km
	1 meter (m)	100 (10^2) cm 1,000 (10^3) mm	1 m = 1.1 yards = 3.3 feet = 39.4 inches	1 yard = 0.9 m 1 foot = 0.3 m
	1 decimeter (dm)	0.1 (10^{-1}) m	1 dm = 3.94 inches	1 inch = 0.25 dm
	1 centimeter (cm)	0.01 (10^{-2}) m	1 cm = 0.4 inches	1 foot = 30.5 cm 1 inch = 2.54 cm
	1 millimeter (mm)	0.001 (10^{-3}) m 0.1 (10^{-1}) cm	1 mm = 0.04 inches	
	1 micrometer (μm)	0.000001 (10^{-6}) m 0.001 (10^{-3}) mm		
Mass	1 metric ton (t)	1,000 (10^3) kg	1 t = 1.1 ton	1 ton = 0.91 t
	1 kilogram (kg)	1,000 (10^3) g	1 kg = 2.2 pounds	1 pound = 0.45 kg
	1 gram (g)	1,000 (10^3) mg	1 g = 0.04 ounce	1 pound = 454 g 1 ounce = 28.35 g
	1 milligram (mg)	0.001 (10^{-3}) g		
Volume (liquids and gases)	1 liter (L)	1,000 (10^3) mL	1 L = 1.06 quarts	1 gallon = 3.78 L 1 quart = 0.95 L
	1 milliliter (mL)	0.001 (10^{-3}) L 1 cubic centimeter (cc or cm^3)	1 mL = 0.03 fluid ounce 1 mL = 1⁄5 teaspoon 1 mL = 15–16 drops	1 quart = 946 mL 1 fluid ounce = 29.6 mL 1 teaspoon = 5 mL
Time	1 second (s)	1⁄60 minute	Same	Same
	1 millisecond (ms)	0.001 (10^{-3}) s	Same	Same
Temperature	Degrees Celsius (°C)		°F = 9⁄5 °C + 32	°C = 5⁄9 (°F – 32)

FIGURE 1.2 Measurement of upper limb length. ©J & J Photography

each person in centimeters by measuring them without shoes against a wall (fig. 1.3). The height of each person can also be calculated by multiplying each individual's height in inches by 2.54 to obtain his/her height in centimeters. Record all your measurements in Part A of Laboratory Assessment 1.

4. The data collected from all of the measurements can now be analyzed. The expected (predicted) correlation between upper limb length and height is determined using the following equation:

   Height × 0.4 = expected upper limb length

   The observed (actual) correlation to be used to test the hypothesis is determined by

   Length of upper limb/height = actual % of height

5. A graph is an excellent way to display a visual representation of the data. Plot the subjects' data in Part A of the laboratory assessment. Plot the upper limb length of each subject on the x-axis (independent variable) and the height of each person on the y-axis (dependent variable). A line is already located on the graph that represents a hypothetical relationship of 0.4 (40%) upper limb length compared to height. This is a graphic representation of the original hypothesis.
6. Compare the distribution of all of the points (actual height and upper limb length) that you placed on the graph with the distribution of the expected correlation represented by the hypothesis.
7. Complete Part A of the laboratory assessment.

FIGURE 1.3 Measurement of height. ©J & J Photography

PROCEDURE B: Design an Experiment

You have completed the steps of the scientific method with guidance directions in Procedure A. This procedure will allow for less guidance and more flexibility using the scientific method.

CRITICAL THINKING ACTIVITY

You have probably concluded that there is some correlation of the length of body parts to height. Often, when a skeleton is found, it is not complete. It is occasionally feasible to use the length of a single bone to estimate the height of an individual. Observe human skeletons and locate the humerus bone in an upper limb or the femur bone in a lower limb. Use your observations to identify a mathematical relationship between the length of the humerus or femur and height. Formulate a hypothesis that can be tested. Make measurements, analyze data, and develop a conclusion from your experiment. Complete Part B of the laboratory assessment.

LABORATORY
ASSESSMENT

1

Name _____

Date _____

Section _____

The A corresponds to the indicated Learning Outcome(s) O found at the beginning of the Laboratory Exercise.

Scientific Method and Measurements

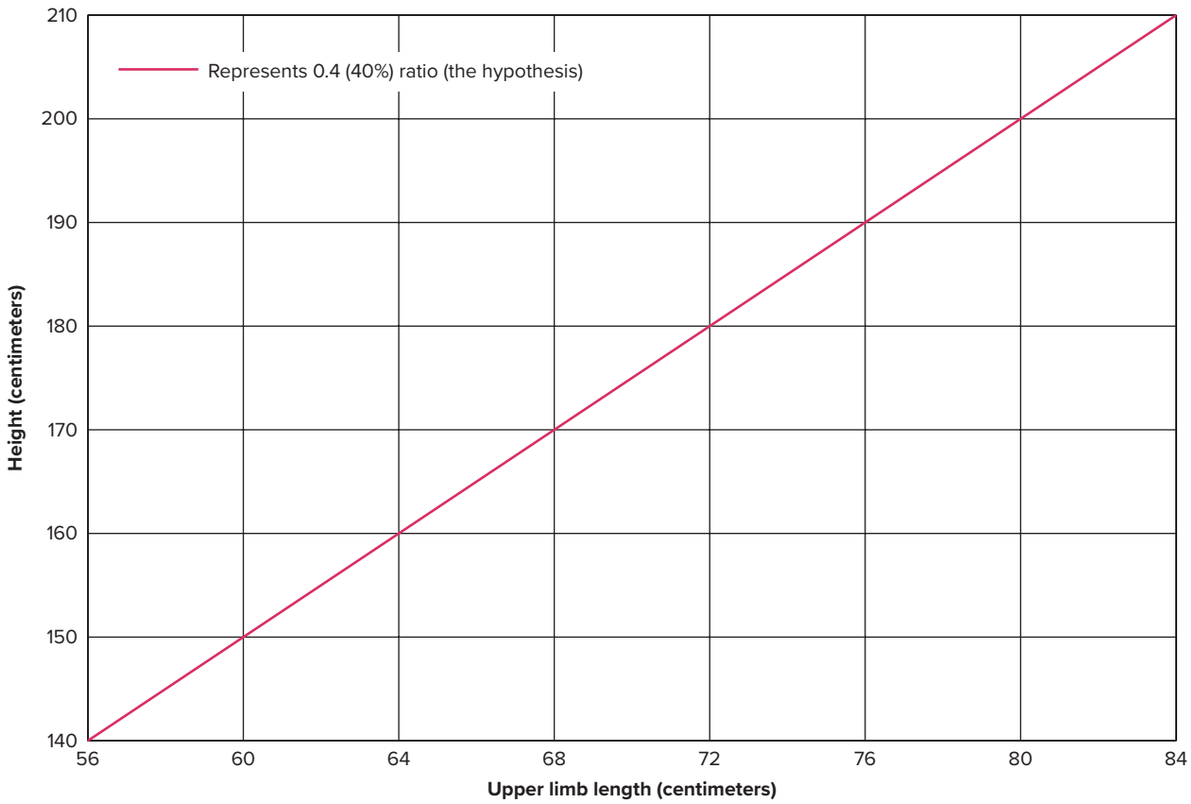
PART A: Assessments

1. Record measurements for the upper limb length and height of ten subjects. Use a calculator to determine the expected upper limb length and the actual percentage (as a decimal or a percentage) of the height for the ten subjects. Record your results in the following table. A2

Subject	Measured Upper Limb Length (cm)	Height* (cm)	Height × 0.4 = Expected Upper Limb Length (cm)	Actual % of Height = Measured Upper Limb Length (cm)/Height (cm)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

*The height of each person can be calculated by multiplying each individual's height in inches by 2.54 to obtain his/her height in centimeters. A1

2. Plot the distribution of data (upper limb length and height) collected for the ten subjects on the following graph. The line located on the graph represents the *expected* 0.4 (40%) ratio of upper limb length to measured height (the original hypothesis). (The x-axis represents upper limb length, and the y-axis represents height.) Draw a line of *best fit* through the distribution of points of the plotted data of the ten subjects. Compare the two distributions (expected line and the distribution line drawn for the ten subjects). A3



3. Does the distribution of the ten subjects' measured upper limb lengths support or reject the original hypothesis? _____ Explain your answer. A3

PART B: Assessments

1. Describe your observations of a possible correlation between the humerus or femur length and height. A4

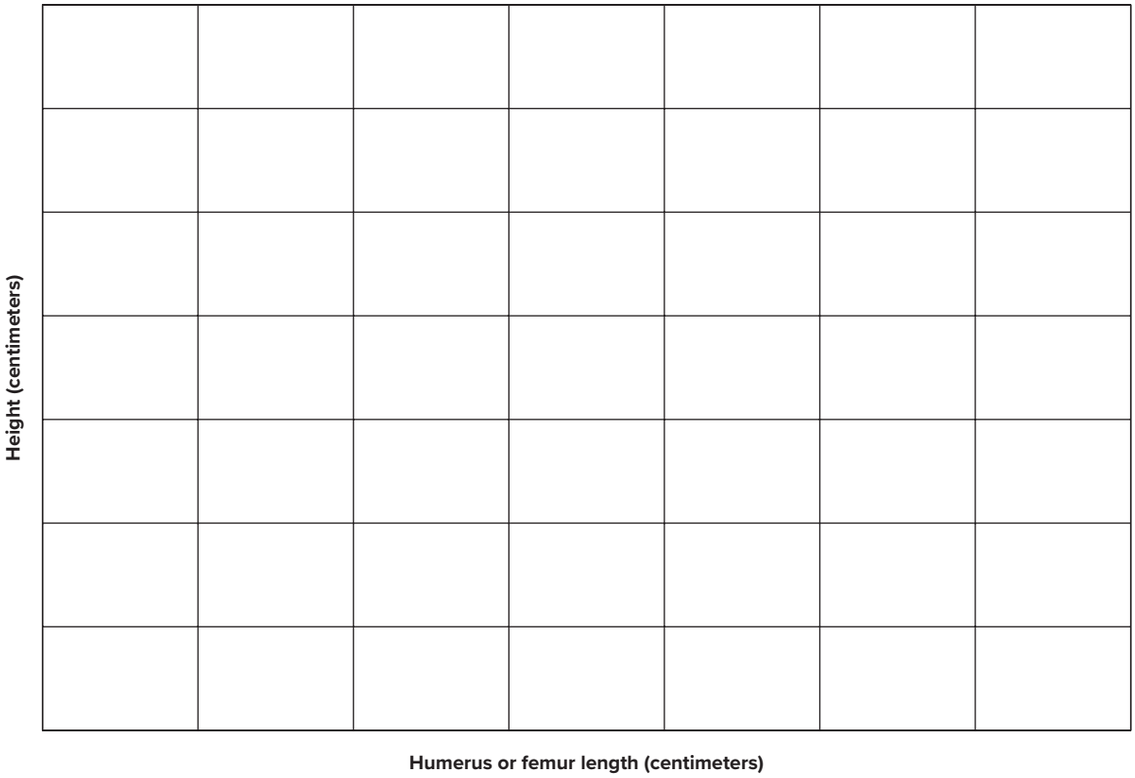
2. Write a hypothesis based on your observations. A4

3. Describe the design of the experiment that you devised to test your hypothesis. A4

4. Place your analysis of the data in this space in the form of a table and a graph. A4

a. Table:

b. Graph:



5. Based on an analysis of your data, what can you conclude? Did these conclusions confirm or refute your original hypothesis? A4

6. Discuss your results and conclusions with classmates. What common conclusion can the class formulate about the correlation between the humerus or femur length and height? A4

LABORATORY
EXERCISE 2

Body Organization, Membranes, and Terminology

Purpose of the Exercise

To review the organizational pattern of the human body, to review its organ systems and the organs included in each system, and to become acquainted with the terms used to describe the relative position of body parts, body sections, and body regions.

MATERIALS NEEDED

Dissectible human torso model (manikin)

Variety of specimens or models sectioned along various planes

Learning Outcomes APR

After completing this exercise, you should be able to:

- **O1** Locate and name the major body cavities and identify the membranes associated with each cavity.
- **O2** Associate the organs and functions included within each organ system and locate the organs in a dissectible human torso model.
- **O3** Select the terms used to describe the relative positions of body parts.
- **O4** Differentiate the terms used to identify body sections and identify the plane along which a particular specimen is cut.
- **O5** Label body regions and associate the terms used to identify body regions.

The **O** corresponds to the assessments **A** indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Be familiar with body cavities, membranes, organ systems, and body regions from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. The basis for communication in anatomy and physiology assumes
   a. the person is lying down. **b.** relative positions.
   c. anatomical position. **d.** the person is sleeping.
2. Which of the following is *not* a body cavity?
   a. diaphragm **b.** thoracic
   c. cranial **d.** abdominopelvic
3. The pericardium is associated with the
   a. lung. **b.** intestine.
   c. liver. **d.** heart.
4. The _____ plane divides the body into left and right sides.
   a. frontal **b.** cranial
   c. sagittal **d.** transverse
5. The abdominopelvic cavity can be subdivided into
   a. pleural cavities. **b.** pericardial cavities.
   c. quadrants. **d.** vertebral canals.
6. The larynx is part of the _____ system.
   a. urinary **b.** respiratory
   c. lymphatic **d.** nervous

Chapter Opener: ©101cats/Getty Images

7. The epigastric region is a portion of the _____ cavity.
   a. pelvic **b.** pleural
   c. vertebral **d.** abdominal
8. In the posterior view, the cubital region is _____ to the carpal region.
   a. distal **b.** medial
   c. superficial **d.** proximal
9. The brachial surface region pertains to the wrist.
   a. True **b.** False
10. A frontal plane divides the body into anterior and posterior parts.
   a. True **b.** False

The major features of the organization of the human body include certain body cavities. A body cavity may contain an organ and/or a specific fluid. The *cranial cavity* contains the brain and the *vertebral canal (spinal cavity)* contains the spinal cord. These body cavities also contain cerebrospinal fluid (CSF). Two major cavities are found in the trunk of the body and are separated by the diaphragm, a skeletal muscle important in breathing. The *thoracic cavity* is located in the chest, superior to the diaphragm. This cavity is subdivided into a mediastinum containing primarily the heart, esophagus, and trachea, with the lungs located on either side of the mediastinum. The *abdominopelvic cavity* lies inferior to the diaphragm. This cavity is composed of an *abdominal cavity* and *pelvic cavity*. The entire abdominopelvic cavity is further subdivided into either nine regions or four quadrants. The large size of the abdominopelvic cavity, with its many visceral organs, warrants these further subdivisions into regions or quadrants for convenience and for accuracy in describing organ locations, injury sites, and pain locations.

The *pericardium*, *pleura*, and *peritoneum* are thin double-layered *serous membranes* that line the thoracic and abdominopelvic cavities. Each serous membrane has an outer parietal layer that forms the outer cavity wall which folds in on itself to form an inner visceral layer that covers the surface of an organ. Between each serous membrane is a narrow space called a cavity that is filled with serous fluid. This slippery fluid provides organs some freedom of movement without friction as they carry out their functions. In the thoracic cavity, the pericardium surrounds the heart. Between its parietal pericardium and visceral pericardium is the pericardial cavity that is filled with pericardial fluid. The thoracic cavity also includes a parietal pleura and visceral pleura surrounding each lung. Between the pleura layers is the pleural cavity that contains pleural fluid. Within the abdominopelvic cavity is the parietal peritoneum and visceral peritoneum with a peritoneal cavity containing peritoneal fluid. Several abdominopelvic organs, such as the kidneys and pancreas, are located just behind (are retroperitoneal to) the parietal peritoneum, thus lacking a mesentery (visceral peritoneum).

Some other body cavities include the orbital cavity of the eye, nasal cavity of the nose, oral cavity of the mouth, cavity of the middle ear, and synovial cavity of a movable joint such as the knee or elbow.

Although the human body functions as one entire unit, it is customary to divide the body into eleven body organ systems. In order to communicate effectively with each other about the body, scientists have devised anatomical terminology. Foremost in this task we use *anatomical position* as our basis for communication, including directional terms, body regions, and planes of the body. A person in anatomical position is standing erect, facing forward, with upper limbs at the sides and palms forward. This standard position allows us to describe relative positions of various body parts using such directional terms as left-right, anterior-posterior, proximal-distal, medial-lateral, and superior-inferior. Body regions include certain surface areas, portions of limbs, and portions of body cavities. In order to study internal structures, often the body is depicted as sectioned into a sagittal plane, frontal plane, or transverse plane.

PROCEDURE A: Body Cavities and Membranes

This procedure outlines the body cavities by location. Certain cavities contain thin layers of cells, called membranes, that line the cavity and cover the organs within the cavity. The figures included in Procedure A will allow you to locate and identify the associated membrane location and name appropriate for the cavity and the organs involved.

1. Study figures 2.1 to 2.5 to become familiar with body cavities and associated membranes.
2. Locate as many of the following features as you can on a dissectible human torso model (fig. 2.5):

body cavities

- cranial cavity—houses brain
- vertebral canal (spinal cavity)—houses spinal cord
- thoracic cavity
  - mediastinum—region between the lungs; includes pericardial cavity
  - pleural cavities (2)
- abdominopelvic cavity
  - abdominal cavity
  - pelvic cavity

diaphragm—separates thoracic and abdominopelvic cavities; functions in respiration

smaller cavities within the head

- oral cavity (mouth)
- nasal cavity with connected sinuses
- orbital cavity—houses eye and associated structures
- middle ear cavity (tympanic cavity)—air-filled and contains auditory ossicles

membranes and cavities

- pleural cavity—associated with lungs; contains pleural (serous) fluid
  - parietal pleura—outer layer; lines thoracic cavity wall
  - visceral pleura—inner layer; covers surface of lungs

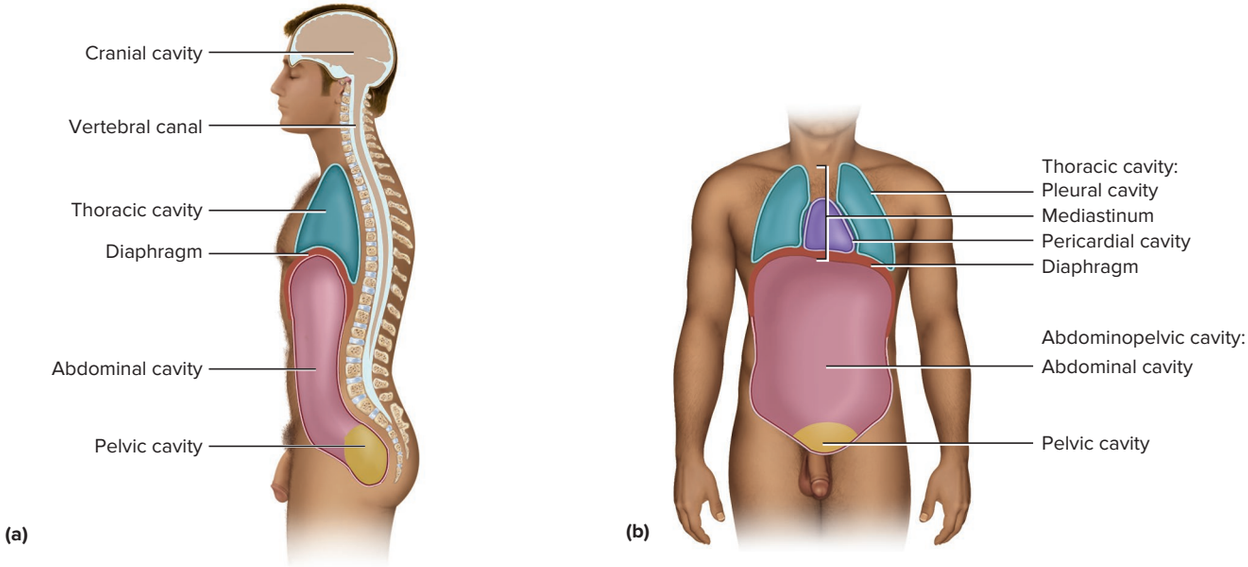


FIGURE 2.1 Major body cavities: (a) left lateral view; (b) anterior view.

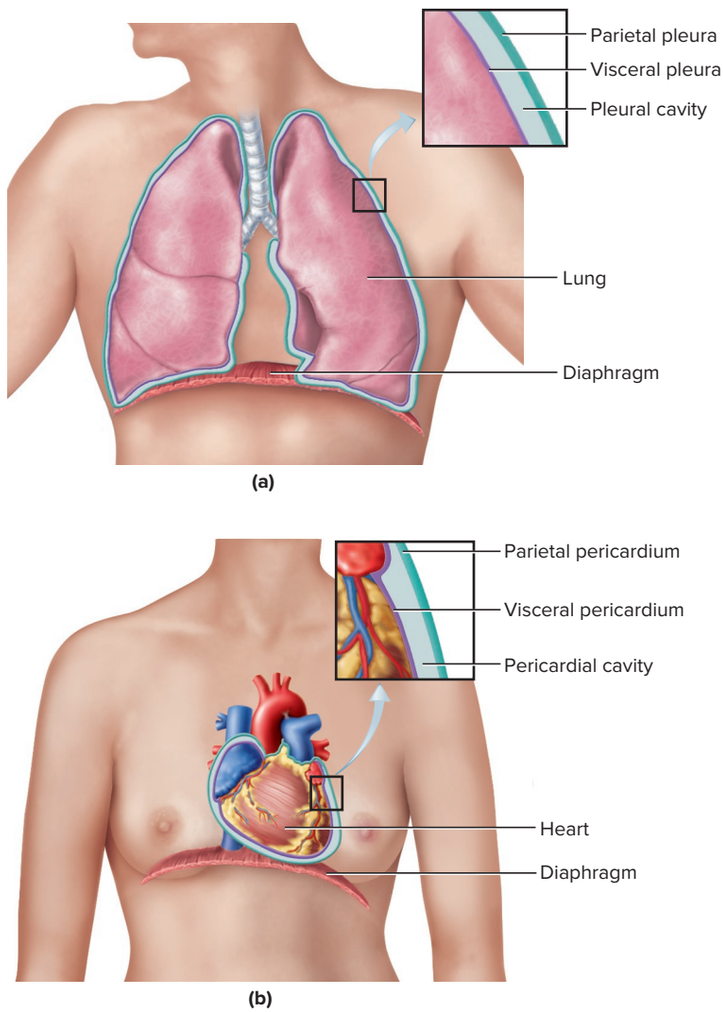


FIGURE 2.2 Thoracic serous membranes and cavities associated with (a) the lungs and (b) the heart.

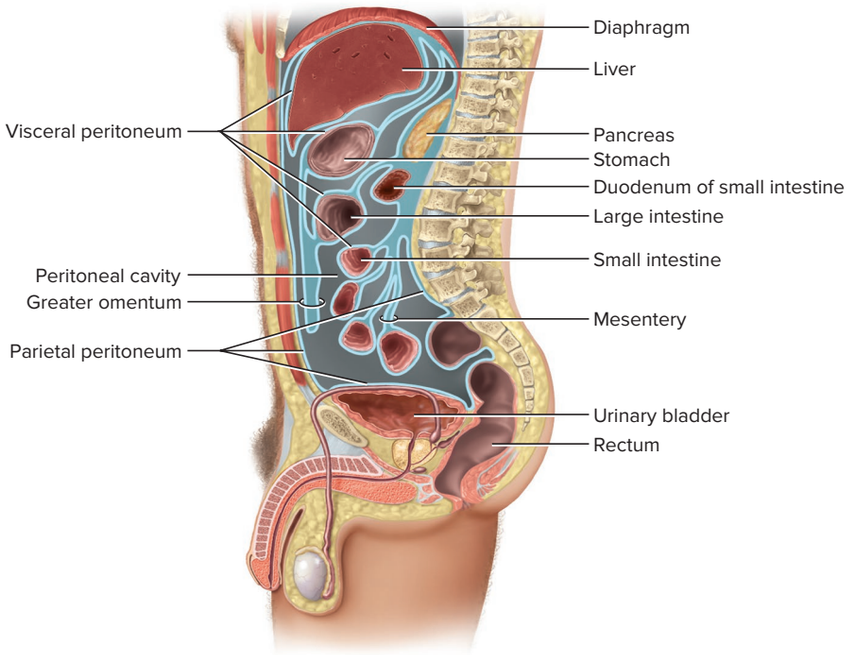


FIGURE 2.3 Serous membranes of the abdominal cavity are shown in this left lateral view. APR

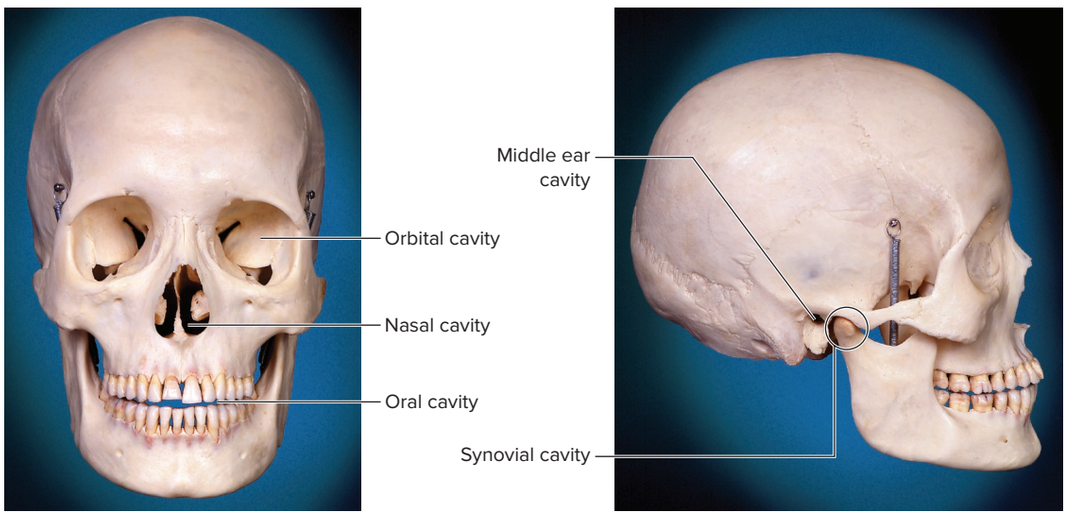


FIGURE 2.4 Other body cavities include the orbital, nasal, oral, middle ear, and synovial cavities, indicated in these images of the (a) anterior view and (b) lateral view of the skull. ©J & J Photography

- pericardial cavity—associated with heart; contains pericardial (serous) fluid
  - parietal pericardium—outer layer; covered by fibrous pericardium
  - visceral pericardium (epicardium)—inner layer; covers surface of heart
- peritoneal cavity—associated with abdominal organs; contains peritoneal (serous) fluid
  - parietal peritoneum—outer layer; lines cavity wall
  - visceral peritoneum—inner layer; covers surface of organs

3. Complete Part A of Laboratory Assessment 2.

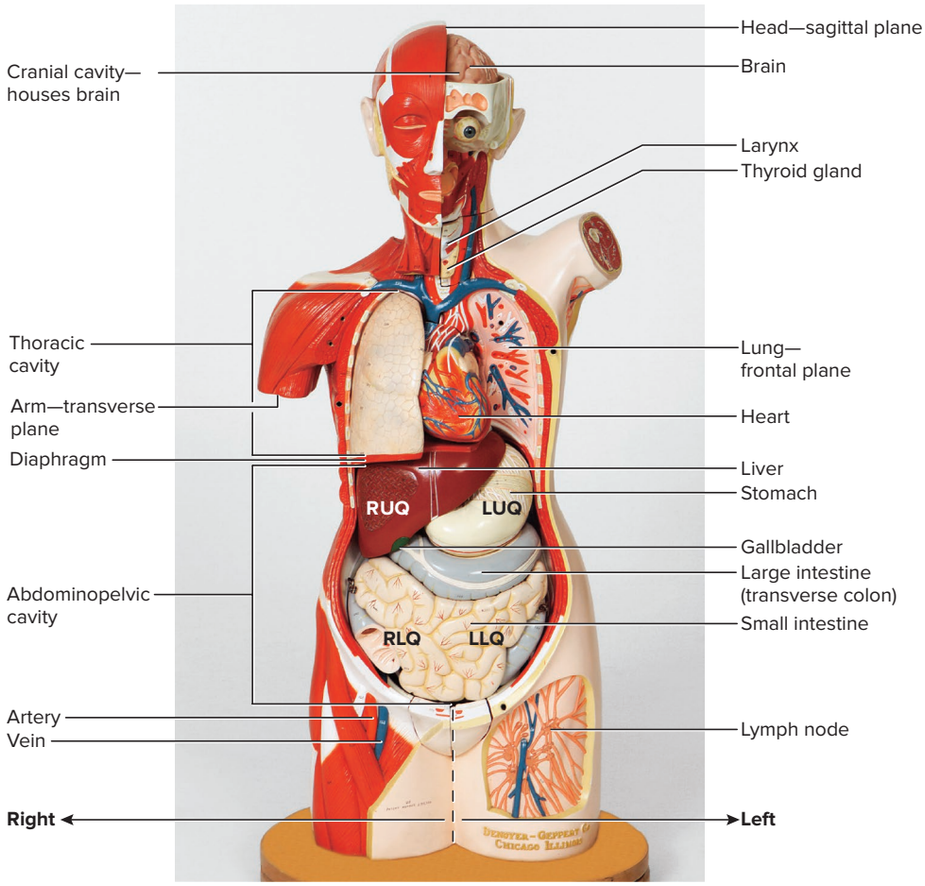


FIGURE 2.5 Dissectible human torso model with body cavities, abdominopelvic quadrants, body planes, and major organs indicated. The abdominopelvic quadrants include right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ), and left lower quadrant (LLQ). ©J & J Photography

PROCEDURE B: Organ Systems

The eleven body systems are listed in this procedure, and a major function of each system is included. Representative major organs are listed within each of the systems. By using models, charts, and images to locate each major organ included within the system, you will have an early overview of each system of the human body. More detailed organs and functions are covered within each system during later laboratory exercises.

1. Use a dissectible human torso model (fig. 2.5) to locate the following systems and their major organs:

integumentary system—protection
- skin—composed of epidermis and dermis
- accessory organs—such as hair and nails

skeletal system—support and protection
- bones—in head, torso, and limbs
- ligaments—connect bones to bones

muscular system—movement
- skeletal muscles—allow voluntary movements
- tendons—connect muscles to bones

nervous system—detects changes; interprets sensory information; stimulates muscles and glands
- brain—within cranial cavity
- spinal cord—extends through vertebral canal
- nerves—conduct impulses into and from brain and spinal cord

endocrine system—secretes hormones
- pituitary gland—attached to base of brain
- thyroid gland—anterior neck; inferior to larynx
- parathyroid glands—four glands; embedded on posterior thyroid gland
- adrenal glands—located superior to kidneys
- pancreas—most in left upper quadrant (LUQ); influence blood sugar

- ovaries—in females; produce reproductive hormones
- testes—in males; produce testosterone
- pineal gland—small gland within brain
- thymus—within mediastinum

cardiovascular system—transports gases, nutrients, and wastes
- heart—muscular pump for blood
- arteries—transport blood away from heart
- veins—transport blood back to heart

lymphatic system—produces and houses immune cells and returns tissue fluid to blood
- lymphatic vessels—carry lymph fluid
- lymph nodes—along lymphatic vessels; contain leukocytes that help fight infections
- thymus—within mediastinum
- spleen—large organ in LUQ

respiratory system—gas exchange between air and blood
- nasal cavity—superior to mouth cavity
- pharynx—passage for air superior to larynx
- larynx—anterior neck; houses vocal cords
- trachea—tube between larynx and bronchi
- bronchi—airway tubes within lungs
- lungs—large organs within thoracic cavity

digestive system—food breakdown and absorption
- mouth—contains tongue and teeth
- tongue—for food manipulation
- teeth—for biting and chewing food
- salivary glands—secrete saliva into mouth
- pharynx—passageway for food superior to esophagus
- esophagus—tube from pharynx to stomach
- stomach—between esophagus and small intestine; in LUQ
- liver—produces bile; in right upper quadrant (RUQ)
- gallbladder—stores bile; in RUQ
- pancreas—produces digestive enzymes; most in LUQ
- small intestine—tube from stomach to large intestine
- large intestine—tube from small intestine to anus

urinary system—removes liquids and wastes from blood
- kidneys—two large urine-forming organs in upper abdominopelvic cavity
- ureters—tubes from kidneys to urinary bladder
- urinary bladder—pelvic organ; stores urine
- urethra—tube from urinary bladder to external opening

male reproductive system—sperm production
- scrotum—encloses testes
- testes—produces sperm and hormones
- penis—external reproductive organ
- urethra—transports semen and urine

female reproductive system—egg production and fetal development
- ovaries—produce eggs and hormones
- uterine tubes (oviducts; fallopian tubes)—transport eggs
- uterus—muscular organ in pelvis; structure for fetal development
- vagina—tube from uterus to external opening

2. Complete Part B of the laboratory assessment.

PROCEDURE C: Relative Positions, Planes, and Regions

This procedure illustrates and incorporates planes (sections), abdominopelvic subdivisions, and surface regions using the anatomical position of the human body. Communications and directions for anatomical study assume the person is in an anatomical position.

Directional terms may be used to compare one part of the body to another part for better understanding of location and orientation. For example, the esophagus is posterior to the trachea, or the tarsal bones are distal to the tibia bone.

Anatomical planes (sections; cuts) of the entire body and individual organs allow a better understanding of the internal structure and function. Sectional anatomy is accomplished by cutting the body in standard ways to maximize the view of the particular organ. The anatomical planes include the *sagittal, frontal,* and *transverse* sections or cuts. Radiologic images by such techniques as a computed tomography (CT) scan or an magnetic resonance imaging (MRI) are examples of the advances and the importance of sectional anatomy for the diagnosis and treatment of medical situations.

The abdominopelvic area of the body is rather large and contains numerous viscera representing structural and functional parts of several body systems. People with abdominopelvic discomfort will often complain about it using terms like a "stomach ache." This is too general a term to be used for medical tests and procedures. Therefore, this abdominopelvic portion of the body is further subdivided into four *quadrants* and/or *nine regions.* Some medical disciplines prefer the use of quadrants, while others prefer the more specific use of regions.

The general surface of the entire body is subdivided into regions using anatomical terms appropriate for that particular portion of the body. This becomes helpful for descriptions of injuries or pain locations that are more specific than using broader general terms such as head, neck, and upper limb.

1. Observe the person standing in anatomical position (fig. 2.6). Anatomical terminology assumes the body is in anatomical position even though a person is often observed differently.
2. Study table 2.1 and figures 2.6 to 2.9 to become familiar with directional terms, anatomical planes, abdominopelvic quadrants and regions, and body surface regions.
3. Examine the sectioned specimens on the demonstration table and identify the plane along which each is cut.
4. Complete Parts C, D, E, and F of the laboratory assessment.

Table 2.1 Directional Terms and Their Meaning

Directional Term	Meaning
Left	Toward the left side of the body.
Right	Toward the right side of the body.
Anterior (ventral)	Toward the front or belly.
Posterior (dorsal)	Toward the back.
Superior (cephalad)	Toward the head or upward or above; pertains to the trunk anatomy.
Inferior (caudal)	Toward the tail or downward or below; pertains to the trunk anatomy.
Proximal	Toward the trunk or origin of a structure; pertains to the limb anatomy.
Distal	Further from the trunk or origin of a structure; pertains to the limb anatomy.
Medial	Toward the midline (median plane).
Lateral	Further from the midline (median plane).
Superficial	Toward the body surface.
Deep	Further away from the body surface.
Ipsilateral	On the same side of the body (right or left).
Contralateral	On opposite sides of the body (right and left).

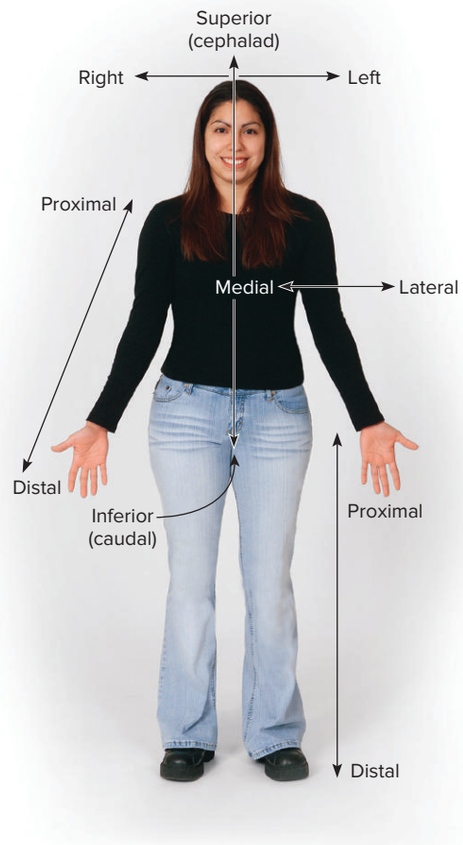


FIGURE 2.6 Anatomical position with directional terms indicated. The body is standing erect, face forward, with upper limbs at the sides and palms forward. When the palms are forward (supinated) the radius and ulna in the forearm are nearly parallel. This results in an anterior view of the body as shown. The relative positional terms are used to describe a body part's location in relation to other body parts. ©J & J Photography APR

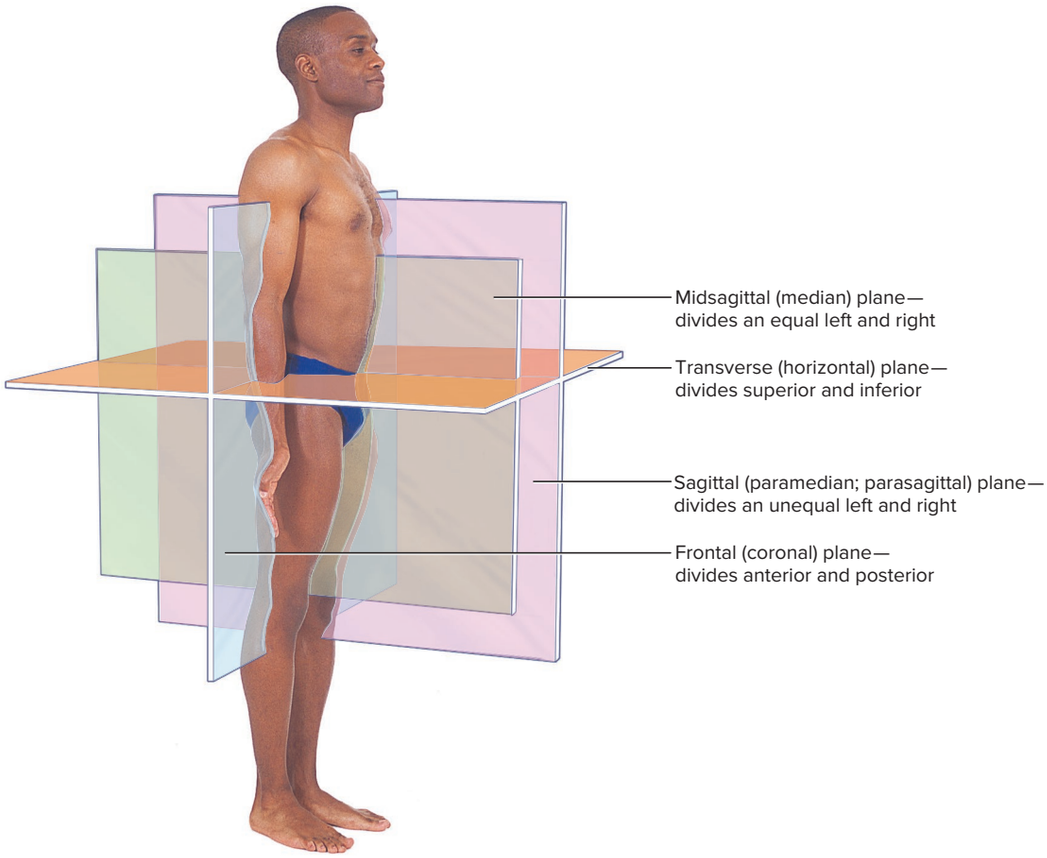
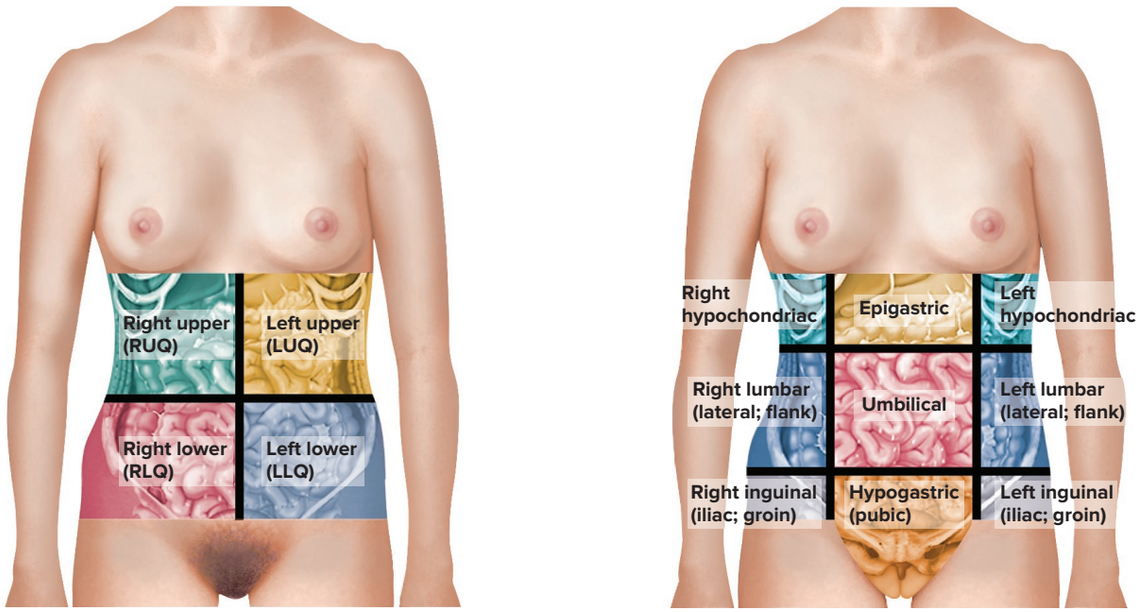


FIGURE 2.7 Anatomical planes (sections) of the body. Eric Wise/McGraw Hill APR



(a) Quadrants (4) **(b)** Regions (9)

FIGURE 2.8 Abdominopelvic (a) quadrants and (b) regions. An area as large as the abdominopelvic cavity is subdivided into either four quadrants or nine regions for purposes of locating organs, injuries, or pain, or for performing medical procedures. APR

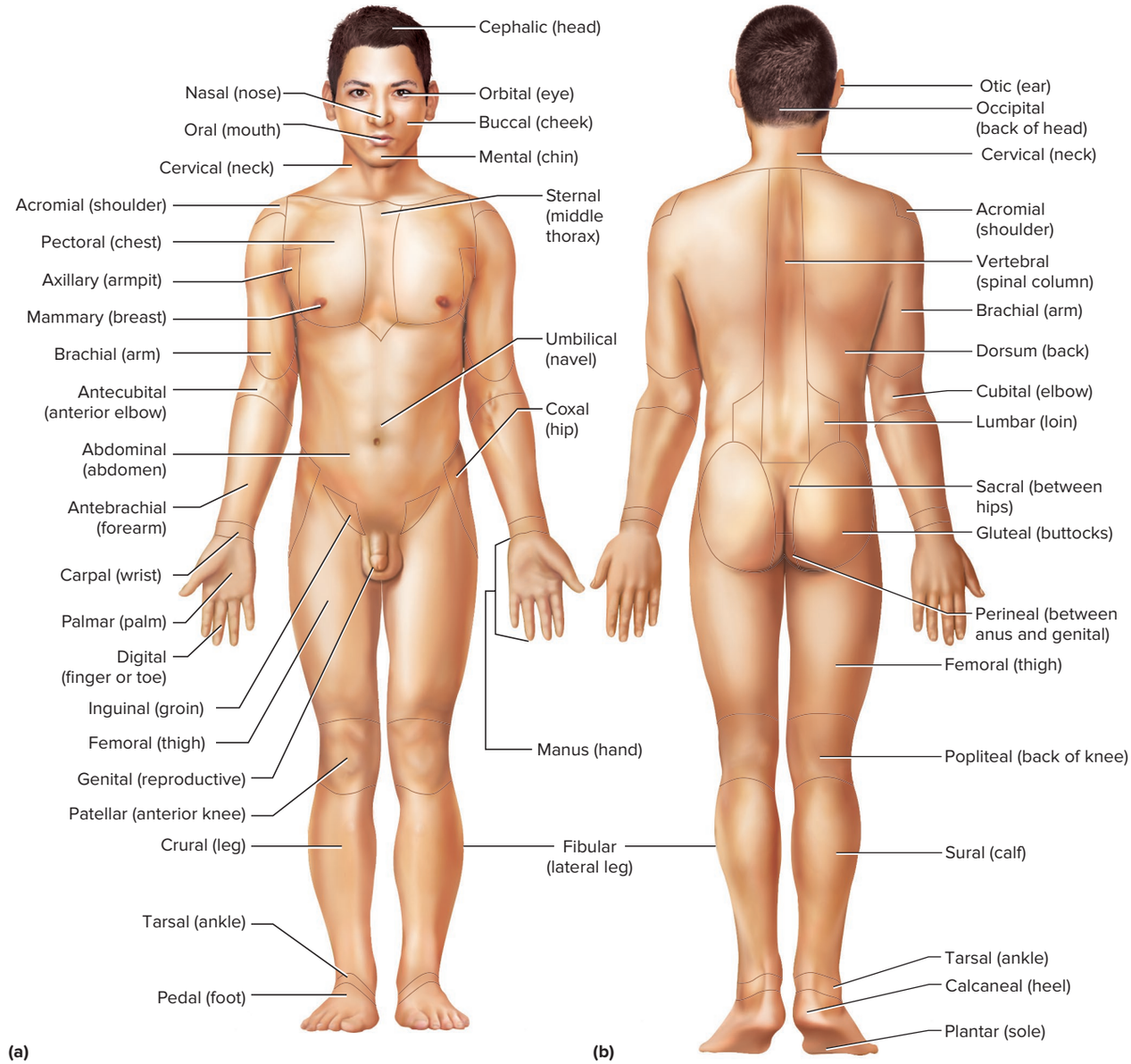


FIGURE 2.9 Diagrams of the body surface regions: (a) anterior view of regions; (b) posterior view of regions.

NOTES

LABORATORY
ASSESSMENT
2

Name _____

Date _____

Section _____

The A corresponds to the indicated Learning Outcome(s) O found at the beginning of the Laboratory Exercise.

Body Organization, Membranes, and Terminology

PART A: Assessments

1. Match the body cavities in column A with the organs contained in the cavities in column B. Place the letter of your choice in the space provided. A1 A2

Column A	Column B
a. Abdominal cavity	_____ **1.** Liver
b. Cranial cavity	_____ **2.** Lungs
c. Pelvic cavity	_____ **3.** Spleen
d. Thoracic cavity	_____ **4.** Stomach
e. Vertebral canal (spinal cavity)	_____ **5.** Brain
	_____ **6.** Internal reproductive organs
	_____ **7.** Urinary bladder
	_____ **8.** Spinal cord
	_____ **9.** Heart
	_____ **10.** Small intestine

2. Label figures 2.10 to 2.13. A1 A2

Terms:
Brain
Gallbladder
Lung
Spinal cord
Urethra

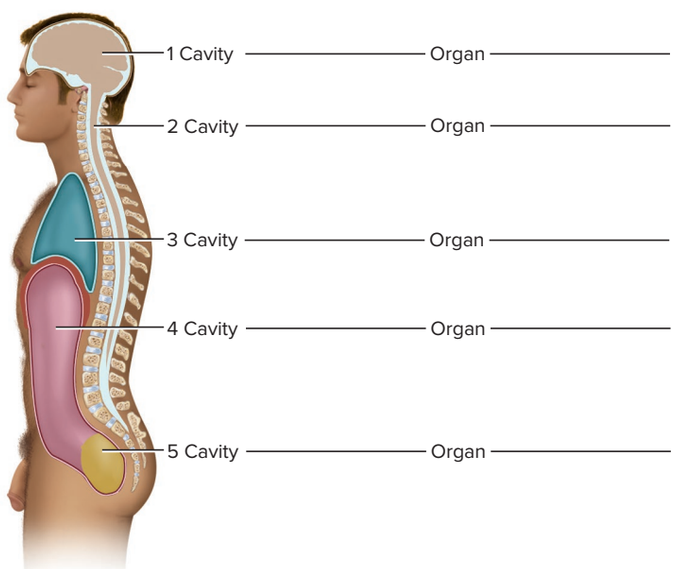


FIGURE 2.10 Label body cavities 1–5. Add a representative organ located in the cavity, using the terms provided.

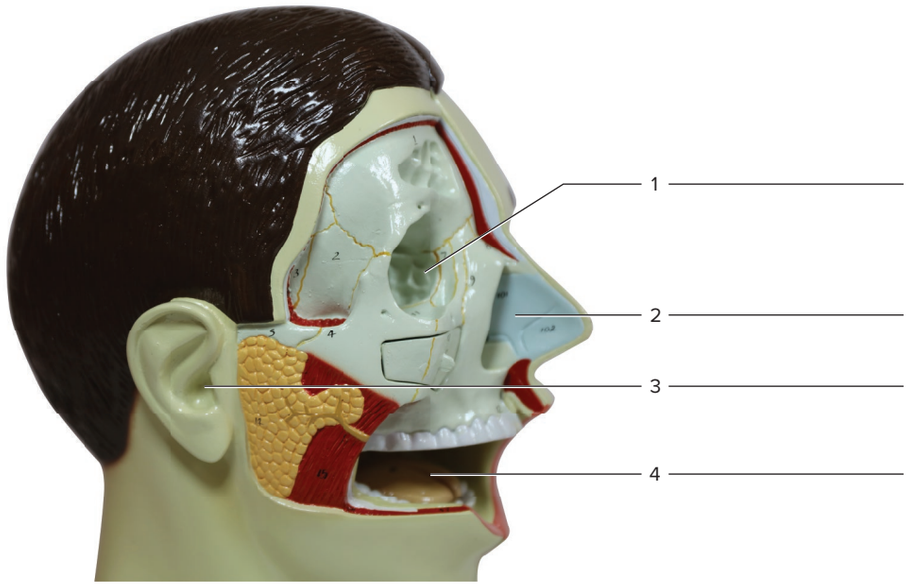


FIGURE 2.11 Label the body cavities of the head shown in this image of a model (lateral view).

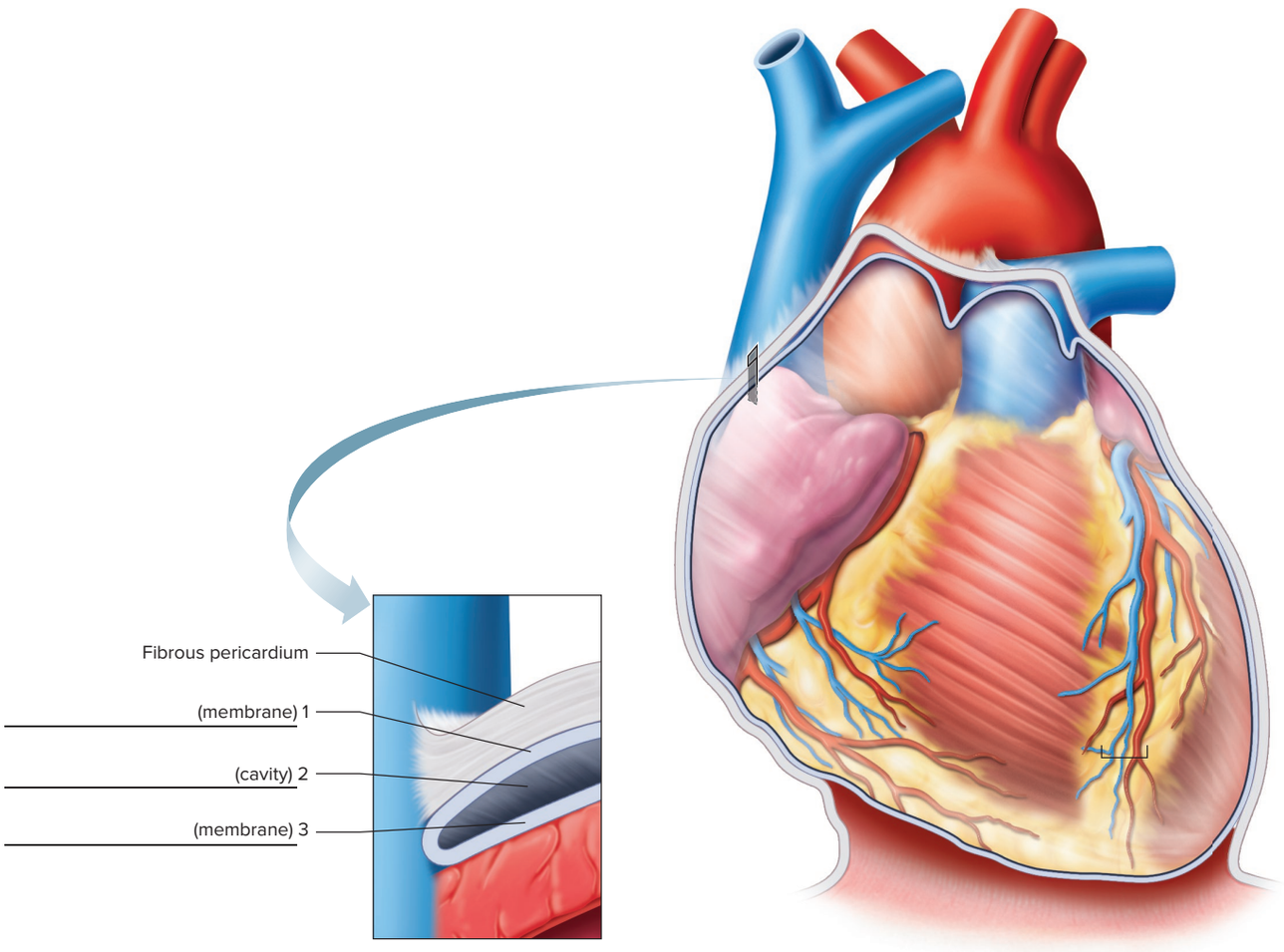


FIGURE 2.12 Label the specific serous membranes and cavity (1–3) shown in the frontal section of the heart.

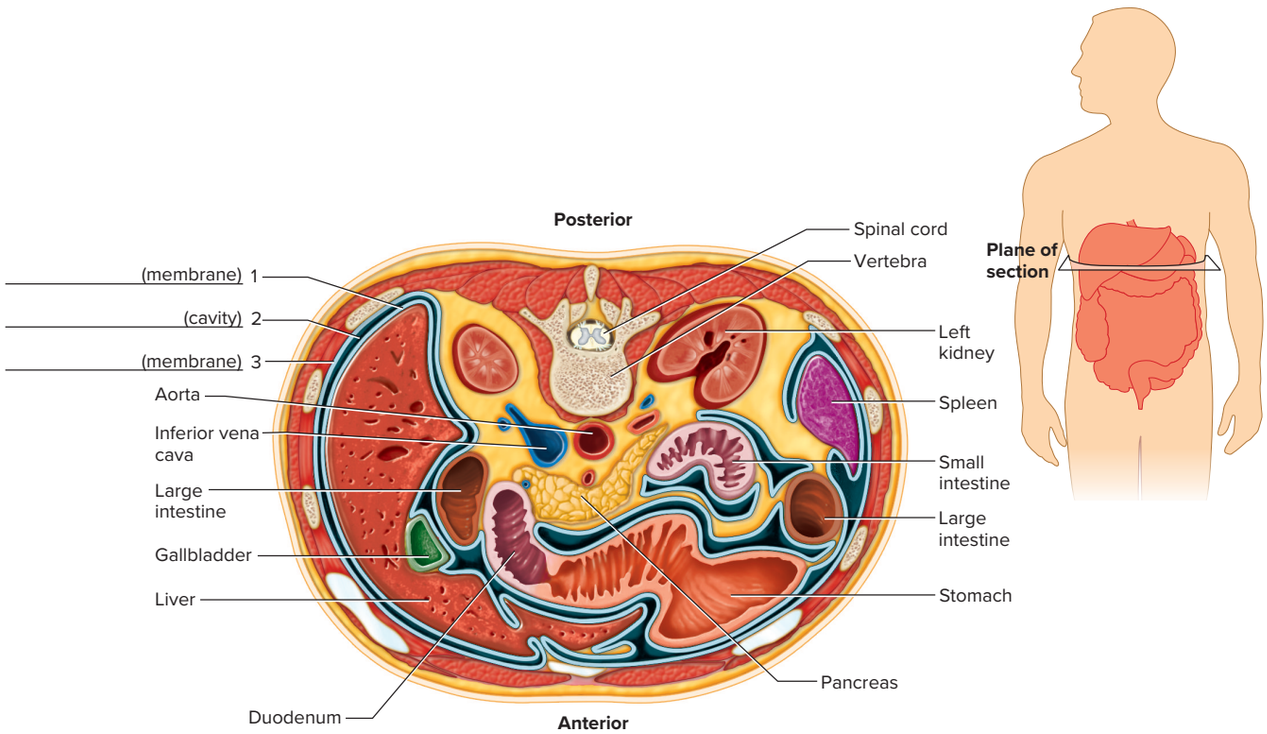


FIGURE 2.13 Label the specific serous membranes and cavity shown in this superior view of a transverse section of the abdominopelvic cavity.

PART B: Assessments

Match the organ systems in column A with the principal functions in column B. Place the letter of your choice in the space provided. A2

Column A	Column B
a. Cardiovascular system	_____ **1.** The main system that secretes hormones
b. Digestive system	_____ **2.** Provides an outer covering of the body for protection
c. Endocrine system	_____ **3.** Produces gametes (eggs and sperm) and offspring
d. Integumentary system	_____ **4.** Stimulates muscles to contract, interprets information from sensory organs, and functions in the integration and coordination of the body
e. Lymphatic system	_____ **5.** Provides a framework and support for soft tissues and produces blood cells in red marrow
f. Muscular system	_____ **6.** Exchanges gases between air and blood
g. Nervous system	_____ **7.** Transports excess fluid from tissues to blood and contains immune cells that help defend the body against infectious agents
h. Reproductive system	_____ **8.** Involves contractions that apply forces on body parts to cause movement, and creates most body heat
i. Respiratory system	_____ **9.** Removes liquid and wastes from blood and transports them to the outside of the body
j. Skeletal system	_____ **10.** Converts food molecules into forms that are absorbable
k. Urinary system	_____ **11.** Transports nutrients, wastes, and gases throughout the body

PART C: Assessments

Indicate whether each of the following sentences makes correct or incorrect usage of the word in boldface type (assume that the body is in the anatomical position). If the sentence is incorrect, in the space provided supply a term that will make it correct. A3

1. The mouth is **superior** to the nose. _____
2. The stomach is **inferior** to the diaphragm. _____
3. The trachea is **anterior** to the spinal cord. _____
4. The appendix is **ipsilateral** to the liver. _____
5. The larynx is **posterior** to the esophagus. _____
6. The heart is **medial** to the lungs. _____
7. The kidneys are **inferior** to the lungs. _____
8. The hand is **proximal** to the elbow. _____
9. The ascending colon is **ipsilateral** to the descending colon. _____
10. The knee is **proximal** to the ankle. _____
11. The thumb is the **lateral** digit of a hand. _____
12. The popliteal surface region is **anterior** to the patellar region. _____
13. The dermis is **superficial** to the epidermis. _____
14. The medulla is **deep** to the cortex of the kidney. _____

PART D: Assessments

Label figure 2.14.

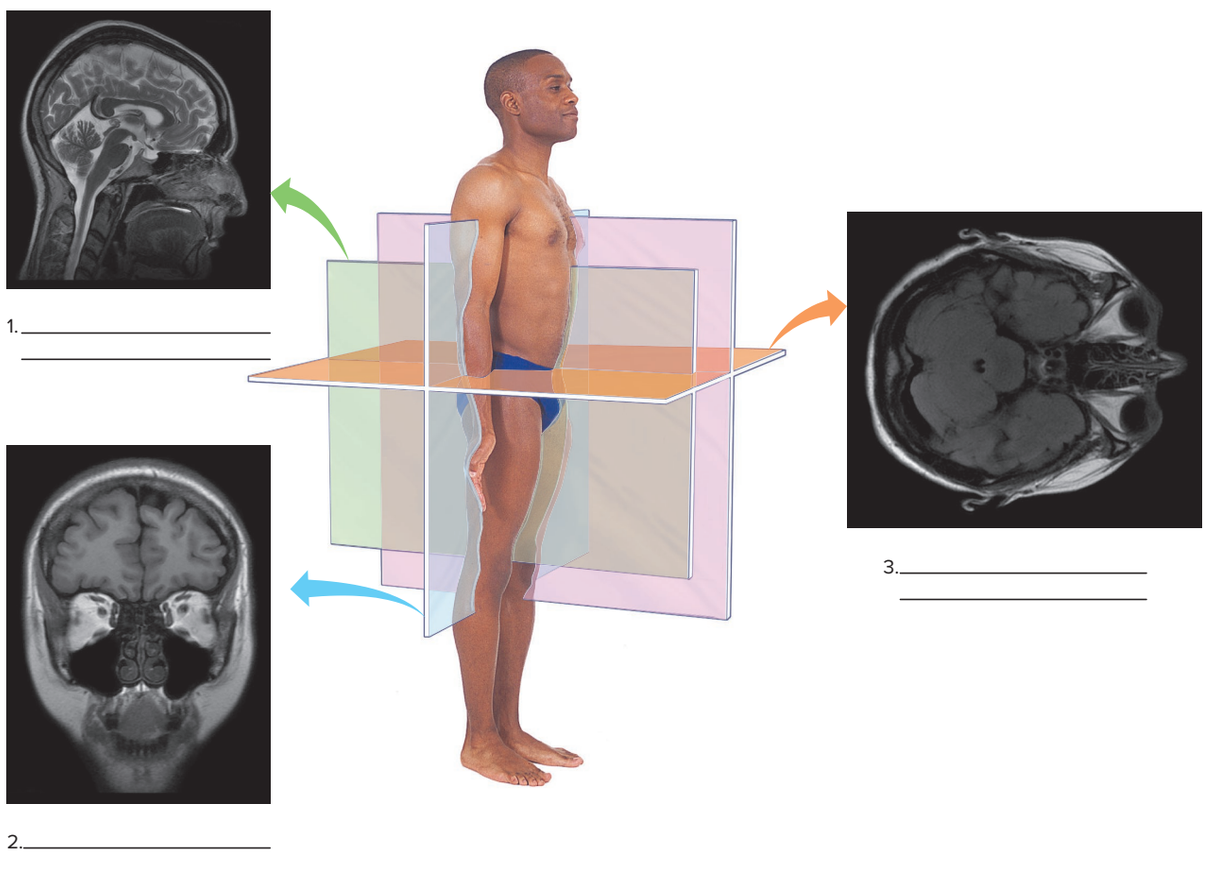


FIGURE 2.14 Label the planes of the sectioned (cut) body part. (1, 2, 3): kalewa/Shutterstock; (4): Eric Wise/McGraw Hill A4

PART E: Assessments

Label figure 2.15.

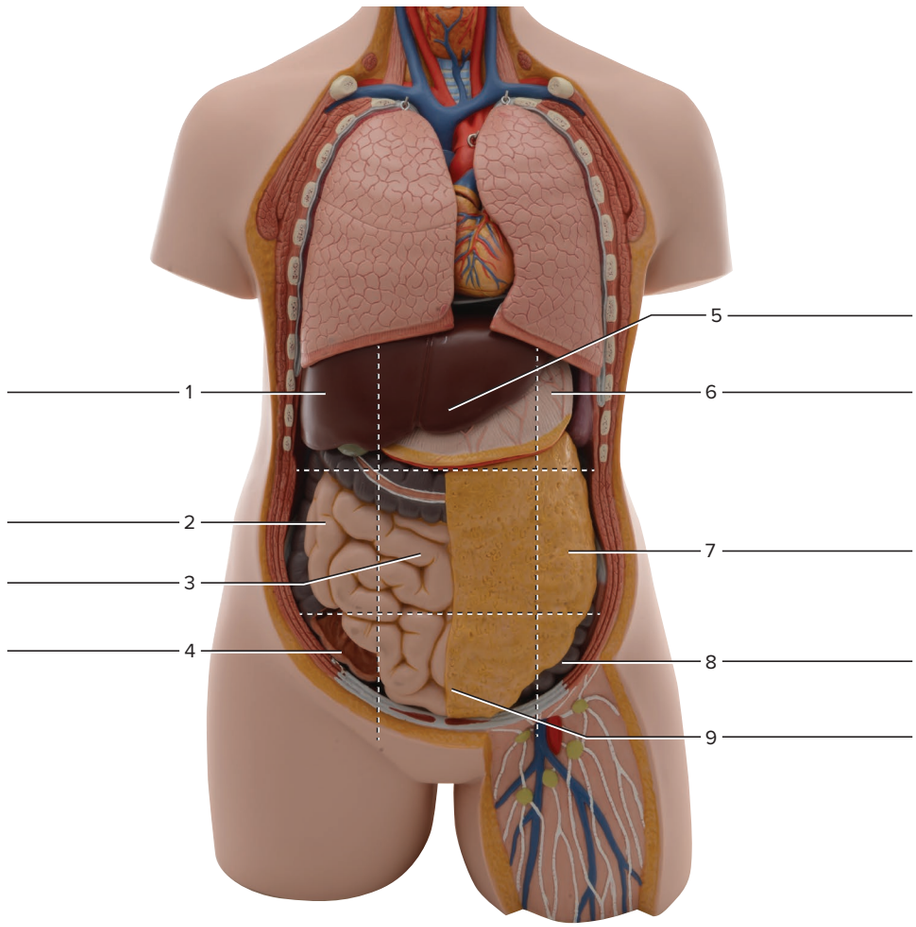


FIGURE 2.15 Label the nine abdominopelvic regions shown on the image of a torso model (anterior view). © 3B Scientific GmbH, Germany, 2017, www.3bscientific.com A5

CRITICAL THINKING ASSESSMENT—PART E

State the quadrant of the abdominopelvic cavity where the pain or sound would be located for each of the six conditions listed. In some cases, there may be more than one correct answer, and pain is sometimes referred to another region. This phenomenon, called *referred pain,* occurs when pain is interpreted as originating from some area other than the parts being stimulated. When referred pain is involved in the patient's interpretation of the pain location, the proper diagnosis of the ailment is more challenging. For the purpose of this exercise, assume the pain is interpreted as originating from the organ involved. A5

1. Stomach ulcer _____
2. Appendicitis _____
3. Bowel sounds _____
4. Gallbladder attack _____
5. Kidney stone in left ureter _____
6. Ruptured spleen _____

PART F: Assessments

Label figure 2.16.

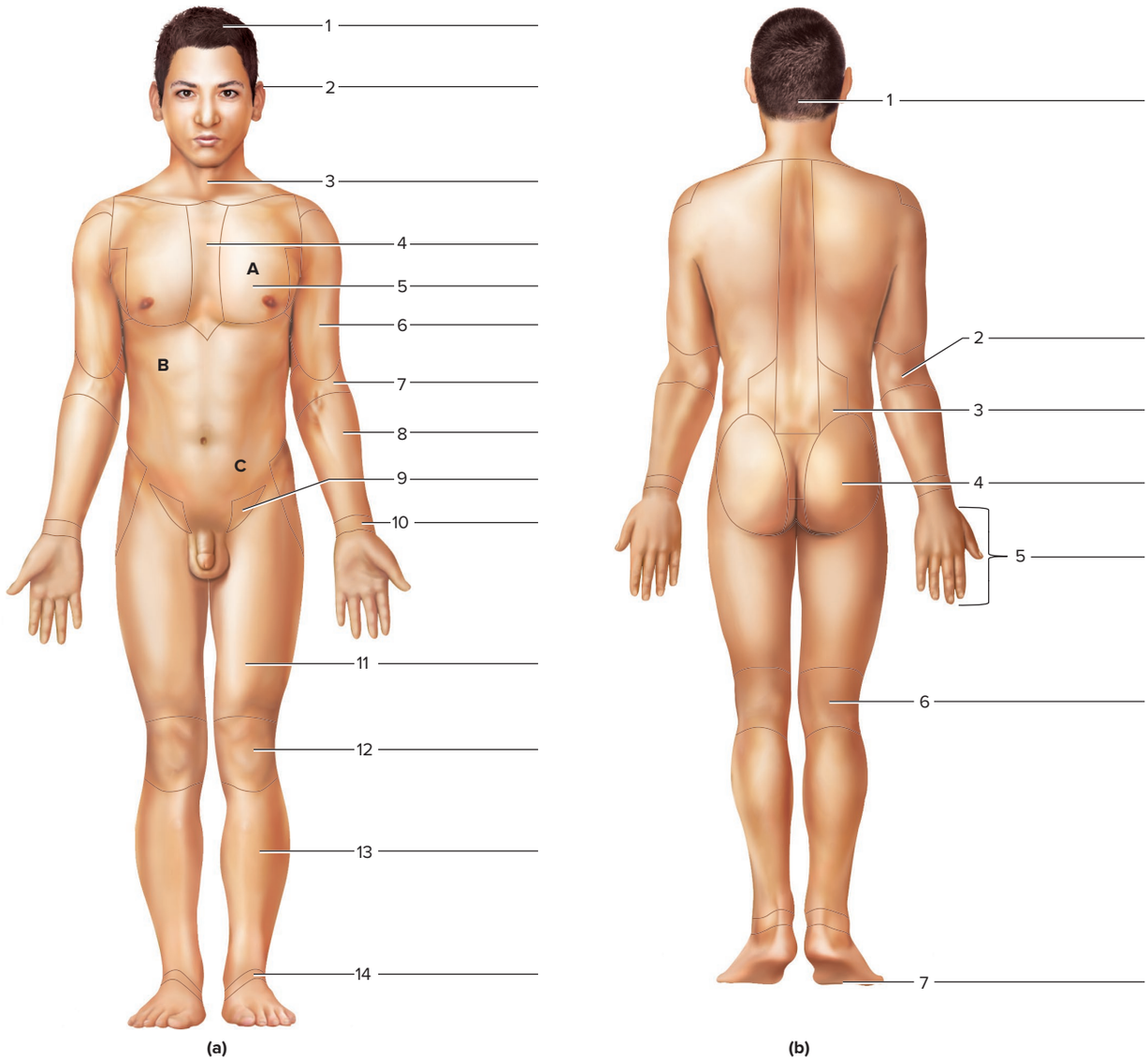


FIGURE 2.16 Label the indicated body surface regions: (a) anterior view; (b) posterior view. A5

CRITICAL THINKING ASSESSMENT—PART F

Examine the letters A, B, and C indicated on figure 2.16*a* that indicate a possible site of a deep puncture wound. Name the body cavity and the major internal organs that could be damaged from the injury. A1 A2

Injury Site	Body Cavity	Internal Organ
A		
B		
C		

LABORATORY EXERCISE 3

Chemistry of Life

Purpose of the Exercise

To review pH and basic categories of organic compounds, and to differentiate between types of organic compounds.

MATERIALS NEEDED

For pH Tests:

- Chopped fresh red cabbage
- Beaker (250 mL)
- Distilled water
- Tap water
- Vinegar
- Baking soda
- Pipets for measuring
- Laboratory scoop for measuring
- Full-range pH test papers
- Seven assorted common liquids clearly labeled in closed bottles on a tray or in a tub
- Droppers labeled for each liquid

For Organic Tests:

- Test tubes
- Test-tube rack
- Test-tube clamps
- China marker
- Hot plate
- Beaker for hot water bath (500 mL)
- Pipets for measuring
- Benedict's solution
- Sudan IV dye
- Biuret reagent (or 10% NaOH and 1% $CuSO_4$)
- Iodine-potassium-iodide (IKI) solution
- Egg albumin
- 10% glucose solution
- Clear carbonated soft drink
- 10% starch solution
- Potatoes for potato water
- Distilled water
- Vegetable oil
- Brown paper
- Numbered unknown organic samples

SAFETY

- Review all safety guidelines in Appendix 1 of your laboratory manual.
- Clean laboratory surfaces before and after laboratory procedures using soap and water.
- Use extreme caution when working with chemicals.
- Wear protective eyewear.
- Wear disposable gloves while working with the chemicals.
- Take precautions to prevent chemicals from contacting your skin.
- Do not mix any of the chemicals together unless instructed to do so.
- Clean up any spills immediately and notify the instructor at once.
- Wash your hands before leaving the laboratory.

Learning Outcomes APR

After completing this exercise, you should be able to:

- O1 Measure pH values of various substances through testing methods.
- O2 Determine categories of organic compounds with basic colorimetric tests.
- O3 Discover the organic composition of an unknown sample solution.

The O corresponds to the assessments A indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Be familiar with pH and organic molecules from lecture or the textbook. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. The most basic unit of matter is
   a. energy. **b.** an element.
   c. a molecule. **d.** a cell.
2. Which number would represent a neutral pH?
   a. 100 **b.** 0
   c. 7 **d.** 14
3. The building block of a protein is
   a. an amino acid. **b.** a monosaccharide.
   c. a lipid. **d.** starch.
4. The building block of a carbohydrate is
   a. glycerol. **b.** an amino acid.
   c. fatty acids. **d.** a monosaccharide.
5. The test to indicate the presence of starch uses which substance?
   a. IKI (iodine solution) **b.** Benedict's solution
   c. Sudan IV dye **d.** Biuret reagent

6. Using brown paper, a positive test for lipids results in a
   a. pinkish color change.
   b. yellow color change.
   c. translucent stain.
   d. blue to red color change.
7. Which of the following pH numbers would represent the strongest acid?
   a. 1 **b.** 5
   c. 7 **d.** 14
8. Which of the following solutions has the greatest H^+ concentration?
   a. Solution with pH 2
   b. Solution with pH 4
   c. Solution with pH 8
   d. Solution with pH 10
9. Red cabbage pigment can be used as a colorimetric indicator to determine pH value.
   a. True **b.** False

The complexities of the human body arise from the organization and interactions of chemicals. Organisms are made of matter, and the most basic unit of matter is the chemical element. The smallest unit of an element is an atom, and two or more of those can unite to form a molecule. All processes that occur within the body involve chemical reactions—interactions between atoms and molecules. We breathe to supply oxygen to our cells for energy. We eat and drink to bring chemicals into our bodies that our cells need. Water fills and bathes all of our cells and allows an amazing array of reactions to occur, all of which are designed to keep us alive. Chemistry forms the very basis of life and thus forms the foundation of anatomy and physiology.

The pH scale is from 0 to 14 with the midpoint of 7.0 (pure water) representing a *neutral* solution. If the solution has a pH lower than 7.0, it represents an *acidic* solution with more hydrogen ions (H^+) than hydroxide ions (OH^-). A *basic (alkaline)* solution has a pH higher than 7.0 with more OH^- ions than H^+ ions. The weaker acids and bases are closer to 7, with the strongest acids near 0 and the strongest bases near 14. A seemingly minor change in the pH actually represents a more significant change as there is a tenfold difference in hydrogen ion concentrations with each whole number represented on the pH scale. Our cells can only function within minimal pH fluctuations.

The *organic molecules* (biomolecules) that are tested in this laboratory exercise include *carbohydrates, lipids,* and *proteins.* Carbohydrates are used to supply energy to our cells. The polysaccharide starch is composed of simple sugar (monosaccharide) building blocks. Lipids include fats (triglycerides), phospholipids, and steroids that provide some cellular structure and energy for cells. The building blocks of most lipids include fatty acids and glycerol. Proteins compose important cellular structures, antibodies, and enzymes. Amino acids are the building blocks of proteins.

PROCEDURE A: The pH Scale

In this section, you will be able to determine the pH of various substances. The abbreviation pH is traditionally used to measure the power of H (hydrogen). The pH is a mathematical way to refer to the negative logarithm of the hydrogen ion (H^+) concentration in a solution. Each change of a number on the pH scale actually represents a tenfold increase or decrease of the hydrogen ion concentration.

The pH of various body fluids is very important in the homeostasis of a particular body system and the entire living organism. Blood, urine, saliva, and gastric secretions are examples of some body fluids with characteristic pH ranges for a healthy individual. Some body fluids like blood must fall within a very narrow pH range, while others like urine have a much wider normal range. In order to maintain normal ranges of the pH of body fluids, various buffering systems are involved to resist pH fluctuations. Some of these systems entail chemical buffers, such as the bicarbonate buffer system, and others consist of physiological buffers involving the kidneys and the lungs to help regulate the pH levels. The acid-base balance is important since our bodies are composed predominantly of water. Various acid-base relationships are covered within the discussion of each body system.

1. Study figure 3.1, which shows the pH scale. Note the range of the scale and the pH value that is considered neutral. Notice the pH of various foods and household items.

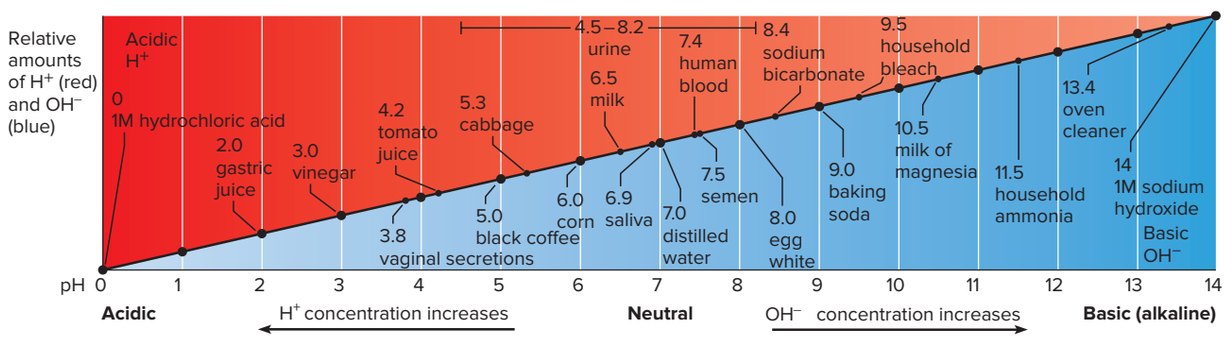


FIGURE 3.1 As the concentration of hydrogen ions (H^+) increases, a solution becomes more acidic and the pH value decreases. As the concentration of ions that combine with hydrogen ions (such as hydroxide ions) increases, a solution becomes more basic (alkaline) and the pH value increases. The pH values of some common substances are shown. APR

2. **Cabbage water tests.** Many tests can determine a pH value, but among the more interesting are colorimetric tests in which an indicator chemical changes color when it reacts. Many plant pigments, especially anthocyanins (which give plants color, from blue to red), can be used as colorimetric pH indicators. One that works well is the red pigment in red cabbage.
   a. Prepare cabbage water to be used as a general pH indicator. Fill a 250 mL beaker to the 100 mL level with chopped red cabbage. Add water to make 150 mL. Place the beaker on a hot plate and simmer the mixture until the pigments come out of the cabbage and the water turns deep purple. Allow the water to cool. (You may proceed to step 3 while you wait for this to finish.)
   b. Label three clean test tubes: one for water, one for vinegar, and one for baking soda.
   c. Place 2 mL of cabbage water into each test tube.
   d. To the first test tube, add 2 mL of distilled water and swirl the mixture. Note and record the color in Part A of Laboratory Assessment 3.
   e. Repeat this procedure for test tube 2, adding 2 mL of vinegar and swirling the mixture. Note and record the results in Part A of the laboratory assessment.
   f. Repeat this procedure for test tube 3, adding one laboratory scoop of baking soda. Swirl the mixture. Note and record the results in Part A of the laboratory assessment.
3. **Testing with pH paper.** Many commercial pH indicators are available. A very simple one to use is pH paper, which comes in small strips. Don gloves for this procedure so your skin secretions do not contaminate the paper, and to protect you from the chemicals you are testing.
   a. Test the pH of distilled water by dropping one or two drops of distilled water onto a strip of pH paper, and note the color. Compare the color to the color guide on the container. Note the results of the test as soon as color appears, as drying of the paper will change the results. Record the pH value in Part A of the laboratory assessment.
   b. Repeat this procedure for tap water. Record the results.
   c. Individually test the various common substances found on your lab table. Record your results.
   d. Complete Part A of the laboratory assessment.

PROCEDURE B: Organic Molecules

In this section, you will perform some simple tests to check for the presence of the following categories of organic molecules (biomolecules): protein, carbohydrate—sugar and starch, and lipid. Specific color changes will occur if the target compound is present. Please note the original color of the indicator being added so you can tell if the color really changed. For example, Biuret reagent and Benedict's solution are both initially blue, so an end color of blue would indicate no change. Use caution when working with these chemicals and follow all directions. Carefully label the test tubes and avoid contaminating any of your samples. Only the Benedict's test requires heating and a time delay for accurate results. Do not heat any other tubes. To prepare for the Benedict's test, fill a 500 mL beaker half full with water and place it on the hot plate. Turn the hot plate on and bring the water to a boil. To save time, start the water bath before doing the Biuret test.

1. **Biuret test for protein.** In the presence of protein, Biuret reagent reacts with peptide bonds and changes to violet or purple. A pinkish color indicates that shorter polypeptides are present. The color intensity is proportional to the number of peptide bonds; thus, the intensity reflects the length of polypeptides (amount of protein).
   a. Label six test tubes as follows: 1W, 1E, 1G, 1D, 1S, and 1P. The codes placed on the six test tubes used for the protein test include a number *1* referring to test 1 (biuret test for protein) followed by a letter. Letter *W* represents water (distilled); letter *E* represents egg (albumin); letter *G* represents glucose (10% solution); letter *D* represents drink (carbonated soft); letter *S* represents starch (solution); and letter *P* represents potato (juice). Similar codes are used for the tests for sugar (test 2) and starch (test 3) of Procedure B of this exercise.
   b. To each test tube, add 2 mL of one of the samples as follows:
   1W—2 mL distilled water
   1E—2 mL egg albumin
   1G—2 mL 10% glucose solution
   1D—2 mL carbonated soft drink
   1S—2 mL 10% starch solution
   1P—2 mL potato juice
   c. To each, add 2 mL of Biuret reagent, swirl the tube to mix it, and note the final color. [*Note:* If Biuret reagent is not available, add 2 mL of 10% NaOH (sodium hydroxide) and about ten drops of 1% $CuSO_4$ (copper sulfate).] **Be careful—NaOH is very caustic.**
   d. Record your results in Part B of the laboratory assessment.
   e. Mark a "+" on any tubes with positive results and retain them for comparison while testing your unknown sample. Put remaining test tubes aside so they will not be confused with future trials.
2. **Benedict's test for sugar (monosaccharides).** In the presence of sugar, Benedict's solution changes from its initial blue to a green, yellow, orange, or reddish color, depending on the amount of sugar present. Orange and red indicate greater amounts of sugar.
   a. Label six test tubes as follows: 2W, 2E, 2G, 2D, 2S, and 2P.
   b. To each test tube, add 2 mL of one of the samples as follows:
   2W—2 mL distilled water
   2E—2 mL egg albumin
   2G—2 mL 10% glucose solution

2D—2 mL carbonated soft drink
2S—2 mL 10% starch solution
2P—2 mL potato juice

c. To each, add 2 mL of Benedict's solution, swirl the tube to mix it, and place all tubes into the boiling water bath for 3 to 5 minutes.

d. Note the final color of each tube after heating and record the results in Part B of the laboratory assessment.

e. Mark a "+" on any tubes with positive results and retain them for comparison while testing your unknown sample. Put remaining test tubes aside so they will not be confused with future trials.

3. **Iodine test for starch.** In the presence of starch, iodine turns a dark purple or blue-black color. Starch is a long chain formed by many glucose units linked together side by side. This regular organization traps the iodine molecules and produces the dark color.

a. Label six test tubes as follows: 3W, 3E, 3G, 3D, 3S, and 3P.

b. To each test tube, add 2 mL of one of the samples as follows:
3W—2 mL distilled water
3E—2 mL egg albumin
3G—2 mL 10% glucose solution
3D—2 mL carbonated soft drink
3S—2 mL 10% starch solution
3P—2 mL potato juice

c. To each, add 0.5 mL of IKI (iodine solution) and swirl the tube to mix it.

d. Record the final color of each tube in Part B of the laboratory assessment.

e. Mark a "+" on any tubes with positive results and retain them for comparison while testing your unknown sample. Put remaining test tubes aside so they will not be confused with future trials.

4. **Tests for lipids.**

a. Label two separate areas of a piece of brown paper as "water" and "oil."

b. Place a drop of water on the area marked "water" and a drop of vegetable oil on the area marked "oil."

c. Let the spots dry several minutes, then record your observations in Part B of the laboratory assessment. Upon drying, oil leaves a translucent stain (grease spot) on brown paper; water does not leave such a spot.

d. In a test tube, add 2 mL of water and 2 mL of vegetable oil and observe. Shake the tube vigorously; then let it sit for 5 minutes and observe again. Record your observations in Part B of the laboratory assessment.

e. Sudan IV is a dye that is lipid-soluble but not water-soluble. If lipids are present, the Sudan IV will stain them a reddish color. Add a small amount of Sudan IV to the test tube that contains the oil and water. Swirl it; then let it sit for a few minutes. Record your observations in Part B of the laboratory assessment.

PROCEDURE C: Identifying Unknown Compounds

Now you will apply the information you gained with the tests in the previous section. You will retrieve an unknown sample that contains none, one, or any combination of the following types of organic compounds: protein, sugar, starch, or lipid. You will test your sample using each test from the previous section and record your results in Part C of the laboratory assessment.

1. Label four test tubes as follows: (1, 2, 3, and 4).
2. Add 2 mL of your unknown sample to each test tube.
3. **Test for protein.** Add 2 mL of Biuret reagent to tube 1. Swirl the tube and observe the color. Record your observations in Part C of the laboratory assessment.
4. **Test for sugar.** Add 2 mL of Benedict's solution to tube 2. Swirl the tube and place it in a boiling water bath for 3 to 5 minutes. Record your observations in Part C of the laboratory assessment.
5. **Test for starch.** Add several drops of iodine solution to tube 3. Swirl the tube and observe the color. Record your observations in Part C of the laboratory assessment.
6. **Test for lipid.** Add 2 mL of water to tube 4. Swirl the tube and note if there is any separation.
7. Add a small amount of Sudan IV to test tube 4, swirl the tube, and record your observations in Part C of the laboratory assessment.
8. Based on the results of these tests, determine if your unknown sample contains any organic compounds and, if so, what they are. Record and explain your identification in Part C of the laboratory assessment.

LABORATORY
ASSESSMENT
3
Chemistry of Life

Name _____

Date _____

Section _____

The A corresponds to the indicated Learning Outcome(s) O found at the beginning of the Laboratory Exercise.

PART A: Assessments

1. Results from cabbage water tests: A1

Substance	Cabbage Water	Distilled Water	Vinegar	Baking Soda
Color				
Acid, base, or neutral?				

2. Results from pH paper tests: A1

Substance Tested	Distilled Water	Tap Water	Sample 1: _____	Sample 2: _____	Sample 3: _____	Sample 4: _____	Sample 5: _____	Sample 6: _____	Sample 7: _____
pH Value									

3. Are the pH values the same for distilled water and tap water? _____

4. If not, what might explain this difference? _____

5. Draw the pH scale below, and indicate the following values: 0, 7 (neutral), and 14. Now label the scale with the sample names and indicate the location of the pH values for each substance you tested.

CRITICAL THINKING ASSESSMENT—PART A

A person's blood pH of 7.20 is considered acidosis, even though this pH is above 7 on the pH scale. Explain why. A1

_____

_____ .

PART B: Assessments

1. **Biuret test results for protein.** Enter your results from the Biuret test for protein. A color change to purple indicates that protein is present; pink indicates that short polypeptides are present. A2

Tube	Contents	Color	Protein Present (+) or Absent (–)
1W	Distilled water		
1E	Egg albumin		
1G	Glucose solution		
1D	Soft drink		
1S	Starch solution		
1P	Potato juice		

2. **Benedict's test results for most sugars (monosaccharides).** Enter your results from the Benedict's test for sugars. A color change to green, yellow, orange, or red indicates that sugar is present. Note the color after the mixture has been heated for 3 to 5 minutes. A2

Tube	Contents	Color	Sugar Present (+) or Absent (–)
2W	Distilled water		
2E	Egg albumin		
2G	Glucose solution		
2D	Soft drink		
2S	Starch solution		
2P	Potato juice		

3. **Iodine test results for starch.** Enter your results from the iodine test for starch. A color change to dark blue or black indicates that starch is present. A2

Tube	Contents	Color	Sugar Present (+) or Absent (–)
3W	Distilled water		
3E	Egg albumin		
3G	Glucose solution		
3D	Soft drink		
3S	Starch solution		
3P	Potato juice		

4. **Lipid test results.** What did you observe when you allowed the drops of oil and water to dry on the brown paper? A2

_____

What did you observe when you mixed the oil and water together? _____

_____

What did you observe when you added the Sudan IV dye? A2 _____

CRITICAL THINKING ASSESSMENT—PART B

If a person were on a low-carbohydrate, high-protein diet, which of the six substances tested would the person want to increase? A2 _____

Explain your answer. _____

_____

_____

_____

_____

PART C: Assessments

1. What is the number of your sample? _____

2. Record the results of your tests on the unknown sample here: A3

Test Performed	Results
Biuret test for protein	
Benedict's test for sugars	
Iodine test for starch	
Water test for lipid	
Sudan IV test for lipid	

3. Based on these results, what organic compound(s) does your unknown sample contain? A3 _____

_____

4. Explain your answer. A3 _____

_____

NOTES

LABORATORY EXERCISE 4

Care and Use of the Microscope

Purpose of the Exercise

To become familiar with the major parts of a compound light microscope. Be able to use the microscope to observe small objects.

MATERIALS NEEDED

Compound light microscope
Lens paper
Microscope slides
Coverslips
Transparent plastic millimeter ruler
Prepared slide of letter *e*
Slide of three colored threads
Medicine dropper
Dissecting needle (needle probe)
Specimen examples for wet mounts
Methylene blue (dilute) or iodine-potassium-iodide stain

For Demonstration Activity:
Stereomicroscope (dissecting microscope)

SAFETY

- Review all the safety guidelines inside Appendix 1 of your laboratory manual.
- Clean laboratory surfaces before and after laboratory procedures.
- Wear disposable gloves for the wet mount procedures.
- Dispose of laboratory gloves, slides, coverslips, and specimens as instructed.
- Take precautions to prevent stains from contacting clothes and skin.
- Wash your hands before leaving the laboratory.

Chapter Opener: ©101cats/Getty Images

Learning Outcomes

After completing this exercise, you should be able to:

- **O1** Locate and identify the major parts of a compound light microscope and differentiate the functions of these parts.
- **O2** Calculate the total magnification produced by various combinations of eyepiece and objective lenses.
- **O3** Demonstrate proper use of the microscope to observe and measure small objects.
- **O4** Prepare simple wet mount microscope slides and sketch the objects you observed.

The **O** corresponds to the assessments **A** indicated in the Laboratory Assessment for this Exercise.

Pre-Lab

Carefully read the introductory material and examine the entire lab. Answer the pre-lab questions.

Pre-Lab Questions Select the correct answer for each of the following questions:

1. The human eye cannot perceive objects less than
   a. 1 inch. **b.** 1 mm.
   c. 0.1 mm. **d.** 1 cm.
2. The objective lenses of the compound light microscope are attached to the
   a. stage. **b.** base.
   c. body tube. **d.** rotating nosepiece.
3. Which objective lens provides the least total magnification?
   a. scanning **b.** low power
   c. high power **d.** oil immersion
4. The _____increases or decreases the light intensity of the compound light microscope.
   a. eyepiece **b.** stage
   c. adjustment knob **d.** iris diaphragm
5. Basic lens cleaning is accomplished using
   a. water. **b.** lens paper.
   c. a paper towel. **d.** xylene.
6. When preparing a wet mount specimen for viewing, it should be covered with
   a. clear paper. **b.** another glass slide.
   c. a coverslip. **d.** transparent tape.