Preface

This laboratory manual was prepared to be used with any human anatomy and physiology textbook. The major dissection specimen is the fetal pig.

The laboratory manual contains sixty-two laboratory exercises and reports. The exercises are planned to illustrate and review anatomical and physiological facts and principles presented in a textbook and to help students investigate some of these ideas in greater detail.

Often the laboratory exercises are short or are divided into several separate procedures. This allows an instructor to select those exercises or parts of exercises that will best meet the needs of a particular program. Also, exercises requiring a minimal amount of laboratory equipment have been included.

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 special features include the following:

MATERIALS NEEDED

This section lists the laboratory materials that are required to complete the exercise and to perform the demonstrations and optional activities.

SAFETY

A list of safety guidelines is included inside the front cover. Each lab session that requires special safety guidelines has a safety section following “Materials Needed.” Your instructor might require some modifications of these guidelines.

INTRODUCTION

The introduction briefly describes the subject of the exercise or the ideas that will be investigated.

PURPOSE OF THE EXERCISE

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

LEARNING OBJECTIVES

The learning objectives list in general terms what a student should be able to do after completing the 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 through the exercise in stepwise fashion. Frequently, the student is referred to particular sections of a textbook for necessary background information or for review of subject matter presented previously.

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

LABORATORY REPORTS

A laboratory report to be completed by the student immediately follows each exercise. These reports include various types of review activities, spaces for sketches of microscopic objects, tables for recording observations and experimental results, and questions dealing with the analysis of such data.

It is hoped that 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. Some of the exercises also include demonstrations, optional activities, and useful illustrations.

DEMONSTRATIONS

Demonstrations 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.

OPTIONAL ACTIVITIES

Optional 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 that the student plan an investigation or experiment and carry it out after receiving approval from the laboratory instructor.

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

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

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 NABT or the ILAR (2101 Constitution Avenue, NW, Washington, DC 20418; 202 334–2590).

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.

In some exercises, the figures include line drawings that are suitable for students to color with colored pencils. This activity may motivate students to observe the illustrations more carefully and help them to locate the special features represented in the figures. Students can check their work by referring to the corresponding full-color illustrations in a textbook.

REVIEWERS

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:

Beth M. Atkin
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Robert D. Ayres
Newbury College

Susan T. Baxley
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Palm Beach Community College

Charles R. Wert
Linn-Benton Community College

Louis Wigginton
St. Clair County Community College

Arlene Wolff
Fox Valley Technical College

FEATURES OF THIS EDITION

This new edition of the laboratory manual has been made user-friendly. It contains many of the features of other laboratory manuals by the author. Many of the incorporations are a result of evaluations and suggestions from anatomy and physiology students. Numerous suggestions from reviewers have been incorporated. Some features include the following:

1. To meet the need for clearer and more definite safety guidelines, a safety list is located inside the front cover and safety sections are found in appropriate labs.
2. A section called Study Skills for Anatomy and Physiology is located in the front material. This section was written by students enrolled in a Human Anatomy and Physiology course.
3. The Materials Needed section is located at the beginning of the laboratory exercise to enable greater ease in laboratory preparations.
4. Many of the leader lines on the figures have been enhanced for clarity by using more brackets for regional labels.
5. To clarify whether a figure label refers to a general area or a specific structure, "clue" words in parentheses have been added to some figures to direct students in their answers. The first example is figure 2.1.
6. References for laboratory exercise correlations to *The Virtual Physiology Lab CD-ROM* are indicated by the  icon in the appropriate lab following "Materials Needed." The ten animal-based physiological experiments can be used for prelab preparation, for an actual lab alternative or supplement, or for postlab review.
7. Critical thinking applications are included within most  of the laboratory exercises to enhance valuable critical thinking skills that students need throughout their lives.
8. Computer literacy is integrated to relevant laboratory  exercises. Web Quest activities are found at the end of most exercises. Discover the answer to many scientific questions at http://www.mhhe.com/biosci/abio/martinlmwg.mhtml Here you'll find links to help you with your quest.
9. Two assessment tools (rubrics) for laboratory reports are included in Appendix 2.
10. A supplement of four computerized physiology labs with laboratory reports using Intelitool products is available. The title is *Intelitool Supplementary Lab Exercises to Accompany the Laboratory Manual for Hole's Human Anatomy and Physiology* (0-697-27976-6).
11. The *Instructor's Manual to Accompany Human Anatomy and Physiology Laboratory Manual, Fetal Pig Dissection* describes the purpose of the laboratory manual and its special features, and provides suggestions for presenting the laboratory exercises to students, (0-07-235890-4)

To the Student

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

The following list of suggestions may help to 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. It is important to have some understanding of what will be done in the laboratory before you come to class.
2. Bring your laboratory manual and textbook to each laboratory session. These books are closely integrated and will help you complete most of the exercises.
3. 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 concerning special techniques to be used and precautions to be taken.
4. Keep your work area clean and your materials neatly arranged so that you can locate needed items quickly. This will enable you to proceed efficiently and will reduce the chances of making mistakes.
5. Pay particular attention to the purpose of the exercise, which states what you are to accomplish in general terms, and to the learning objectives, which list what you should be able to do as a result of the laboratory experience. Then, before you leave the class, review the objectives and make sure that you can meet them.
6. 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.
7. Handle all laboratory materials with care. These materials often are fragile and expensive to replace. Whenever you have questions about the proper treatment of equipment, ask the instructor.
8. Treat all living specimens humanely and try to minimize any discomfort they might experience.
9. 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.
10. Record your observations immediately after making them. In most cases, such data can be entered in spaces provided in the laboratory reports.
11. Read the instructions for each section of the laboratory report 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.
12. 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

My students have found that certain study skills worked well for them while enrolled in Human Anatomy and Physiology. Although each individual has a somewhat different learning style, there are techniques that work well for the majority of students. Utilizing some of the skills listed here could make your course more enjoyable and rewarding.

1. **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. Study your notes daily, as they provide sequential building blocks of the course content.
2. **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.
3. **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 to remember the eight carpals in the correct sequence. *Acronyms* are words that are formed by the first letters of the items to remember. *IPMAT* is an example of this type of mnemonic device to help remember the phases of the cell cycle in the correct sequence. Try some of your own.
4. **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.
5. **Recording and recitation:** An auditory learner can benefit by recording lectures and review sessions with a cassette recorder. 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). Talk about anatomy and physiology in everyday conversations.
6. **Note cards/flash cards:** Make your own. Add labels and colors to enhance the material. Keep them with you in your pocket or purse. Study them frequently and for short periods of time. 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.
7. **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 for exams. Prioritize your time so that you still have time for work and leisure activities. Find an appropriate study atmosphere with minimum distractions.

Best wishes on your anatomy and physiology endeavor.

Laboratory Exercise 1

Scientific Method and Measurements

MATERIALS NEEDED

meter stick
calculator
human skeleton

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

The scientific method begins with *observations* related to the topic under investigation. This step commonly involves the accumulation of previously acquired information and/or your own observations of the phenomenon. These observations are used to formulate a tentative explanation known as the *hypothesis.* An important attribute of an hypothesis is that it must be testable. The testing of the hypothesis involves performing a carefully controlled experiment to obtain data that can be used to support, disprove, or modify the hypothesis. An *analysis of data* is conducted using all of the information collected during the experiment. Data analysis includes organization and presentation of data as tables, graphs, and drawings. From the interpretation of the data analysis, *conclusions* are drawn. 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 numerous investigators working independently can validate the hypothesis by arriving at the same conclusions, the explanation becomes a **theory.** A theory that is verified continuously over a period of time and accepted by the scientific community becomes known as a **scientific law** or **principle.** A scientific law serves as the standard explanation for an observation unless it is disproved by later 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. Because the English system of measurements is often used in the United States, the investigator must make conversions from the English system to the metric system. A reference table for the conversion of English units of measure to metric units for length, mass, volume, time, and temperature is located inside the back cover of the laboratory manual.

PURPOSE

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

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. list in the correct order and describe all steps of the scientific method;
2. use the scientific method to test the validity of a hypothesis concerning the direct, linear relationship between human height and upper limb length;
3. make conversions from English measurements to the metric system and vice versa;
4. formulate an hypothesis and test it using the scientific method.

Figure 1.1 Measurement of upper limb length.

PROCEDURE A—USING THE STEPS OF THE SCIENTIFIC METHOD

1. Many people have observed a correlation between the length of the upper and lower limbs and the height (height for this lab means overall height of the subject) 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 in your class to observe a possible correlation.
2. From such observations, the following hypothesis is formulated: The length of a person's upper limb is equal to 0.4 (40%) of the height of the person. Test this hypothesis by performing the following experiment.
3. In this experiment, use a meter stick to measure an upper limb length of ten subjects. For each measurement, place the meter stick in the axilla (armpit) and record the length in centimeters to the end of the longest finger (see fig. 1.1). Obtain the height of each person in centimeters by measuring them without shoes against a wall (see fig. 1.2). 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. Record all your measurements in Part A of Laboratory Report 1.
4. The data collected from all of the measurements can now be analyzed. The expected correlation

Figure 1.2 Measurement of height.

between upper limb length and height is determined using the following equation:

Height × 0.4 = expected upper limb length.

The observed correlation that will be used to test the hypothesis is determined by:

Length of upper limb/Height
= actual % of height

5. A graph is an excellent method to obtain a visual representation of the data. Plot the subjects' data in Part A of the laboratory report. Plot the upper limb length of each subject on the x-axis and the height of each person on the y-axis. 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 report.

PROCEDURE B—DESIGN AN EXPERIMENT

Critical Thinking Application

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

Laboratory Report 1

Name ______________________

Date ______________________

Section ______________________

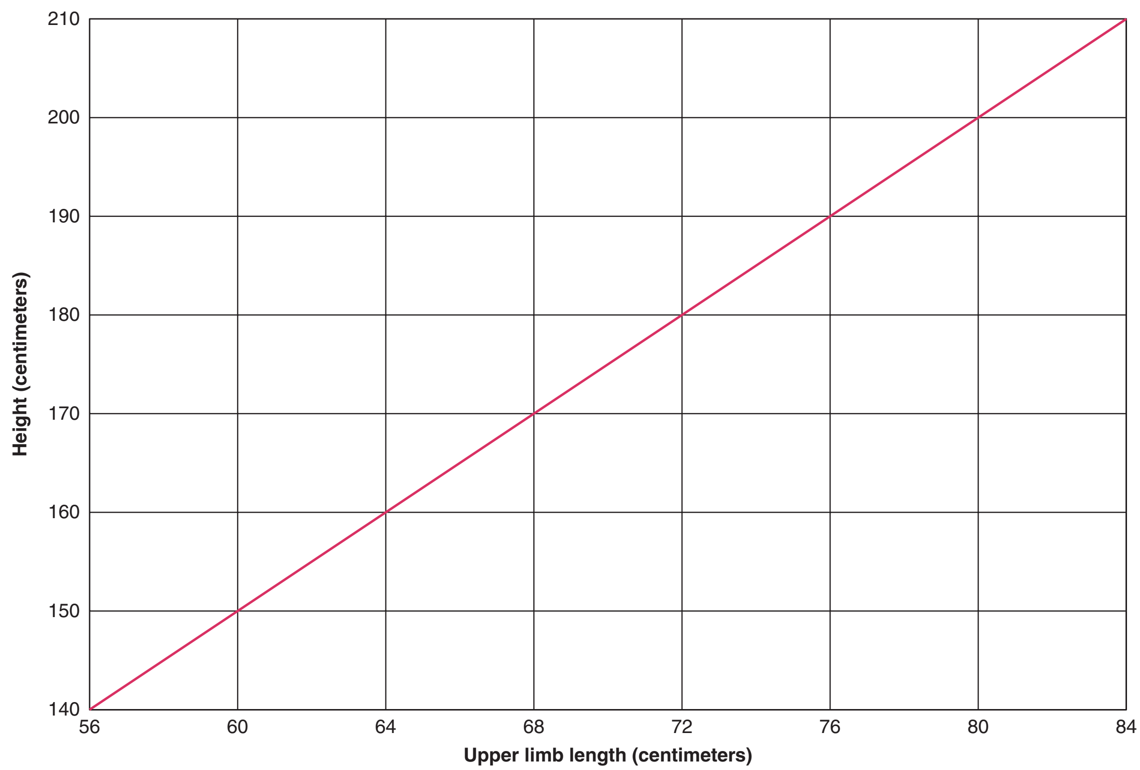
Scientific Method and Measurements

Part A

1. Record measurements for height and the upper limb length 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:

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

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%) upper limb length compared to measured height (the original hypothesis). (Note that the x-axis represents upper limb length and the y-axis represents height.) Draw a line of *best fits* through the distribution of points. Compare the two distributions.



3. Does the distribution of the ten subjects' measured upper limb length support or disprove the original hypothesis? ____________ Explain your answer.

Part B

1. Describe your observations of a possible correlation between the radius length to height.

2. Write an hypothesis based on your observations.

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

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

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

6. Discuss your results and conclusions with other classmates. What common conclusion can the class formulate concerning the correlation between radius length to height?

LABORATORY EXERCISE 2

BODY ORGANIZATION AND TERMINOLOGY

MATERIALS NEEDED

textbook
dissectible torso (manikin)
variety of specimens or models sectioned along various planes

For Optional Activity:

colored pencils

The major features of the human body include certain cavities, a set of membranes associated with these cavities, and a group of organ systems composed of related organs. In order to communicate effectively with each other about the body, scientists have devised names to describe these body features. They also have developed terms to represent the relative positions of body parts, imaginary planes passing through these parts, and body regions.

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.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and name the major body cavities and identify the membranes associated with each cavity;
2. name the organ systems of the human organism;
3. list the organs included within each system and locate the organs in a dissectible torso;
4. describe the general functions of each system;
5. define the terms used to describe the relative positions of body parts;
6. define the terms used to identify body sections and identify the plane along which a particular specimen is cut;
7. define the terms used to identify body regions.

PROCEDURE A—BODY CAVITIES AND MEMBRANES

1. Review a textbook section on *body cavities* and *thoracic and abdominopelvic membranes.*
2. As a review activity, label figures 2.1, 2.2, and 2.3.
3. Locate the following features on textbook figures and on the dissectible torso:

dorsal cavity

cranial cavity

vertebral canal (spinal cavity)

ventral cavity

thoracic cavity

mediastinum

pleural cavity

abdominopelvic cavity

abdominal cavity

pelvic cavity

diaphragm

smaller cavities within the head

oral cavity

nasal cavity with connected sinuses

orbital cavity

middle ear cavity

membranes and cavities

pleural cavity

parietal pleura

visceral pleura

pericardial cavity

parietal pericardium (covered by fibrous pericardium)

visceral pericardium (epicardium)

Figure 2.1 Label the major body cavities.

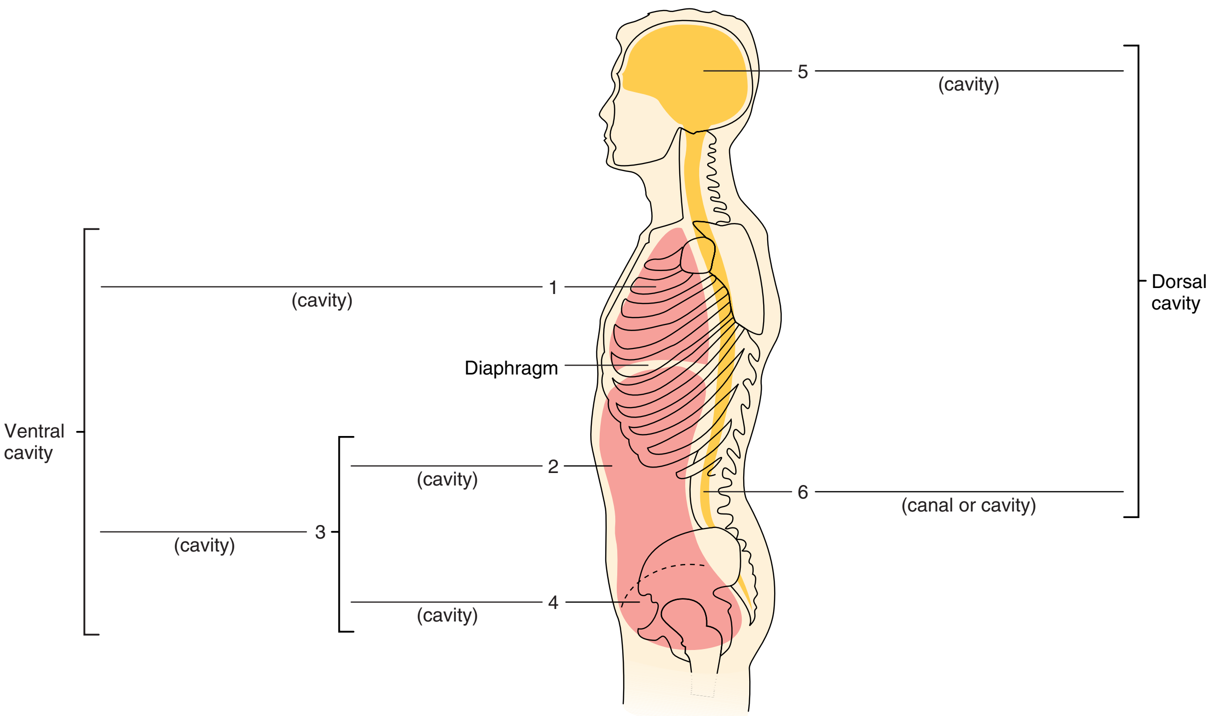


Figure 2.2 Label the smaller cavities and sinuses within the head.

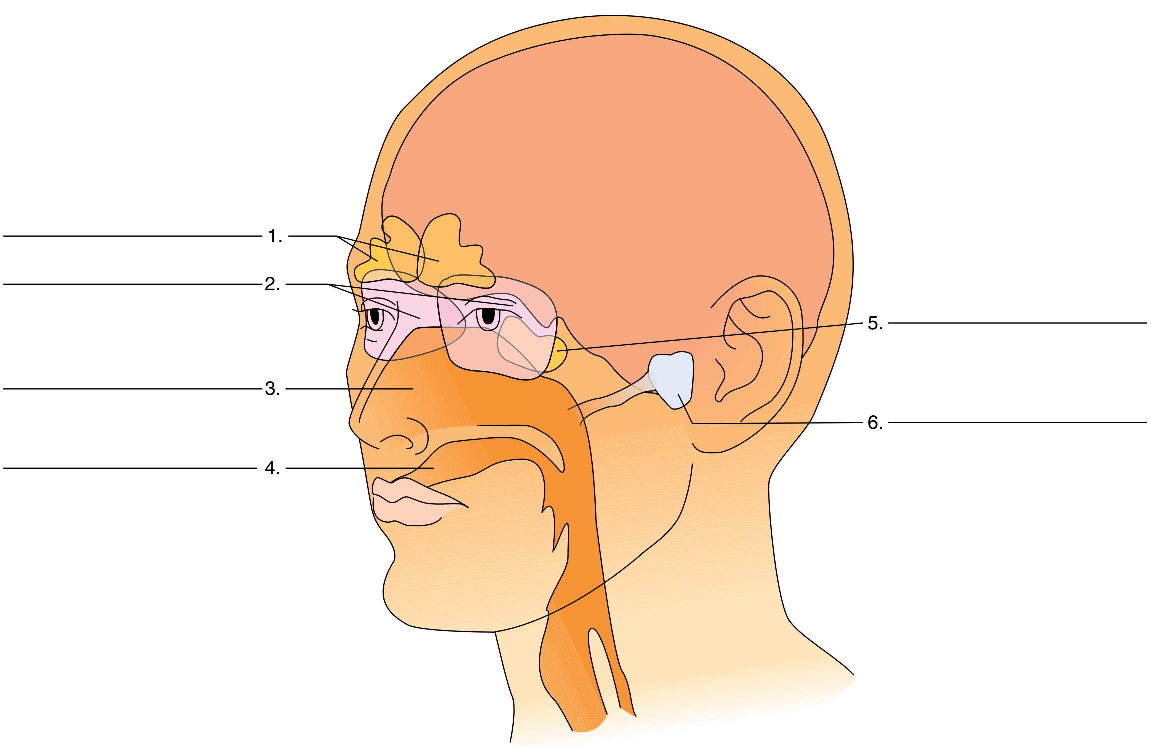
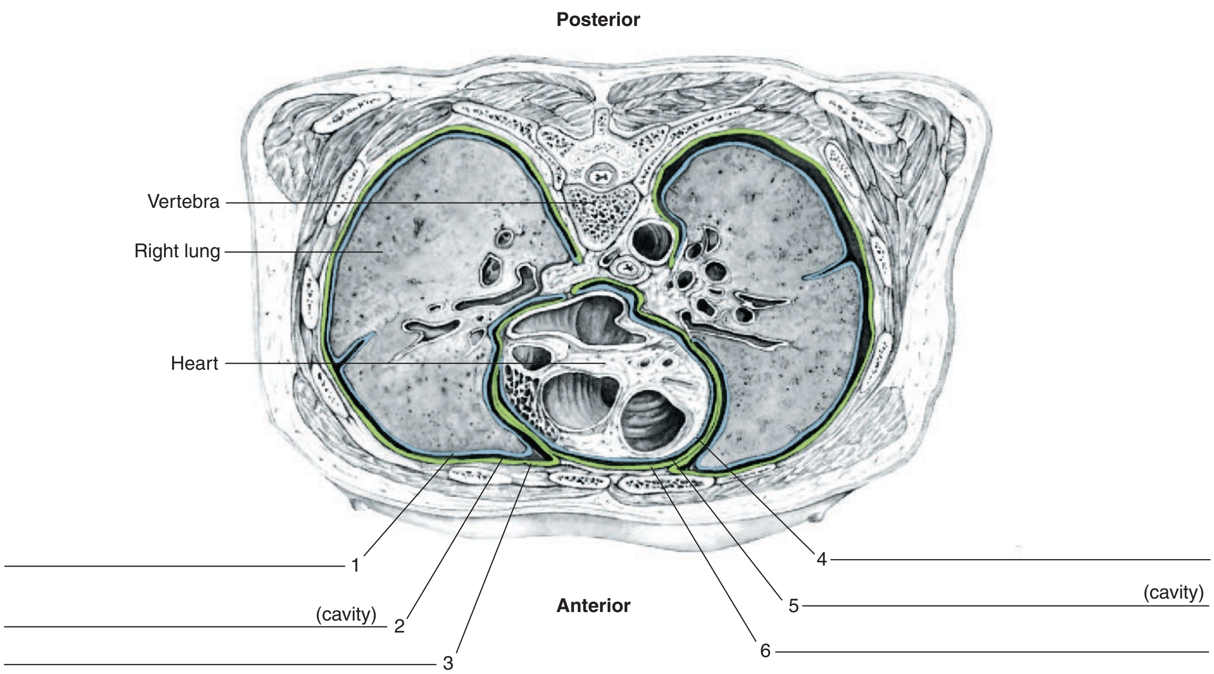
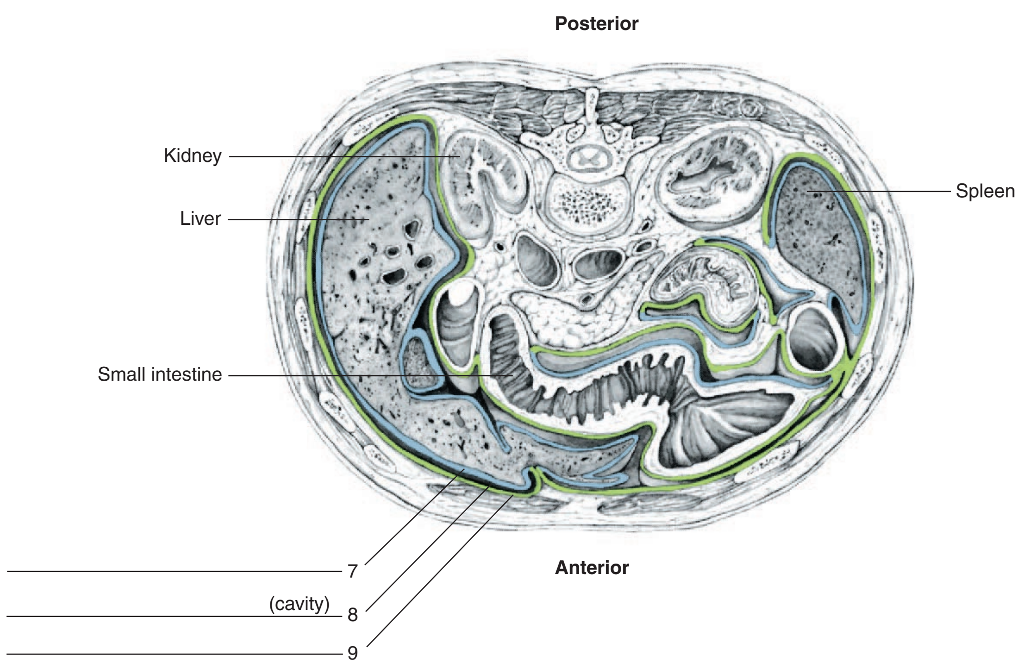


Figure 2.3 Label the thoracic membranes and cavities in (*a*) and the abdominopelvic membranes and cavity in (*b*) as shown in these superior views of transverse sections.



(a)



(b)

peritoneal cavity

parietal peritoneum

visceral peritoneum

4. Complete Parts A and B of Laboratory Report 2.

PROCEDURE B—ORGAN SYSTEMS

1. Review a textbook section on *organ systems.*
2. Use textbook figures and the dissectible torso to locate the following organs:

integumentary system

skin

accessory organs such as hair and nails

skeletal system

bones

ligaments

muscular system

skeletal muscles

tendons

nervous system

brain

spinal cord

nerves

endocrine system

pituitary gland

thyroid gland

parathyroid glands

adrenal glands

pancreas

ovaries

testes

pineal gland

thymus gland

cardiovascular system

heart

arteries

veins

lymphatic system

lymphatic vessels

lymph nodes

thymus gland

spleen

digestive system

mouth

tongue

teeth

salivary glands

pharynx

esophagus

stomach

liver

gallbladder

pancreas

small intestine

large intestine

respiratory system

nasal cavity

pharynx

larynx

trachea

bronchi

lungs

urinary system

kidneys

ureters

urinary bladder

urethra

male reproductive system

scrotum

testes

penis

urethra

female reproductive system

ovaries

uterine tubes (oviducts; fallopian tubes)

uterus

vagina

3. Complete Parts C and D of the laboratory report.

PROCEDURE C—RELATIVE POSITIONS, PLANES, SECTIONS, AND REGIONS

1. Review a textbook section on *anatomical terminology*.
2. As a review activity, label figures 2.4, 2.5, and 2.6.
3. Examine the sectioned specimens on the demonstration table, and identify the plane along which each is cut.
4. Complete Parts E, F, G, H, and I of the laboratory report.

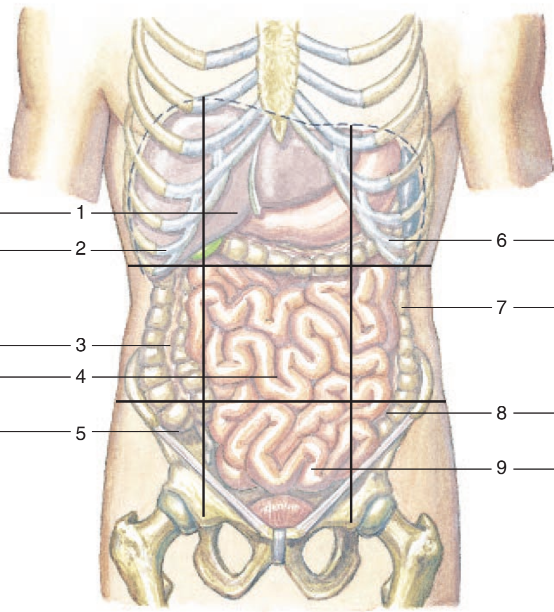
OPTIONAL ACTIVITY

Use different colored pencils to distinguish body regions in figure 2.6.

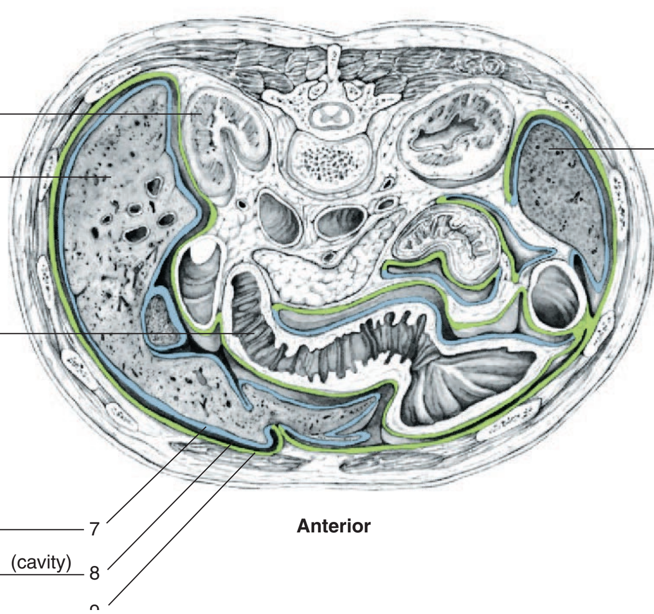
Web Quest

Identify organs in the three planes of the body from digitized sections of a human body. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 2.4 Label (*a*) the regions and (*b*) the quadrants of the abdominal area.



(a)



(b)

Figure 2.5 Label the planes represented in this illustration.

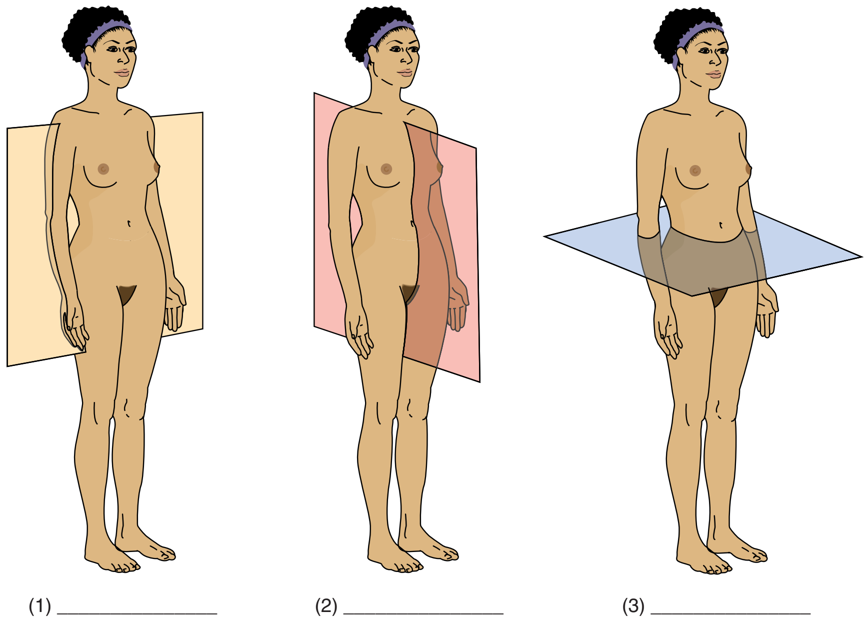
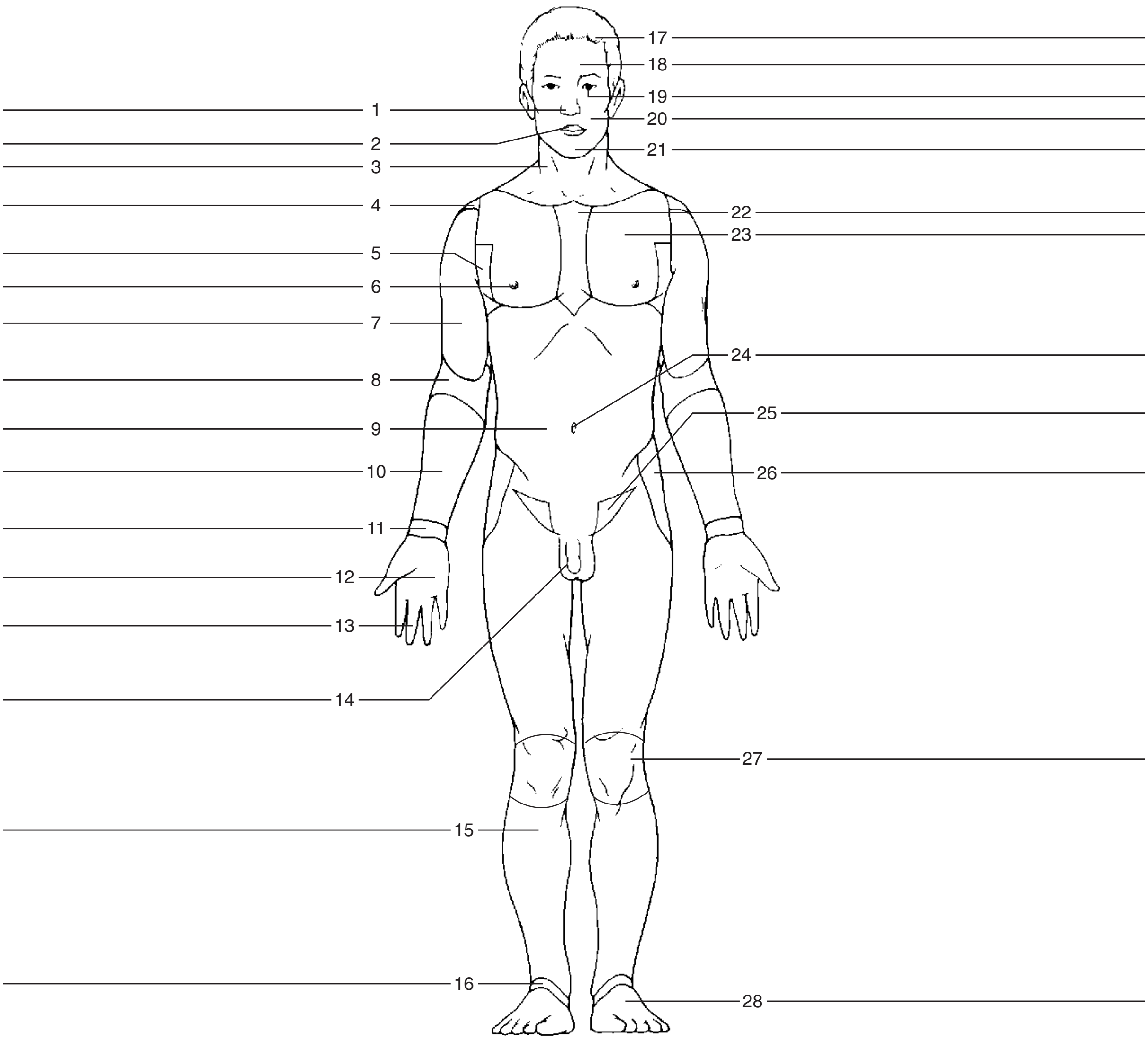
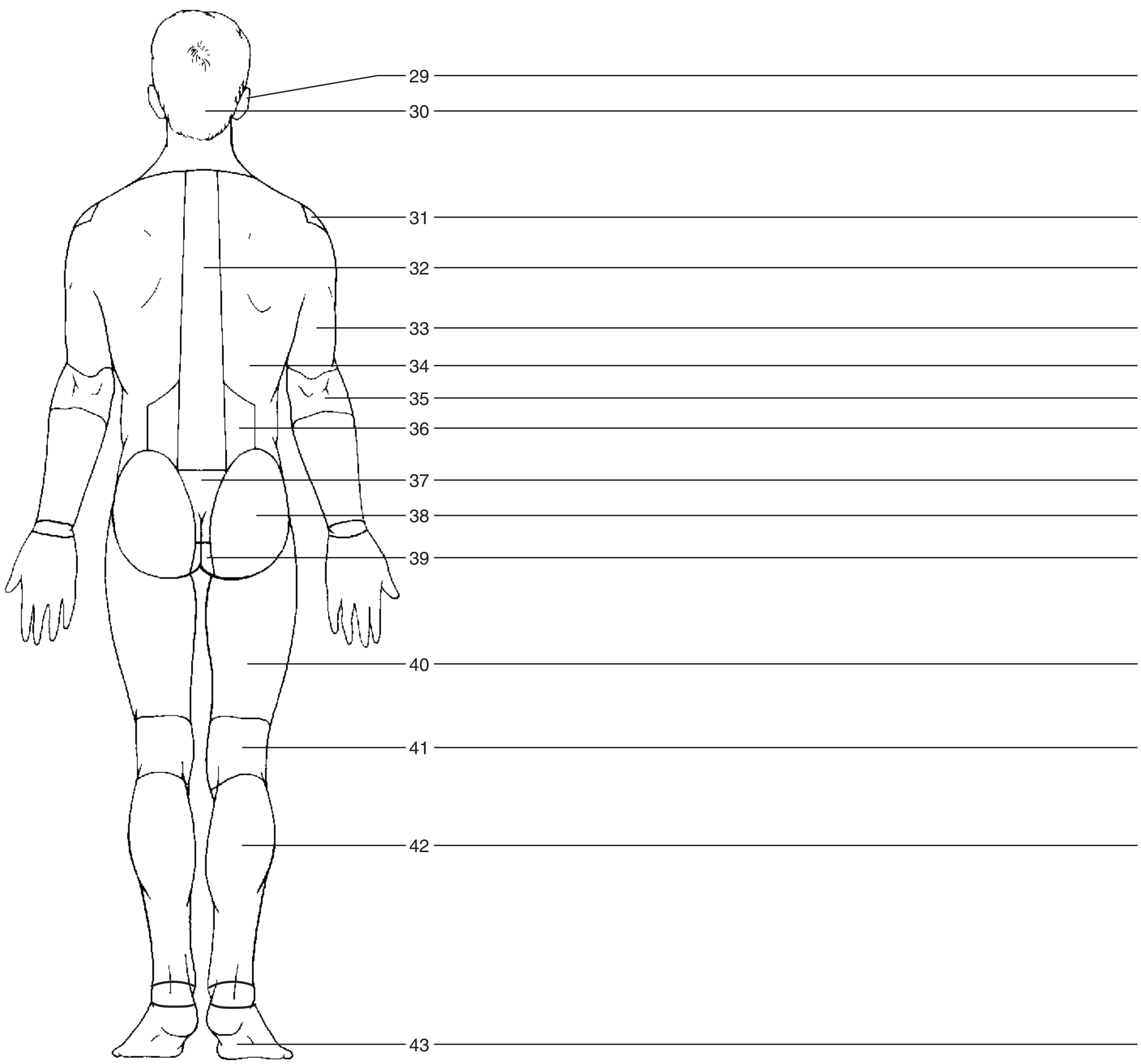


Figure 2.6 Label these diagrams with terms used to describe body regions: (*a*) anterior regions; (*b*) posterior regions.



(a)

Figure 2.6 *Continued*



(b)

Laboratory Report 2

Name ______________________________

Date ______________________________

Section ______________________________

Body Organization and Terminology

Part A

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.

Column A		Column B
a. abdominal cavity	____	1. liver
b. cranial cavity	____	2. lungs
c. middle ear cavity	____	3. spleen
d. oral cavity	____	4. stomach
e. orbital cavity	____	5. brain
f. pelvic cavity	____	6. teeth
g. thoracic cavity	____	7. gallbladder
h. vertebral canal (spinal cavity)	____	8. urinary bladder
	____	9. eyes
	____	10. spinal cord
	____	11. rectum
	____	12. ear bones
	____	13. heart
	____	14. esophagus

Part B

Complete the following statements:

1. The membrane on the surface of the lung is called the ______________________________.
2. The membrane on the surface of the heart is called the ______________________________.
3. The membrane that lines the wall of the abdominopelvic cavity is called the ______________________________.
4. The membrane on the surface of the stomach is called the ______________________________.
5. The thin, watery fluid located between the pleural membranes is called ______________________________.
6. Epicardium is another name for ______________________________.

7. The region of the thoracic cavity between the two lungs is called the ________________________.

8. The muscular structure that separates the thoracic and abdominopelvic cavities is called the ____________.

Part C

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

Column A

a. cardiovascular system
b. digestive system
c. endocrine system
d. integumentary system
e. lymphatic system
f. muscular system
g. nervous system
h. reproductive system
i. respiratory system
j. skeletal system
k. urinary system

Column B

____ 1. the main system that secretes hormones
____ 2. provides an outer covering of the body
____ 3. produces a new organism
____ 4. stimulates muscles to contract and interprets information from sensory units
____ 5. provides a framework for soft tissues and produces blood cells in red marrow
____ 6. exchanges gases between air and blood
____ 7. transports excess fluid from tissues to blood
____ 8. maintains posture and generates most body heat
____ 9. removes liquid and wastes from blood and transports to the outside
____ 10. converts food molecules into forms that are absorbed
____ 11. transports nutrients, wastes, and gases throughout the body

Part D

Match the organ systems in column A with the organs in column B. Place the letter of your choice in the space provided. (In some cases, there may be more than one correct answer.)

Column A

a. cardiovascular system
b. digestive system
c. endocrine system
d. integumentary system
e. lymphatic system
f. muscular system
g. nervous system
h. reproductive system (female)
i. reproductive system (male)
j. respiratory system
k. skeletal system
l. urinary system

Column B

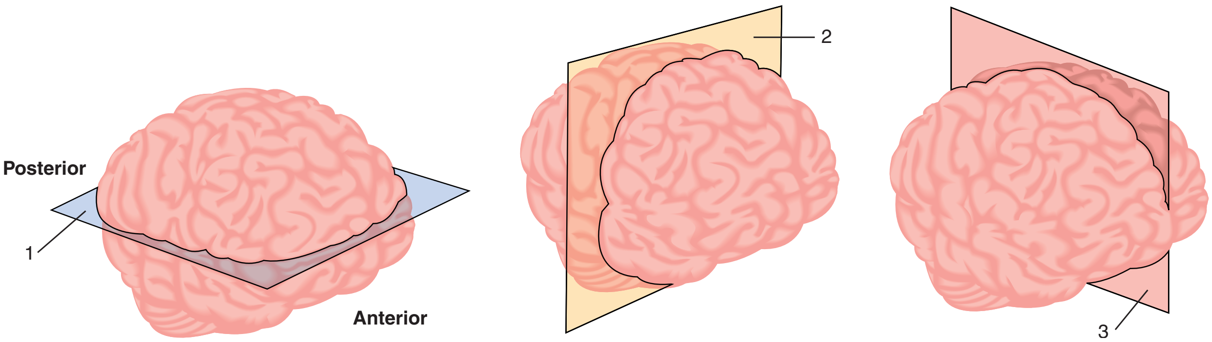
____ 1. adrenal and parathyroid glands
____ 2. arteries and veins
____ 3. brain and spinal cord
____ 4. gallbladder and esophagus
____ 5. kidneys and ureters
____ 6. larynx and lungs
____ 7. ligaments
____ 8. ovaries and uterus
____ 9. prostate gland and testes
____ 10. skin
____ 11. spleen and lymph nodes
____ 12. tendons

Part E

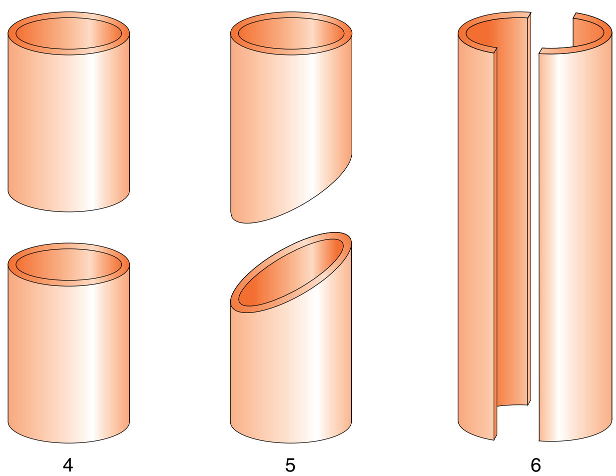
Indicate if each of the following sentences makes correct or incorrect usage of the word in boldface type (assume that the body is in the anatomical position). If the sentence is incorrect, supply a term that will make it correct in the space provided.

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 larynx is **posterior** to the esophagus. ____________
5. The heart is **medial** to the lungs. ____________
6. The kidneys are **inferior** to the adrenal glands. ____________
7. The hand is **proximal** to the elbow. ____________
8. The knee is **proximal** to the ankle. ____________
9. Blood in **deep** blood vessels gives color to the skin. ____________
10. A **peripheral** nerve passes from the spinal cord into the limbs. ____________
11. The spleen and gallbladder are **ipsilateral.** ____________
12. The dermis is the **superficial** layer of the skin. ____________

Figure 2.7 Name (*a*) the planes and (*b*) the sections represented in these diagrams.



(a) Planes



(b) Sections

Part F

Name each of the planes represented in figure 2.7*a* and the sections represented in figure 2.7*b*.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

Part G

Match the body regions in column A with the locations in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. antebrachial	____	1. wrist
b. antecubital	____	2. ribs
c. axillary	____	3. reproductive organs
d. brachial	____	4. armpit
e. buccal	____	5. elbow
f. carpal	____	6. forehead
g. cephalic	____	7. buttocks
h. cervical	____	8. forearm
i. costal	____	9. back
j. crural	____	10. neck
k. cubital	____	11. arm
l. dorsal	____	12. cheek
m. frontal	____	13. leg
n. genital	____	14. head
o. gluteal	____	15. space in front of elbow

Part H

Match the body regions in column A with the locations in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. inguinal	____	1. pelvis
b. lumbar	____	2. breasts
c. mammary	____	3. ear
d. mental	____	4. between anus and reproductive organs
e. occipital	____	5. sole
f. otic	____	6. middle of thorax
g. palmar	____	7. chest
h. pectoral	____	8. navel
i. pedal	____	9. chin
j. pelvic	____	10. behind knee
k. perineal	____	11. foot
l. plantar	____	12. lower posterior region of head
m. popliteal	____	13. abdominal wall near thigh
n. sternal	____	14. lower back
o. umbilical	____	15. palm

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Part I

Critical Thinking Application

State the quadrant of the abdominopelvic cavity where the pain or sound would be located for each of the six common conditions listed. In some cases, there may be more than one correct answer, and pain is sometimes referred to another region. The phenomenon called *referred pain* occurs when pain in interpreted as originating from some area other than the parts being stimulated.

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

Laboratory Exercise 3

Care and Use of the Compound Microscope

MATERIALS NEEDED

compound microscope
lens paper
microscope slides
coverslips
transparent plastic millimeter ruler
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 Demonstrations:

micrometer scale
stereomicroscope (dissecting microscope)

Because the human eye is unable to perceive objects less than 0.1 mm in diameter, a microscope is an essential tool for the study of small structures such as cells. The microscope usually used for this purpose is the *compound microscope.* It is called compound because it utilizes two sets of lenses: an eyepiece lens and an objective lens system. The eyepiece lens system magnifies or compounds the image reaching it after being magnified by the objective lens system. Such an instrument can magnify images of small objects up to about one thousand times.

PURPOSE OF THE EXERCISE

To become familiar with the major parts of a compound microscope and their functions, and to make use of the compound microscope to observe small objects.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the major parts of a compound microscope;
2. describe the functions of these parts;
3. calculate the total magnification produced by various combinations of eyepiece and objective lenses;
4. prepare a simple microscope slide;
5. make proper use of the microscope to observe small objects.

PROCEDURE

1. Observe a compound microscope, and study figure 3.1 to learn the names of its major parts. Note that the lens system of a compound microscope includes three parts—the condenser, objective lens, and eyepiece.

   Light enters this system from a *substage illuminator (lamp)* or *mirror* and usually is concentrated and focused by a *condenser* onto a microscope slide or specimen placed on the *stage.* The condenser, which contains a set of lenses, usually is kept in its highest position possible.

   The *iris diaphragm,* which is located between the light source and the condenser, can be used to increase or decrease the intensity of the light entering the condenser. Locate the lever that operates the iris diaphragm beneath the stage, and move it back and forth. Note how this movement causes the size of the opening in the diaphragm to change. (Some microscopes have a revolving plate called a disc diaphragm beneath the stage instead of an iris diaphragm. Disc diaphragms have different-sized holes to admit varying amounts of light.) Which way do you move the diaphragm to increase the light intensity? ___________ Which way to decrease it? ___________

   After light passes through a specimen mounted on a microscope slide, it enters an *objective lens system.* This lens projects the light upward into the *body tube,* where it produces a magnified image of the object being viewed.

   The *eyepiece (ocular) lens* system then magnifies this image to produce another image which is seen by the eye. Typically, the eyepiece lens magnifies the image ten times (10×). Look for the number in the metal of the eyepiece that indicates its power (fig. 3.2). What is the eyepiece power of your microscope? ___________

Figure 3.1 Major parts of a compound microscope with a monocular body and a mechanical stage. Some compound microscopes are equipped with a binocular body.

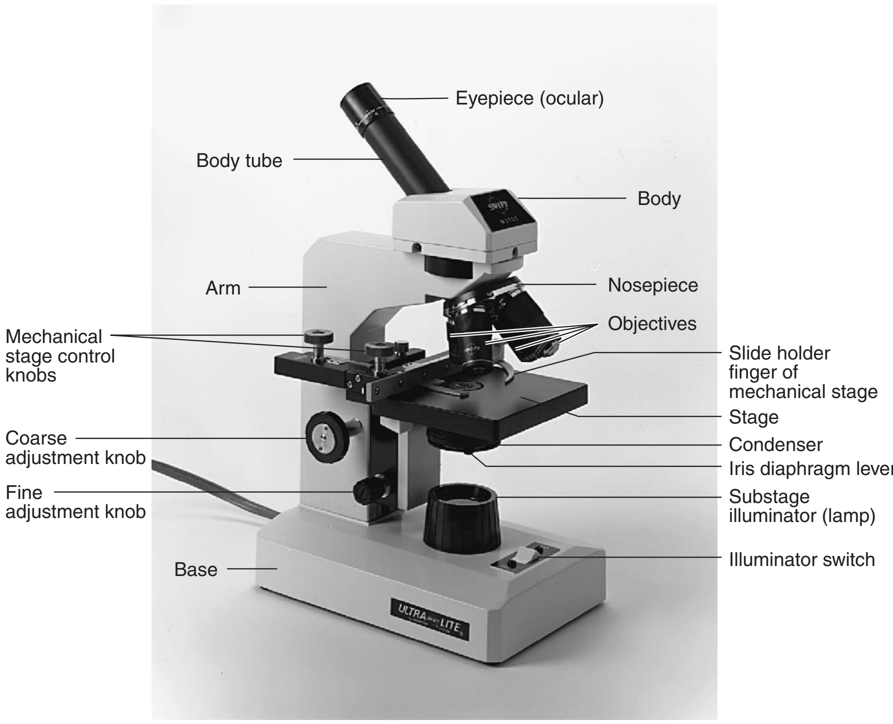


Figure 3.2 The powers of this 10× eyepiece (*a*) and this 40× objective (*b*) are marked in the metal. DIN is an international optical standard on quality optics. The 0.65 on the 40× objective is the numerical aperture, which is a measure of the light-gathering capabilities.

(a)

(b)

The objective lenses are mounted in a revolving *nosepiece* so that different magnifications can be achieved by rotating any one of several objective lenses into position above the specimen. Commonly, this set of lenses includes a scanning objective (4×), a low-power objective (10×), and a high-power objective, also called a high-dry-power objective (about 40×). Sometimes an oil immersion objective (about 100×) is present. Look for the number marked in the metal of each objective that indicates its power. What are the objective lens powers of your microscope? ___________

To calculate the *total magnification* achieved when using a particular objective, multiply the power of the eyepiece by the power of the objective used. Thus, the 10× eyepiece and the 40× objective produce a total magnification of 10×40, or 400×.

2. Complete Part A of Laboratory Report 3.
3. Familiarize yourself with the following list of rules for care of the microscope:
   a. Handle the microscope with great care. It is an expensive and delicate instrument. To move it or carry it, hold it by its *arm* with one hand and support its *base* with the other hand.
   b. Keep the microscope under its *dustcover* and in a cabinet when it is not being used.
   c. To clean the lenses, rub them gently with *lens paper* or a high-quality cotton swab. If the lenses need additional cleaning, follow the directions in the lens cleaning technique section that follows.
   d. If the microscope has a substage lamp, be sure the electric cord does not hang off the laboratory table where someone might trip over it. The bulb life can be extended if the lamp is cool before the microscope is moved.
   e. Never remove parts of the microscope or try to disassemble the eyepiece or objective lenses.

LENS CLEANING TECHNIQUE

1. Moisten one end of a high-quality cotton swab with one drop of Kodak lens cleaner. Keep the other end dry.
2. Clean the optical surface with the wet end. Dry it with the other end, using a circular motion.
3. Use a hand aspirator to remove lingering dust particles.
4. Start with the scanning objective and work upward in magnification, using a new cotton swab for each objective.
5. When cleaning the eyepiece, do not open the lens unless it is absolutely necessary.
6. Use alcohol for difficult cleaning, and only as a last resort use xylene. Regular use of xylene will destroy lens coatings.

   f. If your microscope is not functioning properly, report the problem to your laboratory instructor immediately.
4. Turn on the substage illuminator and look through the eyepiece. You will see a lighted circular area called the *field of view.*

   You can measure the diameter of this field of view by focusing the lenses on the millimeter scale of a transparent plastic ruler. To do this, follow these steps:
   a. Place the ruler on the microscope stage in the spring clamp of a slide holder finger on a mechanical stage or under the stage (slide) clips. (*Note:* If your microscope is equipped with a mechanical stage, it may be necessary to use a short section cut from a transparent plastic ruler. The section should be several millimeters long and can be mounted on a microscope slide for viewing.)
   b. Center the millimeter scale in the beam of light coming up through the condenser and rotate the scanning objective into position.
   c. While you watch from the side to prevent the lens from touching anything, lower the objective until it is as close to the ruler as possible, using the *coarse adjustment knob* and then using the *fine adjustment knob* (fig. 3.3). (*Note:* The adjustment knobs on some microscopes move the stage upward and downward for focusing.)
   d. Look into the eyepiece, and use the coarse adjustment knob to raise the objective lens until the lines of the millimeter scale come into sharp focus.
   e. Adjust the light intensity by moving the *iris diaphragm lever* so that the field of view is brightly illuminated but comfortable to your eye. At the same time, take care not to overilluminate the field, because transparent objects tend to disappear in very bright light.
   f. Position the millimeter ruler so that its scale crosses the greatest diameter of the field of view. Also, move the ruler so that one of the millimeter marks is against the edge of the field of view.
   g. Measure the distance across the field of view in millimeters.
5. Complete Part B of the laboratory report.
6. Most microscopes are designed to be *parfocal.* This means that when a specimen is in focus with a lower-power objective, it will be in focus (or nearly so) when a higher-power objective is rotated into position. Always center the specimen in the field of view before changing to higher objectives.

   Rotate the low-power objective into position, and then look at the millimeter scale of the transparent plastic ruler. If you need to move the low-power objective to sharpen the focus, use the *fine adjustment knob.*

Figure 3.3 When you focus using a particular objective, you can prevent it from touching the specimen by watching from the side.

Adjust the iris diaphragm so that the field of view is properly illuminated. Once again, adjust the millimeter ruler so that the scale crosses the field of view through its greater diameter, and position the ruler so that a millimeter mark is against one edge of the field.

Try to measure the distance across the field of view in millimeters.

7. Rotate the high-power objective into position, while you watch from the side, and then observe the millimeter scale on the plastic ruler. All focusing using high-power magnification should be done only with the fine adjustment knob. If you use the coarse adjustment knob with the high-power objective, you can accidently force the objective into the coverslip. This is because the *working distance* (the distance from the objective lens to the slide on the stage) is much shorter when using higher magnifications.

   Adjust the iris diaphragm for proper illumination. Usually more illumination when using higher magnifications will help to view the objects more clearly. Try to measure the distance across the field of view in millimeters.
8. Locate the numeral 4 (or 9) on the plastic ruler and focus on it using the scanning objective. Note how the number appears in the field of view. Move the plastic ruler to the right, and note which way the image moves. Slide the ruler away from you and again note how the image moves.
9. Examine the slide of the three colored threads using the low-power objective and then the high-power objective. Focus on the location where the three threads cross. By using the fine adjustment knob, determine the order from top to bottom by noting which color is in focus at different depths. The other colored threads will still be visible, but they will be blurred. Be sure to notice whether the stage or the body tube moves up and down with the adjustment knobs of the microscope that is being used for this depth determination. The vertical depth of the specimen that is clearly in focus is called the *depth of field (focus).* Whenever specimens are examined, continue to use the fine adjustment focusing knob to determine relative depths of structures that are clearly in focus within cells, giving a three-dimensional perspective. It should be noted that the depth of field is less at higher magnifications.

Critical Thinking Application

What was the sequence of the three colored threads from top to bottom?

10. Complete Parts C and D of the laboratory report.

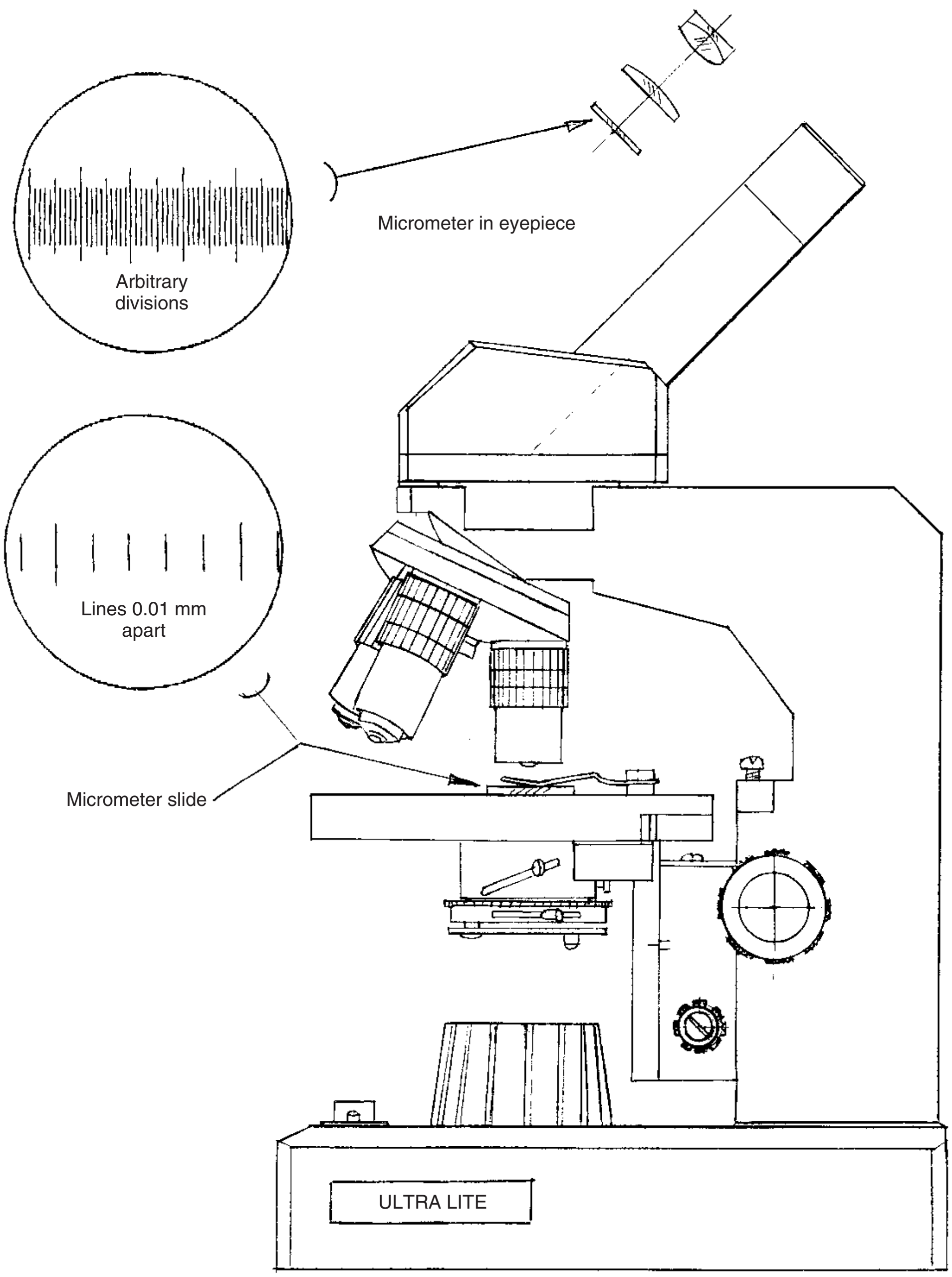
DEMONSTRATION

A compound microscope is sometimes equipped with a micrometer scale mounted in the eyepiece. Such a scale is subdivided into fifty to one hundred equal divisions (fig.3.4). These arbitrary divisions can be calibrated against the known divisions of a micrometer slide placed on the microscope stage. Once the values of the divisions are known, the length and width of a microscopic object can be measured by superimposing the scale over the magnified image of the object.

Observe the micrometer scale in the eyepiece of the demonstration microscope. Focus the low-power objective on the millimeter scale of a micrometer slide (or a plastic ruler), and measure the distance between the divisions on the micrometer scale in the eyepiece. What is the distance between the finest divisions of the scale in micrometers? ____________________

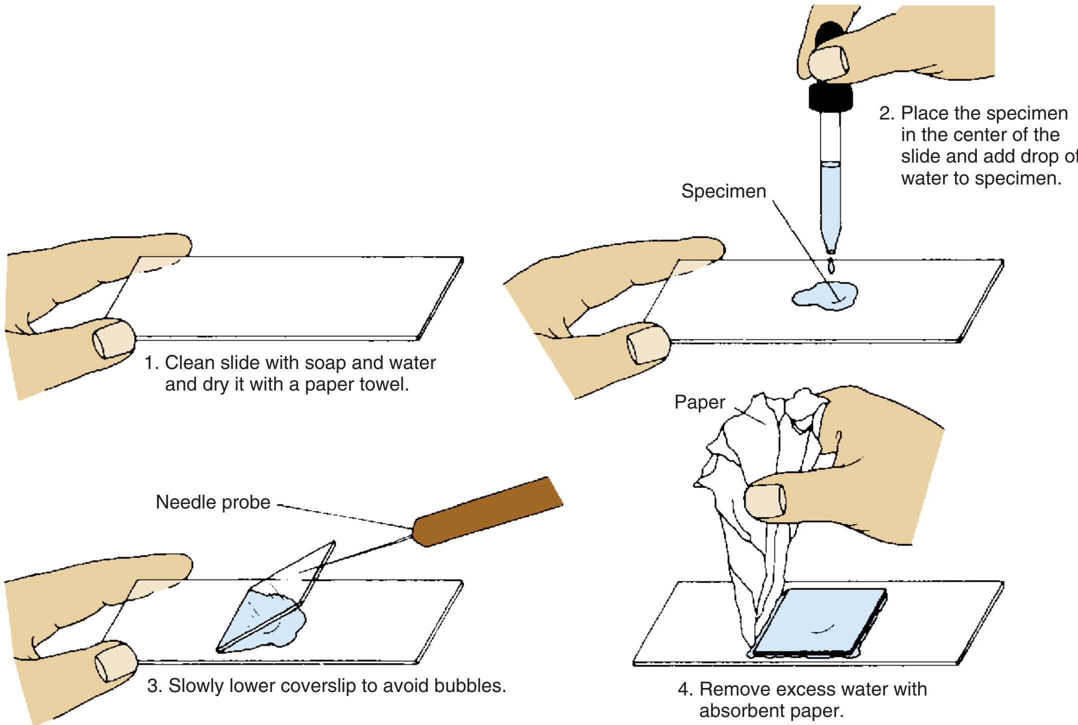
11. Prepare several temporary *wet mounts* using any small, transparent objects of interest, and examine the specimens using the low-power objective and then a high-power objective to observe their details. To prepare a wet mount, follow these steps (fig. 3.5):
    a. Carefully clean a microscope slide with soap and water, and dry it with a paper towel.
    b. Place a tiny, thin piece of the specimen you want to observe in the center of the slide, and use a medicine dropper to put a drop of water over it. Consult with your instructor if a drop of stain might enhance the image of any cellular structures of your specimen. If the specimen is solid, you might want to tease some of it apart with dissecting needles. In any case, the specimen must be thin enough so that light can pass through it. Why is it necessary for the specimen to be so thin?
    c. Cover the specimen with a coverslip. Try to avoid trapping bubbles of air beneath the coverslip by slowly lowering it at an angle into the drop of water.
    d. Remove any excess water from the edge of the coverslip with absorbent paper. If your microscope has an inclination joint, do not tilt the microscope while observing wet mounts.
    e. Place the slide under the stage (slide) clips or in the slide holder on a mechanical stage, and position the slide so that the specimen is centered in the light beam passing up through the condenser.
    f. Focus on the specimen using the scanning objective first. Next focus using the low-power objective, and then examine it with the high-power objective.
12. If an oil immersion objective is available, use it to examine the specimen. To use the oil immersion objective, follow these steps:
    a. Center the object you want to study under the high-power field of view.
    b. Rotate the high-power objective away from the microscope slide, place a small drop of immersion oil on the coverslip, and swing the oil immersion objective into position. To achieve sharp focus, use the fine adjustment knob only.
    c. You will need to open the iris diaphragm more fully for proper illumination. More light is needed because the oil immersion objective covers a very small lighted area of the microscope slide.
    d. Because the oil immersion objective must be very close to the coverslip to achieve sharp focus, care must be taken to avoid breaking the coverslip or damaging the objective lens. For this reason, never lower the objective when you are looking into the eyepiece. Instead, always raise the objective to achieve focus, or prevent the objective from touching the coverslip by watching the microscope slide and coverslip from the side if the objective needs to be lowered.
13. When you have finished working with the microscope, remove the microscope slide from the stage and wipe any oil from the objective lens with lens paper or a high-quality cotton swab. Swing the scanning objective or the low-power objective into position. Wrap the electric cord around the base of the microscope and replace the dustcover.
14. Complete Part E of the laboratory report.

Figure 3.4 The divisions of a micrometer scale in an eyepiece can be calibrated against the known divisions of a micrometer slide.



Courtesy of Swift Instruments Inc., San Jose, California

Figure 3.5 Steps in the preparation of a wet mount.



DEMONSTRATION

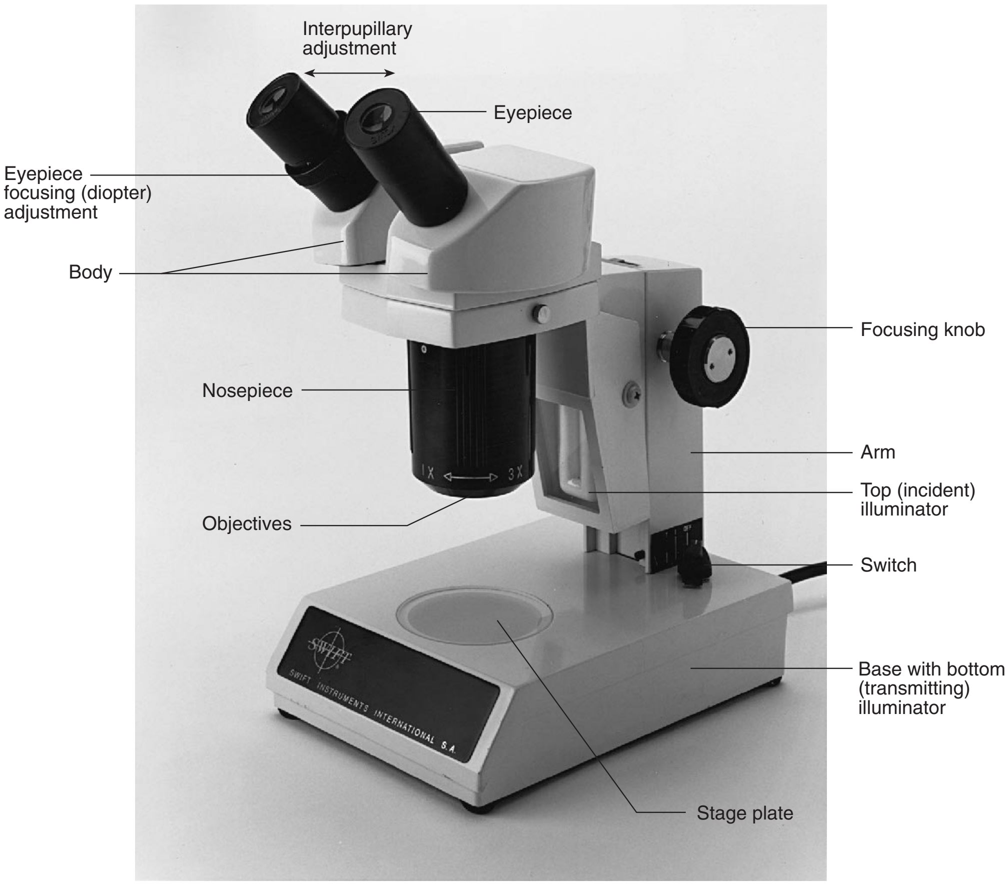
A stereomicroscope (dissecting microscope) (fig. 3.6) is useful for observing the details of relatively large, opaque specimens. Although this type of microscope achieves less magnification than a compound microscope, it has the advantage of producing a three-dimensional image rather than the flat, two-dimensional image of the compound microscope. In addition, the image produced by the stereomicroscope is positioned in the same manner as the specimen, rather than being reversed and inverted as it is by the compound microscope.

Observe the stereomicroscope. Note that the eyepieces can be pushed apart or together to fit the distance between your eyes. Focus the microscope on the end of your finger. Which way does the image move when you move your finger to the right? ____________

When you move it away? ______________________

If the instrument has more than one objective, change the magnification to higher power. Use the instrument to examine various small, opaque objects available in the laboratory.

Figure 3.6 A stereomicroscope, which is also called a dissecting microscope.



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Laboratory Report 3

Name ______________________________

Date ______________________________

Section ______________________________

Care and Use of the Compound Microscope

Part A

Complete the following:

1. What total magnification will be achieved if the 10× eyepiece and the 10× objective are used?___________
2. What total magnification will be achieved if the 10× eyepiece and the 100× objective are used?___________

Part B

Complete the following:

1. Sketch the millimeter scale as it appears under the scanning objective magnification. (The circle represents the field of view through the microscope.)
2. What is the diameter of the scanning field of view in millimeters? ___________
3. Microscopic objects often are measured in *micrometers.* A micrometer equals 1/1000 of a millimeter and is symbolized by µm. What is the diameter of the scanning power field of view in micrometers? ___________
4. If a circular object or specimen extends halfway across the scanning field, what is its diameter in millimeters? ___________
5. What is its diameter in micrometers? ___________

Part C

Complete the following:

1. Sketch the millimeter scale as it appears using the low-power objective.
2. What do you estimate the diameter of this field of view to be in millimeters? ___________
3. How does the diameter of the scanning power field of view compare with that of the low-power field?

   ____

4. Why is it more difficult to measure the diameter of the high-power field of view than the low-power field?
____
____

5. What change occurred in the light intensity of the field of view when you exchanged the low-power objective for the high-power objective? ____________
6. Sketch the numeral 4 (or 9) as it appears through the scanning objective of the compound microscope.
7. What has the lens system done to the image of the numeral? (Is it right side up, upside down, or what?) ______________________________
8. When you moved the ruler to the right, which way did the image move? ____________
9. When you moved the ruler away, which way did the image move? ____________

Part D

Match the names of the microscope parts in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. adjustment knob
b. arm
c. condenser
d. eyepiece (ocular)
e. field of view
f. iris diaphragm
g. nosepiece
h. objective lens system
i. stage
j. stage (slide) clip

Column B

____ 1. increases or decreases the light intensity
____ 2. platform that supports a microscope slide
____ 3. concentrates light onto the specimen
____ 4. causes objective lens (or stage) to move upward to downward
____ 5. after light passes through the specimen, it next enters this lens system
____ 6. holds a microscope slide in position
____ 7. contains a lens at the top of the body tube
____ 8. serves as a handle for carrying the microscope
____ 9. part to which the objective lenses are attached
____ 10. circular area seen through the eyepiece

Part E

Prepare sketches of the objects you observed using the microscope. For each sketch, include the name of the object, the magnification you used to observe it, and its estimated dimensions in millimeters and micrometers.

Laboratory Exercise 4

Cell Structure and Function

MATERIALS NEEDED

textbook
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
compound microscope

For Optional Activity:

single-edged razor blade
plant materials such as leaves, soft stems, fruits, onion peel, and vegetables
cultures of *Amoeba* and *Paramecium*

SAFETY

- Clean laboratory surfaces before and after laboratory procedures.
- Wear disposable gloves for the wet mount procedures of the cells lining the inside of the cheek.
- Dispose of laboratory gloves, slides, coverslips, and toothpicks as instructed.
- Wash your hands before leaving the laboratory.

Cells are the "building blocks" from which all parts of the human body are formed. They account for the shape, organization, and construction of the body and are responsible for carrying on its life processes. A cell consists of three major parts—the **cell (plasma) membrane,** the **cytoplasm,** and the **nucleus.** The cytoplasm is composed of a clear fluid, the *cytosol,* and numerous *cytoplasmic organelles* suspended in the cytosol.

PURPOSE OF THE EXERCISE

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

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name and locate the major components of a cell on a model or diagram and describe the general functions of these components;
2. prepare a wet mount of cells lining the inside of the cheek, stain the cells, and identify the major components of these cells;
3. locate cells on prepared slides of human tissues, and identify their major components;
4. identify major cellular components in a transmission electron micrograph.

PROCEDURE

1. Review a textbook section on a *composite cell.*
2. Observe the animal cell model and identify its major parts.
3. As a review activity, label figure 4.1 and study figure 4.2.
4. Complete Part A of Laboratory Report 4.
5. Prepare a wet mount of cells lining the inside of the cheek. To do this, follow these steps:
   a. Gently scrape (force is not necessary and should be avoided) the inner lining of your cheek with the broad end of a flat toothpick.
   b. Stir the toothpick in a drop of water on a clean microscope slide and dispose of the toothpick as directed by your instructor.
   c. Cover the drop with a coverslip.
   d. Observe the cheek cells by using the microscope. Compare your image with figure 4.3. To report what you observe, sketch a single cell in the space provided in Part B of the laboratory report.
6. Prepare a second wet mount of cheek cells, but this time add a drop of dilute methylene blue or iodine-potassium-iodide stain to the cells. Cover the liquid with a coverslip and observe the cells with the microscope. Add to your sketch any additional structures you observe in the stained cells.

Figure 4.1 Label the structures of this composite animal cell.

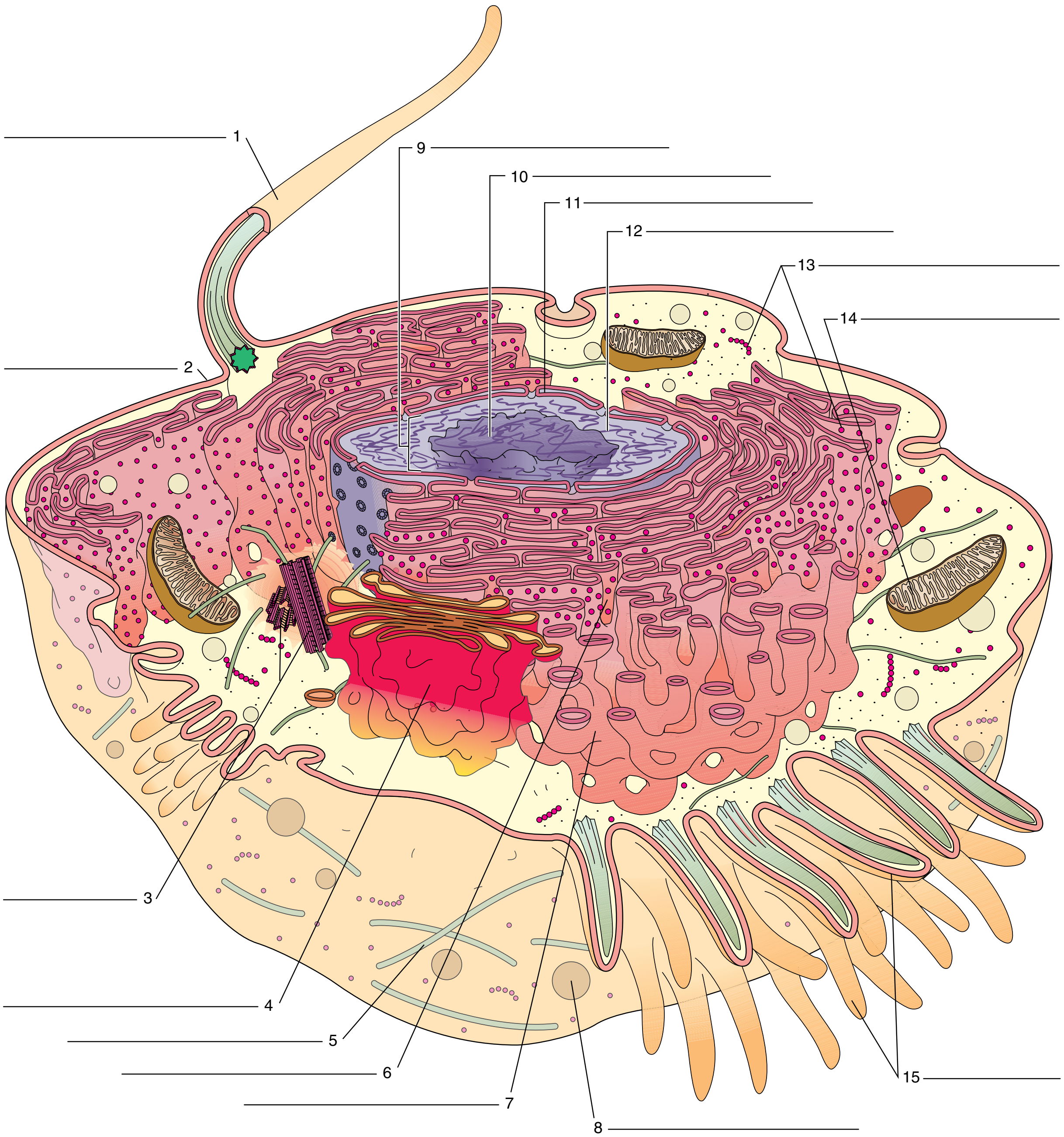


Figure 4.2 The structures of the cell membrane.

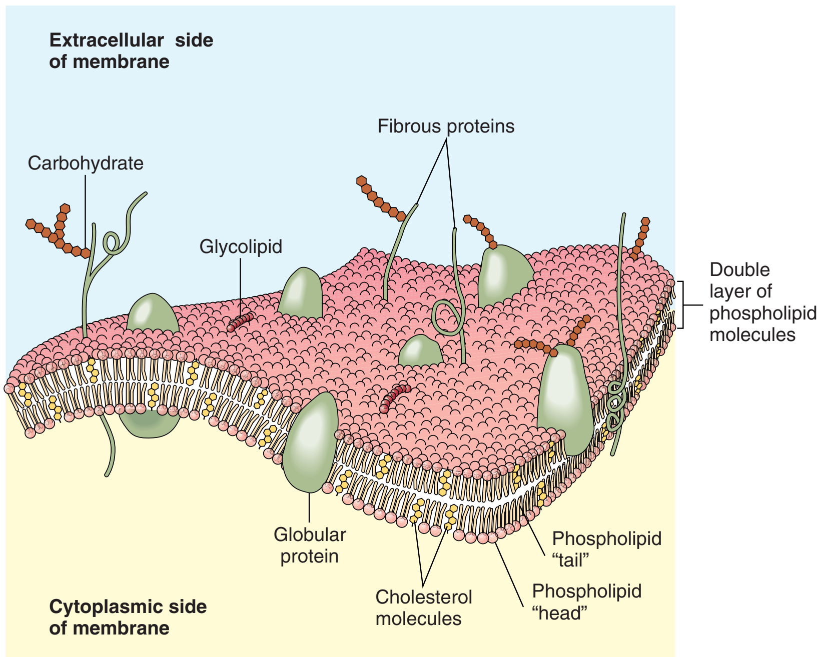
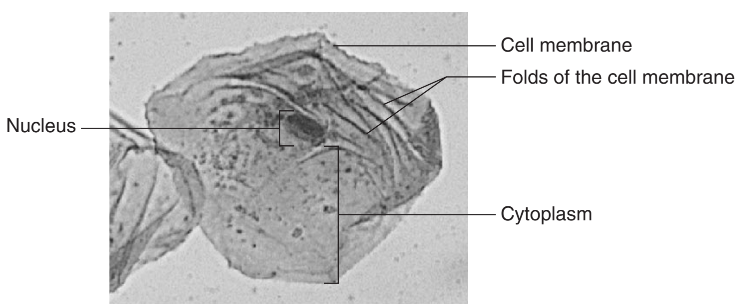


Figure 4.3 Stained cell lining the inside of the cheek as viewed through the compound microscope using the high-power objective (400×).



7. Answer the questions in Part B of the laboratory report.
8. Observe each of the prepared slides of human tissues using the microscope. To report what you observe, sketch a single cell of each type in the space provided in Part C of the laboratory report.
9. Answer the questions in Part C of the laboratory report.

Critical Thinking Application

The cells lining the inside of the cheek are frequently removed for making observations of basic cell sructure. The cells are from stratified squamous epithelium. Explain a reason these cells are used instead of outer body surface tissue. Why was the removal of inside cheek cells painless and lacked any blood loss?

____

____

____

____

____

____

____

OPTIONAL ACTIVITY

Investigate the microscopic structure of various plant materials. To do this, prepare very tiny, thin slices of plant specimens using a single-edged razor blade. *(Take care not to injure yourself with the blade.)* Keep the slices in a container of water until you are ready to observe them. To observe a specimen, place it in a drop of water on a clean microscope slide and cover it with a coverslip. Use the microscope and view the specimen using low- and high-power magnifications. Observe near the edges where your section of tissue is most likely to be one cell thick. Add a drop of dilute methylene blue or iodine-potassium-iodide stain and note if any additional structures become visible. How are the microscopic structures of the plant specimens similar to the human tissues you observed? ____________________

____

How are they different? ____________________________

____

OPTIONAL ACTIVITY

Prepare a wet mount of the *Amoeba* and *Paramecium* by putting a drop of culture on a clean glass slide. Gently cover 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 cell membrane, nuclear envelope, nucleus, mitochondria, and contractile vacuoles. Describe the movement of the *Amoeba.* ________________________

____

____

Describe the movement of the *Paramecium.* ________

____

____

Laboratory Report **4**

Name ______________________________

Date ______________________________

Section ______________________________

Cell Structure and Function

Part A

Match the cellular components in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. cell (plasma) membrane
b. centrosome
c. chromatin
d. cilia
e. cytoplasm
f. endoplasmic reticulum
g. Golgi apparatus
h. inclusion
i. lysosome
j. microfilament
k. microtubule
l. mitochondrion
m. nuclear envelope
n. nucleolus
o. nucleus
p. peroxisome
q. ribosome
r. vesicle/vacuole

Column B

____ 1. loosely coiled fibers containing protein and DNA within nucleus
____ 2. cellular product, such as a pigment melanin in skin
____ 3. energy release from food molecules
____ 4. nonmembranous structure that contains the centrioles
____ 5. small RNA-containing particles for the synthesis of proteins
____ 6. membranous sac formed by the pinching off pieces of cell membrane
____ 7. dense body of RNA within the nucleus
____ 8. slender tubes that provide movement in cilia and flagella
____ 9. organelles composed of membrane-bound sacs, canals, and vesicles
____ 10. outside boundary of the cell
____ 11. occupies space between cell membrane and nucleus
____ 12. flattened membranous sacs that package a secretion
____ 13. motile processes that are numerous and short and are associated with some cells
____ 14. tiny rods in meshworks or bundles that help cell to shorten
____ 15. membranous sac that contains digestive enzymes
____ 16. contains enzymes that decompose hydrogen peroxide
____ 17. separates nuclear contents from cytoplasm
____ 18. spherical organelle that contains chromatin and nucleolus

Part B

Complete the following:

1. Sketch a single cheek cell that has been stained. Label the cellular components you recognize. (The circle represents the field of view through the microscope.)

Magnification ______________ ×

2. After comparing the wet mount and the stained cheek cells, state the advantage that was gained by staining cells.

____

____

3. Are all the stained cheek cells nearly the same size and shape? __________ Propose an explanation for your answer. ____

____

Part C

Complete the following:

______________ ×

Tissue ______________

______________ ×

Tissue ______________

1. Sketch a single cell of each kind you observed in the prepared slides of human tissues. Name the tissue and label the cellular components you recognize.

2. What do the various kinds of cells in these tissues have in common? ______________________________

____

3. What are the main differences you observed among these cells? ______________________________

____

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Laboratory Exercise 5

Movements Through Cell Membranes

MATERIALS NEEDED

For Procedure A—Diffusion:

textbook
petri dish
white paper
forceps
potassium permanganate crystals
millimeter ruler (transparent)

For Procedure B—Osmosis:

textbook
thistle tube
molasses (or Karo dark corn syrup)
selectively permeable (semipermeable) membrane (presoaked dialysis tubing of 1 5/16" or greater diameter)
ring stand and clamp
beaker
rubber band
millimeter ruler

For Procedure C—Hypertonic, Hypotonic, and Isotonic Solutions:

textbook
test tubes
marking pen
test-tube rack
10 mL graduated cylinder
medicine dropper
uncoagulated animal blood
distilled water
0.9% NaCl (aqueous solution)
3.0% NaCl (aqueous solution)
clean microscope slides
coverslips
microscope

For Procedure D—Filtration:

textbook
glass funnel
filter paper
ring stand and ring
beaker
powdered charcoal
1% glucose (aqueous solution)
1% starch (aqueous solution)
test tubes
10 mL graduated cylinder
water bath (boiling water)
Benedict's solution
iodine-potassium-iodide solution
medicine dropper
Virtual Physiology Lab: 9, Diffusion, Osmosis, and Tonicity

SAFETY

- Clean laboratory surfaces before and after laboratory procedures.
- Wear disposable gloves when handling chemicals and animal blood.
- Wear safety glasses when using chemicals.
- Dispose of laboratory gloves and blood-contaminated items as instructed.
- Wash your hands before leaving the laboratory.

A cell membrane functions as a gateway through which chemical substances and small particles may enter or leave a cell. These substances move through the membrane by physical processes such as diffusion, osmosis, and filtration, or by physiological processes such as active transport, phagocytosis, or pinocytosis.

PURPOSE OF THE EXERCISE

To demonstrate some of the physical processes by which substances move through cell membranes.

LEARNING OBJECTIVES

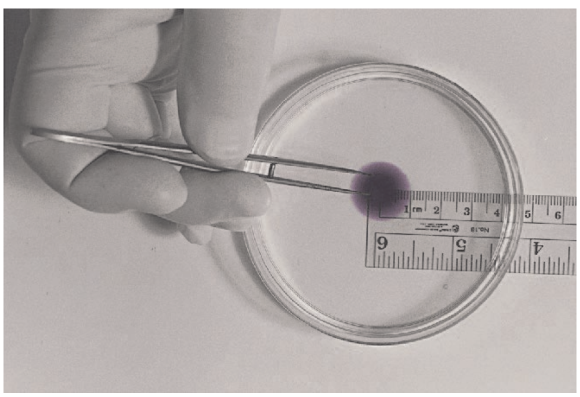
After completing this exercise, you should be able to

1. define *diffusion* and identify examples of diffusion;
2. define *osmosis* and identify examples of osmosis;
3. distinguish among hypertonic, hypotonic, and isotonic solutions and observe the effects of these solutions on animal cells;
4. define *filtration* and identify examples of filtration.

PROCEDURE A—DIFFUSION

1. Review a textbook section on *diffusion.*
2. To demonstrate diffusion, follow these steps:
   a. Place a petri dish half filled with water on a piece of white paper that has a millimeter ruler positioned on the paper. Wait until the water surface is still. Allow approximately 3 minutes.
   b. Using forceps, place one crystal of potassium permanganate near the center of the petri dish and near the millimeter ruler (fig. 5.1).
   c. Measure the radius of the purple circle at 1-minute intervals for 10 minutes.
3. Complete Part A of Laboratory Report 5.

Figure 5.1 To demonstrate diffusion, place one crystal of potassium permanganate in the center of a petri dish containing water. Place the crystal near the millimeter ruler (positioned under the petri dish).



OPTIONAL ACTIVITY

Repeat the demonstration of diffusion using a petri dish filled with ice-cold water and a second dish filled with very hot water. At the same moment, add a crystal of potassium permanganate to each dish and observe the circle as before. What difference do you note in the rate of diffusion in the two dishes? How do you explain this difference? ______________________________

____

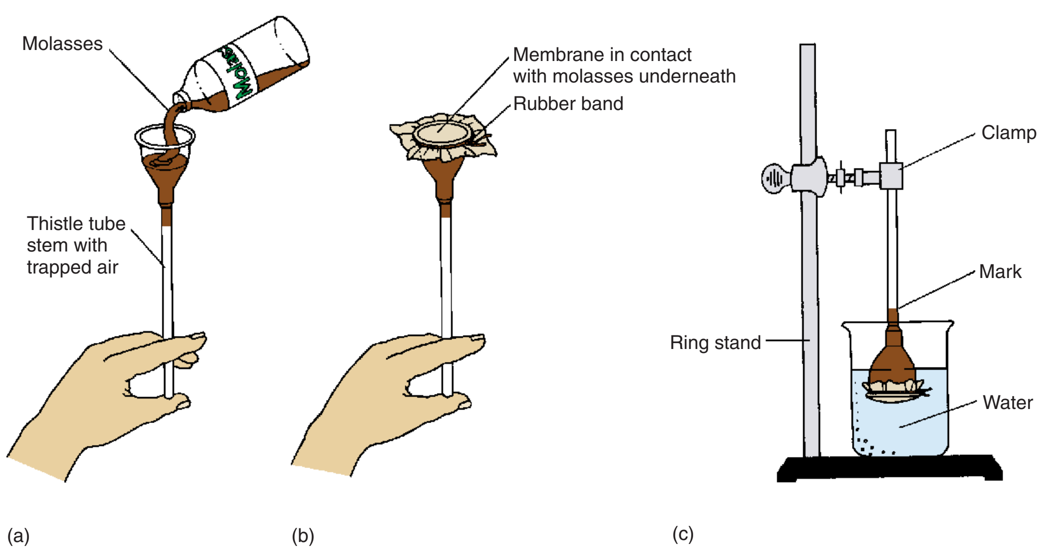
____

____

PROCEDURE B—OSMOSIS

1. Review a textbook section on *osmosis.*
2. To demonstrate osmosis, refer to figure 5.2 as you follow these steps:
   a. One person plugs the tube end of a thistle tube with a finger.
   b. Another person then fills the bulb with molasses until it is about to overflow at the top of the bulb. Note that air remains trapped in the stem.
   c. Cover the bulb opening with a single-thickness piece of moist selectively permeable (semipermeable) membrane. Dialysis tubing that has been soaked for 30 minutes can easily be cut open because it becomes pliable.
   d. Tightly secure the membrane in place with several wrappings of a rubber band.
   e. Immerse the bulb end of the tube in a beaker of water. If leaks are noted, repeat the procedures.

Figure 5.2 (*a*) Fill the bulb of the thistle tube with molasses; (*b*) tightly secure a piece of selectively permeable (semipermeable) membrane over the bulb opening; and (*c*) immerse the bulb in a beaker of water. *Note:* These procedures require participation of two people.



f. Support the upright portion of the tube with a clamp on a ring stand. Folded paper under the clamp will protect the thistle tube stem from breakage.
g. Mark the meniscus level of the molasses in the tube. *Note:* The best results will occur if the mark of the molasses is a short distance up the stem of the thistle tube when the experiment starts.
h. Measure the level changes after 10 minutes and 30 minutes.

3. Complete Part B of the laboratory report.

OPTIONAL ACTIVITY

Repeat the demonstration of osmosis, but this time use two thistle tubes. Fill the bulbs with different concentrations of molasses—25% molasses in water for one and 50% molasses in water for the other. Set up the tubes as before and observe the rates at which the levels of molasses change. What difference did you note between the rates of change in the two tubes? How do you explain this difference? ______________________

____

____

____

PROCEDURE C—HYPERTONIC, HYPOTONIC, AND ISOTONIC SOLUTIONS

1. Review a textbook section on *tonicity.*
2. To demonstrate the effect of hypertonic, hypotonic, and isotonic solutions on animal cells, follow these steps:
   a. Place three test tubes in a rack and mark them as *tube 1, tube 2,* and *tube 3.* (*Note:* One set of tubes can be used to supply test samples for the entire class.)
   b. Using 10 mL graduated cylinders, add 3 mL of distilled water to tube 1; add 3 mL of 0.9% NaCl to tube 2; and add 3 mL of 3.0% NaCl to tube 3.
   c. Place three drops of fresh uncoagulated animal blood into each of the tubes and gently mix the blood with the solutions. Wait 5 minutes.
   d. Using three separate medicine droppers, remove a drop from each tube and place the drops on three separate microscope slides marked *1, 2,* and *3.*
   e. Cover the drops with coverslips and observe the blood cells, using the high power of the microscope.
3. Complete Part C of the laboratory report.

ALTERNATIVE PROCEDURE

Various substitutes for blood can be used for Procedure C. Onion, cucumber, or cells lining the inside of the cheek represent three possible options.

PROCEDURE D—FILTRATION

1. Review a textbook section on *filtration.*
2. To demonstrate filtration, follow these steps:
   a. Place a glass funnel in the ring of a ring stand over an empty beaker. Fold a piece of filter paper in half and then in half again. Open one thickness of the filter paper to form a cone, wet the cone, and place it in the funnel. The filter paper is used to demonstrate how movement across membranes is limited by the size of the molecules, but it does not represent a working model of biological membranes.
   b. Prepare a mixture of 5 cc (approximately 1 teaspoon) powdered charcoal and equal amounts of 1% glucose solution and 1% starch solution in a beaker. Pour some of the mixture into the funnel until it nearly reaches the top of the filter paper cone. Collect the filtrate in the beaker below the funnel (fig. 5.3).
   c. Test some of the filtrate in the beaker for the presence of glucose. To do this, place 1 mL of filtrate in a clean test tube and add 1 mL of Benedict's solution. Place the test tube in a water bath of boiling water for 2 minutes and then allow the liquid to cool slowly. If the color of the solution changes to green, yellow, or red, glucose is present (fig. 5.4).
   d. Test some of the filtrate in the beaker for the presence of starch. To do this, place a few drops of filtrate in a test tube and add a few drops of iodine-potassium-iodide solution. If the color of the solution changes to blue-black, starch is present.
   e. Observe any charcoal in the filtrate.
3. Complete Part D of the laboratory report.

Figure 5.3 Apparatus used to illustrate filtration.

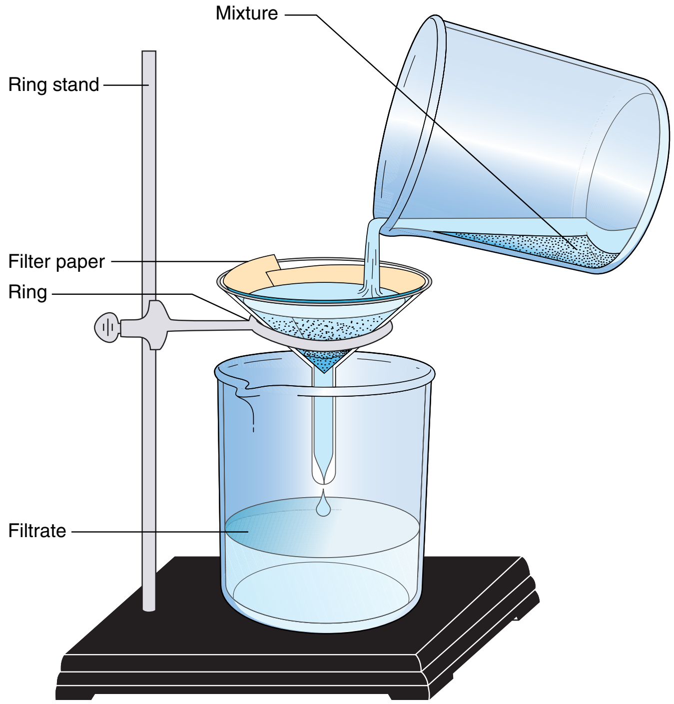
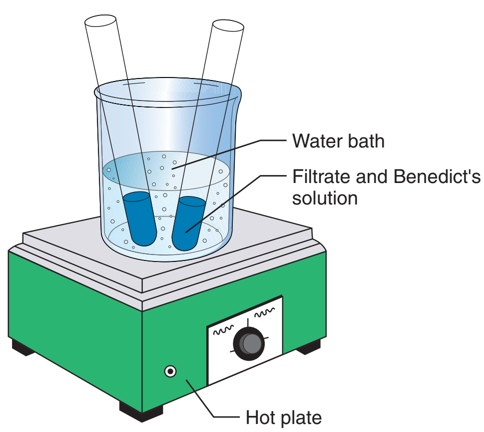


Figure 5.4 Heat the filtrate and Benedict's solution in a boiling water bath for 2 minutes.



Laboratory Report **5**

Name ______________________

Date ______________________

Section ______________________

Movements Through Cell Membranes

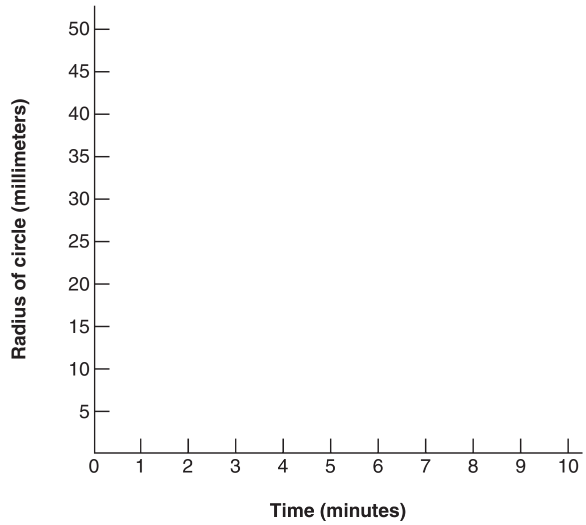
Part A

Complete the following:

1. Enter data for changes in the movement of the potassium permanganate.

Elapsed Time	Radius of Purple Circle in Millimeters
initial	______________
1 minute	______________
2 minutes	______________
3 minutes	______________
4 minutes	______________
5 minutes	______________
6 minutes	______________
7 minutes	______________
8 minutes	______________
9 minutes	______________
10 minutes	______________

2. Prepare a graph that illustrates the diffusion distance of potassium permanganate in 10 minutes.



3. Explain your graph. ____

____

4. Briefly define *diffusion.* ____

____

Critical Thinking Application

Indicate which of the following provides an example of diffusion by answering yes or no.

1. A perfume bottle is opened and soon the odor can be sensed in all parts of the room.____________
2. A sugar cube is dropped into a cup of hot water and, without being stirred, all of the liquid becomes sweet tasting.____________
3. Water molecules move from a faucet through a garden hose when the faucet is turned on.____________
4. A person blows air molecules into a balloon by exhaling forcefully.____________
5. A crystal of blue copper sulfate is placed in a test tube of water. The next day the solid is gone, but the water is evenly colored.____________

Part B

Complete the following:

1. What was the change in the level of molasses in 10 minutes?____________
2. What was the change in the level of molasses in 30 minutes?____________
3. How do you explain this change? ____

____

4. Briefly define *osmosis.* ____

____

Critical Thinking Application

Indicate which of the following involves osmosis by answering yes or no.

1. A fresh potato is peeled, weighed, and soaked in a strong salt solution. The next day it is discovered that the potato has lost weight.___________
2. Garden grass wilts after being exposed to dry chemical fertilizer.___________
3. Air molecules escape from a punctured tire as a result of high pressure inside. ___________
4. Plant seeds soaked in water swell and become several times as large as before soaking.___________
5. When the bulb of a thistle tube filled with water is sealed by a selectively permeable membrane and submerged in a beaker of molasses, the water level in the tube falls.___________

Part C

Complete the following:

1. In the spaces, sketch a few blood cells from each of the test tubes and indicate the magnification.

Tube 1 (distilled water)	Tube 2 (0.9% NaCl)	Tube 3 (3.0% NaCl)
__________×	__________×	__________×

2. Based on your results, which tube contained a solution that was hypertonic to the blood cells?___________

   Give the reason for your answer. ____

3. Which tube contained a solution that was hypotonic to the blood cells?___________

   Give the reason for your answer. ____

4. Which tube contained a solution that was isotonic to the blood cells?___________

   Give the reason for your answer. ____

Part D

Complete the following:

1. Which of the substances in the mixture you prepared passed through the filter paper into the filtrate? ____________

2. What evidence do you have for your answer to question 1? ____________

3. What force was responsible for the movement of substances through the filter paper? ____________

4. What substances did not pass through the filter paper? ____________

5. What factor prevented these substances from passing through? ____________

6. Briefly define *filtration.* ____________

Critical Thinking Application

Indicate which of the following involves filtration by answering yes or no.

1. Oxygen molecules move into a cell and carbon dioxide molecules leave a cell because of differences in the concentrations of these substances on either side of the cell membrane.____________
2. Blood pressure forces water molecules from the blood outward through the thin wall of a blood capillary.____________
3. Urine is forced from the urinary bladder through the tubular urethra by muscular contractions.____________
4. Air molecules enter the lungs through the airways when air pressure is greater outside these organs than inside.____________
5. Coffee is made using a coffee maker (not instant).____________

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Laboratory Exercise 6

The Cell Cycle

MATERIALS NEEDED

textbook
models of animal mitosis
microscope slides of whitefish mitosis (blastula)
compound microscope

For Demonstration:

microscope slide of human chromosomes from leukocytes in mitosis
oil immersion objective

The cell cycle consists of the series of changes a cell undergoes from the time it is formed until it reproduces. Interphase, mitosis, cytoplasmic division, and differentiation are stages of a cell cycle. Typically, a newly formed cell grows to a certain size and then divides to form two new cells (*daughter cells*). This reproductive process involves two major steps: (1) division of the cell's nuclear parts, which is called *mitosis* (karyokinesis) and (2) division of the cell's cytoplasm (cytokinesis). Before the cell divides it must synthesize biochemicals and other contents. This period of preparation is called *interphase.* The extensive period of interphase is divided into three phases. The S phase when DNA synthesis occurs is between two gap phases (G_1 and G_2) when cell growth occurs and cytoplasmic organelles duplicate.

PURPOSE OF THE EXERCISE

To review the stages in the cell cycle, and to observe cells in various stages of their life cycles.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the cell cycle;
2. identify the stages in the life cycle of a particular cell;
3. arrange into a correct sequence a set of models or drawings of cells in various stages of their life cycles.

PROCEDURE

1. Review a textbook section on the *cell cycle.*
2. As a review activity, label the various stages of the cell's life cycle represented in figure 6.1 and the structures indicated in figure 6.2.
3. Observe the animal mitosis models and review the major events in a cell's life cycle represented by each of them. Be sure you can arrange these models in correct sequence if their positions are changed. The acronym IPMAT can help you arrange the correct order of phases in the cell cycle. This includes interphase followed by the four phases of mitosis.
4. Complete Part A of Laboratory Report 6.
5. Obtain a slide of the whitefish mitosis (blastula).
   a. Examine the slide using the high-power objective of a microscope. The tissue on this slide was obtained from a developing embryo (blastula) of a fish, and many of the embryonic cells are undergoing mitosis. Note that the chromosomes of these reproducing cells are darkly stained (fig. 6.3).
   b. Search the tissue for cells in various stages of reproduction. Note that there are several sections on the slide. If you cannot locate different stages in one section, examine the cells of another section since the stages occur at random.
   c. Each time you locate a cell in a different stage, sketch it in an appropriate circle in Part B of the laboratory report.

Critical Thinking Application

Which stage (phase) of the cell cycle was the most numerous in the blastula? ______________

Explain your answer. ______________________________

____

____

Figure 6.1 Label the major phases during mitosis.

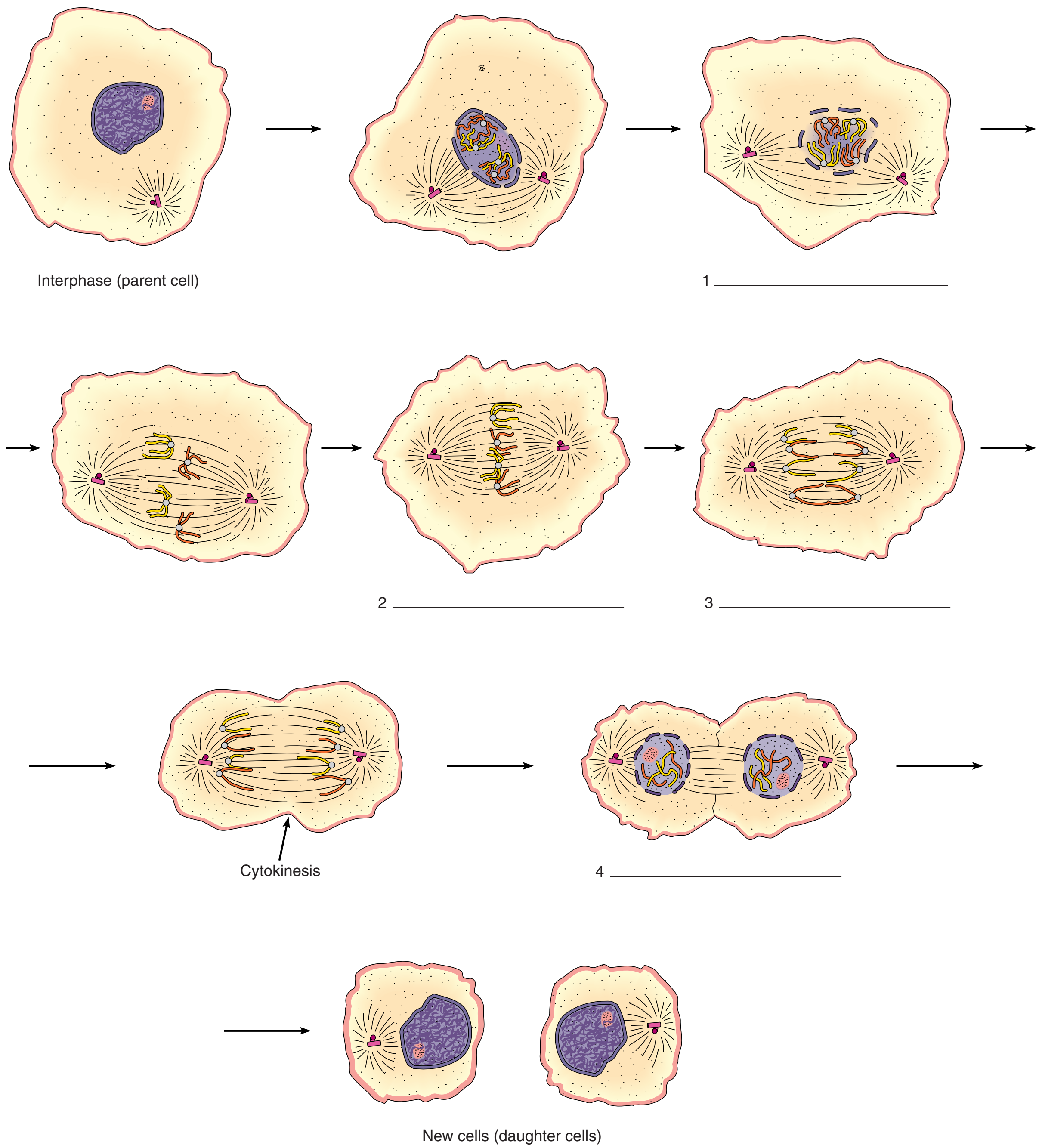


Figure 6.2 Label the structures indicated in the dividing cell.

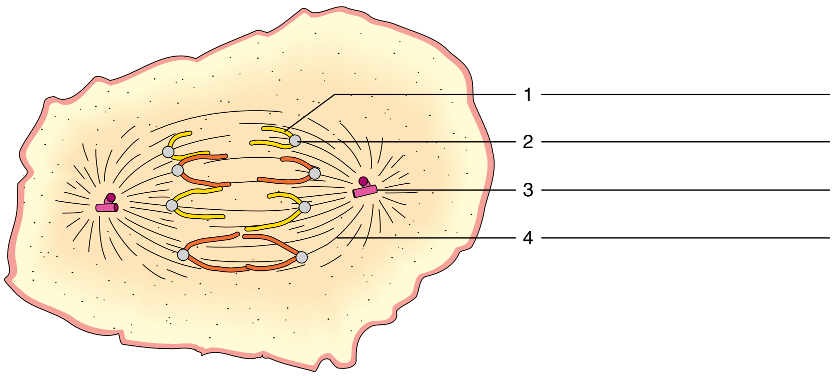
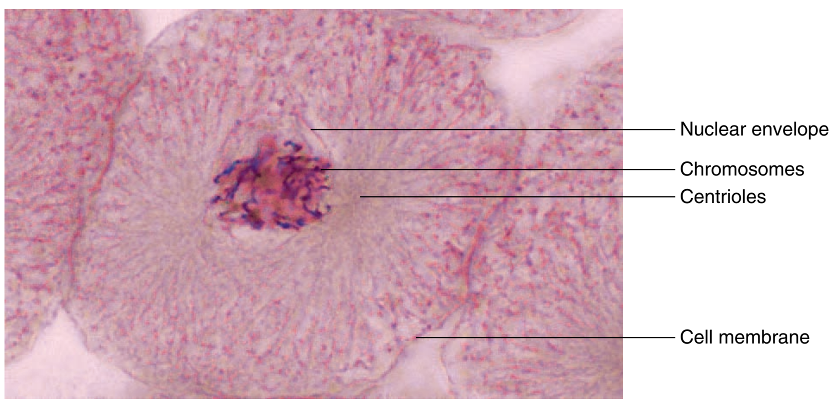


Figure 6.3 Cell in prophase (250× micrograph enlarged to 1,000×).



6. Complete Parts C, D, and E of the laboratory report.

DEMONSTRATION

Using the oil immersion objective of a microscope, see if you can locate some human chromosomes by examining a prepared slide of human chromosomes from leukocytes. The cells on this slide were cultured in a special medium and were stimulated to undergo mitosis. The mitotic process was arrested in metaphase by exposing the cells to a chemical called colchicine, and the cells were caused to swell osmotically. As a result of this treatment, the chromosomes were spread apart. A complement of human chromosomes should be visible when they are magnified about 1,000×. Note that each chromosome is double-stranded and consists of two chromatids joined by a common centromere (fig. 6.4).

Figure 6.4 A complement of human chromosomes (2,700×). How many chromosomes does a human cell contain? A *karyotype* can be constructed by arranging the homologous chromosome pairs together in a chart.

Laboratory Report 6

Name ______________________________

Date ______________________________

Section ______________________________

The Cell Cycle

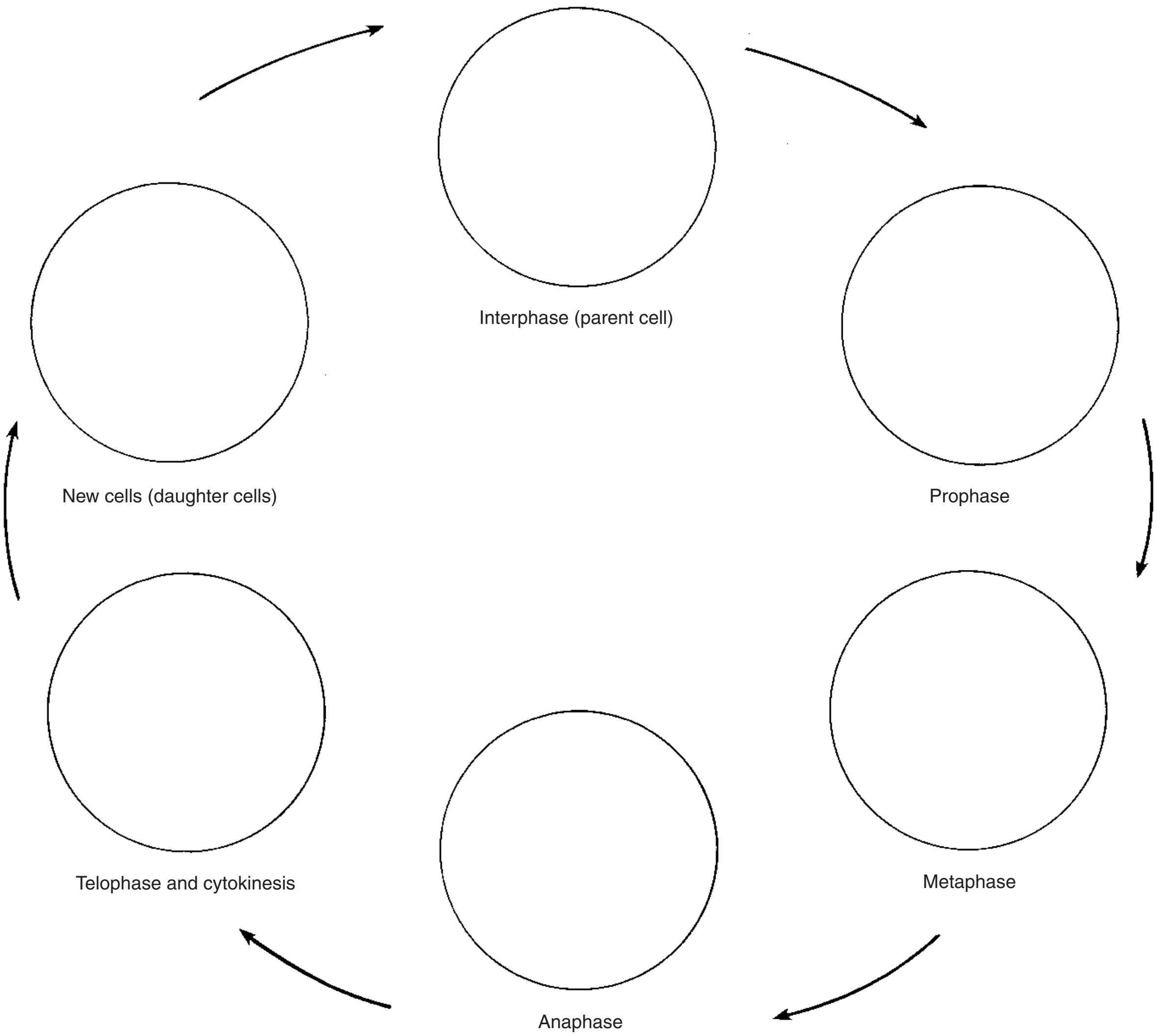
Part A

Complete the table:

Stage	Major Events Occurring
Interphase (G$_1$, S, and G$_2$)	
Mitosis (karyokinesis) Prophase	
Metaphase	
Anaphase	
Telophase	
Cytoplasmic division (cytokinesis)	

Part B

Sketch an interphase cell and cells in different stages of mitosis to illustrate the whitefish cell's life cycle. Label the major cellular structures represented in the sketches and indicate cytokinesis locations. (The circles represent fields of view through the microscope.)



Magnification ____________ ×

Part C

Complete the following:

1. In what ways are the new cells (daughter cells), which result from a cell cycle, similar? ____
____
____

2. How do the new cells differ slightly? ______________________________

____

____

3. Distinguish between mitosis (karyokinesis) and cytoplasmic division (cytokinesis). ______________________________

____

____

Part D

Identify the mitotic stage represented by each of the micrographs in figure 6.5.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Part E

Identify the structures indicated in figure 6.5*d.*

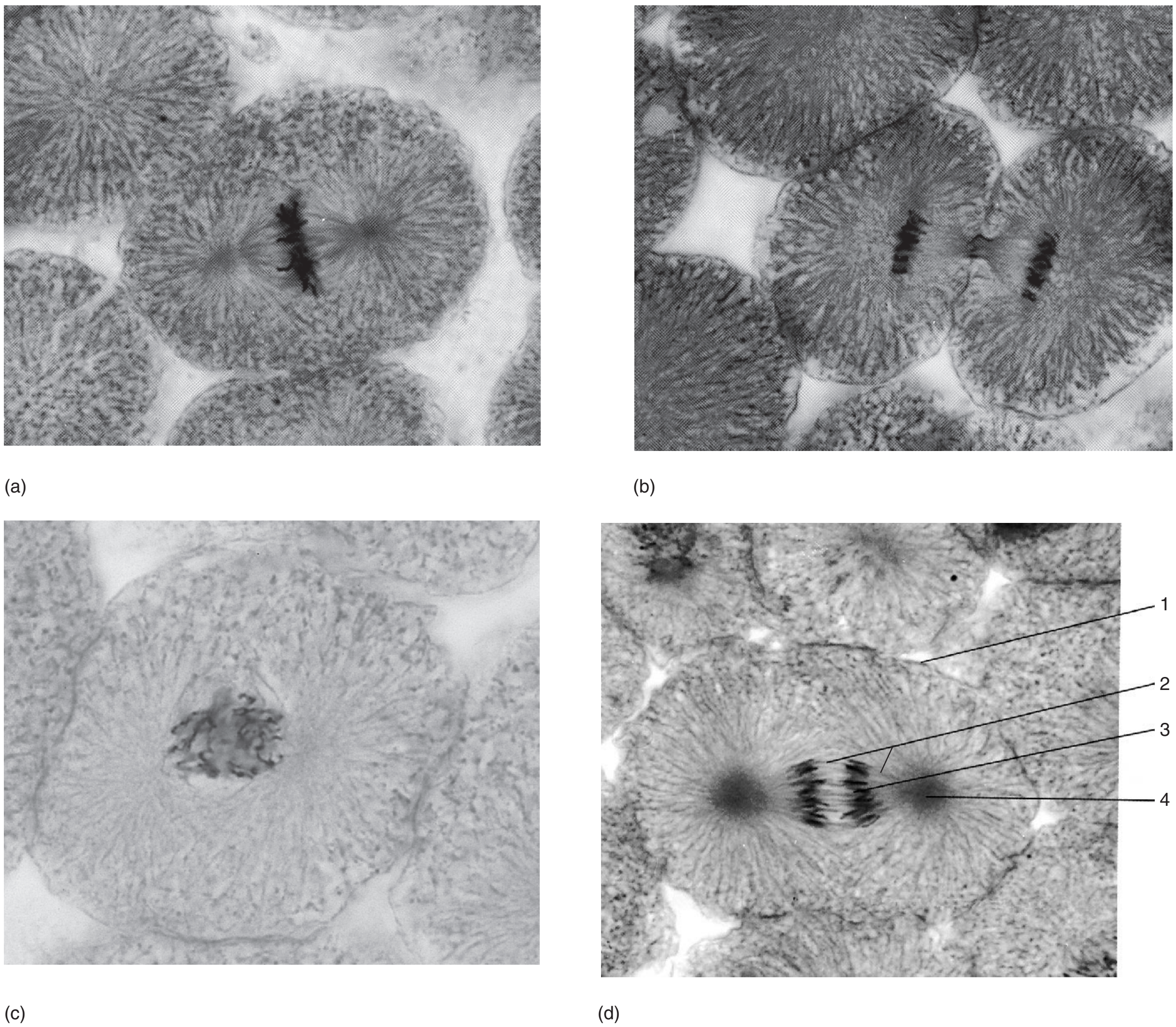
1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Figure 6.5 Identify the mitotic stage of the cell in each of these micrographs of the whitefish blastula (250× micrographs enlarged to 900×).



Laboratory Exercise 7

Epithelial Tissues

MATERIALS NEEDED

textbook
compound microscope
prepared slides of the following epithelial tissues:
- simple squamous epithelium (lung)
- simple cuboidal epithelium (kidney)
- simple columnar epithelium (small intestine)
- pseudostratified (ciliated) columnar epithelium (trachea)
- stratified squamous epithelium (esophagus)
- transitional epithelium (urinary bladder)

For Optional Activity:

colored pencils

A tissue is composed of a layer or group of cells—cells that are similar in size, shape, and function. Within the human body, there are four major types of tissues: (1) epithelial, which cover the body's external and internal surfaces; (2) connective, which bind and support parts; (3) muscle, which make movement possible; and (4) nervous, which conduct impulses from one part of the body to another and help to control and coordinate body activities.

Epithelial tissues are tightly packed single (simple) to multiple (stratified) layers of cells that provide protective barriers. The underside of this tissue layer contains a basement membrane layer to which the epithelial cells anchor. Epithelial cells always have a free surface that is exposed to the outside or to an open space internally. Numerous shapes of the cells exist that are used to name and identify the variations. Many of the prepared slides contain more than the tissue to be studied, so care should be taken to be certain that your view matches the correct tissue. Also be aware that stained colors of all tissues might vary.

PURPOSE OF THE EXERCISE

To review the characteristics of epithelial tissues and to observe examples.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the general characteristics of epithelial tissues;
2. list six types of epithelial tissue;
3. describe the special characteristics of each type of epithelial tissue;
4. indicate a location and function of each type of epithelial tissue;
5. identify examples of epithelial tissues.

PROCEDURE

1. Review a textbook section on *epithelial tissues.*
2. Complete Part A of Laboratory Report 7.
3. Use the microscope to observe the prepared slides of types of epithelial tissues. As you observe each tissue, look for its special distinguishing features as described in the textbook, such as cell size, shape, and arrangement.
4. Complete Part B of the laboratory report.
5. Test your ability to recognize each type of epithelial tissue. To do this, have a laboratory partner select one of the prepared slides, cover its label, and focus the microscope on the tissue. Then see if you can correctly identify the tissue.

Web Quest

Identify tissues from micrographs and examine the structural components of tissues. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 7

Name ______________________________

Date ______________________________

Section ______________________________

Epithelial Tissues

Part A

Match the tissues in column A with the characteristics in column B. Place the letter of your choice in the space provided. (Some answers may be used more than once.)

Column A

a. simple columnar epithelium
b. simple cuboidal epithelium
c. simple squamous epithelium
d. pseudostratified columnar epithelium
e. stratified squamous epithelium
f. transitional epithelium

Column B

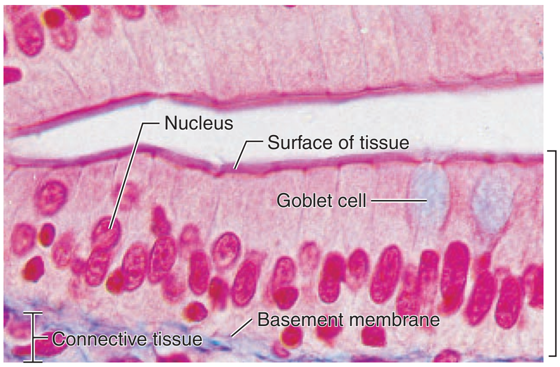
____ 1. consists of several layers of cube-shaped and elongated cells
____ 2. commonly possesses cilia that move sex cells and mucus
____ 3. single layer of flattened cells
____ 4. nuclei located at different levels within cells
____ 5. forms walls of capillaries and air sacs of lungs
____ 6. forms linings of respiratory passages
____ 7. younger cells cuboidal, older cells flattened
____ 8. forms inner lining of urinary bladder
____ 9. lines kidney tubules and ducts of salivary glands
____ 10. forms lining of stomach and intestines
____ 11. nuclei located near basement membrane
____ 12. forms lining of oral cavity, anal canal, and vagina

Part B

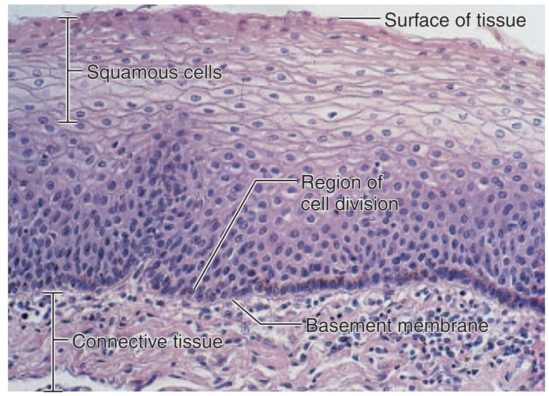
In the space that follows, sketch a few cells of each type of epithelium you observed. For each sketch, label the major characteristics, indicate the magnification used, write an example of a location, and provide a function. Compare the tissues observed to those shown in figure 7.1.

Simple squamous epithelium (____×) Location ________________________ Function ________________________	Simple cuboidal epithelium (____×) Location ________________________ Function ________________________
Simple columnar epithelium (____×) Location ________________________ Function ________________________	Pseudostratified columnar epithelium with cilia (____×) Location ________________________ Function ________________________
Stratified squamous epithelium (____×) Location ________________________ Function ________________________	Transitional epithelium (____×) Location ________________________ Function ________________________

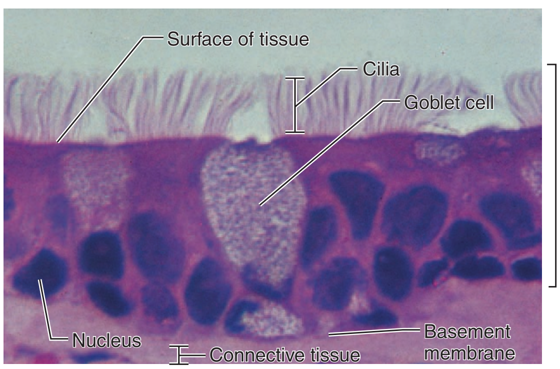
Figure 7.1 Identify each of the epithelial tissues shown in these micrographs. *Note:* The brackets indicate the tissue to be identified. Magnifications: (*a*) 650×; (*b*) 67× micrograph enlarged to 370×; (*c*) 500× micrograph enlarged to 1,500×; (*d*) 250× micrograph enlarged to 800×; (*e*) 190×; (*f*) 250× micrograph enlarged to 1,100×.



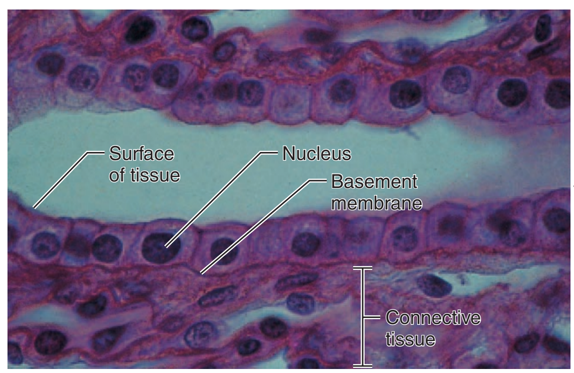
(a) Simple columnar epithelium



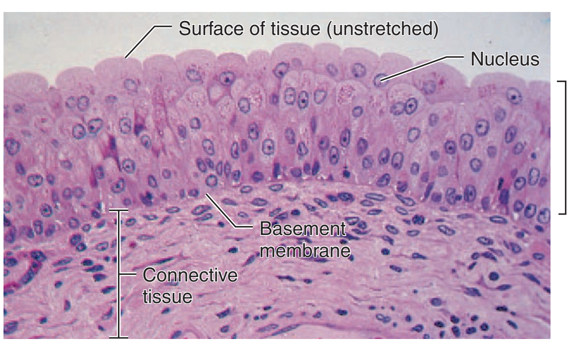
(b) Stratified squamous epithelium



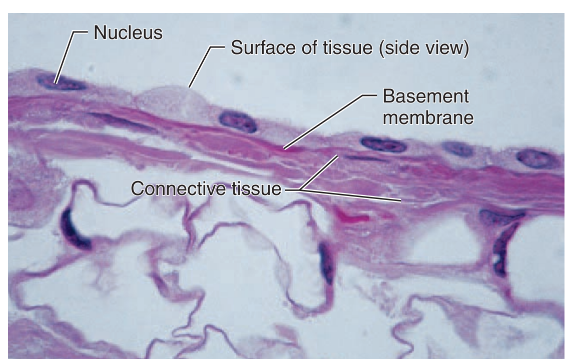
(c) Pseudostratified columnar epithelium



(d) Simple cuboidal epithelium



(e) Transitional epithelium



(f) Simple squamous epithelium

Critical Thinking Application

As a result of all of your observations of epithelial tissues, which one(s) provide(s) the best protection? Explain your answer.

____

____

____

____

OPTIONAL ACTIVITY

Use colored pencils to differentiate various cellular structures in Part B. Select a different color for a nucleus, cytoplasm, cell membrane, basement membrane, goblet cell, and cilia whenever visible.

Laboratory Exercise 8

Connective Tissues

MATERIALS NEEDED

textbook
compound microscope
prepared slides of the following:
- loose (areolar) connective tissue
- adipose tissue
- dense connective tissue (regular type)
- elastic connective tissue
- reticular connective tissue
- hyaline cartilage
- elastic cartilage
- fibrocartilage
- bone (compact, ground, c.s.)
- blood (human smear)

For Optional Activity:

colored pencils

Connective tissues contain a variety of cell types and occur in all regions of the body. They bind structures together, provide support and protection, fill spaces, store fat, and produce blood cells.

Connective tissue cells are often widely scattered in an abundance of intercellular matrix. The matrix consists of fibers and a ground substance of various densities. Many of the prepared slides contain more than the tissue to be studied, so care should be taken to be certain that your view matches the correct tissue. Additional study of bone and blood will be found in later laboratory exercises.

PURPOSE OF THE EXERCISE

To review the characteristics of connective tissues and to observe examples of the major types.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the general characteristics of connective tissues;
2. list the major types of connective tissues;
3. describe the special characteristics of each of the major types of connective tissue;
4. indicate a location and function of each type of connective tissue;
5. identify the major types of connective tissues on microscope slides.

PROCEDURE

1. Review a textbook section on *connective tissues.*
2. Complete Part A of Laboratory Report 8.
3. Use a microscope to observe the prepared slides of various connective tissues. As you observe each tissue, look for its special distinguishing features as described in the textbook.
4. Complete Part B of the laboratory report.
5. Test your ability to recognize each of these connective tissues by having a laboratory partner select a slide, cover its label, and focus the microscope on this tissue. Then see if you correctly identify the tissue.

Web Quest

Identify tissues from micrographs and examine the structural components of tissues. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 8

Name ____________________

Date ____________________

Section ____________________

Connective Tissues

Part A

Match the tissues in column A with the characteristics in column B. Place the letter of your choice in the space provided. (Some answers may be used more than once.)

Column A

a. adipose tissue
b. blood
c. bone
d. dense connective tissue
e. elastic cartilage
f. elastic connective tissue
g. fibrocartilage
h. hyaline cartilage
i. loose (areolar) connective tissue
j. reticular connective tissue

Column B

____ 1. forms framework of outer ear

____ 2. functions as heat insulator beneath skin

____ 3. contains large amounts of fluid and lacks fibers

____ 4. cells arranged around osteonic canal

____ 5. binds skin to underlying organs

____ 6. main tissue of tendons and ligaments

____ 7. provides stored energy supply in fat vacuoles

____ 8. forms the flexible part of the nasal septum

____ 9. pads between vertebrae that are shock absorbers

____ 10. forms supporting rings of respiratory passages

____ 11. cells greatly enlarged with nuclei pushed to sides

____ 12. matrix contains collagen fibers and mineral salts

____ 13. occurs in ligament attachments between vertebrae and artery walls

____ 14. forms supporting tissue in walls of liver and spleen

Part B

In the space that follows, sketch a small section of each of the types of connective tissues you observed. For each sketch, label the major characteristics, indicate the magnification used, write an example of a location, and provide a function. Compare the tissues observed to those shown in figure 8.1.

Loose (areolar) connective tissue (____×) Location ________________________ Function ________________________	Adipose tissue (____×) Location ________________________ Function ________________________
Dense connective tissue (____×) Location ________________________ Function ________________________	Elastic connective tissue (____×) Location ________________________ Function ________________________
Reticular connective tissue (____×) Location ________________________ Function ________________________	Hyaline cartilage (____×) Location ________________________ Function ________________________

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Elastic cartilage (____×) Location ________________________ Function ________________________	Fibrocartilage (____×) Location ________________________ Function ________________________
Bone (____×) Location ________________________ Function ________________________	Blood (____×) Location ________________________ Function ________________________

Critical Thinking Application

Abdominal impact injuries often involve the spleen. Explain the structural tissue characteristics that make the spleen so vulnerable to serious injury.

____

____

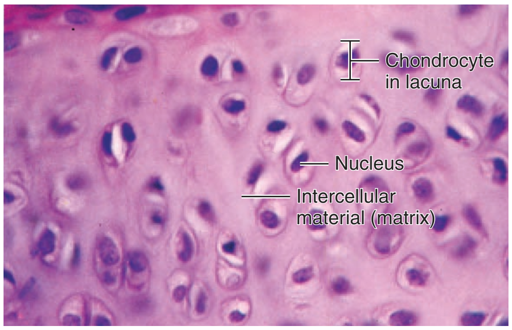
____

____

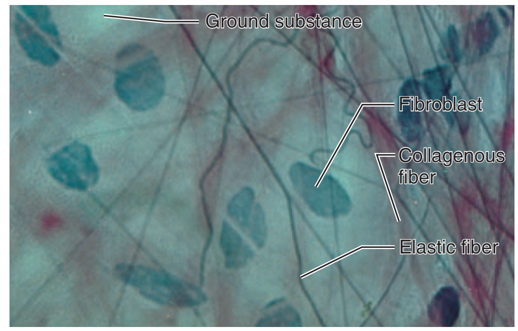
OPTIONAL ACTIVITY

Use colored pencils to differentiate various cellular structures in Part B. Select a different color for the cells, fibers, and ground substance whenever visible.

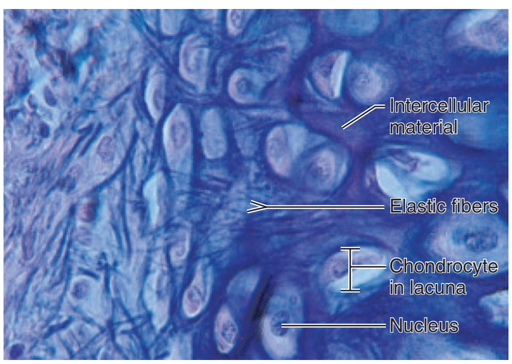
Figure 8.1 Identify each of the connective tissues shown in these micrographs. Magnifications: (*a*) 250× micrograph enlarged to 500×; (*b*) 400×; (*c*) 100× micrograph enlarged to 1,200×; (*d*) 450× micrograph enlarged to 1,800×; (*e*) 50× micrograph enlarged to 100×; (*f*) 265×; (*g*) 250× micrograph enlarged to 1,000×; (*h*) 1,200×; (*i*) 250× micrograph enlarged to 1,000×; (*j*) 170× micrograph enlarged to 680×.



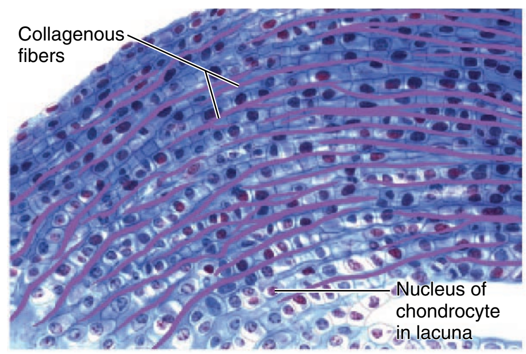
(a) Hyaline cartilage



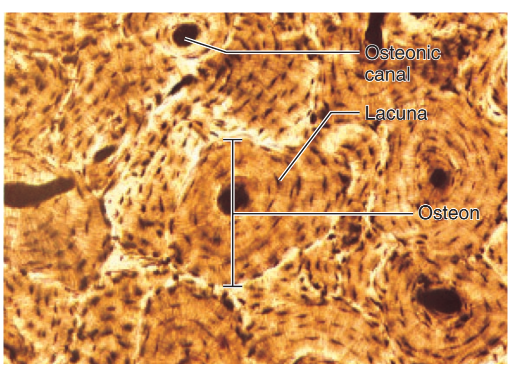
(b) Loose (areolar) connective



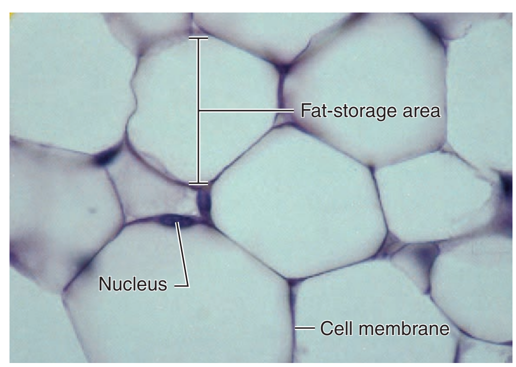
(c) Elastic cartilage



(d) Fibrocartilage

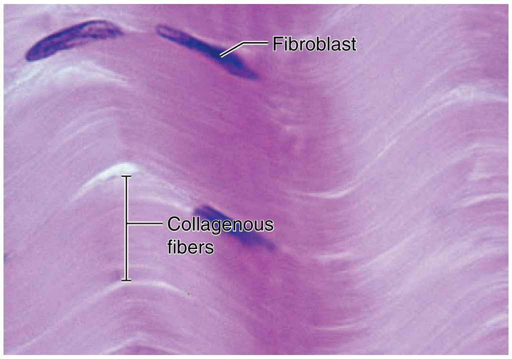


(e) Bone

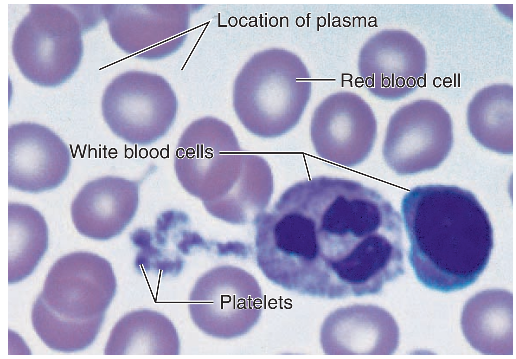


(f) Adipose

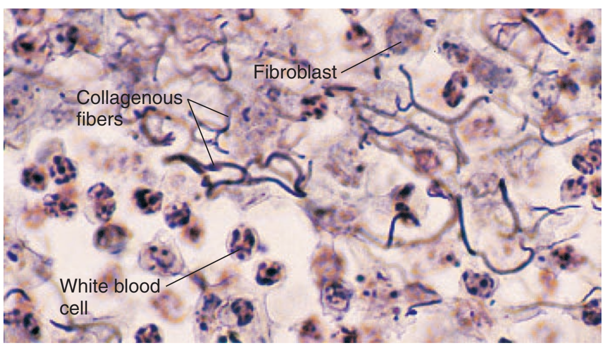
Figure 8.1 *Continued*



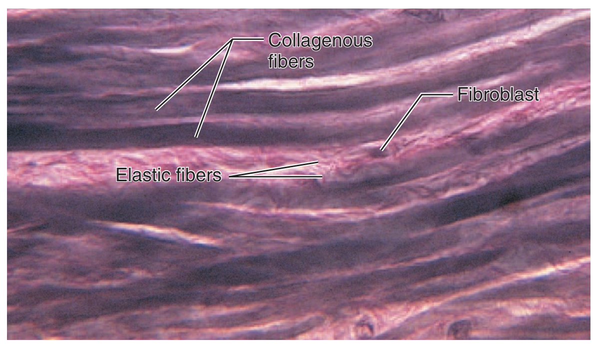
(g) Dense connective (regular)



(h) Blood



(i) Reticular connective



(j) Elastic connective

Laboratory Exercise 9

Muscle and Nervous Tissues

MATERIALS NEEDED

textbook
compound microscope
prepared slides of the following:
  skeletal muscle tissue
  smooth muscle tissue
  cardiac muscle tissue
  nervous tissue (spinal cord smear and/or cerebellum)

For Optional Activity:

colored pencils

Muscle tissues are characterized by the presence of elongated cells or muscle fibers that can contract. As they shorten, these fibers pull at their attached ends and cause body parts to move. The three types of muscle tissues are skeletal, smooth, and cardiac.

Nervous tissues occur in the brain, spinal cord, and nerves. They consist of neurons (nerve cells), which are the impulse conducting cells of the nervous system, and neuroglial cells, which perform supportive and protective functions.

PURPOSE OF THE EXERCISE

To review the characteristics of muscle and nervous tissues and to observe examples of these tissues.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. list the three types of muscle tissues;
2. describe the general characteristics of muscle tissues;
3. describe the special characteristics of each type of muscle tissue;
4. indicate a location and function of each type of muscle tissue;
5. identify examples of muscle tissues;
6. describe the general characteristics of nervous tissues;
7. identify nervous tissue.

PROCEDURE

1. Review textbook sections on *muscle tissues* and *nervous tissues.*
2. Complete Part A of Laboratory Report 9.
3. Using the microscope, observe each of the types of muscle tissues on the prepared slides. Look for the special features of each type, as described in the textbook.
4. Observe the prepared slide of nervous tissue and identify neurons (nerve cells), nerve fibers, and neuroglial cells.
5. Complete Part B of the laboratory report.
6. Test your ability to recognize each of these muscle and nervous tissues by having your laboratory partner select a slide, cover its label, and focus the microscope on this tissue. Then see if you correctly identify the tissue.

Web Quest

Identify tissues from micrographs and examine the structural components of tissues. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 9

Name ____________________

Date ____________________

Section ____________________

Muscle and Nervous Tissues

Part A

Match the tissues in column A with the characteristics in column B. Place the letter of your choice in the space provided. (Some answers may be used more than once.)

Column A

a. cardiac muscle
b. nervous tissue
c. skeletal muscle
d. smooth muscle

Column B

____ 1. coordinates, regulates, and integrates body functions
____ 2. contains intercalated disks
____ 3. muscle that lacks striations
____ 4. striated and involuntary
____ 5. striated and voluntary
____ 6. contains neurons and neuroglial cells
____ 7. muscle attached to bones
____ 8. muscle that composes heart
____ 9. moves food through the digestive tract
____ 10. transmits impulses along cytoplasmic extensions

Part B

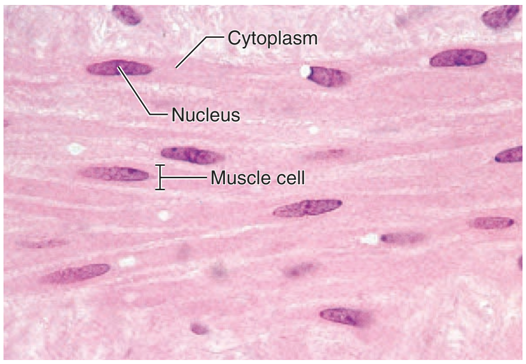
In the space that follows, sketch a few cells or fibers of each of the three types of muscle tissues and of nervous tissue as they appear through the microscope. For each sketch, label the major structures of the cells or fibers, indicate the magnification used, write an example of a location, and provide a function. Compare the tissues observed to those shown in figure 9.1.

Skeletal muscle tissue (____×) Location ________________________ Function ________________________	Smooth muscle tissue (____×) Location ________________________ Function ________________________
Cardiac muscle tissue (____×) Location ________________________ Function ________________________	Nervous tissue (____×) Location ________________________ Function ________________________

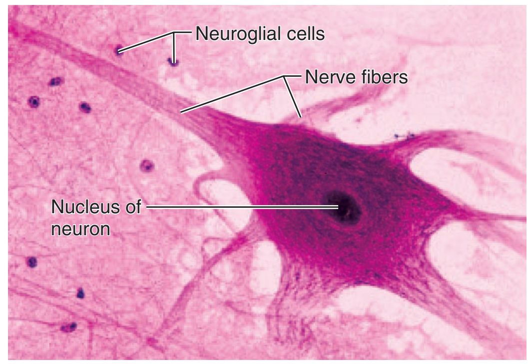
OPTIONAL ACTIVITY

Use colored pencils to differentiate various cellular structures in Part B.

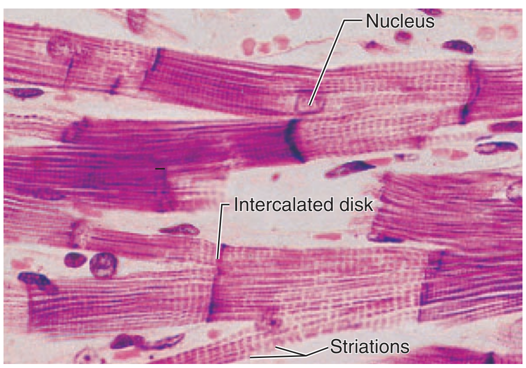
Figure 9.1 Identify the tissues illustrated by these micrographs (*a–d*). Magnifications: (*a*) 250× micrograph enlarged to 900×; (*b*) 50× micrograph enlarged to 300×; (*c*) 400×; (*d*) 250× micrograph enlarged to 700×.



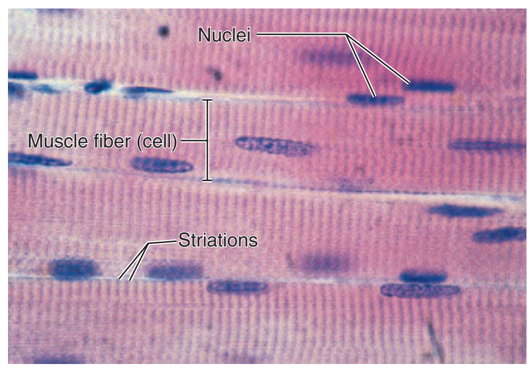
(a) Smooth muscle



(b) Nervous tissue



(c) Cardiac muscle



(d) Skeletal muscle

Laboratory Exercise 10

Integumentary System

MATERIALS NEEDED

textbook
skin model
hand magnifier or dissecting microscope
forceps
microscope slide and coverslip
compound microscope
prepared microscope slide of human scalp or axilla
prepared slide of heavily pigmented human skin
prepared slide of thick skin (plantar or palmar)

For Optional Activity:

tattoo slide

The integumentary system includes the skin, hair, nails, sebaceous glands, and sweat glands. These organs provide a protective covering for deeper tissues, aid in regulating body temperature, retard water loss, house sensory receptors, synthesize various chemicals, and excrete small quantities of wastes.

PURPOSE OF THE EXERCISE

To observe the organs and tissues of the integumentary system and to review the functions of these parts.

LEARNING OBJECTIVES

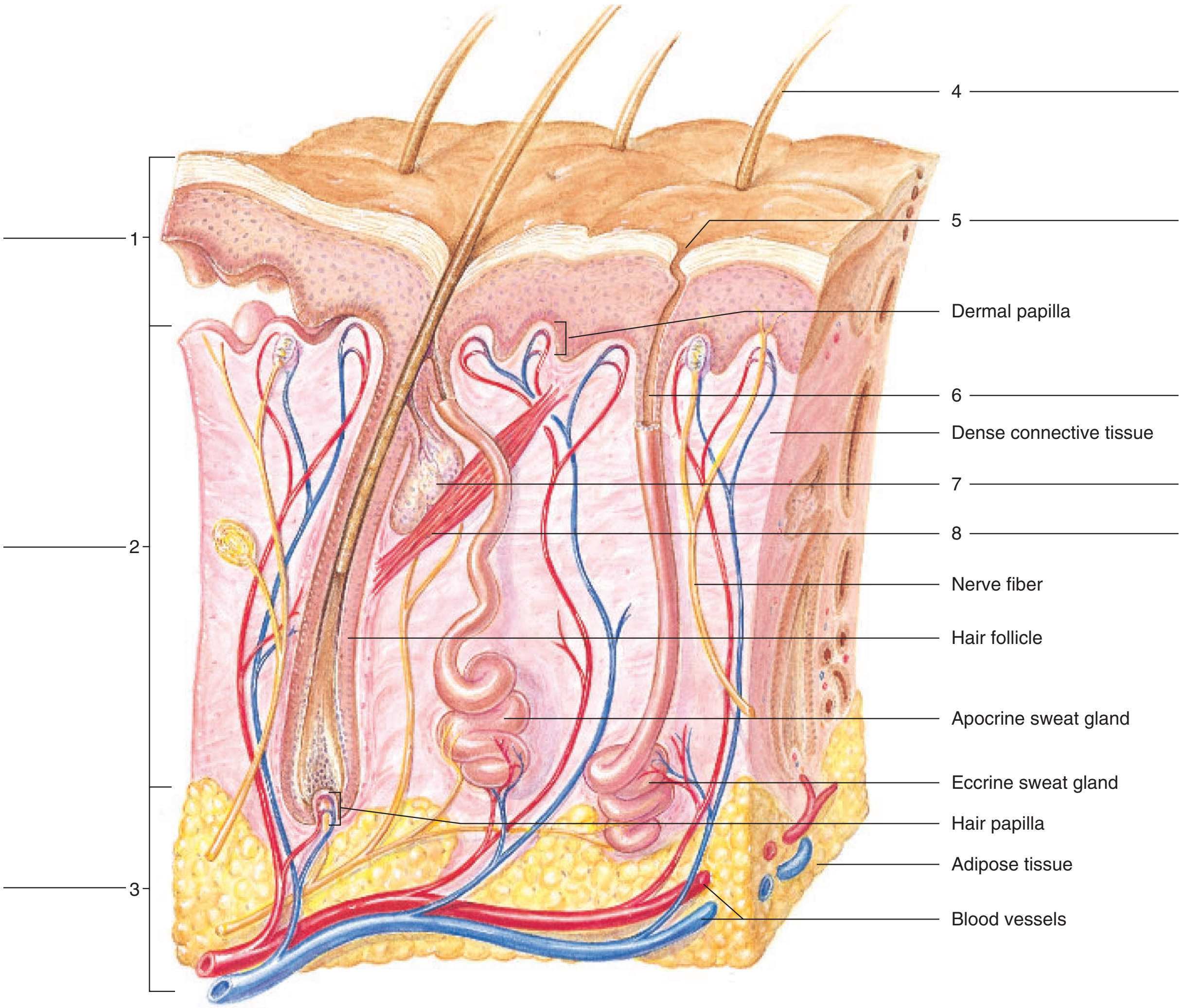
After completing this exercise, you should be able to

1. name the organs of the integumentary system;
2. describe the major functions of these organs;
3. distinguish among epidermis, dermis, and the subcutaneous layer;
4. identify the layers of the skin, a hair follicle, an arrector pili muscle, a sebaceous gland, and a sweat gland on a microscope slide, diagram, or model.

PROCEDURE

1. Review the textbook sections on *skin* and *accessory organs of the skin.*
2. As a review activity, label figures 10.1 and 10.2. Locate as many of these structures as possible on a skin model.
3. Complete Part A of Laboratory Report 10.
4. Use the hand magnifier or dissecting microscope and proceed as follows:
   a. Observe the skin, hair, and nails on your hand.
   b. Compare the type and distribution of hairs on the front and back of your forearm.
5. Use low-power magnification of the compound microscope and proceed as follows:
   a. Pull out a single hair with forceps and mount it on a microscope slide under a coverslip.
   b. Observe the root and shaft of the hair and note the scalelike parts that make up the shaft.
6. Complete Part B of the laboratory report.
7. As vertical sections of human skin are observed, remember that the lenses of the microscope invert and reverse images. It is important to orient the position of the epidermis, dermis, and subcutaneous (hypodermis) layers using scan magnification before continuing with additional observations. Compare all of your skin observations to figure 10.3. Use low-power magnification of the compound microscope and proceed as follows:
   a. Observe the prepared slide of human scalp or axilla.
   b. Locate the epidermis, dermis, and subcutaneous layer, a hair follicle, an arrector pili muscle, a sebaceous gland, and a sweat gland.
   c. Focus on the epidermis with high power and locate the stratum corneum and stratum basale (stratum germinativum). Note how the shapes of the cells in these two layers differ.
   d. Observe the dense connective tissue (irregular type) that makes up the bulk of the dermis.
   e. Observe the adipose tissue that composes most of the subcutaneous layer.
8. Observe the prepared slide of heavily pigmented human skin with low-power magnification. Note that the pigment is most abundant in the epidermis. Focus on this region with the high-power objective. The pigment-producing cells, or melanocytes, are located among the deeper layers of epidermal cells. Differences in skin color are primarily due to the amount of pigment (melanin) produced by these cells. The number of melanocytes in the skin is about the same for members of all racial groups.

Figure 10.1 Label this vertical section of skin.



Critical Thinking Application

Explain the advantage for melanin granules being located in the deep layer of the epidermis.

____

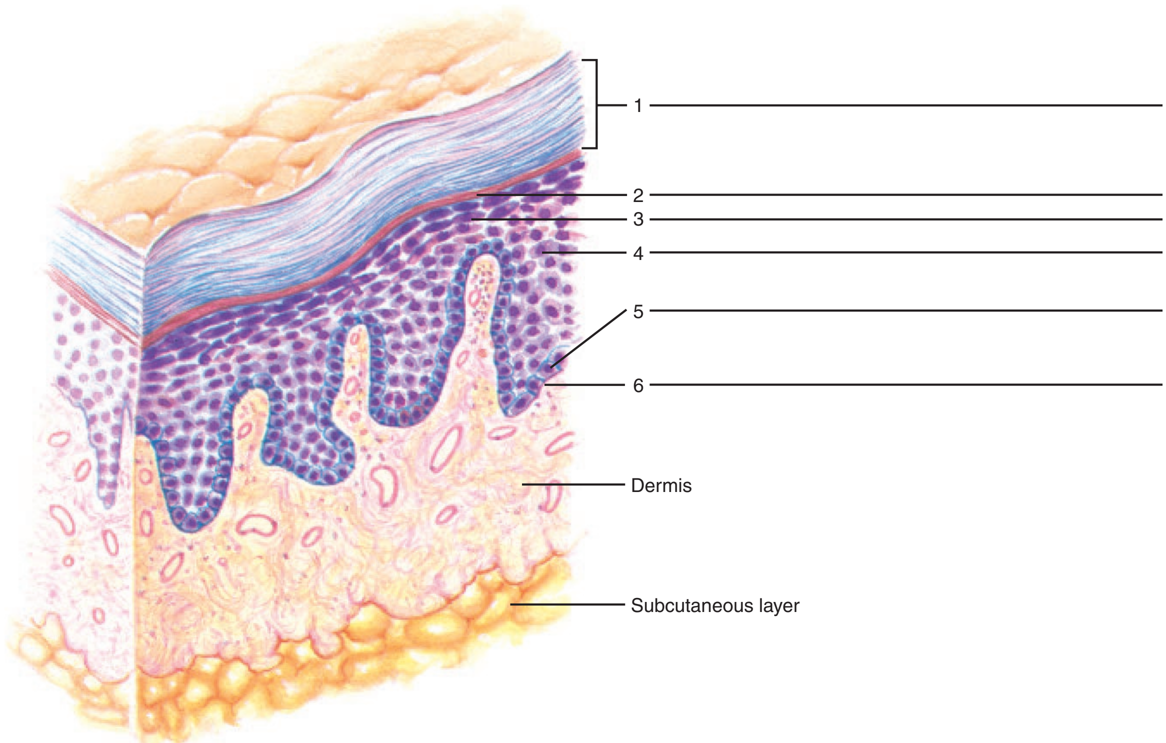
____

____

____

9. Observe the prepared slide of thick skin from the palm of a hand or the sole of a foot. Locate the stratum lucidum. Note how the stratum corneum compares to your observation of human scalp.
10. Complete Part C of the laboratory report.
11. Using low-power magnification, locate a hair follicle that has been sectioned longitudinally through its bulblike base. Also locate a sebaceous gland close to the follicle and find a sweat gland. Observe the detailed structure of these parts with high-power magnification.
12. Complete Parts D and E of the laboratory report.

Figure 10.2 Label the epidermal layers in this section of thick skin from the palm of the hand.



OPTIONAL ACTIVITY

Observe a vertical section of human skin through a tattoo using low-power magnification. Note the location of the dispersed ink granules within the upper portion of the dermis. From a thin vertical section of a tattoo, it is not possible to determine the figure or word of the entire tattoo as seen on the surface of the skin. Compare this to the location of melanin granules found in heavily pigmented skin. Describe reasons a tattoo is permanent and a suntan is not. ______________________

____

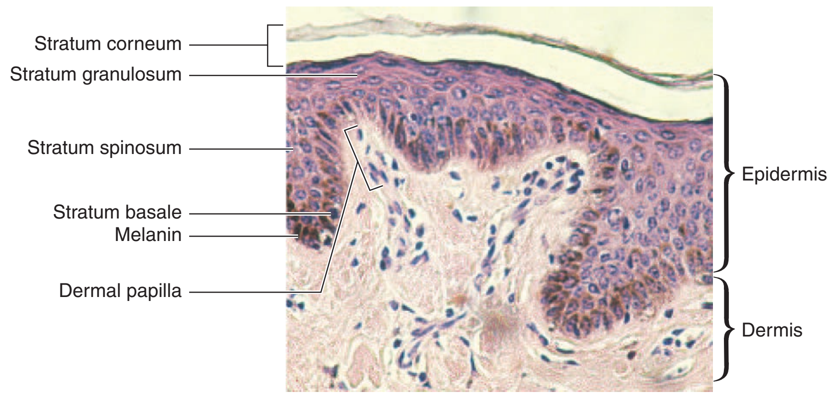
____

____

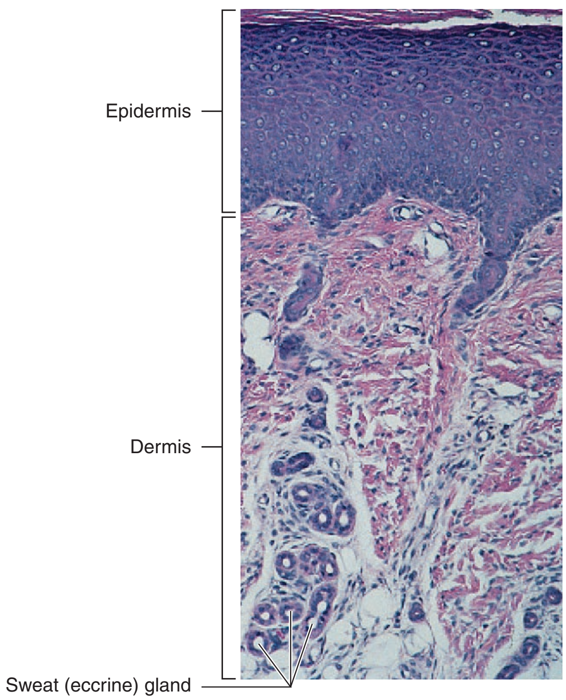
Web Quest

Identify skin layers from micrographs and review the functions of the skin structures. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 10.3 Features of human skin are indicated in these micrographs. Magnifications: (*a*) 290×; (*b*) 30× micrograph enlarged to 280×; (*c*) 45×; (*d*) 110×.

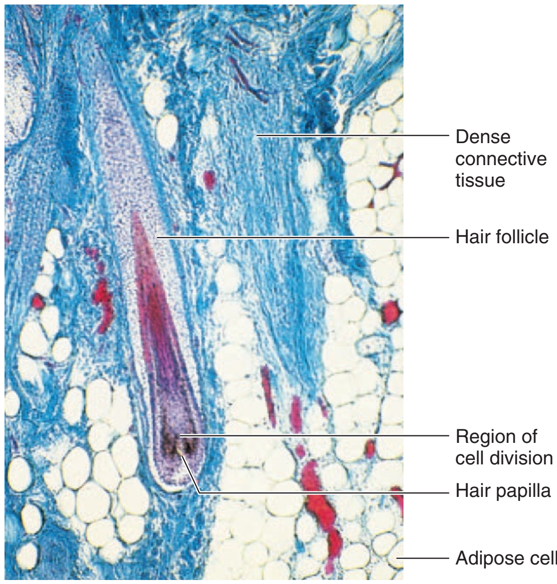


(a)

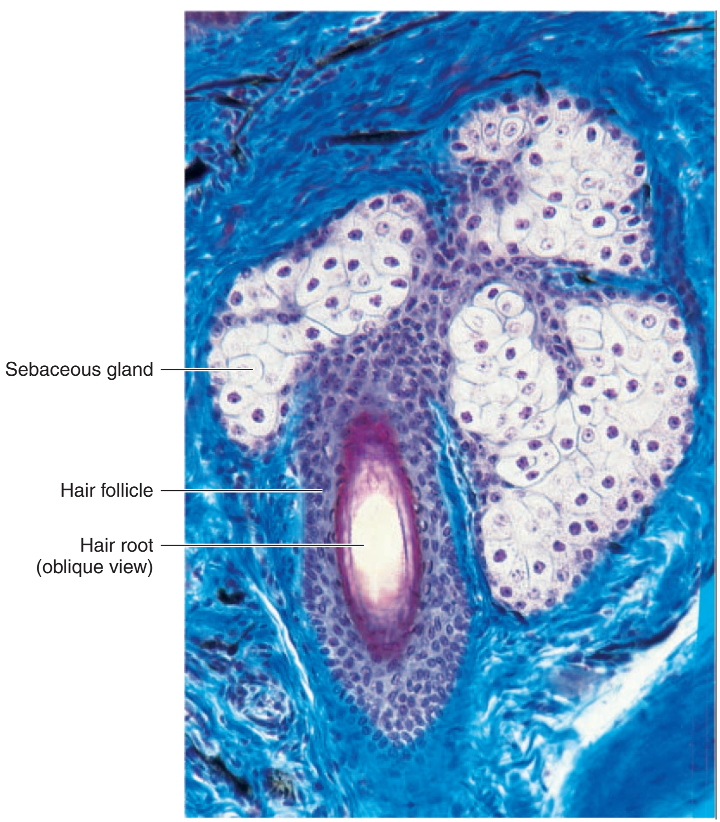


(b)

Figure 10.3 Continued



(c)



(d)

Laboratory Report **10**

Name ______________________

Date ______________________

Section ______________________

Integumentary System

Part A

Match the structures in column A with the description and functions in column B. Place the letter of your choice in the space provided.

Column A

a. apocrine sweat gland
b. arrector pili muscle
c. dermis
d. eccrine sweat gland
e. epidermis
f. hair follicle
g. keratin
h. melanin
i. melanocyte
j. sebaceous gland
k. sebum
l. stratum basale
m. stratum corneum
n. subcutaneous layer

Column B

____ 1. an oily secretion that helps to waterproof body surface
____ 2. outermost layer of epidermis
____ 3. become active at puberty
____ 4. epidermal pigment
____ 5. inner layer of skin
____ 6. responds to elevated body temperature
____ 7. pigment-producing cell
____ 8. general name of entire superficial layer of the skin
____ 9. gland that secretes an oily substance
____ 10. hard protein of nails and hair
____ 11. binds skin to underlying organs
____ 12. cell division and deepest layer of epidermis
____ 13. tubelike part that contains the root of the hair
____ 14. causes hair to stand on end and goose bumps to appear

Part B

Complete the following:

1. How does the skin of your palm differ from that on the back (posterior) of your hand? ______________________

____

____

2. Describe the differences you observed in the type and distribution of hair on the front (anterior) and back (posterior) of your forearm. ______________________

____

3. Explain how a hair is formed. ____________________

4. What cells produce the pigment in hair? ____________________

Part C

Complete the following:

1. Distinguish among epidermis, dermis, and subcutaneous layer. ____________________

2. How do the cells of stratum corneum and stratum basale differ? ____________________

3. State the specific location of melanin observed in heavily pigmented skin. ____________________

4. What special qualities does the connective tissue of the dermis have? ____________________

Part D

Complete the following:

1. What part of the hair extends from the hair papilla to the body surface? ____________________
2. In which layer of skin are sebaceous glands found? ____________________
3. How are sebaceous glands associated with hair follicles? ____________________

4. In which layer of skin are sweat glands usually located? ____________________

Part E

Sketch and label a vertical section of human skin using the scanning objective.

Laboratory Exercise 11

Structure and Classification of Bone

MATERIALS NEEDED

textbook
prepared microscope slide of ground compact bone
human bone specimens including long, short, flat, and irregular types
human long bone, sectioned longitudinally
fresh animal bones, sectioned longitudinally and transversely
dissecting microscope

For Demonstration:

fresh chicken bones (radius and ulna from wings)
vinegar or dilute hydrochloric acid

SAFETY

- Wear disposable gloves for handling fresh bones and for the demonstration of a bone soaked in vinegar or dilute hydrochloric acid.
- Wash your hands before leaving the laboratory.

A bone represents an organ of the skeletal system. As such, it is composed of a variety of tissues including bone tissue, cartilage, dense connective tissue, blood, and nervous tissue.

Although various bones of the skeleton vary greatly in size and shape, they have much in common structurally and functionally.

PURPOSE OF THE EXERCISE

To review the way bones are classified, and to examine the structure of a long bone.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name four groups of bones based on their shapes, and give an example for each group;
2. locate and name the major structures of a long bone;
3. describe the functions of various structures of a bone;
4. distinguish between compact and spongy bone.

PROCEDURE

1. Reexamine the microscopic structure of bone tissue by observing a prepared microscope slide of ground compact bone. Use the figures of bone tissue in a textbook to locate the following features:

   osteon (Haversian system)

   osteonic canal (Haversian canal)

   lamella

   lacuna (small chamber for an osteocyte)

   canaliculus

Critical Thinking Application

Explain how bone cells embedded in a solid ground substance obtain nutrients and eliminate wastes.

____

____

____

____

2. Review a textbook section on *bone structure.*
3. As a review activity, label figures 11.1 and 11.2.
4. Observe the individual bone specimens and arrange them into groups, according to the following shapes:

   long

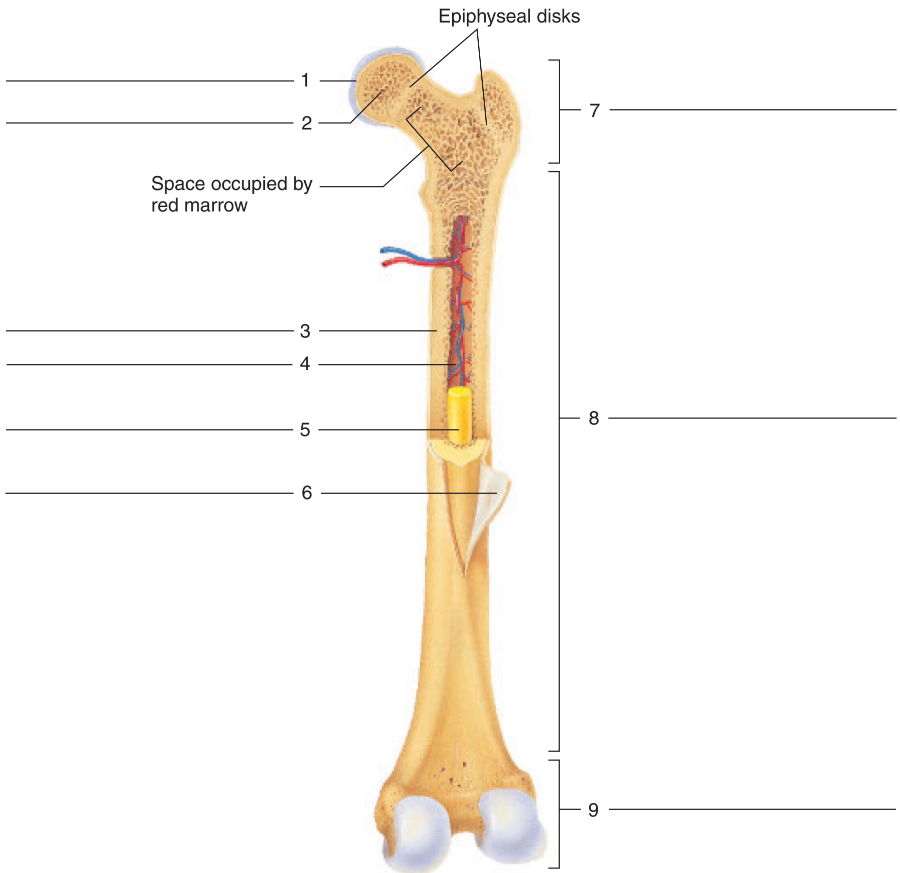
   short

   flat

   irregular

   sesamoid (round)

Figure 11.1 Label the major structures of this long bone (femur).



5. Complete Part A of Laboratory Report 11.
6. Examine the sectioned long bones and locate the following:

   epiphysis (proximal and distal)

   epiphyseal disk

   articular cartilage

   diaphysis

   periosteum

   compact bone

   spongy bone

   trabeculae

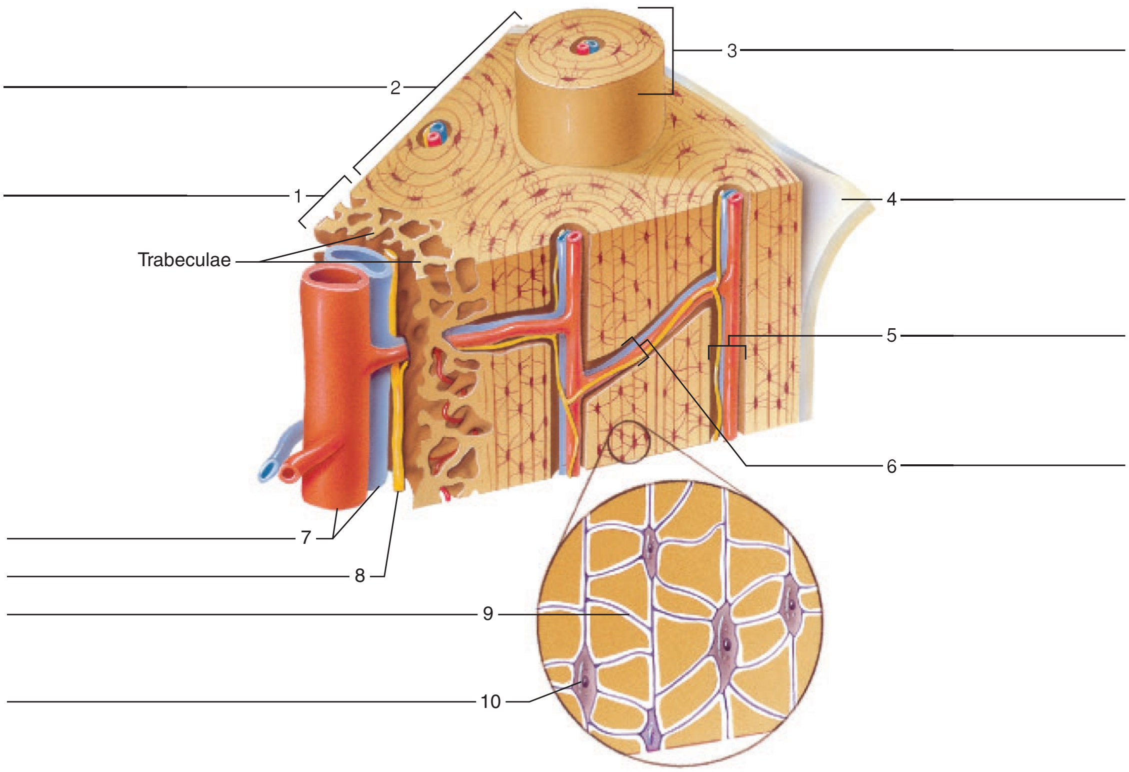
   medullary cavity

   endosteum

   yellow marrow

   red marrow
7. Use the dissecting microscope to observe the compact bone and spongy bone of the sectioned specimens. Also examine the marrow in the medullary cavity and the spaces within the spongy bone of the fresh specimen.
8. Complete Part B of the laboratory report.

Figure 11.2 Label the features associated with the microscopic structure of bone.



DEMONSTRATION

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 matrix. Rinse the bones in water and note the texture and flexibility of each. Based on your observations, what quality of the fresh bone seems to be due to the inorganic salts that were removed by the acid treatment? ________________

____

____

Examine the specimen of chicken bone that has been exposed to high temperature (baked at 121°C/250°F for 2 hours). This treatment removes the protein and other organic substances from the bone matrix. What quality of the fresh bone seems to be due to these organic materials? ________________________

____

____

Laboratory Report 11

Name ________________________________

Date ________________________________

Section ________________________________

Structure and Classification of Bone

Part A

Complete the following statements: (*Note:* Questions 1–6 pertain to bone classification by shape.)

1. A bone that is platelike is classified as a(an) ______________________ bone.
2. The bones of the wrist are examples of ______________________ bones.
3. The bone of the thigh is an example of a(an) ______________________ bone.
4. Vertebrae are examples of ______________________ bones.
5. The patella (kneecap) is an example of a large ______________________ bone.
6. The bones of the skull that form a protective covering of the brain are examples of ______________________ bones.
7. Distinguish between the epiphysis and the diaphysis of a long bone. ______________________
8. Describe where cartilage is found on a long bone. ______________________
9. Describe where dense connective tissue is found on a long bone. ______________________
10. Distinguish between the periosteum and the endosteum. ______________________

Part B

Complete the following:

1. What differences did you note between the structure of compact bone and spongy bone? ______________________

2. How are these structural differences related to the locations and functions of these two types of bone? ____________

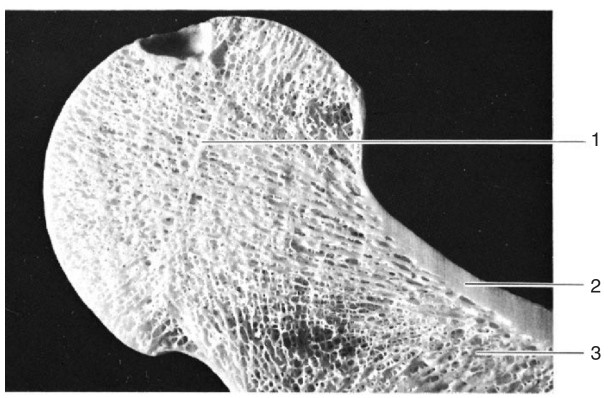
3. From your observations, how does the marrow in the medullary cavity compare with the marrow in the spaces of the spongy bone? ____________

Part C

Identify the structures indicated in figure 11.3.

1. ____________ (remnant)
2. ____________
3. ____________
4. ____________
5. ____________

Figure 11.3 Identify the structures indicated in (*a*) the epiphysis of a long bone and (*b*) the diaphysis of a long bone.



(a)

(b)

Laboratory Exercise 12

Organization of the Skeleton

MATERIALS NEEDED

textbook
articulated human skeleton

For Demonstration:

radiographs (X rays) of skeletal structures

The skeleton can be divided into two major portions: (1) the axial skeleton, which consists of the bones and cartilages of the head, neck, and trunk, and (2) the appendicular skeleton, which consists of the bones of the limbs and those that anchor the limbs to the axial skeleton.

PURPOSE OF THE EXERCISE

To review the organization of the skeleton, the major bones of the skeleton, and the terms used to describe skeletal structures.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. distinguish between the axial skeleton and the appendicular skeleton;
2. locate and name the major bones of the human skeleton;
3. define the terms used to describe skeletal structures and locate examples of such structures on the human skeleton.

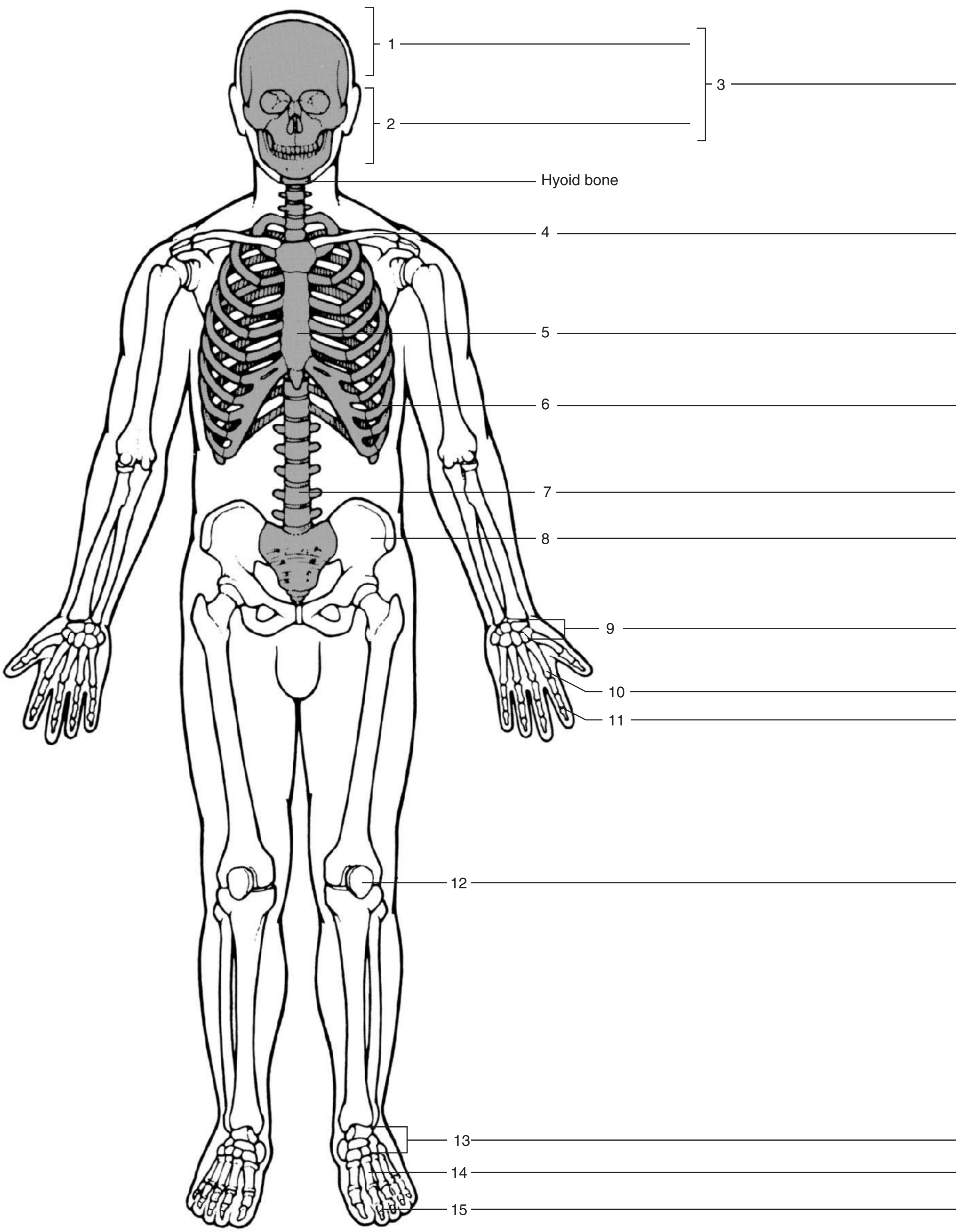
PROCEDURE

1. Review textbook sections on the *axial skeleton* and the *appendicular skeleton.*
2. As a review activity, label figure 12.1.
3. Examine the human skeleton and locate the following parts. Palpate as many of the corresponding bones in your own skeleton as possible.

axial skeleton
- skull
  - cranial bones
  - facial bones
- hyoid bone
- vertebral column
  - vertebrae
  - intervertebral disks
  - sacrum
  - coccyx
- thoracic cage
  - ribs
  - sternum

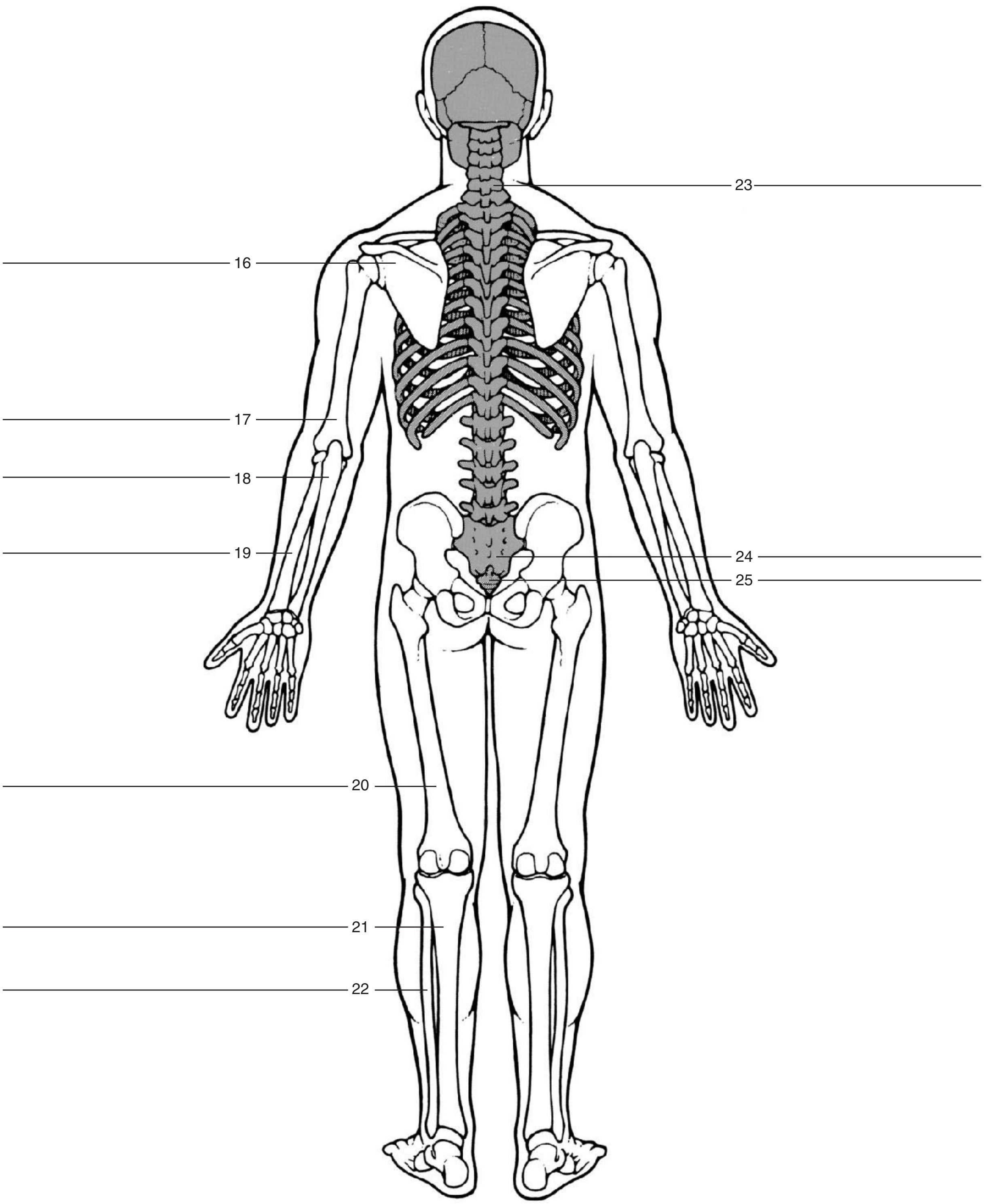
appendicular skeleton
- pectoral girdle
  - scapulae
  - clavicles
- upper limbs
  - humerus
  - radius
  - ulna
  - carpals
  - metacarpals
  - phalanges
- pelvic girdle
  - coxal bones
- lower limbs
  - femur

Figure 12.1 Label the major bones of the skeleton: (*a*) anterior view; (*b*) posterior view.



(a)

Figure 12.1 *Continued*



(b)

tibia

fibula

patella

tarsals

metatarsals

phalanges

OPTIONAL ACTIVITY

Use colored pencils to distinguish the individual bones in figure 12.1.

4. Study a textbook section on *skeletal structures.* Locate each of the following features (bone markings) on the bone listed, noting the size, shape, and location in the human skeleton:

condyle—occipital

crest—coxal

epicondyle—femur

facet—vertebra

fissure—skull (orbit)

fontanel—skull

foramen—vertebra

fossa—humerus

fovea—femur

head—humerus

linea—femur

meatus—temporal

process—temporal

ramus—mandible

sinus—frontal

spine—scapula

suture—skull

trochanter—femur

tubercle—humerus

tuberosity—tibia

Critical Thinking Application

Locate and name the largest foramen in the skull.

____

____

Locate and name the largest foramen in the skeleton.

____

____

5. Complete Parts A, B, and C of Laboratory Report 12.

DEMONSTRATION

Images on radiographs (X rays) are produced by allowing X rays from an X-ray tube to pass through a body part and to expose photographic film that is positioned on the opposite side of the part. The image that appears on the film after it is developed reveals the presence of parts with different densities. Bone, for example, is very dense tissue and is a good absorber of X rays. Thus, bone generally appears light on the film. Air-filled spaces, on the other hand, absorb almost no X rays and appear as dark areas on the film. Liquids and soft tissues absorb intermediate quantities of X rays, so they usually appear in various shades of gray.

Examine the available radiographs (X rays) of skeletal structures by holding each film in front of a light source. Identify as many of the bones and features as you can.

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Laboratory Report **12**

Name ______________________

Date ______________________

Section ______________________

ORGANIZATION OF THE SKELETON

Part A

Complete the following statements:

1. The extra bones that sometimes develop between the flat bones of the skull are called ______________.
2. Small bones occurring in some tendons are called ______________ bones.
3. The cranium and facial bones compose the ______________.
4. The ______________ bone supports the tongue.
5. The ______________ at the inferior end of the sacrum is composed of several fused vertebrae.
6. Most ribs are attached anteriorly to the ______________.
7. The thoracic cage is composed of ______________ pairs of ribs.
8. The scapulae and clavicles together form the ______________.
9. The humerus, radius, and ______________ articulate to form the elbow joint.
10. The wrist is composed of eight bones called ______________.
11. The coxal bones are attached posteriorly to the ______________.
12. The pelvic girdle (coxal bones), sacrum, and coccyx together form the ______________.
13. The ______________ covers the anterior surface of the knee.
14. The bones that articulate with the distal ends of the tibia and fibula are called ______________.
15. All finger and toe bones are called ______________.

Part B

Match the terms in column A with the definitions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. condyle	____	1. small, nearly flat articular surface
b. crest	____	2. deep depression
c. facet	____	3. rounded process
d. fontanel	____	4. opening or passageway
e. foramen	____	5. interlocking line of union
f. fossa	____	6. narrow, ridgelike projection
g. suture	____	7. soft region between bones of skull

Part C

Match the terms in column A with the definitions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. fovea	____	1. tubelike passageway
b. head	____	2. tiny pit or depression
c. meatus	____	3. small, knoblike process
d. sinus	____	4. thornlike projection
e. spine	____	5. rounded enlargement at end of bone
f. trochanter	____	6. air-filled cavity within bone
g. tubercle	____	7. relatively large process

Laboratory Exercise 13

The Skull

MATERIALS NEEDED

textbook
human skull, articulated
human skull, disarticulated (Beauchene)
human skull, sagittal section

For Optional Activity:

colored pencils

For Demonstration:

fetal skull

A human skull consists of twenty-two bones that, except for the lower jaw, are firmly interlocked along sutures. Eight of these immovable bones make up the braincase, or cranium, and thirteen more immovable bones and the mandible form the facial skeleton.

PURPOSE OF THE EXERCISE

To examine the structure of the human skull and to identify the bones and major features of the skull.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. distinguish between the cranium and the facial skeleton;
2. locate and name the bones of the skull and their major features;
3. locate and name the major sutures of the cranium;
4. locate and name the sinuses of the skull.

PROCEDURE

1. Review a textbook section on the *skull*.
2. As a review activity, label figures 13.1, 13.2, 13.3, 13.4, and 13.5.
3. Examine the **cranial bones** of the articulated human skull and the sectioned skull. Also observe the corresponding disarticulated bones. Locate the following bones and features in the laboratory specimens and, at the same time, palpate as many of these bones and features in your own skull as possible.

frontal bone

- supraorbital foramen
- frontal sinuses

parietal bones

- sagittal suture
- coronal suture

occipital bone

- lambdoidal suture
- foramen magnum
- occipital condyles

temporal bones

- squamosal suture
- external auditory meatus
- mandibular fossae
- mastoid process
- styloid process
- carotid canal
- jugular foramen
- internal acoustic meatus
- zygomatic process

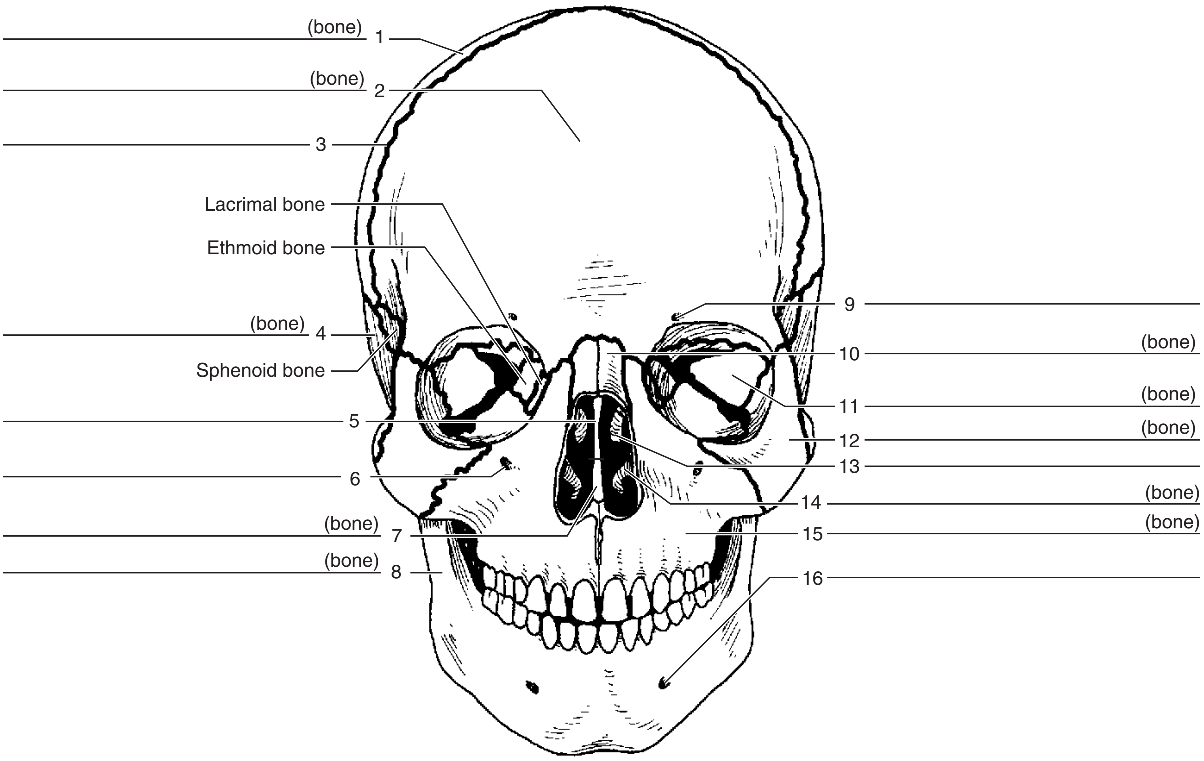
sphenoid bone

- sella turcica
- greater and lesser wings
- sphenoidal sinuses

ethmoid bone

- cribriform plates
- perpendicular plate
- superior nasal concha

Figure 13.1 Label the anterior bones and features of the skull. (If the line lacks the word *bone,* label the particular feature of that bone.)



middle nasal concha

ethmoidal sinuses

crista galli

4. Complete Parts A and B of Laboratory Report 13.
5. Examine the **facial bones** of the articulated and sectioned skulls and the corresponding disarticulated bones. Locate the following:

maxillary bones

maxillary sinuses

palatine processes

alveolar processes

alveolar arch

palatine bones

zygomatic bones

temporal process

zygomatic arch

lacrimal bones

nasal bones

vomer bone

inferior nasal conchae

mandible

ramus

mandibular condyle

coronoid process

alveolar border

mandibular foramen

mental foramen

6. Complete Part C of the laboratory report.

OPTIONAL ACTIVITY

Use colored pencils to differentiate the bones illustrated in figures 13.1–13.5. Select a different color for each individual bone in the series. This activity should help you locate various bones that are shown in different views in the figures. You can check your work by referring to the corresponding figures in a textbook, which are presented in full color.

7. Locate the following features of the human skull:

carotid canal

foramen lacerum

Figure 13.2 Label the lateral bones and features of the skull.

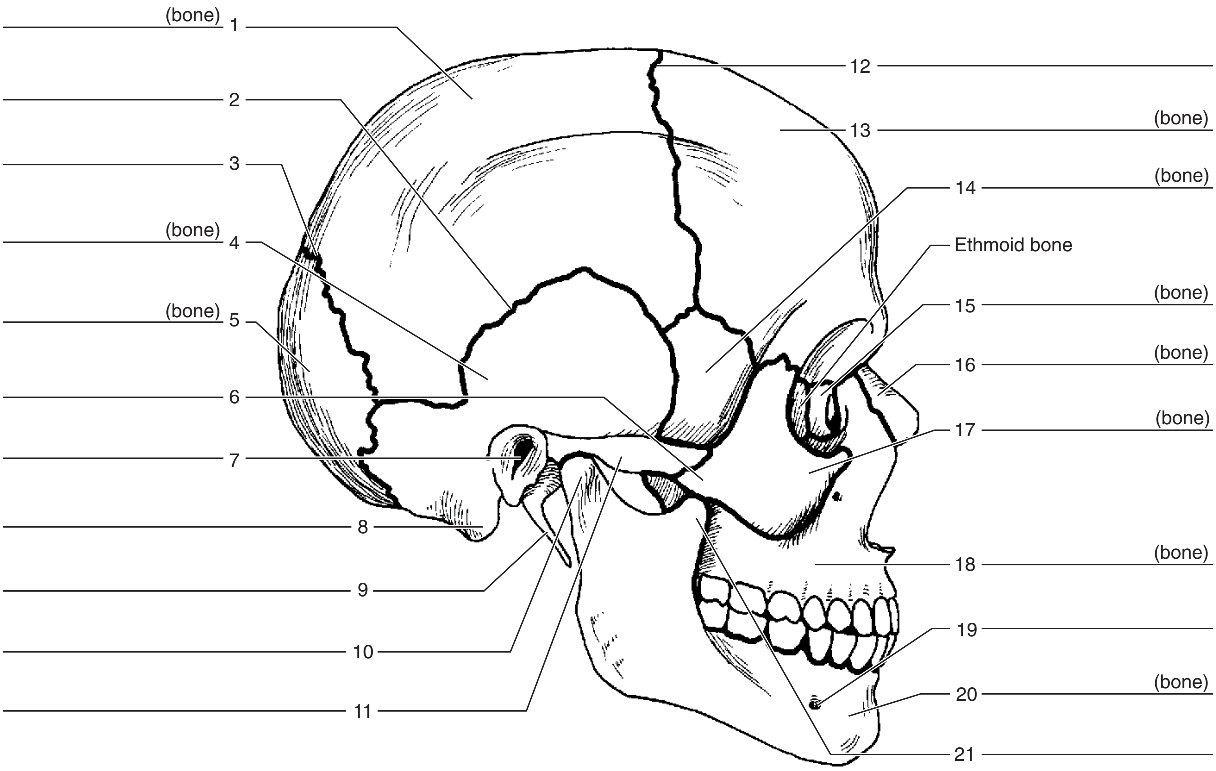


Figure 13.3 Label the inferior bones and features of the skull.

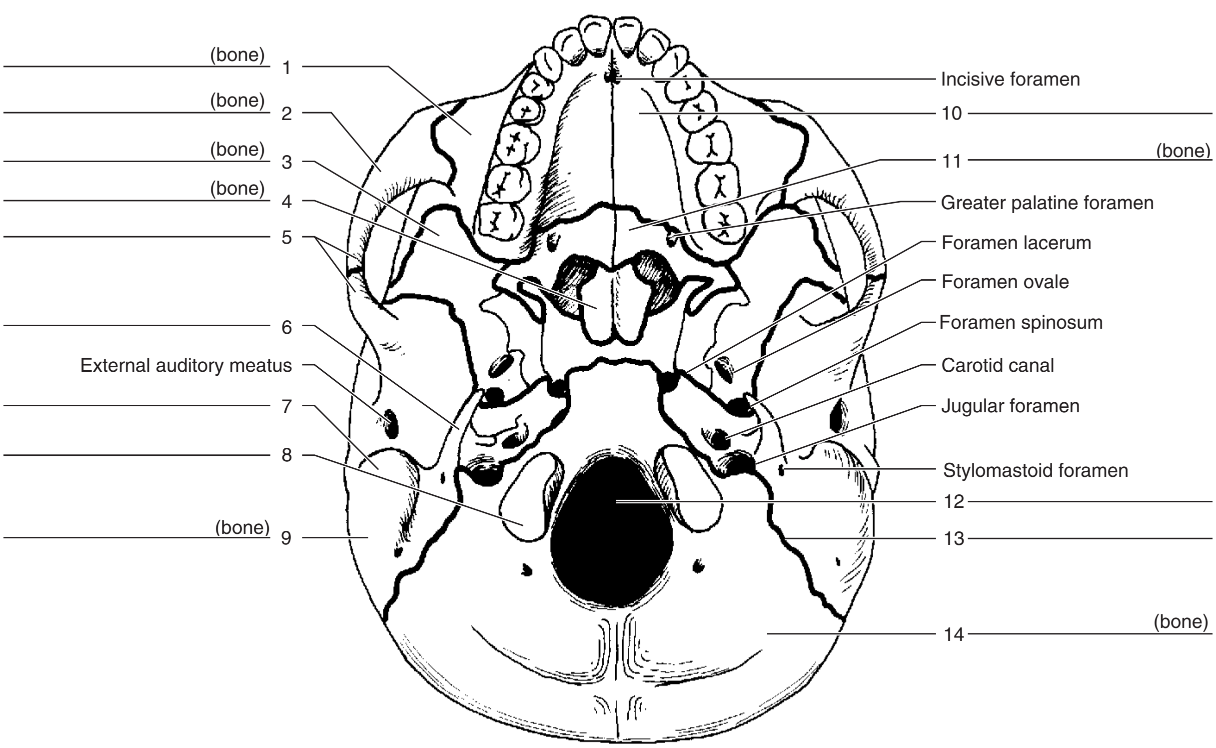
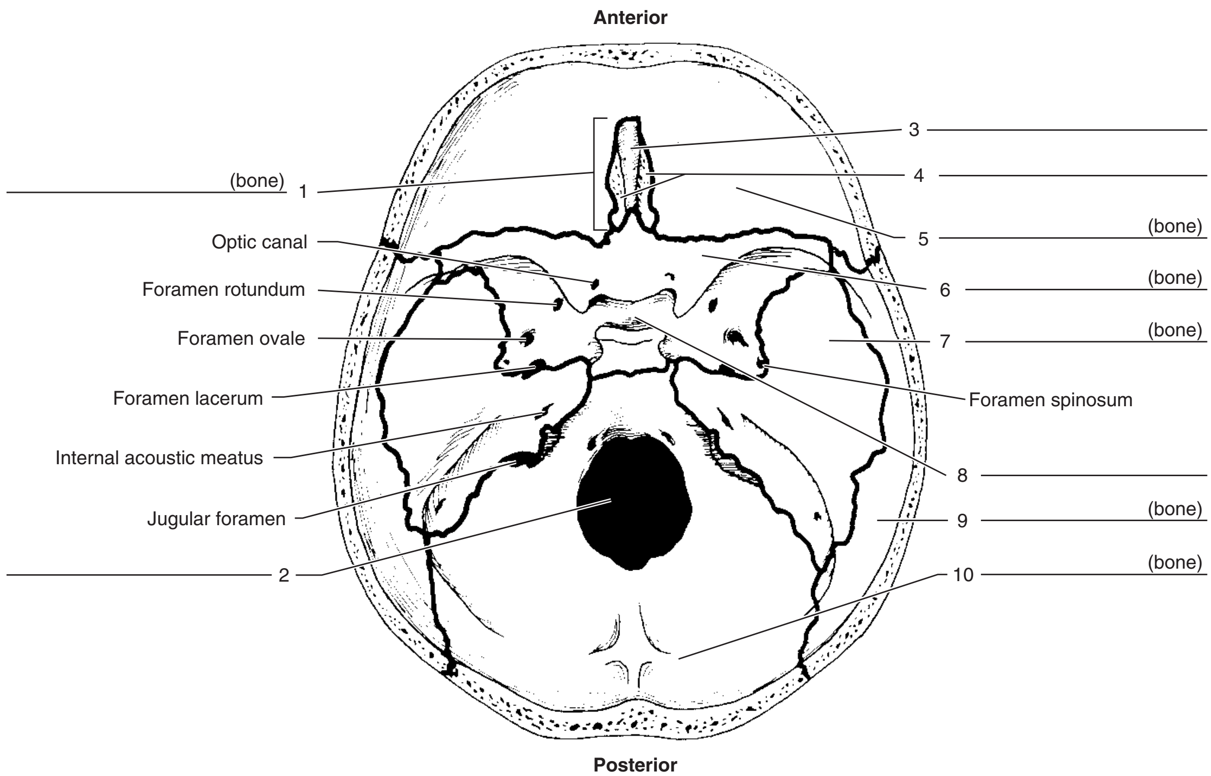


Figure 13.4 Label the bones and features of the floor of the cranial cavity.



foramen magnum
foramen ovale
foramen rotundum
foramen spinosum
greater palatine foramen
hypoglossal canal
incisive foramen
inferior orbital fissure
infraorbital foramen
internal acoustic meatus
jugular foramen
mandibular foramen
mental foramen
optic canal
stylomastoid foramen
superior orbital fissure
supraorbital foramen

8. Complete Parts D and E of the laboratory report.

DEMONSTRATION

Examine the fetal skull (fig. 13.6). Note that the skull is incompletely developed and that the cranial bones are separated by fibrous membranes. These membranous areas are called fontanels, or "soft spots." The fontanels close as the cranial bones grow together. The posterior fontanel usually closes within a few months after birth, whereas the anterior fontanel may not close until the middle or end of the second year. What other features characterize the fetal skull? ________________

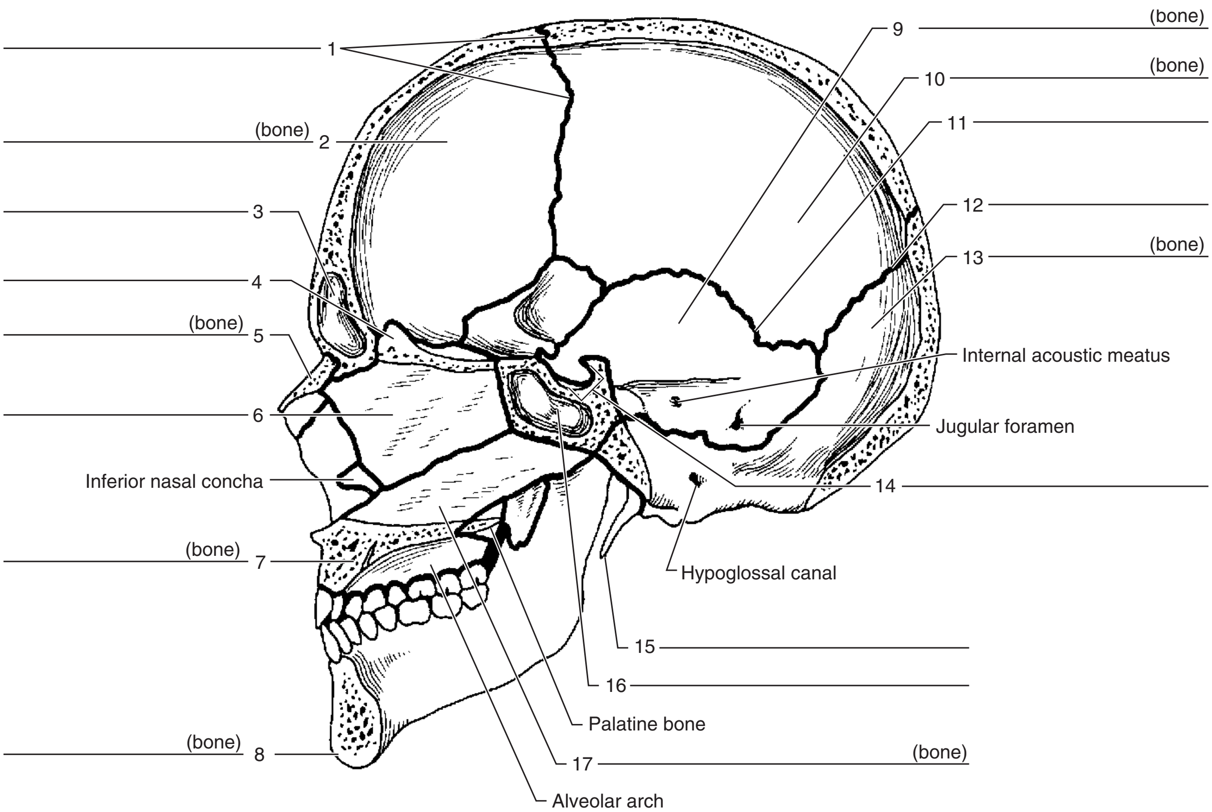
____

____

____

____

Figure 13.5 Label the bones and features of the sagittal section of the skull.



Critical Thinking Application

Explain how a severe blow under the nose could result in brain damage or death.

Web Quest

What are the functions of individual bones and features? Search these and review the anatomy of the skeleton at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

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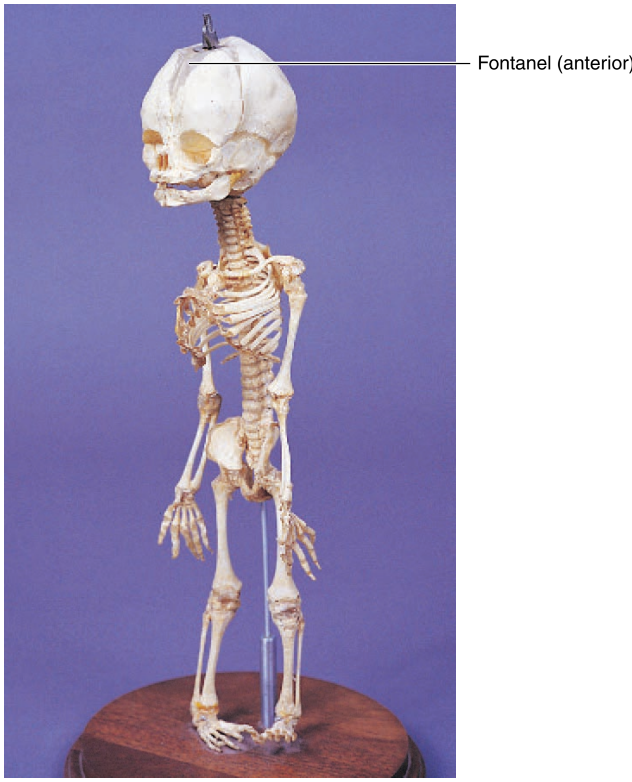
Figure 13.6 Human fetal skeleton.



Laboratory Report 13

Name ____________________

Date ____________________

Section ____________________

THE SKULL

Part A

Match the bones in column A with the features in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. ethmoid bone	____	1. forms sagittal, coronal, squamosal, and lambdoidal sutures
b. frontal bone	____	2. cribriform plate
c. occipital bone	____	3. crista galli
d. parietal bone	____	4. external auditory meatus
e. sphenoid bone	____	5. foramen magnum
f. temporal bone	____	6. mandibular fossa
	____	7. mastoid process
	____	8. middle nasal concha
	____	9. occipital condyle
	____	10. sella turcica
	____	11. styloid process
	____	12. supraorbital foramen

Part B

Complete the following statements:

1. The ____________________ suture joins the frontal bone to the parietal bones.
2. The parietal bones are firmly interlocked along the midline by the ____________________ suture.
3. The ____________________ suture joins the parietal bones to the occipital bone.
4. The temporal bones are joined to the parietal bones along the ____________________ sutures.
5. Name the three cranial bones that contain sinuses. ____________________

   ____
6. Name a facial bone that contains a sinus. ____________________

Part C

Match the bones in column A with the characteristics in column B. Place the letter of your choice in the space provided.

Column A

a. inferior nasal concha
b. lacrimal bone
c. mandible
d. maxillary bone
e. nasal bone
f. palatine bone
g. vomer bone
h. zygomatic bone

Column B

____ 1. forms bridge of nose
____ 2. only movable bone in the facial skeleton
____ 3. contains coronoid process
____ 4. creates prominence of cheek inferior and lateral to the eye
____ 5. contains sockets of upper teeth
____ 6. forms inferior portion of nasal septum
____ 7. forms anterior portion of zygomatic arch
____ 8. scroll-shaped bone
____ 9. forms anterior roof of mouth
____ 10. contains mental foramen
____ 11. forms posterior roof of mouth
____ 12. scalelike part in medial wall of orbit

Part D

Match the passageways in column A with the structures transmitted through them in column B. Place the letter of your choice in the space provided.

Column A

a. foramen magnum
b. foramen ovale
c. foramen rotundum
d. incisive foramen
e. internal acoustic meatus
f. jugular foramen
g. optic canal

Column B

____ 1. maxillary division of trigeminal nerve
____ 2. nerve fibers of spinal cord
____ 3. optic nerve
____ 4. vagus and accessory nerves
____ 5. nasopalatine nerves
____ 6. mandibular division of trigeminal nerve
____ 7. vestibular and cochlear nerves

Part E

Identify the numbered bones and features of the skulls indicated in figures 13.7, 13.8, 13.9, and 13.10.

Figure 13.7 Identify the bones and features indicated on this sagittal section of a skull.

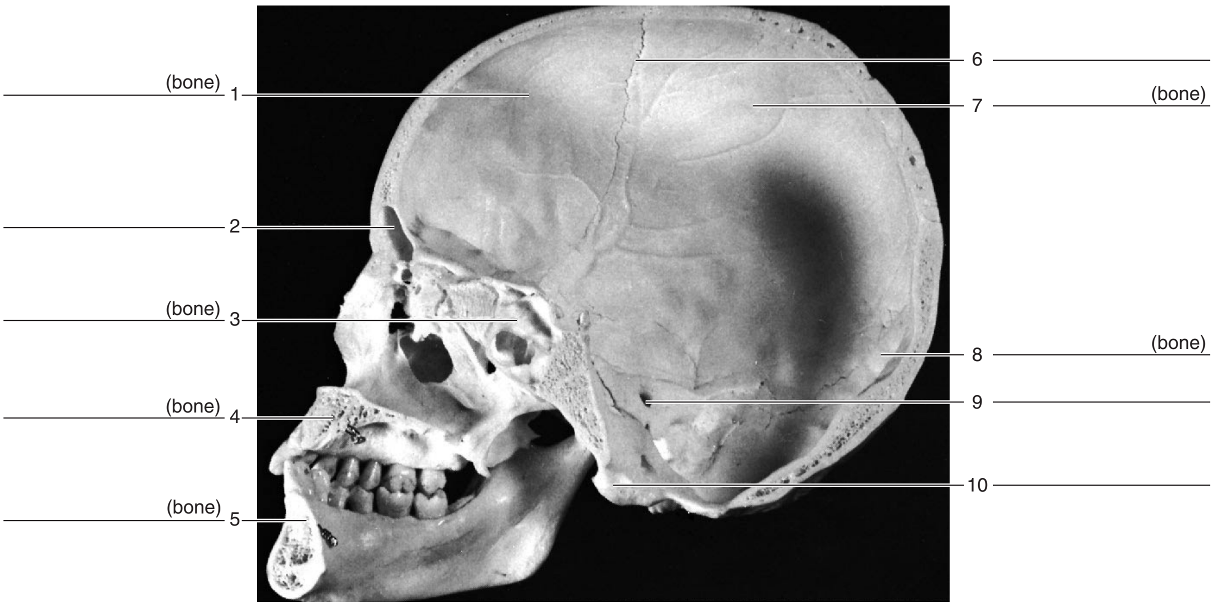


Figure 13.8 Identify the bones and features on this floor of the cranial cavity of a skull.

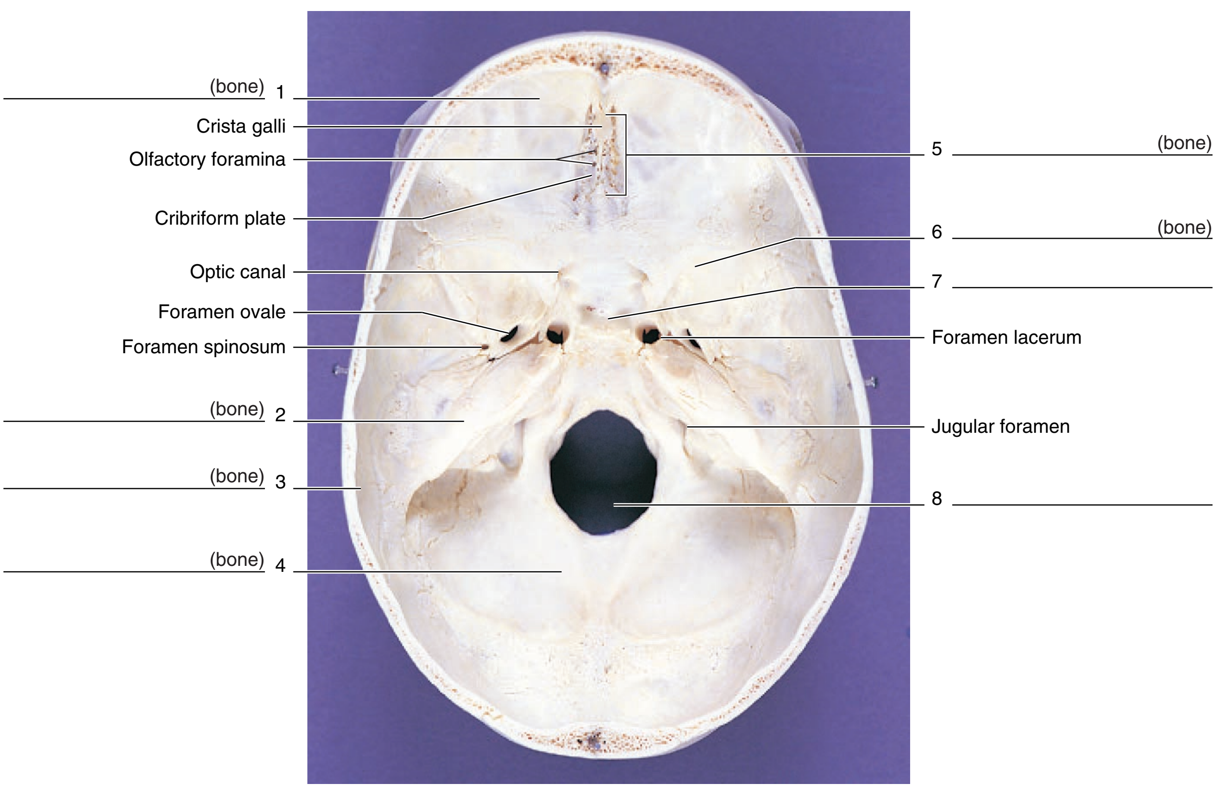


Figure 13.9 Identify the bones and features indicated on this inferior view of the skull.

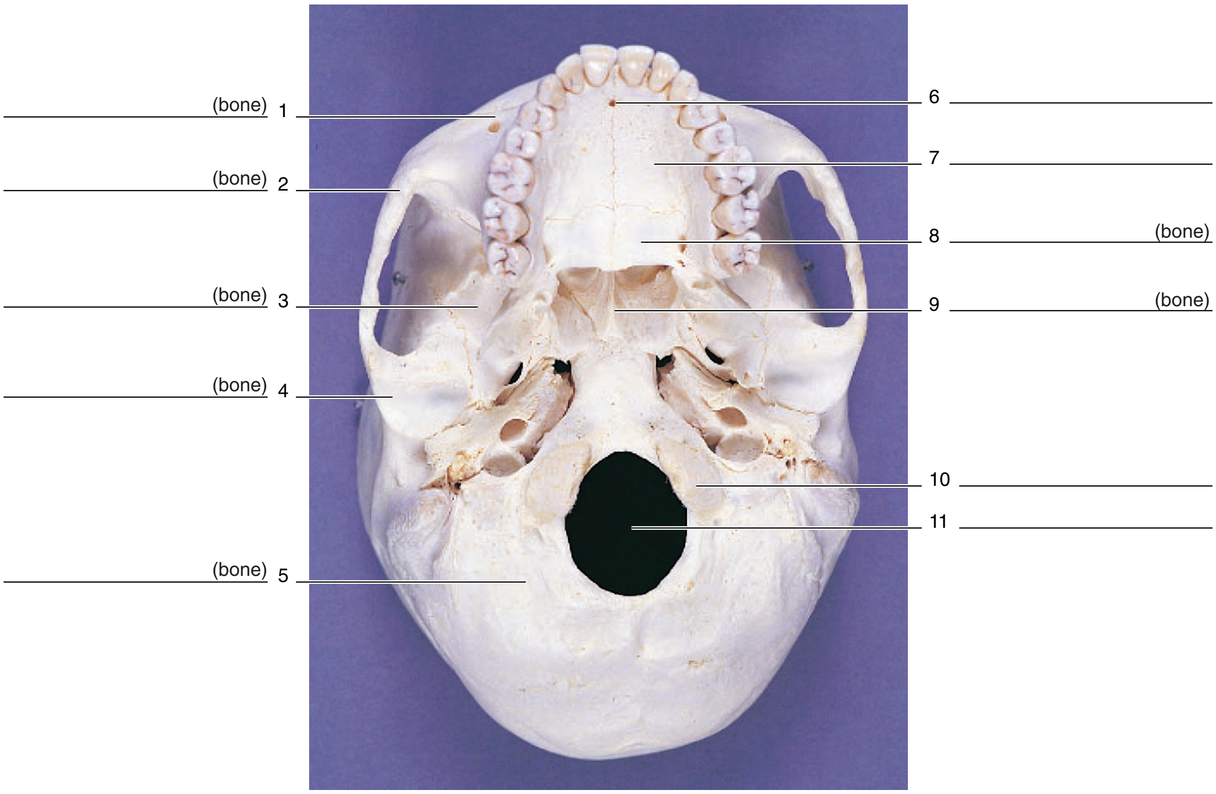
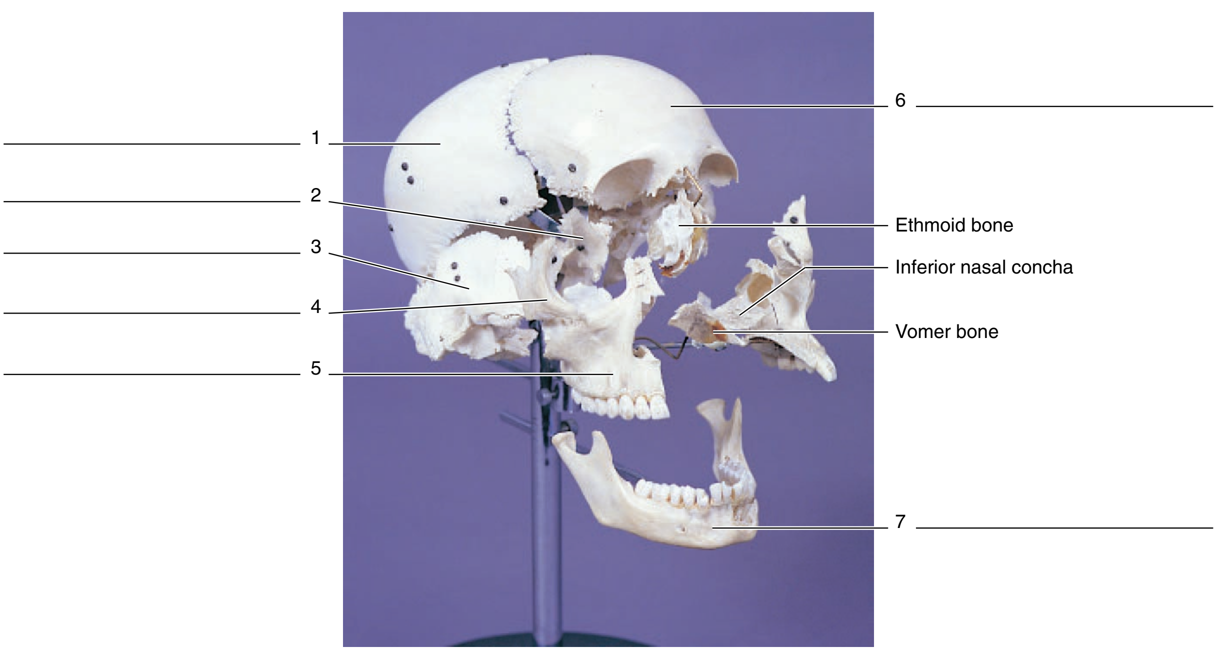


Figure 13.10 Identify the bones on this disarticulated skull.



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Laboratory Exercise 14

Vertebral Column and Thoracic Cage

MATERIALS NEEDED

textbook
human skeleton, articulated
samples of cervical, thoracic, and lumbar vertebrae
human skeleton, disarticulated

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 column is composed of many vertebrae, which are separated from one another by cartilaginous intervertebral disks 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.

PURPOSE OF THE EXERCISE

To examine the vertebral column and the thoracic cage of the human skeleton, and to identify the bones and major features of these parts.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major features of the vertebral column;
2. name the features of a typical vertebra;
3. distinguish between a cervical, thoracic, and lumbar vertebra, and locate the sacrum and coccyx;
4. identify the structures of the thoracic cage;
5. distinguish between true and false ribs.

PROCEDURE A—THE VERTEBRAL COLUMN

1. Review a textbook section on the *vertebral column.*
2. As a review activity, label figures 14.1, 14.2, 14.3, and 14.4.
3. Examine the vertebral column of the human skeleton and locate the following bones and features. At the same time, locate as many of the corresponding bones and features in your own skeleton as possible.

   atlas

   axis

   cervical vertebrae

   thoracic vertebrae

   lumbar vertebrae

   intervertebral disks

   vertebral canal

   sacrum

   coccyx

   cervical curvature

   thoracic curvature

   lumbar curvature

   pelvic curvature

   intervertebral foramina

Critical Thinking Application

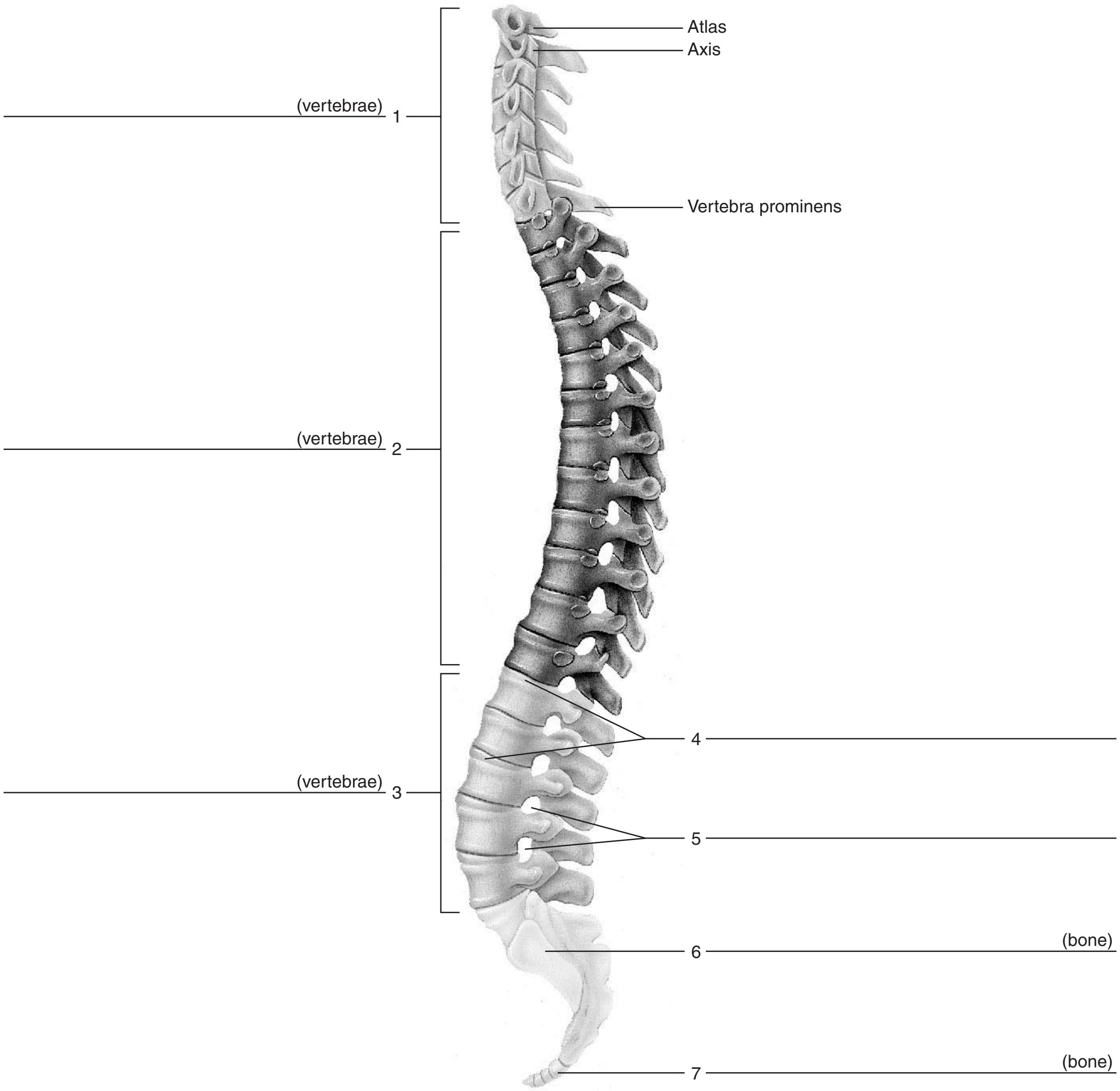
Note the four curvatures of the vertebral column. What functional advantages exist with curvatures for skeletal structure instead of a straight vertebral column?

4. Compare the available samples of cervical, thoracic, and lumbar vertebrae by noting differences in size, shapes, and by locating the following:

   body

   pedicles

Figure 14.1 Label the bones and features of the vertebral column.



vertebral foramen

laminae

spinous process

vertebral arch

transverse processes

facets

superior articulating processes

inferior articulating processes

transverse foramina

vertebra prominens (spinous process of seventh cervical vertebra)

dens of axis

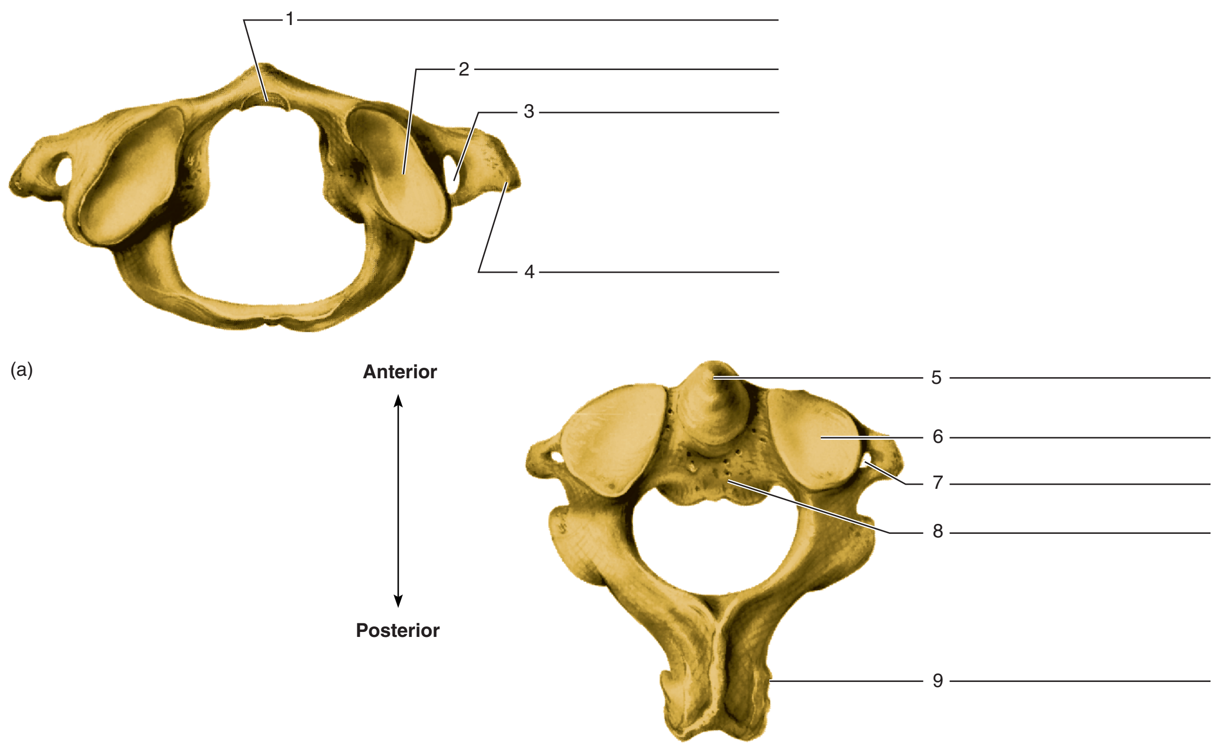
5. Examine the sacrum and coccyx. Locate the following features:

sacrum

superior articulating process

dorsal sacral foramen

Figure 14.2 Label the superior features of (*a*) the atlas and (*b*) the axis.



(b)

pelvic (ventral) sacral foramen

sacral promontory

sacral canal

tubercles

sacral hiatus

coccyx

6. Complete Parts A and B of Laboratory Report 14.

PROCEDURE B— THE THORACIC CAGE

1. Review a textbook section on the *thoracic cage.*
2. As a review activity, label figures 14.5 and 14.6.
3. Examine the thoracic cage of the human skeleton and locate the following bones and features:

rib

head

tubercle

neck

shaft

anterior (sternal) end

facets

true ribs

false ribs

floating ribs

costal cartilages

sternum

sternal notch

clavicular notch

manubrium

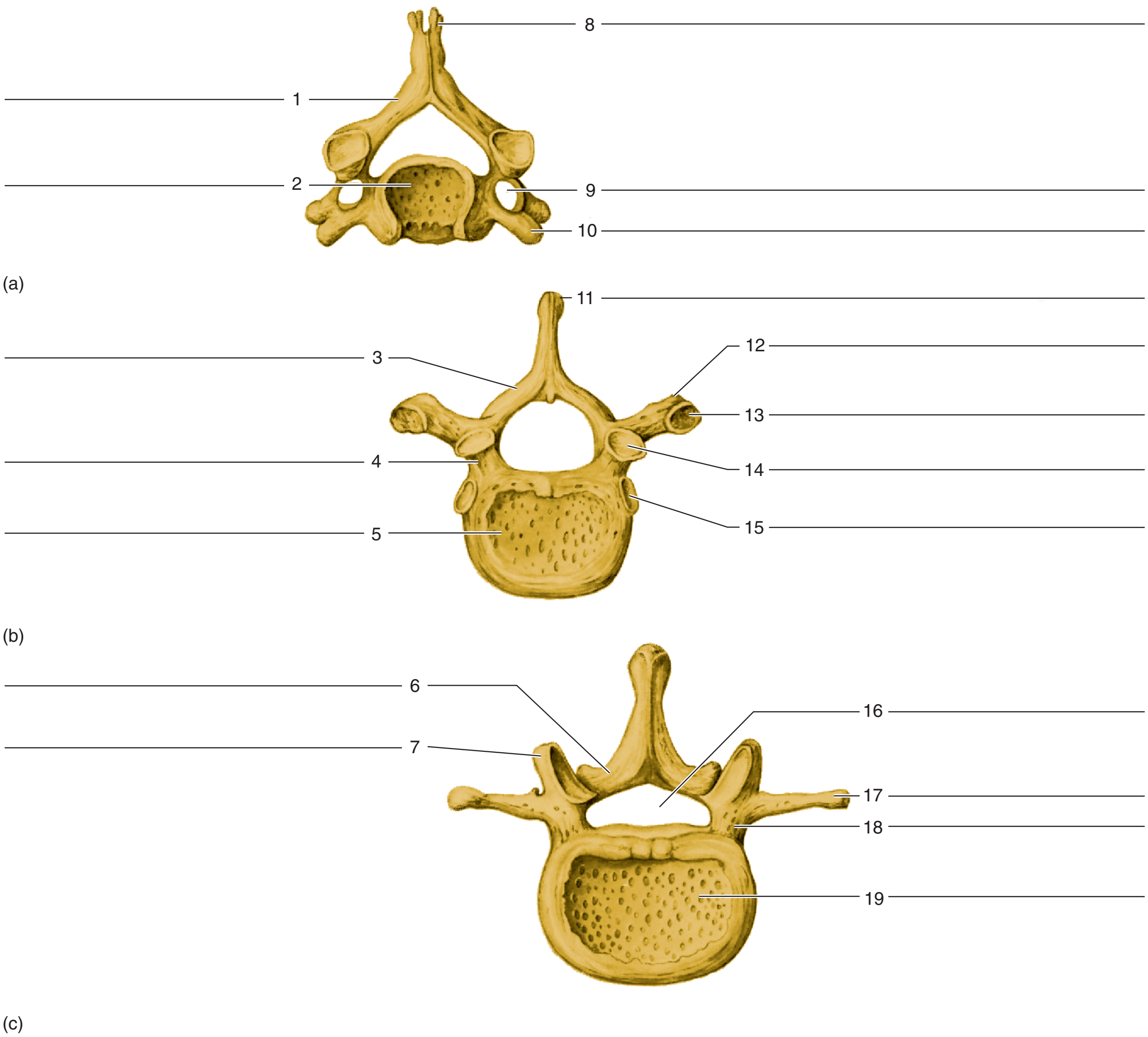
body

xiphoid process

sternal angle

4. Complete Parts C and D of the laboratory report.

Figure 14.3 Label the features of the (*a*) cervical, (*b*) thoracic, and (*c*) lumbar vertebrae.



Web Quest

What are the functions of individual bones and features? Search these and review the anatomy of the skeleton at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 14.4 Label the features of the sacrum: (*a*) anterior view; (*b*) posterior view.

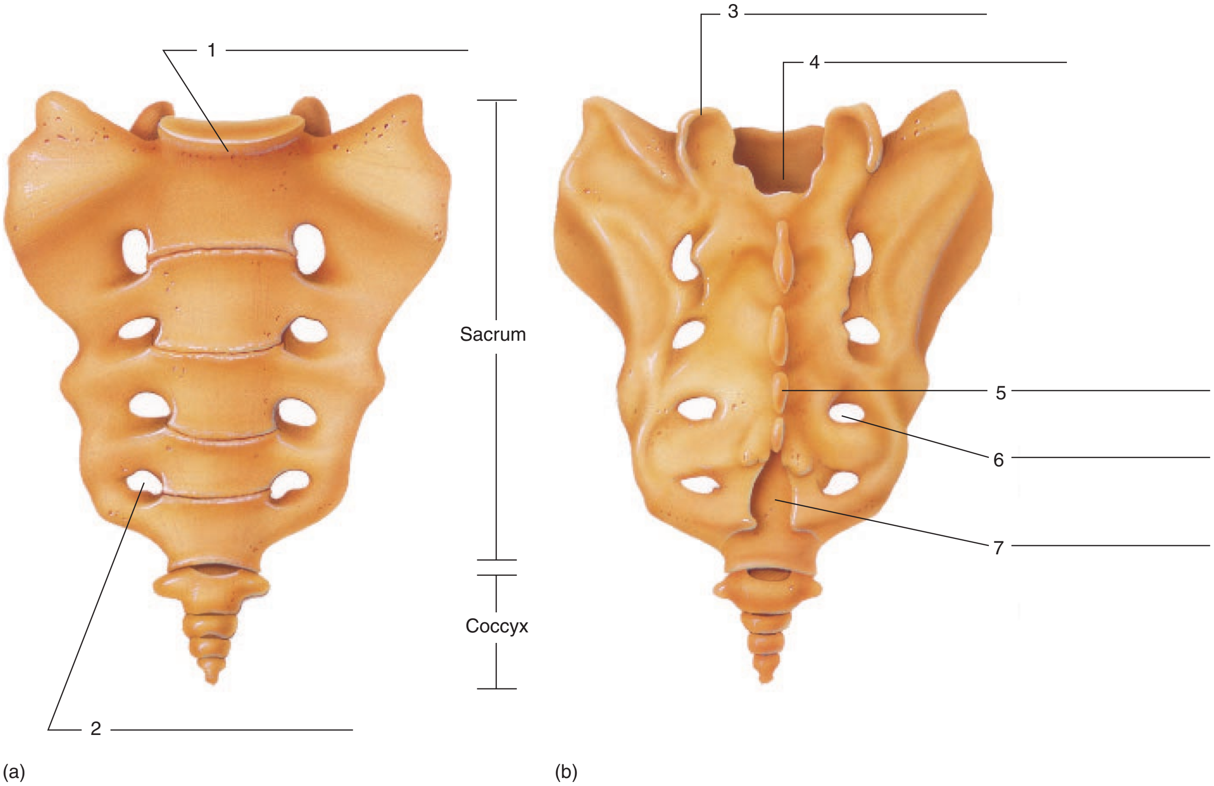


Figure 14.5 Label the bones and features of the thoracic cage.

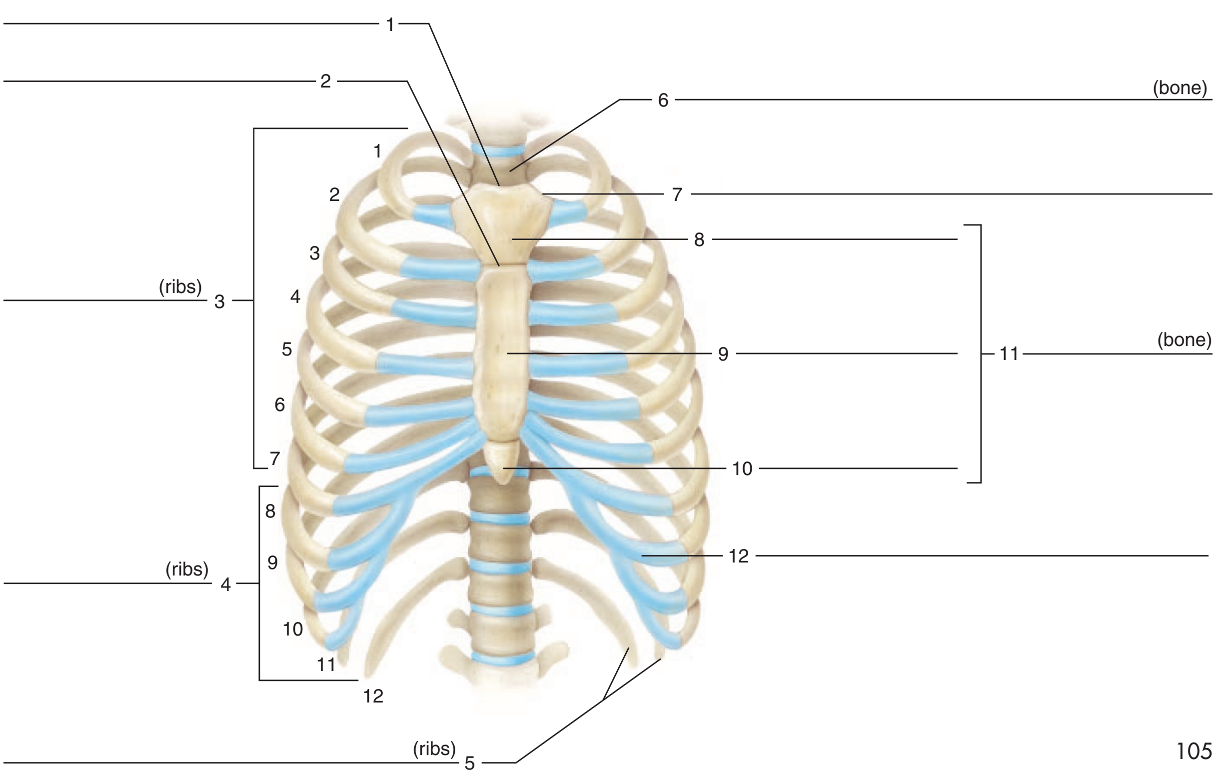
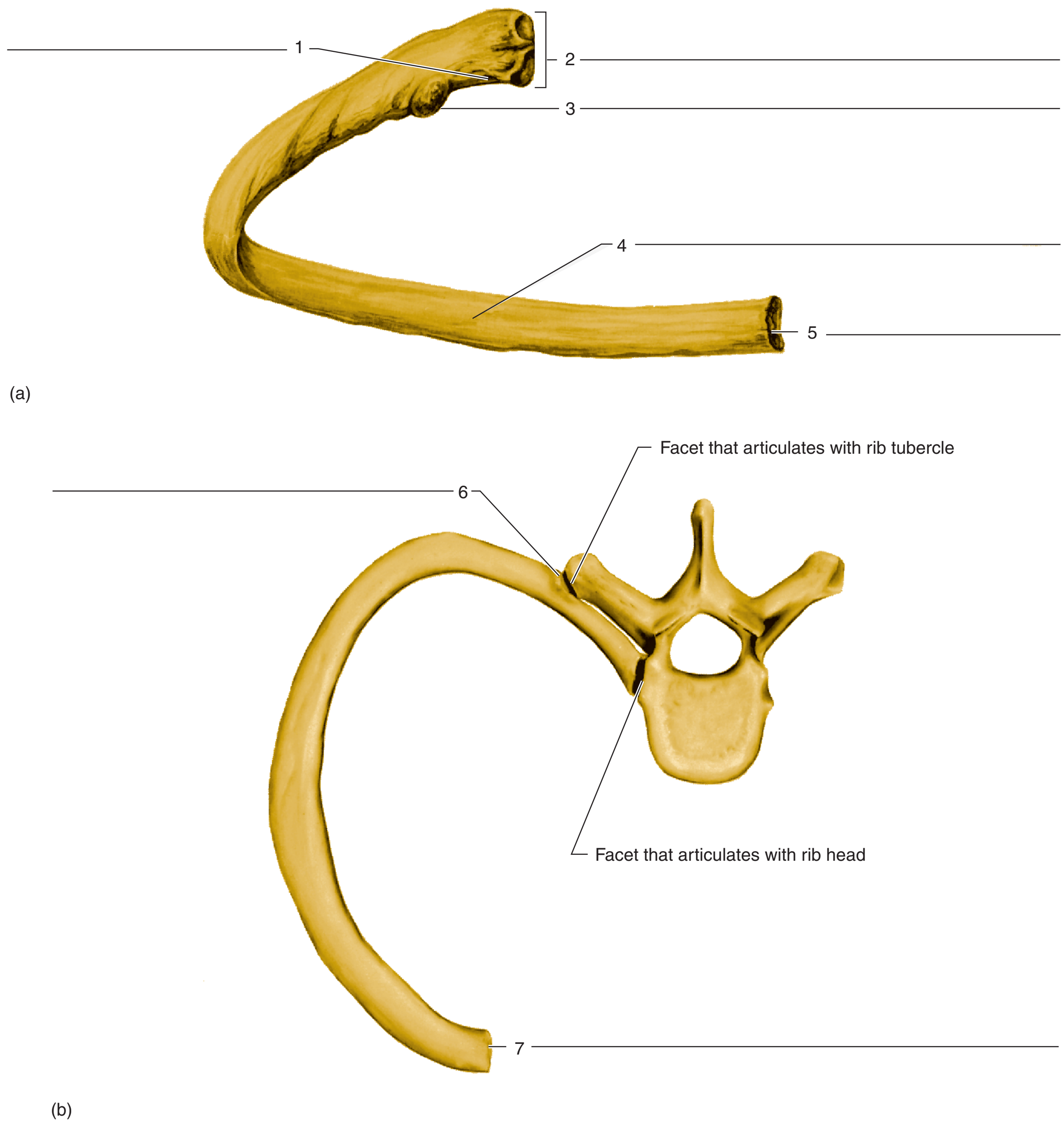


Figure 14.6 Label the features of the ribs: (*a*) posterior view; (*b*) superior view showing articulations with a thoracic vertebra.



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Laboratory Report **14**

Name ______________________________

Date ______________________________

Section ______________________________

Vertebral Column and Thoracic Cage

Part A

Complete the following statements:

1. The vertebral column encloses and protects the ______________________.
2. The number of separate bones in the vertebral column of an adult is ______________________.
3. The spinous process of the seventh cervical vertebra is called the ______________________ and is an obvious surface feature that can be palpated.
4. The ______________________ of the vertebrae support the weight of the head and trunk.
5. The ______________________ separate adjacent vertebrae, and they soften the forces created by walking.
6. The pedicles, laminae, and ______________________ of a vertebra form the vertebral arch.
7. The intervertebral foramina provide passageways for ______________________.
8. Transverse foramina of cervical vertebrae serve as passageways for ______________________ leading to the brain.
9. The first vertebra also is called the ______________________.
10. When the head is moved from side to side, the first vertebra pivots around the ______________________ of the second vertebra.
11. The ______________________ vertebrae have the largest and strongest bodies.
12. The number of vertebrae that fuse to form the sacrum is ______________________.
13. The joint between a coxal bone of the pelvis and the sacrum is called the ______________________ joint.
14. The upper, anterior margin of the sacrum that projects forward is called the ______________________.
15. An opening called the ______________________ exists at the tip of the sacral canal.

Part B

Based on your observations, compare typical cervical, thoracic, and lumbar vertebrae in relation to the characteristics indicated in the table.

Vertebra	Number	Size	Body	Spinous Process	Transverse Foramina
Cervical					
Thoracic					
Lumbar					

Part C

Complete the following statements:

1. The adult skeleton of most men and women contains a total number of ________________________ bones.
2. The last two pairs of ribs that have no cartilaginous attachments to the sternum are sometimes called ________________________ ribs.
3. The tubercles of the ribs articulate with the ________________________ processes of the thoracic vertebrae.
4. Costal cartilages are composed of ________________________ tissue.
5. The manubrium articulates with the ________________________ on its superior border.
6. List three general functions of the thoracic cage. ____

____

Part D

Identify the bones and features indicated in the radiograph (X ray) of the neck in figure 14.7.

Figure 14.7 Identify the bones and features indicated in this radiograph (X ray) of the neck (lateral view).

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Laboratory Exercise 15

Pectoral Girdle and Upper Limb

MATERIALS NEEDED

textbook
human skeleton, articulated
human skeleton, disarticulated

For Optional Activity:

colored pencils

The pectoral girdle consists of two clavicles and two scapulae. These parts function to support the upper limbs and to serve as attachments for various muscles that move these limbs.

Each upper limb includes a humerus, radius, ulna, and several carpals, metacarpals, and phalanges. These bones form the framework of the arm, forearm, and hand. They also function as parts of levers when the limbs are moved.

PURPOSE OF THE EXERCISE

To examine the bones of the pectoral girdle and upper limb, and to identify the major features of these bones.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the bones of the pectoral girdle and their major features;
2. locate and identify the bones of the upper limb and their major features.

PROCEDURE A—THE PECTORAL GIRDLE

1. Review a textbook section on the *pectoral girdle.*
2. As a review activity, label figures 15.1 and 15.2.
3. Examine the bones of the pectoral girdle and locate the following features. At the same time, locate as many of the corresponding surface bones and features of your own skeleton as possible.

   clavicle

   medial (sternal) end

   lateral (acromial) end

   scapula

   spine

   lateral (axillary) border

   medial (vertebral) border

   superior border

   acromion process

   coracoid process

   glenoid cavity (fossa)

   supraspinous fossa

   infraspinous fossa

Critical Thinking Application

Why is a clavicle a bone that can easily fracture?

4. Complete Part A of Laboratory Report 15.

PROCEDURE B—THE UPPER LIMB

1. Review a textbook section on the *upper limb.*
2. As a review activity, label figures 15.3, 15.4, 15.5, and 15.6.
3. Examine the following bones and features of the upper limb:

   humerus

   head

   greater tubercle

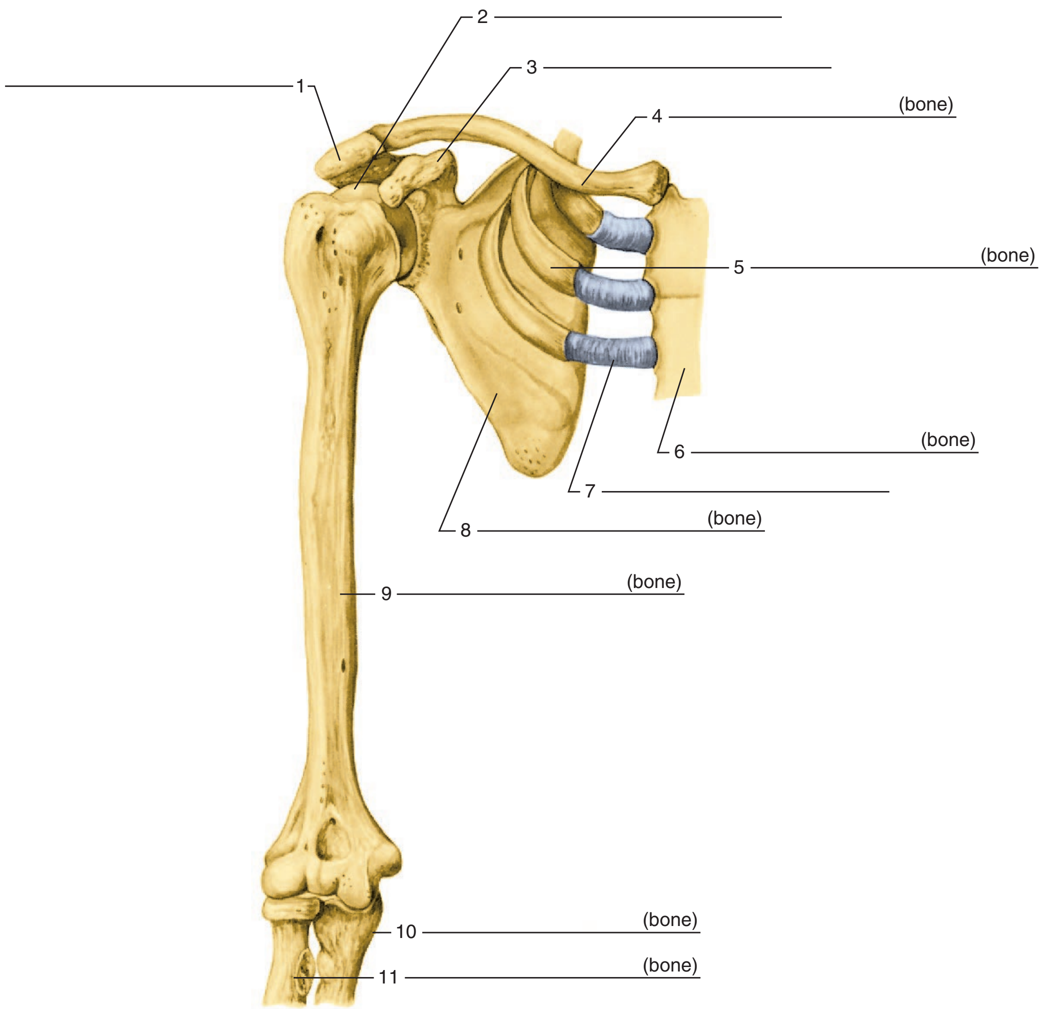
   lesser tubercle

   intertubercular groove

   anatomical neck

   surgical neck

Figure 15.1 Label the bones and features of the shoulder and upper limb (anterior view).



deltoid tuberosity

capitulum

trochlea

medial epicondyle

lateral epicondyle

coronoid fossa

olecranon fossa

radius

head

radial tuberosity

styloid process

ulnar notch

ulna

trochlear notch (semilunar notch)

radial notch

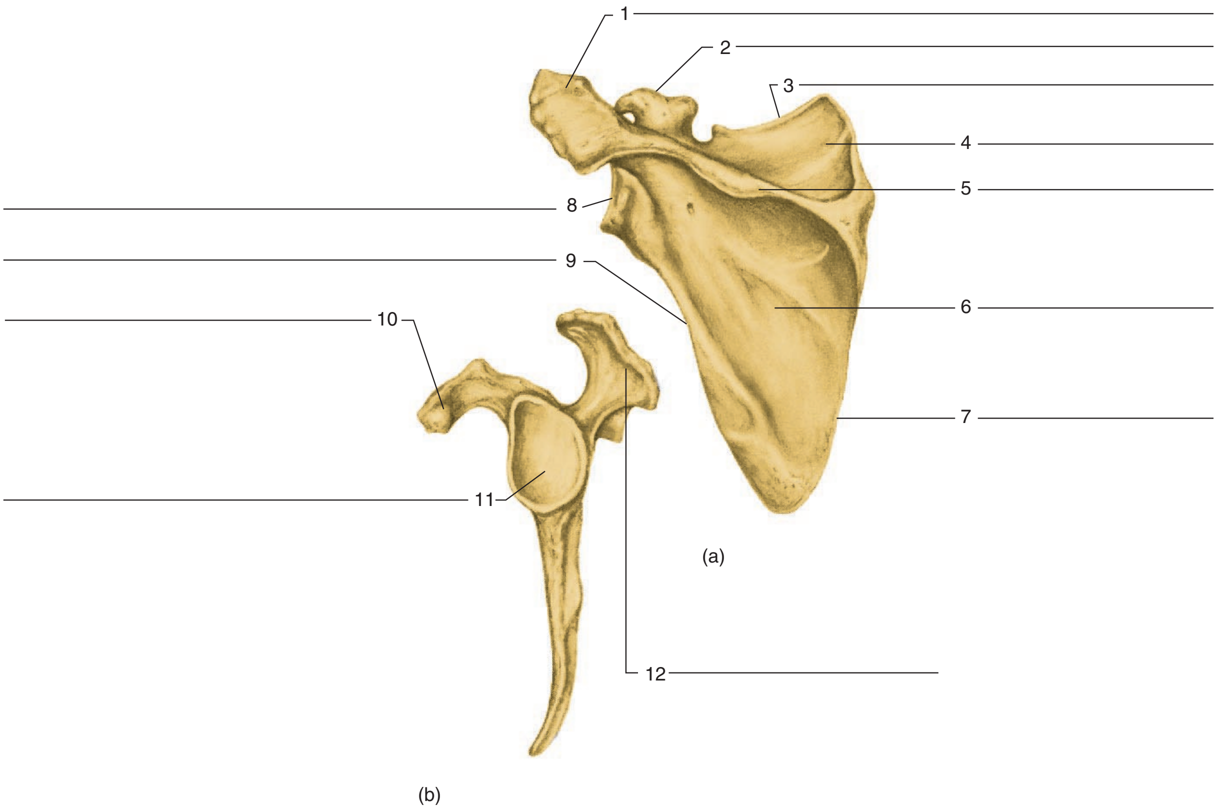
olecranon process

coronoid process

styloid process

head

Figure 15.2 Label (*a*) the posterior surface of the left scapula and (*b*) the lateral aspect of the left scapula.



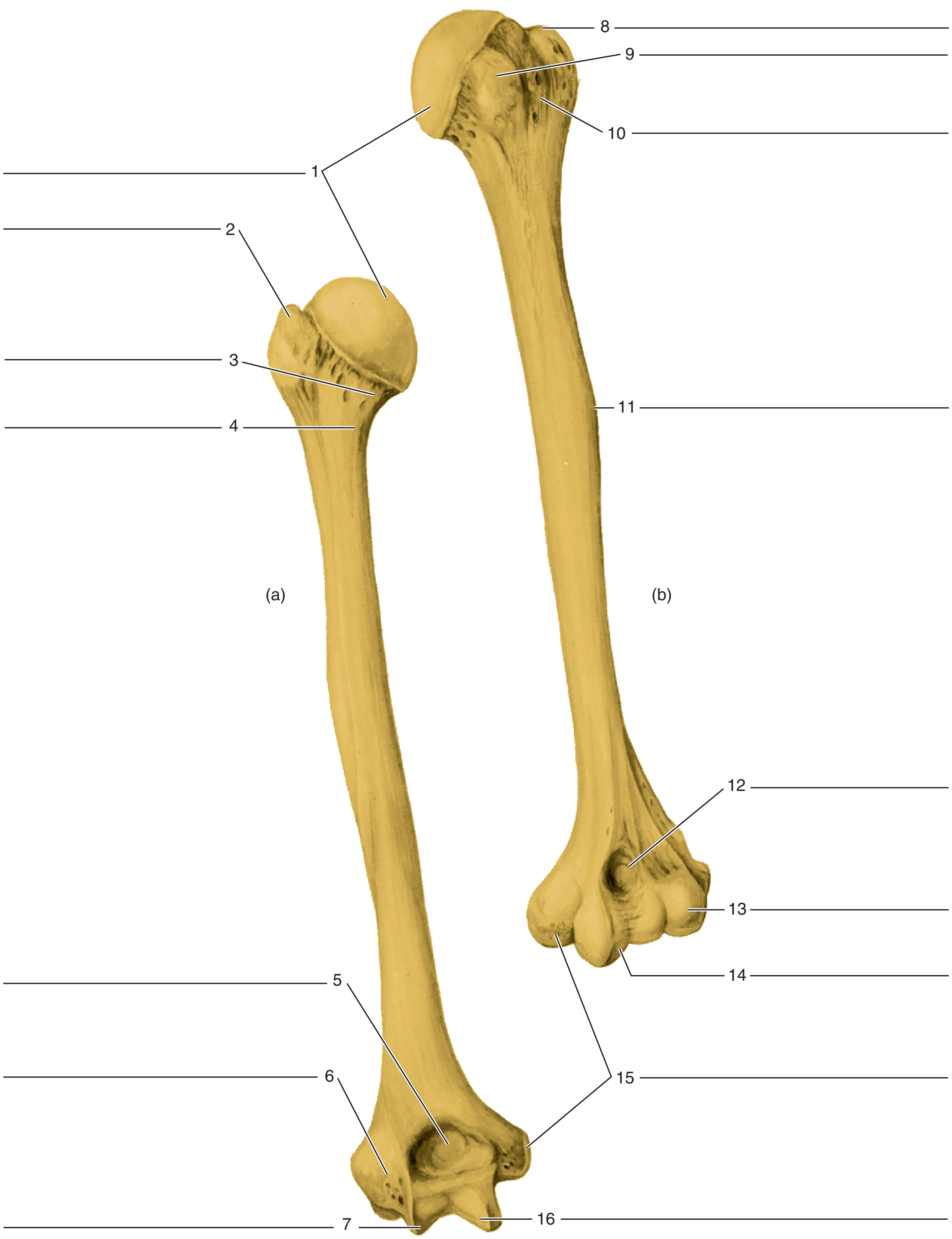


Figure 15.3 Label the (*a*) posterior surface and (*b*) anterior surface of the left humerus.

Figure 15.4 Label the major features of the radius and ulna.

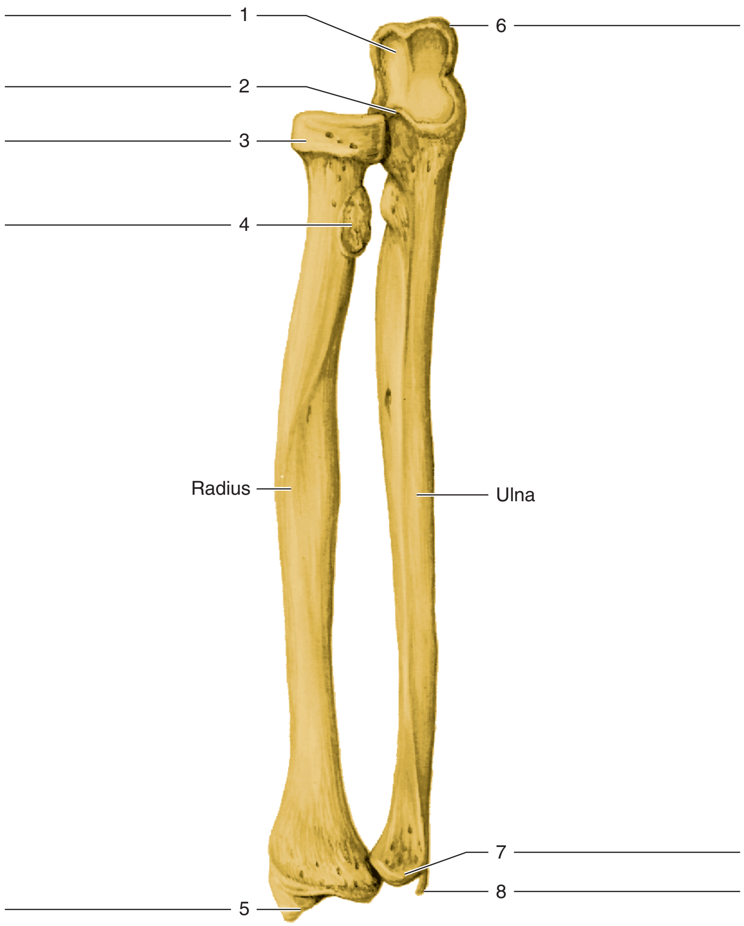


Figure 15.5 Label the bones and features of the right elbow, posterior view.

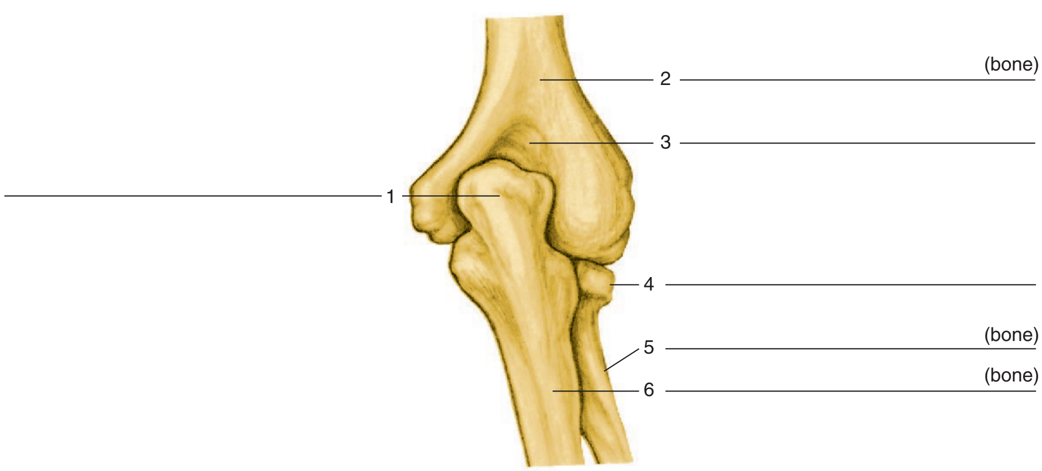
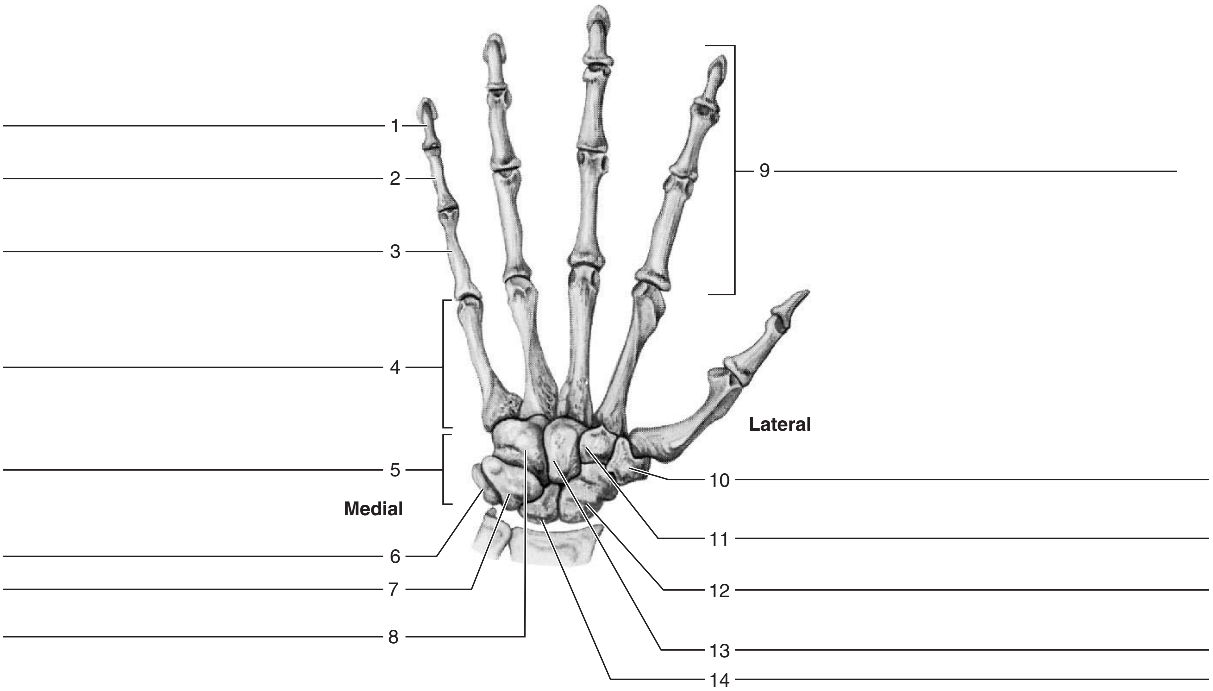


Figure 15.6 Label the bones and groups of bones in this posterior view of the left hand.



carpal bones

proximal row (listed lateral to medial)

scaphoid

lunate

triquetrum

pisiform

distal row (listed medial to lateral)

hamate

capitate

trapezoid

trapezium

The following mnemonic device will help you learn the eight carpals:

So **L**ong **T**op **P**art
Here **C**omes **T**he **T**humb

The first letter of each word corresponds to the first letter of a carpal. Notice that this device arranges the carpals in order for the proximal, transverse row of four bones from lateral to medial, followed by the distal, transverse row from medial to lateral, which ends nearest the thumb. This arrangement assumes the hand is in the anatomical position.

---

metacarpal bones phalanges

proximal phalanx

middle phalanx

distal phalanx

4. Complete Parts B and C of the laboratory report.

OPTIONAL ACTIVITY

Use different colored pencils to distinguish the individual bones in figure 15.6

Web Quest

What are the functions of individual bones and features? Search these and review the anatomy of the skeleton at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report **15**

Name ______________________________

Date ______________________________

Section ______________________________

Pectoral Girdle and Upper Limb

Part A

Complete the following statements:

1. The pectoral girdle is an incomplete ring because it is open in the back between the ________________________.
2. The medial ends of the clavicles articulate with the ________________________ of the sternum.
3. The lateral ends of the clavicles articulate with the ________________________ of the scapulae.
4. The ________________________ is a bone that serves as a brace between the sternum and the scapula.
5. The ________________________ divides the scapula into unequal portions.
6. The tip of the shoulder is the ________________________ of the scapula.
7. At the lateral end of the scapula, the ________________________ curves anteriorly and inferiorly from the clavicle.
8. The glenoid cavity of the scapula articulates with the ________________________ of the humerus.

Part B

Match the bones in column A with the bones and features in column B. Place the letter of your choice in the space provided.

Column A

a. carpals
b. humerus
c. metacarpals
d. phalanges
e. radius
f. ulna

Column B

____ 1. capitate
____ 2. capitulum
____ 3. coronoid fossa
____ 4. five palmar bones
____ 5. fourteen bones in digits
____ 6. intertubercular groove
____ 7. lunate
____ 8. olecranon fossa
____ 9. radial notch
____ 10. radial tuberosity
____ 11. trapezium
____ 12. triquetrum
____ 13. trochlea
____ 14. trochlear notch
____ 15. ulnar notch

Part C

Identify the bones and features indicated in the radiographs (X rays) of figures 15.7, 15.8, and 15.9.

Figure 15.7 Identify the bones and features indicated on this radiograph of the elbow.

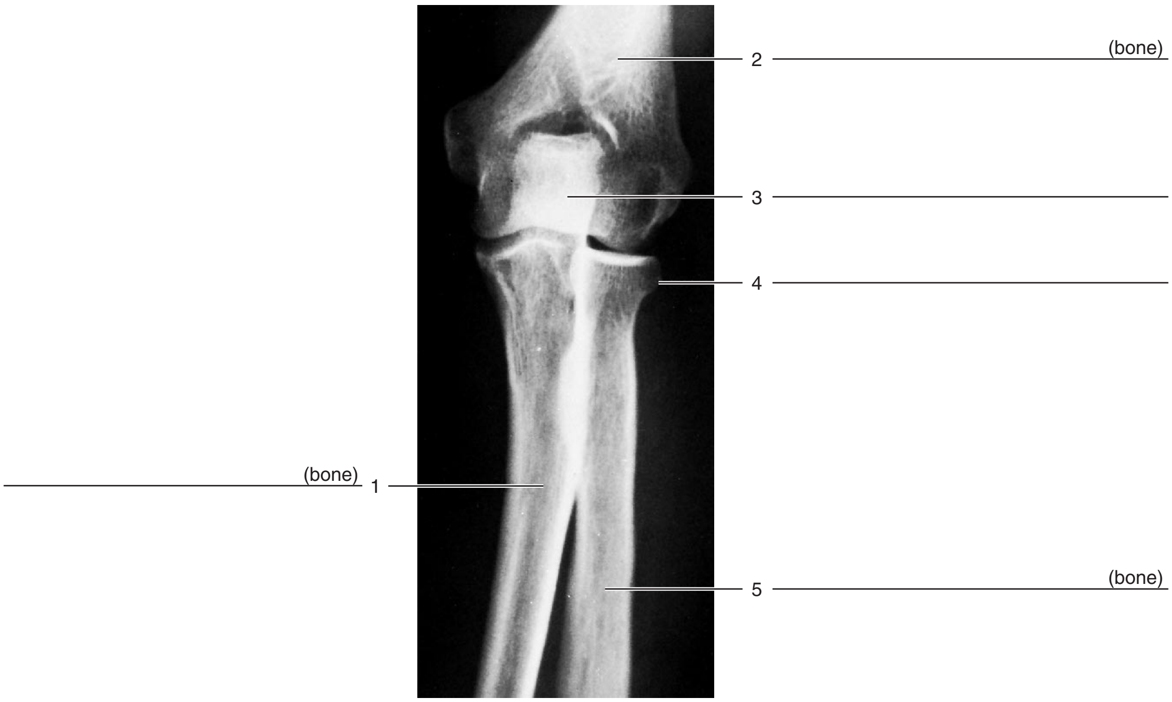


Figure 15.8 Identify the bones and features indicated on this radiograph of the shoulder.

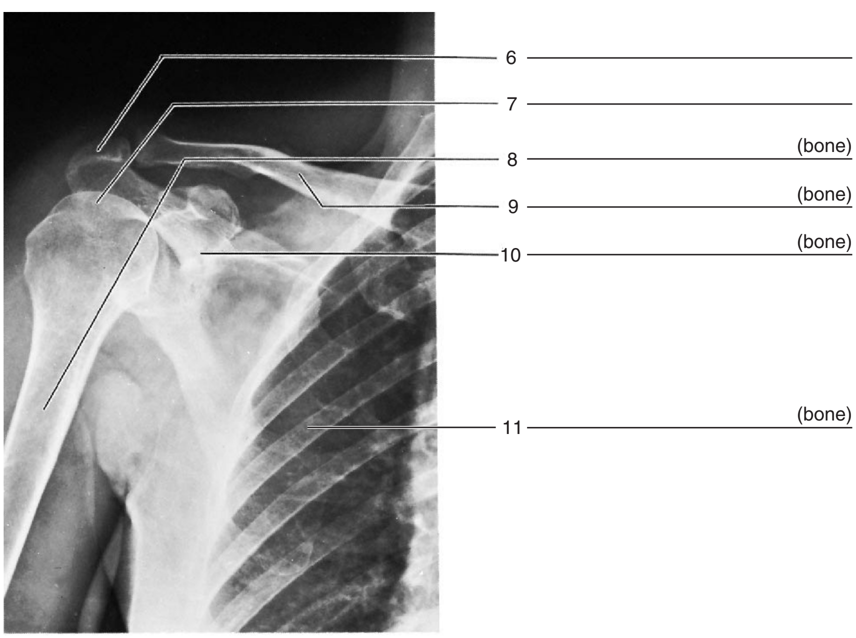
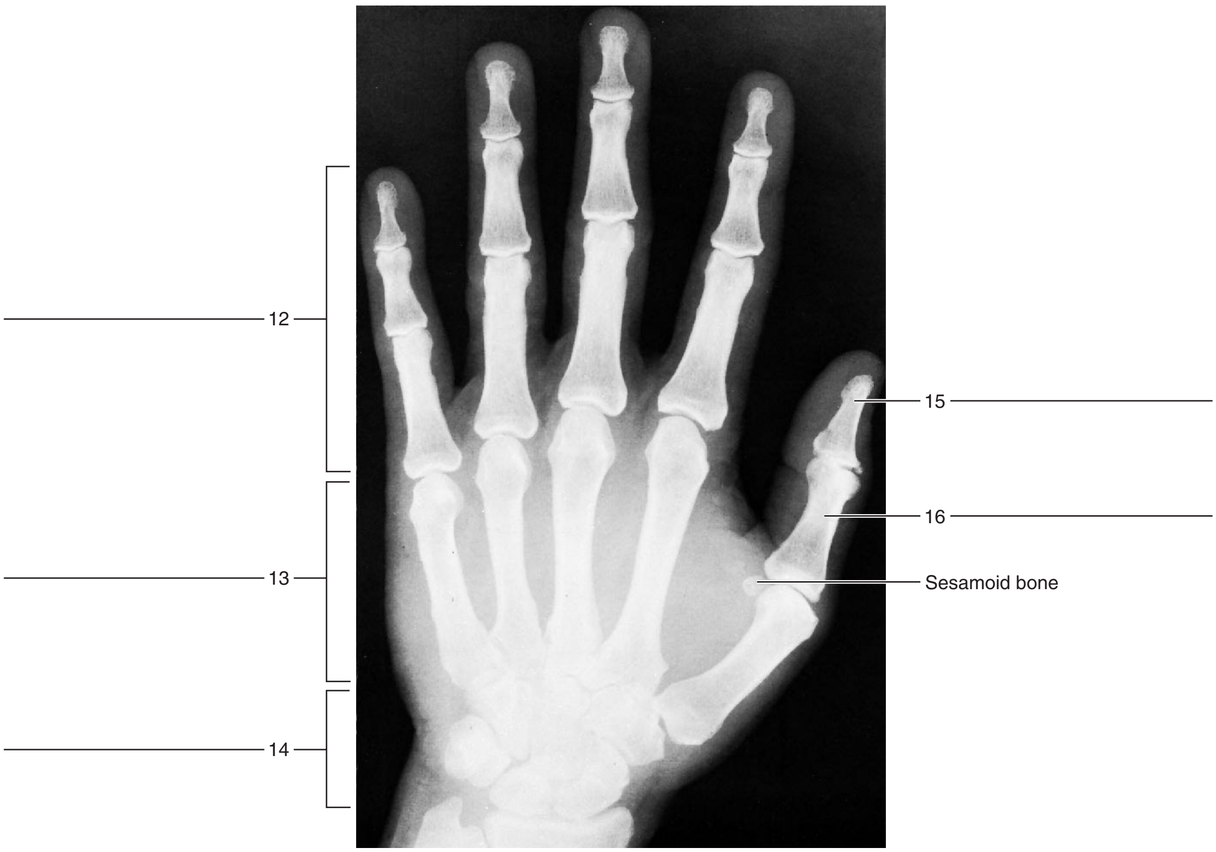


Figure 15.9 Identify the bones indicated on this radiograph of the left hand.



LABORATORY EXERCISE 16

PELVIC GIRDLE AND LOWER LIMB

MATERIALS NEEDED

textbook
human skeleton, articulated
human skeleton, disarticulated
male and female pelves

For Optional Activity:

colored pencils

The pelvic girdle includes two coxal bones that articulate with each other anteriorly at the symphysis pubis and with the sacrum posteriorly. Together, the pelvic girdle, sacrum, and coccyx comprise the pelvis. The pelvis, in turn, provides support for the trunk of the body and provides attachments for the lower limbs.

The bones of the lower limb form the framework of the thigh, leg, and foot. Each limb includes a femur, a patella, a tibia, a fibula, and seven tarsals, five metatarsals, and fourteen phalanges.

PURPOSE OF THE EXERCISE

To examine the bones of the pelvic girdle and lower limb, and to identify the major features of these bones.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the bones of the pelvic girdle and their major features;
2. locate and identify the bones of the lower limb and their major features.

PROCEDURE A— THE PELVIC GIRDLE

1. Review a textbook section on the *pelvic girdle.*
2. As a review activity, label figures 16.1 and 16.2.
3. Examine the bones of the pelvic girdle and locate the following:

   coxal bone

   - acetabulum
   - ilium
   - iliac crest
   - iliac fossa
   - sacroiliac joint
   - anterior superior iliac spine
   - posterior superior iliac spine
   - greater sciatic notch
   - lesser sciatic notch
   - ischium
   - ischial tuberosity
   - ischial spine
   - pubis
   - symphysis pubis
   - pubic arch
   - obturator foramen

4. Complete Part A of Laboratory Report 16.

Critical Thinking Application

Examine the male and female pelves. Look for major differences between them. Note especially the flare of the iliac bones, the angle of the pubic arch, the distance between the ischial spines and ischial tuberosities, and the curve and width of the sacrum. In what ways are the differences you observed related to the function of the female pelvis as a birth canal?

____

____

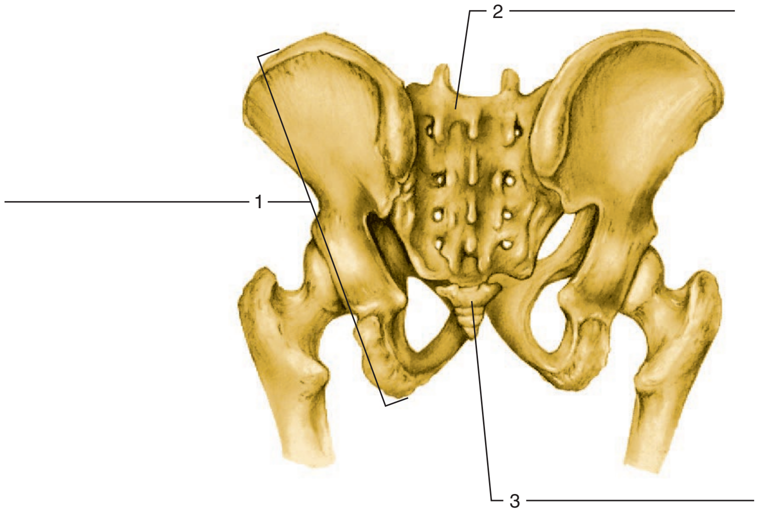
____

____

PROCEDURE B—THE LOWER LIMB

1. Review a textbook section on the *lower limb.*
2. As a review activity, label figures 16.3, 16.4, 16.5, and 16.6.

Figure 16.1 Label the posterior bones of the pelvis.



3. Examine the bones of the lower limb and locate each of the following:

femur

head

fovea capitis

neck

greater trochanter

lesser trochanter

linea aspera

lateral condyle

medial condyle

lateral epicondyle

medial epicondyle

patella

tibia

medial condyle

lateral condyle

tibial tuberosity

anterior crest

medial malleolus

fibula

head

lateral malleolus

tarsal bones

talus

calcaneus

navicular

cuboid

lateral cuneiform

intermediate cuneiform

medial cuneiform

metatarsal bones

phalanges

proximal phalanx

middle phalanx

distal phalanx

4. Complete Parts B and C of the laboratory report.

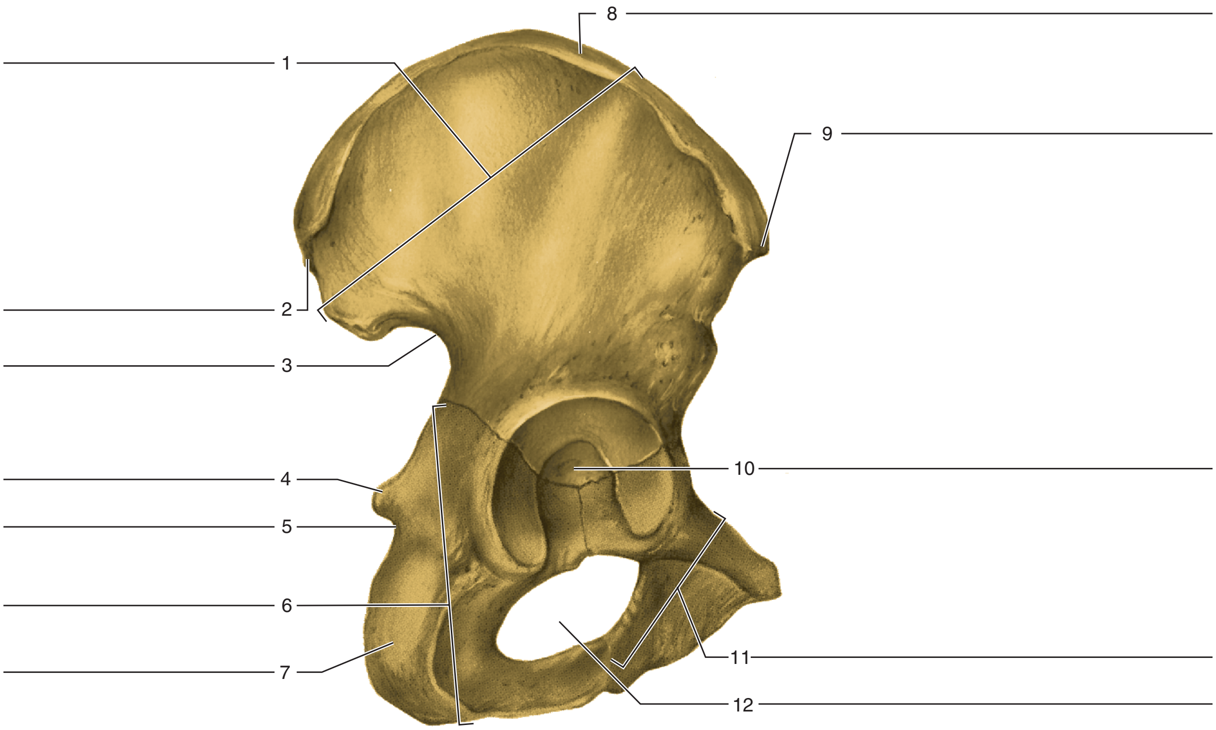
OPTIONAL ACTIVITY

Use different colored pencils to distinguish the individual bones in figure 16.6.

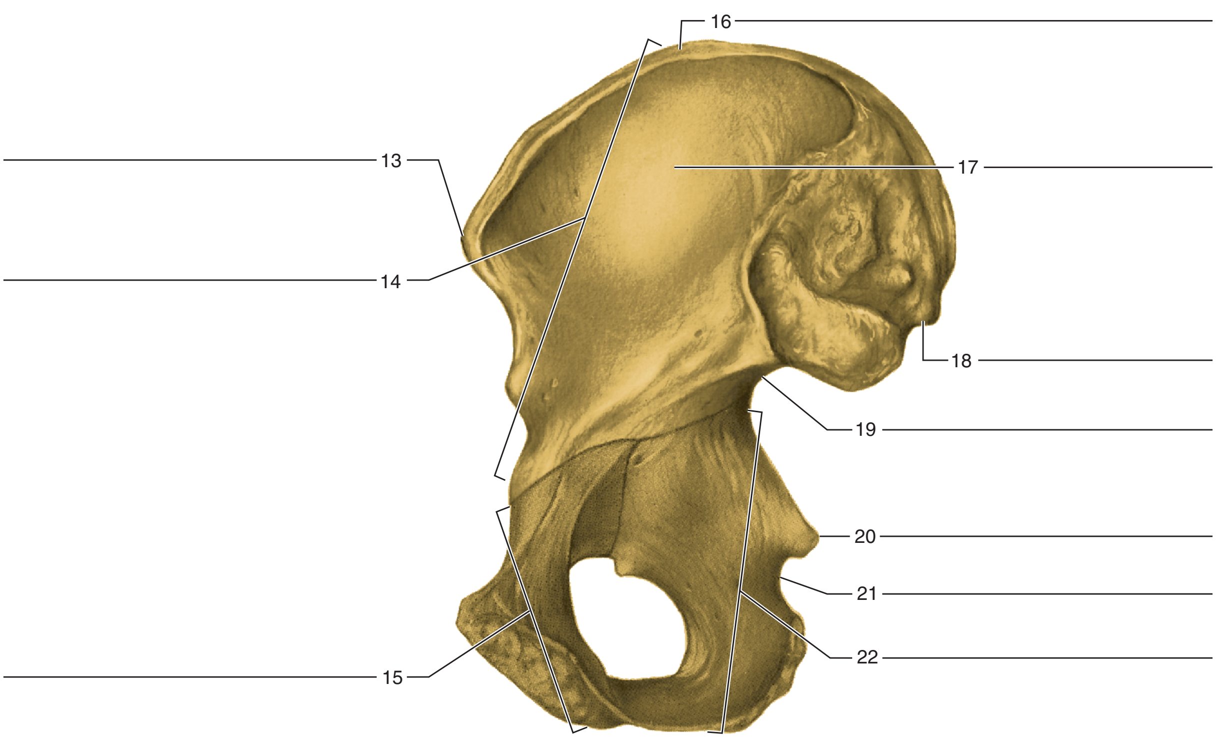
Web Quest

What are the functions of individual bones and features? Search these and review the anatomy of the skeleton at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 16.2 Label (*a*) the lateral and (*b*) the medial features of the right coxal bone.



(a)



(b)

Figure 16.3 Label the features of (*a*) the anterior surface and (*b*) the posterior surface of the left femur.

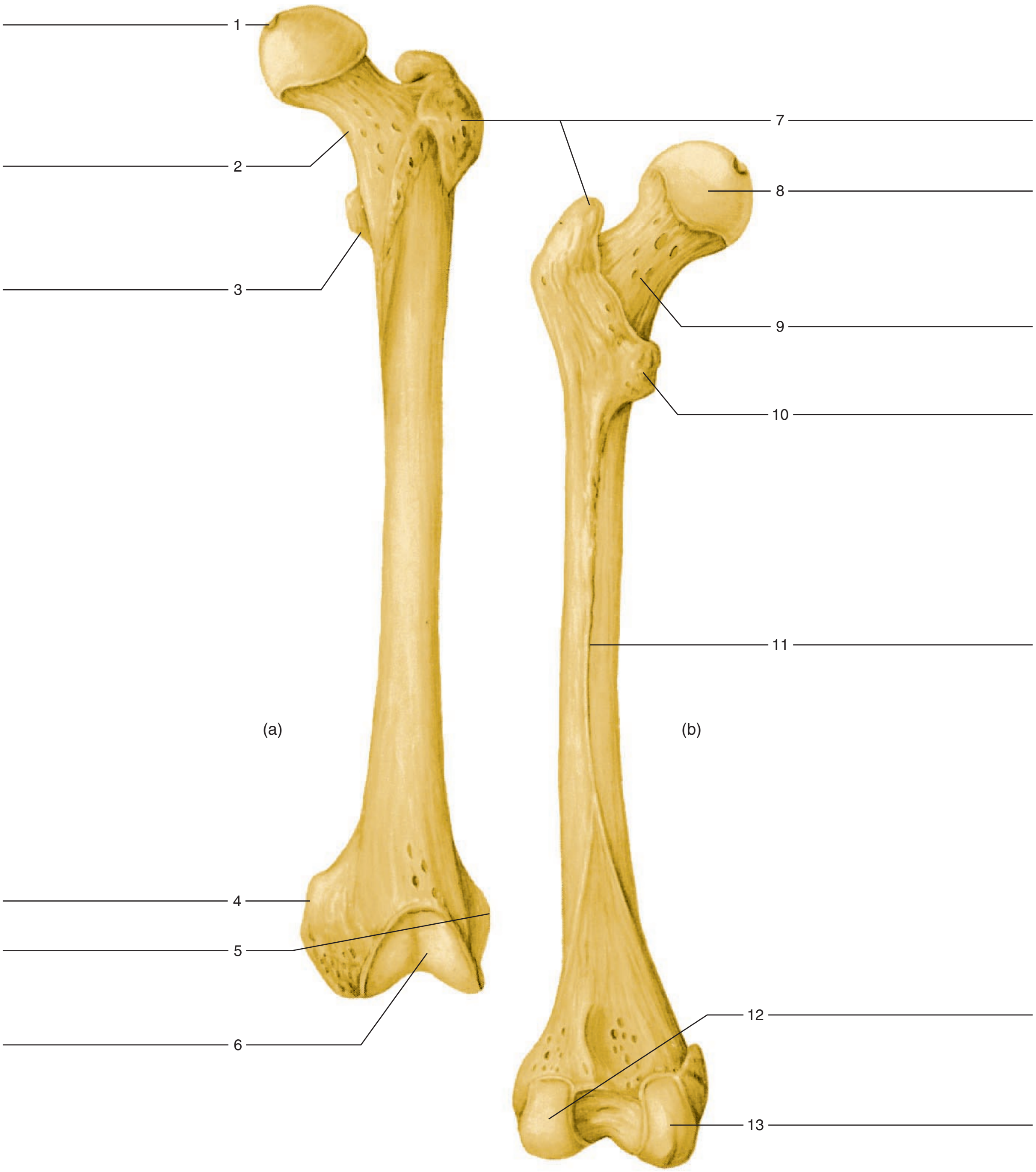


Figure 16.4 Label the bones and features of the left tibia and fibula in this anterior view.

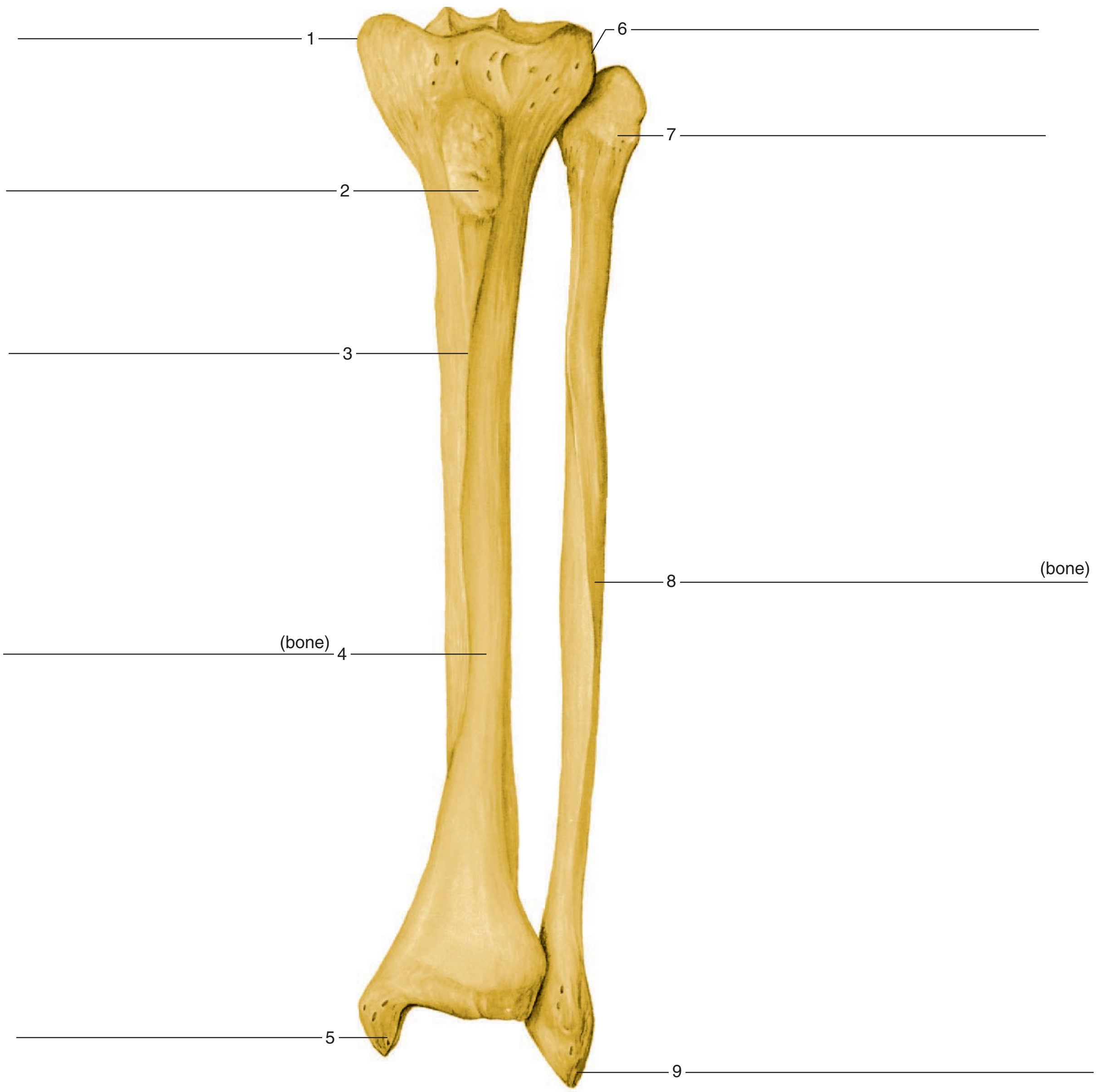


Figure 16.5 Label the bones and features of the right knee, posterior view.

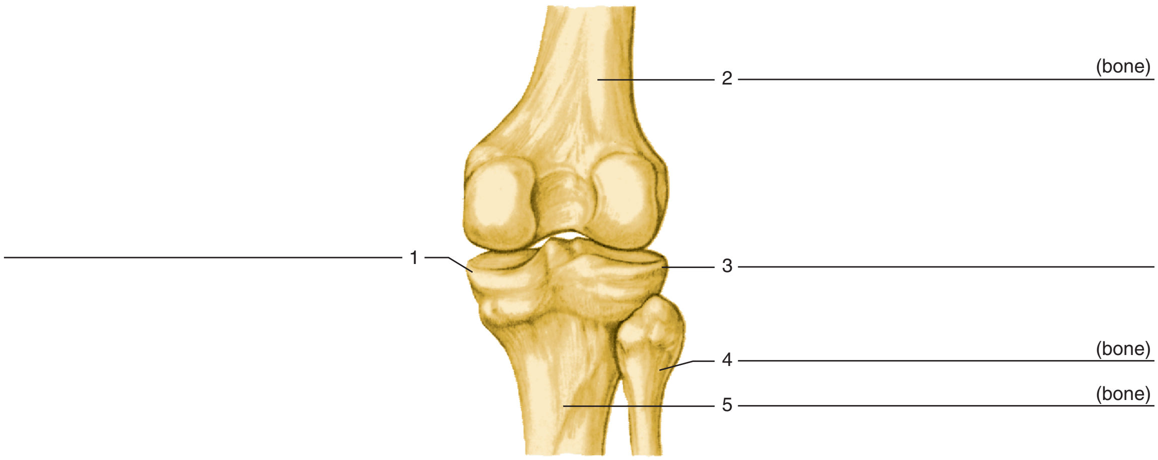
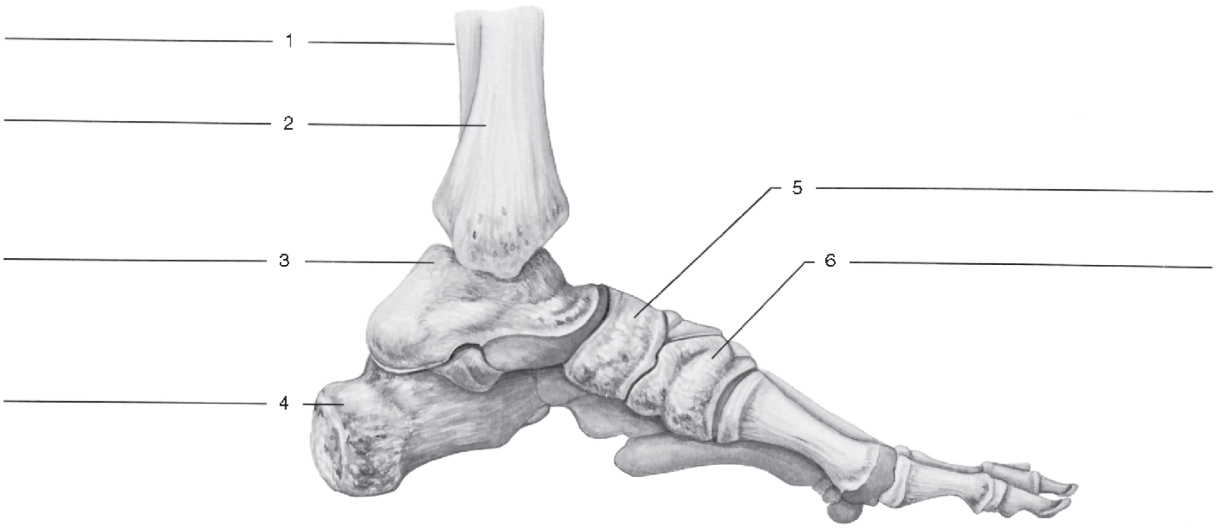
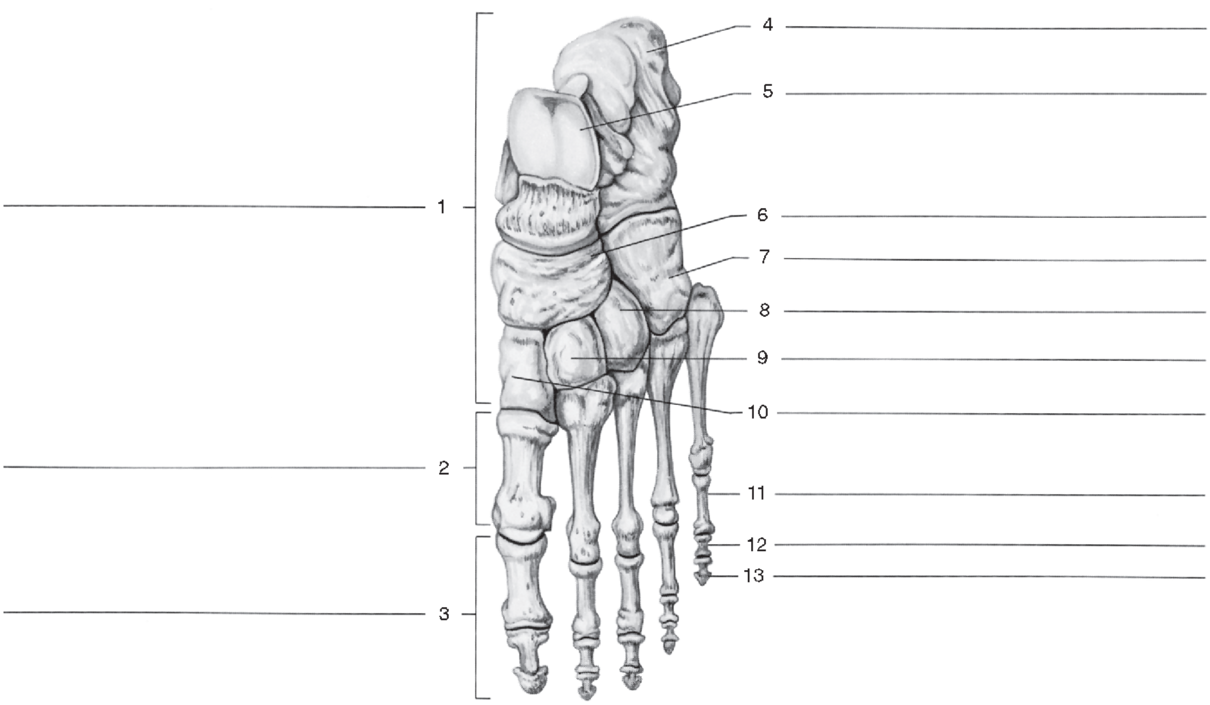


Figure 16.6 Label the bones of (*a*) the medial surface and (*b*) the superior surface of the left foot.



(a)



(b)

Laboratory Report **16**

Name ______________________________

Date ______________________________

Section ______________________________

Pelvic Girdle and Lower Limb

Part A

Complete the following statements:

1. The pelvic girdle consists of two ________________________.
2. The head of the femur articulates with the ________________________ of the coxal bone.
3. The ________________________ is the largest portion of the coxal bone.
4. The distance between the ________________________ represents the shortest diameter of the pelvic outlet.
5. The pubic bones come together anteriorly to form the joint called the ________________________.
6. The ________________________ is the superior margin of the ilium that causes the prominence of the hip.
7. When a person sits, the ________________________ of the ischium supports the weight of the body.
8. The angle formed by the pubic bones below the symphysis pubis is called the ________________________.
9. ________________________ is the largest foramen in the skeleton.
10. The ilium joins the sacrum at the ________________________ joint.

Part B

Match the bones in column A with the features in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. femur	____	1. middle phalanx
b. fibula	____	2. lesser trochanter
c. metatarsals	____	3. medial malleolus
d. patella	____	4. fovea capitis
e. phalanges	____	5. calcaneus
f. tarsals	____	6. lateral cuneiform
g. tibia	____	7. tibial tuberosity
	____	8. talus
	____	9. linea aspera
	____	10. lateral malleolus
	____	11. sesamoid bone
	____	12. five bones that form the instep

Part C

Identify the bones and features indicated in the radiographs (X rays) of figures 16.7, 16.8, and 16.9.

Figure 16.7 Identify the bones and features indicated on this radiograph (X ray) of the pelvic region.

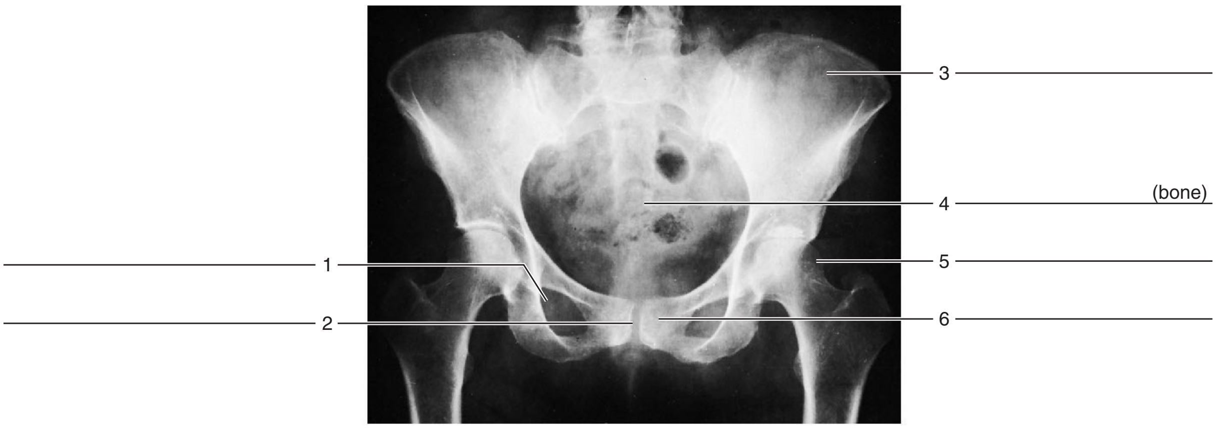


Figure 16.8 Identify the bones and features indicated on this radiograph of the knee.

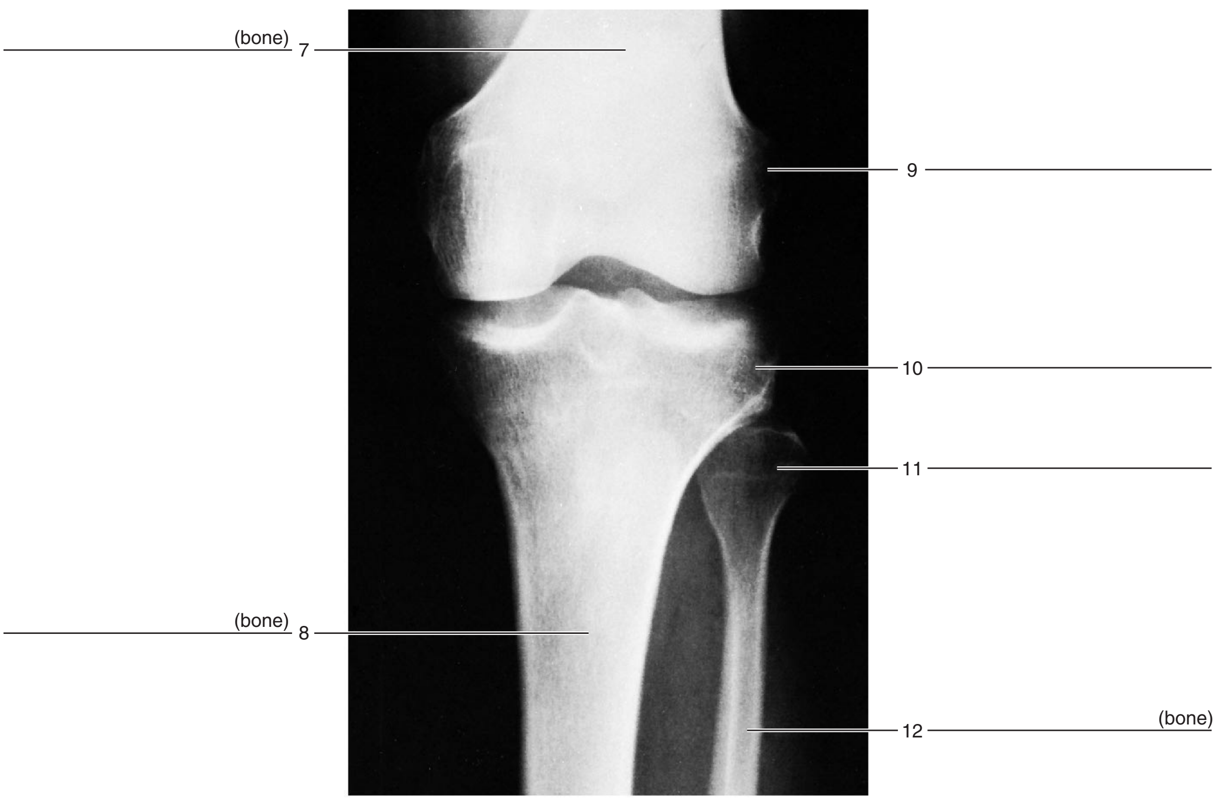
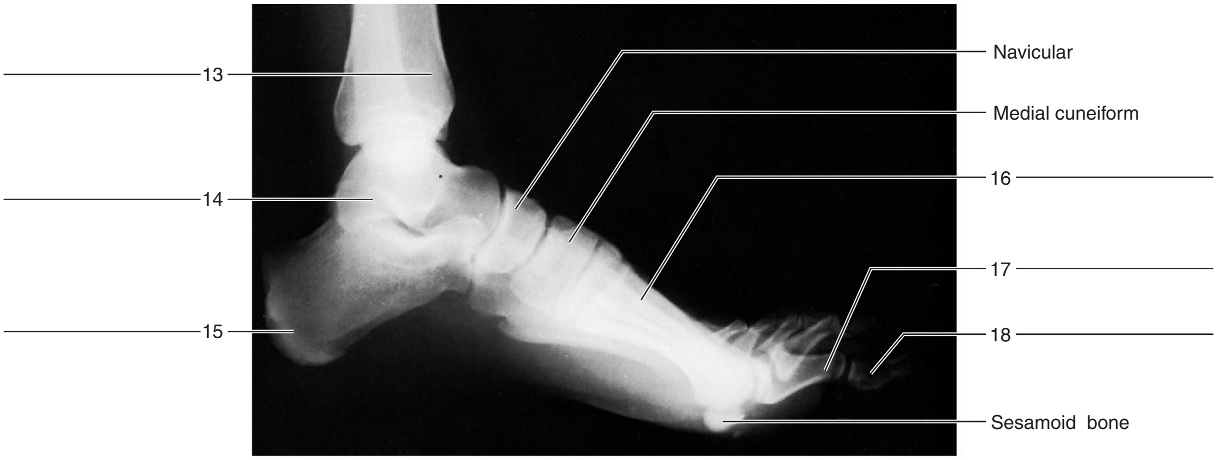


Figure 16.9 Identify the bones indicated on this radiograph of the left foot.



Laboratory Exercise 17

The Joints

MATERIALS NEEDED

textbook
human skull
human skeleton, articulated
models of synovial joints (shoulder, elbow, hip, and knee)

For Demonstration:

fresh animal joint (knee joint preferred)
radiographs of major joints

SAFETY

- Wear disposable gloves when handling the fresh animal joint.
- Wash your hands before leaving the laboratory.

Joints are junctions between bones. Although they vary considerably in structure, they can be classified according to the type of tissue that binds the bones together. Thus, the three groups of joints can be identified as (1) fibrous joints, (2) cartilaginous joints, and (3) synovial joints.

Movements occurring at freely movable synovial joints are due to the contractions of skeletal muscles. In each case, the type of movement depends on the kind of joint involved and the way in which the muscles are attached to the bones on either side of the joint.

PURPOSE OF THE EXERCISE

To examine examples of the three types of joints, to identify the major features of these joints, and to review the types of movements produced at synovial joints.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. distinguish among fibrous, cartilaginous, and synovial joints;
2. identify examples of each type of joint;
3. identify the major features of each type of joint;
4. locate and identify examples of each of the six types of synovial joints;
5. identify the types of movements that occur at synovial joints;
6. describe the structure of the shoulder, elbow, hip, and knee joints.

PROCEDURE A—TYPES OF JOINTS

1. Review a textbook section on *classification of joints.*
2. Examine the human skull and articulated skeleton to locate examples of the following types of joints:

   fibrous joints

   syndesmosis

   suture

   gomphosis

   cartilaginous joints

   synchondrosis

   symphysis

   synovial joints

3. Complete Part A of Laboratory Report 17.
4. Locate examples of the following types of synovial joints in the skeleton. At the same time, examine the corresponding joints in the models and in your own skeleton. Experiment with each joint to experience its range of movements.

   ball-and-socket joint

   condyloid joint

   gliding joint

   hinge joint

   pivot joint

   saddle joint

5. Complete Parts B and C of the laboratory report.

DEMONSTRATION

Examine a longitudinal section of a fresh synovial animal joint. Locate the dense connective tissue that forms the joint capsule and the hyaline cartilage that forms the articular cartilage on the ends of the bones. Locate the synovial membrane on the inside of the joint capsule. Does the joint have any semilunar cartilages (menisci)?

____

____

What is the function of such cartilages? ______________

____

____

PROCEDURE B—JOINT MOVEMENTS

1. Review a textbook section on *types of joint movements.*
2. When the body is in anatomical position most joints are extended and/or adducted. Skeletal muscle action involves the movable end *(insertion)* being pulled toward the stationary end *(origin).* In the limbs, the origin is usually proximal to the insertion; in the trunk, the origin is usually medial to the insertion. Use these concepts as reference points as you move joints. Move various parts of your own body to demonstrate the following joint movements:

   flexion

   extension

   hyperextension

   dorsiflexion

   plantar flexion

   abduction

   adduction

   rotation

   circumduction

   supination

   pronation

   eversion

   inversion

   protraction

   retraction

   elevation

   depression
3. Have your laboratory partner do some of the preceding movements and see if you can identify correctly the movements made.

Critical Thinking Application

Describe a body position that can exist when all major body parts are flexed.

____

____

____

____

4. Complete Part D of the laboratory report.

PROCEDURE C—EXAMPLES OF SYNOVIAL JOINTS

1. Study and compare the shoulder, elbow, hip, and knee joints in figures 17.1, 17.2, 17.3, 17.4, and 17.5.
2. Examine models of the shoulder, elbow, hip, and knee joints. Locate as many features as possible on the models that are illustrated in figures 17.1 through 17.5.
3. Complete Part E of the laboratory report.

DEMONSTRATION

Study the available radiographs of joints by holding the films in front of a light source. Identify the type of joint and the bones incorporated in the joint. Also identify other major features that are visible.

Web Quest

Why does the shoulder joint allow extensive movement? What is joint fluoroscopy? Search these and review joints at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 17.1 Shoulder joint structures (coronal section).

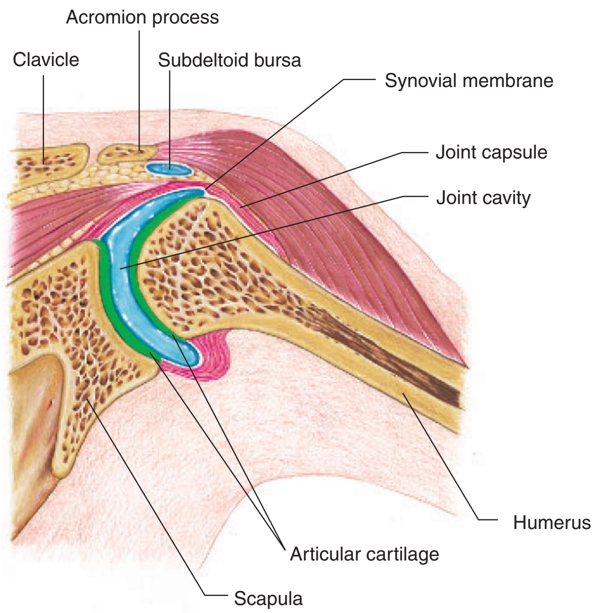


Figure 17.2 Elbow joint structures (sagittal section).

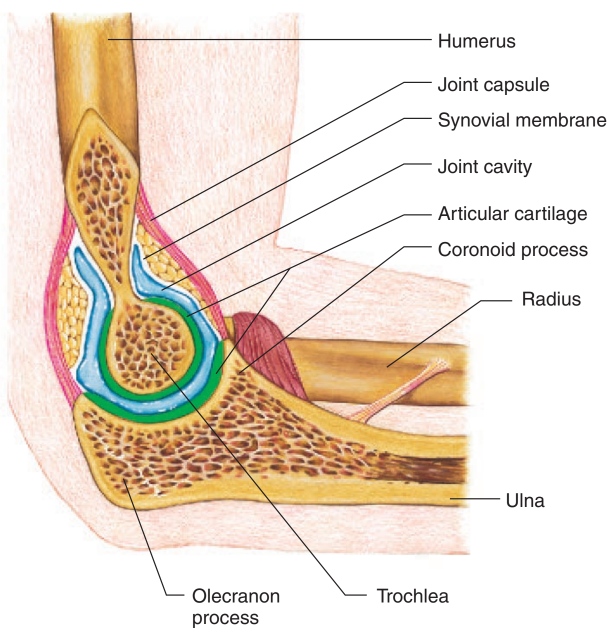


Figure 17.3 Hip joint structures (coronal section).

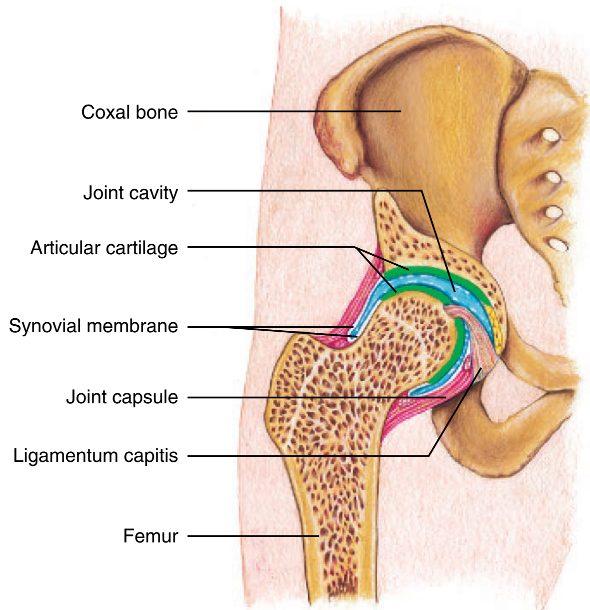


Figure 17.4 Knee joint structures (sagittal section).

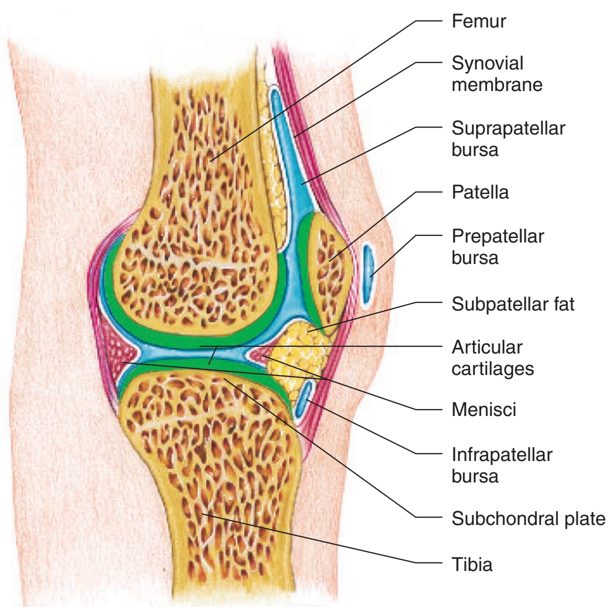
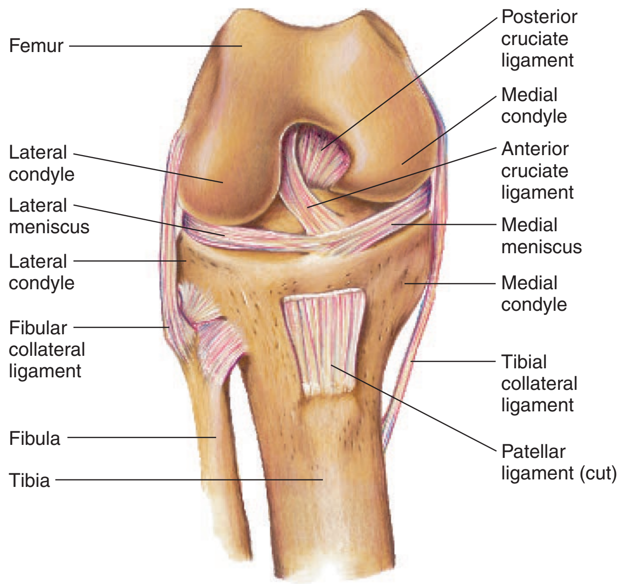


Figure 17.5 Anterior view of right knee (patella removed).



Laboratory Report 17

Name ____________________

Date ____________________

Section ____________________

The Joints

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

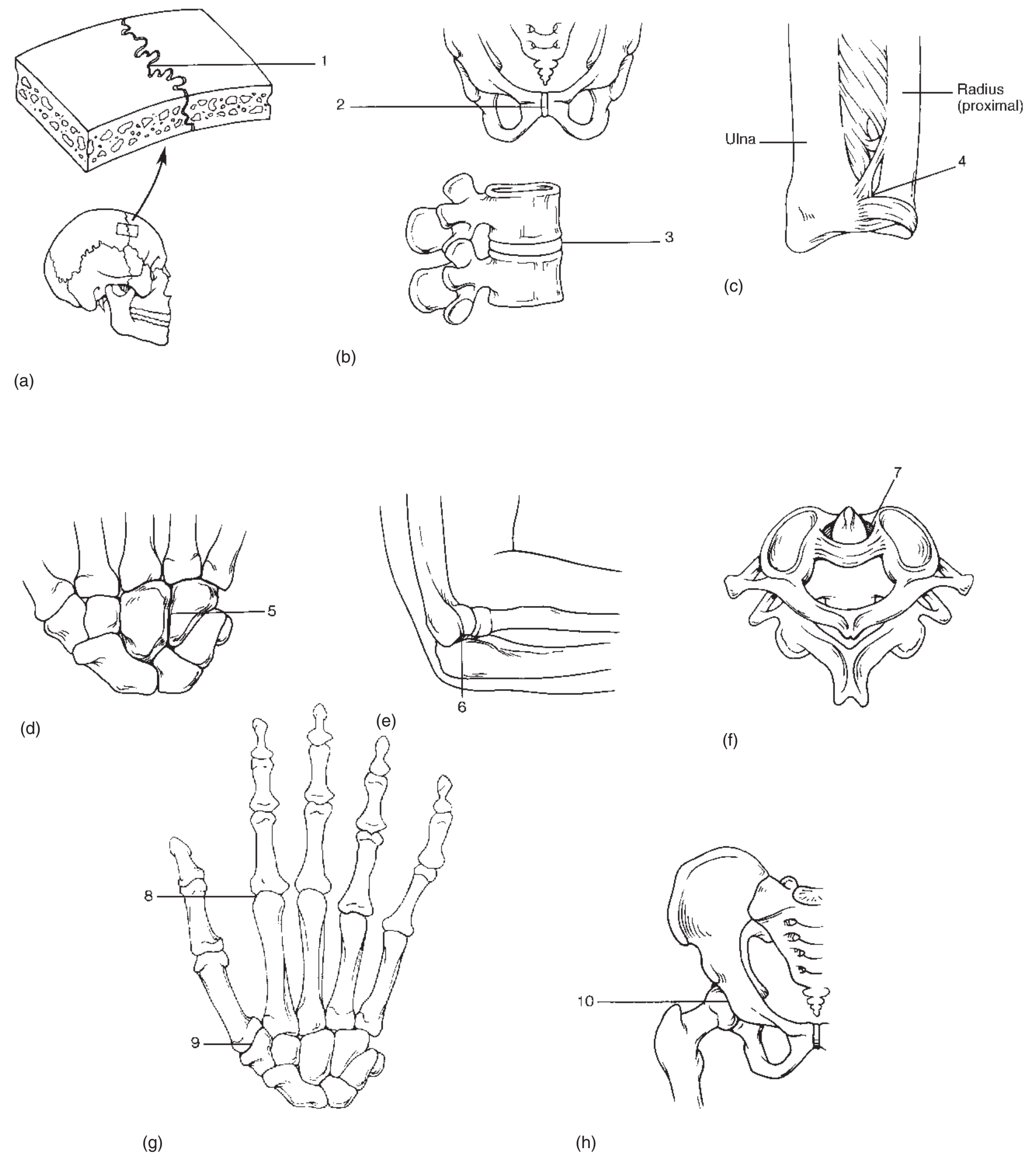
Column A		Column B
a. gomphosis	____	1. immovable joint between flat bones of the skull united by a thin layer of connective tissue
b. suture	____	2. articular cartilages at joint attached by pad of fibrocartilage
c. symphysis	____	3. temporary joint in which bones are united by bands of hyaline cartilage
d. synchondrosis	____	4. slightly movable joint in which bones are united by interosseous ligament
e. syndesmosis	____	5. joint formed by union of cone-shaped bony process in bony socket

Part B

Identify the types of joints that are numbered in figure 17.6.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

Figure 17.6 Identify the types of joints that are numbered in these illustrations.



Part C

Match the types of synovial joints in column A with the examples in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. ball-and-socket	____	1. hip joint
b. condyloid	____	2. metacarpal-phalanx
c. gliding	____	3. proximal radius-ulna
d. hinge	____	4. humerus-ulna of the elbow joint
e. pivot	____	5. phalanx-phalanx
f. saddle	____	6. shoulder joint
	____	7. knee joint
	____	8. carpal-metacarpal of the thumb
	____	9. carpal-carpal
	____	10. tarsal-tarsal

Part D

Identify the types of joint movements that are numbered in figure 17.7.

1. ____________________ (of head)
2. ____________________ (of shoulder)
3. ____________________ (of hand)
4. ____________________ (of hand)
5. ____________________ (of arm at shoulder)
6. ____________________ (of arm at shoulder)
7. ____________________ (of hand at wrist)
8. ____________________ (of hand at wrist)
9. ____________________ (of thigh at hip)
10. ____________________ (of thigh at hip)
11. ____________________ (of chin/mandible)
12. ____________________ (of chin/mandible)
13. ____________________ (of vertebral column/trunk)
14. ____________________ (of vertebral column/trunk)
15. ____________________ (of head and neck)
16. ____________________ (of head and neck)
17. ____________________ (of arm at shoulder)
18. ____________________ (of arm at shoulder)
19. ____________________ (of forearm at elbow)
20. ____________________ (of forearm at elbow)
21. ____________________ (of thigh at hip)
22. ____________________ (of thigh at hip)
23. ____________________ (of leg at knee)
24. ____________________ (of leg at knee)
25. ____________________ (of foot at ankle)
26. ____________________ (of foot at ankle)

Figure 17.7 Identify each of the types of movements that are numbered and illustrated: (*a*) anterior view; (*b*) lateral view of head; (*c*) lateral view.

Original illustration drawn by Ross Martin

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Part E

Complete the following table:

Name of Joint	Type of Joint	Bones Included	Types of Movement Possible
Shoulder joint			
Elbow joint			
Hip joint			
Knee joint			

Laboratory Exercise 18

Skeletal Muscle Structure

MATERIALS NEEDED

textbook
compound microscope
prepared microscope slide of skeletal muscle tissue
torso with musculature
model of skeletal muscle fiber

For Demonstration

fresh round beefsteak

SAFETY

- Wear disposable gloves when handling the fresh beefsteak.
- Wash your hands before leaving the laboratory.

A skeletal muscle represents an organ of the muscular system and is composed of several kinds of tissues. These tissues include skeletal muscle tissue, nervous tissue, blood, and various connective tissues.

Each skeletal muscle is surrounded by connective tissue. The connective tissue often extends beyond the end of a muscle, providing an attachment to other muscles or to bones. Connective tissue also extends into the structure of a muscle and separates it into compartments.

PURPOSE OF THE EXERCISE

To review the structure of a skeletal muscle.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe how connective tissue is associated with muscle tissue within a skeletal muscle;
2. name and locate the major structures of a skeletal muscle fiber on a model;
3. distinguish between the origin and insertion of a muscle;
4. describe the general actions of prime movers, synergists, and antagonists.

PROCEDURE

1. Review a textbook section on *skeletal muscle tissue.*
2. Reexamine the microscopic structure of skeletal muscle by observing a prepared microscope slide of this tissue. Use figure 18.1 of skeletal muscle tissue to locate the following features:

   skeletal muscle fiber (cell)

   nuclei

   striations (alternating light and dark)

3. Review a textbook section on *structure of a skeletal muscle.*
4. Study figures 18.2 and 18.3.
5. Examine the torso and locate examples of fascia, tendons, and aponeuroses. Locate examples of tendons in your own body.
6. Complete Part A of Laboratory Report 18.

DEMONSTRATION

Examine the fresh round beefsteak. It represents a cross section through the beef thigh muscles. Note the white lines of connective tissue that separate the individual skeletal muscles. Also note how the connective tissue extends into the structure of a muscle and separates it into small compartments of muscle tissue. Locate the epimysium and the perimysium of the deep fascia.

7. Examine the model of the skeletal muscle fiber and locate the following:

   sarcolemma

   sarcoplasm

   myofibril

   myosin filament

   actin filament

   sarcomere

   A band

   I band

Figure 18.1 Structures found in skeletal muscle fibers (cells) (250× micrograph enlarged to 700×).

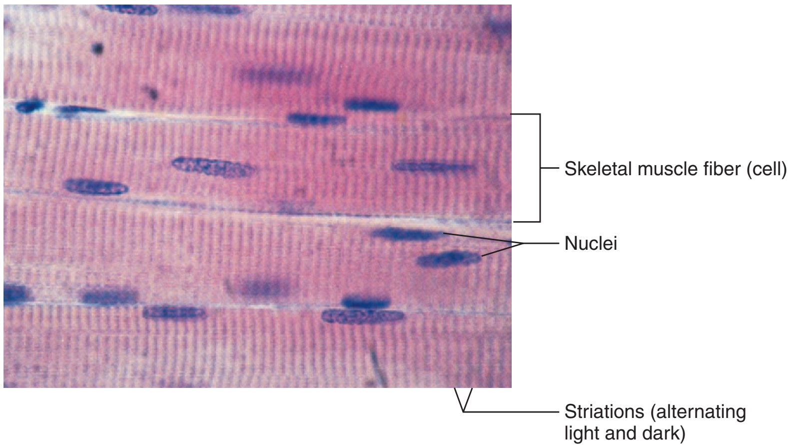
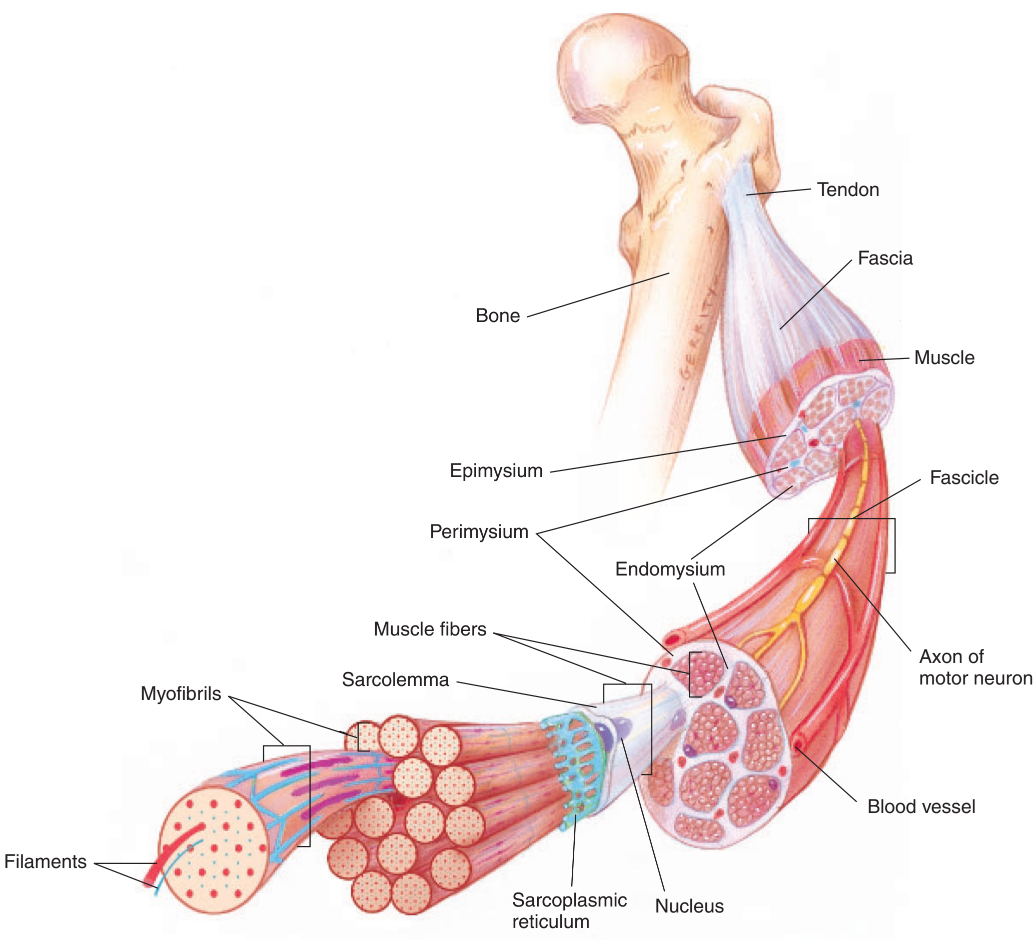


Figure 18.2 Skeletal muscle structure from the gross anatomy to the microscopic arrangement. Note the distribution pattern of the epimysium, perimysium, and endomysium.



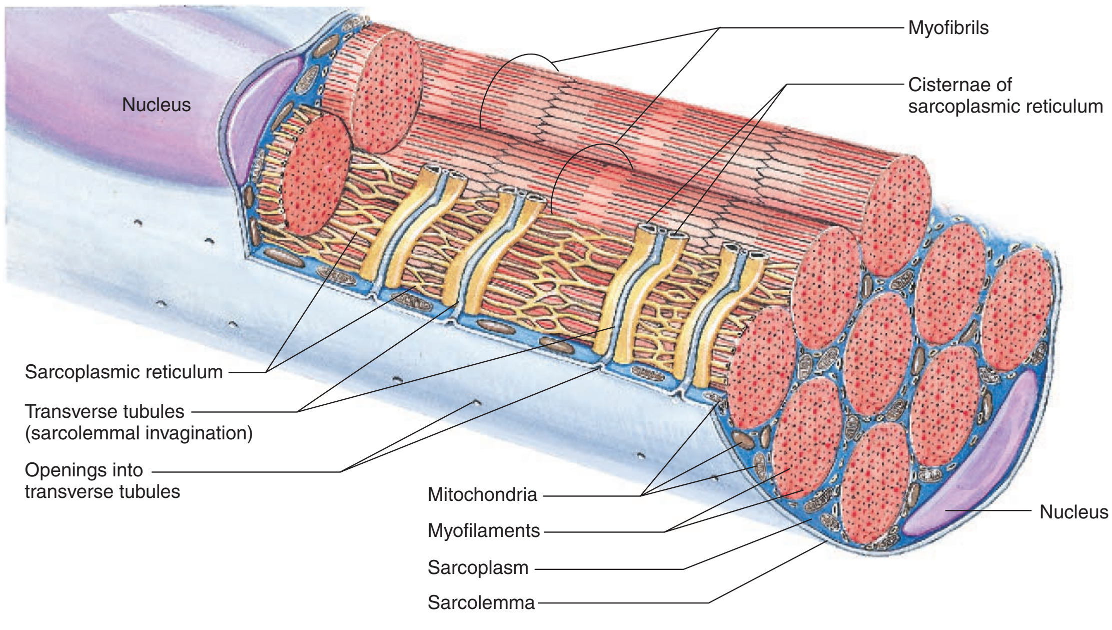


Figure 18.3 Structures of a skeletal muscle fiber.

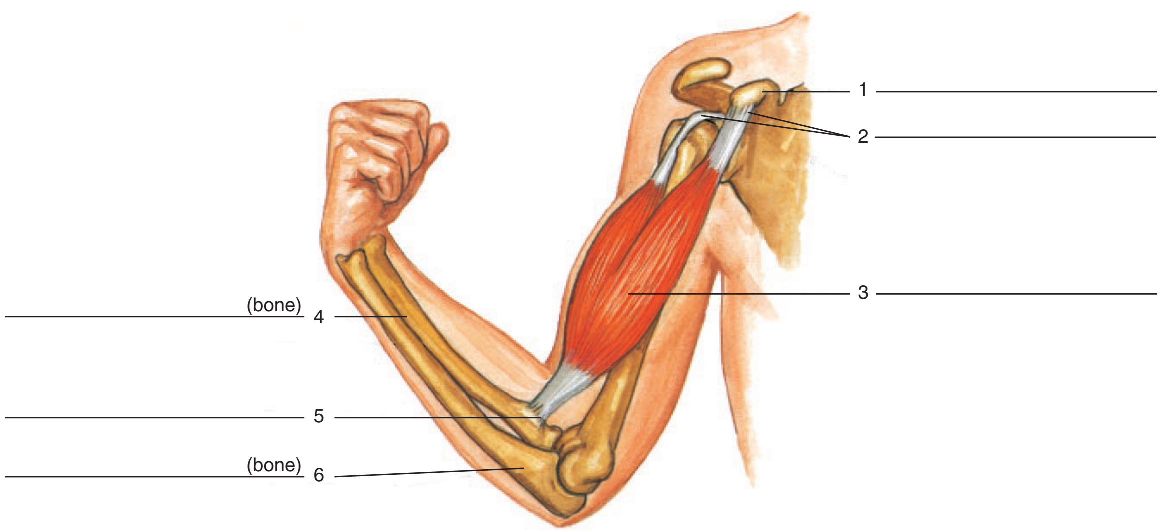


Figure 18.4 Label the major features of the upper limb.

H zone

M line

Z line

sarcoplasmic reticulum

cisternae

transverse tubules

8. Complete Part B of the laboratory report.
9. Review a textbook section on *skeletal muscle actions.*
10. Provide labels for figure 18.4.
11. Locate the biceps brachii and its origins and insertions in the torso and in your own body.
12. Make various movements with your upper limb at the shoulder and elbow. For each movement, determine the location of the muscles functioning as prime movers and as antagonists. **(Remember, when a prime mover contracts, its antagonist must relax.)**
13. Complete Part C of the laboratory report.

Laboratory Report **18**

Name ______________________________

Date ______________________________

Section ______________________________

SKELETAL MUSCLE STRUCTURE

Part A

Match the terms in column A with the definitions in column B. Place the letter of your choice in the space provided.

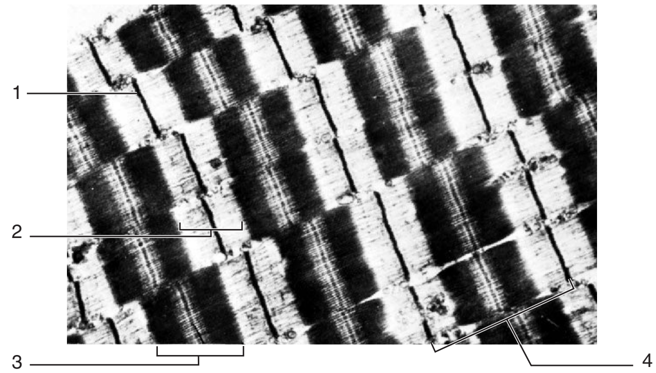
Column A		Column B
a. aponeurosis	____	1. membranous channel extending inward from muscle fiber membrane
b. cisterna	____	2. cytoplasm of a muscle fiber
c. endomysium	____	3. network of connective tissue that extends throughout the muscular system
d. epimysium	____	4. layer of connective tissue that separates a muscle into small bundles called fascicles
e. fascia	____	5. enlarged portion of sarcoplasmic reticulum on either side of a transverse tubule
f. fascicle	____	6. broad sheet of connective tissue that attaches coverings of adjacent muscles
g. myosin	____	7. cell membrane of a muscle fiber
h. perimysium	____	8. layer of connective tissue that surrounds a skeletal muscle
i. sarcolemma	____	9. unit of alternating light and dark striations between Z lines
j. sarcomere	____	10. layer of connective tissue that surrounds an individual muscle fiber
k. sarcoplasm	____	11. cellular organelle in muscle fiber corresponding to the endoplasmic reticulum
l. sarcoplasmic reticulum	____	12. cordlike part that attaches a muscle to a bone
m. tendon	____	13. protein found within thick myofibril
n. transverse tubule	____	14. a small bundle of muscle fibers

Part B

Provide the labels for the electron micrograph in figure 18.5.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Figure 18.5 Identify the bands and lines of the striations in this transmission electron micrograph of relaxed sarcomeres (8,400×).



Part C

Complete the following statements:

1. The ________________________ of a muscle is usually attached to a fixed part.
2. The ________________________ of a muscle is usually attached to a movable part.
3. The forearm is flexed at the elbow when the ________________________ muscle contracts.
4. A muscle responsible for most of a movement is called a(n) ________________________.
5. Assisting muscles are called ________________________.
6. Antagonists are muscles that resist the actions of ________________________ and cause movement in the opposite direction.

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Laboratory Exercise 19

Skeletal Muscle Contraction

MATERIALS NEEDED

textbook
recording system (kymograph, Physiograph, etc.)
stimulator and connecting wires
live frog
dissecting tray
dissecting instruments
probe for pithing
heavy thread
frog Ringer's solution

For Demonstration A—the Kymograph:

kymograph recording system
electronic stimulator (or inductorium)
frog muscles (from pithed frog)
probe for pithing
dissecting instruments
frog Ringer's solution

For Demonstration B—the Physiograph:

Physiograph
myograph and stand
frog muscle (from pithed frog)
probe for pithing
dissecting instruments
frog Ringer's solution
Virtual Physiology Lab: 3, Frog Muscle

SAFETY

- Wear disposable gloves when handling the frogs.
- Dispose of gloves and frogs as instructed.
- Wash your hands before leaving the laboratory.

To study the characteristics of certain physiological events such as muscle contractions, it often is necessary to use a recording device, such as a *kymograph* or a *Physiograph.* These devices are relatively simple to use, and they can provide accurate recordings of various physiological changes.

To observe the phenomenon of skeletal muscle contractions, muscles can be removed from anesthetized frogs. These muscles can be attached to recording systems and stimulated by electrical shocks of varying strength, duration, and frequency. Recordings obtained from such procedures can be used to study the basic characteristics of skeletal muscle contractions.

PURPOSE OF THE EXERCISE

To observe and record the responses of an isolated frog muscle to electrical stimulation of varying strength and frequency.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

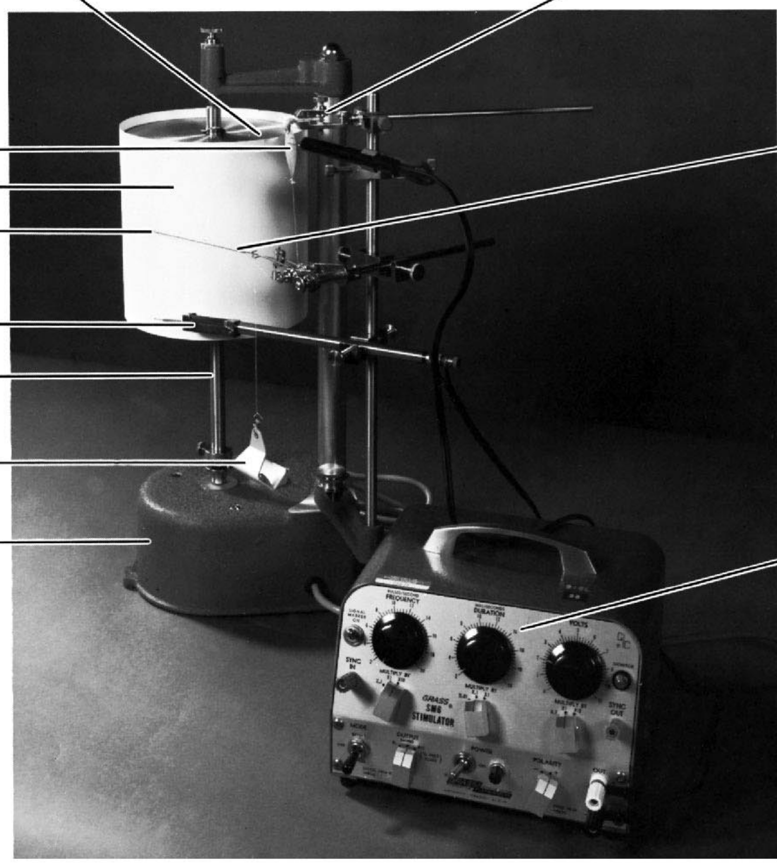
1. make use of a recording system and stimulator to record frog muscle responses to electrical stimulation;
2. determine the threshold level of electrical stimulation in frog muscle;
3. determine the intensity of stimulation needed for maximal muscle contraction;
4. record a single muscle twitch and identify its phases;
5. record the response of a muscle to increasing frequency of stimulation, and identify the patterns of tetanic contraction and fatigue.

DEMONSTRATION A—THE KYMOGRAPH

1. Observe the kymograph and, at the same time, study figure 19.1 to learn the names of its major parts.
2. Note that the kymograph consists of a cylindrical *drum* around which a sheet of paper is wrapped. The drum is mounted on a motor-driven *shaft,* and the speed of the motor can be varied. Thus, the drum can be rotated rapidly if rapid physiological events are being recorded or rotated slowly for events that occur more slowly.

   A *stylus* that can mark on the paper is attached to a *movable lever,* and the lever, in turn, is connected to an isolated muscle. The origin of the muscle is fixed in position by a *clamp,* and its

Figure 19.1 Kymograph setup to record frog muscle contractions.



insertion is hooked to the muscle lever. The muscle also is connected by wires to an *electronic stimulator* (or inductorium). The stimulator can deliver single or multiple electrical shocks to the muscle, and it can be adjusted so that the intensity (voltage), duration (milliseconds), and frequency (stimuli per second) can be varied. Another stylus, on the *signal marker,* records the time each stimulus is given to the muscle. As the muscle responds, the duration and relative length of its contraction are recorded by the stylus on the muscle lever.

3. Watch carefully while the laboratory instructor demonstrates the operation of the kymograph to record a frog muscle contraction.

DEMONSTRATION B—THE PHYSIOGRAPH

1. Observe the Physiograph and, at the same time, study figures 19.2 and 19.3 to learn the names of its major parts.
2. Note that the recording system of the Physiograph includes a transducer, an amplifier, and a recording pen. The *transducer* is a sensing device that can respond to some kind of physiological change by sending an electrical signal to the amplifier. The *amplifier* increases the strength of the electrical signal and relays it to an electric motor that moves the *recording pen.* As the pen moves, a line is drawn on paper.

   To record a frog muscle contraction, a transducer called a *myograph* is used (fig. 19.3). The origin of the muscle is held in a fixed position, and its insertion is attached to a small lever in the myograph by a thread. The myograph, in turn, is connected to the amplifier by a transducer cable. The muscle also is connected by wires to the electronic stimulator, which is part of the Physiograph. This stimulator can be adjusted to deliver single or multiple electrical shocks to the muscle, and the intensity (voltage), duration (milliseconds), and frequency (stimuli per second) can be varied.

Figure 19.2 Major parts of a Physiograph.

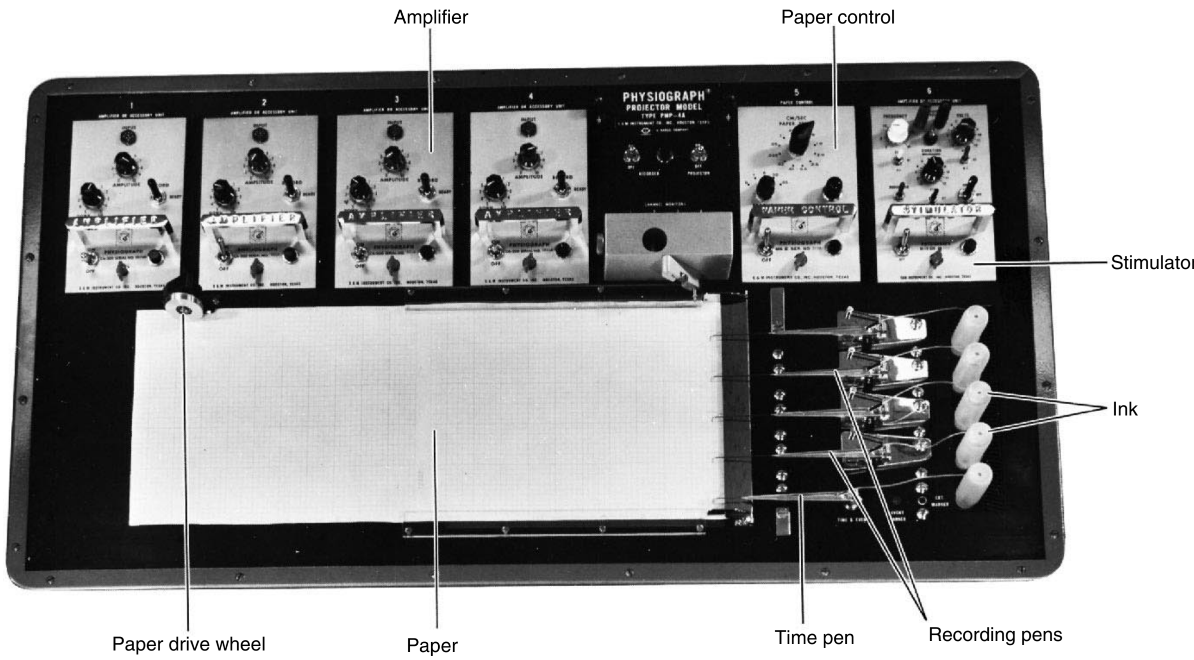
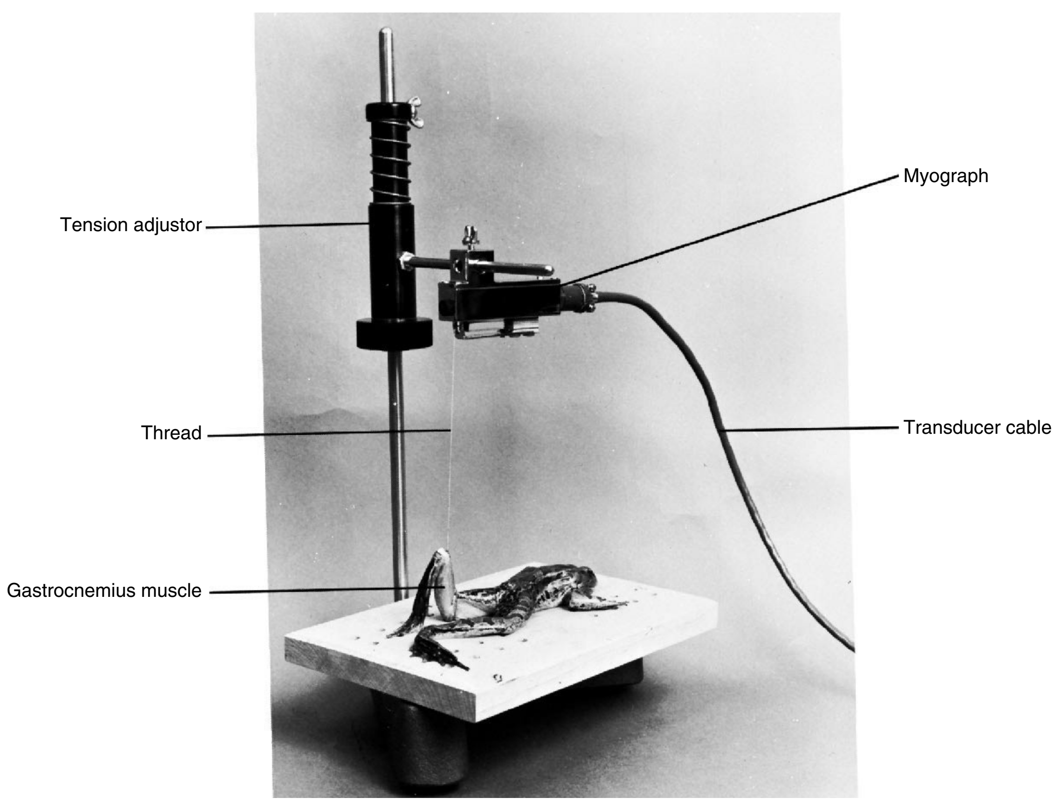


Figure 19.3 Myograph attached to frog muscle.



The speed at which the paper moves under the recording pen can be controlled. A second pen, driven by a timer, marks time units on the paper and indicates when the stimulator is activated. As the muscle responds to stimuli, the recording pen records the duration and relative length of each muscle contraction.

3. Watch carefully while the laboratory instructor operates the Physiograph to record a frog muscle contraction.

PROCEDURE A—TEXTBOOK REVIEW

1. Review a textbook section on *muscular responses.*
2. Complete Part A of Laboratory Report 19.

PROCEDURE B—RECORDING SYSTEM

1. Set up the recording system and stimulator to record the contractions of a frog muscle according to the directions provided by the laboratory instructor.
2. Obtain a live frog, and prepare its calf muscle (gastrocnemius) as described in Procedure C.

PROCEDURE C—MUSCLE PREPARATION

1. Prepare the live frog by pithing so that it will have no feelings or movements when its muscle is removed. To do this, follow these steps:
   a. Hold the frog securely in one hand so that its legs are extended downward.
   b. Position the frog's head between your thumb and index finger.
   c. Bend the frog's head forward at an angle of about 90° by pressing on its snout with your index finger (fig. 19.4).
   d. Use a sharp probe to locate the foramen magnum between the occipital condyles in the midline between the frog's tympanic membranes.
   e. Insert the probe through the skin and into the foramen magnum, and then quickly move the probe from side to side to separate the brain from the spinal cord.
   f. Slide the probe forward into the braincase, and continue to move the probe from side to side to destroy the brain.
   g. Remove the probe from the braincase, and insert it into the spinal cord through the same opening in the skin.
   h. Move the probe up and down the spinal cord to destroy it. If the frog has been pithed correctly, its legs will be extended and relaxed. Also, the eyes will not respond when touched with a probe.

ALTERNATIVE PROCEDURE

An anesthetizing agent, tricaine methane sulfonate, can be used to prepare frogs for this lab. This procedure eliminates the need to pith frogs.

2. Remove the frog's gastrocnemius muscle by proceeding as follows:
   a. Place the pithed frog in a dissecting tray.
   b. Use scissors to cut through the skin completely around the leg in the thigh.
   c. Pull the skin downward and off the leg.
   d. Locate the gastrocnemius muscle in the calf and the calcaneal tendon (Achilles tendon) at its distal end.
   e. Separate the calcaneal tendon from the underlying tissue, using forceps.
   f. Tie a thread firmly around the tendon (fig. 19.5).
   g. When the thread is secure, free the distal end of the tendon by cutting it with scissors.
   h. Attach the frog muscle to the recording system in the manner suggested by your laboratory instructor (see figs. 19.1 and 19.3).
   i. Insert the ends of the stimulator wires into the muscle so that one wire is located on either side of the belly of the muscle.

   Keep the frog muscle moist at all times by dripping frog Ringer's solution on it. When the muscle is not being used, cover it with some paper toweling that has been saturated with frog Ringer's solution.

   Before you begin operating the recording system and stimulator, have the laboratory instructor inspect your setup.

PROCEDURE D—THRESHOLD STIMULATION

1. To determine the threshold or minimal strength of electrical stimulation (voltage) needed to elicit a contraction in the frog muscle, follow these steps:
   a. Set the stimulus duration to a minimum (about 0.1 milliseconds).
   b. Set the voltage to a minimum (about 0.1 volts).
   c. Set the stimulator so that it will administer single stimuli.
2. Administer a single stimulus to the muscle and watch to see if it responds. If no response is observed, increase the voltage to the next higher setting and repeat the procedure until the muscle responds by contracting.

Figure 19.4 Hold the frog's head between your thumb and index finger to pith (*a*) its brain and (*b*) its spinal cord.

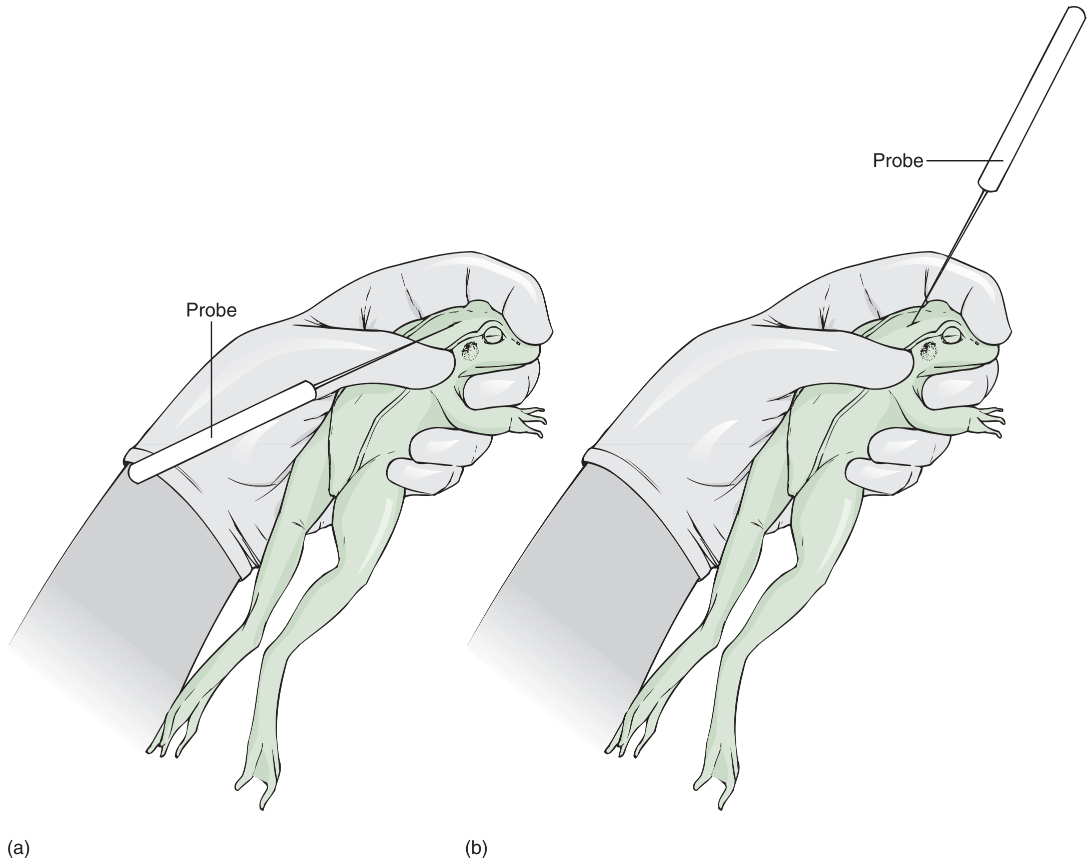
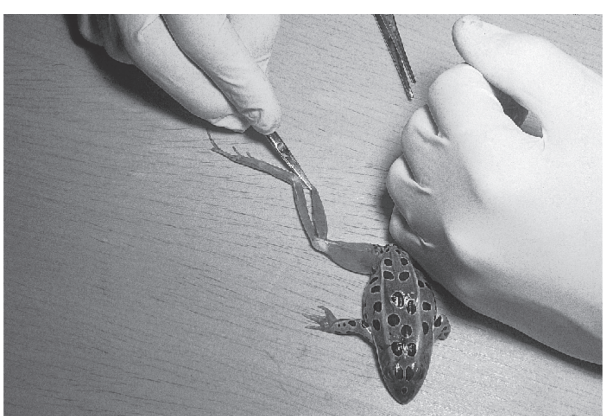
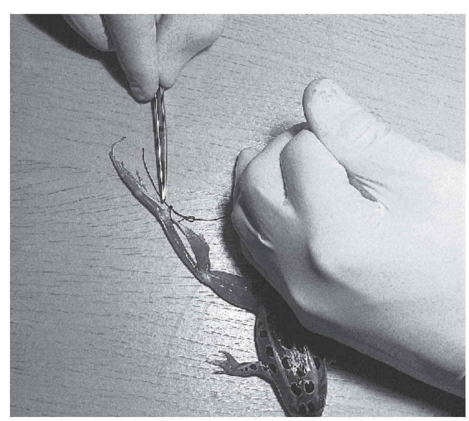


Figure 19.5 (*a*) Separate the calcaneal (Achilles) tendon from the underlying tissue. (*b*) Tie a thread around the tendon, and cut its distal attachment.


(a)


(b)

3. After determining the threshold level of stimulation, continue to increase the voltage in increments of 1 or 2 volts until a maximal muscle contraction is obtained.
4. Complete Part B of the laboratory report.

PROCEDURE E— SINGLE MUSCLE TWITCH

1. To record a single muscle twitch, set the voltage for a maximal muscle contraction as determined in Procedure D.
2. Set the paper speed at maximum, and with the paper moving, administer a single electrical stimulus to the frog muscle.
3. Repeat this procedure to obtain several recordings of single muscle twitches.
4. Complete Part C of the laboratory report.

PROCEDURE F— SUSTAINED CONTRACTION

1. To record a sustained muscle follow these steps:
   a. Set the stimulator for continuous stimulation.
   b. Set the voltage for maximal muscle contraction as determined in Procedure D.
   c. Set the frequency of stimulation at a minimum.
   d. Set the paper speed at about 0.05 cm/sec.
   e. With the paper moving, administer electrical stimulation and slowly increase the frequency of stimulation until the muscle sustains a contraction (tetanic contraction or tetanus).
   f. Continue to stimulate the muscle at the frequency that produces sustained contractions until the muscle fatigues and relaxes.
2. Every 15 seconds for the next several minutes, stimulate the muscle to see how long it takes to recover from the fatigue.
3. Complete Part D of the laboratory report.

OPTIONAL ACTIVITY

To demonstrate the staircase effect (treppe), obtain a fresh frog gastrocnemius muscle and attach it to the recording system as before. Set the paper control for slow speed, and set the stimulator voltage to produce a maximal muscle contraction. Stimulate the muscle once each second for several seconds. How do you explain the differences in the lengths of successive muscle contractions? ____________________________________

____

____

____

____

Laboratory Report 19

Name ______________________________

Date ______________________________

Section ______________________________

Skeletal Muscle Contraction

Part A

Match the terms in column A with the definitions in column B. Place the letter of your choice in the space provided.

Column A

a. all-or-none
b. latent period
c. motor unit
d. muscle tone
e. myogram
f. refractory period
g. tetanic contraction (tetanus)
h. threshold stimulus
i. twitch

Column B

____ 1. minimal intensity of stimulation necessary to trigger a muscle contraction

____ 2. response of a muscle fiber/motor unit complete contraction if stimulated sufficiently

____ 3. consists of a single motor neuron and all of the muscle fibers with which the neuron is associated

____ 4. an action of a muscle contraction and immediate relaxation when exposed to a single stimulus

____ 5. the time between stimulation and response

____ 6. the time following a muscle contraction during which the muscle remains unresponsive to stimulation

____ 7. forceful, sustained contraction

____ 8. some contraction of muscle fibers when a muscle is at rest

____ 9. the recording of the pattern of a muscle contraction

Part B—Threshold Stimulation

Complete the following:

1. What was the threshold voltage for stimulation of the frog gastrocnemius muscle? ______________________
2. What voltage produced maximal contraction of this muscle? ______________________

Critical Thinking Application

Do you think other frog muscles would respond in an identical way to these voltages of stimulation?

____

Why or why not?

____

____

____

Part C—Single Muscle Twitch

Complete the following:

1. Fasten a recording of two single muscle twitches in the space below.

2. On a muscle twitch recording, label the *latent period, period of contraction,* and *period of relaxation,* and indicate the time it took for each of these phases to occur.
3. What differences, if any, do you note in the two myograms of a single muscle twitch? How do you explain these differences? ______________________________

____

____

Part D—Sustained Contraction

Complete the following:

1. Fasten a recording of a sustained contraction in the space below.

2. On the sustained contraction recording, indicate when the muscle twitches began to combine (summate), and label the period of tetanic contraction and the period of fatigue.
3. At what frequency of stimulation did tetanic contraction occur? ______________________________
4. How long did it take for the tetanic muscle to fatigue? ______________________________
5. Is the length of muscle contraction at the beginning of tetanic contraction the same or different from the length of the single muscle contractions before tetanic contraction occurred? ____________ How do you explain this?

____

____

6. How long did it take for the fatigued muscle to become responsive again? ______________________________

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Laboratory Exercise 20

Muscles of the Face, Head, and Neck

MATERIALS NEEDED

textbook
torso with musculature
human skull
human skeleton, articulated

The skeletal muscles of the face and head include the muscles of facial expression, which lie just beneath the skin, the muscles of mastication, which are attached to the mandible, and the muscles that move the head, which are located in the neck.

PURPOSE OF THE EXERCISE

To review the locations, actions, origins, and insertions of the muscles of the face, head, and neck.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the muscles of facial expression, the muscles of mastication, and the muscles that move the head;
2. describe and demonstrate the action of each of these muscles;
3. locate the origin and insertion of each of these muscles in a human skeleton and the musculature of the torso.

PROCEDURE

1. Review textbook sections on *muscles of facial expression, muscles of mastication,* and *muscles that move the head and vertebral column.*
2. As a review activity, label figures 20.1, 20.2, and 20.3.
3. Locate the following muscles in the torso and in your own body whenever possible:

   epicranius (frontalis and occipitalis)

   orbicularis oculi

   orbicularis oris

   buccinator

   zygomaticus

   platysma

   masseter

   temporalis

   medial pterygoid

   lateral pterygoid

   sternocleidomastoid

   splenius capitis

   semispinalis capitis

   longissimus capitis (of erector spinae group)
4. Demonstrate the action of these muscles in your own body.
5. Locate the origins and insertions of these muscles in the human skull and skeleton.
6. Complete Parts A, B, and C of Laboratory Report 20.

Web Quest

Determine the origin, insertion, action, nerve innervation, and blood supply of all the major muscles.

Identify muscles and detailed explanations from an interactive site.

Find information about these topics at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 20.1 Label the muscles of expression and mastication.

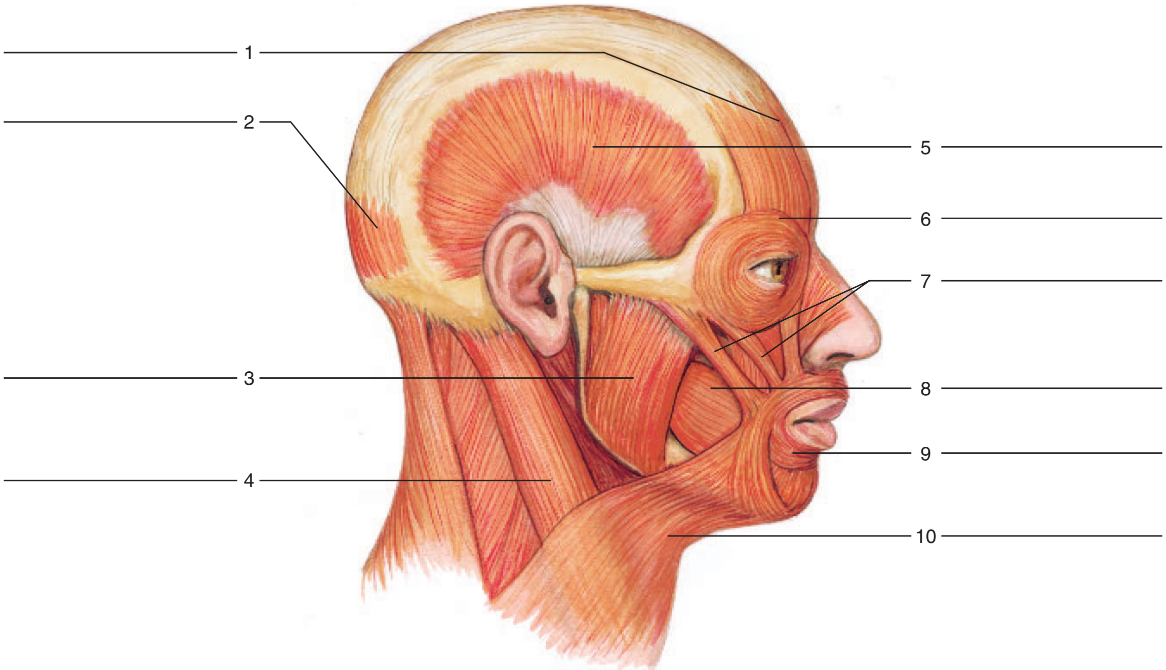


Figure 20.2 Label these muscles of mastication.

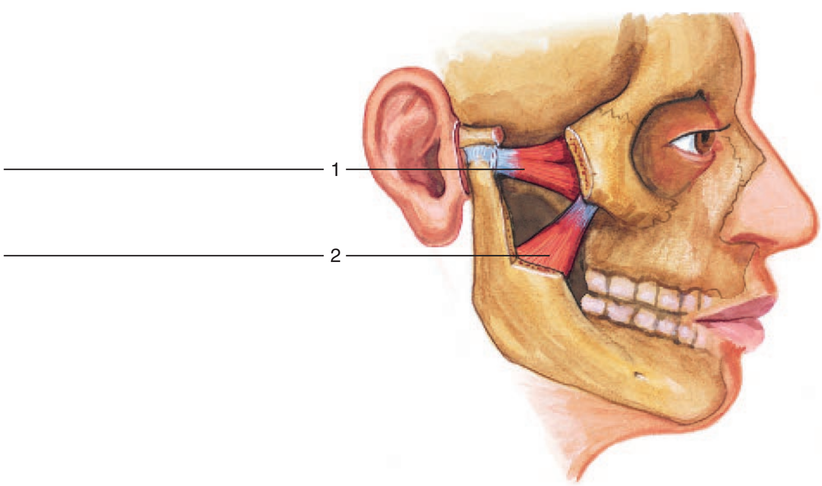
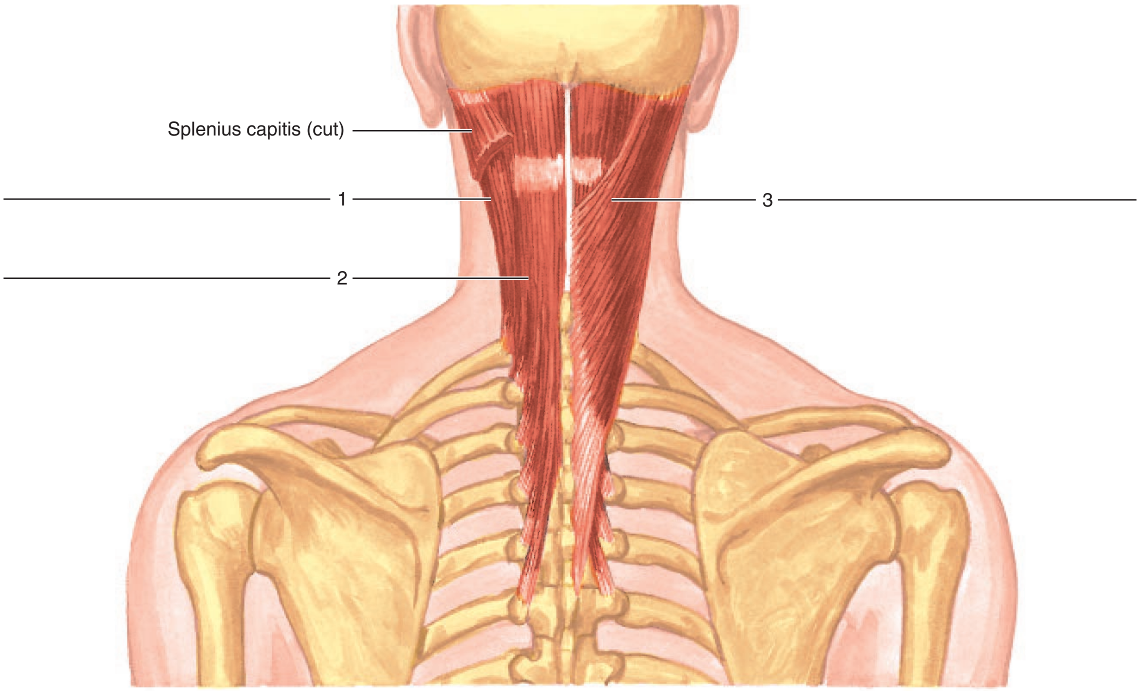


Figure 20.3 Label these deep muscles of the posterior neck (trapezius removed).



Laboratory Report **20**

Name ______________________________

Date ______________________________

Section ______________________________

Muscles of the Face, Head, and Neck

Part A

Complete the following statements:

1. When the ________________________ contracts, the corner of the mouth is drawn upward.
2. The ________________________ acts to compress the wall of the cheeks when air is blown out of the mouth.
3. The ________________________ causes the lips to close and pucker.
4. The ________________________ and platysma help to lower the mandible.
5. The temporalis acts to ________________________.
6. The ________________________ pterygoid can close the jaw and can pull it sideways.
7. The ________________________ pterygoid can protrude the jaw, pull the jaw sideways, and open the mouth.
8. The ________________________ can close the eye as in blinking.
9. The ________________________ can pull the head toward the chest.
10. The ________________________ can pull the head to one side, rotate it, or bring it into an upright position.
11. The muscle used for pouting and to express horror is the ________________________.
12. The muscle used to smile and laugh is the ________________________.

Part B

Name the muscle indicated by the following combinations of origin and insertion.

	Origin	Insertion	Muscle
1.	occipital bone	skin and muscle around eye	________________
2.	zygomatic bone	orbicularis oris	________________
3.	zygomatic arch	lateral surface of mandible	________________
4.	sphenoid bone	anterior surface of mandibular condyle	________________
5.	anterior surface of sternum and upper clavicle	mastoid process of temporal bone	________________
6.	outer surfaces of mandible and maxilla	orbicularis oris	________________
7.	fascia in upper chest	lower border of mandible and skin around corner of mouth	________________
8.	temporal bone	coronoid process and anterior ramus of mandible	________________
9.	spinous processes of cervical and thoracic vertebrae	mastoid process of temporal bone and occipital bone	________________
10.	processes of cervical and thoracic vertebrae	occipital bone	________________

Part C

Critical Thinking Application

Identify the muscles of various facial expressions in the photographs of figure 20.4.

1. ____
2. ____
3. ____
4. ____
5. ____

Figure 20.4 Identify the muscles of expression being contracted in each of these photographs (*a–c*).

Laboratory Exercise 21

Muscles of the Chest, Shoulder, and Upper Limb

MATERIALS NEEDED

textbook
torso
human skeleton, articulated
muscular models of the upper limb

The muscles of the chest and shoulder are responsible for moving the scapula and arm, whereas those within the arm and forearm act to move joints in the elbow and hand.

PURPOSE OF THE EXERCISE

To review the locations, actions, origins, and insertions of the muscles in the chest, shoulder, and upper limb.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the muscles of the chest, shoulder, and upper limb;
2. describe and demonstrate the action of each of these muscles;
3. locate the origin and insertion of each of these muscles.

PROCEDURE

1. Review textbook sections on *muscles that move the pectoral girdle, muscles that move the arm, muscles that move the forearm,* and *muscles that move the hand.*
2. As a review activity, label figures 21.1, 21.2, 21.3, and 21.4.
3. Locate the following muscles in the torso and models of the upper limb. Also, locate in your own body as many of the muscles as you can.

muscles that move the pectoral girdle

trapezius

rhomboideus major

levator scapulae

serratus anterior

pectoralis minor

muscles that move the arm

coracobrachialis

pectoralis major

teres major

latissimus dorsi

supraspinatus

deltoid

subscapularis

infraspinatus

teres minor

muscles that move the forearm

biceps brachii

brachialis

brachioradialis

triceps brachii

supinator

pronator teres

pronator quadratus

muscles that move the hand

flexor carpi radialis

flexor carpi ulnaris

palmaris longus

flexor digitorum profundus

flexor digitorum superficialis

extensor carpi radialis longus

extensor carpi radialis brevis

extensor carpi ulnaris

extensor digitorum

Figure 21.1 Label the muscles of the posterior shoulder. Superficial muscles are illustrated on the left side and deep muscles on the right side.

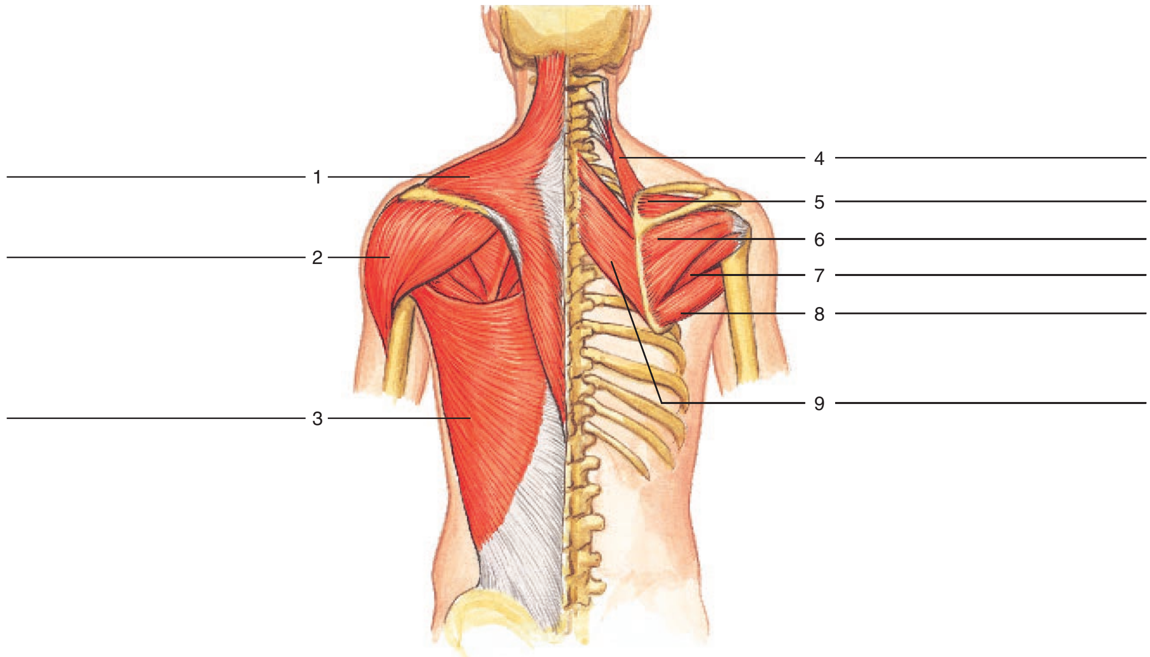


Figure 21.2 Label the muscles of the anterior chest. Superficial muscles are illustrated on the left side and deep muscles on the right side.

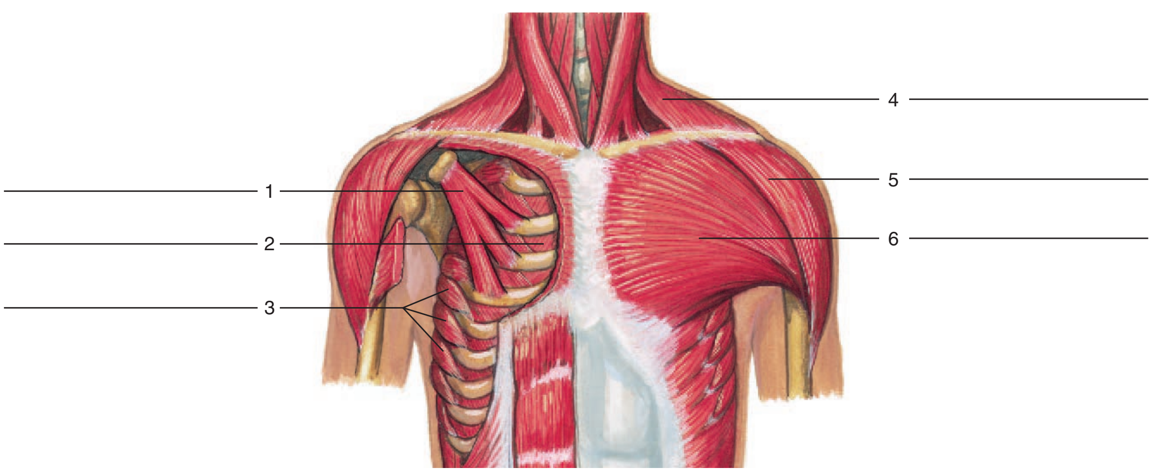
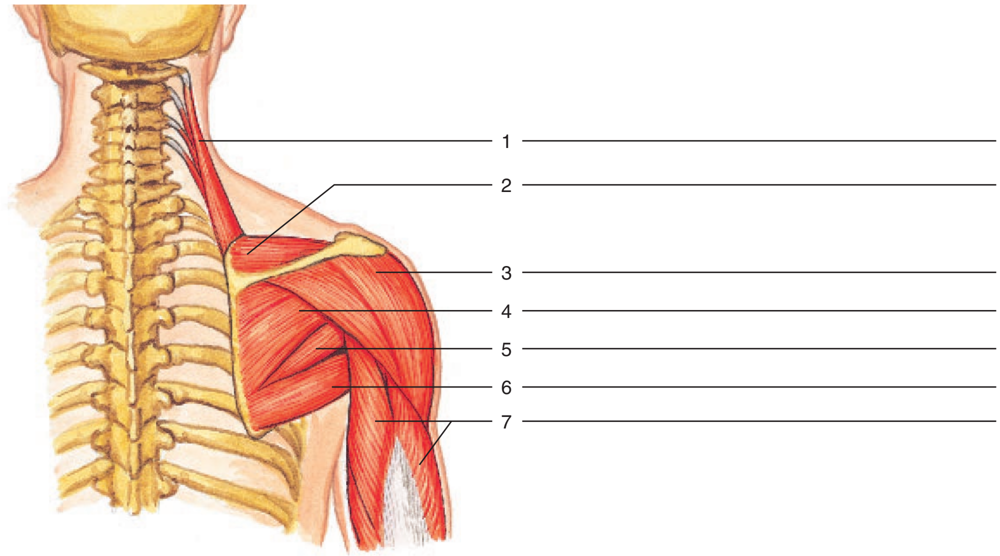
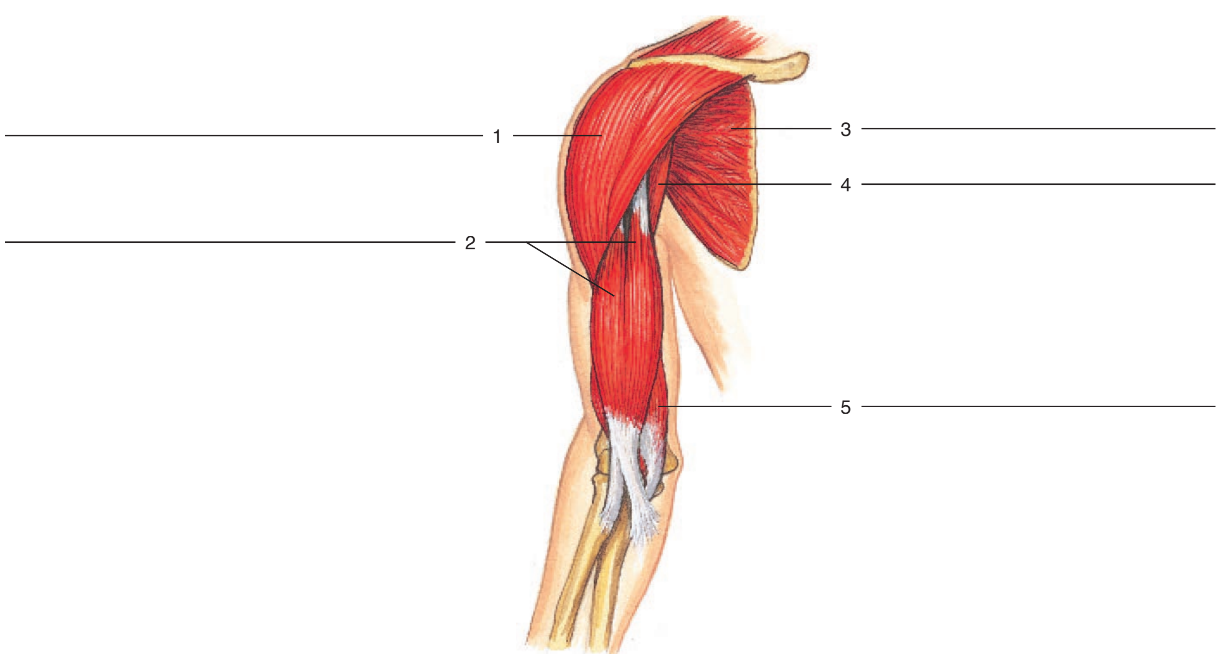


Figure 21.3 Label (*a*) the muscles of the posterior shoulder and arm and (*b*) the muscles of the anterior shoulder and arm.

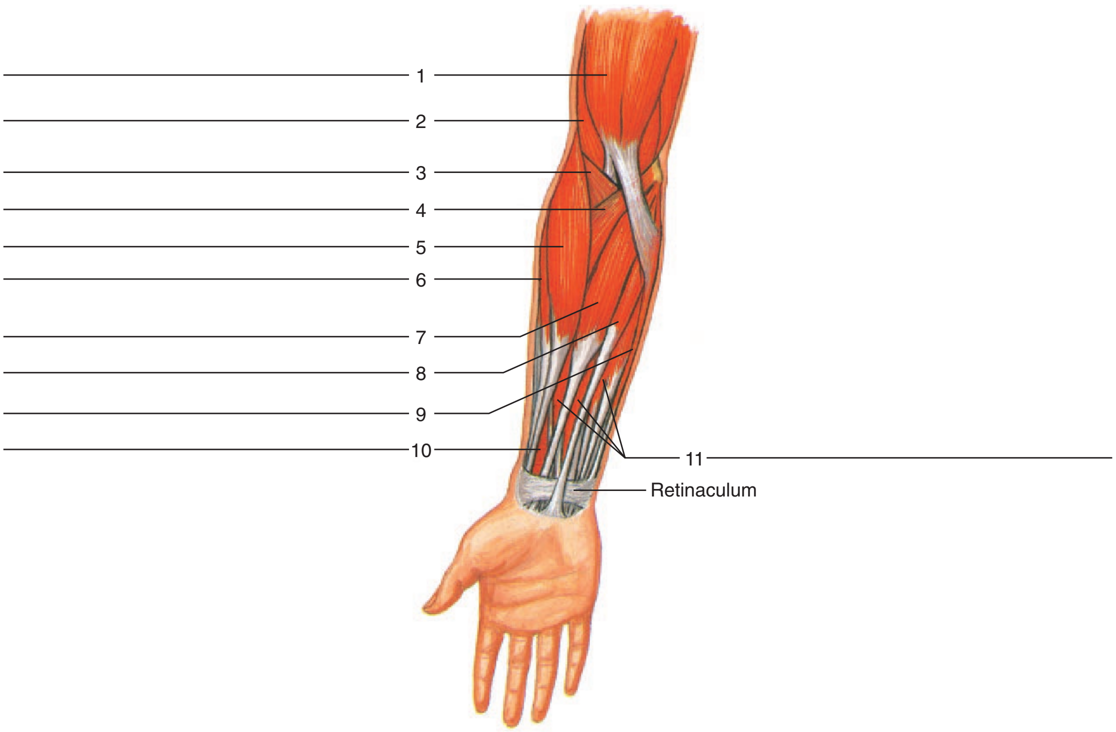


(a)

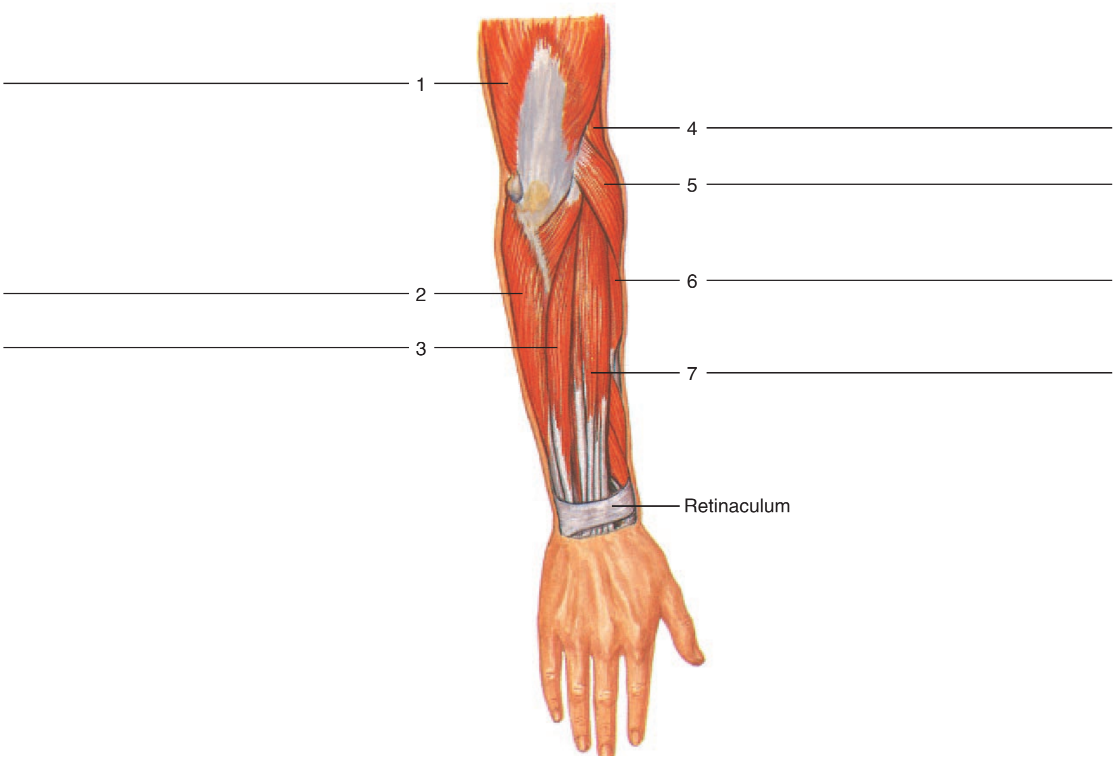


(b)

Figure 21.4 Label (*a*) the muscles of the anterior forearm and (*b*) the muscles of the posterior forearm.



(a)



(b)

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4. Demonstrate the action of these muscles in your own body.
5. Locate the origins and insertions of these muscles in the human skeleton.
6. Complete Parts A, B, and C of Laboratory Report 21.

Web Quest

Determine the origin, insertion, action, nerve innervation, and blood supply of all the major muscles.

Identify muscles and detailed explanations from an interactive site.

Find information about these topics at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

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Laboratory Report **21**

Name ______________________

Date ______________________

Section ______________________

Muscles of the Chest, Shoulder, and Upper Limb

Part A

Match the muscles in column A with the actions in column B. Place the letter of your choice in the space provided.

Column A

a. brachialis
b. coracobrachialis
c. deltoid
d. extensor carpi ulnaris
e. flexor carpi ulnaris
f. flexor digitorum profundus
g. infraspinatus
h. pectoralis major
i. pectoralis minor
j. pronator teres
k. rhomboideus major
l. serratus anterior
m. supinator
n. teres major
o. triceps brachii

Column B

____ 1. abducts arm
____ 2. pulls arm forward and across chest and rotates arm medially
____ 3. flexes and adducts hand at the wrist
____ 4. raises and adducts scapula
____ 5. rotates forearm medially
____ 6. raises ribs in forceful inhalation or pulls scapula forward and downward
____ 7. turns forearm laterally
____ 8. used to thrust shoulder anteriorly, as when pushing something
____ 9. flexes the forearm at the elbow
____ 10. flexes and adducts arm at the shoulder along with pectoralis major
____ 11. extends the forearm at the elbow
____ 12. extends, adducts, and rotates arm medially
____ 13. extends and adducts hand at the wrist
____ 14. rotates arm laterally
____ 15. flexes distal joints of fingers 2–5

Part B

Name the muscle indicated by the following combinations of origin and insertion.

	Origin	Insertion	Muscle
1.	spines of upper thoracic vertebrae	medial border of scapula	______________
2.	outer surfaces of upper ribs	ventral surface of scapula	______________
3.	sternal ends of upper ribs	coracoid process of scapula	______________
4.	coracoid process of scapula	shaft of humerus	______________
5.	lateral border of scapula	intertubercular groove of humerus	______________
6.	anterior surface of scapula	lesser tubercle of humerus	______________
7.	lateral border of scapula	greater tubercle of humerus	______________
8.	anterior shaft of humerus	coronoid process of ulna	______________
9.	medial epicondyle of humerus and coronoid process of ulna	lateral surface of radius	______________
10.	anterior distal end of ulna	anterior distal end of radius	______________
11.	distal lateral end of humerus	lateral surface of radius above styloid process	______________
12.	medial epicondyle of humerus	base of second and third metacarpals	______________
13.	medial epicondyle of humerus	fascia of palm	______________
14.	distal end of humerus	base of second metacarpal	______________
15.	lateral epicondyle of humerus	base of fifth metacarpal	______________

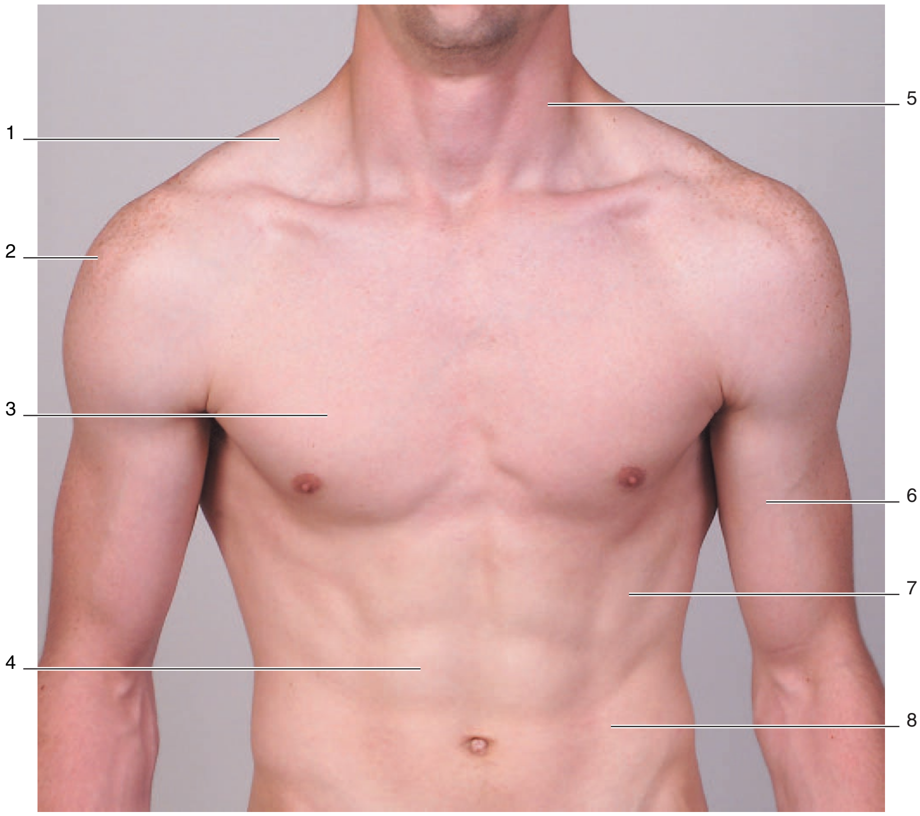
Part C

Critical Thinking Application

Identify the muscles indicated in figure 21.5.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
11. ______________________
12. ______________________
13. ______________________
14. ______________________
15. ______________________
16. ______________________
17. ______________________
18. ______________________
19. ______________________
20. ______________________
21. ______________________

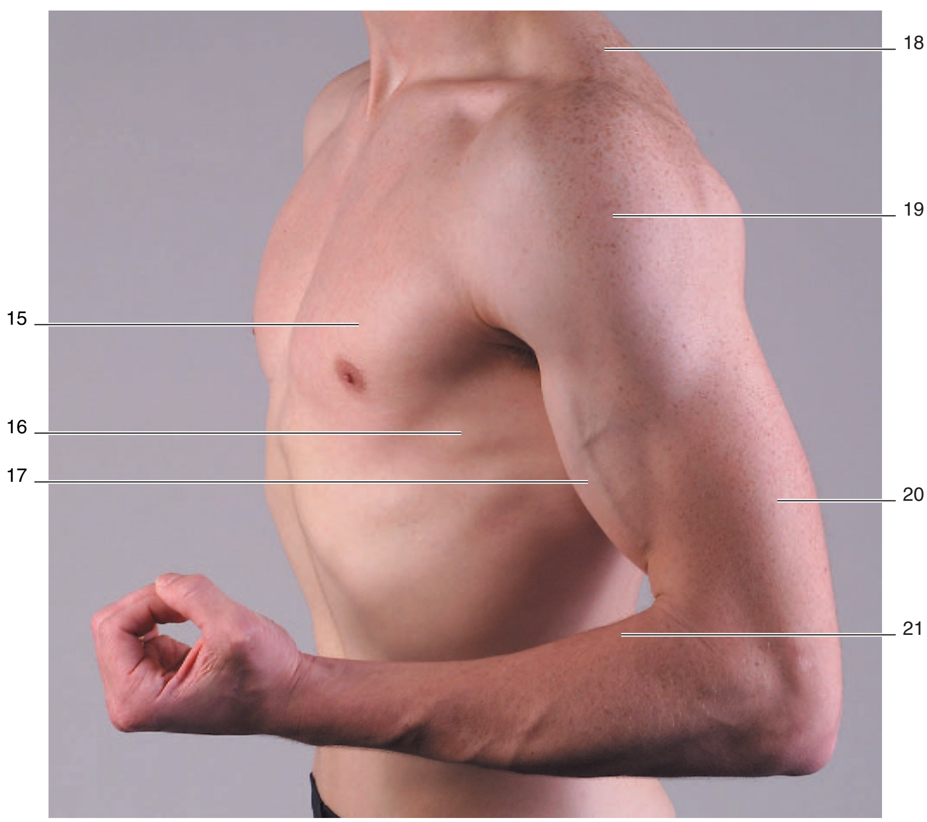
Figure 21.5 Identify the muscles that appear as body surface features in these photographs (*a, b,* and *c*).



(a)

Figure 21.5 *Continued*

(b)



(c)

Laboratory Exercise 22

Muscles of the Deep Back, Abdominal Wall, and Pelvic Outlet

MATERIALS NEEDED

textbook
torso with musculature
human skeleton, articulated
muscular models of male and female pelves

The deep muscles of the back extend the vertebral column. Because the muscles have numerous origins, insertions, and subgroups, the muscles overlap each other. The deep back muscles can extend the spine when contracting as a group but also help to maintain posture and normal spine curvatures.

The anterior and lateral walls of the abdomen contain broad, flattened muscles arranged in layers. These muscles connect the rib cage and vertebral column to the pelvic girdle.

The muscles of the pelvic outlet are arranged in two muscular sheets: (1) a deeper pelvic diaphragm that forms the floor of the pelvic cavity and (2) a urogenital diaphragm that fills the space within the pubic arch.

PURPOSE OF THE EXERCISE

To review the actions, origins, and insertions of the muscles of the deep back, abdominal wall, and pelvic outlet.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the muscles of the deep back, abdominal wall, and pelvic outlet;
2. describe the action of each of these muscles;
3. locate the origin and insertion of each of these muscles.

PROCEDURE

1. Review textbook sections on *muscles of the abdominal wall* and *muscles of the pelvic outlet.*
2. As a review activity, label figures 22.1, 22.2, 22.3, and 22.4.
3. Locate the following muscles in the torso:

   erector spinae group

   iliocostalis (lateral group)

   longissimus (intermediate group)

   spinalis (medial group)

   external oblique

   internal oblique

   transversus abdominis

   rectus abdominis

4. Demonstrate the actions of these muscles in your own body.
5. Locate the origin and insertion of each of these muscles in the human skeleton.
6. Complete Part A of Laboratory Report 22.
7. Locate the following muscles in the models of the male and female pelves:

   levator ani

   coccygeus

   superficial transversus perinei

   bulbospongiosus

   ischiocavernosus

8. Locate the origin and insertion of each of these muscles in the human skeleton.
9. Complete Part B of the laboratory report.

Critical Thinking Application

List the muscles from superficial to deep for an appendectomy incision.

____

____

____

____

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Figure 22.1 Label the three deep back muscle groups of the erector spinae group.

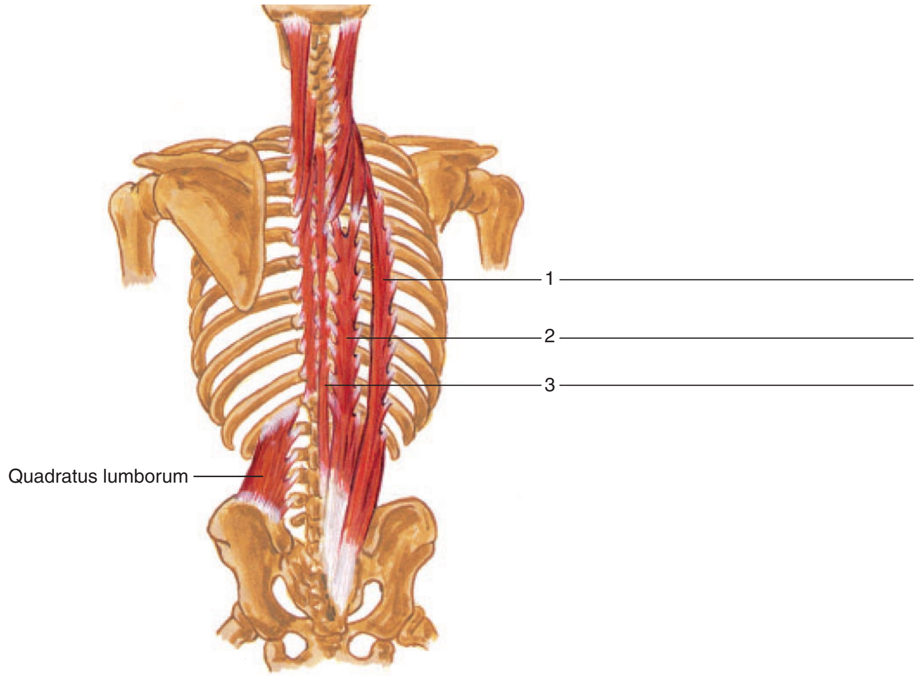


Figure 22.2 Label the muscles of the abdominal wall.

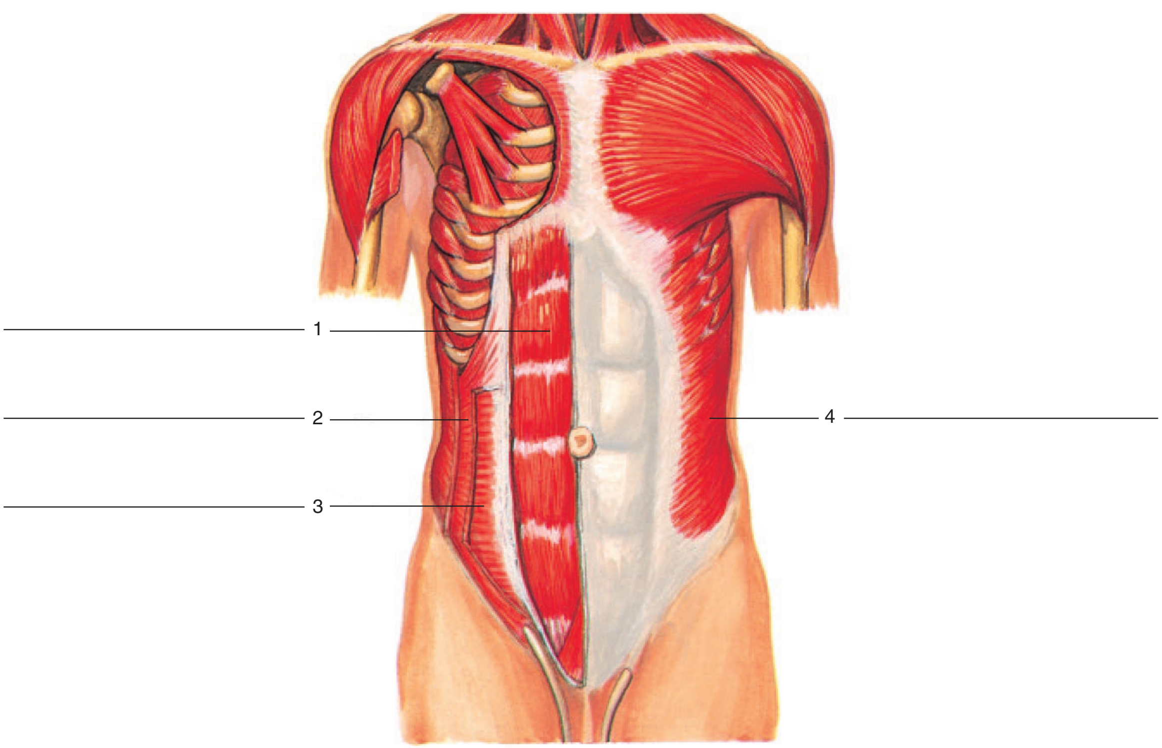


Figure 22.3 Label the muscles of the male pelvic outlet.

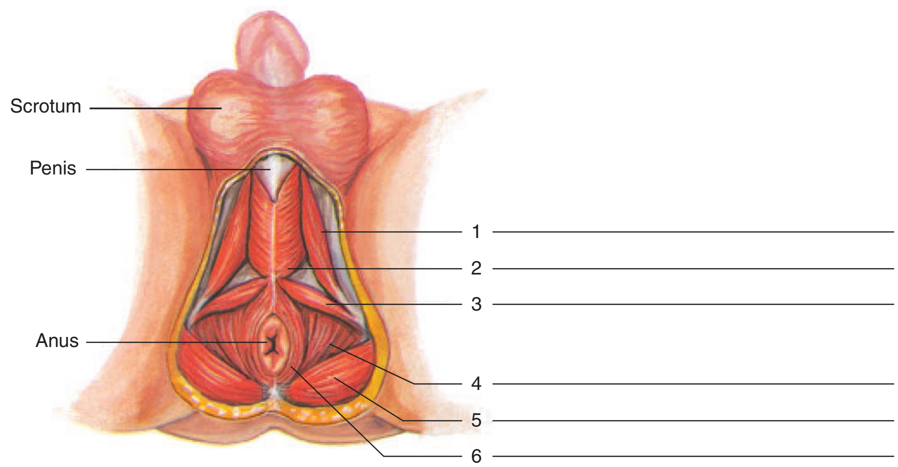
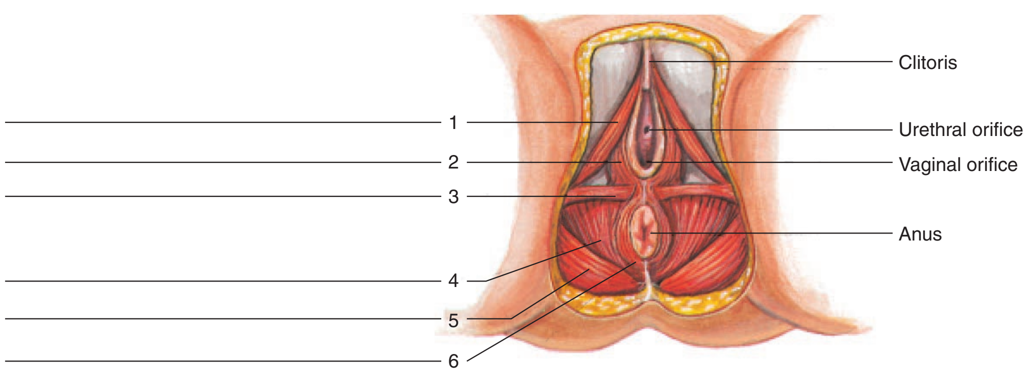


Figure 22.4 Label the muscles of the female pelvic outlet.



Web Quest

Determine the origin, insertion, action, nerve innervation, and blood supply of all the major muscles.

Identify muscles and detailed explanations from an interactive site.

Find information about these topics at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

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Laboratory Report **22**

Name ______________________________

Date ______________________________

Section ______________________________

Muscles of the Deep Back, Abdominal Wall, and Pelvic Outlet

Part A

Complete the following statements:

1. A band of tough connective tissue in the midline of the anterior abdominal wall called the ________________________ serves as a muscle attachment.
2. The ______________________________ muscle spans from the ribs and sternum to the pubic bones.
3. The ______________________________ forms the third layer (deepest layer) of the abdominal wall muscles.
4. The action of the external oblique muscle is to ______________________________.
5. The action of the rectus abdominis is to ______________________________.
6. The iliocostalis, longissimus, and spinalis muscles together form the ______________________________.

Part B

Complete the following statements:

1. The levator ani and coccygeus together form the ______________________________.
2. The levator ani provides a sphincterlike action in the ______________________________.
3. The action of the coccygeus is to ______________________________
______________________________.
4. The ________________________ surrounds the base of the penis.
5. In females, the bulbospongiosus acts to ______________________________.
6. The ischiocavernosus extends from the margin of the pubic arch to the ______________________________.
7. In the female, the ________________________ muscles are separated by the vagina, urethra, and anal canal.
8. The action of the superficial transversus perinei is to ______________________________.
9. The coccygeus extends from the coccyx and sacrum to the ________________________.
10. The ______________________________ assists in closing the urethra.

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Laboratory Exercise 23

Muscles of the Hip and Lower Limb

MATERIALS NEEDED

textbook
torso with musculature
human skeleton, articulated
muscular models of the lower limb

The muscles that move the thigh are attached to the femur and to some part of the pelvic girdle. Those attached anteriorly primarily act to flex the thigh at the hip, whereas those attached posteriorly act to extend, abduct, or rotate the thigh.

The muscles that move the leg connect the tibia or fibula to the femur or to the pelvic girdle. They function to flex or extend the leg at the knee. Other muscles, located in the leg, act to move the foot.

PURPOSE OF THE EXERCISE

To review the actions, origins, and insertions of the muscles that move the thigh, leg, and foot.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the muscles that move the thigh, leg, and foot;
2. describe and demonstrate the actions of each of these muscles;
3. locate the origin and insertion of each these muscles.

PROCEDURE

1. Review textbook sections on *muscles that move the thigh, muscles that move the leg,* and *muscles that move the foot.*
2. As a review activity, label figures 23.1, 23.2, 23.3, 23.4, 23.5, and 23.6.
3. Locate the following muscles in the torso and in the lower limb models. Also locate as many of them as possible in your own body.

muscles that move the thigh

- iliopsoas group
  - psoas major
  - iliacus
- psoas minor
- gluteus maximus
- gluteus medius
- gluteus minimus
- tensor fasciae latae
- pectineus
- adductor longus
- adductor magnus
- adductor brevis
- gracilis

muscles that move the leg

- hamstring group
  - biceps femoris
  - semitendinosus
  - semimembranosus
- sartorius
- quadriceps femoris group
  - rectus femoris
  - vastus lateralis
  - vastus medialis
  - vastus intermedius

muscles that move the foot

- tibialis anterior
- peroneus tertius
- extensor digitorum longus

gastrocnemius

soleus

flexor digitorum longus

tibialis posterior

peroneus longus

peroneus brevis

4. Demonstrate the action of each of these muscles in your own body.
5. Locate the origin and insertion of each of these muscles in the human skeleton.
6. Complete Parts A, B, and C of Laboratory Report 23.

Web Quest

Determine the origin, insertion, action, nerve innervation, and blood supply of all the major muscles.

Identify muscles and detailed explanations from an interactive site.

Find information about these topics at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 23.1 Label the muscles of the anterior right hip and thigh.

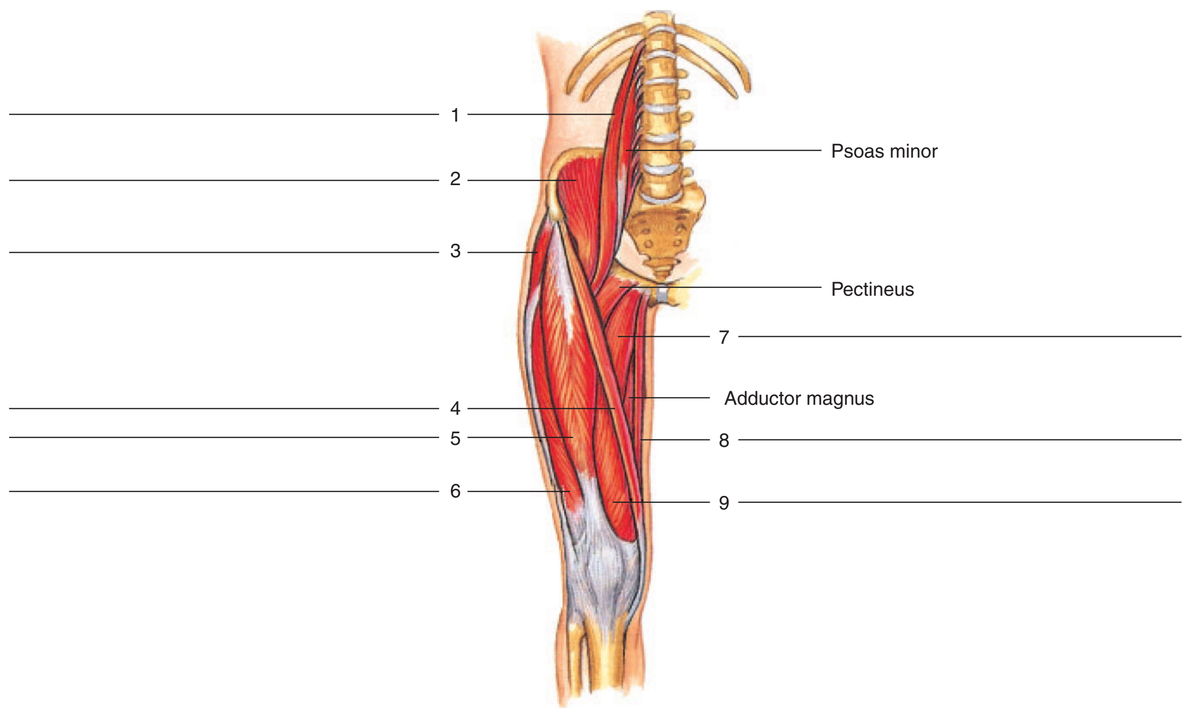


Figure 23.2 Label the muscles of the lateral right hip and thigh.

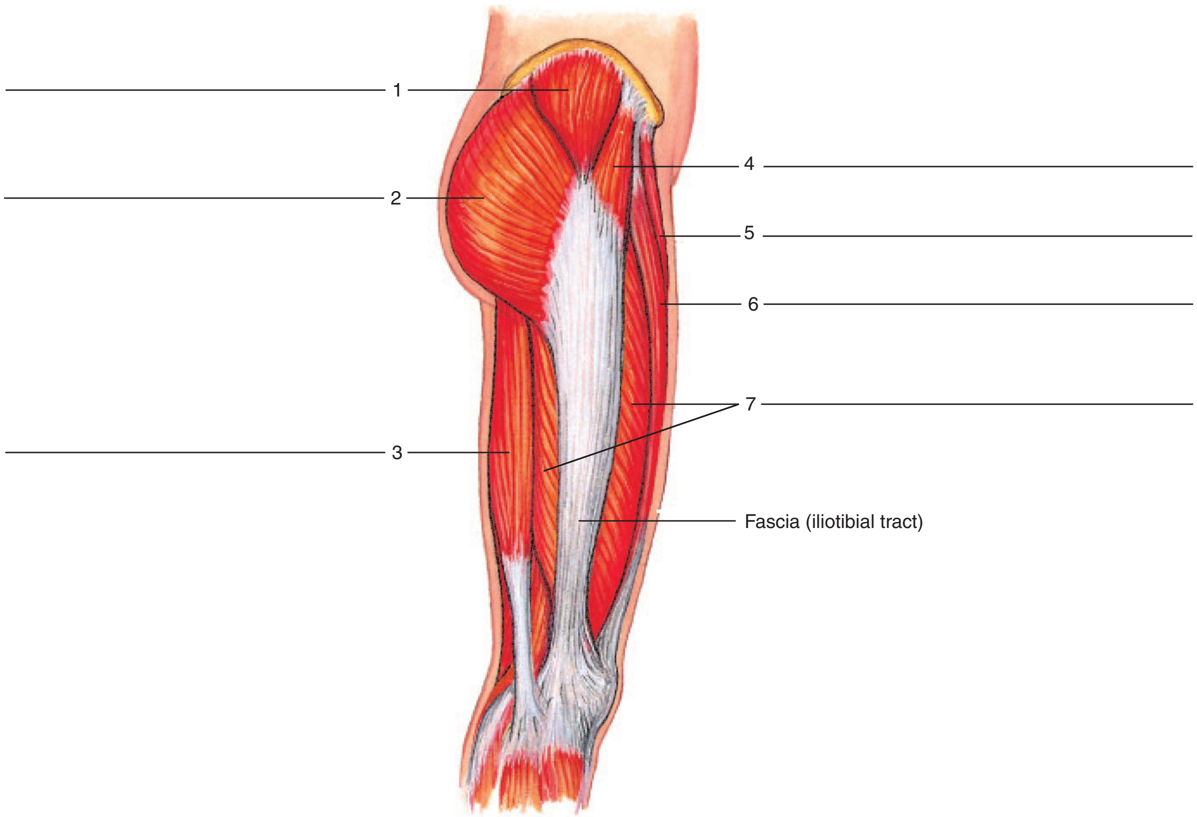


Figure 23.3 Label the muscles of the posterior right hip and thigh.

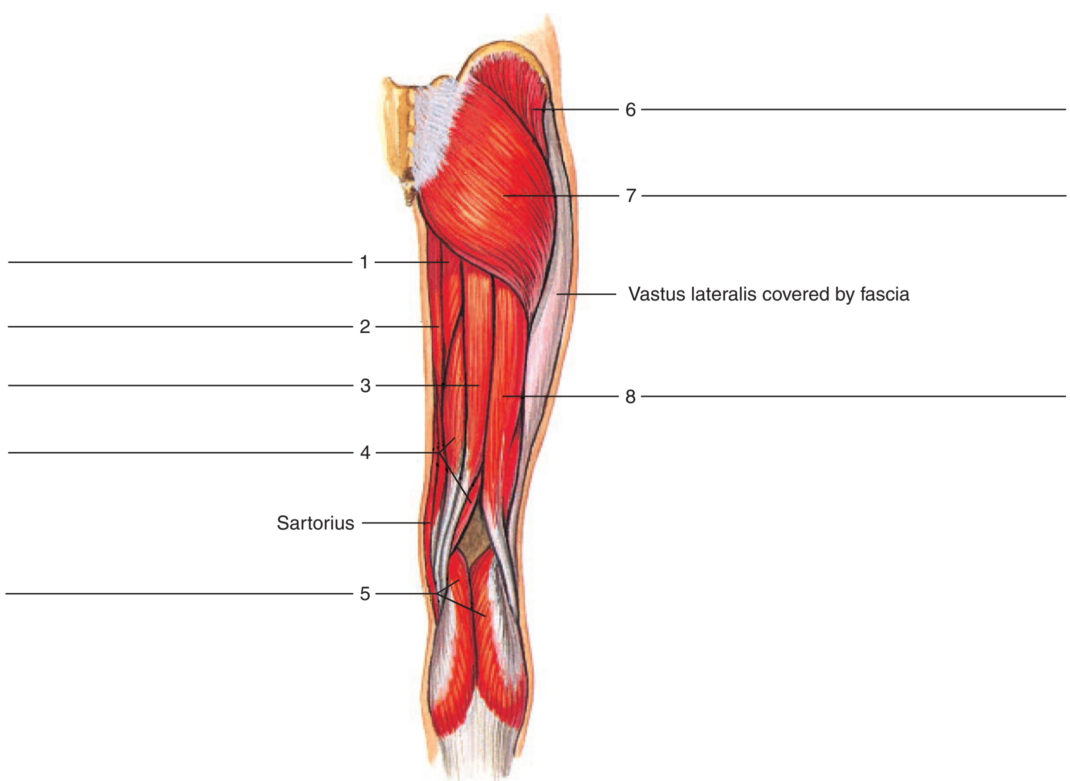


Figure 23.4 Label the muscles of the anterior right leg.

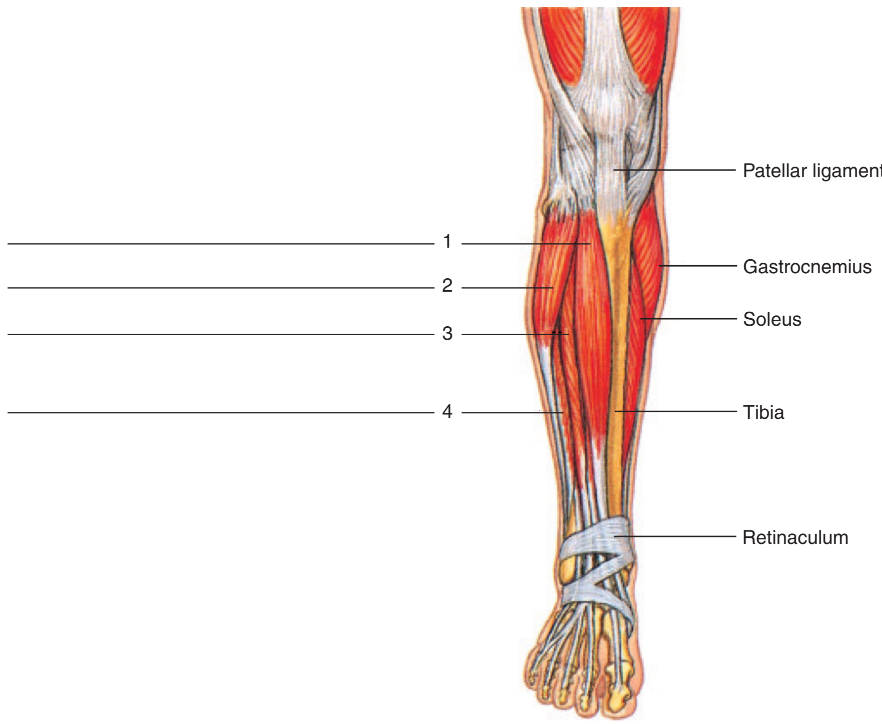
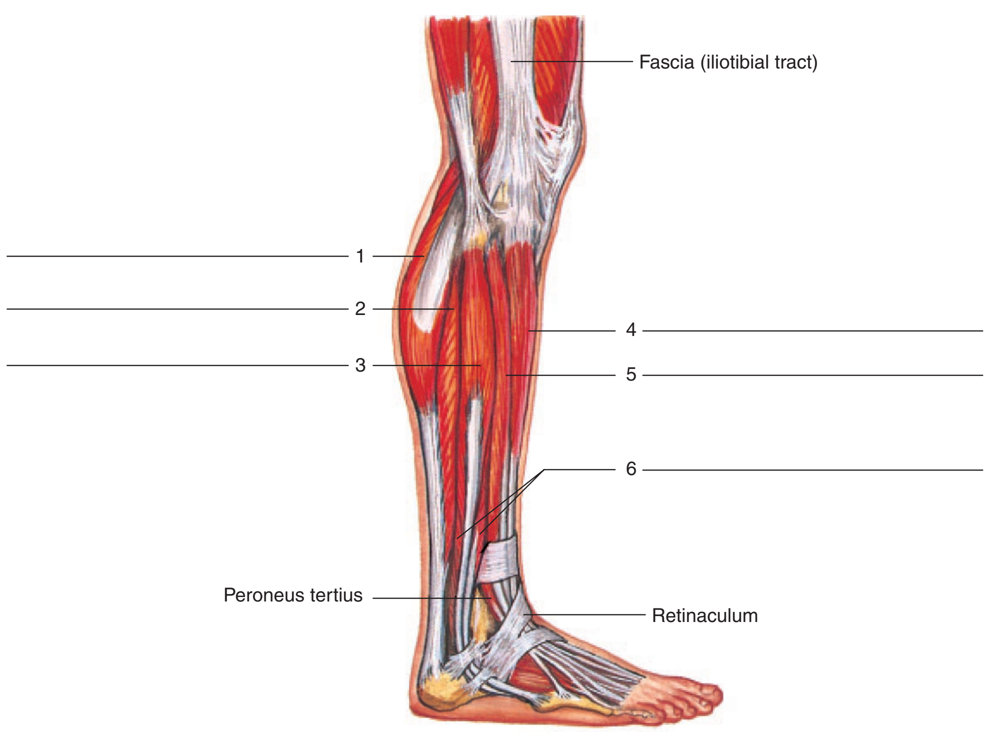


Figure 23.5 Label the muscles of the lateral right leg.



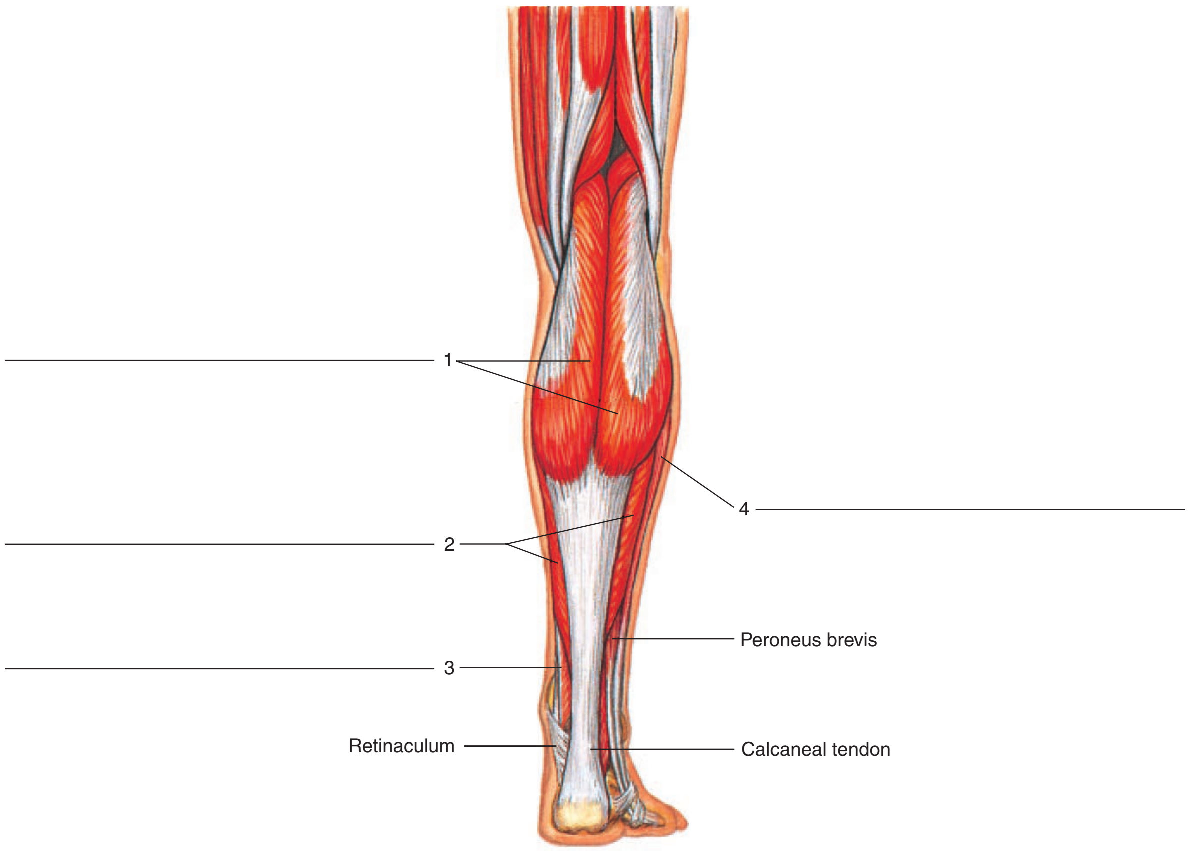


Figure 23.6 Label the muscles of the posterior right leg.

Laboratory Report 23

Name ____________________

Date ____________________

Section ____________________

Muscles of the Hip and Lower Limb

Part A

Match the muscles in column A with the actions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. biceps femoris	____	1. adducts thigh
b. gluteus medius	____	2. plantar flexion and eversion of foot
c. gracilis	____	3. flexes thigh at the hip
d. peroneus longus	____	4. abducts thigh and rotates it laterally
e. peroneus tertius	____	5. dorsiflexion and eversion of foot
f. psoas major and iliacus	____	6. abducts thigh and rotates it medially
g. quadriceps femoris group	____	7. plantar flexion and inversion of foot
h. sartorius	____	8. flexes leg at the knee
i. tibialis anterior	____	9. extends leg at the knee
j. tibialis posterior	____	10. dorsiflexion and inversion of foot

Part B

Name the muscle indicated by the following combinations of origin and insertion.

Origin	Insertion	Muscle
1. lateral surface of ilium	greater trochanter of femur	____________
2. ischial tuberosity	posterior surface of femur	____________
3. anterior superior iliac spine	medial surface of tibia	____________
4. lateral and medial condyles of femur	posterior surface of calcaneus	____________
5. anterior iliac crest	fascia (iliotibial tract) of the thigh	____________
6. greater trochanter and posterior surface of femur	patella to tibial tuberosity	____________
7. ischial tuberosity	medial surface of tibia	____________

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8.	medial surface of femur	patella to tibial tuberosity	________________________
9.	posterior surface of tibia	distal phalanges of four lateral toes	________________________
10.	lateral condyle and lateral surface of tibia	cuneiform and first metatarsal	________________________

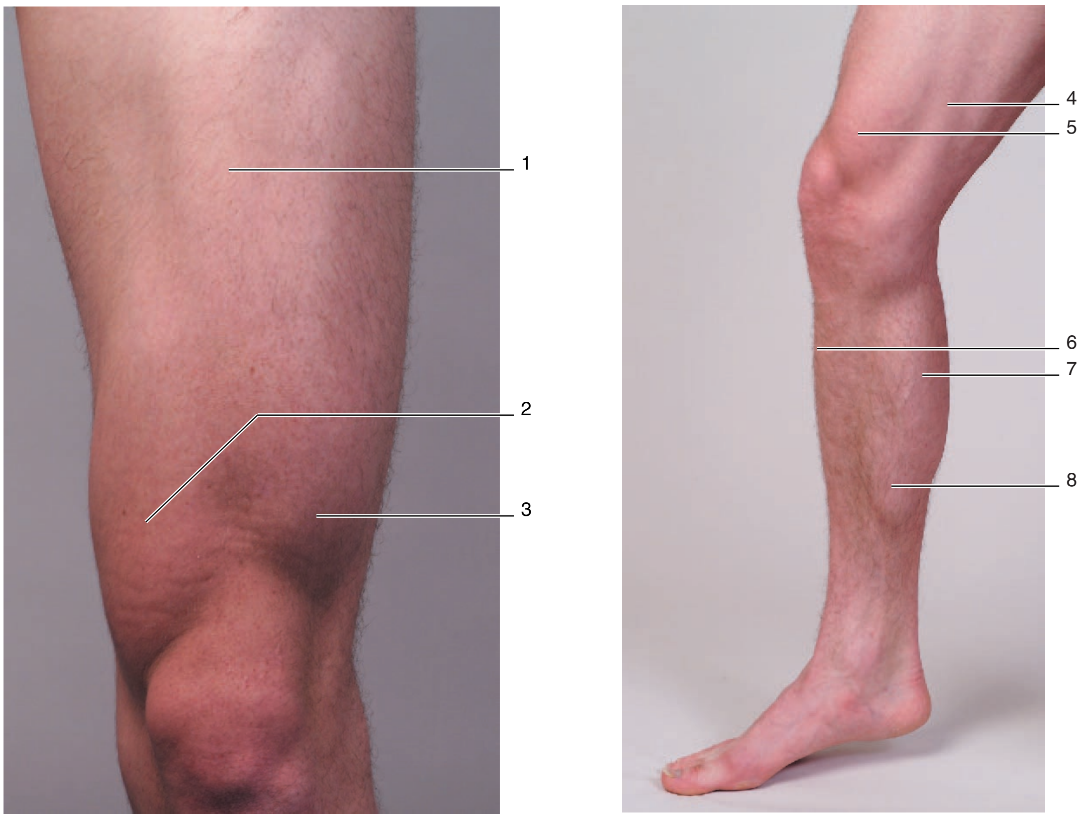
Part C

Critical Thinking Application

Identify the muscles indicated in figure 23.7.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

Figure 23.7 Identify the muscles that appear as lower limb surface features in these photographs (*a* and *b*).



(a) Left thigh, anterior view

(b) Right lower limb, medial view

Laboratory Exercise 24

Fetal Pig Dissection: Musculature

MATERIALS NEEDED

textbook
preserved fetal pig (double injection)
dissecting tray
dissecting instruments
twine
plastic bag
identification tag
disposable gloves
bone shears
human torso
human upper and lower limb models

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

Although the aim of this exercise is to become more familiar with the human musculature, human cadavers are not always available for dissection. Instead, preserved fetal pigs often are used for dissection because they are relatively small and can be purchased from biological suppliers. Also, as mammals, pigs have many features in common with humans, including similar skeletal muscles (with similar names).

On the other hand, pigs make use of four limbs for support whereas humans use only two limbs. Because the musculature of each type of organism is adapted to provide for its special needs, comparisons of the muscles of pigs and humans may not be precise.

As you continue your dissection of various systems of the fetal pig, many anatomical similarities will be observed. These fundamental similarities are homologous structures. Although homologous structures have a similar structure and embryological origin, the functions are sometimes different.

PURPOSE OF THE EXERCISE

To observe the musculature of the fetal pig and to compare it with that of the human.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name and locate the major skeletal muscles of the fetal pig;
2. name and locate the corresponding muscles of the human;
3. name the origins, insertions, and actions of the muscles designated by the laboratory instructor.

MUSCLE DISSECTION TECHNIQUES

Dissect: to expose the entire length of the muscle from origin to insertion. Most of the procedures are accomplished with blunt probes used to separate various connective tissues that hold adjacent structures together. It does not mean to remove or to cut into the muscles or other organs.

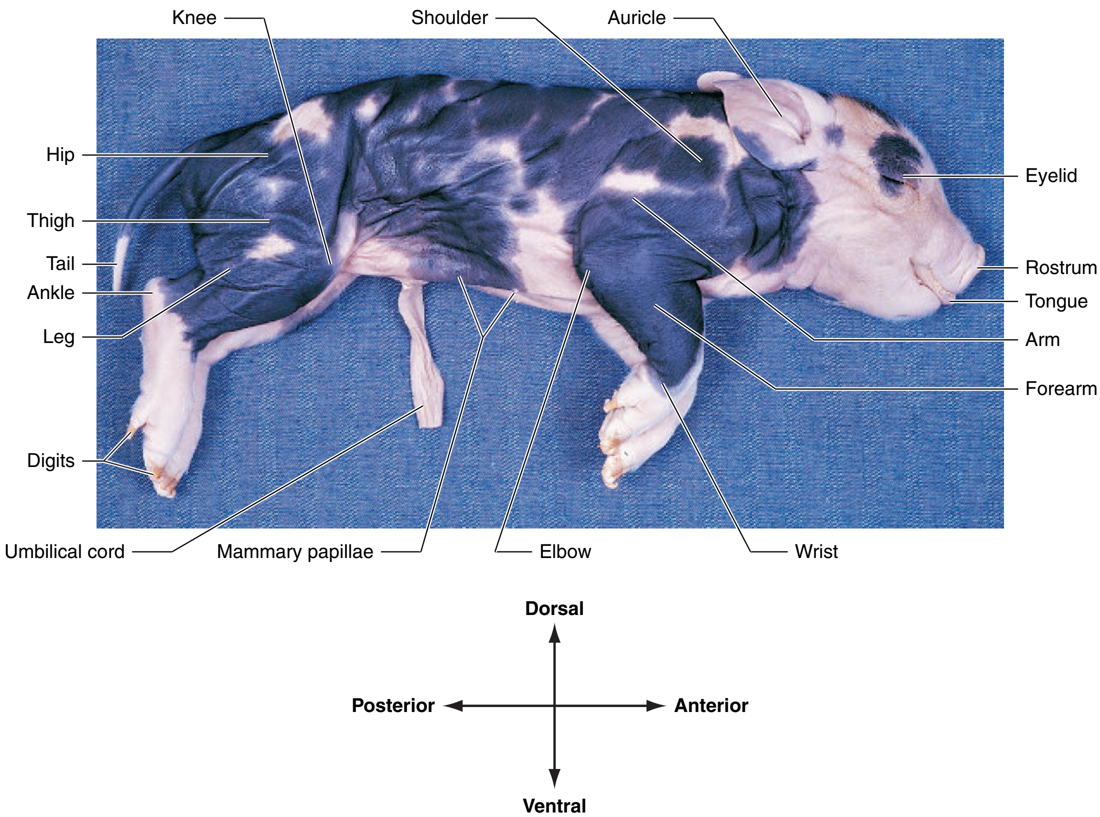
Transect: to cut through the muscle near its midpoint. The cut is perpendicular to the muscle fibers.

Reflect: to lift a transected muscle aside to expose deeper muscles or other organs.

PROCEDURE A—EXTERNAL FEATURES

1. Fetal pigs usually are embalmed with a mixture of propylene glycol, formaldehyde, and phenol, which prevents microorganisms from causing the tissues to decompose. However, because fumes from this embalming fluid may be annoying and may irritate skin, be sure to work in a well-ventilated room and wear disposable gloves to protect your hands. If your fetal pig has an incision in the neck, it marks the location where colored latex was injected into the blood vessels. Rinse the pig off before the dissection begins.

Figure 24.1 External features of a fetal pig, lateral view.



2. Obtain a preserved fetal pig, a dissecting tray, a set of dissecting instruments, a large plastic bag, twine, and an identification tag.
3. If the fetal pig is in a storage bag, dispose of any excess embalming fluid in the bag, as directed by the laboratory instructor. However, you may want to save some of the embalming fluid to keep the fetal pig moist until you have completed your work later in the year.
4. If the fetal pig is too wet with embalming fluid, blot the pig dry with paper towels.
5. Study figure 24.1 and locate the following external features:

   auricle

   tongue

   external nares

   rostrum (snout)

   eyelid

   shoulder

   arm

   elbow

   forearm

   wrist

   digits

   hip

   thigh

   knee

   leg

   ankle

   umbilical cord

   tail

   mammary papillae

   anus
6. Study the external features of a male and a female pig (fig. 24.2) by comparing your pig to others in the laboratory. Identify the following:

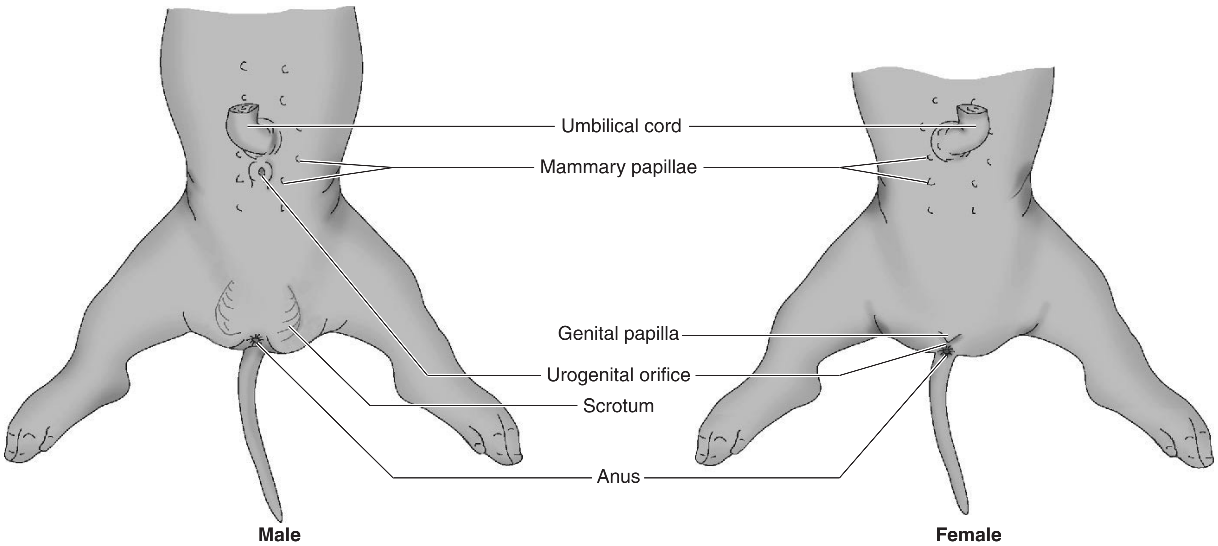
   male

   urogenital orifice

   scrotum

   mammary papillae

Figure 24.2 External features of a male and female fetal pig, ventral view.



female

genital papilla

urogenital orifice

mammary papillae

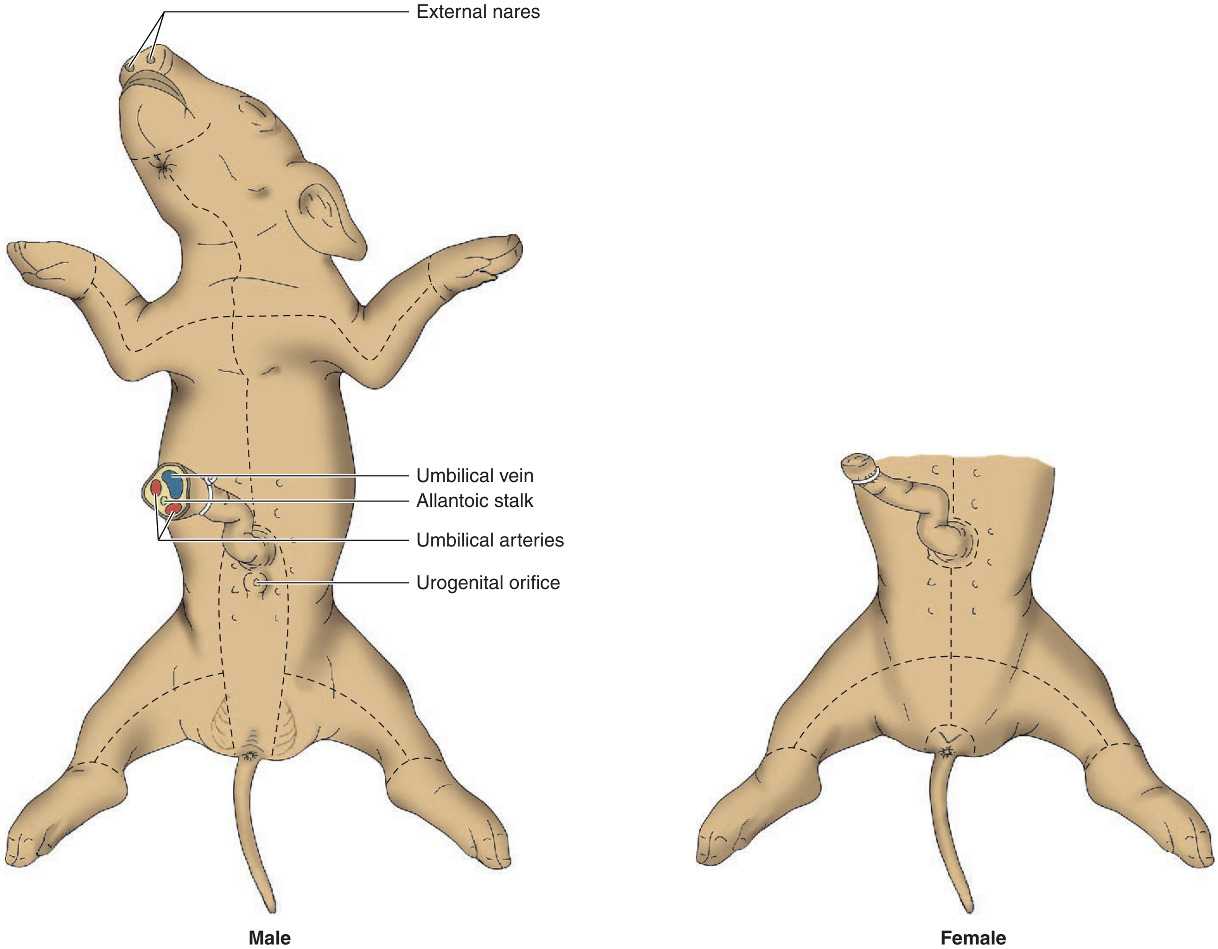
PROCEDURE B—SKIN REMOVAL

1. Remove the skin from the fetal pig. To do this, follow these steps:
   a. Place the fetal pig in the dissecting tray with its dorsal side down.
   b. Use a sharp scalpel to make short, shallow incisions through the skin as illustrated in figure 24.3. Note that the incisions are different for the male and female in the genital regions.
   c. Your incisions should encircle the neck, wrists, ankles, and the urogenital regions. Note that more skin is left attached on the male pig in the urogenital region.
   d. Use a blunt probe to separate the skin from the muscles. Observe the loose connective tissue (superficial fascia) that binds the skin to muscle. As you pull the skin away, you may note a thin sheet of skeletal muscle attached to it. These are *cutaneous muscles* and they function to move the skin to get rid of any irritants. Humans lack cutaneous muscles, but a similar sheet of muscle (platysma) is present in the neck of a human.
   e. As you remove the skin, work toward the dorsal surface, then work toward the head, and finally work toward the tail. Pull the skin over each limb as if you were removing a glove.
   f. After the skin has been pulled away, carefully remove as much of the remaining connective tissue as possible to expose the underlying skeletal muscles. This task only needs to be performed on the right side and ventrally so you can study the muscles. The muscles should appear light brown and fibrous.
2. After skinning the fetal pig, follow these steps:
   a. Discard the tissues you have removed as directed by the laboratory instructor.
   b. Wrap the skin around the pig to help keep its body moist, and place it in a plastic storage bag.
   c. Write your name in pencil on an identification tag, and tie the tag to the storage bag so that you can identify your specimen.
3. Observe the recommended safety procedures for the conclusion of a laboratory session.

PROCEDURE C—SKELETAL MUSCLE DISSECTION

1. The purpose of a skeletal muscle dissection is to separate the individual muscles from any surrounding tissues and thus expose the muscles for observation. To do a muscle dissection, follow these steps:
   a. Use the appropriate figure as a guide and locate the muscle to be dissected in the specimen.
   b. Use a blunt probe to separate the muscle from the surrounding connective tissue along its natural borders. The muscle should separate

Figure 24.3 The dotted lines indicate the shallow skin incisions on the male and female fetal pig to view the underlying muscles.



smoothly. If the border appears ragged, you probably have torn the muscle fibers. Because the fetal pig's muscles are incompletely developed, they are easily damaged and hard to distinguish, especially in small to medium sizes.

2. If it is necessary to transect a superficial muscle to observe a deeper one, use scissors to transect the muscle about halfway between its origin and insertion. Then, reflect the cut ends, leaving their attachments intact.
3. The following procedures will instruct you to dissect some of the larger and more easily identified muscles of the fetal pig. In each case, the procedure will include the names of the muscles to be dissected, figures illustrating their locations, and tables listing the origins, insertions, and actions of the muscles. Compare the muscle origins and insertions to the fetal pig skeleton (fig. 24.4). (More detailed dissection instructions can be obtained by consulting an additional guide or atlas for fetal pig dissection.)

As you dissect each muscle, study the figures and tables in a textbook and identify any corresponding (homologous) muscles of the human body. Also locate these homologous muscles in the torso or models of the human upper and lower limbs.

PROCEDURE D—MUSCLES OF THE HEAD AND NECK

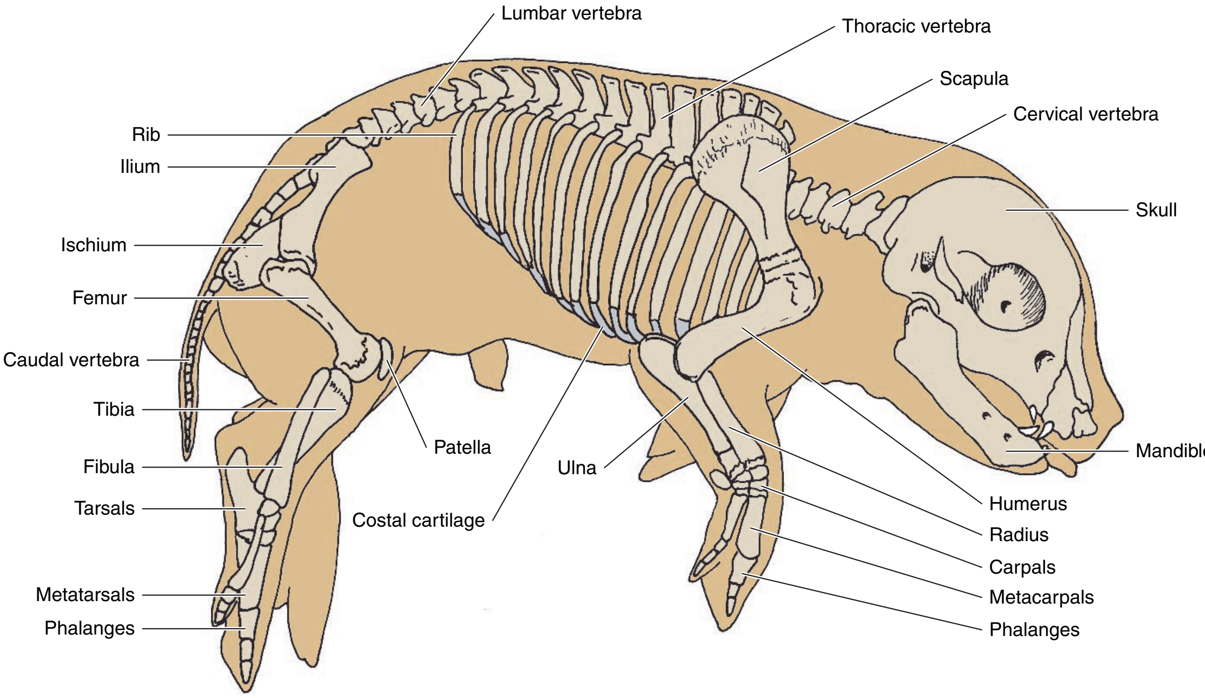
1. Place the fetal pig in the dissecting tray with its ventral side up.
2. Remove the skin and underlying connective tissues from one side of the neck, forward to the chin, and up to the ear.
3. Study figure 24.5, and then locate and dissect the following muscles:

   sternomastoid

   sternohyoid

   digastric

Figure 24.4 Skeleton of a fetal pig, lateral view.



mylohyoid

masseter

4. To find the deep *sternothyroid* muscle in the neck, transect and reflect the sternohyoid muscle from the right side.
5. See table 24.1 for the origins, insertions, and actions of these head and neck muscles.
6. Complete Part A of Laboratory Report 24.

PROCEDURE E—MUSCLES OF THE THORAX

1. Place the fetal pig in the dissecting tray with its ventral side up. Spread and secure all four limbs with twine.
2. Remove any remaining fat and connective tissue to expose the muscles in the walls of the thorax and abdomen.
3. Study figure 24.5. Locate and transect the superficial pectoral to expose the anterior deep pectoral. Locate and dissect the following pectoral muscles:

   superficial pectoral (pectoralis superficialis)—homologous to pectoralis major

   posterior deep pectoral (pectoralis profundus)—homologous to pectoralis minor

   anterior deep pectoral

4. To find the deep *serratus ventralis* thoracic muscle, transect the pectoral muscles, and reflect their cut edges to the sides. The fingerlike origins on the ribs can be located by pulling the forelimb away from the thorax.
5. See table 24.2 for the origins, insertions, and actions of these muscles.

PROCEDURE F—MUSCLES OF THE ABDOMINAL WALL

1. Study figure 24.5.
2. Locate the *external oblique muscle* in the abdominal wall.
3. Make a shallow, longitudinal incision through the external oblique. Lift up the cut edge and expose the *internal oblique muscle* beneath. Note that the fibers of the internal oblique run at a right angle to those of the external oblique.
4. Make a longitudinal incision through the internal oblique. Lift up the cut edge and expose the *transversus abdominis.*
5. Expose the *rectus abdominis muscle* on one side of the midventral line. This muscle lies beneath an aponeurosis.
6. See table 24.3 for the origins, insertions, and actions of these muscles.
7. Complete Part B of the laboratory report.

Figure 24.5 Muscles of the head, neck, thorax, and abdominal wall, ventral view.

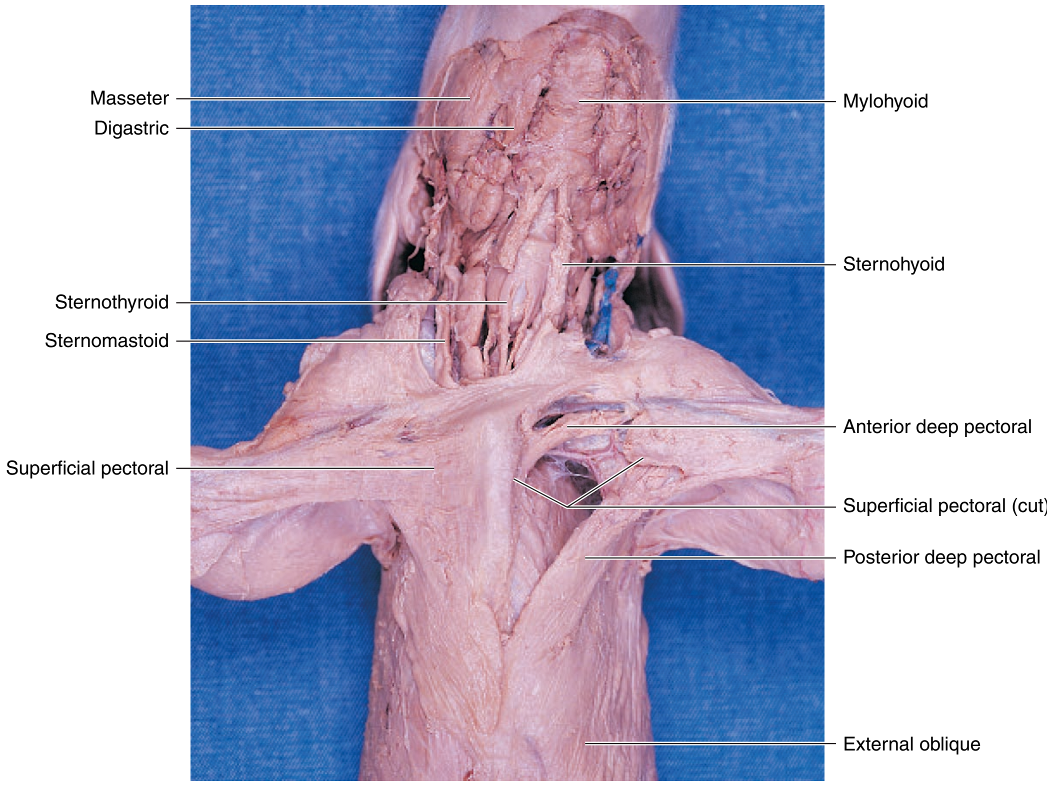


Table 24.1 Muscles of the Head and Neck

Muscle	Origin	Insertion	Action
Sternomastoid	Sternum	Mastoid process of temporal bone	Turns and depresses head
Sternohyoid	Costal cartilage	Hyoid bone	Depresses hyoid bone
Digastric	Mastoid process and occipital bone	Mandible	Depresses mandible
Mylohyoid	Mandible	Hyoid bone	Raises floor of mouth
Masseter	Zygomatic arch	Mandible	Elevates mandible
Sternothyroid	Sternum	Thyroid cartilage	Pulls larynx back

Table 24.2 Muscles of the Thorax

Muscle	Origin	Insertion	Action
Superficial pectoral	Sternum	Humerus	Adducts arm
Posterior deep pectoral	Sternum and costal cartilages	Humerus	Adducts arm
Anterior deep pectoral	Sternum and costal cartilages	Scapula	Pulls scapula toward midline of body
Serratus ventralis	Ribs and cervical vertebrae	Vertebral border of scapula	Pulls scapula posteriorly and transfers weight from trunk to pectoral girdle

Figure 24.6 Muscles of the shoulder, arm, and forearm, lateral view.

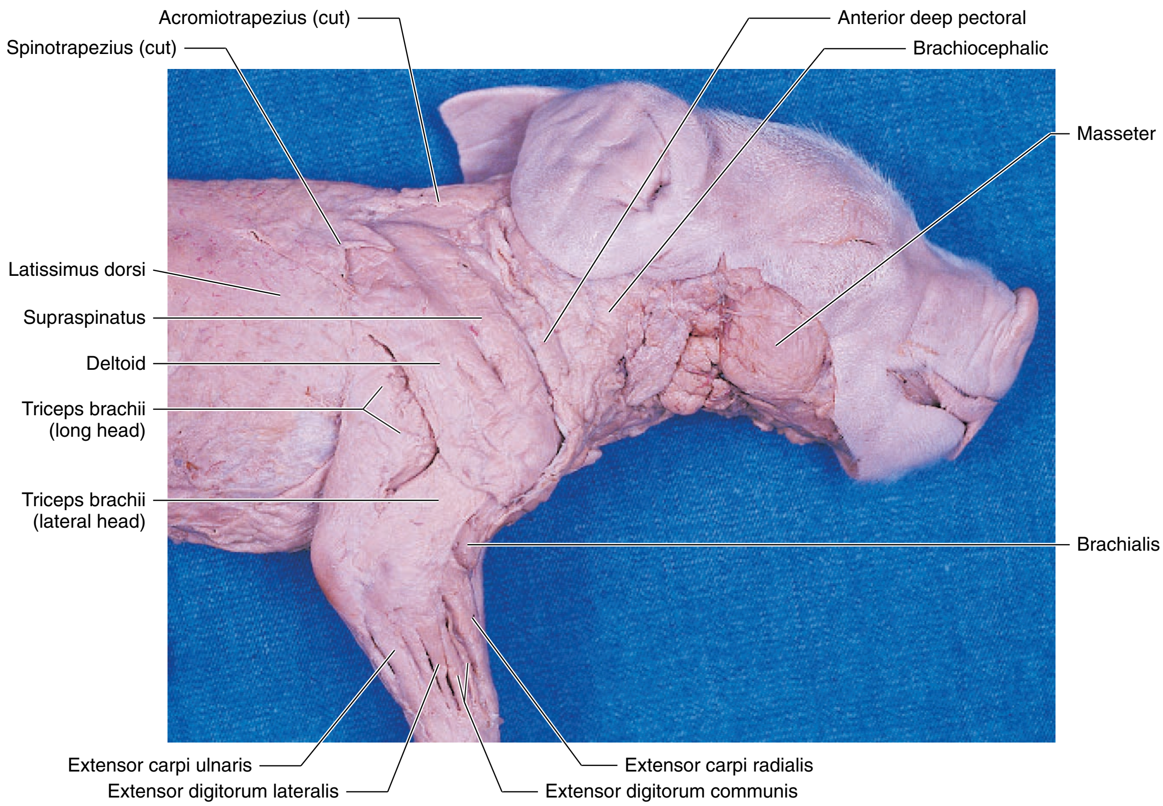


Table 24.3 Muscles of the Abdominal Wall

Muscle	Origin	Insertion	Action
External oblique	Ribs and fascia of back	Linea alba	Compresses abdominal wall
Internal oblique	Fascia of back	Linea alba	Compresses abdominal wall
Transversus abdominis	Lower ribs and fascia of back	Linea alba	Compresses abdominal wall
Rectus abdominis	Pubis	Sternum and costal cartilages	Compresses abdominal wall and flexes trunk

PROCEDURE G—MUSCLES OF THE SHOULDER AND BACK

1. Place the fetal pig in the dissecting tray onto its lateral surface.
2. Remove any remaining fat and connective tissue to expose the muscles of the shoulder and back.
3. Study figure 24.6, and then locate and dissect the following superficial muscles:

   brachiocephalic

   acromiotrapezius

   spinotrapezius

   deltoid

   latissimus dorsi
4. Using scissors, transect the latissimus dorsi and the group of trapezius muscles. Lift aside their cut edges and remove any underlying fat and connective tissue. Study figure 24.7, and then locate and dissect the following deep muscles of the shoulder and back:

   supraspinatus

   infraspinatus

   teres major

   rhomboideus

   rhomboideus capitis

   splenius

Figure 24.7 Deep muscles of the shoulder and arm, lateral view.

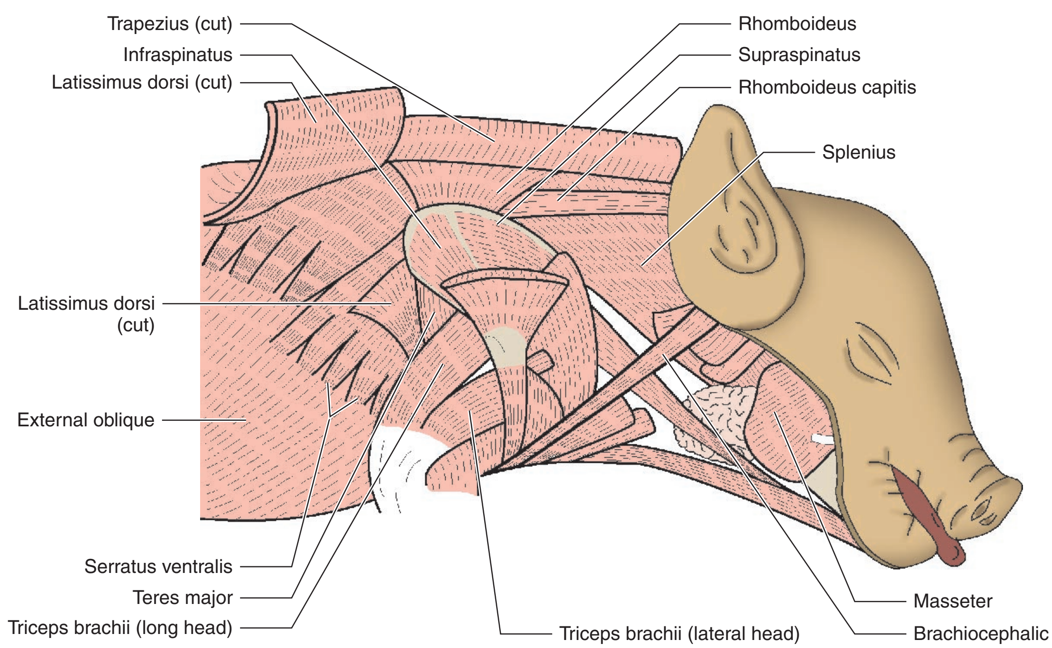


Table 24.4 Muscles of the Shoulder and Back

Muscle	Origin	Insertion	Action
Acromiotrapezius	Spines of cervical and thoracic vertebrae	Spine and acromion process of scapula	Pulls scapula upward
Spinotrapezius	Spines of thoracic vertebrae	Spine of scapula	Pulls scapula upward and back
Brachiocephalic (clavotrapezius and clavobrachialis)	Occipital bone and mastoid process	Distal end of humerus	Flexes forelimb
Deltoid	Spine of scapula	Proximal end of humerus	Flexes forelimb
Latissimus dorsi	Thoracic and lumbar vertebrae	Proximal end of humerus	Pulls forelimb upward and back
Supraspinatus	Fossa above spine of scapula	Proximal end of humerus	Extends forelimb
Infraspinatus	Fossa below spine of scapula	Proximal end of humerus	Rotates and abducts forelimb
Teres major	Posterior border of scapula	Proximal end of humerus	Extends and adducts forelimb
Rhomboideus	Spines of cervical and thoracic vertebrae	Medial border of scapula	Pulls scapula upward and forward
Rhomboideus capitis	Occipital bone	Medial border of scapula	Pulls scapula forward
Splenius	Fascia of neck	Occipital bone	Raises head

5. See table 24.4 for the origins, insertions, and actions of these muscles in the shoulder and back.
6. Complete Part C of the laboratory report.

PROCEDURE H—MUSCLES OF THE FORELIMB

1. Place the fetal pig in the dissecting tray with its ventral side up.
2. Remove any remaining fat and connective tissue from a forelimb to expose the muscles.
3. Transect the pectoral muscles and lift aside their cut edges.
4. Study figure 24.8, and then locate and dissect the following muscles from the medial surface of the arm and forearm of the forelimb:

medial arm muscles

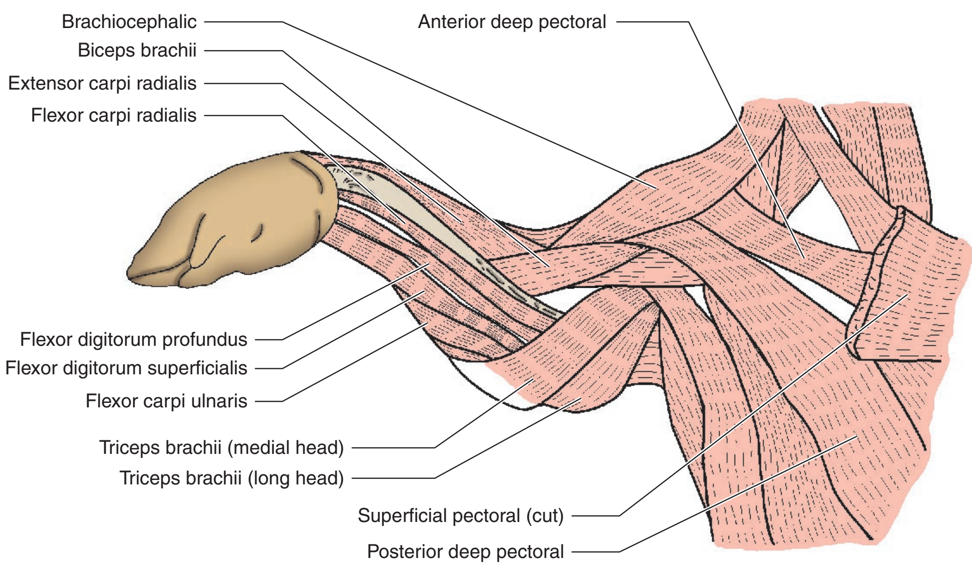
biceps brachii

triceps brachii

long head

medial head

Figure 24.8 Medial muscles of the right forelimb, ventral view.



medial forearm muscles

extensor carpi radialis

flexor carpi radialis

flexor digitorum profundus

flexor digitorum superficialis

flexor carpi ulnaris

5. Place your pig onto its lateral surface. Study figure 24.6, which shows the lateral surface of the forelimb. Locate and dissect the following muscles on the lateral surface of the arm and forearm of the forelimb:

lateral arm muscles

triceps brachii

long head

lateral head

brachialis

lateral forearm muscles

extensor carpi radialis

extensor digitorum communis

extensor digitorum lateralis

extensor carpi ulnaris

6. See table 24.5 for the origins, insertions, and actions of these muscles of the forelimb.
7. Complete Part D of the laboratory report.

PROCEDURE I—MUSCLES OF THE HIP AND HINDLIMB

1. Place the fetal pig in the dissecting tray with its ventral side up.
2. Remove any remaining fat and connective tissue from the hip and hindlimb to expose the muscles.
3. Study figure 24.9, and then locate and dissect the following muscles from the medial surface of the thigh:

sartorius

gracilis

4. Using scissors, transect the sartorius and gracilis, and lift aside their cut edges to observe the deeper muscles of the thigh.
5. Study figure 24.9, and then locate and dissect the following muscles:

tensor fasciae latae

rectus femoris

vastus medialis

adductor group

semimembranosus

semitendinosus

6. Transect the tensor fasciae latae and rectus femoris muscles and turn their ends aside. Locate the *vastus intermedius* and *vastus lateralis* muscles beneath. (*Note:* In some specimens, the vastus intermedius, vastus lateralis, and vastus medialis

Figure 24.9 Medial superficial and deep muscles of the hindlimb, ventral view.

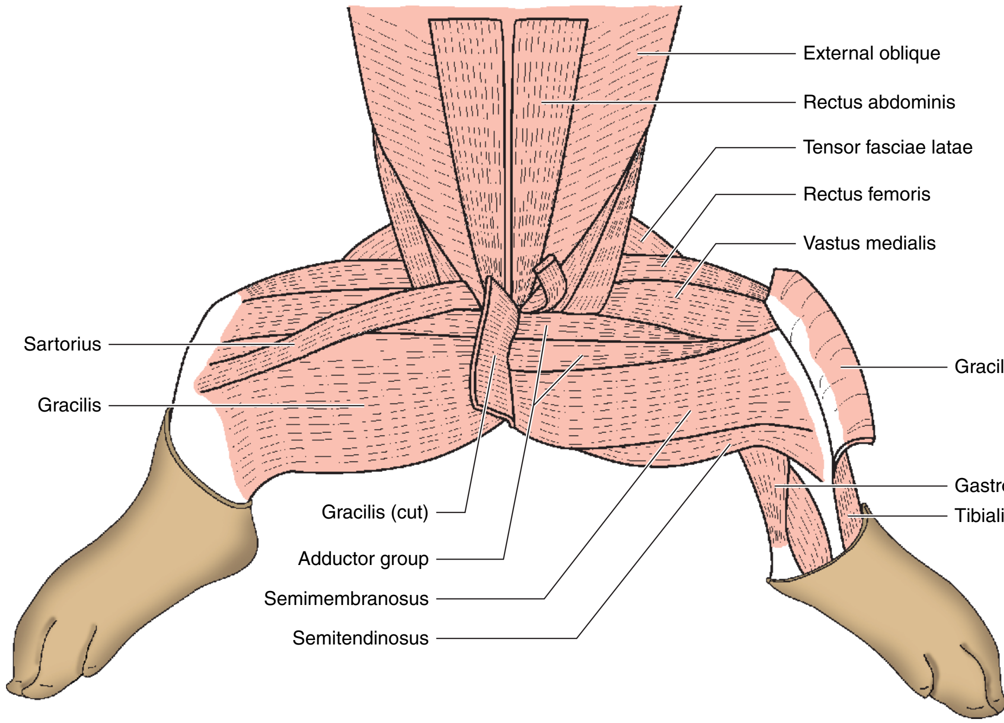


Table 24.5 Muscles of the Forelimb

Muscle	Origin	Insertion	Action
Triceps brachii			
Lateral head	Deltoid tuberosity of humerus	Olecranon process of ulna	Extends forelimb
Long head	Border of glenoid cavity of scapula	Olecranon process of ulna	Extends forelimb
Medial head	Shaft of humerus	Olecranon process of ulna	Extends forelimb
Brachialis	Lateral surface of humerus	Proximal end of ulna	Flexes forelimb
Biceps brachii	Scapula	Radius and ulna	Flexes forelimb
Extensor carpi ulnaris	Lateral epicondyle of humerus	Fifth metacarpal	Extends wrist
Extensor digitorum lateralis	Distal end of humerus	Digits	Extends digits
Extensor digitorum communis	Lateral surface of humerus	Digits	Extends digits
Extensor carpi radialis	Distal end of humerus	Distal end of radius	Rotates foot
Flexor carpi ulnaris	Medial epicondyle of humerus	Carpals	Flexes wrist
Flexor digitorum superficialis	Medial epicondyle of humerus	Distal phalanges	Flexes digits
Flexor digitorum profundus	Medial epicondyle of humerus	Distal phalanges	Flexes digits
Flexor carpi radialis	Medial epicondyle of humerus	Metacarpals	Flexes metacarpals

muscles are closely united by connective tissue and are difficult to separate.)

7. Study figure 24.10, and then locate and dissect the following muscles from the lateral surface of the hip and thigh:

   biceps femoris

   gluteus superficialis (gluteus maximus)

   gluteus medius

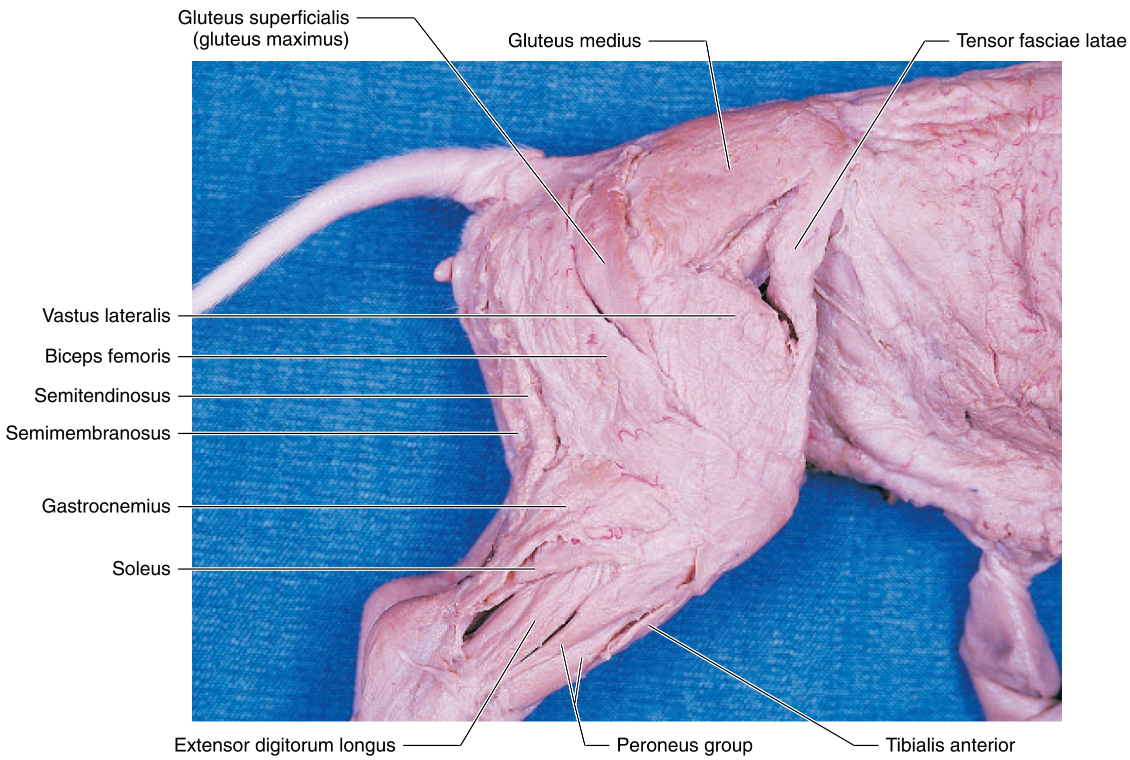
8. Using scissors, transect the tensor fasciae latae and biceps femoris, and lift aside their cut edges to observe the deeper muscles of the thigh.
9. On the lateral surface of the leg (see fig. 24.10), locate and dissect the following muscles:

   gastrocnemius

   soleus

   extensor digitorum longus

Figure 24.10 Muscles of the hip, thigh, and leg, lateral view.



tibialis anterior

peroneus group

10. See table 24.6 for the origins, insertions, and actions of these muscles of the hip and hindlimb.
11. Complete Part E of the laboratory report.

Table 24.6 Muscles of the Hip and Hindlimb

Muscle	Origin	Insertion	Action
Tensor fasciae latae	Iliac crest	Fascia lata of thigh	Tighten fascia lata
Gluteus superficialis	Sacral and caudal vertebrae	Greater trochanter of femur	Abducts thigh
Gluteus medius	Ilium	Greater trochanter of femur	Abducts thigh
Quadriceps femoris			
Vastus lateralis	Shaft of femur and greater trochanter	Patella	Extends hindlimb
Vastus intermedius	Shaft of femur	Patella	Extends hindlimb
Rectus femoris	Ilium	Patella	Extends hindlimb
Vastus medialis	Shaft of femur	Patella	Extends hindlimb
Hamstring muscles			
Biceps femoris	Ischium	Tibia	Abducts thigh and flexes lower hindlimb
Semimembranosus	Ischium	Tibia	Flexes lower hindlimb
Semitendinosus	Ischium	Tibia	Flexes lower hindlimb
Sartorius	Crest of ilium	Proximal end of tibia	Adducts thigh
Gracilis	Pubis	Proximal end of tibia	Adducts hindlimb
Adductor group	Pubis	Femur	Adducts hindlimb
Gastrocnemius	Lateral and medial epicondyles of femur	Calcaneus	Extends foot
Soleus	Proximal end of fibula	Calcaneus	Extends foot
Tibialis anterior	Proximal end of tibia	Second metatarsal	Flexes foot
Peroneus group	Shaft of tibia and fibula	Metatarsals	Flexes foot
Extensor digitorum longus	Proximal end of tibia and fibula	Digits	Extends digits

Laboratory Report **24**

Name ______________________________

Date ______________________________

Section ______________________________

Fetal Pig Dissection: Musculature

Part A

Complete the following statements:

1. The ____________________ muscle of the human is homologous to the sternomastoid muscle of the pig.
2. The ____________________ muscle elevates the mandible in the human and in the pig.
3. Two muscles of the pig that are inserted on the hyoid bone are the ____________________ and the ____________________.

Part B

Complete the following:
Name two pectoral muscles that are found in the thoracic wall of the human.

1. ______________________________
2. ______________________________

Name three pectoral muscles that are found in the thoracic wall of the pig.

3. ______________________________
4. ______________________________
5. ______________________________

Name four muscles that are found in the abdominal wall of the pig and the human.

6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________

Part C

Complete the following:
Name three muscles of the pig that together correspond to the trapezius muscle in the human.

1. ______________________________
2. ______________________________
3. ______________________________

Name the muscle in the pig and in the human that occupies the fossa above the spine of the scapula.

4. ______________________________

Name the muscle in the pig and in the human that occupies the fossa below the spine of the scapula.

5. ______________________________

Part D

Complete the following:
Name two muscles found in the pig and in the human that can flex the forelimb.

1. ______________________________
2. ______________________________

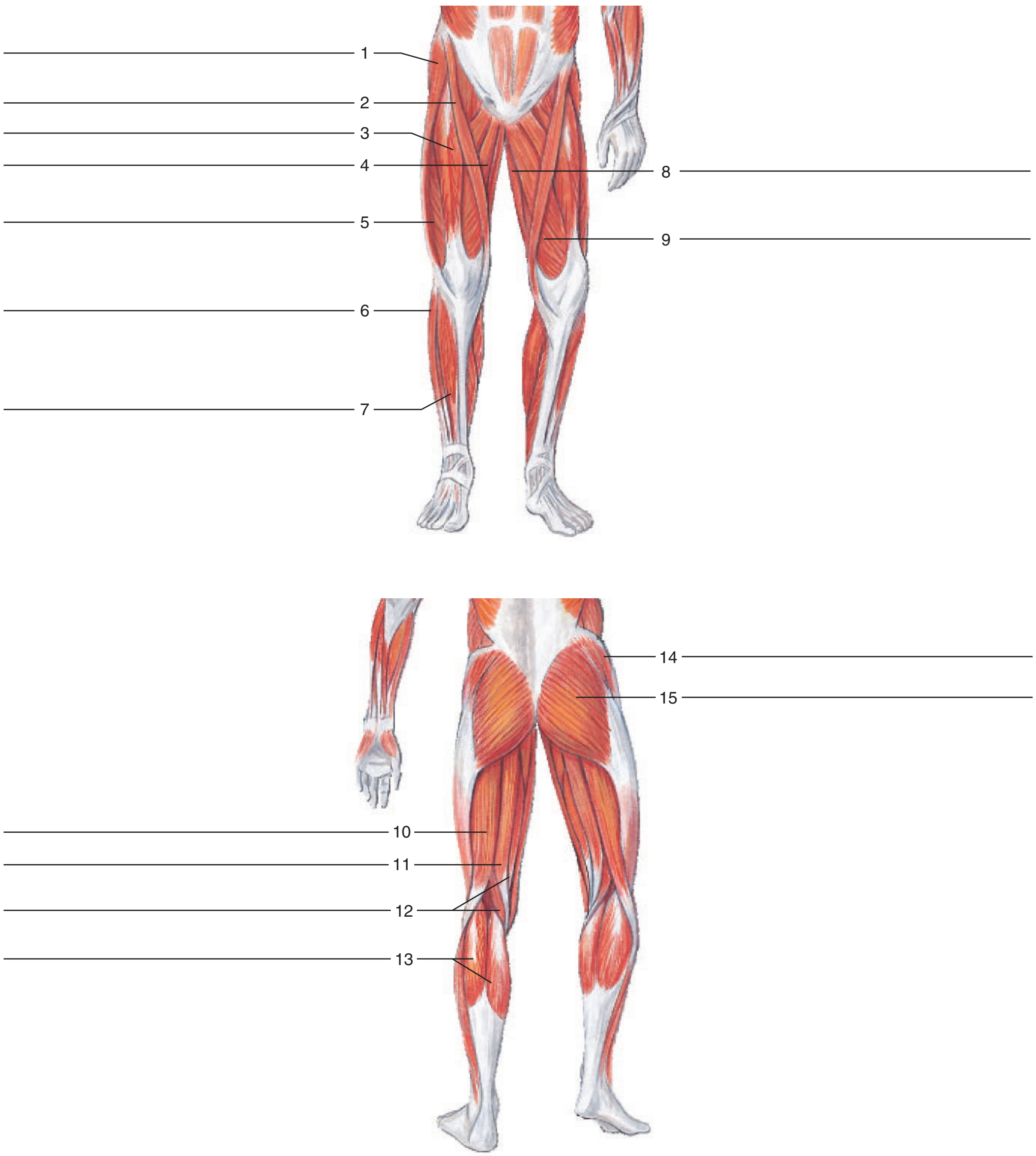
Name a muscle that has three heads, can extend the forelimb, and is found in the pig and in the human.

3. ______________________________

Part E

Each of the muscles in figure 24.11 is found both in the pig and in the human. Identify each of the numbered muscles in the figure by placing its name in the space next to its number.

Figure 24.11 Identify the numbered muscles that occur in both the pig and the human.



Laboratory Exercise 25

Nervous Tissue and Nerves

MATERIALS NEEDED

textbook
compound microscope
prepared microscope slides of the following:
spinal cord (smear)
dorsal root ganglion (section)
neuroglial cells (astrocytes)
peripheral nerve (cross section and longitudinal section)
neuron model

For Optional Activity:

prepared microscope slide of Purkinje cells from cerebellum

Nervous tissue, which occurs in the brain, spinal cord, and nerves, contains neurons and neuroglial cells. The neurons are the basic structural and functional units of the nervous system involved in decision-making processes, detecting stimuli, and conducting messages. The neuroglial cells perform various supportive and protective functions for neurons.

PURPOSE OF THE EXERCISE

To review the characteristics of nervous tissue and to observe neurons, neuroglial cells, and various features of the nerves.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the general characteristics of nervous tissue;
2. distinguish between neurons and neuroglial cells;
3. identify the major structures of a neuron and a nerve.

PROCEDURE

1. Review textbook sections on *neuron structure* and *classification of neurons and neuroglia.*
2. As a review activity, label figures 25.1 and 25.2.
3. Complete Parts A and B of Laboratory Report 25.
4. Obtain a prepared microscope slide of a spinal cord smear. Using low-power magnification, search the slide and locate the relatively large, deeply stained cell bodies of motor neurons (multipolar neurons).
5. Observe a single motor neuron, using high-power magnification, and note the following features:

   cell body

   nucleus

   nucleolus

   chromatophilic substance (Nissl bodies)

   neurofibrils (threadlike structures extending into the nerve fibers)

   nerve fibers (axon and dendrites)

   Compare the slide to the neuron model and to figure 25.3. You also may note small, darkly stained nuclei of neuroglial cells around the motor neuron.
6. Sketch and label a single motor neuron in the space provided in Part C of the laboratory report.
7. Obtain a prepared microscope slide of a dorsal root ganglion. Search the slide and locate a cluster of sensory neuron cell bodies. You also may note bundles of nerve fibers passing among groups of neuron cell bodies (fig. 25.4).
8. Sketch and label a single sensory neuron cell body in the space provided in Part C of the laboratory report.
9. Obtain a prepared microscope slide of neuroglial cells. Search the slide and locate some darkly stained astrocytes with numerous long, slender processes (fig. 25.5).
10. Sketch a single neuroglial cell in the space provided in Part C of the laboratory report.
11. Obtain a prepared microscope slide of a nerve. Locate the cross section of the nerve, and note the many round nerve fibers inside. Nerve fiber is a

Figure 25.1 Label this diagram of a motor neuron.

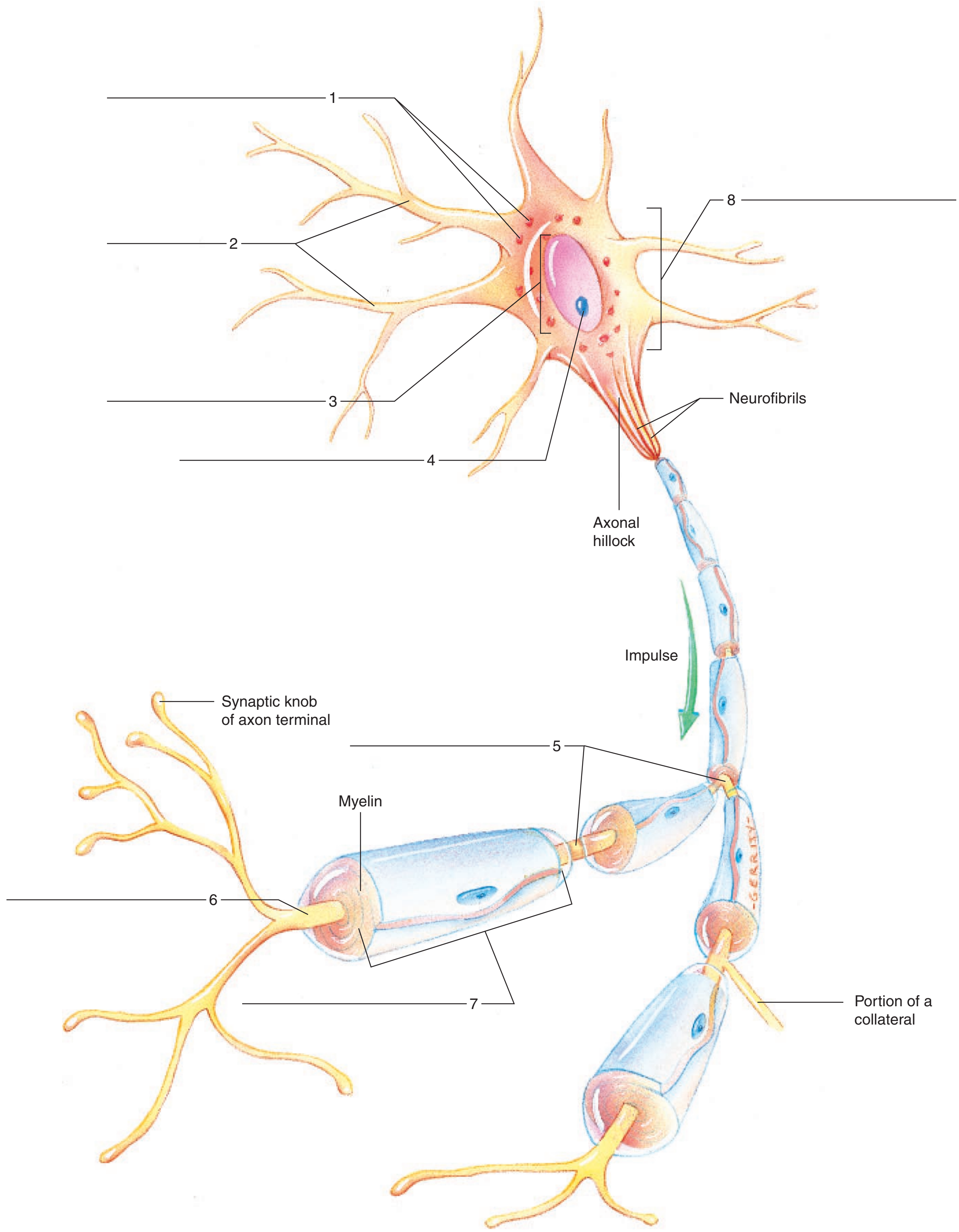


Figure 25.2 Label the features of the myelinated nerve fiber.

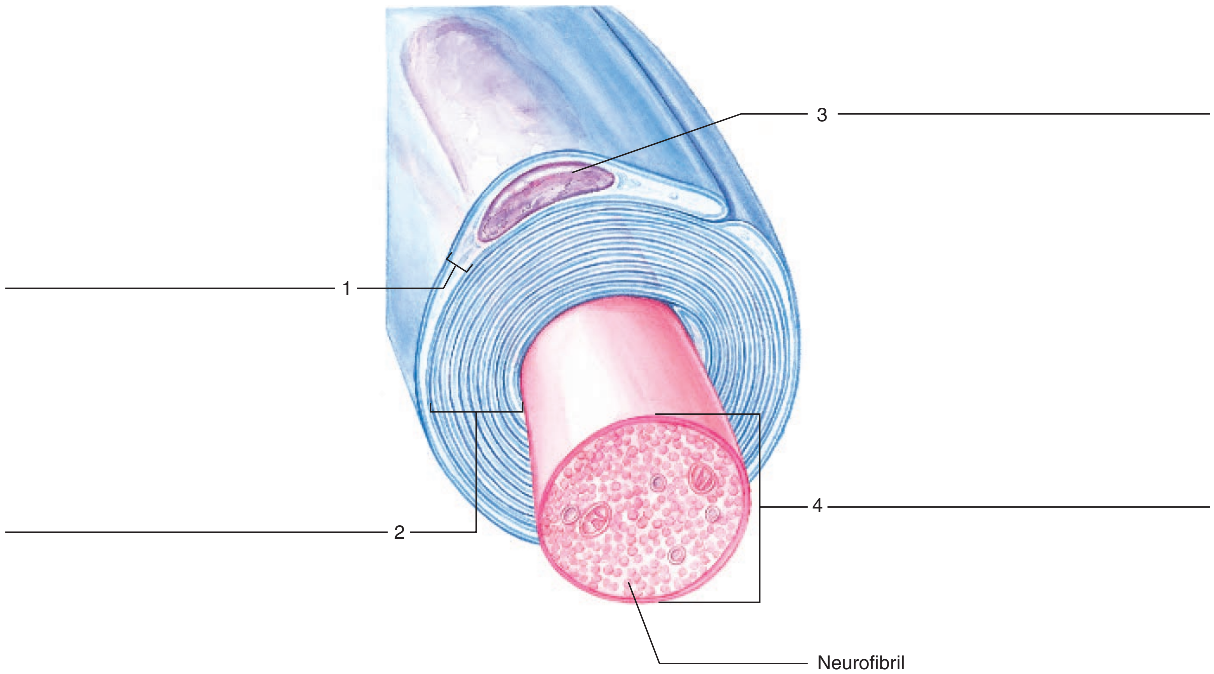


Figure 25.3 Micrograph of a multipolar neuron and neuroglia from a spinal cord smear (100× micrograph enlarged to 600×).

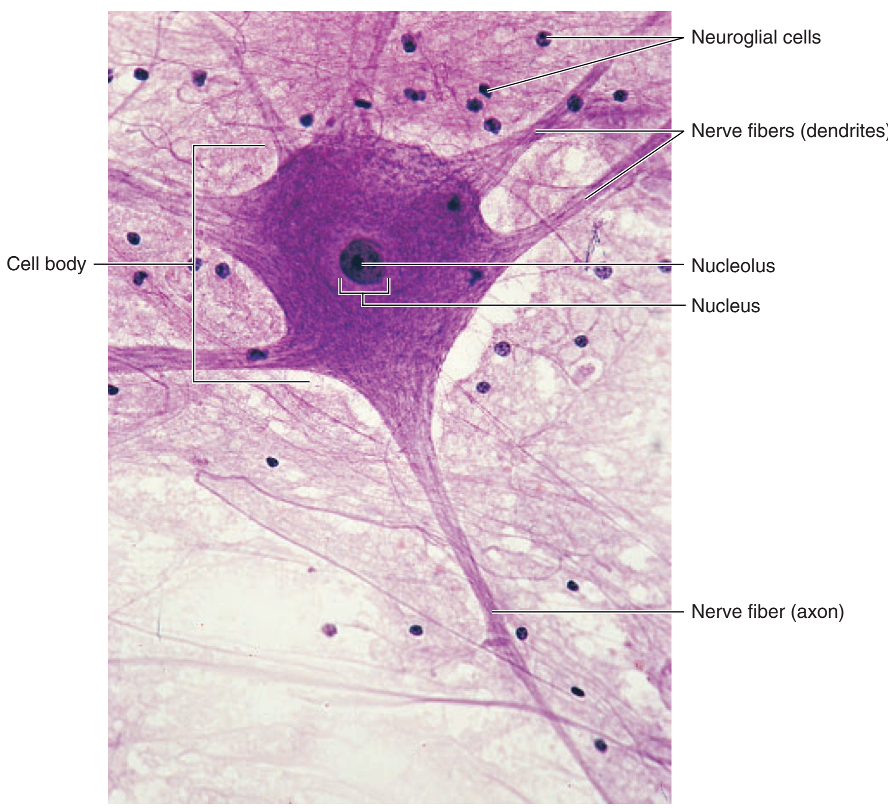
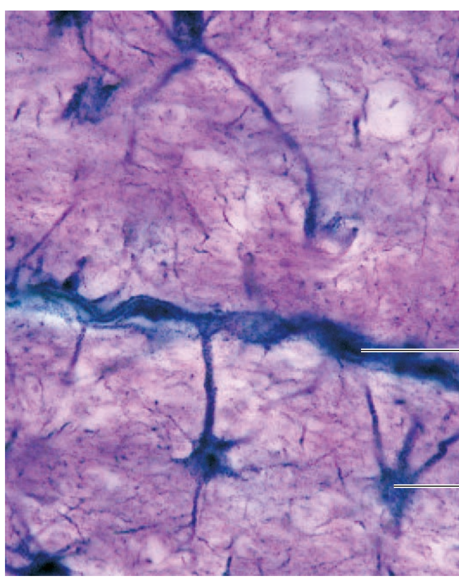


Figure 25.4 Micrograph of a dorsal root ganglion (50× micrograph enlarged to 100×).

Figure 25.5 Micrograph of astrocytes (250× micrograph enlarged to 1,000×).



general name for processes (either dendrites or axon) of the neuron. Also note the dense layer of connective tissue (perineurium) that encircles the nerve fibers and holds them together in a bundle. The individual nerve fibers are surrounded by a layer of more delicate connective tissue (endoneurium) (fig. 25.6).

12. Using high-power magnification, observe a single nerve fiber and note the following features:

    central axon

    myelin around the axon (actually, most of the myelin may have been dissolved and lost during the slide preparation)

    neurilemma

13. Sketch and label a single nerve fiber with Schwann cell (cross section) in the space provided in Part D of the laboratory report.

Figure 25.6 Cross section of a bundle of neurons within a nerve (400×).

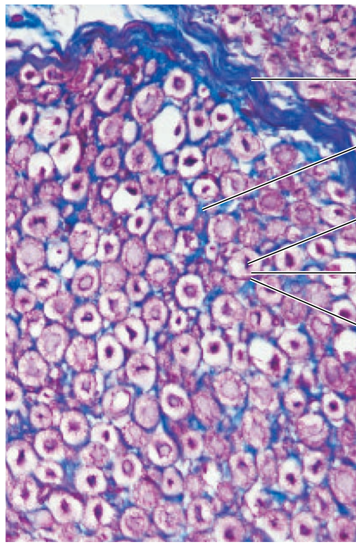
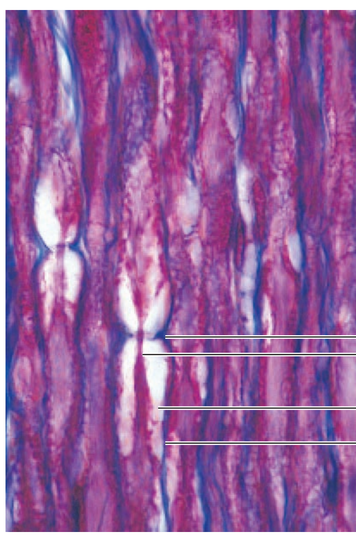


Figure 25.7 Longitudinal section of a nerve (250× micrograph enlarged to 2,000×).



14. Locate the longitudinal section of the nerve on the slide (fig. 25.7). Note the following:

    central axons

    myelin sheaths of Schwann cells

    neurilemmal sheaths of Schwann cells

    nodes of Ranvier

15. Sketch and label a single nerve fiber with Schwann cell (longitudinal section) in the space provided in Part D of the laboratory report.

OPTIONAL ACTIVITY

Obtain a prepared microscope slide of Purkinje cells. To locate these neurons, search the slide for large, flask-shaped cell bodies. Note that each cell body has one or two large, thick dendrites that give rise to branching networks of fibers. These cells are found in a particular region of the brain (cerebellar cortex).

Laboratory Report 25

Name ______________________________

Date ______________________________

Section ______________________________

Nervous Tissue and Nerves

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. astrocyte
b. axon
c. chromatophilic substance (Nissl body)
d. collateral
e. dendrite
f. myelin
g. neurilemma
h. neurofibrils

Column B

____ 1. sheath of Schwann cell containing cytoplasm and nucleus that encloses myelin

____ 2. corresponds to rough endoplasmic reticulum in other cells

____ 3. network of fine threads within nerve fiber

____ 4. substance of Schwann cell composed of lipoprotein

____ 5. nerve fiber with many tiny, thornlike spines that conducts an impulse toward the cell body

____ 6. branch of an axon

____ 7. star-shaped neuroglial cell between neurons and blood vessels

____ 8. nerve fiber arising from a slight elevation of the cell body that conducts an impulse away from the cell body

Part B

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. effector
b. ependyma
c. ganglion
d. interneuron
e. microglia
f. motor neuron
g. oligodendrocyte
h. sensory neuron

Column B

____ 1. transmits impulse from sensory to motor neuron within central nervous system

____ 2. transmits impulse out of the brain or spinal cord to effectors

____ 3. transmits impulse into brain or spinal cord from receptors

____ 4. myelin-forming neuroglial cell in brain and spinal cord

____ 5. phagocytic neuroglial cell

____ 6. structure capable of responding to motor impulse

____ 7. specialized mass of neuron cell bodies outside the brain or spinal cord

____ 8. covers the inside spaces of the ventricles

Part C

1. Sketch and label a single motor neuron.

2. Sketch and label a single sensory neuron cell body.

3. Sketch a single neuroglial cell.

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Part D

1. Sketch and label a single nerve fiber with Schwann cell (cross section).

2. Sketch and label a single nerve fiber with Schwann cell (longitudinal section).

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Laboratory Exercise 26

Nerve Impulse Stimulation

MATERIALS NEEDED

textbook
live frog
dissecting tray
dissecting instruments
frog Ringer's solution
electronic stimulator
filter paper
glass rod
glass plate
ring stand and ring
microscope slides
Bunsen burner
ice
1% HCl
1% NaCl

For Optional Activity:

2% Novocain solution (procaine hydrochloride)
Virtual Physiology Lab: 1, Action Potential

SAFETY

- Wear disposable gloves when handling the frogs and chemicals.
- Keep loose hair and clothes away from the Bunsen burner.
- Wear heat-resistant gloves when heating the glass rod.
- Dispose of gloves, frogs, and chemicals as instructed.
- Wash your hands before leaving the laboratory.

A nerve cell usually is polarized due to an unequal distribution of ions on either side of its membrane. When such a polarized membrane is stimulated at or above its threshold intensity, a wave of action potentials is triggered to move in all directions away from the site of stimulation. This wave constitutes a nerve impulse, and if it reaches a muscle, the muscle may respond by contracting.

PURPOSE OF THE EXERCISE

To review the characteristics of a nerve impulse and to investigate the effects of certain stimuli on a nerve.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the events that lead to the stimulation of a nerve impulse;
2. list four types of factors that can stimulate a nerve impulse;
3. test the effects of various factors on a nerve-muscle preparation.

PROCEDURE

1. Review a textbook section on *cell membrane potential.*
2. Complete Part A of Laboratory Report 26.
3. Obtain a live frog, and pith its brain and spinal cord as described in Procedure C of Laboratory Exercise 19.

ALTERNATIVE PROCEDURE

An anesthetizing agent, tricaine methane sulfonate, can be used to prepare frogs for this lab. This procedure eliminates the need to pith frogs.

4. Place the pithed frog in a dissecting tray and remove the skin from its hindlimb; beginning at the waist, as described in Procedure C of Laboratory Exercise 19. (As the skin is removed, keep the exposed tissues moist by flooding them with frog Ringer's solution.)
5. Expose the frog's sciatic nerve. To do this, follow these steps:
   a. Use a glass rod to separate the gastrocnemius muscle from the adjacent muscles.
   b. Locate the calcaneal (Achilles) tendon at the distal end of the gastrocnemius, and cut it with scissors.
   c. Place the frog ventral side down, and separate the muscles of the thigh to locate the sciatic nerve. The nerve will look like a silvery white thread passing through the thigh, dorsal to the femur (fig. 26.1).
   d. Dissect the nerve to its origin in the spinal cord.

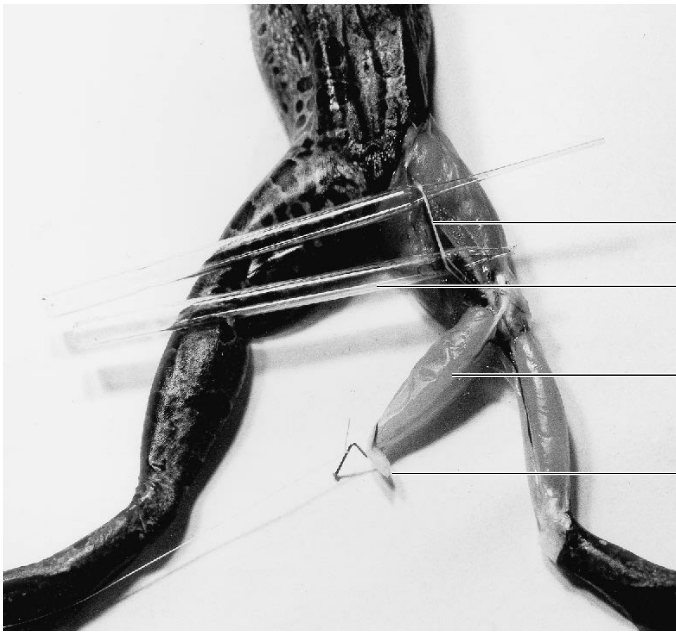


Figure 26.1 The sciatic nerve appears as a silvery white thread between the muscles of the thigh.

e. Use scissors to cut the nerve at its origin, and carefully snip off all of the branch nerves in the thigh, leaving only its connection to the gastrocnemius muscle.
f. Use a scalpel to free the proximal end of the gastrocnemius.
g. Carefully remove the nerve and attached muscle, and transfer the preparation to a glass plate supported on the ring of a ring stand.
h. Use a glass rod to position the preparation so that the sciatic nerve is hanging over the edge of the glass plate. (Be sure to keep the preparation moistened with frog Ringer's solution at all times.)

6. Determine the threshold voltage and the voltage needed for maximal muscle contraction by using the electronic stimulator, as described in Procedure D of Laboratory Exercise 19.
7. Expose the cut end of the sciatic nerve to each of the following conditions, and observe the response of the gastrocnemius muscle. Add frog Ringer's solution after each of the experiments.
   a. Firmly pinch the end of the nerve between two glass microscope slides or pinch using forceps.
   b. Touch the cut end with a glass rod that is at room temperature.
   c. Touch the cut end with a glass rod that has been cooled in ice water for 5 minutes.
   d. Touch the cut end with a glass rod that has been heated in the flame of a Bunsen burner. Wear heat-resistant gloves for this procedure.
   e. Dip the cut end in 1% HCl.
   f. Dip the cut end in 1% NaCl.
8. Complete Part B of the laboratory report.

OPTIONAL ACTIVITY

Test the effect of Novocain on a frog sciatic nerve. To do this, follow these steps:

1. Place a nerve-muscle preparation on a glass plate supported by the ring of a ring stand, as before.
2. Use the electronic stimulator to determine the voltage needed for maximal muscle contraction.
3. Saturate a small piece of filter paper with 2% Novocain solution, and wrap the paper around the midsection of the sciatic nerve.
4. At 2-minute intervals, stimulate the nerve using the voltage needed for maximal contraction until the muscle fails to respond.
5. Remove the filter paper, and flood the nerve with frog Ringer's solution.
6. At 2-minute intervals, stimulate the nerve until the muscle responds again. How long did it take for the nerve to recover from the effect of the Novocain?________________________________

Laboratory Report **26**

Name ______________________________

Date ______________________________

Section ______________________________

Nerve Impulse Stimulation

Part A

Complete the following statements:

1. ________________________ ions tend to pass through cell membranes more easily than sodium ions.
2. When a nerve cell is at rest, there is a relatively greater concentration of ________________________ ions outside of its membrane.
3. When sodium ions are actively transported outward through a nerve cell membrane, ________________________ ions are transported inward.
4. The difference in electrical charge between the inside and the outside of a nerve cell membrane is called the ________________________ potential.
5. As a result of an additive phenomenon called ________________________, the threshold potential of a membrane may be reached.
6. An action potential is a rapid sequence of changes involving ________________________ and repolarization.
7. The moment following the passage of an action potential during which a threshold stimulus will not trigger another impulse is called the ____________________ period.
8. Muscle fiber contraction and nerve impulse conduction are similar in that both are ________________________ responses.
9. Myelin contains a high proportion of ________________________.
10. Nodes of Ranvier occur between adjacent ________________________.
11. The type of conduction in which an impulse seems to jump from node to node is called ________________________.
12. The greater the diameter of a nerve fiber, the ________________________ the impulse travels.

Part B

1. What was the threshold voltage for the frog sciatic nerve? ________________________
2. What was the voltage needed for maximal contraction of the gastrocnemius muscle? ________________________

3. Complete the following table:

Factor Tested	Muscle Response	Effect on Nerve
Pinching		
Glass rod (room temperature)		
Glass rod (cooled)		
Glass rod (heated)		
1% HCl		
1% NaCl		

4. Write a statement to summarize the results of these tests.

Laboratory Exercise 27

The Meninges and Spinal Cord

MATERIALS NEEDED

textbook
compound microscope
prepared microscope slide of a spinal cord cross section with spinal nerve roots
spinal cord model

For Demonstration:

preserved spinal cord with meninges intact

The meninges consist of layers of membranes located between the bones of the skull and vertebral column and the soft tissues of the central nervous system. They include the dura mater, the arachnoid mater, and the pia mater.

The spinal cord is a column of nerve fibers that extends down through the vertebral canal. Together with the brain, it makes up the central nervous system.

Neurons within the spinal cord provide a two-way communication system between the brain and body parts outside the central nervous system. The cord also contains the processing centers for spinal reflexes.

PURPOSE OF THE EXERCISE

To review the characteristics of the meninges and the spinal cord and to observe the major features of these structures.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name the layers of the meninges and describe the structure of each;
2. identify the major features of the spinal cord;
3. locate the ascending and descending tracts of the spinal cord.

PROCEDURE A—MENINGES

1. Review a textbook section on *meninges.*
2. Complete Part A of Laboratory Report 27.

DEMONSTRATION

Observe the preserved section of spinal cord. Note the heavy covering of dura mater, which is firmly attached to the cord on each side by a set of ligaments (denticulate ligaments) originating in the pia mater. The intermediate layer of meninges, the arachnoid mater, is devoid of blood vessels, but in a live human being, the space beneath this layer contains cerebrospinal fluid. The pia mater, which is closely attached to the surface of the spinal cord, contains many blood vessels. What are the functions of these layers?____________________

____

____

____

____

PROCEDURE B—STRUCTURE OF THE SPINAL CORD

1. Review a textbook section on the *spinal cord.*
2. As a review activity, label figures 27.1, 27.2, and 27.3.
3. Complete Parts B and C of the laboratory report.
4. Obtain a prepared microscope slide of a spinal cord cross section. Use the low power of the microscope to locate the following features:

posterior median sulcus

anterior median fissure

central canal

gray matter

gray commissure

posterior horn

lateral horn

anterior horn

Figure 27.1 Label the features of the spinal cord and the surrounding structures.

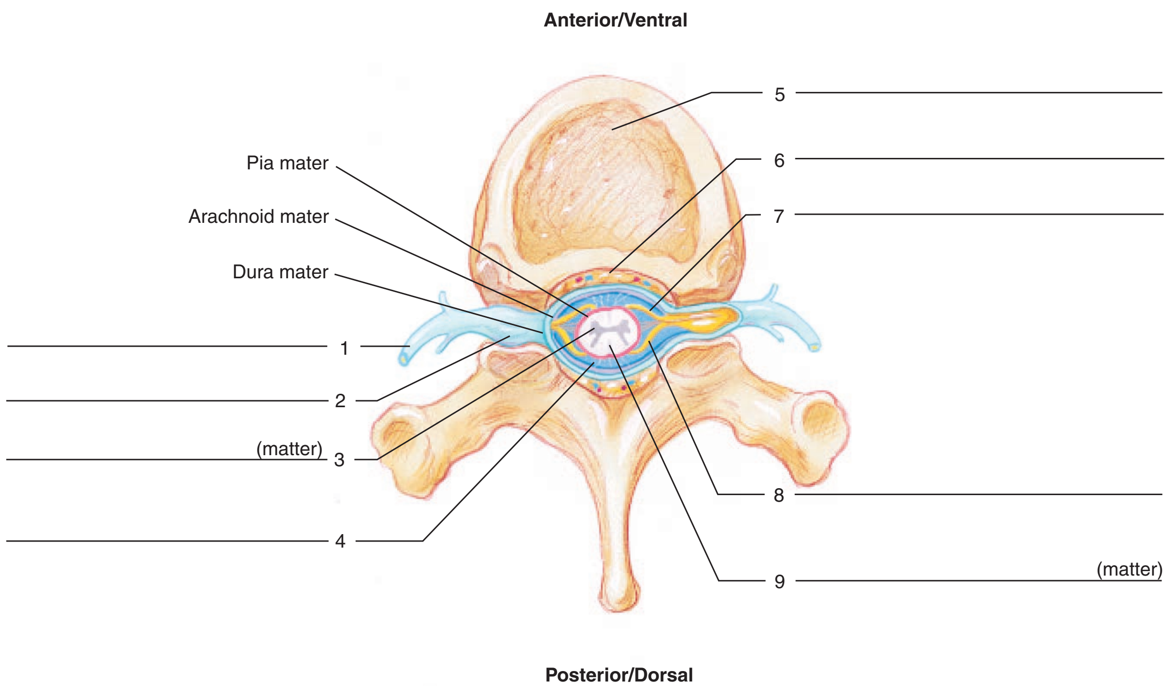


Figure 27.2 Label this cross section of the spinal cord, including the features of the white and gray matter.

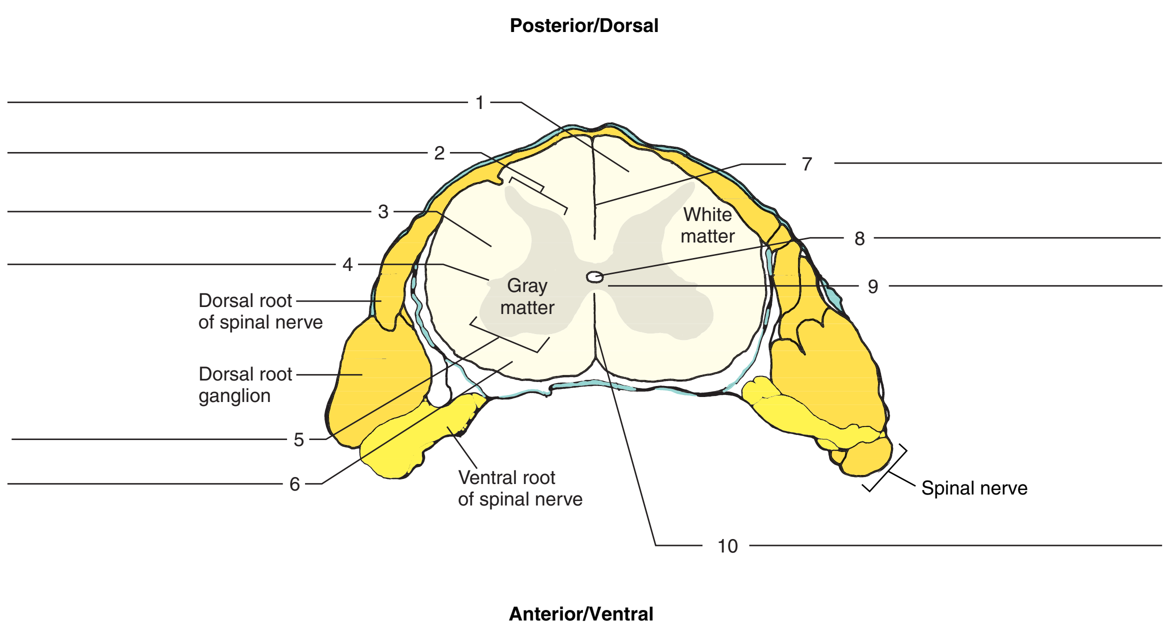
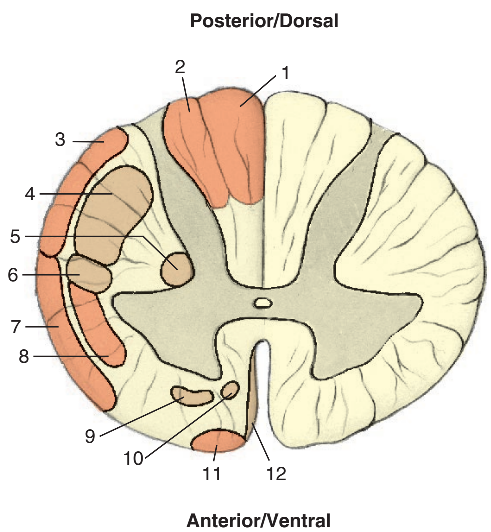


Figure 27.3 Label the ascending and descending tracts of the spinal cord by placing the correct numbers in the spaces provided. (*Note:* These tracts are not visible as individually stained structures on microscope slides.)



___ Anterior corticospinal tract
___ Anterior reticulospinal tract
___ Anterior spinocerebellar tract
___ Anterior spinothalamic tract
___ Fasciculus cuneatus
___ Fasciculus gracilis
___ Lateral corticospinal tract
___ Lateral reticulospinal tract
___ Lateral spinothalamic tract
___ Medial reticulospinal tract
___ Posterior spinocerebellar tract
___ Rubrospinal tract

white matter

posterior funiculus

lateral funiculus

anterior funiculus

roots of spinal nerve

dorsal roots

dorsal root ganglia

ventral roots

5. Observe the model of the spinal cord, and locate the features listed in step 4.
6. Complete Part D of the laboratory report.

Web Quest

Describe the development of the nervous system and review the brain, cranial nerves, spinal cord, and CSF. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 27

Name ____

Date ____

Section ____

The Meninges and Spinal Cord

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. arachnoid mater	____	1. band of pia mater that attaches dura mater to cord
b. denticulate ligament	____	2. channel through which venous blood flows
c. dural sinus	____	3. outermost layer of meninges
d. dura mater	____	4. follows irregular contours of spinal cord surface
e. epidural space	____	5. contains cerebrospinal fluid
f. pia mater	____	6. thin, weblike middle membrane
g. subarachnoid space	____	7. separates dura mater from bone of vertebra

Part B

Complete the following statements:

1. Each of the thirty-one segments of the spinal cord gives rise to a pair of ________________________.
2. The bulge in the spinal cord that gives off nerves to the upper limbs is called the ________________________ enlargement.
3. The bulge in the spinal cord that gives off nerves to the lower limbs is called the ________________________ enlargement.
4. The ________________________ is a groove that extends the length of the spinal cord posteriorly.
5. In a spinal cord cross section, the posterior ________________________ of the gray matter appear as the upper wings of a butterfly.
6. The cell bodies of motor neurons are found in the ________________________ horns of the spinal cord.
7. The ________________________ connects the gray matter on the left and right sides of the spinal cord.
8. The ____________________ in the gray commissure of the spinal cord contains cerebrospinal fluid and is continuous with the ventricles of the brain.
9. The white matter of the spinal cord is divided into anterior, lateral, and posterior ________________________.
10. Collectively, the dura mater, arachnoid mater, and pia mater are called the ________________________.

Part C

Match the nerve tracts in column A with the descriptions in column B. Place the letter of your choice in the space provided.

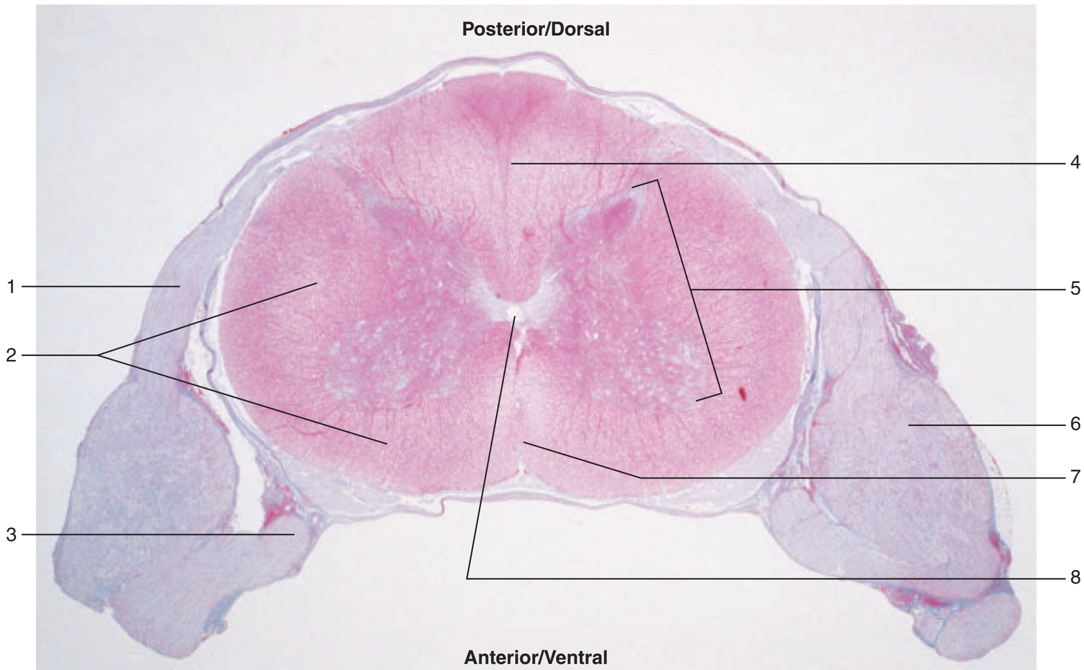
Column A	Column B
a. corticospinal	____ 1. ascending tract to the brain to interpret touch, pressure, and body movements
b. fasciculus gracilis	____ 2. descending tract whose fibers conduct motor impulses to sweat glands and muscles to control tone
c. lateral spinothalamic	____ 3. descending tract whose fibers conduct motor impulses to skeletal muscles
d. posterior spinocerebellar	____ 4. ascending tract to the cerebellum necessary for coordination of skeletal muscles
e. reticulospinal	____ 5. ascending tract to the brain to give rise to sensations of temperature and pain

Part D

Identify the features indicated in the spinal cord cross section of figure 27.4.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________

Figure 27.4 Micrograph of a spinal cord cross section with spinal nerve roots (35×).



Laboratory Exercise 28

The Reflex Arc and Reflexes

MATERIALS NEEDED

textbook
rubber percussion hammer

A reflex arc represents the simplest type of nerve pathway found in the nervous system. This pathway begins with a receptor at the end of a sensory nerve fiber. The sensory fiber leads into the central nervous system and may communicate with one or more interneurons. Some of these interneurons, in turn, communicate with motor neurons, whose fibers lead outward to effectors.

Thus, when a sensory receptor is stimulated by some kind of change occurring inside or outside the body, nerve impulses may pass through a reflex arc, and, as a result, effectors may respond. Such an automatic, subconscious response is called a *reflex.*

Most reflexes demonstrated in this lab are stretch reflexes. When a tendon is stretched by a tap over its tendon, stretch receptors called *muscle spindles* are stretched within the muscle, which initiates an impulse over a reflex arc. The stretched muscle responds by contracting to resist or reverse further stretching. These stretch reflexes are important to maintain proper posture, balance, and movements. Observations of many of these reflexes in clinical tests on patients may indicate damage to a level of the spinal cord or peripheral nerves of the particular reflex arc.

PURPOSE OF THE EXERCISE

To review the characteristics of reflex arcs and reflex behavior and to demonstrate some of the reflexes that occur in the human body.

LEARNING OBJECTIVES

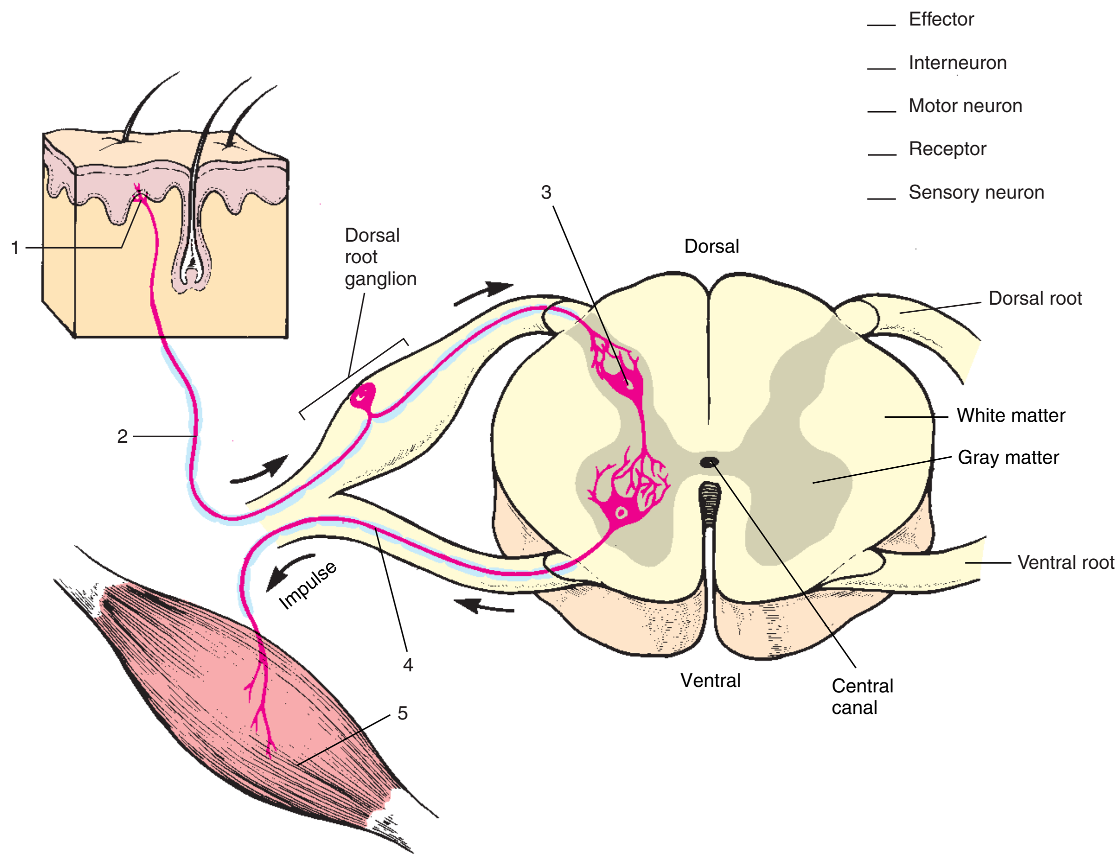
After completing this exercise, you should be able to

1. describe a reflex arc;
2. distinguish between a reflex arc and a reflex;
3. identify and demonstrate several reflex actions that occur in humans.

PROCEDURE

1. Review a textbook section on *reflex arcs.*
2. As a review activity, label figure 28.1.
3. Complete Part A of Laboratory Report 28.
4. Work with a laboratory partner to demonstrate each of the reflexes listed. (See fig. 28.2 also.) *It is important that muscles involved in the reflexes be totally relaxed in order to observe proper responses.* After each demonstration, record your observations in the table provided in Part B of the laboratory report.
   a. *Knee-jerk reflex (patellar reflex).* Have your laboratory partner sit on a table (or sturdy chair) with legs relaxed and hanging freely over the edge without touching the floor. Gently strike your partner's patellar ligament (just below the patella) with the blunt side of a rubber percussion hammer. The normal response is a moderate extension of the leg.
   b. *Ankle-jerk reflex.* Have your partner kneel on a chair with back toward you and with feet slightly dorsiflexed over the edge and relaxed. Gently strike the calcaneal tendon (just above its insertion on the calcaneus) with the blunt side of the rubber hammer. The normal response is plantar flexion of the foot.
   c. *Biceps-jerk reflex.* Have your partner place a bare arm bent about 90° at the elbow on the table. Press your thumb on the inside of the elbow over the tendon of the biceps brachii, and gently strike your finger with the rubber hammer. Watch the biceps brachii for a response. The response might be a slight twitch of the muscle or flexion of the forearm at the elbow joint.
   d. *Triceps-jerk reflex.* Have your partner lie supine with an upper limb bent about 90° across the abdomen. Gently strike the tendon of the triceps brachii near its insertion just proximal to the olecranon process at the tip of the elbow. Watch the triceps brachii for a response. The response might be a slight twitch of the muscle or extension of the forearm at the elbow joint.

Figure 28.1 Label this diagram of a reflex arc by placing the correct numbers in the spaces provided. Some reflex arcs demonstrated in this lab lack the interneuron.



e. *Plantar reflex.* Have your partner remove a shoe and sock and lie supine with the lateral surface of the foot resting on the table. Draw the metal tip of the rubber hammer, applying firm pressure, over the sole from the heel to the base of the large toe. The normal response is flexion of the toes and plantar flexion of the foot. If the toes spread apart and dorsiflexion occurs, the reflex is the abnormal *Babinski reflex* response (normal in infants until the nerve fibers have complete myelinization).

5. Complete Part B of the laboratory report.

Figure 28.2 Demonstrate each of the following reflexes: (*a*) knee-jerk reflex; (*b*) ankle-jerk reflex; (*c*) biceps-jerk reflex; (*d*) triceps-jerk reflex; and (*e*) plantar reflex.

(a)

(b)

(c)

Figure 28.2 *Continued*

(d)

(e)

Laboratory Report **28**

Name ______________________________

Date ______________________________

Section ______________________________

The Reflex Arc and Reflexes

Part A

Complete the following statements:

1. A withdrawal reflex employs a total of ________________________ neurons.
2. Interneurons in a withdrawal reflex are located in the ________________________.
3. A reflex arc begins with the stimulation of a ________________________ at the end of a sensory neuron.
4. Effectors of a reflex arc are glands and ________________________.
5. A knee-jerk reflex employs only ________________________ and motor neurons.
6. The effector of the knee-jerk reflex is the ________________________ muscle.
7. The sensory stretch receptors of the knee-jerk reflex are located in the ________________________ muscle.
8. The dorsal root of a spinal nerve contains the ________________________ neurons.
9. The sensory receptors of a withdrawal reflex are located in the ________________________.
10. ________________________ muscles in the limbs are the effectors of a withdrawal reflex.
11. The normal plantar reflex results in ________________________ of toes.
12. Stroking the sole of the foot in infants results in dorsiflexion and toes that spread apart, called the ________________________ reflex.

Part B

1. Complete the following table:

Reflex Tested	Response Observed	Effector Involved
Knee-jerk		
Ankle-jerk		
Biceps-jerk		
Triceps-jerk		
Plantar		

2. List the major events that occur in the knee-jerk reflex from the striking of the patellar ligament to the resulting response. ____

Critical Thinking Application

What characteristics do the reflexes you demonstrated have in common?

Laboratory Exercise 29

The Brain and Cranial Nerves

MATERIALS NEEDED

textbook
dissectible model of the human brain
preserved human brain
anatomic charts of the human brain
Virtual Physiology Lab: 2, Synaptic Transmission

The brain, the largest and most complex part of the nervous system, contains nerve centers associated with sensory functions and is responsible for sensations and perceptions. It issues motor commands to skeletal muscles and carries on higher mental activities. It also functions to coordinate muscular movements, and it contains centers and nerve pathways necessary for the regulation of internal organs.

Twelve pairs of cranial nerves arise from the ventral surface of the brain and are designated by number and name. Although most of these nerves conduct both sensory and motor impulses, some contain only sensory fibers associated with special sense organs. Others are primarily composed of motor fibers and are involved with the activities of muscles and glands.

PURPOSE OF THE EXERCISE

To review the structural and functional characteristics of the human brain and cranial nerves.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major structures in the human brain;
2. locate the major functional regions of the brain;
3. identify each of the cranial nerves;
4. list the functions of each cranial nerve.

PROCEDURE A—HUMAN BRAIN

1. Review a textbook section on the *brain.*
2. As a review activity, label figures 29.1, 29.2, and 29.3.
3. Complete Part A of Laboratory Report 29.
4. Observe the dissectible model and the preserved specimen of the human brain. Locate each of the following features:

cerebrum

cerebral hemispheres

corpus callosum

convolutions (gyri)

sulci

central sulcus

lateral sulcus

fissures

longitudinal fissure

transverse fissure

lobes

frontal lobe

parietal lobe

temporal lobe

occipital lobe

insula

cerebral cortex

basal ganglia

caudate nucleus

putamen

globus pallidus

ventricles

lateral ventricles

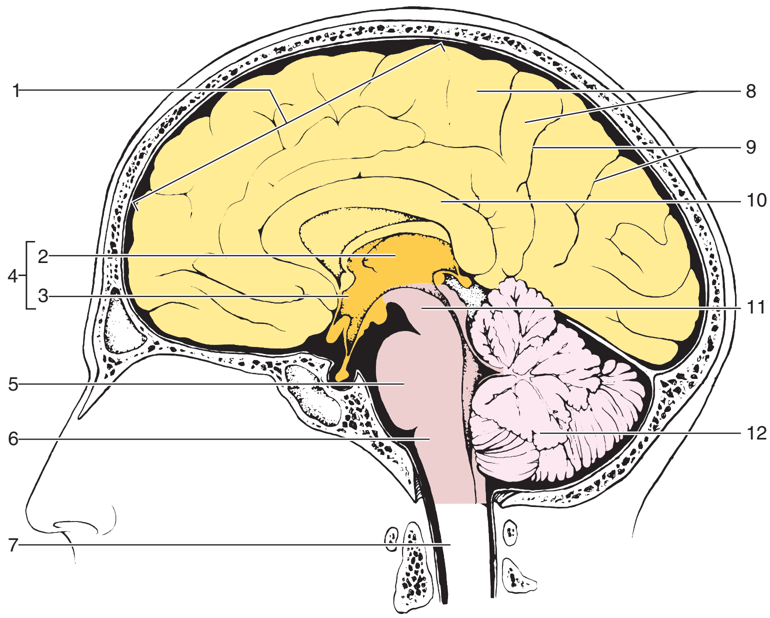
third ventricle

fourth ventricle

choroid plexuses

cerebral aqueduct

Figure 29.1 Label this diagram by placing the correct numbers in the spaces provided.



___ Cerebellum
___ Cerebrum
___ Convolutions/gyri
___ Corpus callosum
___ Diencephalon
___ Hypothalamus
___ Medulla oblongata
___ Midbrain
___ Pons
___ Spinal cord
___ Sulci
___ Thalamus

Figure 29.2 Label the lobes of the cerebrum.

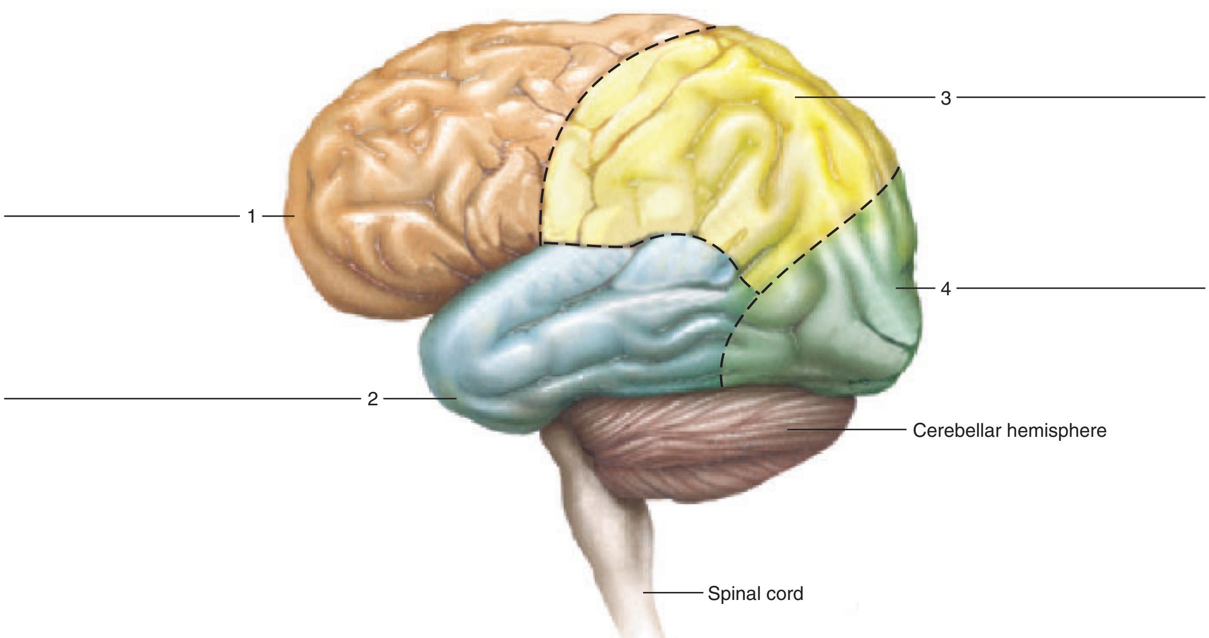
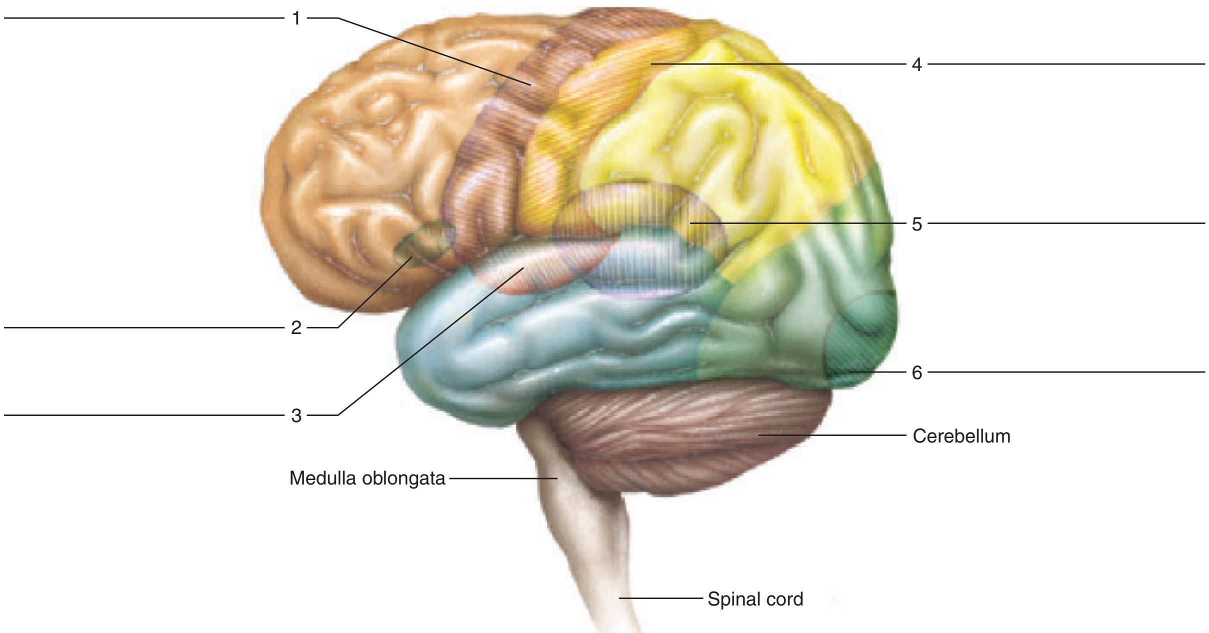


Figure 29.3 Label the functional areas of the cerebrum. (*Note:* These areas are not visible as distinct parts of a brain.)



diencephalon

thalamus

hypothalamus

optic chiasma

mammillary bodies

pineal gland

cerebellum

lateral hemispheres

vermis

cerebellar cortex

arbor vitae

cerebellar peduncles

brain stem

midbrain

cerebral aqueduct

cerebral peduncles

corpora quadrigemina

pons

medulla oblongata

5. Locate the labeled areas in figure 29.3 that represent the following functional regions of the cerebrum:

motor area for voluntary muscle control

motor speech area (Broca's area)

cutaneous sensory area

auditory area

visual area

general interpretative area

6. Complete Parts B and C of the laboratory report.

PROCEDURE B—CRANIAL NERVES

1. Review a textbook section on *cranial nerves.*
2. As a review activity, label figure 29.4.
3. Observe the model and preserved specimen of the human brain, and locate as many of the following cranial nerves as possible:

olfactory nerves

optic nerves

oculomotor nerves

trochlear nerves

trigeminal nerves

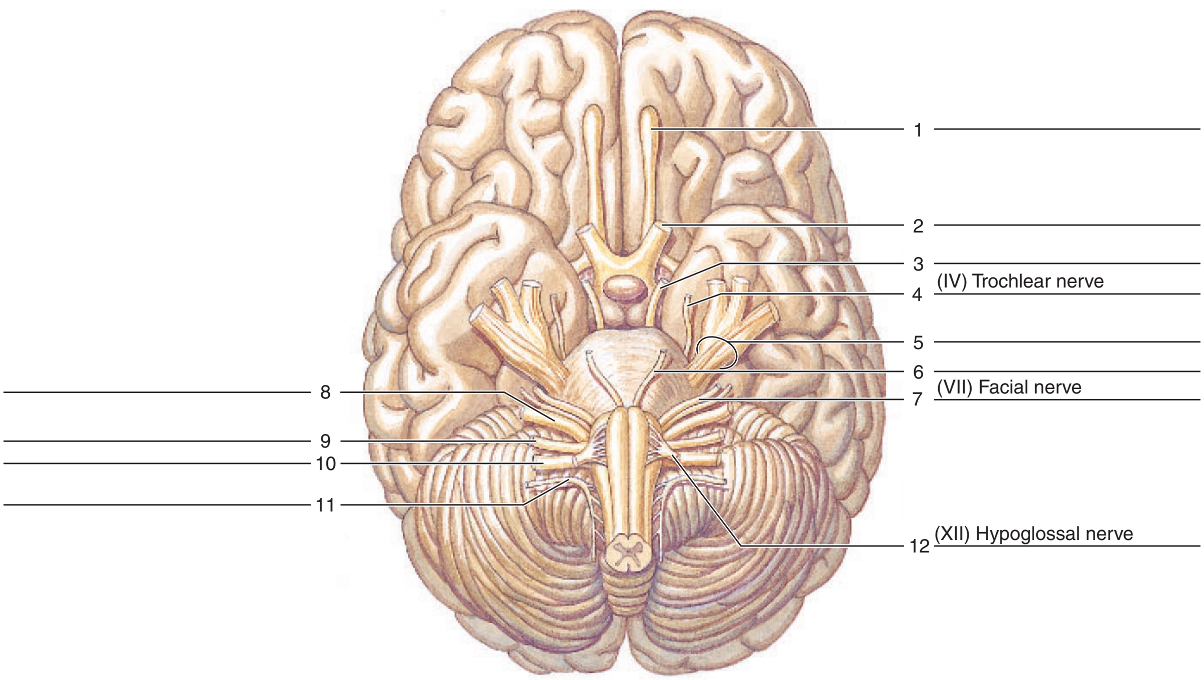
abducens nerves

facial nerves

vestibulocochlear nerves

glossopharyngeal nerves

Figure 29.4 Provide the names of the cranial nerves in this ventral view.



vagus nerves

accessory nerves

hypoglossal nerves

4. Complete Part D of the laboratory report.

Web Quest

Describe the development of the nervous system and review the brain, cranial nerves, spinal cord, and CSF. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report **29**

Name ______________________________

Date ______________________________

Section ______________________________

The Brain and Cranial Nerves

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. central sulcus
b. cerebral cortex
c. convolution (gyrus)
d. corpus callosum
e. falx cerebelli
f. hypothalamus
g. insula
h. medulla oblongata
i. midbrain
j. optic chiasma
k. pineal gland
l. pons
m. tentorium cerebelli

Column B

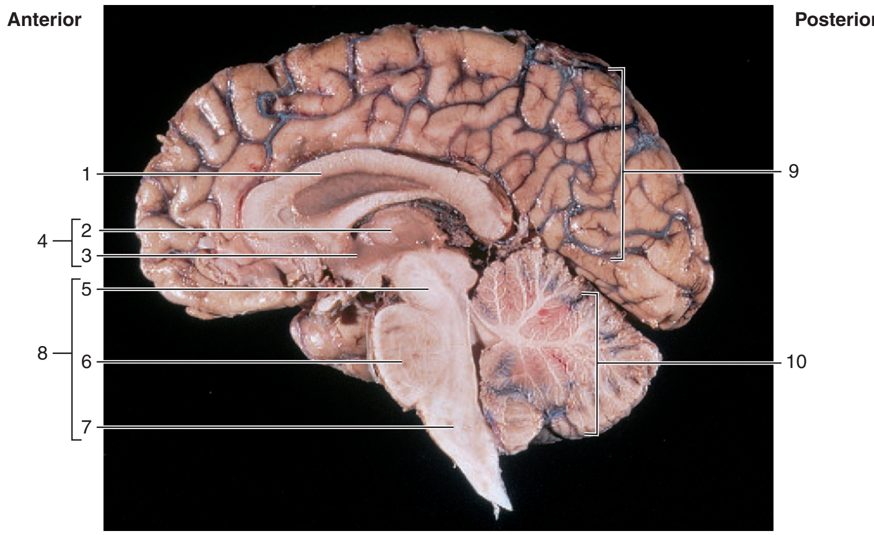
____ 1. structure formed by the crossing-over of the optic nerves
____ 2. part of diencephalon that forms lower walls and floor of third ventricle
____ 3. cone-shaped structure in the upper posterior portion of diencephalon
____ 4. connects cerebral hemispheres
____ 5. ridge on surface of cerebrum
____ 6. separates frontal and parietal lobes
____ 7. part of brain stem between diencephalon and pons
____ 8. rounded bulge on underside of brain stem
____ 9. part of brain stem continuous with the spinal cord
____ 10. a layer of dura mater that separates cerebellar hemispheres
____ 11. a layer of dura mater that separates occipital lobe from cerebellum
____ 12. cerebral lobe located deep within lateral sulcus
____ 13. thin layer of gray matter on surface of cerebrum

Part B

Complete the following table:

Structure	Location	Major Functions
Broca's area		
Cardiac center		
Cerebellar peduncles		
Cerebral peduncles		
Corpora quadrigemina		
Frontal eye fields		
Hypothalamus		
Limbic system		
Respiratory center		
Reticular formation		
Thalamus		
Vasomotor center		

Figure 29.5 Identify the features on this midsagittal section of the right half of the human brain.



Part C

Identify the features indicated in the midsagittal section of the right half of the human brain in figure 29.5.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

Part D

Indicate which cranial nerve(s) is (are) most closely associated with each of the following functions:

1. Sense of hearing ______________________
2. Sense of taste ______________________
3. Sense of sight ______________________
4. Sense of smell ______________________
5. Sense of equilibrium ______________________
6. Conducting sensory impulses from upper teeth ______________________
7. Conducting sensory impulses from lower teeth ______________________
8. Raising eyelids ______________________

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9. Focusing lenses of eyes ________________________________
10. Adjusting amount of light entering eye ________________________________
11. Moving eyes ________________________________
12. Stimulating salivary secretions ________________________________
13. Movement of trapezius and sternocleidomastoid muscles ________________________________
14. Muscular movements associated with speech ________________________________
15. Muscular movements associated with swallowing ________________________________

Laboratory Exercise 30

Dissection of the Sheep Brain

MATERIALS NEEDED

dissectible model of human brain
preserved sheep brain
dissecting tray
dissection instruments
long knife

For Demonstration:

coronal sections of sheep brains

SAFETY

- Wear disposable gloves when handling the sheep brains.
- Save or dispose of the brains as instructed.
- Wash your hands before leaving the laboratory.

Mammalian brains have many features in common. Because human brains may not be available, sheep brains often are dissected as an aid to understanding mammalian brain structure. However, as in the pig, the adaptations of the sheep differ from the adaptations of the human so that comparisons of their structural features may not be precise.

PURPOSE OF THE EXERCISE

To observe the major features of the sheep brain and to compare these features with those of the human brain.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major structures of the sheep brain;
2. locate the larger cranial nerves of the sheep brain;
3. list several differences and similarities between the sheep brain and the human brain.

PROCEDURE

1. Obtain a preserved sheep brain and rinse it thoroughly in water to remove as much of the preserving fluid as possible.
2. Examine the surface of the brain for the presence of meninges. (The outermost layers of these membranes may have been lost during removal of the brain from the cranial cavity.) If meninges are present, locate the following:

   dura mater—the thick, opaque outer layer

   arachnoid mater—the delicate, transparent middle layer that is attached to the undersurface of the dura mater

   pia mater—the thin, vascular layer that adheres to the surface of the brain (should be present)

3. Remove any remaining dura mater by pulling it gently from the surface of the brain.
4. Position the brain with its ventral surface down in the dissecting tray. Study figure 30.1 and locate the following structures on the specimen:

   cerebral hemispheres

   convolutions (gyri)

   sulci

   longitudinal fissure

   frontal lobe

   parietal lobe

   temporal lobe

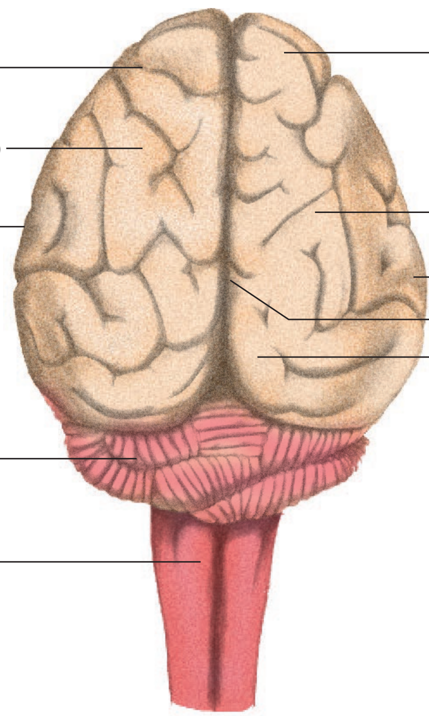
   occipital lobe

   cerebellum

   medulla oblongata

5. Gently separate the cerebral hemispheres along the longitudinal fissure and expose the transverse band of white fibers within the fissure that connects the hemispheres. This band is the *corpus callosum.*
6. Bend the cerebellum and medulla oblongata slightly downward and away from the cerebrum (fig. 30.2). This will expose the *pineal gland* in the upper midline and the *corpora quadrigemina,* which consists of four rounded structures associated with the midbrain.

Figure 30.1 Dorsal surface of the sheep brain.



7. Position the brain with its ventral surface upward. Study figures 30.3 and 30.4, and locate the following structures on the specimen:

   longitudinal fissure

   olfactory bulbs

   optic nerves

   optic chiasma

   optic tract

   mammillary bodies

   infundibulum (pituitary stalk)

   midbrain

   pons

8. Although some of the cranial nerves may be missing or are quite small and difficult to find, locate as many of the following as possible using figures 30.3 and 30.4 as references:

   oculomotor nerves

   trochlear nerves

   trigeminal nerves

   abducens nerves

   facial nerves

   vestibulocochlear nerves

   glossopharyngeal nerves

   vagus nerves

   accessory nerves

   hypoglossal nerves

9. Using a long, sharp knife, cut the sheep brain along the midline to produce a midsagittal section. Study figures 30.5 and 30.6 and locate the following structures on the specimen:

   cerebrum

      cerebral hemisphere

      cerebral cortex

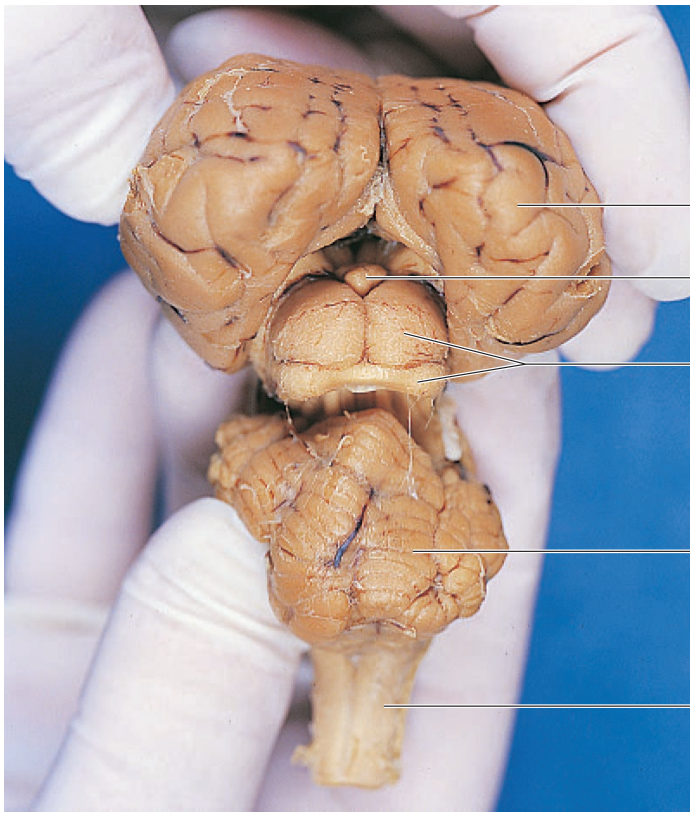
      white matter

      gray matter

   olfactory bulb

   corpus callosum

Figure 30.2 Gently bend the cerebellum and medulla oblongata away from the cerebellum to expose the pineal gland and the corpora quadrigemina.



cerebellum

white matter

gray matter

third ventricle

fourth ventricle

diencephalon

optic chiasma

infundibulum

pituitary gland (this structure may be missing)

mammillary bodies

thalamus

hypothalamus

pineal gland

midbrain

corpora quadrigemina

cerebral peduncles

pons

medulla oblongata

DEMONSTRATION

Observe a sheep brain from a coronal section. Note the longitudinal fissure, gray matter, white matter, corpus callosum, lateral ventricles, third ventricle, and thalamus.

10. Dispose of the sheep brain as directed by the laboratory instructor.
11. Complete Parts A and B of Laboratory Report 30.

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Figure 30.3 Lateral surface of the sheep brain.

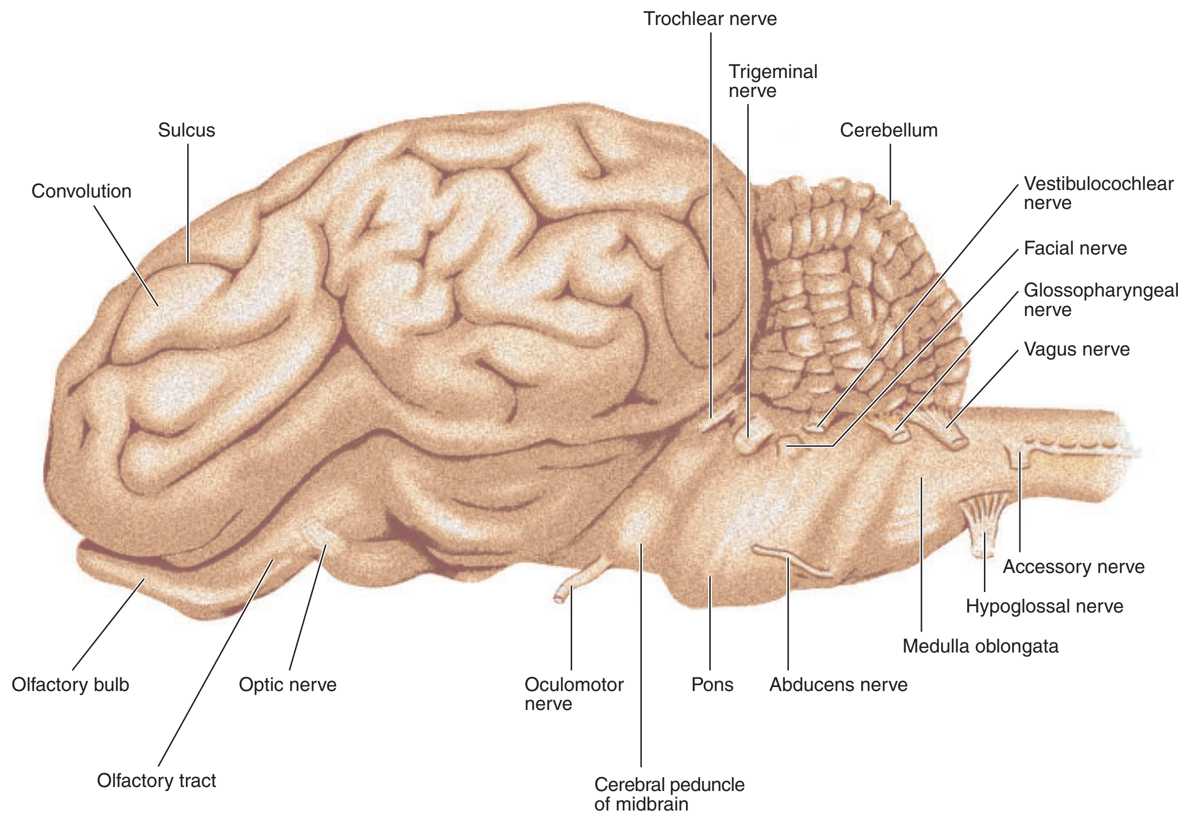


Figure 30.4 Ventral surface of the sheep brain.

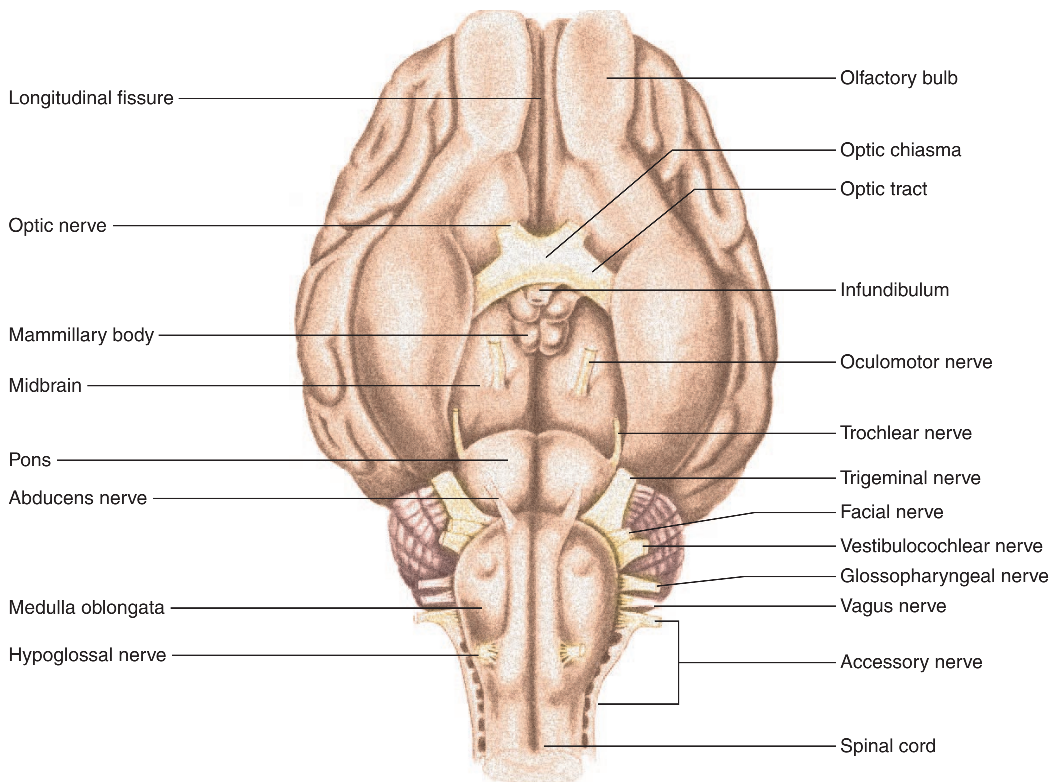


Figure 30.5 Midsagfittal section of the left half of the sheep brain dissection.

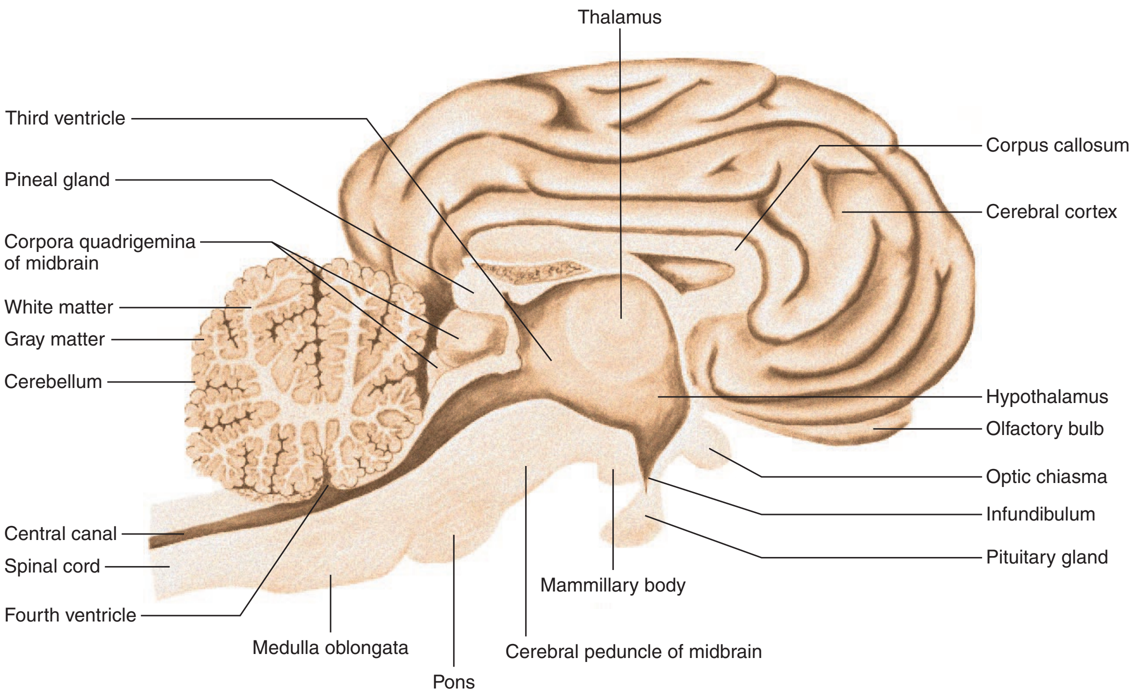
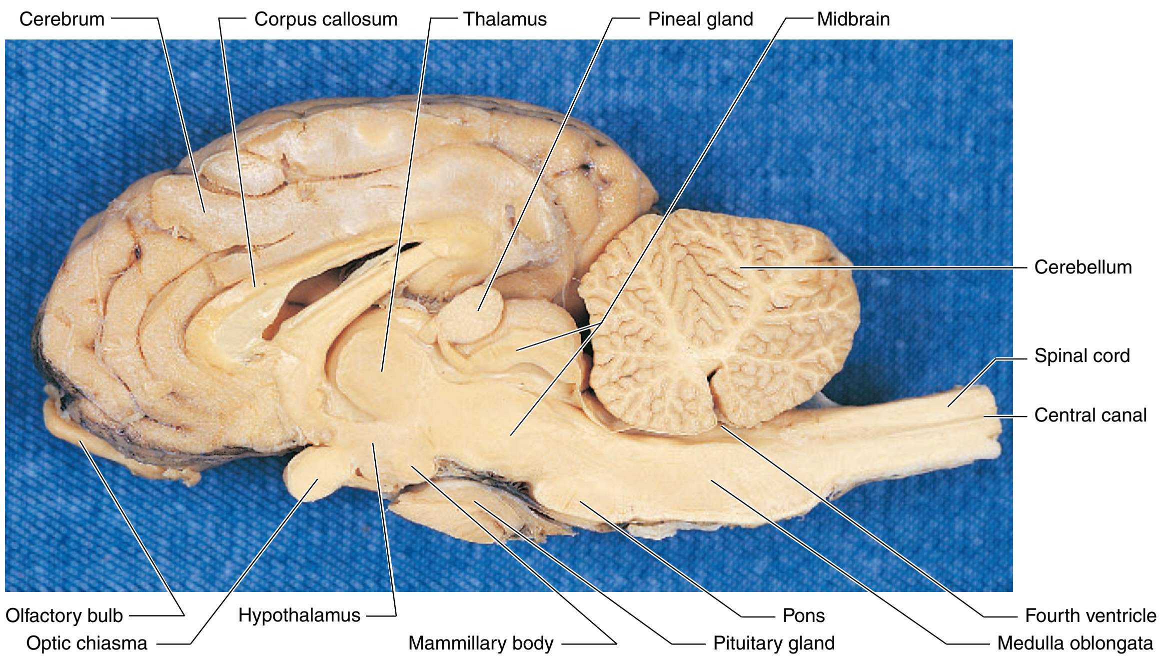


Figure 30.6 Midsagittal section of the right half of the sheep brain dissection.



Laboratory Report **30**

Name ______________________

Date ______________________

Section ______________________

Dissection of the Sheep Brain

Part A

Answer the following questions:

1. How do the relative sizes of the sheep and human cerebral hemispheres differ? ______________________

2. How do the convolutions and sulci of the sheep cerebrum compare with the human cerebrum in numbers?

3. What is the significance of the differences you noted in your answers for questions 1 and 2? ______________________

4. What difference did you note in the structures of the sheep cerebellum and the human cerebellum? ______________________

5. How do the sizes of the olfactory bulbs of the sheep brain compare with those of the human brain? ______________________

6. Based on their relative sizes, which of the cranial nerves seems to be most highly developed in the sheep brain?

7. What is the significance of the observations you noted in your answers for questions 5 and 6? ______________________

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Part B

Critical Thinking Application

Prepare a list of at least five features to illustrate ways in which the brains of sheep and humans are similar.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

Laboratory Exercise 31

Receptors and Somatic Senses

MATERIALS NEEDED

textbook
marking pen (washable)
millimeter ruler
bristle or sharp pencil
forceps (fine points)
blunt metal probes
three beakers (250 mL)
hot tap water or 45°C (113°F) water bath
cold water (ice water)
thermometer

For Demonstration:

prepared microscope slides of Meissner's and Pacinian corpuscles
compound microscope

Sensory receptors are sensitive to changes that occur within the body and its surroundings. When they are stimulated, they initiate nerve impulses that travel into the central nervous system. As a result of the brain interpreting such sensory impulses, the person may experience particular sensations.

The sensory receptors found in skin, muscles, joints, and visceral organs are associated with somatic senses. These senses include touch, pressure, temperature, pain, and the senses of muscle movement and body position.

PURPOSE OF THE EXERCISE

To review the characteristics of sensory receptors and somatic senses, and to investigate some of the somatic senses associated with the skin.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name five general types of receptors;
2. explain how a sensation results;
3. list the somatic senses;
4. determine the distribution of touch, heat, and cold receptors in a region of skin;
5. determine the two-point threshold of a region of skin.

PROCEDURE A—SOMATIC RECEPTORS

1. Review textbook sections on *receptors and sensations* and *somatic senses.*
2. Complete Part A of Laboratory Report 31.

DEMONSTRATION

Observe the Meissner's corpuscle with the microscope set up by the laboratory instructor. This type of receptor is abundant in the superficial dermis in outer regions of the body, such as in the fingertips, soles, lips, and external genital organs. It is responsible for the sensation of light touch. (See fig. 31.1.)

Observe the Pacinian corpuscle in the second demonstration microscope. This corpuscle is composed of many layers of connective tissue cells and has a nerve fiber in its central core. Pacinian corpuscles are numerous in the hands, feet, joints, and external genital organs. They are responsible for the sense of deep pressure (fig. 31.2). How are Meissner's and Pacinian

corpuscles similar? ______________________________

How are they different? ____________________________

____

____

____

____

PROCEDURE B—SENSE OF TOUCH

1. Investigate the distribution of touch receptors in your laboratory partner's skin. To do this, follow these steps:
   a. Use a marking pen and a millimeter ruler to prepare a square with 2.5 cm on each side on the skin of your partner's inner wrist, near the palm.
   b. Divide the square into smaller squares with 0.5 cm on a side, producing a small grid.
   c. Ask your partner to rest the marked wrist on the tabletop and to keep his or her eyes closed throughout the remainder of the experiment.

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Figure 31.1 Meissner's corpuscles, such as this one, are responsible for the sensation of light touch (250×).

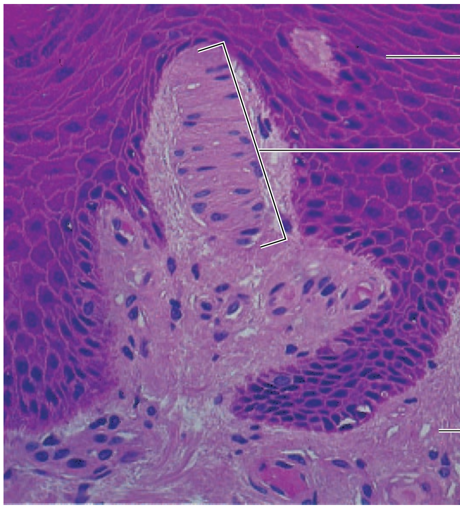


Figure 31.2 Pacinian corpuscles, such as this one, are responsible for the sensation of deep pressure (25× micrograph enlarged to 100×).

d. Press the end of a bristle on the skin in some part of the grid, using just enough pressure to cause the bristle to bend. A sharp pencil could be used as an alternate device.

e. Ask your partner to report whenever the touch of the bristle is felt. Record the results in Part B of the laboratory report.

f. Continue this procedure until you have tested twenty-five different locations on the grid. Move randomly through the grid to help prevent anticipation of the next stimulation site.

2. Test two other areas of exposed skin in the same manner, and record the results in Part B of the laboratory report.
3. Answer the questions in Part B of the laboratory report.

PROCEDURE C—TWO-POINT THRESHOLD

1. Test your partner's ability to recognize the difference between one or two points of skin being

stimulated simultaneously. To do this, follow these steps:

a. Have your partner place a hand with the palm up on the table and close his or her eyes.
b. Hold the tips of a forceps tightly together and gently touch the skin of your partner's index finger.
c. Ask your partner to report if it feels like one or two points are touching the finger.
d. Allow the tips of the forceps to spread so they are 1 mm apart, press both points against the skin simultaneously, and ask your partner to report as before.
e. Repeat this procedure, allowing the tips of the forceps to spread more each time until your partner can feel both tips being pressed against the skin. The minimum distance between the tips of the forceps when both can be felt is called the *two-point threshold.* As soon as you are able to distinguish two points, two separate receptors are being stimulated instead of only one receptor.
f. Record the two-point threshold for the skin of the index finger in Part C of the laboratory report.

2. Repeat this procedure to determine the two-point threshold of the palm, the back of the hand, the back of the neck, the leg, and the sole. Record the results in Part C of the laboratory report.
3. Answer the questions in Part C of the laboratory report.

PROCEDURE D—SENSE OF TEMPERATURE

1. Investigate the distribution of heat receptors in your partner's skin. To do this, follow these steps:
   a. Mark a square with 2.5 cm sides on your partner's palm.
   b. Prepare a grid by dividing the square into smaller squares, 0.5 cm on a side.
   c. Have your partner rest the marked palm on the table and close his or her eyes.
   d. Heat a blunt metal probe by placing it in a beaker of hot water (about 40–45°C/104–113°F) for a minute or so. (*Be sure the probe does not get so hot that it burns the skin.*) Use a thermometer to monitor the appropriate warm water from the tap or the water bath.
   e. Wipe the probe dry and touch it to the skin on some part of the grid.
   f. Ask your partner to report if the probe feels hot. Then record the results in Part D of the laboratory report.
   g. Keep the probe hot, and repeat the procedure until you have randomly tested twenty-five different locations on the grid.
2. Investigate the distribution of cold receptors by repeating the procedure. Use a blunt metal probe that has been cooled by placing it in ice water for a minute or so. Record the results in Part D of the laboratory report.
3. Answer the questions in Part D of the laboratory report.

OPTIONAL ACTIVITY

Prepare three beakers of water of different temperatures. One beaker should contain warm water (about 40°C/104°F), one should be room temperature (about 22°C/72°F), and one should contain cold water (about 10°C/50°F). Place the index finger of one hand in the warm water and, at the same time, place the index finger of the other hand in the cold water for about 2 minutes. Then, simultaneously move both index fingers into the water at room temperature. What temperature do you sense with each finger? How do you explain the resulting sensations?

____

____

____

____

Laboratory Report 31

Name ________________________________

Date ________________________________

Section ______________________________

RECEPTORS AND SOMATIC SENSES

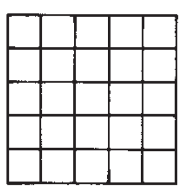
Part A—Somatic Receptors

Complete the following statements:

1. ________________________ are receptors that are sensitive to changes in the concentrations of chemicals.
2. Whenever tissues are damaged, ________________________ receptors are likely to be stimulated.
3. Receptors that are sensitive to temperature changes are called ________________________.
4. ________________________ are sensitive to changes in pressure or to movement of fluid.
5. ________________________ are sensitive to changes in the intensity of light energy.
6. A sensation may seem to fade away when receptors are continuously stimulated as a result of ________________________ adaptation.
7. Meissner's corpuscles are responsible for the sense of light ________________________.
8. Pacinian corpuscles are responsible for the sense of deep ________________________.
9. ________________________ receptors are most sensitive to temperatures between 25°C (77°F) and 45°C (113°F).
10. ________________________ receptors are most sensitive to temperatures between 10°C (50°F) and 20°C (68°F).

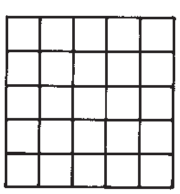
Part B—Sense of Touch

1. Record a + to indicate where the bristle was felt and a *0* to indicate where it was not felt.

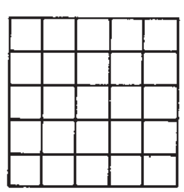


Skin of wrist

2. Show distribution of touch receptors in two other regions of skin.



Region tested ________________



Region tested ________________

3. Answer the following questions:

   a. How do you describe the pattern of distribution for touch receptors in the regions of the skin you tested?

   ____

   ____

   b. How does the concentration of touch receptors seem to vary from region to region? ______________

   ____

Part C—Two-Point Threshold

1. Record the two-point threshold in millimeters for skin in each of the following regions:

   Index finger ______________________

   Palm ______________________

   Back of hand ______________________

   Back of neck ______________________

   Leg ______________________

   Sole ______________________

2. Answer the following questions:

   a. What region of the skin tested has the greatest ability to discriminate two points? ______________

   b. What region of the skin has the least sensitivity to this test? ______________

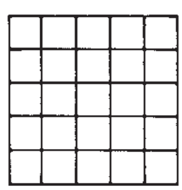
   c. What is the significance of these observations in questions *a* and *b?* ______________

   ____

   ____

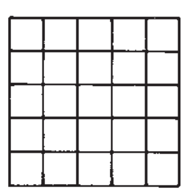
Part D—Sense of Temperature

1. Record a + to indicate where heat was felt and a *0* to indicate where it was not felt.



Skin of palm

2. Record a + to indicate where cold was felt and a *0* to indicate where it was not felt.



Skin of palm

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3. Answer the following questions:

   a. How do temperature receptors appear to be distributed in the skin of the palm? ______________________

   ____

   b. Compare the distribution and concentration of heat and cold receptors in the skin of the palm. __________

   ____

   ____

Laboratory Exercise 32

Senses of Smell and Taste

MATERIALS NEEDED

For Procedure A—Sense of Smell (Olfaction)

textbook
set of substances in stoppered bottles:
cinnamon, sage, vanilla, garlic powder, oil of clove, oil of wintergreen, and perfume

For Procedure B—Sense of Taste (Gustation)

textbook
paper cups (small)
cotton swabs (sterile; disposable)
5% sucrose solution
5% NaCl solution
1% acetic acid or unsweetened lemon juice
0.5% quinine sulfate solution or 0.1% Epsom salt solution

For Demonstrations:

compound microscope
prepared microscope slides of olfactory epithelium and of taste buds

For Optional Activity:

pieces of apple, potato, carrot, and onion

SAFETY

- Prepare fresh solutions for use in Procedure B.
- Wash your hands before starting the taste experiment.
- Use a clean cotton swab for each test. Do not dip a used swab into a test solution.
- Dispose of used cotton swabs and paper towels as directed.
- Wash your hands before leaving the laboratory.

The senses of smell (olfaction) and taste (gustation) are dependent upon chemoreceptors that are stimulated by various chemicals dissolved in liquids. The receptors of smell are found in the olfactory organs, which are located in the upper parts of the nasal cavity and in a portion of the nasal septum. The receptors of taste occur in the taste buds, which are sensory organs primarily found on the surface of the tongue. Chemicals are considered odorless and tasteless if receptor sites for them are absent.

These senses function closely together, because substances that are tasted often are smelled at the same moment, and they play important roles in the selection of foods.

PURPOSE OF THE EXERCISE

To review the structures of the organs of smell and taste, and to investigate the abilities of smell and taste receptors to discriminate various chemical substances.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the general characteristics of the smell (olfactory) receptors;
2. describe the general characteristics of the taste (gustatory) receptors;
3. explain how the senses of smell and taste function together;
4. determine the time needed for olfactory sensory adaptation to occur;
5. determine the distribution of taste receptors on the surface of the tongue.

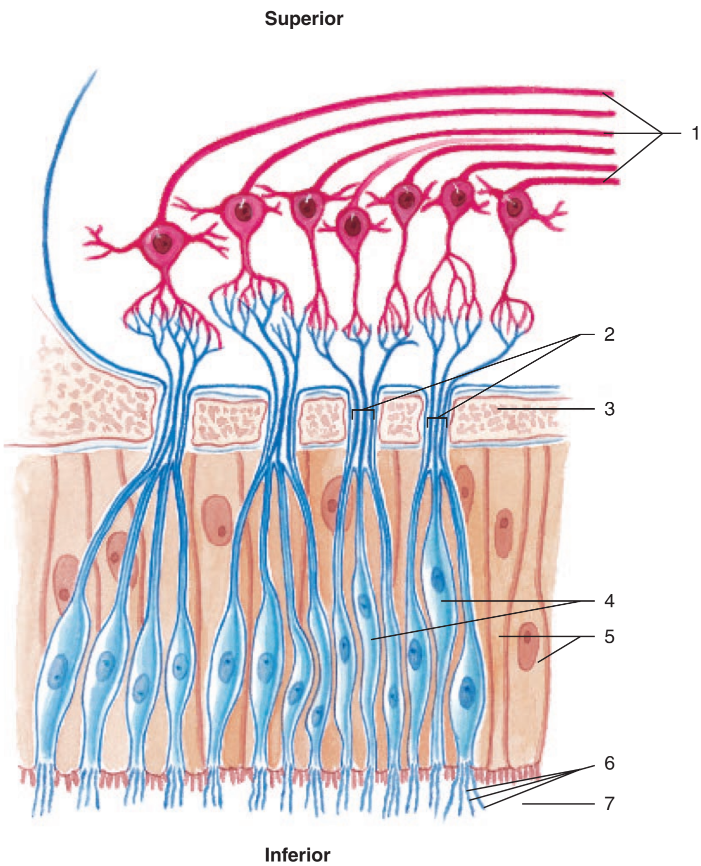
PROCEDURE A—SENSE OF SMELL (OLFACTION)

1. Review a textbook section on *sense of smell.*
2. As a review activity, label figure 32.1.
3. Complete Part A of Laboratory Report 32.

DEMONSTRATION

Observe the olfactory epithelium in the microscope set up by the laboratory instructor. The olfactory receptor cells are spindle-shaped, bipolar neurons with spherical nuclei. They also have six to eight cilia at their distal ends. The supporting cells are pseudostratified columnar epithelial cells. However, in this region the tissue lacks goblet cells. (See fig. 32.2.)

Figure 32.1 Label this diagram of the olfactory organ by placing the correct numbers in the spaces provided.



___ Cilia

___ Columnar epithelial cells

___ Cribriform plate of ethmoid bone

___ Nasal cavity

___ Nerve fibers within olfactory bulb

___ Olfactory nerves

___ Olfactory receptor cells

Figure 32.2 Olfactory receptors have cilia at their distal ends (250×).

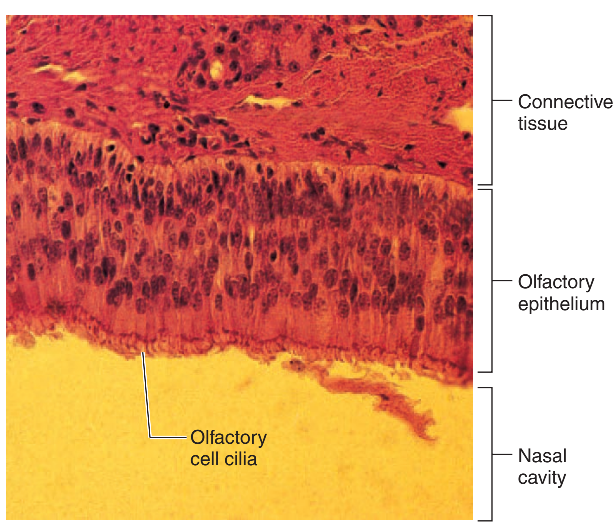
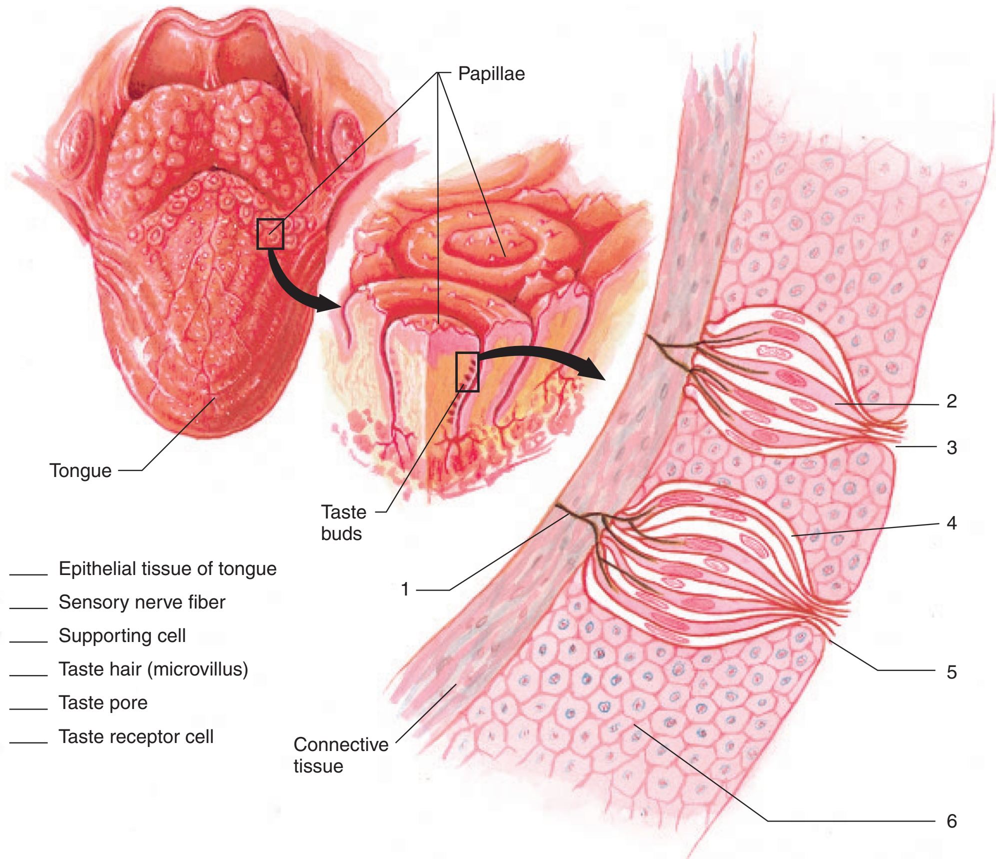


Figure 32.3 Label this diagram by placing the correct numbers in the spaces provided.

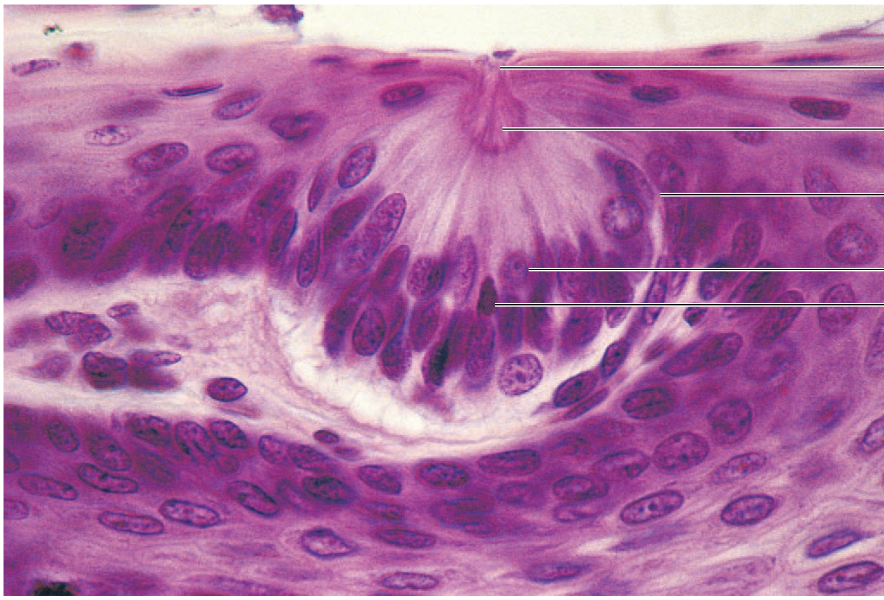


4. Test your laboratory partner's ability to recognize the odors of the bottled substances available in the laboratory. To do this, follow these steps:
   a. Have your partner keep his or her eyes closed.
   b. Remove the stopper from one of the bottles and hold it about 4 cm under your partner's nostrils for about 2 seconds.
   c. Ask your partner to identify the odor, and then replace the stopper.
   d. Record your partner's response in Part B of the laboratory report.
   e. Repeat steps *b–d* for each of the bottled substances.
5. Repeat the preceding procedure, using the same set of bottled substances, but present them to your partner in a different sequence. Record the results in Part B of the laboratory report.
6. Wait 10 minutes and then determine the time it takes for your partner to experience olfactory sensory adaptation. To do this, follow these steps:
   a. Ask your partner to breathe in through the nostrils and exhale through the mouth.
   b. Remove the stopper from one of the bottles and hold it about 4 cm under your partner's nostrils.
   c. Keep track of the time that passes until your partner is no longer able to detect the odor of the substance.
   d. Record the result in Part B of the laboratory report.
   e. Wait 5 minutes and repeat this procedure, using a different bottled substance.
   f. Test a third substance in the same manner.
   g. Record the results as before.
7. Complete Part B of the laboratory report.

PROCEDURE B—SENSE OF TASTE (GUSTATION)

1. Review a textbook section on *sense of taste.*
2. As a review activity, label figure 32.3.
3. Complete Part C of the laboratory report.
4. Map the distribution of the receptors for the primary taste sensations on your partner's tongue. To do this, follow these steps:

Figure 32.4 Taste receptors are found in taste buds such as this one (250× micrograph enlarged to 1,500×).



DEMONSTRATION

Observe the oval-shaped taste bud in the microscope set up by the laboratory instructor. Note the surrounding epithelial cells. The taste pore, an opening into the taste bud, may be filled with taste hairs (microvilli). Within the taste bud there are supporting cells and thinner taste-receptor cells, which often have lightly stained nuclei (fig. 32.4).

a. Ask your partner to rinse his or her mouth with water and then partially dry the surface of the tongue with a paper towel.
b. Moisten a clean cotton swab with 5% sucrose solution, and touch several regions of your partner's tongue with the swab.
c. Each time you touch the tongue, ask your partner to report if a sweet sensation is experienced.
d. Test the tip, sides, and back of the tongue in this manner.
e. Record your partner's responses in Part D of the laboratory report.
f. Have your partner rinse his or her mouth and dry the tongue again, and repeat the preceding procedure, using each of the other three test solutions—NaCl, acetic acid, and quinine or Epsom salt solution. Be sure to use a fresh swab for each test substance and dispose of used swabs and paper towels as directed.

5. Complete Part D of the laboratory report.

OPTIONAL ACTIVITY

Test your laboratory partner's ability to recognize the tastes of apple, potato, carrot, and onion. To do this, follow these steps:

1. Have your partner close his or her eyes and hold the nostrils shut.
2. Place a small piece of one of the test substances on your partner's tongue.
3. Ask your partner to identify the substance without chewing or swallowing it.
4. Repeat the procedure for each of the other substances.

How do you explain the results of this experiment?

____

____

____

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Laboratory Report 32

Name ______________________________

Date ______________________________

Section ______________________________

Senses of Smell and Taste

Part A

Complete the following statements:

1. Olfactory, or smell, receptors are ________________________ neurons surrounded by columnar epithelial cells.
2. The distal ends of the olfactory neurons are covered with hairlike ________________________.
3. Before gaseous substances can stimulate the olfactory receptors, they must be dissolved in ________________________ that surrounds the cilia.
4. The axons of olfactory receptors pass through small openings in the ________________________ of the ethmoid bone.
5. Olfactory bulbs lie on either side of the ________________________ of the ethmoid bone.
6. The sensory impulses pass from the olfactory bulbs through the ________________________ tracts to the interpreting centers of the brain.
7. The olfactory interpreting centers are located deep within the temporal lobes and at the base of the ________________________ lobes of the cerebrum.
8. Olfactory sensations usually fade rapidly as a result of ________________________.
9. A chemical would be considered ________________________ if a person lacks a particular receptor site on the cilia of the olfactory neurons.

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Part B—Sense of Smell

1. Record the results (as +, if recognized; as *0,* if unrecognized) from the tests of odor recognition in the following table:

Substance Tested	Odor Reported	
	First Trial	**Second Trial**

2. Record the results of the olfactory sensory adaptation time in the following table:

Substance Tested	Adaptation Time in Seconds

3. Complete the following:
   a. How do you describe your partner's ability to recognize the odors of the substances you tested? ____________

   ____

   ____

   b. Compare your experimental results with others in the class. Did you find any evidence to indicate that individuals may vary in their abilities to recognize odors? Explain your answer. ________________________

   ____

   ____

   ____

Critical Thinking Application

Does the time it takes for sensory adaptation to occur seem to vary with the substances tested? Explain your answer.

____

____

____

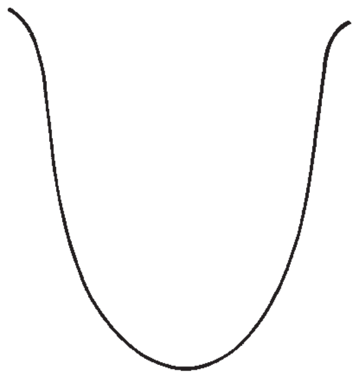
Part C

Complete the following statements:

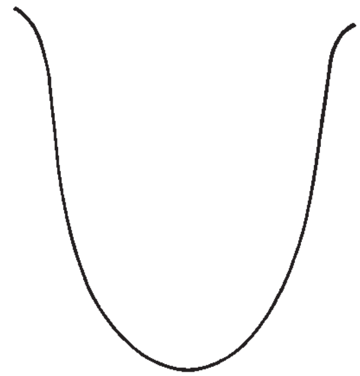
1. Taste receptor cells are modified ________________________ cells.
2. The opening to a taste bud is called a ________________________.
3. The ________________________ of a taste cell are its sensitive part.
4. Before the taste of a substance can be detected, the substance must be dissolved in ________________________.
5. Substances that stimulate taste cells seem to bind with ________________________ sites on the surfaces of taste hairs.
6. There are at least ________________________ kinds of taste cells, although microscopically they all appear to be very much alike.
7. Sweet receptors are most abundant in the ________________________ of the tongue.
8. Sour receptors are mainly stimulated by ________________________.
9. Salt receptors are mainly stimulated by ionized inorganic ________________________.
10. Alkaloids usually have a ________________________ taste.

Part D—Sense of Taste

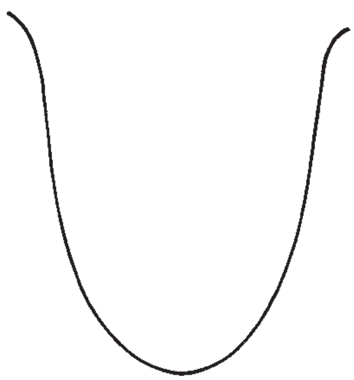
1. *Taste receptor distribution.* Record a + to indicate where a taste sensation seemed to originate and a *0* if no sensation occurred when the spot was stimulated.



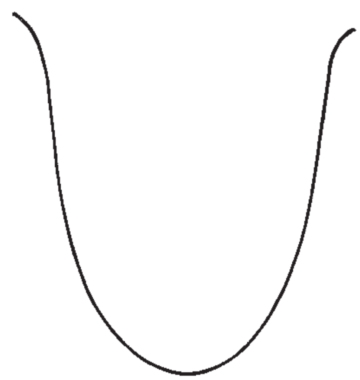
Sucrose (sweet sensation)



NaCl (salt sensation)



Acetic acid (sour sensation)



Quinine (bitter sensation)

2. Complete the following:

   a. Describe how each type of taste receptor is distributed on the surface of your partner's tongue. ______________________________

   ____
   ____
   ____
   ____
   ____

   b. How do your experimental results compare with the distribution of taste receptors described in a textbook?

   ____
   ____
   ____
   ____

Laboratory Exercise 33

The Ear and Hearing

MATERIALS NEEDED

textbook
dissectible ear model
watch that ticks
tuning fork (128 or 256 cps)
rubber hammer
cotton
meter stick

For Demonstrations:

compound microscope
prepared microscope slide of cochlea (section)
audiometer

The ear is composed of external, middle, and inner parts. The external structures gather sound waves and direct them inward to the tympanic membrane of the middle ear. The parts of the middle ear, in turn, transmit vibrations from the tympanic membrane (eardrum) to the inner ear, where the hearing receptors are located. As they are stimulated, these receptors initiate nerve impulses to pass over the vestibulocochlear nerve into the auditory cortex of the brain, where the impulses are interpreted and the sensations of hearing are created.

PURPOSE OF THE EXERCISE

To review the structural and functional characteristics of the ear and to conduct some simple hearing tests.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major structures of the ear;
2. describe the functions of the structures of the ear;
3. trace the pathway of sound vibrations from the tympanic membrane to the hearing receptors;
4. conduct several simple hearing tests.

PROCEDURE A—STRUCTURE AND FUNCTION OF THE EAR

1. Review a textbook section on the *sense of hearing.*
2. As a review activity, label figures 33.1, 33.2, and 33.3.
3. Examine the dissectible model of the ear and locate the following features:

   external ear
   - auricle
   - external auditory meatus

   middle ear
   - tympanic membrane (eardrum)
   - tympanic cavity
   - auditory ossicles
     - malleus
     - incus
     - stapes
   - oval window
   - tensor tympani
   - stapedius

   auditory tube (Eustachian tube)

   inner ear
   - osseous labyrinth
   - membranous labyrinth
   - cochlea
   - round window
   - semicircular canals
   - vestibule

   vestibulocochlear nerve
   - vestibular nerve (balance branch)
   - cochlear nerve (hearing branch)
4. Complete Parts A and B of Laboratory Report 33.

DEMONSTRATION

Observe the section of the cochlea in the microscope set up by the laboratory instructor. Locate one of the turns of the cochlea, and using figures 33.3 and 33.4 as a guide, identify the *scala vestibuli, cochlear duct, scala tympani, vestibular membrane, basilar membrane,* and the *organ of Corti.*

Figure 33.1 Label the major stuctures of the ear.

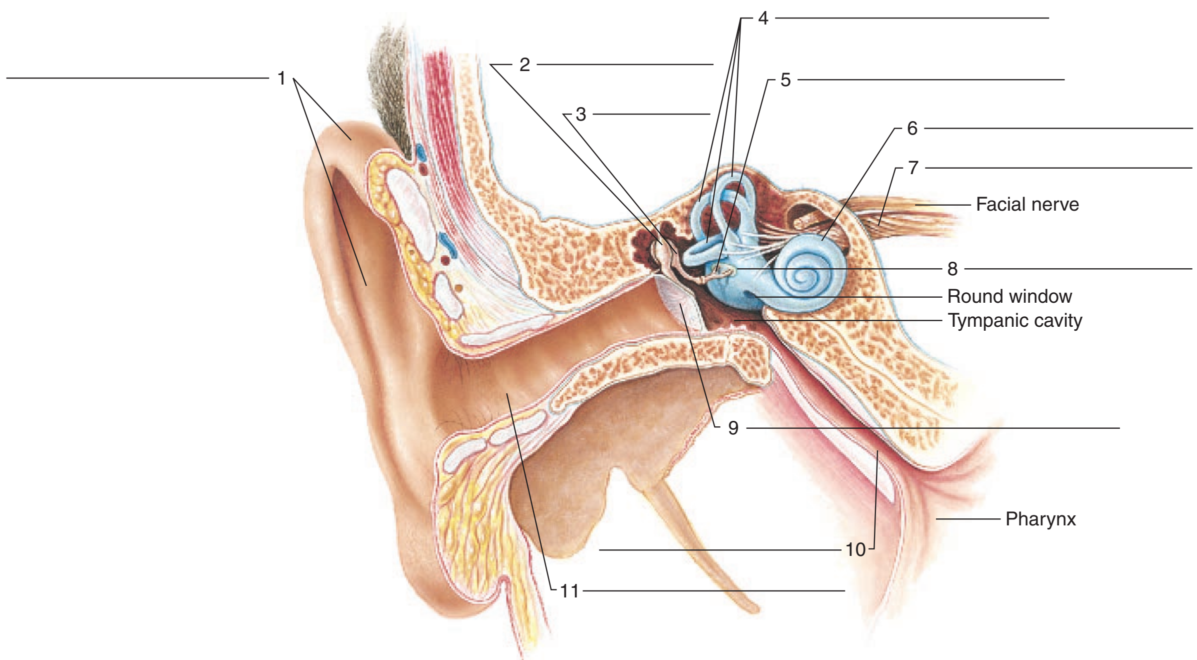


Figure 33.2 Label the structures of the inner ear by placing the correct numbers in the spaces provided.

____ Ampulla
____ Cochlea
____ Endolymph
____ Perilymph
____ Round window
____ Saccule
____ Semicircular canals
____ Utricle
____ Vestibule

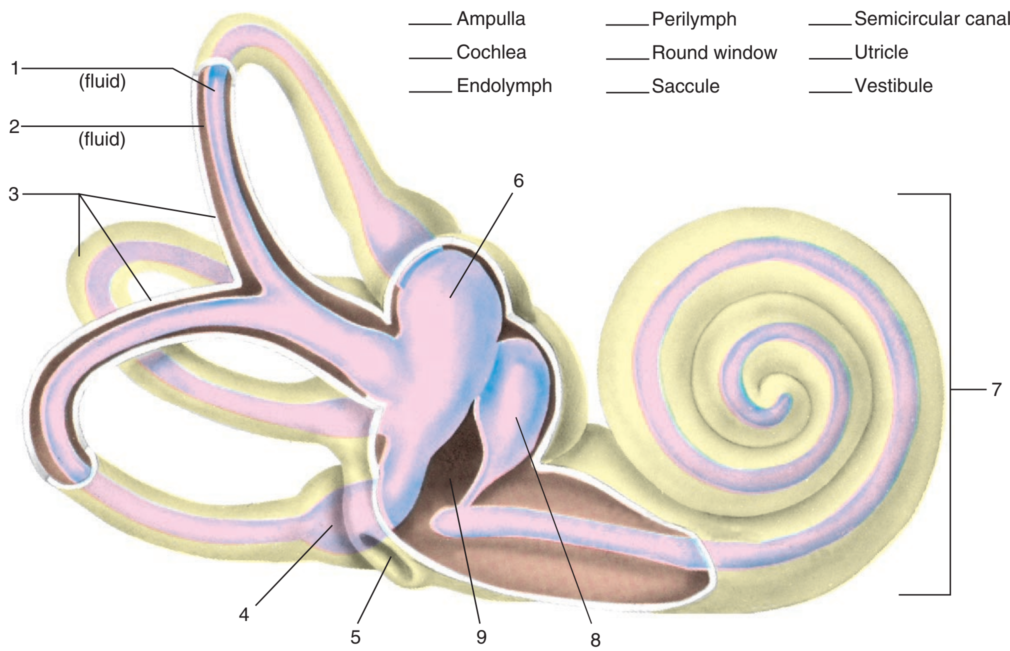
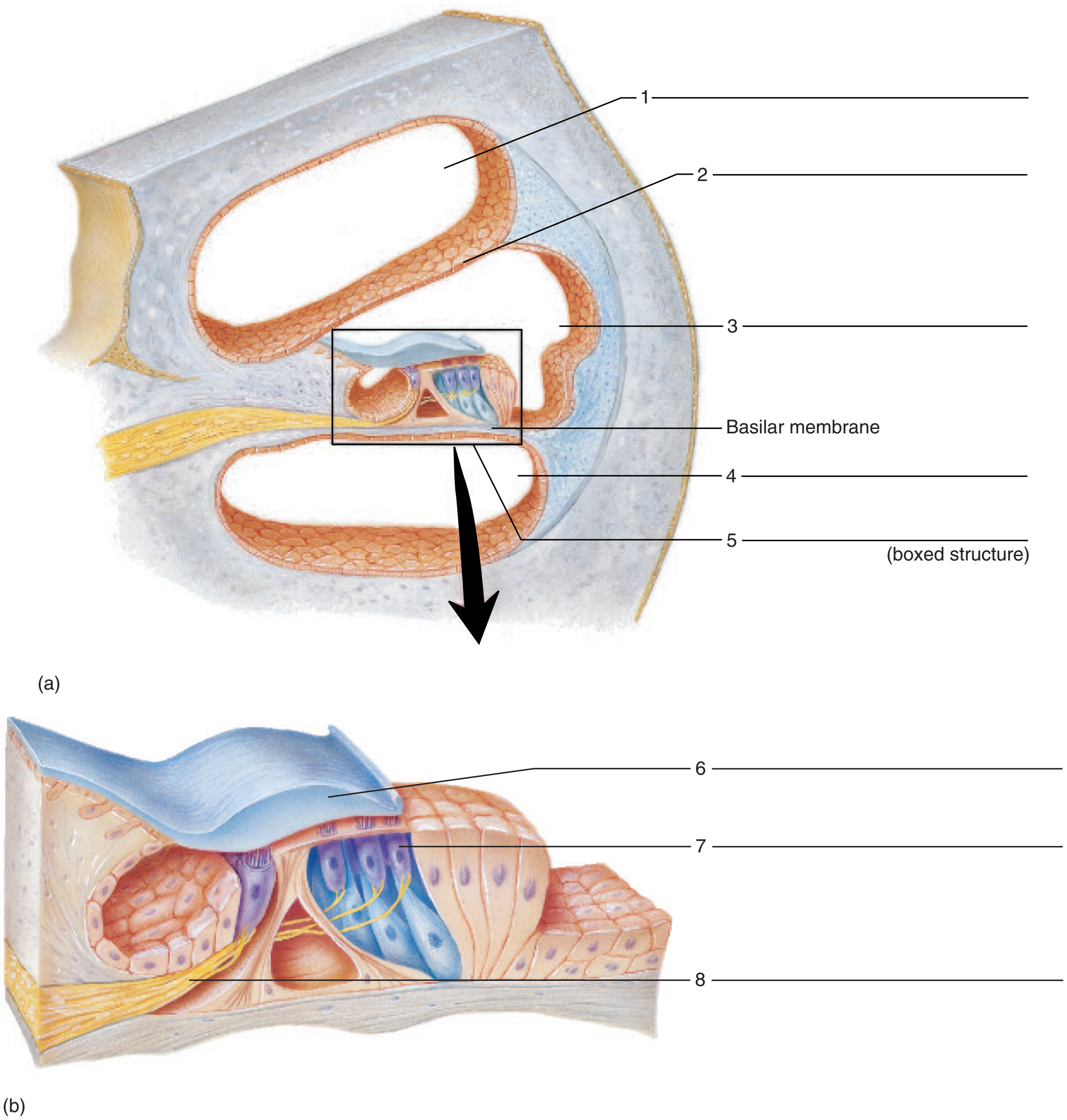


Figure 33.3 Label the structures indicated: (*a*) cross section of one turn of the cochlea; (*b*) organ of Corti.

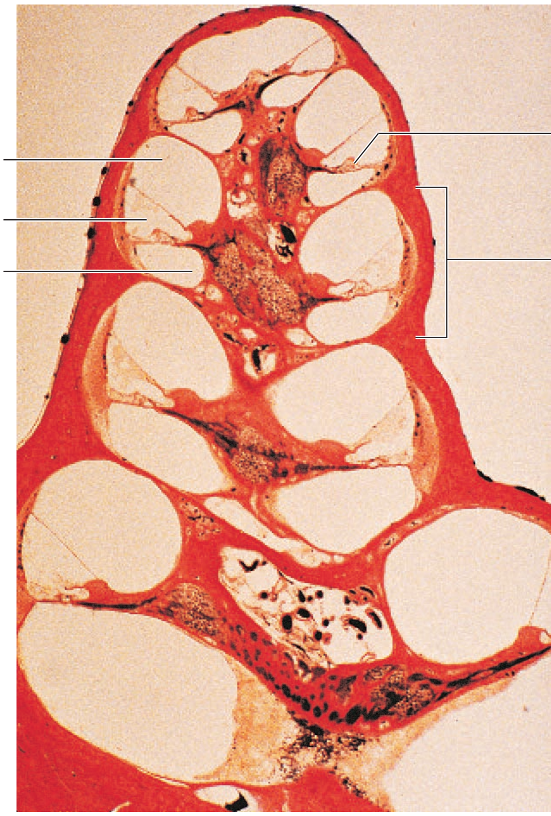


PROCEDURE B—HEARING TESTS

Perform the following tests in a quiet room, using your laboratory partner as the test subject.

1. *Auditory acuity test.* To conduct this test, follow these steps:
   a. Have the test subject sit with eyes closed.
   b. Pack one of the subject's ears with cotton.
   c. Hold a ticking watch close to the open ear and slowly move it straight out and away from the ear.
   d. Have the subject indicate when the sound of the ticking can no longer be heard.
   e. Use a meter stick to measure the distance in centimeters from the ear to the position of the watch.
   f. Repeat this procedure to test the acuity of the other ear.
   g. Record the test results in Part C of the laboratory report.
2. *Sound localization test.* To conduct this test, follow these steps:
   a. Have the subject sit with eyes closed.
   b. Hold the ticking watch somewhere within the audible range of the subject's ears and ask the subject to point to the watch.
   c. Move the watch to another position and repeat the request. In this manner, determine how accurately the subject can locate the watch when it is in each of the following positions: in front of the head, behind the head, above the

Figure 33.4 A section through the cochlea (22×).



head, on the right side of the head, and on the left side of the head.

d. Record the test results in Part C of the laboratory report.

3. *Rinne test.* This test is done to assess possible conduction deafness by comparing bone and air conduction. To conduct this test, follow these steps:
   a. Obtain a tuning fork and strike it with a rubber hammer, or on the heel of your hand, causing it to vibrate.
   b. Place the end of the fork's handle against the subject's mastoid process behind one ear. Have the prongs of the fork pointed downward and away from the ear, and be sure nothing is touching them. (See fig. 33.5*a.*) The sound sensation is that of bone conduction. If no sound is experienced, nerve deafness exists.
   c. Ask the subject to indicate when the sound is no longer heard.
   d. Then quickly remove the fork from the mastoid process and position it in the air close to the opening of the nearby external auditory meatus. (See fig. 33.5*b.*)

      If hearing is normal, the sound (from air conduction) will be heard again; if there is conductive impairment, the sound will not be heard. Conductive impairment involves outer or middle ear defects. Hearing aids can improve hearing for conductive deafness because bone conduction transmits the sound into the inner ear. Surgery could possibly correct this type of defect.
   e. Record the test results in Part C of the laboratory report.
4. *Weber test.* This test is used to distinguish possible conduction or sensory deafness. To conduct this test, follow these steps:
   a. Strike the tuning fork with the rubber hammer.
   b. Place the handle of the fork against the subject's forehead in the midline. (See fig. 33.6.)
   c. Ask the subject to indicate if the sound is louder in one ear than in the other or if it is equally loud in both ears.

      If hearing is normal, the sound will be equally loud in both ears. If there is conductive impairment, the sound will appear louder in the affected ear. If some degree of sensory (nerve)

Figure 33.5 Rinne test: (*a*) first placement of vibrating tuning fork until sound is no longer heard; (*b*) second placement of tuning fork to assess air conduction.

(a)

(b)

Figure 33.6 Weber test.

deafness exists, the sound will be louder in the normal ear. The impairment involves the organ of Corti or the cochlear nerve. Hearing aids will not improve sensory deafness.

d. Have the subject experience the effects of conductive impairment by packing one ear with cotton and repeating the Weber test. Usually the sound appears louder in the plugged (or impaired) ear because extraneous sounds from the room are blocked out.

e. Record the test results in Part C of the laboratory report.

5. Complete Part C of the laboratory report.

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Critical Thinking Application

Ear structures from the outer ear into the inner ear are progressively smaller. Using results obtained from the hearing tests, explain this advantage.

DEMONSTRATION

Ask the laboratory instructor to demonstrate the use of the audiometer. This instrument produces sound vibrations of known frequencies that are transmitted to one or both ears of a test subject through earphones. The audiometer can be used to determine the threshold of hearing for different sound frequencies, and, in the case of hearing impairment, it can be used to determine the percentage of hearing loss for each frequency.

Web Quest

What are the causes of hearing impairment? Search this site and review the anatomy and physiology of the ear at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report **33**

Name ______________________________

Date ______________________________

Section ______________________________

THE EAR AND HEARING

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. auditory tube	____	1. muscle attached to stapes
b. ceruminous gland	____	2. muscle attached to malleus
c. external auditory meatus	____	3. auditory ossicle attached to tympanic membrane
d. malleus	____	4. air-filled space containing auditory ossicles
e. membranous labyrinth	____	5. contacts hairs of hearing receptors
f. osseous labyrinth	____	6. leads from oval window to apex of cochlea
g. scala tympani	____	7. S-shaped tube leading to tympanic membrane
h. scala vestibuli	____	8. wax-secreting structure
i. stapedius	____	9. cone-shaped, semitransparent membrane attached to malleus
j. stapes	____	10. auditory ossicle attached to oval window
k. tectorial membrane	____	11. bony chamber between the cochlea and semicircular canals
l. tensor tympani	____	12. contains endolymph
m. tympanic cavity	____	13. bony canal of inner ear in temporal bone
n. tympanic membrane	____	14. connects middle ear and pharynx
o. vestibule	____	15. extends from apex of cochlea to round window

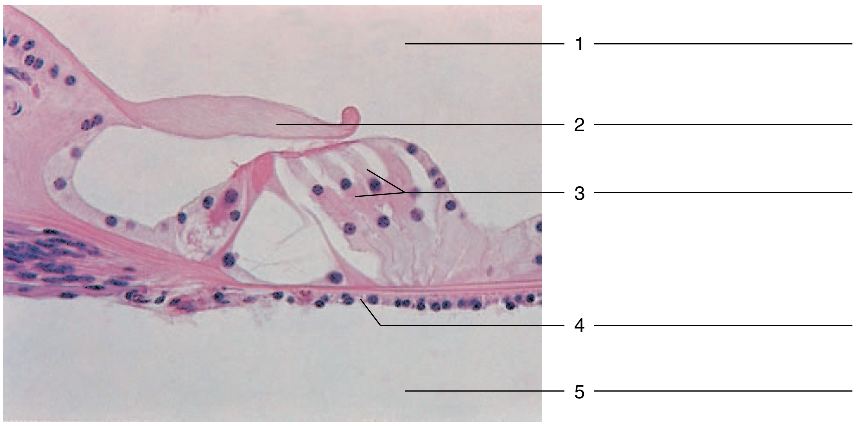


Figure 33.7 Label the structures of this organ of Corti (spiral organ) region of a cochlea (75× micrograph enlarged to 300×).

Part B

Label the structures indicated in the micrograph of the organ of Corti (spiral organ) in figure 33.7.

Part C

1. Results of auditory acuity test:

Ear Tested	Audible Distance (cm)
Right	
Left	

2. Results of sound localization test:

Actual Location	Reported Location
Front of the head	
Behind the head	
Above the head	
Right side of the head	
Left side of the head	

3. Results of experiments using tuning forks:

Test	Left Ear (Normal or Impaired)	Right Ear (Normal or Impaired)
Rinne		
Weber		

4. Summarize the results of the hearing tests you conducted on your laboratory partner.

Laboratory Exercise 34

Sense of Equilibrium

MATERIALS NEEDED

textbook
swivel chair
bright light

For Demonstration:

compound microscope
prepared microscope slide of semicircular canal (cross section through ampulla)

SAFETY

- Do not pick subjects that have frequent motion sickness.
- Have four people surround the subject in the swivel chair in case the person falls from vertigo or loss of balance.
- Stop your experiment if the subject becomes nauseated.

The sense of equilibrium involves two sets of sensory organs. One set functions to help maintain the stability of the head and body when they are motionless and produces a sense of static equilibrium. The other set is concerned with balancing the head and body when they are moved suddenly and produces a sense of dynamic equilibrium.

The organs associated with the sense of static equilibrium are located within the vestibules of the inner ears, whereas those associated with the sense of dynamic equilibrium are found within the ampullae of the semicircular canals of the inner ear.

PURPOSE OF THE EXERCISE

To review the structure and function of the organs of equilibrium, and to conduct some simple tests of equilibrium.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. distinguish between static and dynamic equilibrium;
2. identify the organs of equilibrium and describe their functions;
3. explain the role of vision in the maintenance of equilibrium;
4. conduct the Romberg and Bárány tests of equilibrium.

PROCEDURE A—STRUCTURE AND FUNCTION OF ORGANS OF EQUILIBRIUM

1. Review a textbook section on the *sense of equilibrium.*
2. Complete Part A of Laboratory Report 34.

DEMONSTRATION

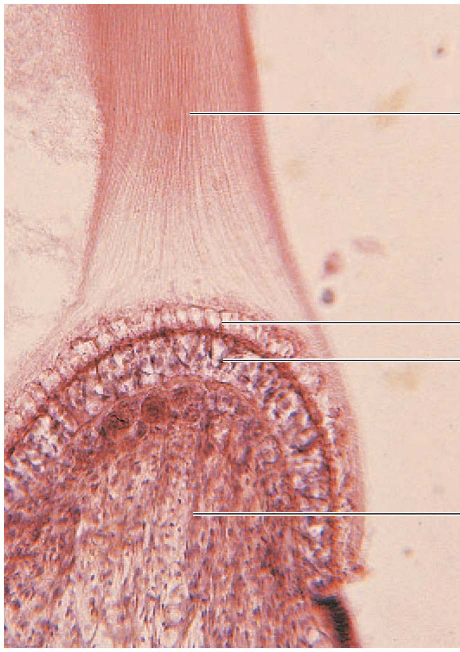
Observe the cross section of the semicircular canal through the ampulla in the microscope set up by the laboratory instructor. Note the crista projecting into the lumen of the membranous labyrinth, which in a living person is filled with endolymph (fig. 34.1). The space between the membranous and osseous labyrinths is normally filled with perilymph.

PROCEDURE B—TESTS OF EQUILIBRIUM

Perform the following tests, using a person as a test subject who is not easily disturbed by dizziness or rotational movement. Also have some other students standing close by to help prevent the test subject from falling during the tests. *The tests should be stopped immediately if the test subject begins to feel uncomfortable or nauseated.*

1. *Vision and equilibrium.* To demonstrate the importance of vision in the maintenance of equilibrium, follow these steps:
   a. Have the test subject stand erect on one foot for 1 minute with his or her eyes open.
   b. Observe the subject's degree of unsteadiness.
   c. Repeat the procedure with the subject's eyes closed. *Be prepared to prevent the subject from falling.*
2. *Romberg test.* To conduct this test, follow these steps:

Figure 34.1 A micrograph of a crista ampullaris (1,400×).



a. Position the test subject close to a chalkboard with the back toward the board.
b. Place a bright light in front of the subject so that a shadow of the body is cast on the board.
c. Have the subject stand erect with feet close together and eyes staring straight ahead for a period of 3 minutes.
d. During the test, make marks on the chalkboard along the edge of the shadow of the subject's shoulders to indicate the range of side-to-side swaying.
e. Measure the maximum sway in centimeters and record the results in Part B of the laboratory report.
f. Repeat the procedure with the subject's eyes closed.
g. Position the subject so one side is toward the chalkboard.
h. Repeat the procedure with the eyes open.
i. Repeat the procedure with the eyes closed.

The Romberg test is used to evaluate a person's ability to integrate sensory information from proprioceptors and receptors within the organs of equilibrium and to relay appropriate motor impulses to postural muscles. A person who shows little unsteadiness when standing with feet together and eyes open, but who becomes unsteady when the eyes are closed, has a positive Romberg test.

3. *Bárány test.* To conduct this test, follow these steps:
   a. Have the test subject sit on a swivel chair with his or her eyes closed, the head tilted forward about 30°, and the hands gripped firmly to the seat. Position four people around the chair for safety. *Be prepared to prevent the subject and the chair from tipping over.*
   b. Rotate the chair ten rotations within 20 seconds.
   c. Abruptly stop the movement of the chair. The subject will still have the sensation of continuous movement and might experience some dizziness (vertigo).
   d. Have the subject open the eyes, and note the nature of the eye movements and their direction. (Such reflex eye movements are called *nystagmus.*) Also note the time it takes for the nystagmus to cease. Nystagmus will continue until the cupula is returned to an original position.
   e. Record your observations in Part B of the laboratory report.
   f. Allow the subject several minutes of rest, then repeat the procedure with the subject's head tilted nearly 90° onto one shoulder.
   g. After another rest period, repeat the procedure with the subject's head bent forward so that the chin is resting on the chest.

   In this test, when the head is tilted about 30°, the lateral semicircular canals receive maximal stimulation, and the nystagmus is normally from side to side. When the head is tilted at 90°, the superior canals are stimulated, and the nystagmus is up and down. When the head is bent forward with the chin on the chest, the posterior canals are stimulated, and the nystagmus is rotary.
4. Complete Part B of the laboratory report.

Laboratory Report **34**

Name ______________________________

Date ______________________________

Section ______________________________

Sense of Equilibrium

Part A

Complete the following statements:

1. The organs of static equilibrium are located within two expanded chambers of the membranous labyrinth called the ________________ and the saccule.
2. All of the balance organs are found within the ________________ bone of the skull.
3. The receptor cells of these organs are found in the wall of the membranous labyrinth in a structure called the ________________.
4. Otoliths are small grains composed of ________________.
5. Sensory impulses travel from the organs of equilibrium to the brain on the ________________ nerve.
6. The sensory organ of a semicircular canal lies within a swelling of the canal called the ________________.
7. The sensory organ within a semicircular canal is called a ________________.
8. The ________________ of this sensory organ consists of a dome-shaped gelatinous mass.
9. When the head is moved, the fluid inside the membranous portion of a semicircular canal tends to remain stationary because of the ________________ of the fluid.
10. Parts of the ________________ of the brain interpret impulses from the semicircular canals.

Part B—Tests of Equilibrium

1. Vision and equilibrium test results:

   a. When the eyes are open, what sensory organs provide information needed to maintain equilibrium? ________

   ____

   ____

   b. When the eyes are closed, what sensory organs provide such information? ________________

   ____

   ____

2. Romberg test results:

   a. Record the test results in the following table:

Conditions	Maximal Movement (cm)
Back toward board, eyes open	
Back toward board, eyes closed	
Side toward board, eyes open	
Side toward board, eyes closed	

   b. Did the test subject's unsteadiness increase when the eyes were closed? ____________ What is the significance of this observation? ____________

   c. Why would you expect a person with impairment of the organs of equilibrium to become more unsteady when the eyes are closed? ____________

3. Bárány test results:

   a. Record the test results in the following table:

Position of Head	Description of Eye Movements	Time for Movement to Cease
Tilted 30° forward		
Tilted 90° onto shoulder		
Tilted forward, chin on chest		

   b. Summarize the results of this test. ____________

Critical Thinking Application

What additional sensory information would you expect a person with impairment of organs of equilibrium to use to supplement their relative lack of some sensory information?

____

Laboratory Exercise 35

The Eye

MATERIALS NEEDED

textbook
dissectible eye model
compound microscope
prepared microscope slide of a mammalian eye (sagittal section)
sheep or beef eye (fresh or preserved)
dissecting tray
dissecting instruments—forceps, sharp scissors, and dissecting needle

For Optional Activity:

ophthalmoscope

SAFETY

- Wear disposable gloves when working on the eye dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

The eye contains photoreceptors, which are modified neurons located on its inner wall. Other parts of the eye provide protective functions or make it possible to move the eyeball. Still other structures serve to focus light entering the eye so that a sharp image is projected onto the receptor cells. Nerve impulses generated when the receptors are stimulated travel along the optic nerves to the brain, which interprets the impulses and creates the sensation of sight.

PURPOSE OF THE EXERCISE

To review the structure and function of the eye and to dissect a mammalian eye.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major structures of an eye;
2. describe the functions of the structures of an eye;
3. list the structures through which light passes as it travels from the cornea to the retina;
4. dissect a mammalian eye and identify its major features.

PROCEDURE A—STRUCTURE AND FUNCTION OF THE EYE

1. Review a textbook section on the *structure of the eye.*
2. As a review activity, label figures 35.1, 35.2, and 35.3.
3. Complete Part A of Laboratory Report 35.
4. Examine the dissectible model of the eye and locate the following features:

eyelid

conjunctiva

orbicularis oculi

levator palpebrae superioris

lacrimal apparatus

- lacrimal gland
- canaliculi
- lacrimal sac
- nasolacrimal duct

extrinsic muscles

- superior rectus
- inferior rectus
- medial rectus
- lateral rectus
- superior oblique
- inferior oblique

trochlea (pulley)

cornea

sclera

optic nerve

Figure 35.1 Label the structures of the lacrimal apparatus.

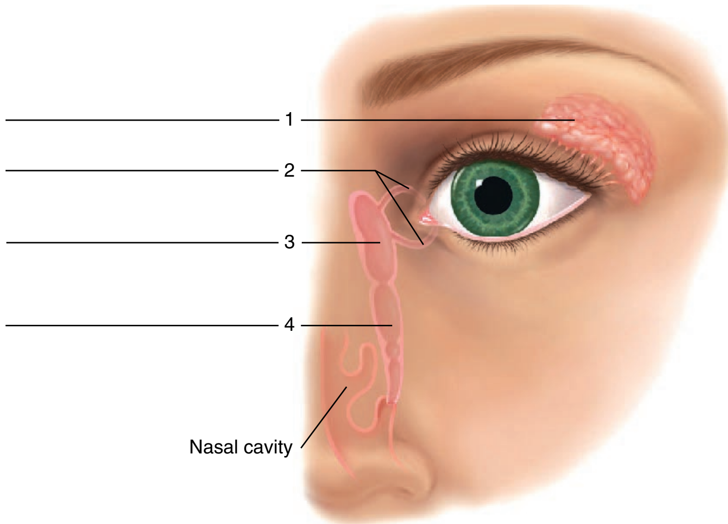
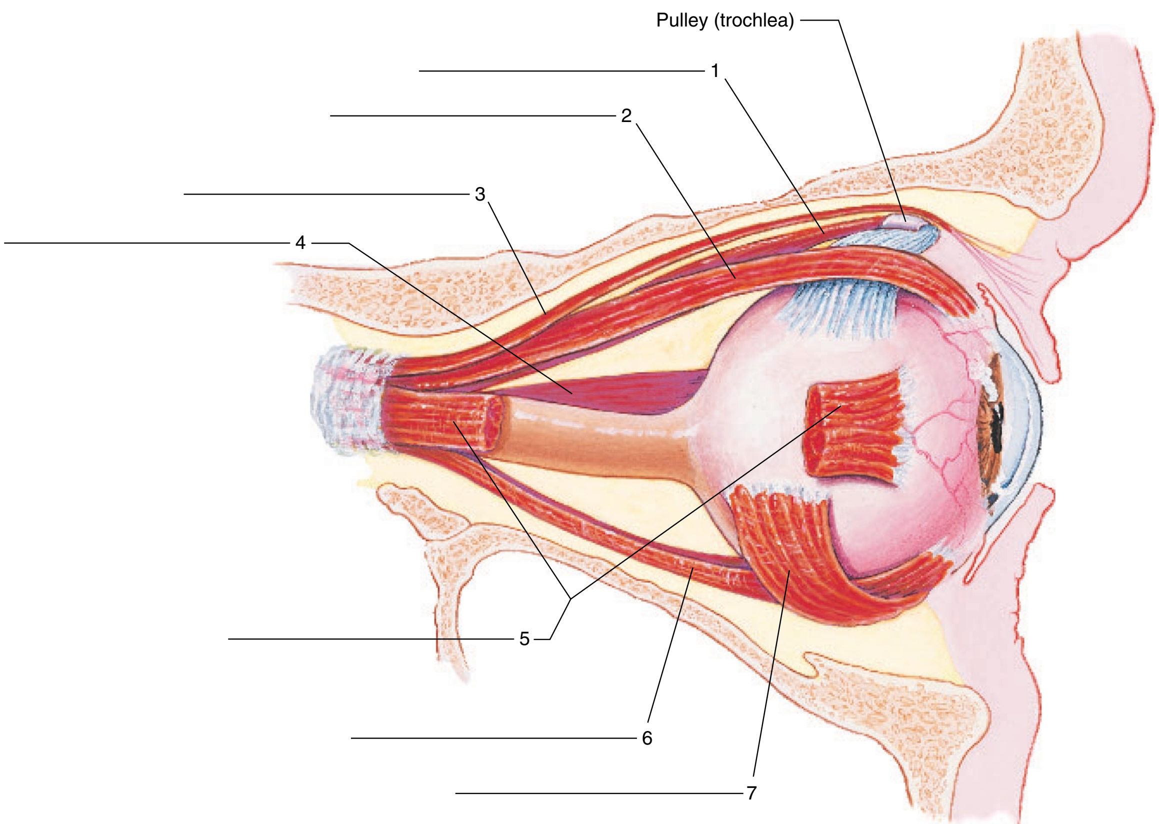


Figure 35.2 Label the extrinsic muscles of the right eye (lateral view).



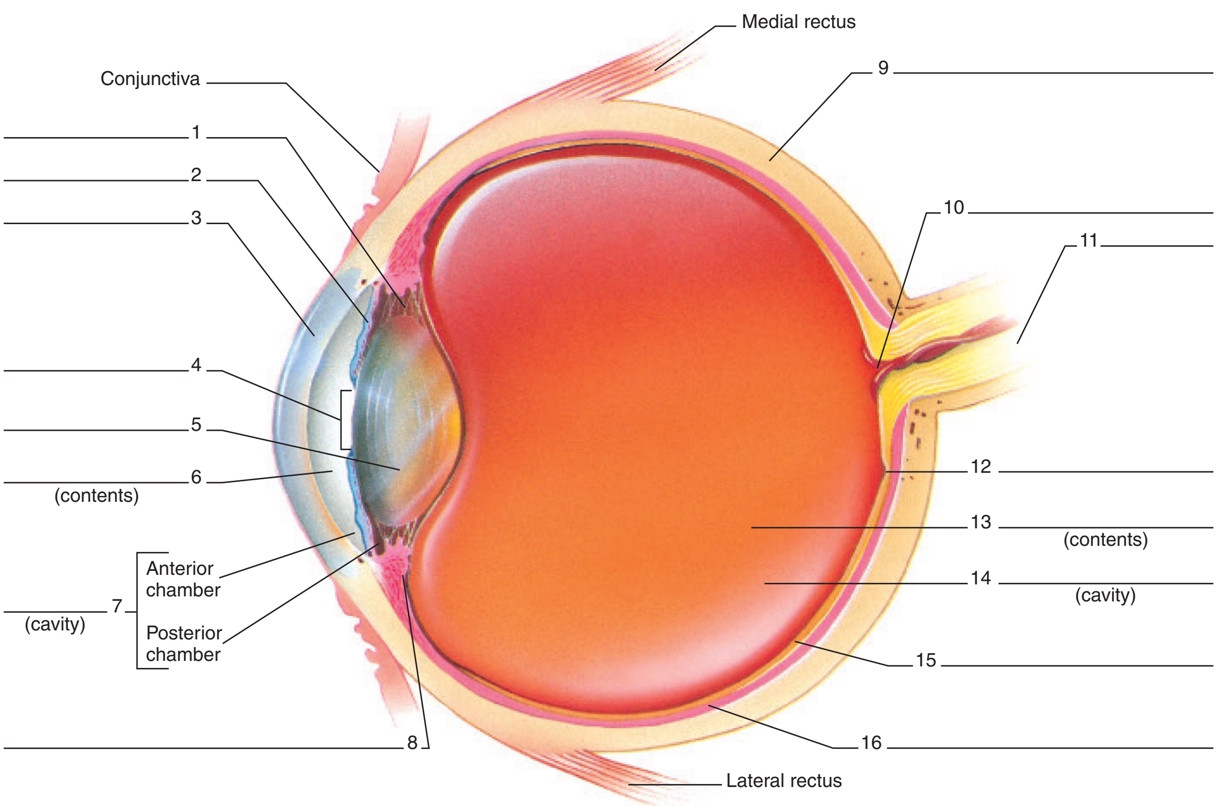


Figure 35.3 Label the structures indicated in this transverse section of the left eye (superior view).

choroid coat

ciliary body

- ciliary processes
- ciliary muscles

lens

suspensory ligaments

iris

anterior cavity

- anterior chamber
- posterior chamber
- aqueous humor

pupil

retina

- macula lutea
- fovea centralis
- optic disk

posterior cavity

- vitreous humor

5. Obtain a microscope slide of a mammalian eye section, and locate as many of the preceding listed features as possible.
6. Observe the posterior portion of the eye wall using high-power magnification, and locate the sclera, choroid coat, and retina.
7. Examine the retina using high-power magnification, and note its layered structure (fig. 35.4). Locate the following:

   nerve fibers leading to the optic nerve (innermost layer of the retina)

   layer of ganglion cells

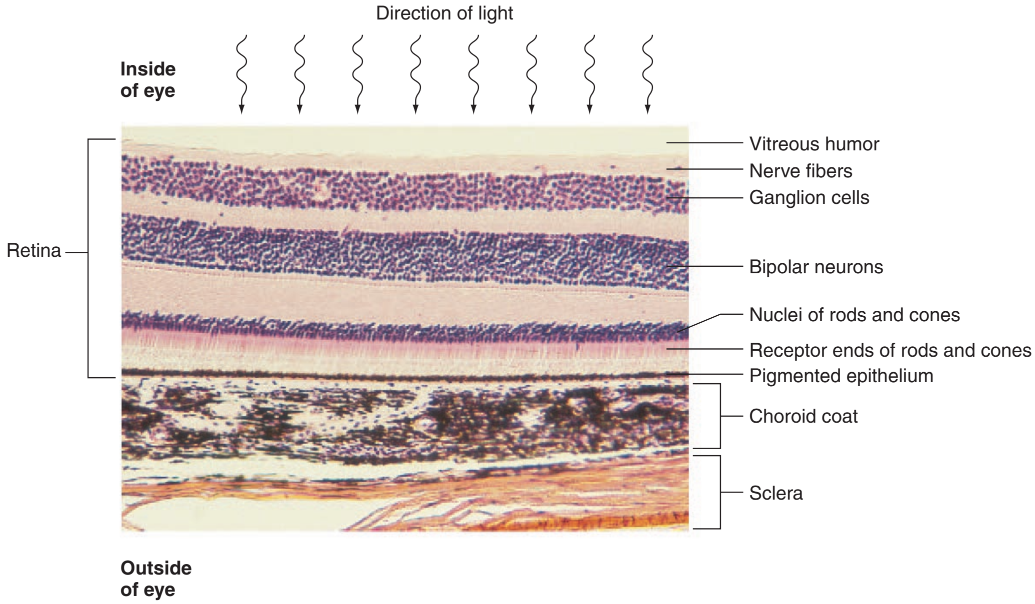
   layer of bipolar neurons

   nuclei of rods and cones

   receptor ends of rods and cones

   pigmented epithelium (outermost layer of the retina)

Figure 35.4 The cells of the retina are arranged in distinct layers (75×).



OPTIONAL ACTIVITY

Use an ophthalmoscope to examine the interior of your laboratory partner's eye. This instrument consists of a set of lenses held in a rotating disk, a light source, and some mirrors that reflect the light into the test subject's eye.

The examination should be conducted in a dimly lighted room. Have your partner seated and staring straight ahead at eye level. Move the rotating disk of the ophthalmoscope so that the *O* appears in the lens selection window. Hold the instrument in your right hand with the end of your index finger on the rotating disk (fig. 35.5). Direct the light at a slight angle from a distance of about 15 cm into the subject's right eye. The light beam should pass along the inner edge of the pupil. Look through the instrument and you should see a reddish, circular area—the interior of the eye. Rotate the disk of lenses to higher values until sharp focus is achieved.

Move the ophthalmoscope to within about 5 cm of the eye being examined *being very careful that the instrument does not touch the eye,* and again rotate the lenses to sharpen the focus (fig. 35.6). Locate the optic disk and the blood vessels that pass through it. Also locate the yellowish macula lutea by having your partner stare directly into the light of the instrument (fig. 35.7).

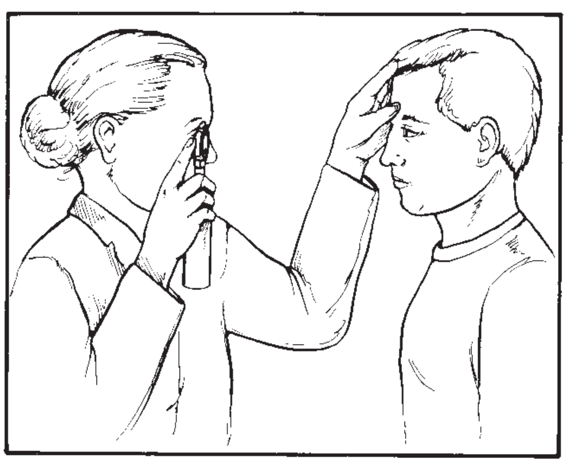
Examine the subject's iris by viewing it from the side and by using a lens with a +15 or +20 value.

PROCEDURE B—EYE DISSECTION

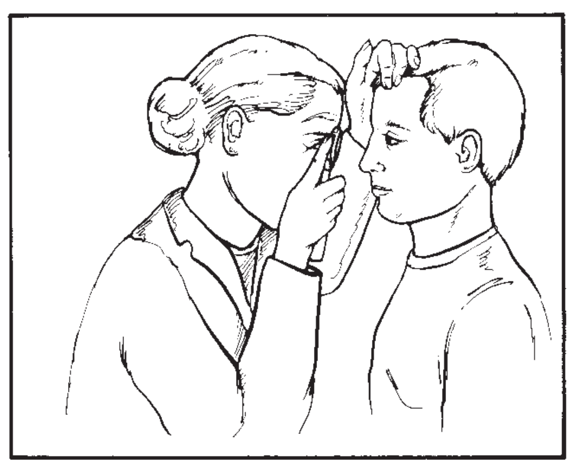
1. Obtain a mammalian eye, place it in a dissecting tray, and dissect it as follows:
   a. Trim away the fat and other connective tissues but leave the stubs of the *extrinsic muscles* and of the *optic nerve.* This nerve projects outward from the posterior region of the eyeball.
   b. Note the *conjunctiva,* which lines the eyelid and is reflected over the anterior surface (except cornea) of the eye. Lift some of this thin membrane away from the eye with forceps and examine it.
   c. Locate and observe the *cornea, sclera,* and *iris.* Also note the *pupil* and its shape. The cornea from a fresh eye will be transparent; when preserved, it becomes opaque.
   d. Use sharp scissors to make a coronal section of the eye. To do this, cut through the wall about 1 cm from the margin of the cornea and continue all the way around the eyeball. Try not to damage the internal structures of the eye (fig. 35.8).
   e. Gently separate the eyeball into anterior and posterior portions. Usually the jellylike vitreous humor will remain in the posterior portion, and the lens may adhere to it. Place the parts in the dissecting tray with their contents facing upward.
   f. Examine the anterior portion of the eye and locate the *ciliary body,* which appears as a dark, circular structure. Also note the *iris* and the *lens* if it remained in the anterior portion. The lens is normally attached to the ciliary body by many *suspensory ligaments,* which appear as delicate, transparent threads.
   g. Use a dissecting needle to gently remove the lens, and examine it. If the lens is still transparent, hold it up and look through it at

Figure 35.5 The opthalmoscope is used to examine the interior of the eye.

Figure 35.6 (*a*) Rotate the disk of lenses until sharp focus is achieved. (*b*) Move the ophthalmoscope to within 5 cm of the eye to examine the optic disk.



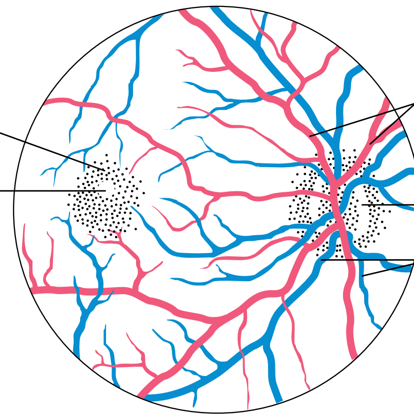
(a)



(b)

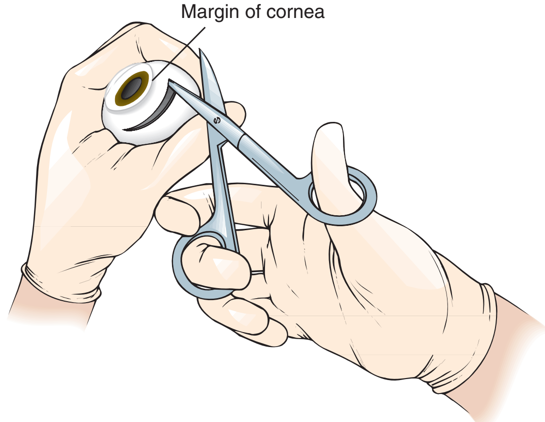
Figure 35.7 The interior of the eye as seen using an ophthalmoscope: (*a*) photograph; (*b*) diagram.

(a)



(b)

Figure 35.8 Prepare a coronal section of the eye.



something in the distance and note that the lens inverts the image. The lens of a preserved eye is usually too opaque for this experience.

h. Examine the posterior portion of the eye. Note the *vitreous humor.* This jellylike mass helps to hold the lens in place anteriorly and helps to hold the *retina* against the choroid coat.

i. Carefully remove the vitreous humor and examine the retina. This layer will appear as a thin, nearly colorless to cream-colored membrane that detaches easily from the choroid coat. Compare the structures identified to figure 35.9.

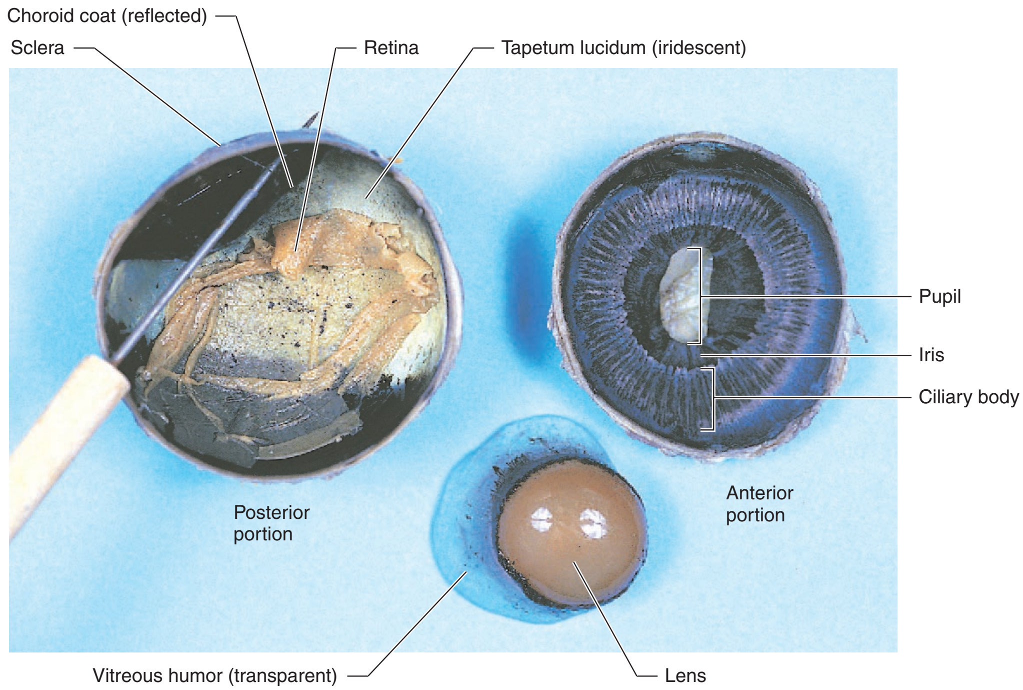
j. Locate the *optic disk*—the point where the retina is attached to the posterior wall of the eyeball and where the optic nerve originates. Because there are no receptor cells in the optic disk, this region is also called the "blind spot."

k. Note the iridescent area of the choroid coat beneath the retina. This colored surface is called the *tapetum lucidum.* It serves to reflect light back through the retina, an action that is thought to aid the night vision of some animals. The tapetum lucidum is lacking in the human eye.

l. Discard the tissues of the eye as directed by the laboratory instructor.

2. Complete Parts B and C of the laboratory report.

Figure 35.9 Internal structures of the beef eye dissection.



Critical Thinking Application

A strong blow to the head might cause the retina to detach. From observations made during the eye dissection, explain why this could happen.

____

____

____

____

Web Quest

How do we see? Search this and review the anatomy and physiology of the eye at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 35

Name ______________________________

Date ______________________________

Section ______________________________

The Eye

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. aqueous humor
b. choroid coat
c. ciliary muscle
d. conjunctiva
e. cornea
f. iris
g. lacrimal gland
h. lysozyme
i. nasolacrimal duct
j. optic disk
k. retina
l. sclera
m. suspensory ligament
n. vitreous humor

Column B

____ 1. posterior five-sixths of middle or vascular tunic
____ 2. white part of outer tunic
____ 3. transparent anterior portion of outer tunic
____ 4. inner lining of eyelid
____ 5. secretes tears
____ 6. empties into nasal cavity
____ 7. fills posterior cavity of eye
____ 8. area where optic nerve originates
____ 9. smooth muscle that controls light intensity
____ 10. fills anterior and posterior chambers of the anterior cavity of the eye
____ 11. contains visual receptors called rods and cones
____ 12. connects lens to ciliary body
____ 13. causes lens to change shape
____ 14. antibacterial agent in tears

Complete the following:

15. List the structures and fluids through which light passes as it travels from the cornea to the retina. ____________

____

____

____

16. List three ways in which rods and cones differ in structure or function. ____________

____

____

____

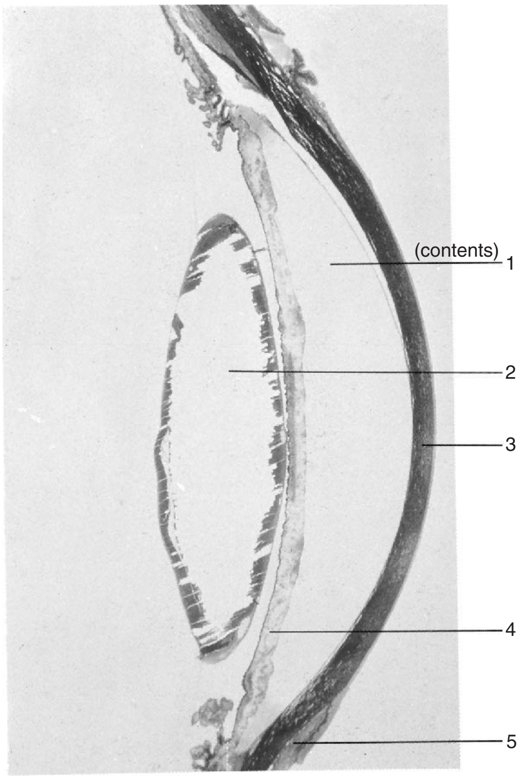
____

Part B

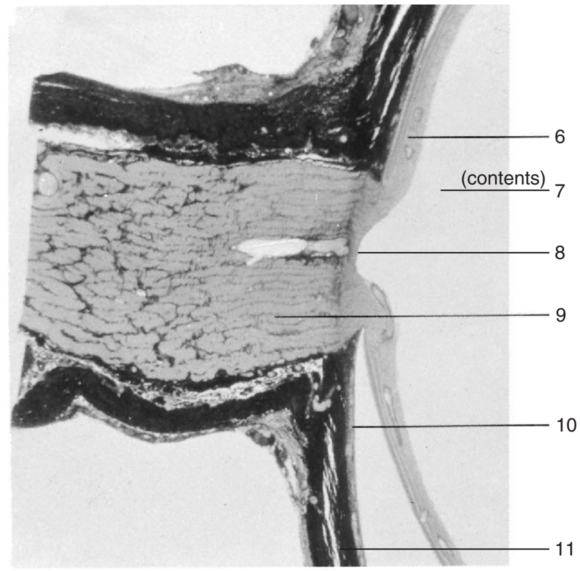
Complete the following:

1. Which tunic/layer of the eye was the most difficult to cut? ______
2. What kind of tissue do you think is responsible for this quality of toughness? ______
3. How do you compare the shape of the pupil in the dissected eye with your own pupil? ______
4. Where do you find aqueous humor in the dissected eye? ______
5. What is the function of the dark pigment in the choroid coat? ______
6. Describe the lens of the dissected eye. ______
7. Describe the vitreous humor of the dissected eye. ______

Figure 35.10 Sections of the eye: (*a*) anterior portion (10×); (*b*) posterior portion (53×).



(a)



(b)

Part C

Identify the features of the eye indicated in figure 35.10.

a. Anterior portion of eye:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

b. Posterior portion of eye:

6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________

Laboratory Exercise 36

Visual Tests and Demonstrations

MATERIALS NEEDED

Snellen eye chart
3″ × 5″ card (plain)
3″ × 5″ card with word typed in center
astigmatism chart
meter stick
metric ruler
pen flashlight
Ichikawa's or Ishihara's color plates for color-blindness test

Normal vision (emmetropia) results when light rays from objects in the external environment are refracted by the cornea and lens of the eye and focused onto the photoreceptors of the retina. Irregular curvatures in the surface of the cornea or lens, inability to change the shape of the lens, or defects in the shape of the eyeball can result in defective vision.

PURPOSE OF THE EXERCISE

To conduct tests for visual acuity, astigmatism, accommodation, color vision, the blind spot, and certain reflexes of the eye.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe four conditions that can lead to defective vision;
2. conduct the tests used to evaluate visual acuity, astigmatism, the ability to accommodate for close vision, and color vision;
3. demonstrate the blind spot, photopupillary reflex, accommodation pupillary reflex, and convergence reflex.

PROCEDURE A—VISUAL TESTS

Perform the following visual tests using your laboratory partner as a test subject. If your partner usually wears glasses, test each eye with and without the glasses.

1. *Visual acuity test.* Visual acuity (sharpness of vision) can be measured by using a Snellen eye chart (fig. 36.1). This chart consists of several sets of letters in different sizes printed on a white card. The letters near the top of the chart are relatively large, and those in each lower set become smaller. At one end of each set of letters is an acuity value in the form of a fraction. One of the sets near the bottom of the chart, for example, is marked 20/20. The normal eye can clearly see these letters from the standard distance of 20 feet and thus is said to have 20/20 vision. The letter at the top of the chart is marked 20/200. The normal eye can read letters of this size from a distance of 200 feet. Thus, an eye that is only able to read the top letter of the chart from a distance of 20 feet is said to have 20/200 vision. This person has less than normal vision. A line of letters near the bottom of the chart is marked 20/15. The normal eye can read letters of this size from a distance of 15 feet, but a person might be able to read it from 20 feet. This person has better than normal vision.

   To conduct the visual acuity test, follow these steps:
   a. Hang the Snellen eye chart on a well-illuminated wall at eye level.
   b. Have your partner stand 20 feet in front of the chart, gently cover the left eye with a 3″ × 5″ card, and read the smallest set of letters possible.
   c. Record the visual acuity value for that set of letters in Part A of Laboratory Report 36.
   d. Repeat the procedure using the left eye.
2. *Astigmatism test.* Astigmatism is a condition that results from a defect in the curvature of the cornea or lens. As a consequence, some portions of the image projected on the retina are sharply focused, and other portions are blurred. Astigmatism can be evaluated by using an astigmatism chart (fig. 36.2). This chart consists of sets of black lines radiating from a central spot like the spokes of a wheel. To a normal eye, these lines appear sharply focused and equally dark; however, if the eye has an astigmatism some sets of lines appear sharply focused and dark while others are blurred and less dark.

   To conduct the astigmatism test, follow these steps:

Figure 36.1 The Snellen eye chart looks similar to this but is somewhat larger.

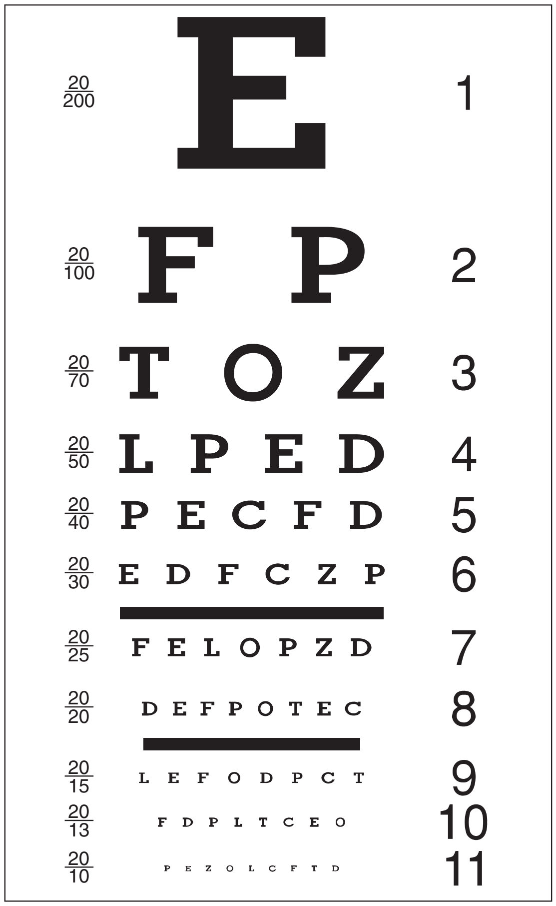


Figure 36.2 Astigmatism is evaluated using a chart such as this one.

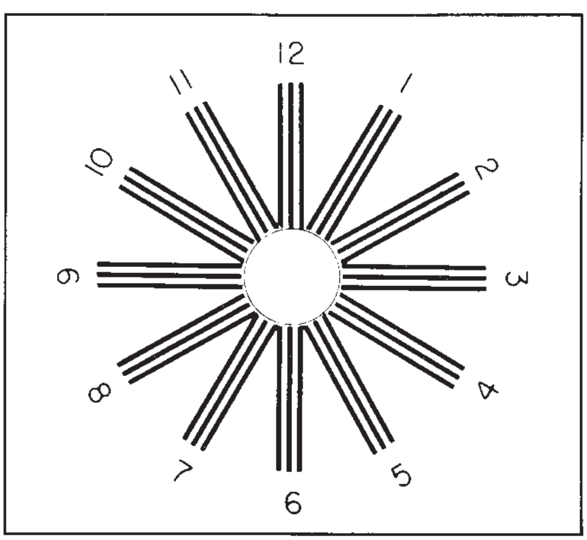


Figure 36.3 To determine the near point of accommodation, slide the 3"×5" card along the meter stick toward your partner's open eye until the closest location where your partner can still see the word sharply focused.

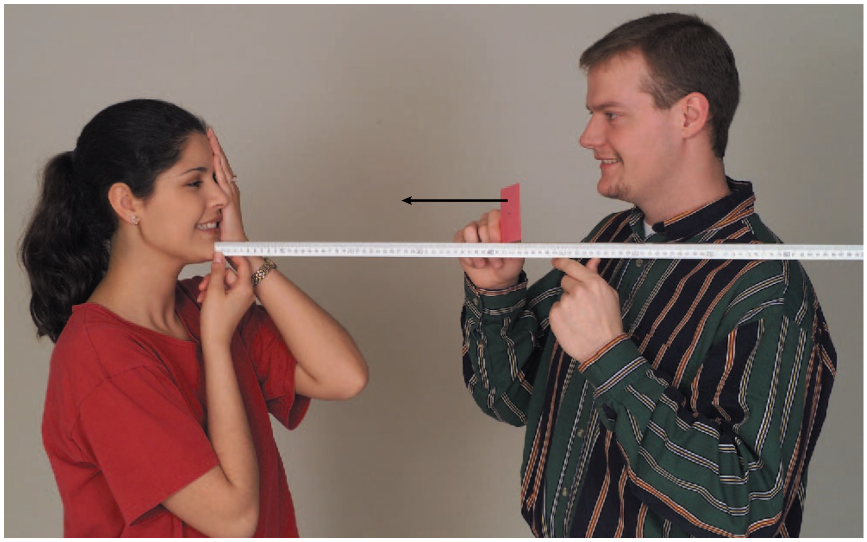


Table 36.1 Near Point of Accommodation

Age (years)	Average Near Point (cm)
10	7
20	10
30	13
40	20
50	45
60	90

a. Hang the astigmatism chart on a well-illuminated wall at eye level.
b. Have your partner stand 20 feet in front of the chart, gently cover the left eye with a 3″ × 5″ card, focus on the spot in the center of the radiating lines, and report which lines, if any, appear more sharply focused and darker.
c. Repeat the procedure using the left eye.
d. Record the results in Part A of the laboratory report.

3. *Accommodation test.* Accommodation is the changing of the shape of the lens that occurs when the normal eye is focused for close vision. It involves a reflex in which muscles of the ciliary body are stimulated to contract, releasing tension on the suspensory ligaments that are fastened to the lens capsule. This allows the capsule to rebound elastically, causing the surface of the lens to become more convex. The ability to accommodate is likely to decrease with age because the tissues involved tend to lose their elasticity.

   To evaluate the ability to accommodate, follow these steps:

   a. Hold the end of a meter stick against your partner's chin so that the stick extends outward at a right angle to the plane of the face (fig. 36.3).
   b. Have your partner close the left eye.
   c. Hold a 3″ × 5″ card with a word typed in the center at the distal end of the meter stick.
   d. Slide the card along the stick toward your partner's open eye, and locate the *point closest to the eye* where your partner can still see the letters of the word sharply focused. This distance is called the *near point of accommodation,* and it tends to increase with age (table 36.1).
   e. Repeat the procedure with the right eye closed.
   f. Record the results in Part A of the laboratory report.

4. *Color vision test.* Some individuals exhibit defective color vision because they lack certain cones, usually those sensitive to the reds or greens. Because this trait is an X-linked (sex-linked) inheritance, the condition is more prevalent in males (7%) than in females (0.4%). Individuals who lack or possess decreased sensitivity to the red-sensitive cones possess protanopia color blindness; those who lack or possess decreased sensitivity to green-sensitive cones possess deuteranopia color blindness. The color-blindness condition is often more of a deficiency or a weakness than one of blindness.

   To conduct the color vision test, follow these steps:

   a. Examine the color test plates in Ichikawa's or Ishihara's book to test for any red-green color vision deficiency. Also examine figure 36.4.
   b. Hold the test plates approximately 30 inches from the subject in bright light. All responses should occur within 3 seconds.

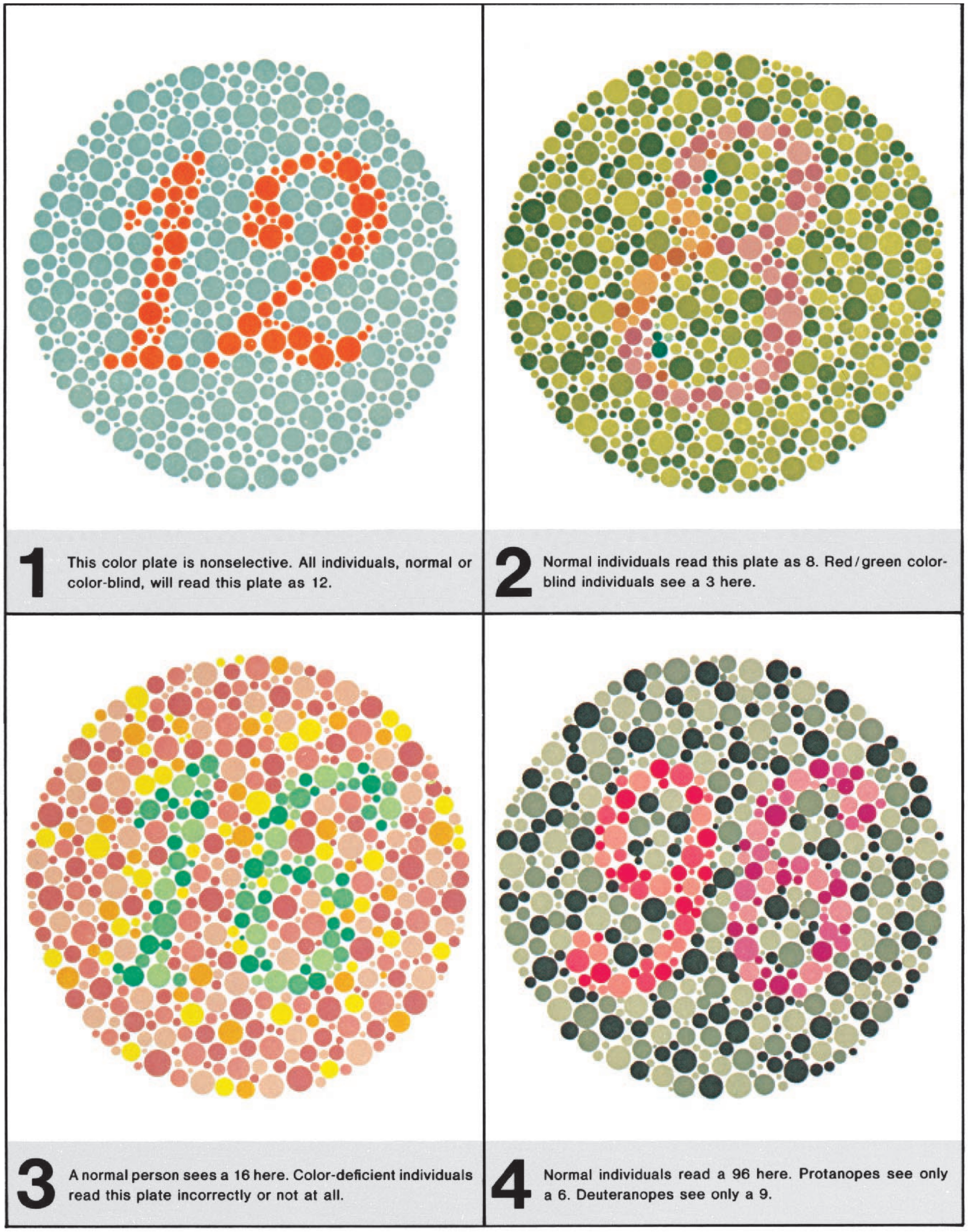


Figure 36.4 Samples of Ishihara's color plates. These plates are reproduced from *Ishihara's Tests for Colour Blindness* published by KANEHARA & CO., LTD., Tokyo, Japan, but tests for color blindness cannot be conducted with this material. For accurate testing, the original plates should be used.

Figure 36.5 Blind-spot demonstration.

c. Compare your responses with the correct answers in Ichikawa's or Ishihara's book. Determine the percentage of males and females in your class who exhibit any color-deficient vision. If an individual exhibits color-deficient vision, determine if the condition is protanopia or deuteranopia.

d. Record the class results in Part A of the laboratory report.

5. Complete Part A of the laboratory report.

PROCEDURE B—VISUAL DEMONSTRATIONS

Perform the following demonstrations with the help of your laboratory partner.

1. *Blind-spot demonstration.* There are no photoreceptors in the optic disk, which is located where the nerve fibers of the retina leave the eye and enter the optic nerve. Consequently, this region of the retina is commonly called the *blind spot.*

   To demonstrate the blind spot, follow these steps:

   a. Close your left eye, hold figure 36.5 about 35 cm away from your face, and stare at the + sign in the figure with your right eye.

   b. Move the figure closer to your face as you continue to stare at the + until the dot on the figure suddenly disappears. This happens when the image of the dot is focused on the optic disk. Measure the distance using a metric ruler or a meter stick.

   c. Repeat the procedures with your right eye closed. This time stare at the dot, and the + will disappear when the image falls on the optic disk. Measure the distance.

   d. Record the results in Part B of the laboratory report.

Critical Thinking Application

Under normal visual circumstances, explain why small objects are not lost from our vision.

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2. *Photopupillary reflex.* The smooth muscles of the iris function to control the size of the pupil. For example, when the intensity of light entering the eye increases, a photopupillary reflex is triggered, and the circular muscles of the iris are stimulated to contract. As a result, the size of the pupil decreases, and less light enters the eye.

   To demonstrate this reflex, follow these steps:

   a. Ask your partner to sit with his or her hands thoroughly covering his or her eyes for 2 minutes.

   b. Position a pen flashlight close to one eye with the light shining on the hand that covers the eye.

   c. Ask your partner to remove the hand quickly.

   d. Observe the pupil and note any change in its size.

   e. Have your partner remove the other hand, but keep that uncovered eye shielded from extra light.

   f. Observe both pupils and note any difference in their sizes.

3. *Accommodation pupillary reflex.* The pupil constricts as a normal accommodation reflex response to focusing on close objects. To demonstrate the accommodation reflex, follow these steps:

   a. Have your partner stare for several seconds at some dimly illuminated object in the room that is more than 20 feet away.

   b. Observe the size of the pupil of one eye. Then hold a pencil about 25 cm in front of your partner's face and have your partner stare at it.

   c. Note any change in the size of the pupil.

4. *Convergence reflex.* The eyes converge as a normal convergence response to focusing on close objects. To demonstrate the convergence reflex, follow these steps:

   a. Repeat the procedure outlined for the accommodation pupillary reflex.

   b. Note any change in the position of the eyeballs as your partner changes focus from the distant object to the pencil.

5. Complete Part B of the laboratory report.

Laboratory Report **36**

Name ______________________

Date ______________________

Section ______________________

Visual Tests and Demonstrations

Part A

1. Visual acuity test results:

Eye Tested	Acuity Values
Right eye	
Right eye with glasses (if applicable)	
Left eye	
Left eye with glasses (if applicable)	

2. Astigmatism test results:

Eye Tested	Darker Lines
Right eye	
Right eye with glasses (if applicable)	
Left eye	
Left eye with glasses (if applicable)	

3. Accommodation test results:

Eye Tested	Near Point (cm)
Right eye	
Right eye with glasses (if applicable)	
Left eye	
Left eye with glasses (if applicable)	

4. Color vision test results:

	Males			Females		
Condition	Class Number	Class Percentage	Expected Percentage	Class Number	Class Percentage	Expected Percentage
Normal color vision			93			99.6
Deficient red-green color vision			7			0.4
Protanopia (lack red-sensitive cones)			less-frequent type			less-frequent type
Deuteranopia (lack green-sensitive cones)			more-frequent type			more-frequent type

5. Complete the following:

   a. What is meant by 20/70 vision? ______________________________

   b. What is meant by 20/10 vision? ______________________________

   c. What visual problem is created by astigmatism? ______________________________

   d. Why does the near point of accommodation often increase with age? ______________________________

e. Describe the eye defect that causes color-deficient vision. ______________________________

____

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Part B

1. Blind-spot results:

   a. Right eye distance ______________________

   b. Left eye distance ______________________

Complete the following:

2. Explain why an eye has a blind spot. ______________________________

____

____

3. Describe the photopupillary reflex. ______________________________

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4. What difference did you note in the size of the pupils when one eye was exposed to bright light and the other eye was shielded from the light? ______________________________

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5. Describe the accommodation pupillary reflex. ______________________________

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6. Describe the convergence reflex. ______________________________

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Laboratory Exercise 37

Endocrine System

MATERIALS NEEDED

textbook
human torso
compound microscope
prepared microscope slides of the following:
pituitary gland
thyroid gland
parathyroid gland
adrenal gland
pancreas

For Optional Activity:

water bath equipped with temperature control mechanism set at 37.0°C (98.6°F)
laboratory thermometer

The endocrine system consists of ductless endocrine glands that act together with parts of the nervous system to help control body activities. The endocrine glands secrete hormones that are transported in body fluids and affect cells possessing appropriate receptor molecules. In this way, hormones influence the rate of metabolic reactions, the transport of substances through cell membranes, and the regulation of water and electrolyte balances. By controlling cellular activities, endocrine glands play important roles in the maintenance of homeostasis.

PURPOSE OF THE EXERCISE

To review the structure and function of major endocrine glands and to examine microscopically the tissues of these glands.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. name and locate the major endocrine glands;
2. name the hormones secreted by each of the major glands;
3. describe the principal functions of each hormone;
4. recognize tissue sections from the pituitary gland, thyroid gland, parathyroid glands, adrenal glands, and pancreas.

PROCEDURE

1. Review textbook sections on the *pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas,* and *other endocrine glands.*
2. As a review activity, label figures 37.1, 37.2, 37.3, 37.4, 37.5, and 37.6.
3. Complete Part A of Laboratory Report 37.
4. Examine the human torso and locate the following:

hypothalamus

pituitary stalk (infundibulum)

pituitary gland

anterior lobe

posterior lobe

thyroid gland

parathyroid glands

adrenal glands

adrenal medulla

adrenal cortex

pancreas

pineal gland

thymus gland

ovaries

testes

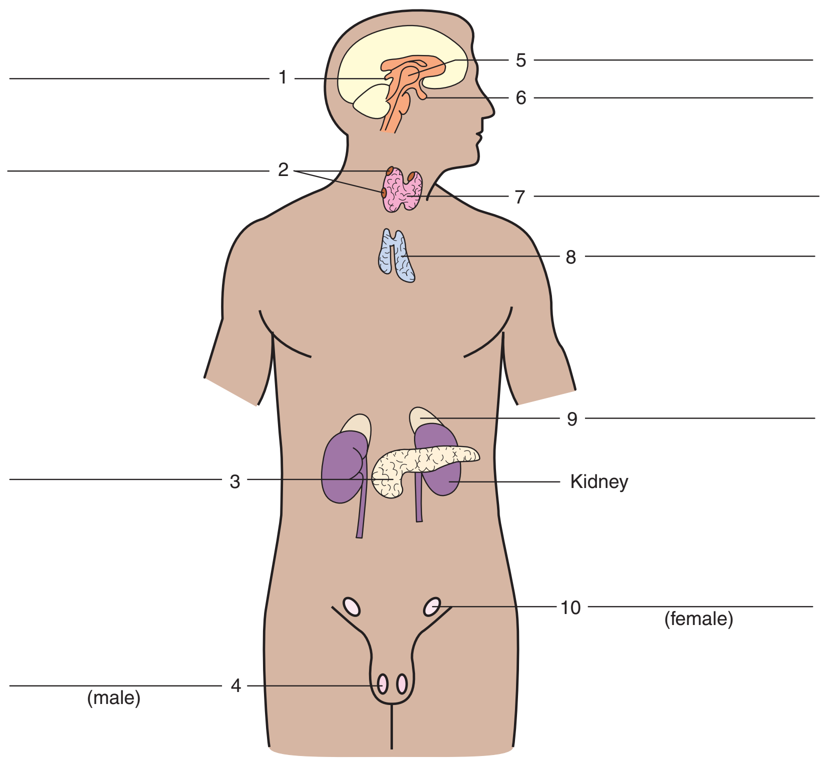


Figure 37.1 Label the major endocrine glands.

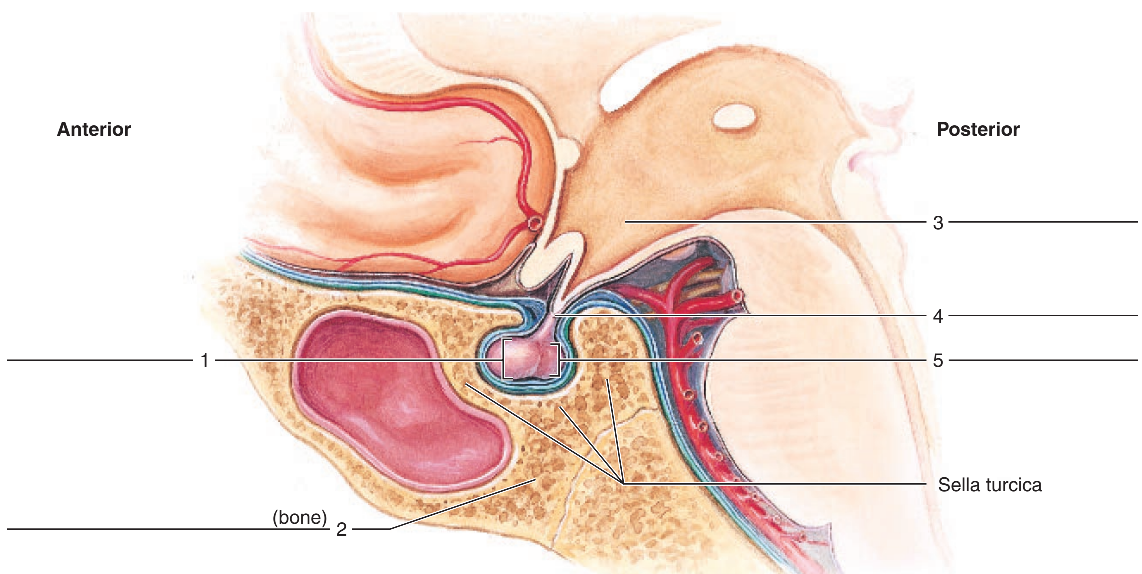


Figure 37.2 Label the features associated with the pituitary gland.

Figure 37.3 Label the features associated with the thyroid gland.

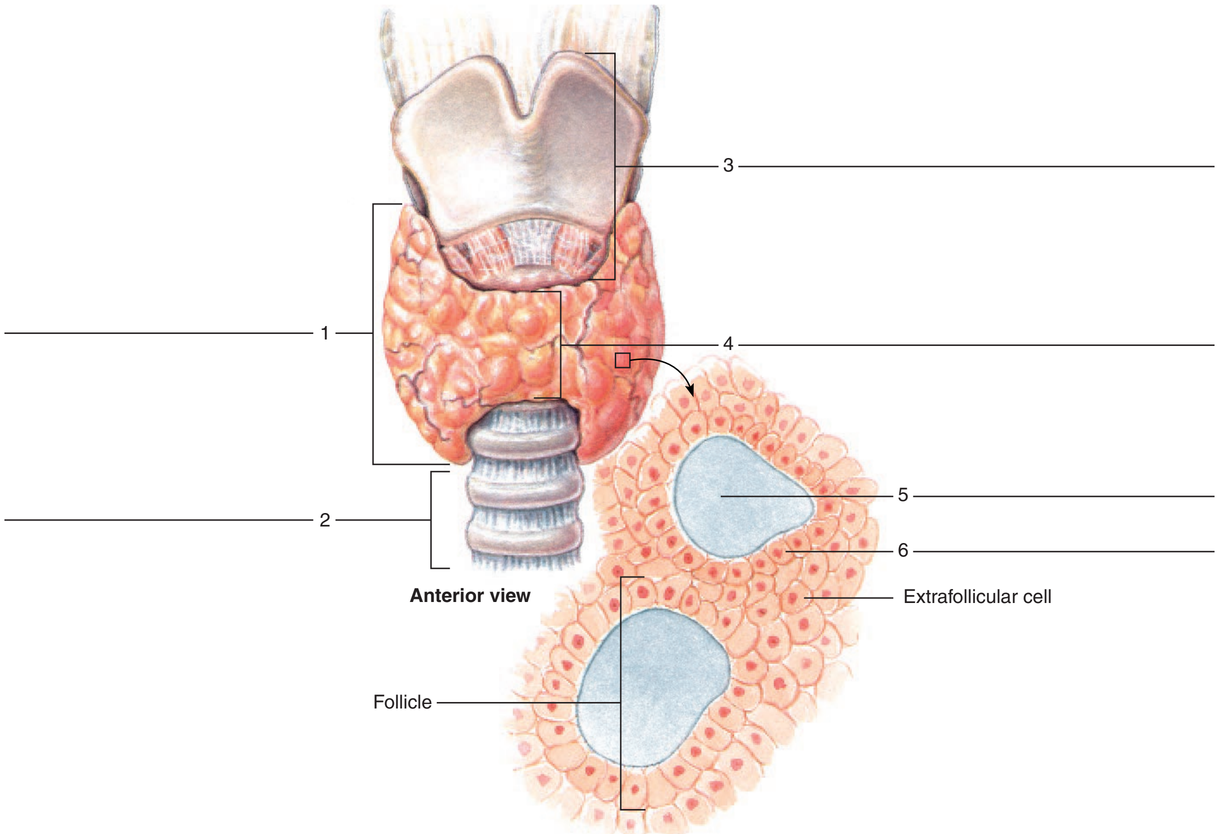


Figure 37.4 Label the features associated with the parathyroid glands.

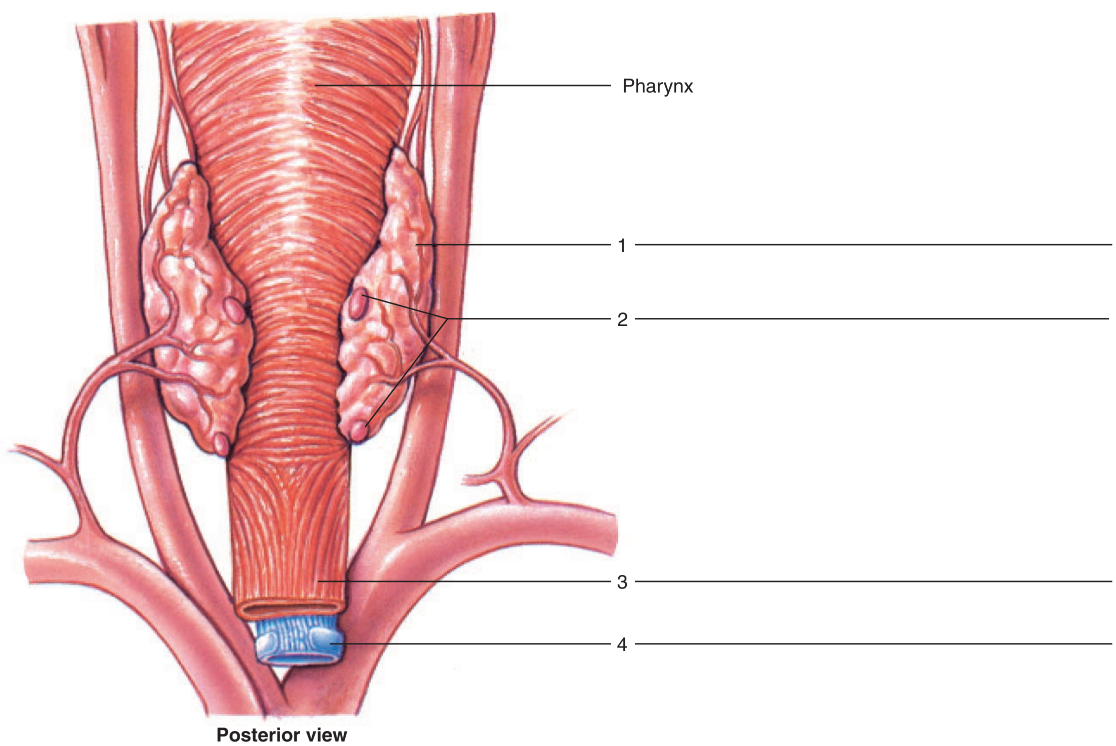
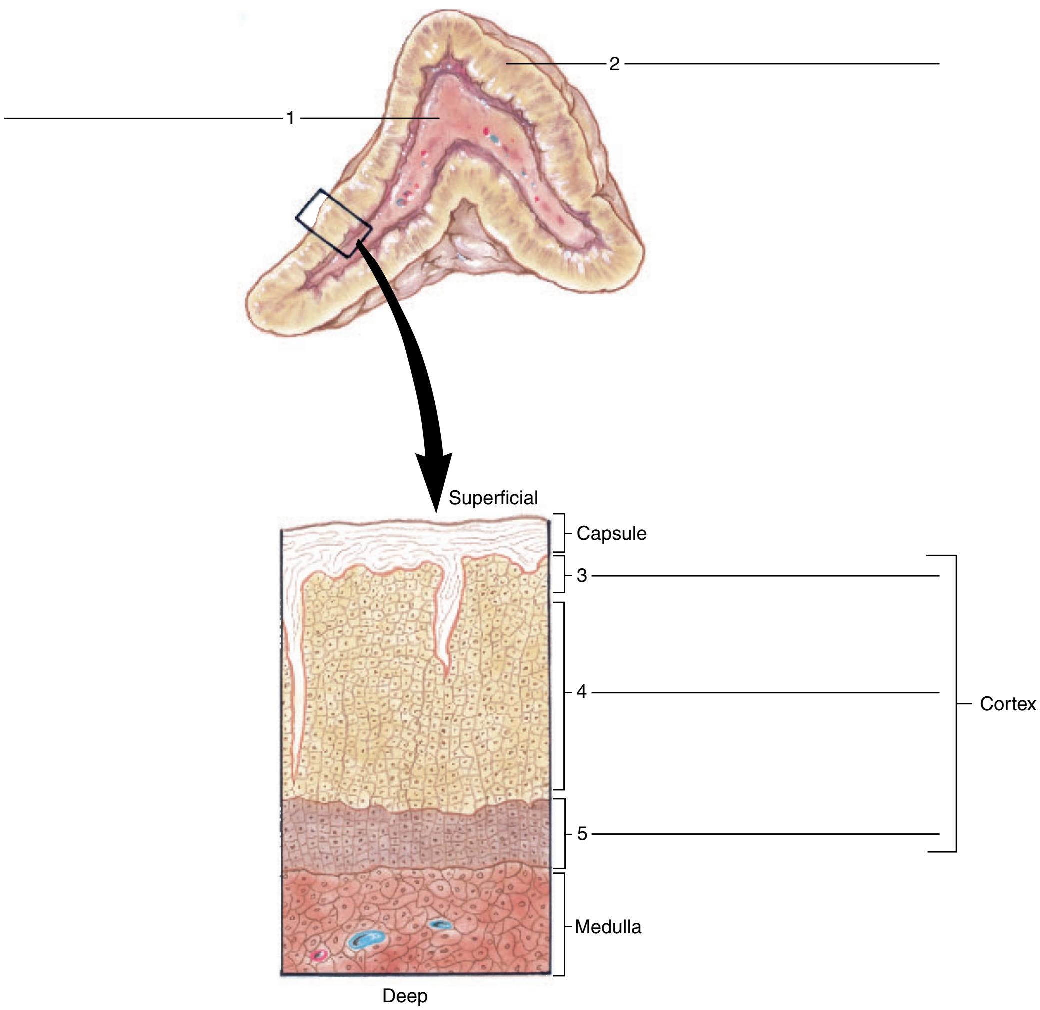


Figure 37.5 Label the features associated with the adrenal gland.



OPTIONAL ACTIVITY

The secretions of endocrine glands are usually controlled by negative feedback systems. As a result, the concentrations of hormones in body fluids remain relatively stable, although they will fluctuate slightly within a normal range.

Similarly, the mechanism used to maintain the temperature of a laboratory water bath involves negative feedback. In this case, a temperature-sensitive thermostat in the water allows a water heater to operate whenever the water temperature drops below the thermostat's set point. Then, when the water temperature reaches the set point, the thermostat causes the water heater to turn off (a negative effect), and the water bath begins to cool again.

Use a laboratory thermometer to monitor the temperature of the water bath in the laboratory. Measure the temperature at regular intervals, until you have recorded ten readings. What was the lowest temperature you recorded? _______________ The highest temperature? ____________________________________

What was the average temperature of the water bath?

_______________ How is the water bath temperature control mechanism similar to a hormonal control mechanism in the body?______________________________

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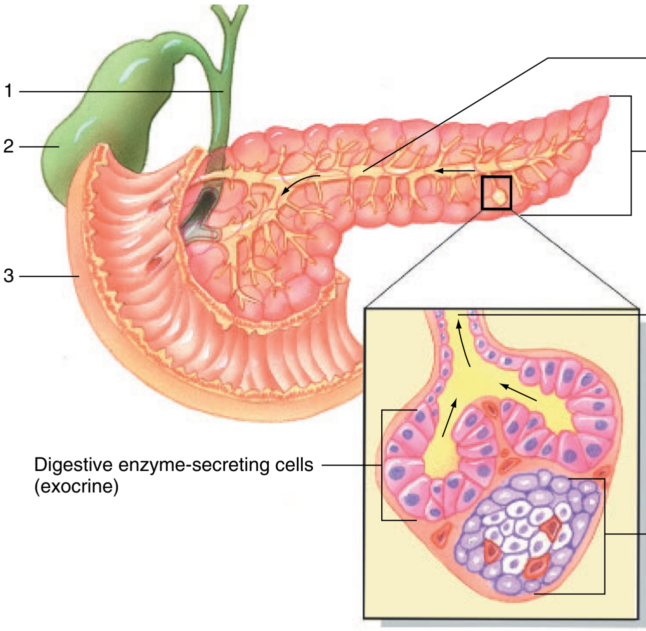
Figure 37.6 Label the features associated with the pancreas.



5. Examine the microscopic tissue sections of the following glands, and identify the features described:
   Pituitary gland. To examine the pituitary tissue, follow these steps:
   a. Observe the tissues using low-power magnification (fig. 37.7).
   b. Locate the *infundibulum (pituitary stalk),* the *anterior lobe* (the largest part of the gland), and the *posterior lobe.*
   c. Observe an area of the anterior lobe with high-power magnification. Locate a cluster of relatively large cells and identify some *acidophil cells,* which contain pink-stained granules, and some *basophil cells,* which contain blue-stained granules. These acidophil and basophil cells are hormone-secreting cells.
   d. Observe an area of the posterior lobe with high-power magnification. Note the numerous unmyelinated nerve fibers present in this lobe. Also locate some *pituicytes,* a type of neuroglial cell, scattered among the nerve fibers.
   e. Prepare labeled sketches of representative portions of the anterior and posterior lobes of the pituitary gland in Part B of the laboratory report.

   Thyroid gland. To examine the thyroid tissue, follow these steps:
   a. Use low-power magnification to observe the tissue (fig. 37.8). Note the numerous *follicles,* each of which consists of a layer of cells surrounding a colloid-filled cavity.
   b. Observe the tissue using high-power magnification. Note that the cells forming the wall of a follicle are simple cuboidal epithelial cells.
   c. Prepare a labeled sketch of a representative portion of the thyroid gland in Part B of the laboratory report.

Figure 37.7 Micrograph of the pituitary gland (6×).

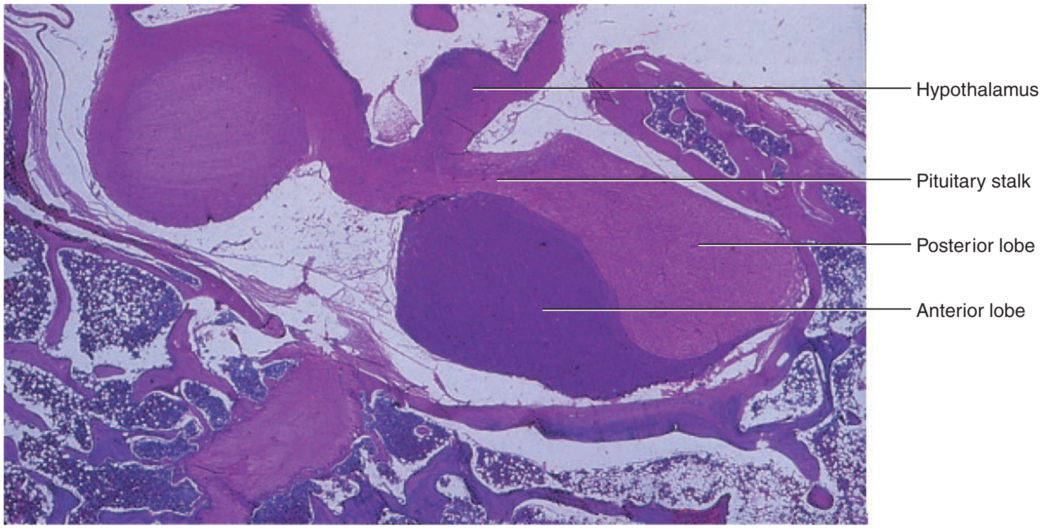


Figure 37.8 Micrograph of the thyroid gland (100× micrograph enlarged to 300×).

Parathyroid gland. To examine the parathyroid tissue, follow these steps:

a. Use low-power magnification to observe the tissue (fig. 37.9). Note that the gland consists of numerous tightly packed secretory cells.
b. Switch to high-power magnification and locate two types of cells—a smaller form (chief cells) that are arranged in cordlike patterns and a larger form (oxyphil cells) that have distinct cell boundaries and are present in clusters. *Chief cells* secrete parathyroid hormone, whereas the function of *oxyphil cells* is not clearly understood.

Figure 37.9 Micrograph of the parathyroid gland (65×).

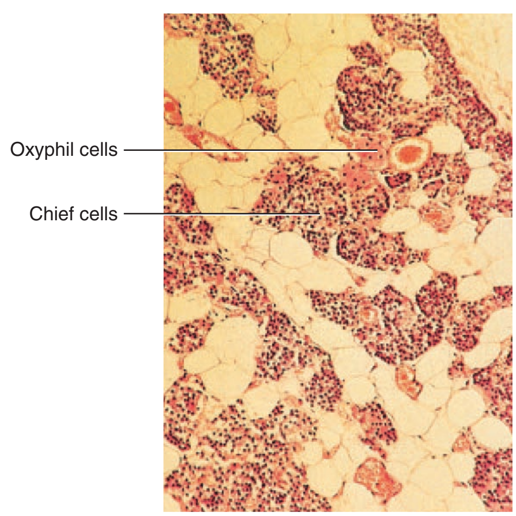


Figure 37.10 Micrograph of the adrenal cortex and the adrenal medulla (75×).

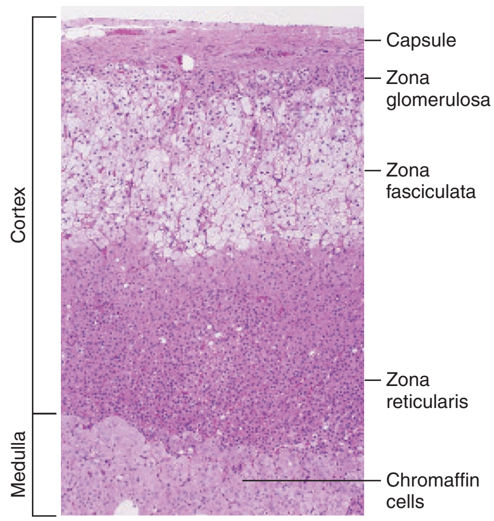
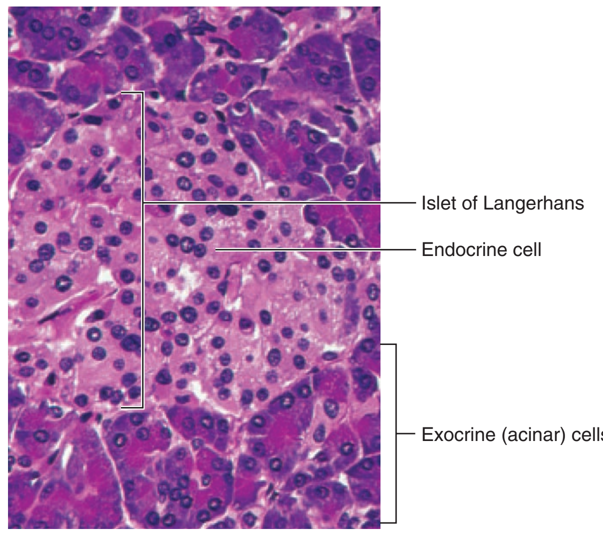


Figure 37.11 Micrograph of the pancreas (100× micrograph enlarged to 400×).



c. Prepare a labeled sketch of a representative portion of the parathyroid gland in Part B of the laboratory report.

Adrenal gland. To examine the adrenal tissue, follow these steps:

a. Use low-power magnification to observe the tissue (fig. 37.10). Note the thin capsule of connective tissue that covers the gland. Just beneath the capsule there is a relatively thick *adrenal cortex.* The central portion of the gland is the *adrenal medulla.* The cells of the cortex are in three poorly defined layers. Those of the outer layer (zona glomerulosa) are arranged irregularly; those of the middle layer (zona fasciculata) are in long cords; and those of the inner layer (zona reticularis) are arranged in an interconnected network of cords. The cells of the medulla are relatively large and irregularly shaped, and they often occur in clusters.
b. Observe each of the layers of the cortex and the cells of the medulla using high-power magnification.
c. Prepare labeled sketches of representative portions of the adrenal cortex and medulla in Part B of the laboratory report.

Pancreas. To examine the pancreas tissue, follow these steps:

a. Use low-power magnification to observe the tissue (fig. 37.11). Note that the gland largely consists of deeply stained exocrine cells arranged in clusters around secretory ducts. These exocrine cells (acinar cells) secrete pancreatic juice rich in digestive enzymes. There are circular masses of lightly stained cells scattered throughout the gland. These clumps of cells constitute the *islets of Langerhans* (*pancreatic islets*), and they represent the endocrine portion of the pancreas.
b. Examine an islet using high-power magnification.
c. Prepare a labeled sketch of a representative portion of the pancreas in Part B of the laboratory report.

Web Quest

What are common endocrine gland disorders? How can they be treated? Search these and review the endocrine system at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 37

Name ______________________________

Date ______________________________

Section ______________________________

Endocrine System

Part A

Complete the following:

1. Name six hormones secreted by the anterior lobe of the pituitary gland. ______________________________

2. Name two hormones secreted by the posterior lobe of the pituitary gland. ______________________________

3. Name the pituitary hormone responsible for the following actions: ______________________________
   a. stimulates ovarian follicle to secrete estrogen and egg development ______________________________
   b. causes kidneys to conserve water ______________________________
   c. stimulates cells to increase in size and divide more rapidly ______________________________
   d. essential for egg release from the ovary ______________________________
   e. stimulates secretion from thyroid gland ______________________________
   f. causes contraction of uterine wall muscles ______________________________
   g. stimulates secretion from adrenal cortex ______________________________
   h. stimulates milk production ______________________________
4. Name two thyroid hormones that affect metabolic rate. ______________________________

5. Name a hormone secreted by the thyroid gland that acts to lower blood calcium. ______________________________
6. Name a hormone that acts to raise blood calcium. ______________________________
7. Name three target organs of parathyroid hormone. ______________________________

8. Name two hormones secreted by the adrenal medulla. ______________________________

9. List five different effects produced by these medullary hormones. ______________________________

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10. Name the most important mineralocorticoid secreted by the adrenal cortex. ______________________________

11. List three actions of this mineralocorticoid. ______________________________

____

____

12. Name the most important glucocorticoid secreted by the adrenal cortex. ______________________________

13. List three actions of this glucocorticoid. ______________________________

____

____

14. Distinguish the hormones secreted by the alpha and beta cells of the islets of Langerhans. ______________________________

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Critical Thinking Application

Briefly explain how the actions of pancreatic hormones complement one another.

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Part B

Prepare labeled sketches to illustrate representative portions of the following endocrine glands:

Pituitary gland (____×) (anterior lobe)	Pituitary gland (____×) (posterior lobe)
Thyroid gland (____×)	Parathyroid gland (____×)

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Adrenal gland (____×)
(medulla)

Adrenal gland (____×)
(cortex)

Pancreas (____×)

Laboratory Exercise 38

Blood Cells

MATERIALS NEEDED

textbook
compound microscope
prepared microscope slides of human blood (Wright's stain)

For Demonstration:

microscope slides
borax (or similar cleaning agent)
sterile disposable blood lancets
sterile absorbent cotton
70% alcohol
slide staining rack and tray
Wright's stain
distilled water

For Optional Activity:

prepared slides of pathological blood, such as eosinophilia, leukocytosis, leukopenia, and lymphocytosis

SAFETY

- It is important that students learn and practice correct procedures for handling body fluids. Consider using either mammal blood other than human or contaminant-free blood that has been tested and is available from various laboratory supply houses. Some of the procedures might be accomplished as demonstrations only. If student blood is utilized, it is important that students handle only their own blood.
- Use an appropriate disinfectant to wash the laboratory tables before and after the procedures.
- Wear disposable gloves when handling blood samples.
- Clean end of a finger with 70% alcohol before the puncture is performed.
- The sterile blood lancet should be used only once.
- Dispose of used lancets and blood-contaminated items in an appropriate container (never use the wastebasket).
- Wash your hands before leaving the laboratory.

Blood is a type of connective tissue whose cells are suspended in a liquid intercellular substance. These cells are mainly formed in red bone marrow, and they include red blood cells, white blood cells, and some cellular fragments called platelets.

Red blood cells function to transport gases between the body cells and the lungs, white blood cells serve to defend the body against infections, and platelets play an important role in stoppage of bleeding (hemostasis).

PURPOSE OF THE EXERCISE

To review the characteristics of blood cells, to examine them microscopically, and to perform a differential white blood cell count.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the structure and function of red blood cells, white blood cells, and platelets;
2. identify red blood cells, five types of white blood cells, and platelets on a stained blood slide;
3. perform a differential white blood cell count.

WARNING

Because of the possibility of blood infections being transmitted from one student to another if blood slides are prepared in the classroom, it is suggested that commercially prepared blood slides be used in this exercise. The instructor, however, may wish to demonstrate the procedure for preparing such a slide. Observe all safety procedures for this lab.

DEMONSTRATION—BLOOD SLIDE PREPARATION

To prepare a stained blood slide, follow these steps:

1. Clean two microscope slides with a cleaning agent (such as borax) and water, and thereafter avoid touching their flat surfaces.
2. Thoroughly wash hands with soap and water and dry them with paper towels.

3. Cleanse the end of the middle finger with some sterile cotton moistened with 70% alcohol and let the finger dry in the air.
4. Remove a sterile disposable blood lancet from its package without touching the sharp end.
5. Puncture the skin on the side near the tip of the middle finger with the lancet and properly discard the lancet.
6. Wipe away the first drop of blood with the cotton ball. Place a drop of blood about 2 cm from the end of a clean microscope slide.
7. Use a second slide to spread the blood across the first slide, as illustrated in figure 38.1. Discard the slide used for spreading the blood in the appropriate container.
8. Place the blood slide on a slide staining rack and let it dry in the air.
9. Put enough Wright's stain on the slide to cover the smear but not overflow the slide. Count the number of drops of stain that are used.
10. After 2–3 minutes, add an equal volume of distilled water to the stain and let the slide stand for 4 minutes. From time to time, gently blow on the liquid to mix the water and stain.
11. Flood the slide with distilled water until the blood smear appears light blue.
12. Tilt the slide to pour off the water and let the slide dry in the air.

Examine the blood smear with low-power magnification and locate an area where the blood cells are well distributed. Observe these cells using high-power magnification and then with an oil immersion objective if one is available.

PROCEDURE A—TYPES OF BLOOD CELLS

1. Review textbook sections on *red blood cells, white blood cells,* and *platelets.*
2. Complete Part A of Laboratory Report 38.
3. Refer to textbook figures and figure 38.2 as an aid in identifying the various types of blood cells. Use the prepared slide of blood and locate each of the following:

   red blood cell (erythrocyte)

   white blood cell (leukocyte)

   granulocytes

   neutrophil

   eosinophil

   basophil

   agranulocytes

   lymphocyte

   monocyte

   platelet (thrombocyte)

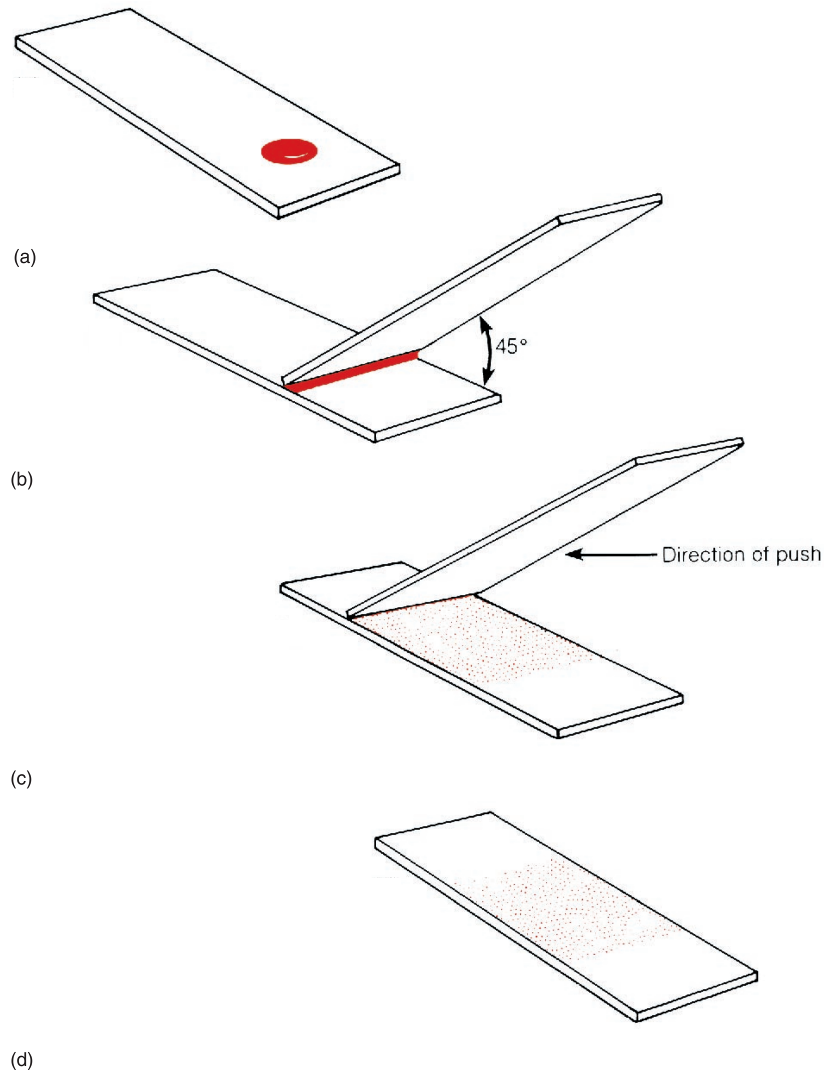
4. In Part B of the laboratory report, prepare sketches of single blood cells to illustrate each type. Pay particular attention to relative size, nuclear shape, and color of granules in the cytoplasm (if present).

PROCEDURE B—DIFFERENTIAL WHITE BLOOD CELL COUNT

A differential white blood cell count is performed to determine the percentage of each of the various types of white blood cells present in a blood sample. The test is useful because the relative proportions of white blood cells may change in particular diseases. Neutrophils, for example, usually increase during bacterial infections, whereas eosinophils may increase during certain parasitic infections and allergic reactions.

1. To make a differential white blood cell count, follow these steps:
   a. Using high-power magnification or an oil immersion objective, focus on the cells at one end of a prepared blood slide where the cells are well distributed.
   b. Slowly move the blood slide back and forth, following a path that avoids passing over the same cells twice (fig. 38.3).
   c. Each time you encounter a white blood cell, identify its type and record it in Part C of the laboratory report.
   d. Continue searching for and identifying white blood cells until you have recorded 100 cells in the data table. Because *percent* means "parts of 100," for each type of white blood cell, the total number observed is equal to its percentage in the blood sample.
2. Complete Part C of the laboratory report.

Figure 38.1 To prepare a blood smear: (*a*) place a drop of blood about 2 cm from the end of a clean slide; (*b*) hold a second slide at about a 45° angle to the first one, allowing the blood to spread along its edge; (*c*) push the second slide over the surface of the first so that it pulls the blood with it; (*d*) observe the completed blood smear. The ideal smear should be 1½ inches in length, be evenly distributed, and contain a smooth, feathered edge.



OPTIONAL ACTIVITY

Obtain a prepared slide of pathological blood that has been stained with Wright's stain. Perform a differential white blood cell count using this slide and compare the results with the values for normal blood listed in table 38.1.

What differences do you note?________________________

____

____

____

Table 38.1 Differential White Blood Cell Count

Cell Type	Normal Value (percent)
Neutrophil	54–62
Eosinophil	1–3
Basophil	<1
Lymphocyte	25–33
Monocyte	3–9

Figure 38.2 Blood cells illustrating some of the numerous variations of each type.

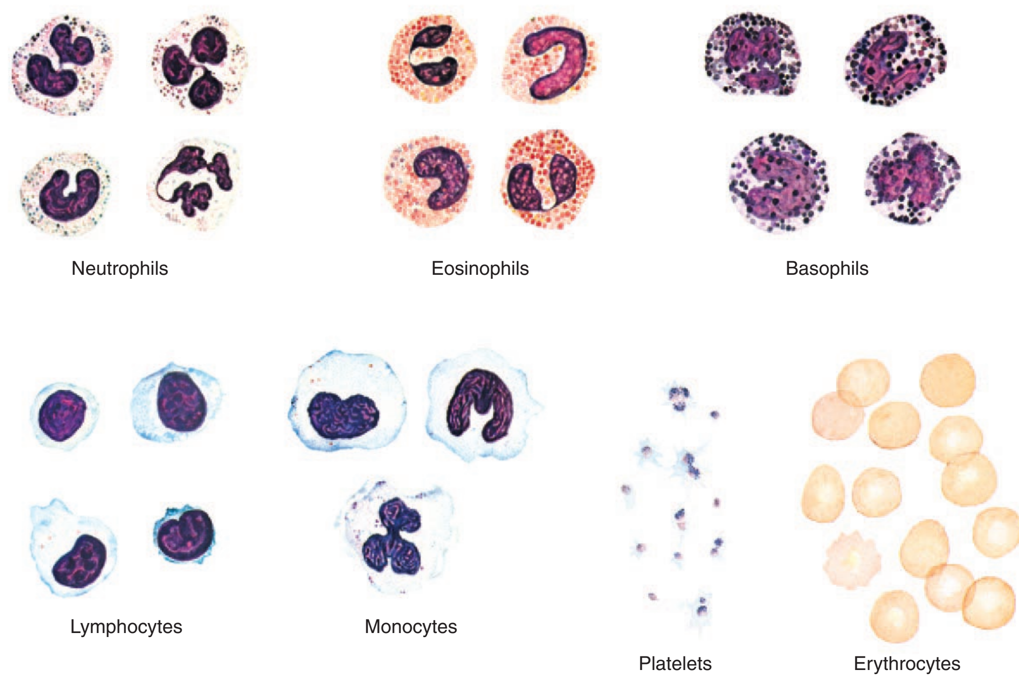
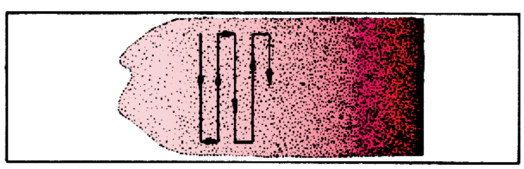


Figure 38.3 Move the blood slide back and forth to avoid passing the same cells twice.



Web Quest

What are the functions of the various blood components? What do abnormal amounts indicate? Search these and review blood cell identification at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 38

Name ____

Date ____

Section ____

Blood Cells

Part A

Complete the following statements:

1. Red blood cells are also called ________________________.
2. The shape of a red blood cell can be described as a ________________________ disk.
3. The shape of a red blood cell is related to its function of ________________________.
4. ________________________ is the oxygen-carrying substance in a red blood cell.
5. Red blood cells with high oxygen concentrations are bright red because of the presence of ________________________.
6. A mature red blood cell cannot reproduce because the ________________________ was extruded during late development.
7. White blood cells are also called ________________________.
8. White blood cells with granular cytoplasm are called ________________________.
9. White blood cells lacking granular cytoplasm are called ________________________.
10. Polymorphonuclear leukocyte is another name for a ________________________ with a segmented nucleus.
11. Normally, the most numerous white blood cells are ________________________.
12. White blood cells whose cytoplasmic granules stain red in acid stain are called ________________________.
13. ________________________ are normally the least abundant of the white blood cells.
14. ________________________ are the largest of the white blood cells.
15. ________________________ are small agranulocytes that have relatively large, round nuclei with thin rims of cytoplasm.
16. In red bone marrow, platelets develop from cells called ________________________.
17. Upon an injury, platelets adhere to ________________________ found in connective tissue.
18. In the presence of damaged blood vessels, platelets release a substance called ________________________ that causes smooth muscle contraction.

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Part B

Sketch a single blood cell of each type in the spaces provided. Use colored pencils to represent the stained colors of the cells. Label any features that can be identified.

Red blood cell (____×)

Neutrophil (____×)

Lymphocyte (____×)

Monocyte (____×)

Eosinophil (____×)

Basophil (____×)

Platelet (____×)

Part C

1. Differential white blood cell count data table. As you identify white blood cells, record them on the table by using a tally system, such as ~~||||~~ ||. Place tally marks in the "Number Observed" column and total each of the five WBCs when the differential count is completed. Obtain a total of all five WBCs counted to determine the percent of each WBC type.

Type of WBC	Number Observed	Total	Percent
Neutrophil			
Lymphocyte			
Monocyte			
Eosinophil			
Basophil			
		Total of column	

2. How do the results of your differential white blood cell count compare with the normal values listed in table 38.1? ____

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Critical Thinking Application

What is the difference between a differential white blood cell count and a total white blood cell count?

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Laboratory Exercise 39

Blood Testing—A Demonstration

MATERIALS NEEDED

textbook
sterile disposable blood lancets
sterile absorbent cotton
70% alcohol

For Demonstration A:

heparinized microhematocrit capillary tube
sealing clay (or Critocaps)
microhematocrit centrifuge
microhematocrit reader

For Demonstration B:

hemoglobinometer
lens paper
hemolysis applicator

For Demonstration C:

hemocytometer
Unopette system (a Becton Dickinson product) for counting red blood cells (see Instructor's Manual for a supplier)
hand counter (tally)

For Demonstration D:

hemocytometer
Unopette system (a Becton Dickinson product) for counting white blood cells (see Instructor's Manual for a supplier)
hand counter (tally)

SAFETY

- It is important that students learn and practice correct procedures for handling body fluids. Consider using either mammal blood other than human or contaminant-free blood that has been tested and is available from various laboratory supply houses. Some of the procedures might be accomplished as demonstrations only. If student blood is utilized, it is important that students handle only their own blood.
- Use an appropriate disinfectant to wash the laboratory tables before and after the procedures.
- Wear disposable gloves when handling blood samples.
- Clean the end of a finger with 70% alcohol before the puncture is performed.
- The sterile blood lancet should be used only once.
- Dispose of used lancets and blood-contaminated items into an appropriate container (never use the wastebasket).
- Wash your hands before leaving the laboratory.

As an aid in identifying various disease conditions, tests are often performed on blood to determine how its composition compares with normal values. These tests commonly include red blood cell percentage, hemoglobin content, red blood cell count, and total white blood cell count. Common tests performed on the blood and factors that can influence the normal values can be found in a textbook.

PURPOSE OF THE EXERCISE

To observe the blood tests used to determine red blood cell percentage, hemoglobin content, red blood cell count, and total white blood cell count.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. determine the percentage of red blood cells in a blood sample;
2. determine the hemoglobin content of a blood sample;
3. describe how a red blood cell count is performed;
4. describe how a total white blood cell count is performed.

WARNING

Because of the possibility of blood infections being transmitted from one student to another during blood-testing procedures, it is suggested that the following demonstrations be performed by the instructor. Observe all safety procedures listed for this lab.

DEMONSTRATION A—RED BLOOD CELL PERCENTAGE

To determine the percentage of red blood cells in a whole blood sample, the cells must be separated from the liquid plasma. This separation can be rapidly accomplished by placing a tube of blood in a centrifuge. The force created by the spinning motion of the centrifuge causes the cells to be packed into the lower end of the tube. Then the quantities of cells and plasma can be measured, and the percentage of cells (hematocrit or packed cell volume) can be calculated.

1. To determine the percentage of red blood cells in a blood sample, follow these steps:
   a. Lance the end of a finger to obtain a drop of blood. *See the demonstration in Laboratory Exercise 38 for directions.*
   b. Touch the drop of blood with the colored end of a heparinized capillary tube. Hold the tube tilted slightly downward so that the blood will easily move into it by capillary action (fig. 39.1). To prevent an air bubble, keep the tip in the blood until filled.
   c. Allow the blood to fill about two-thirds of the length of the tube.
   d. Plug the blood end of the tube by pushing it with a rotating motion into sealing clay or by adding a plastic Critocap. By holding a finger over the tip of the dry end, blood will not drain out while sealing the blood end.
   e. Place the sealed tube into one of the numbered grooves of a microhematocrit centrifuge. The tube's sealed end should point outward from the center and should touch the rubber lining on the rim of the centrifuge (fig. 39.1).
   f. The centrifuge should be balanced by placing specimen tubes on opposite sides of the moving head, the inside cover should be tightened with the lock wrench, and the outside cover should be securely fastened.
   g. Run the centrifuge for 3–5 minutes.
   h. After the centrifuge has stopped, remove the specimen tube and note that the red blood cells have been packed into the bottom of the tube. The clear liquid on top of the cells is plasma.
   i. Use a microhematocrit reader to determine the percentage of red blood cells in the tube. If a microhematocrit reader is not available, measure the total length of the blood column in millimeters (red cells plus plasma) and the length of the red blood cell column alone in millimeters. Divide the red blood cell length by the total blood column length and multiply the answer by 100 to calculate the percentage of red blood cells.
   j. Record the test result in Part A of Laboratory Report 39.
2. Complete Part B of the laboratory report.

DEMONSTRATION B—HEMOGLOBIN CONTENT

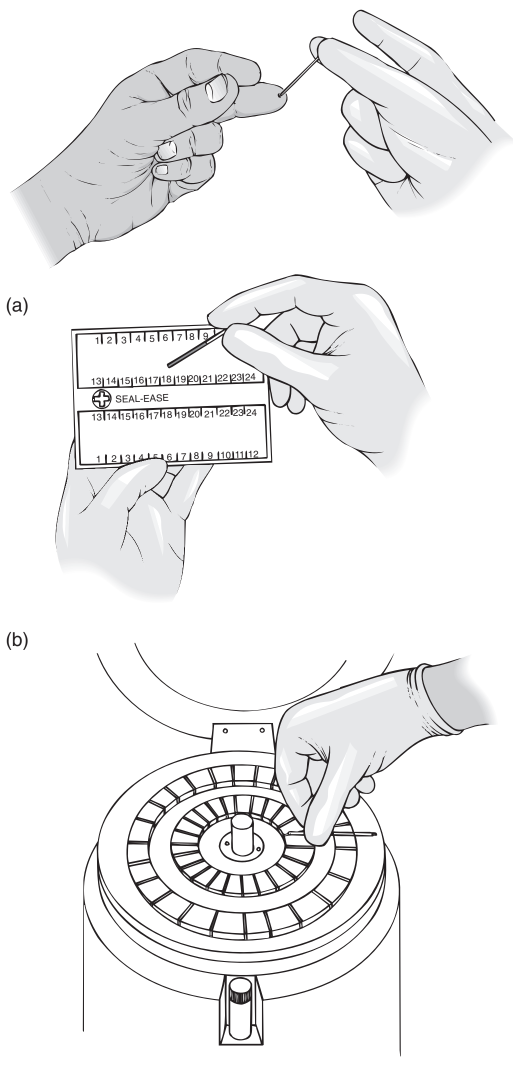
Although the hemoglobin content of a blood sample can be measured in several ways, a common method uses a hemoglobinometer. This instrument is designed to compare the color of light passing through a hemolyzed blood sample with a standard color. The results of the test are expressed in grams of hemoglobin per 100 mL of blood or in percentage of normal values.

1. To measure the hemoglobin content of a blood sample, follow these steps:
   a. Obtain a hemoglobinometer and remove the blood chamber from the slot in its side.
   b. Separate the pieces of glass from the metal clip and clean them with 70% alcohol and lens paper. Note that one of the pieces of glass has two broad, U-shaped areas surrounded by depressions. The other piece is flat on both sides.
   c. Obtain a large drop of blood from a finger, as before.
   d. Place the drop of blood on one of the U-shaped areas of the blood chamber glass.
   e. Stir the blood with the tip of a hemolysis applicator until the blood appears clear rather than cloudy. This usually takes about 45 seconds.
   f. Place the flat piece of glass on top of the blood plate and slide both into the metal clip of the blood chamber.
   g. Push the blood chamber into the slot on the side of the hemoglobinometer, making sure that it is in all the way (fig. 39.2).
   h. Hold the hemoglobinometer in the left hand with the thumb on the light switch on the underside.
   i. Look into the eyepiece and note the green area that is split in half.
   j. Slowly move the slide on the side of the instrument back and forth with the right hand until the two halves of the green area look the same.
   k. Note the value in the upper scale (grams of hemoglobin per 100 mL of blood), indicated by the mark in the center of the movable slide.
   l. Record the test result in Part A of the laboratory report.
2. Complete Part C of the laboratory report.

DEMONSTRATION C—RED BLOOD CELL COUNT

Although modern clinical laboratories commonly use electronic instruments to obtain blood cell counts, a hemocytometer provides a convenient and inexpensive way to count both red and white blood cells. This instrument is a

Figure 39.1 Steps in the red blood cell percentage procedure: (*a*) load a heparinized capillary tube with blood; (*b*) plug the blood end of the tube with sealing clay; (*c*) place the tube in a microhematocrit centrifuge.



special microscope slide on which there are two counting areas (fig. 39.3). Each counting area contains a grid of tiny lines forming nine large squares that are further subdivided into smaller squares (fig. 39.4).

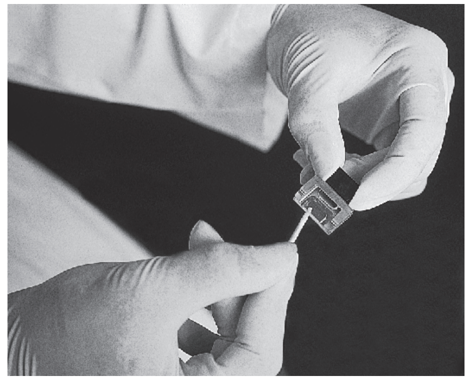
The squares on the counting area have known dimensions. When a coverslip is placed over the area, it is held a known distance above the grid by glass ridges of the hemocytometer. Thus, when a liquid is placed under the coverslip, the volume of liquid covering each part of the grid can be calculated. Also, if the number of blood cells in a tiny volume of blood can be counted, it is possible to calculate the number that must be present in any larger volume.

When red blood cells are counted using a hemocytometer, a small sample of blood is drawn into a special pipette, and the blood is diluted to reduce the number of cells that must be counted. Some of the diluted blood is spread over the counting area, and with the aid of a microscope, all of the cells in the grid areas marked *R* are counted (fig. 39.4). The total count is multiplied by 10,000 to correct for the dilution and for the fact that only a small volume of blood was observed. The final result provides the number of red blood cells per cubic millimeter in the original blood sample.

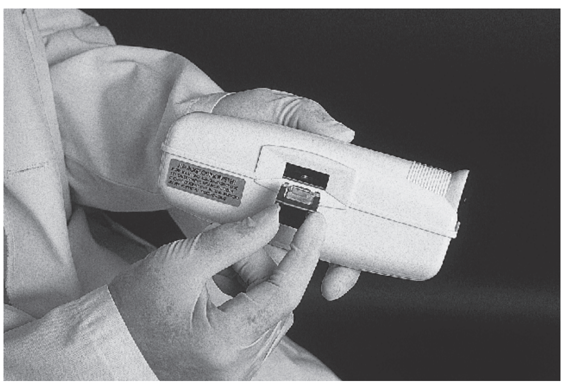
1. To perform a red blood cell count, follow these steps:
   a. Examine a hemocytometer, and use a microscope to locate the grid of a counting area. Focus on the large central square of the grid with low-power and then with high-power

Figure 39.2 Steps in the hemoglobin content procedure: (*a*) Load the blood chamber with blood; (*b*) stir the blood with a hemolysis applicator; (*c*) place the blood chamber in the slot of the hemoglobinometer; (*d*) match the colors in the green area by moving the slide on the side of the instrument.

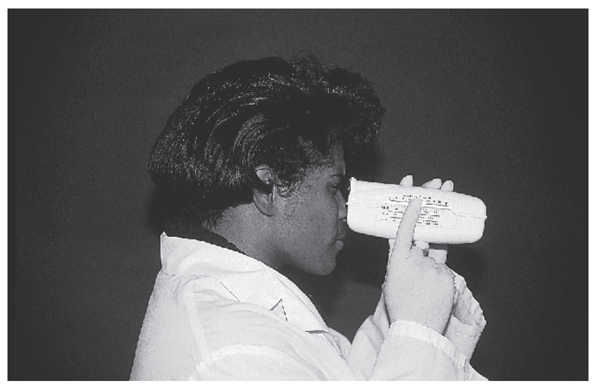
(a)



(b)



(c)



(d)

Figure 39.3 Location of the counting areas of a hemocytometer.

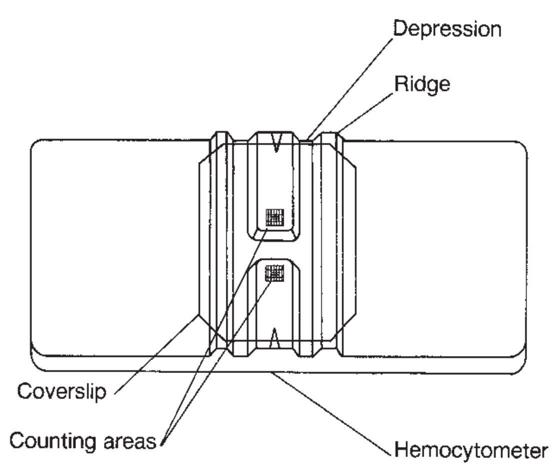


Figure 39.4 The pattern of lines in a counting area of a hemocytometer. The squares marked with *R* are used to count red blood cells, whereas the squares marked with *W* are used to count white blood cells.

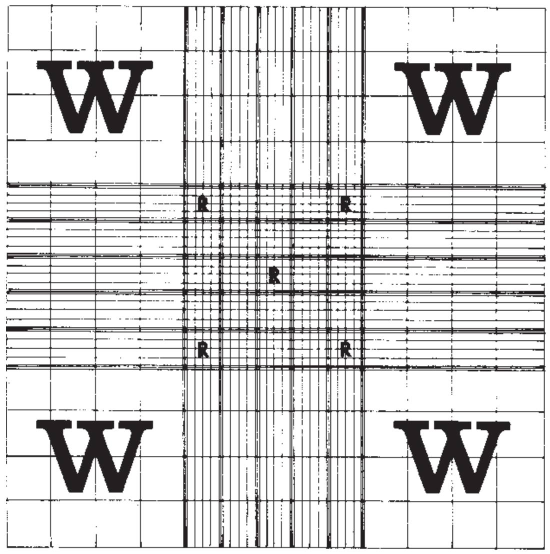
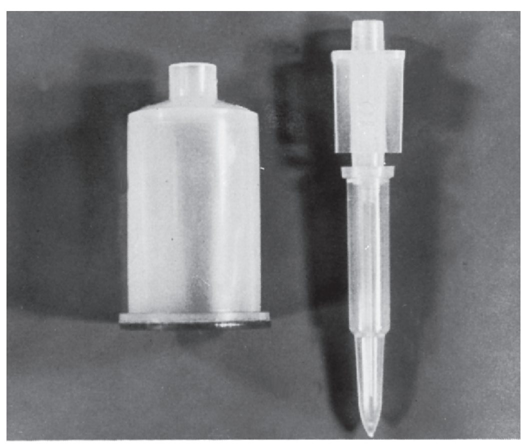


Figure 39.5 The Unopette system consists of a reservoir containing blood cell diluting fluid (*left*) and a plastic capillary tube within a plastic shield (*right*).



magnification. Adjust the light intensity so that the lines are clear and sharp.

b. Wash the hemocytometer with soap and water, and dry it. Place the coverslip over the counting areas and set the instrument aside.
c. Examine the Unopette system for counting red blood cells, which consists of a reservoir containing blood cell diluting fluid and a plastic capillary tube assembly within a plastic shield (fig. 39.5).
d. Place the Unopette reservoir on the table and gently force the pointed tip of the capillary tube shield through the thin diaphragm at the top of the reservoir.
e. Lance the tip of a finger, as before, to obtain a drop of blood.
f. Remove the Unopette capillary tube from its shield and, holding the tube horizontally, touch the tip of the tube to the drop of blood. Allow the tube to fill completely with blood by capillary action (fig. 39.6).
g. Gently squeeze the reservoir, taking care not to expel any of its fluid content, and while maintaining pressure on the sides of the reservoir, insert the capillary tube through the punctured diaphragm of the reservoir. Release the pressure on the sides of the reservoir and allow the blood to be drawn into its chamber.

Figure 39.6 The Unopette capillary tube fills with blood by capillary action.

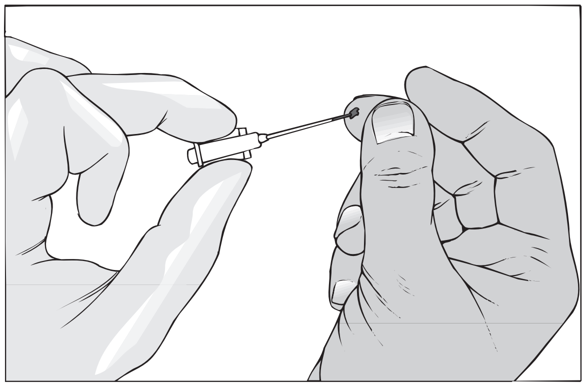
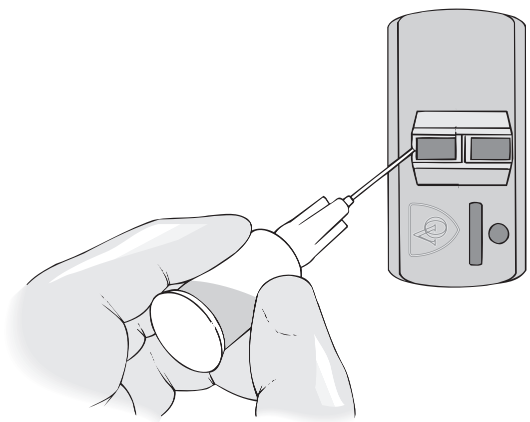


Figure 39.7 The Unopette dropper system being used to fill a hemocytometer with blood. By squeezing the reservoir, a drop of diluted blood enters the counting areas under the coverslip by capillary action.



h. Hold the capillary tube assembly in the reservoir and gently squeeze the sides of the reservoir several times to mix the blood with the diluting fluid inside. Also, invert the reservoir a few times to aid this mixing process.
i. Remove the capillary tube assembly from the reservoir and insert the opposite end of the assembly into the top of the reservoir, thus converting the parts into a dropper system (fig. 39.7).
j. Gently squeeze the sides of the reservoir to expel some of the diluted blood from the capillary tube. Discard the first four drops of this mixture and place the next drop of diluted blood at the edge of the coverslip near a counting area of the hemocytometer (fig. 39.7). If the hemocytometer is properly charged with diluted blood, the space between the counting area and the coverslip will be filled and will lack air bubbles, but no fluid will spill over into the depression on either side.
k. Place the hemocytometer on the microscope stage and focus on the large, central square of the counting area with the low-power objective, and then the high-power objective. Adjust the light so that the grid lines and blood cells are clearly visible.
l. Count all the cells in the five areas corresponding to those marked with *R* in figure 39.4. To obtain an accurate count, include cells that are touching the lines at the tops and left sides of the squares, but do not count those touching the bottoms and right sides of the squares. The use of a hand counter facilitates the counting task.
m. Multiply the total count by 10,000 and record the result (cells per cubic millimeter of blood) in Part A of the laboratory report.

n. Discard or clean the materials as directed by the laboratory instructor.
2. Complete Part D of the laboratory report.

DEMONSTRATION D—TOTAL WHITE BLOOD CELL COUNT

A hemocytometer is used to make a total white blood cell count in much the same way that it was used to count red blood cells. However, in the case of white cell counting, a diluting fluid is used that destroys red blood cells. Also, in making the white cell count, all of the cells in the four large squares marked *W* in figure 39.4 are included. The total count is multiplied by fifty to calculate the total number of white blood cells in a cubic millimeter of the blood sample.

1. To perform a total white blood cell count, follow these steps:
   a. Clean the hemocytometer as before.
   b. Lance the tip of a finger, as before, to obtain a drop of blood.
   c. Repeat steps 1*c*–1*g* of the procedure for counting red blood cells, but use a Unopette system for counting white blood cells.
   d. After mixing the blood with the diluting fluid in the reservoir, discard the first four drops of the mixture and charge the hemocytometer with diluted blood as before.
   e. Use low-power magnification to locate the areas of the grid corresponding to those marked with *W* in figure 39.4.
   f. Count all of the cells in the four large squares (remember that the red blood cells were destroyed by the white blood cell diluting fluid), following the same counting rules as before.
   g. Multiply the total by fifty and record the result in Part A of the laboratory report.
   h. Discard or clean the materials as directed by the laboratory instructor.
2. Complete Part E of the laboratory report.

Laboratory Report 39

Name ______________________

Date ______________________

Section ______________________

Blood Testing—A Demonstration

Part A

Blood test data:

Blood Test	Test Results	Normal Values
Red blood cell percentage (mL per 100 mL blood)		Men: 40–54 Women: 37–47
Hemoglobin content (g per 100 mL blood)		Men: 14–18 Women: 12–16
Red blood cell count (cells per mm^3 blood)		Men: 4,600,000–6,200,000 Women: 4,200,000–5,400,000
White blood cell count (cells per mm^3 blood)		5,000–10,000

Part B

Complete the following:

1. How does the red blood cell percentage from the demonstration blood test compare with the normal value?
____
____

2. What conditions might produce a decreased red blood cell percentage? ______________________
____
____

3. What conditions might produce an increased red blood cell percentage? ______________________
____
____

Part C

Complete the following:

1. How does the hemoglobin content from the demonstration blood test compare with the normal value? ____

2. What conditions might produce a decreased hemoglobin content? ____

3. What conditions might produce an increased hemoglobin content? ____

Part D

Complete the following:

1. How does the red blood cell count from the demonstration blood test compare with the normal value? ____

2. What conditions might produce a decreased red blood cell count? ____

3. What conditions might produce an increased red blood cell count? ____

Part E

Complete the following:

1. How does the white blood cell count from the demonstration blood test compare with the normal value? ____

2. What conditions might produce a decreased white blood cell count? ____

3. What conditions might produce an increased white blood cell count? ____

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Critical Thinking Application

Which blood tests performed in this lab could be used to determine possible anemia?

Laboratory Exercise 40

Blood Typing

MATERIALS NEEDED

textbook
ABO blood-typing kit

For Demonstration:

microscope slide
70% alcohol
sterile absorbent cotton
sterile blood lancet
toothpicks
anti-D serum
slide warming box (Rh blood-typing box or Rh view box)

SAFETY

- It is important that students learn and practice correct procedures for handling body fluids. Consider using contaminant-free blood that has been tested and is available from various laboratory supply houses. Some of the procedures might be accomplished as demonstrations only. If student blood is utilized, it is important that students handle only their own blood.
- Use an appropriate disinfectant to wash the laboratory tables before and after the procedures.
- Wear disposable gloves when handling blood samples.
- Clean the end of a finger with 70% alcohol before the puncture is performed.
- The sterile blood lancet should be used only once.
- Dispose of used lancets and blood-contaminated items into an appropriate container (never use the wastebasket).
- Wash your hands before leaving the laboratory.

Blood typing involves identifying protein substances called antigens that are present in red blood cell membranes. Although there are many different antigens associated with human red blood cells, only a few of them are of clinical importance. These include the antigens of the ABO group and those of the Rh group.

To determine which antigens are present, a blood sample is mixed with blood-typing sera that contain known types of antibodies. If a particular antibody contacts a corresponding antigen, a reaction occurs and the red blood cells clump together (agglutination). Thus, if blood cells are mixed with serum containing antibodies that react with antigen A and the cells clump together, antigen A must be present in those cells.

PURPOSE OF THE EXERCISE

To determine the ABO blood type of a blood sample and to observe an Rh blood-typing test.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. explain the basis of ABO blood typing;
2. determine the ABO type of a blood sample;
3. explain the basis of Rh blood typing;
4. describe how the Rh type of a blood sample is determined.

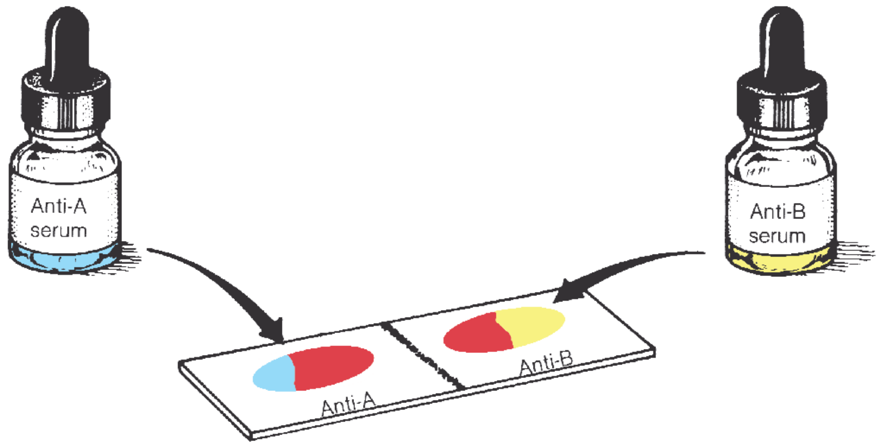
WARNING

Because of the possibility of blood infections being transmitted from one student to another if blood testing is performed in the classroom, it is suggested that commercially prepared blood-typing kits containing virus-free human blood be used for ABO blood typing. The instructor may wish to demonstrate Rh blood typing. Observe all of the safety procedures listed for this lab.

ABO BLOOD TYPING

1. Review a textbook section on the *ABO blood group*.
2. Compete Part A of Laboratory Report 40.
3. Perform the ABO blood type test using the blood-typing kit. To do this, follow these steps:
   a. Obtain a clean microscope slide and mark across its center with a wax pencil to divide it into right and left halves. Also write "anti-A" near the edge of the left half and "anti-B" near the edge of the right half (fig. 40.1).
   b. Place a small drop of blood on each half of the microscope slide. Work quickly so that the blood will not have time to clot.

Figure 40.1 Slide prepared for ABO blood typing.



c. Add a drop of anti-A serum to the blood on the left half and a drop of anti-B serum to the blood on the right half. Note the color coding of the anti-A and anti-B typing sera. To prevent contaminating the serum, avoid touching the blood with the serum while it is in the dropper; instead allow the serum to fall from the dropper onto the blood.
d. Use separate toothpicks to stir each sample of serum and blood together, and spread each over an area about as large as a quarter. Dispose of toothpicks in an appropriate container.
e. Examine the samples for clumping of blood cells (agglutination) after 2 minutes.
f. See table 40.1 for aid in interpreting the test results.
g. Discard contaminated materials as instructed by the laboratory instructor.

4. Complete Part B of the laboratory report.

Critical Thinking Application

Judging from the observations of the blood-typing results, predict the components in the anti-A and anti-B sera that caused clumping.

____

____

____

____

DEMONSTRATION—Rh BLOOD TYPING

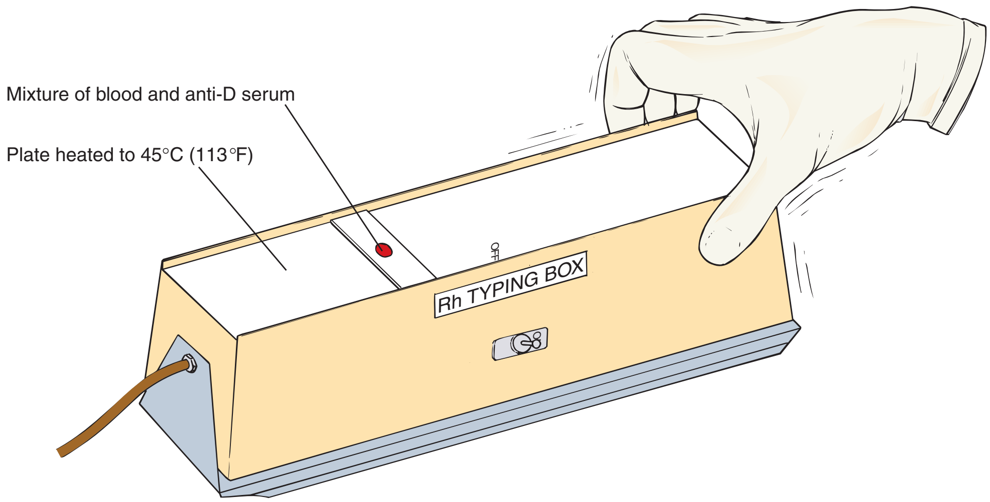
1. Review a textbook section on the *Rh Blood Group*.
2. Complete Part C of the laboratory report.

Table 40.1 Possible Reactions of ABO Blood-Typing Sera

Reactions		Blood Type
Anti-A Serum	**Anti-B Serum**	
Clumping	No clumping	Type A
No clumping	Clumping	Type B
Clumping	Clumping	Type AB
No clumping	No clumping	Type O

3. To determine the Rh blood type of a blood sample, follow these steps:
   a. Lance the tip of a finger. (See the demonstration procedures in Laboratory Exercise 38 for directions.) Place a small drop of blood in the center of a clean microscope slide.
   b. Add a drop of anti-D serum to the blood and mix them together with a clean toothpick.
   c. Place the slide on the plate of a warming box (Rh blood-typing box or Rh view box) that has been prewarmed to 45°C (113°F) (fig. 40.2).
   d. Slowly rock the box back and forth to keep the mixture moving, and watch for clumping of the blood cells. When clumping occurs in anti-D serum, the clumps usually are smaller than those that appear in anti-A or anti-B sera, so they may be less obvious. However, if clumping occurs, the blood is called Rh positive; if no clumping occurs *within 2 minutes,* the blood is called Rh negative.
   e. Discard all contaminated materials in appropriate containers.
4. Complete Part D of the laboratory report.

Figure 40.2 Slide warming box used for Rh blood typing.



Laboratory Report **40**

Name ______________________________

Date ______________________________

Section ______________________________

Blood Typing

Part A

Complete the following statements:

1. The antigens of the ABO blood group are located in the ________________.
2. The blood of every person contains one of (how many possible?) ________________ combinations of antigens.
3. Type A blood contains antigen ________________.
4. Type B blood contains antigen ________________.
5. Type A blood contains antibody ________________ in the plasma.
6. Type B blood contains antibody ________________ in the plasma.
7. Persons with ABO blood type ________________ are sometimes called universal recipients.
8. Persons with ABO blood type ________________ are sometimes called universal donors.

Part B

Complete the following:

1. What was the ABO type of the blood tested? ______________________________
2. What ABO antigens are present in the red blood cells of this type of blood? ________________
3. What ABO antibodies are present in the plasma of this type of blood? ________________
4. If a person with this blood type needed a blood transfusion, what ABO type(s) of blood could be received safely?

   ____

5. If a person with this blood type was serving as a blood donor, what ABO blood type(s) could receive the blood safely? ______________________________

Part C

Complete the following statements:

1. The Rh blood group was named after the ________________.
2. Of the antigens in the Rh group, the most important is ________________.
3. If red blood cells lack Rh antigens, the blood is called ________________.
4. Rh antibodies form only in persons with ________________ type blood in response to special stimulation.

5. If an Rh-negative person who is sensitive to Rh-positive blood receives a transfusion of Rh-positive blood, the donor's cells are likely to ________________________.
6. An Rh-negative woman, who might be carrying an ________________________ fetus, is given an injection of RhoGAM to prevent erythroblastosis fetalis.

Part D

Complete the following:

1. What was the Rh type of the blood tested in the demonstration? ________________________
2. What Rh antigen is present in the red blood cells of this type of blood? ________________________
3. What Rh antibody is normally present in the plasma of this type of blood? ________________________
4. If a person with this blood type needed a blood transfusion, what type of blood could be received safely?

   ____
5. If a person with this blood type was serving as a blood donor, a person with what type of blood could receive the blood safely? ________________________

Laboratory Exercise 41

Structure of the Heart

MATERIALS NEEDED

textbook
dissectible human heart model
preserved sheep or other mammalian heart
dissecting tray
dissecting instruments

SAFETY

- Wear disposable gloves when working on the heart dissection.
- Save or dispose of the dissected heart as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

The heart is a muscular pump located within the mediastinum and resting upon the diaphragm. It is enclosed by the lungs, thoracic vertebrae, and sternum and attached to its top (the base) are several large blood vessels. Its distal end extends downward to the left and terminates as a bluntly pointed apex.

The heart and the proximal ends of the attached blood vessels are enclosed by a double-layered pericardium. The inner layer of this membrane consists of a thin covering that is closely applied to the surface of the heart, whereas the outer layer forms a tough, protective sac surrounding the heart.

PURPOSE OF THE EXERCISE

To review the structural characteristics of the human heart, and to examine the major features of a mammalian heart.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. identify the major structural features of the human heart;
2. compare the features of the human heart with those of another mammal.

PROCEDURE A—THE HUMAN HEART

1. Review a textbook section on the *structure of the heart.*
2. As a review activity, label figures 41.1, 41.2, and 41.3.
3. Complete Part A of Laboratory Report 41.
4. Examine the human heart model and locate the following features:

heart

base

apex

pericardial sac

fibrous pericardium (outer layer)

parietal pericardium (inner lining)

pericardial cavity

epicardium (visceral pericardium)

myocardium

endocardium

atria

right atrium

left atrium

auricles

ventricles

right ventricle

left ventricle

atrioventricular orifices

atrioventricular valves (A-V valves)

tricuspid valve

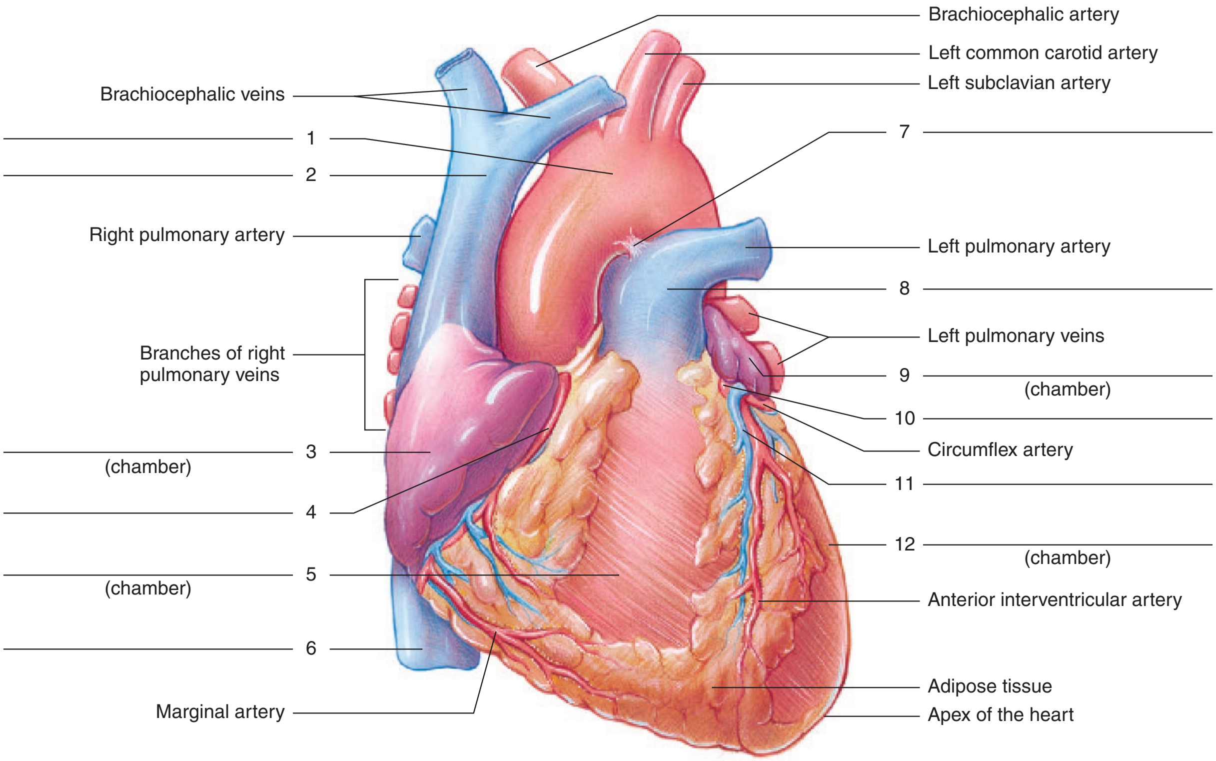
bicuspid (mitral) valve

chordae tendineae

papillary muscles

atrioventricular sulcus

Figure 41.1 Label this anterior view of the human heart.



interventricular sulci

anterior sulcus

posterior sulcus

superior vena cava

inferior vena cava

pulmonary trunk

pulmonary arteries

pulmonary veins

aorta

semilunar valves

pulmonary valve

aortic valve

left coronary artery

circumflex artery

anterior interventricular artery

right coronary artery

posterior interventricular artery

marginal artery

cardiac (coronary) veins

great cardiac vein

middle cardiac vein

small cardiac vein

coronary sinus

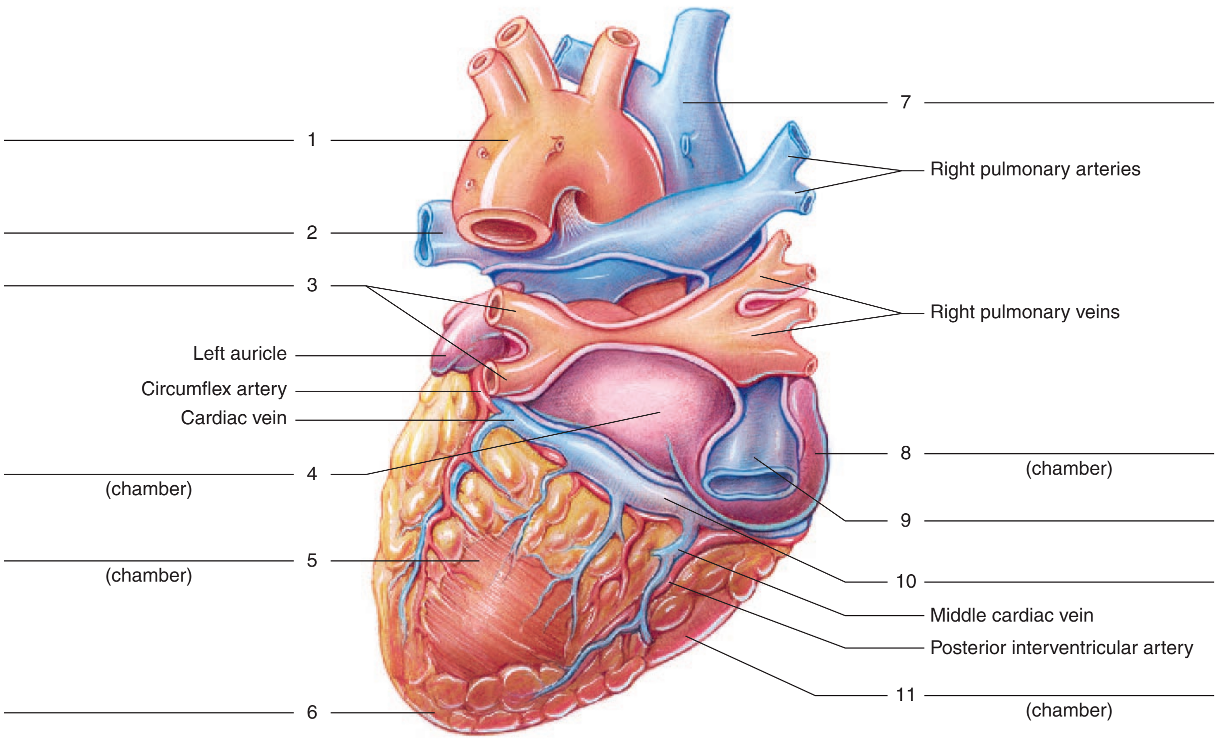
OPTIONAL ACTIVITY

Use red and blue colored pencils to color the blood vessels in figure 41.3. Use red to illustrate a blood vessel high in oxygen, and use blue to illustrate a blood vessel low in oxygen. You can check your work by referring to a corresponding figure in the textbook.

PROCEDURE B— DISSECTION OF A SHEEP HEART

1. Obtain a preserved sheep heart. Rinse it in water thoroughly to remove as much of the preservative as possible. Also run water into the large blood vessels to force any blood clots out of the heart chambers.
2. Place the heart in a dissecting tray with its ventral side up (fig. 41.4) and proceed as follows:

Figure 41.2 Label this posterior view of the human heart.



a. Although the relatively thick *pericardial sac* probably is missing, look for traces of this membrane around the origins of the large blood vessels.

b. Locate the *visceral pericardium* that appears as a thin, transparent layer on the surface of the heart. Use a scalpel to remove a portion of this layer and expose the *myocardium* beneath. Also note the abundance of fat along the paths of various blood vessels. This adipose tissue occurs in the loose connective tissue that underlies the visceral pericardium.

c. Identify the following:

right atrium

right ventricle

left atrium

left ventricle

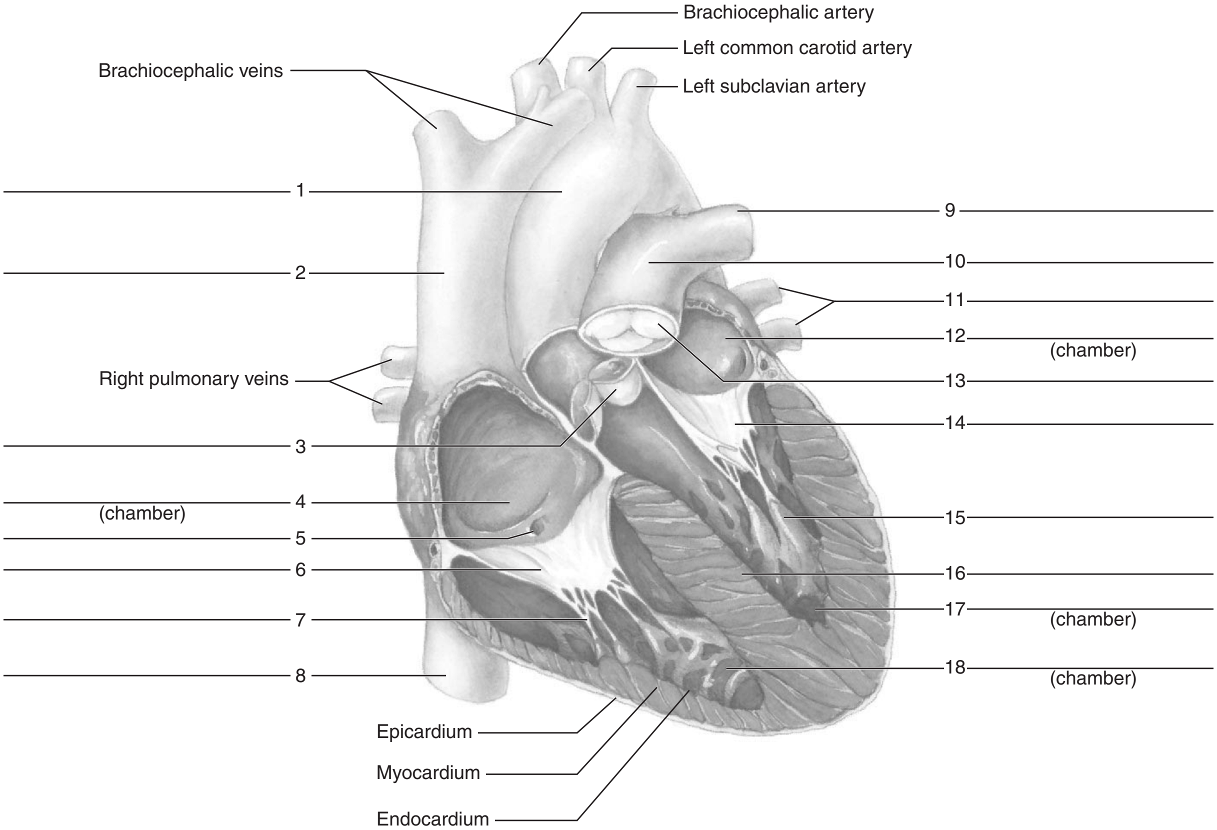
atrioventricular sulcus

anterior interventricular sulcus

d. Carefully remove the fat from the anterior interventricular sulcus, and expose the blood vessels that pass along this groove. They include a branch of the *left coronary artery* (anterior interventricular artery) and a *cardiac vein.*

3. Examine the dorsal surface of the heart (fig. 41.5) and proceed as follows:
   a. Identify the *atrioventricular sulcus* and the *posterior interventricular sulcus.*
   b. Locate the stumps of two relatively thin-walled veins that enter the right atrium. Demonstrate this connection by passing a slender probe through them. The upper vessel is the *superior vena cava,* and the lower one is the *inferior vena cava.*
4. Open the right atrium. To do this, follow these steps:
   a. Insert a blade of the scissors into the superior vena cava, and cut downward through the atrial wall (fig. 41.5).
   b. Open the chamber, locate the *tricuspid valve,* and examine its cusps.
   c. Also locate the opening to the *coronary sinus* between the valve and the inferior vena cava.
   d. Run some water through the tricuspid valve to fill the chamber of the right ventricle.
   e. Gently squeeze the ventricles, and watch the cusps of the valve as the water moves up against them.
5. Open the right ventricle as follows:

Figure 41.3 Label this anterior view of a coronal section of the human heart.



a. Continue cutting downward through the tricuspid valve and the right ventricular wall until you reach the apex of the heart.
b. Locate the *chordae tendineae* and the *papillary muscles.*
c. Find the opening to the *pulmonary trunk,* and use the scissors to cut upward through the wall of the right ventricle. Follow the pulmonary trunk until you have exposed the *pulmonary valve.*
d. Examine the valve and its cusps.

6. Open the left side of the heart. To do this, follow these steps:
   a. Insert the blade of the scissors through the wall of the left atrium and cut downward to the apex of the heart.
   b. Open the left atrium, and locate the four openings of the *pulmonary veins.* Pass a slender probe through each opening, and locate the stump of its vessel.
   c. Examine the *bicuspid valve* and its cusps.
   d. Also examine the left ventricle, and compare the thickness of its wall with that of the right ventricle.
7. Locate the aorta which leads away from the left ventricle and proceed as follows:
   a. Compare the thickness of the aortic wall with that of a pulmonary artery.
   b. Use scissors to cut along the length of the aorta to expose the *aortic valve* at its base.
   c. Examine the cusps of the valve, and locate the openings of the *coronary arteries* just distal to them.
8. As a review, locate and identify the stumps of each of the major blood vessels associated with the heart.
9. Discard or save the specimen as directed by the laboratory instructor.
10. Complete Part B of the laboratory report.

Web Quest

Trace blood flow through an animated heart at various rates. Identify heart structures and take an animated tour of the heart. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 41.4 Ventral side of sheep heart.

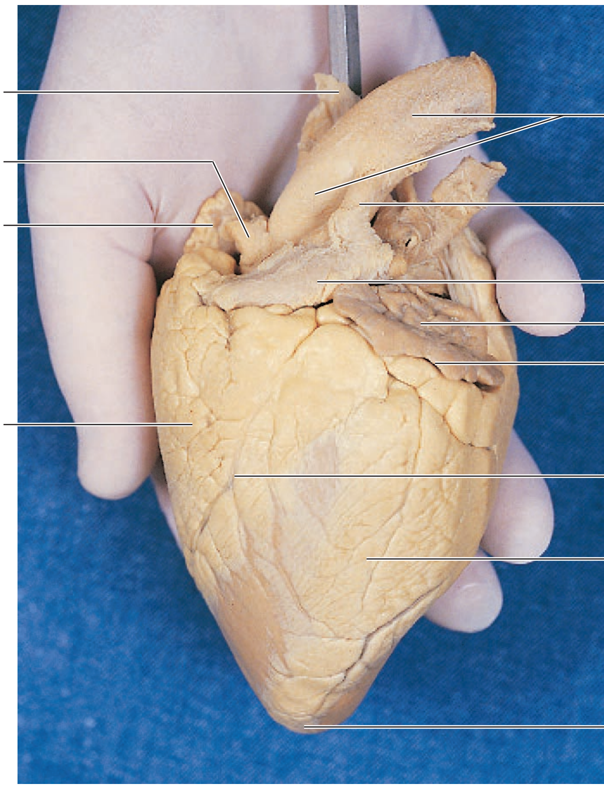
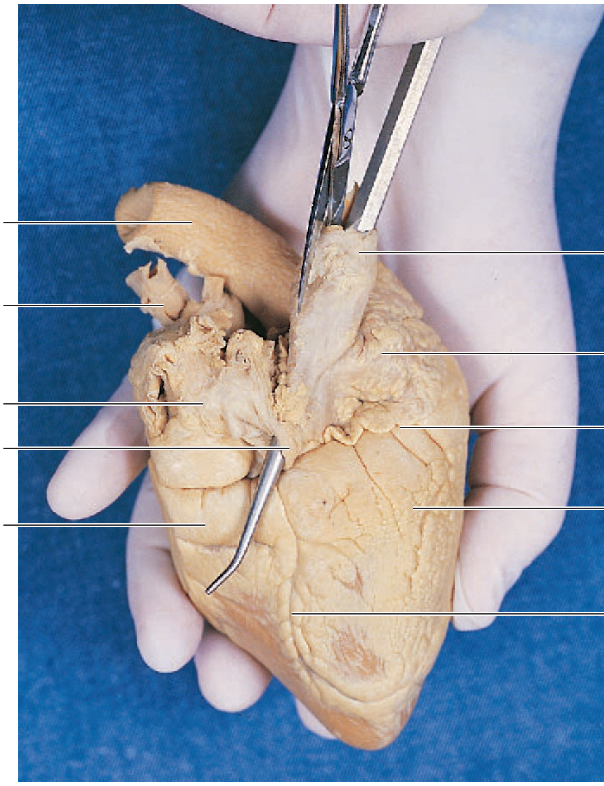


Figure 41.5 Dorsal side of sheep heart. To open the right atrium, insert a blade of the scissors into the superior (anterior in sheep) vena cava and cut downward.



Laboratory Report **41**

Name ____________________

Date ____________________

Section ____________________

Structure of the Heart

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. aorta
b. atrioventricular sulcus
c. atrium
d. bicuspid (mitral) valve
e. cardiac vein
f. coronary artery
g. coronary sinus
h. endocardium
i. interventricular sulcus
j. myocardium
k. papillary muscle
l. pericardial cavity
m. pericardial sac
n. pulmonary trunk
o. tricuspid valve

Column B

____ 1. upper chamber of the heart
____ 2. structure from which chordae tendineae originate
____ 3. prevents blood movement from right ventricle to right atrium
____ 4. double-layered membrane around heart
____ 5. groove separating left and right ventricles
____ 6. prevents blood movement from left ventricle to left atrium
____ 7. gives rise to left and right pulmonary arteries
____ 8. drains blood from myocardium into right atrium
____ 9. inner lining of heart chamber
____ 10. layer largely composed of cardiac muscle tissue
____ 11. space containing serous fluid to reduce friction during heartbeats
____ 12. drains blood from myocardial capillaries
____ 13. supplies blood to heart muscle
____ 14. distributes blood to body organs (systemic circuit) except lungs
____ 15. groove separating atrial and ventricular portions of heart

Part B

Complete the following:

1. Compare the structure of the tricuspid valve with that of the pulmonary valve. ____________________

____

____

____

____

2. Describe the action of the tricuspid valve when you squeezed the water-filled right ventricle. ______________________________

3. Describe the function of the chordae tendineae and the papillary muscles. ______________________________

4. What is the significance of the difference in thickness between the wall of the aorta and the wall of the pulmonary trunk? ______________________________

5. List in order the major blood vessels, chambers, and valves through which a drop of blood must pass in traveling from a vena cava to the aorta. ______________________________

Critical Thinking Application

What is the significance of the difference in thickness of the ventricular walls?

____

Laboratory Exercise 42

The Cardiac Cycle

MATERIALS NEEDED

textbook

For Procedure A—Heart Sounds:

stethoscope
70% alcohol
absorbent cotton

For Procedure B—The Electrocardiogram:

electrocardiograph (or other instrument for recording an ECG)
cot or table
70% alcohol
absorbent cotton
electrode cream (paste)
plate electrodes and cables
lead selector switch
Virtual Physiology Lab: 5, Electrocardiogram

A set of atrial contractions, followed by ventricular contractions, constitutes a cardiac cycle. Such a cycle is accompanied by blood pressure changes within the heart chambers, opening and closing of heart valves, and movement of blood in and out of the chambers. These events produce vibrations in the tissues and thus create the sounds associated with the heartbeat.

A number of electrical changes also occur in the myocardium as it contracts and relaxes. These changes can be detected by using metal electrodes and an instrument called an electrocardiograph. The recording produced by the instrument is an electrocardiogram, or ECG (EKG).

PURPOSE OF THE EXERCISE

To review the events of a cardiac cycle, to become acquainted with normal heart sounds, and to record an electrocardiogram.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the major events of a cardiac cycle;
2. identify the sounds produced during a cardiac cycle;
3. record an electrocardiogram;
4. identify the components of a normal ECG pattern;
5. describe the phases of a cardiac cycle represented by each part of a normal ECG pattern.

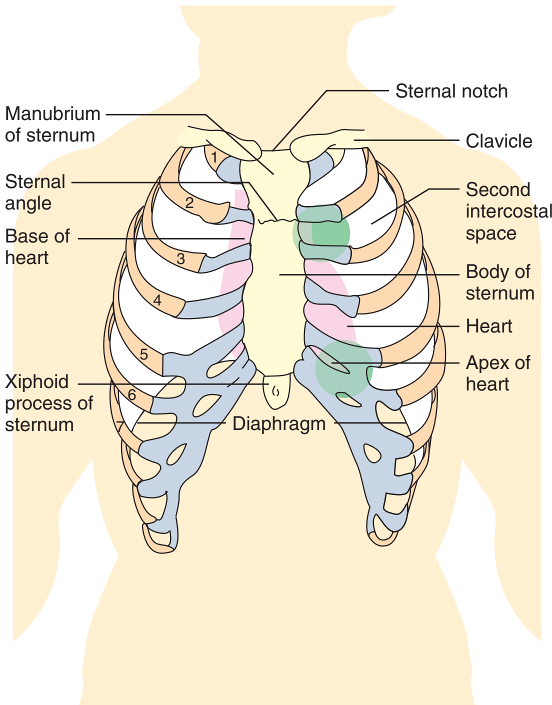
PROCEDURE A—HEART SOUNDS

1. Review textbook sections on the *cardiac cycle* and *heart sounds.*
2. Complete Part A of Laboratory Report 42.
3. Listen to your own heart sounds. To do this, follow these steps:
   a. Obtain a stethoscope, and clean its earpieces and the diaphragm by using cotton moistened with alcohol.
   b. Fit the earpieces into your ear canals so that the angles are positioned in the forward direction.
   c. Firmly place the diaphragm (or bell) of the stethoscope on the chest over the apex of the heart (fig. 42.1) and listen to the sounds. This is a good location to hear the first sound (*lubb*) of a cardiac cycle when the A-V valves close.
   d. Move the diaphragm to the second intercostal space, just to the left of the sternum, and listen to the sounds from this region. You should be able to hear the second sound (*dupp*) of the cardiac cycle clearly when the semilunar valves close.
4. Inhale slowly and deeply, and exhale slowly while you listen to the heart sounds from each of the locations as before. Note any changes that have occurred in the sounds.
5. Exercise vigorously outside the laboratory for a few minutes so that other students listening to heart sounds will not be disturbed. After the exercise period, listen to the heart sounds and note any changes that have occurred in them.
6. Complete Part B of the laboratory report.

PROCEDURE B—THE ELECTROCARDIOGRAM

1. Review textbook sections on the *cardiac conduction system* and the *electrocardiogram*.
2. Complete Part C of the laboratory report.
3. The laboratory instructor will demonstrate the proper adjustment and use of the instrument available to record an electrocardiogram.

Figure 42.1 The first sound of a cardiac cycle can be heard by placing the diaphragm of a stethoscope over the apex of the heart. The second sound can be heard over the second intercostal space, just left of the sternum.



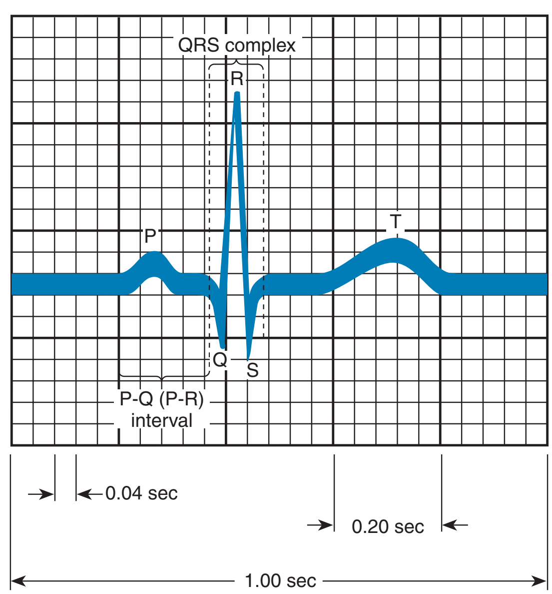
4. Record your laboratory partner's ECG. To do this, follow these steps:
   a. Have your partner lie on a cot or table close to the electrocardiograph, remaining as relaxed and still as possible.
   b. Scrub the electrode placement locations with cotton moistened with alcohol (fig. 42.2). Apply a small quantity of electrode cream to the skin on the insides of the wrists and ankles. (Any jewelry on the wrists or ankles should be removed.)
   c. Spread some electrode cream over the inner surfaces of four plate electrodes and attach one to each of the prepared skin areas, using rubber straps (fig. 42.2). Make sure there is good contact between the skin and the metal of the electrodes. The electrode plate on the right ankle is the grounding system.
   d. Attach the plate electrodes to the corresponding cables of a lead selector switch. When an ECG recording is made, only two electrodes are used at a time, and the selector switch allows various combinations of electrodes (leads) to be activated. Three standard limb leads placed on the two wrists and the left ankle are used for an ECG. This arrangement has become known as *Einthoven's triangle,** which enables the recording of the potential difference between any two of the electrodes.

      The standard Leads I, II, and III are called bipolar leads because they are the potential difference between two electrodes (a positive and a negative). Lead I measures the potential difference between the right wrist (negative) and the left wrist (positive). Lead II measures the potential difference between the right wrist and the left ankle, and Lead III measures the potential difference between the left wrist and the left ankle. The right ankle is always the ground.
   e. Turn on the recording instrument and adjust it as previously demonstrated by the laboratory instructor. The paper speed should be set at 2.5 cm/sec. This is the standard speed for ECG recordings.
   f. Set the lead selector switch to Lead I (right wrist, left wrist electrodes) and record the ECG for 1 minute.
   g. Set the lead selector switch to Lead II (right wrist, left ankle electrodes) and record the ECG for 1 minute.
   h. Set the lead selector switch to Lead III (left wrist, left ankle electrodes) and record the ECG for 1 minute.

*Willem Einthoven (1860–1927), a Dutch physiologist, received the Nobel prize for physiology or medicine for his work with electrocardiograms.

Figure 42.2 To record an ECG, attach electrodes to the wrists and ankles.

Figure 42.3 Components of a normal ECG pattern with a time scale.



i. Remove the electrodes and clean the cream from the metal and skin.
j. Use figure 42.3 to label the ECG components of the results from Leads I, II, and III. The P-Q interval is often called the P-R interval because the Q wave is frequently small or absent. The normal P-Q interval is 0.12–0.20 sec. The normal QRS complex duration is less than 0.10 sec.

5. Complete Part D of the laboratory report.

Web Quest

Identify normal heart sounds and a murmur.

What is the purpose of stress electrocardiography? Compare normal and abnormal ECGs.

Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report **42**

Name ______________________________

Date ______________________________

Section ______________________________

THE CARDIAC CYCLE

Part A

Complete the following statements:

1. The period during which a heart chamber is contracting is called ______________________.
2. The period during which a heart chamber is relaxing is called ______________________.
3. During ventricular contraction, the A-V valves (tricuspid and bicuspid valves) remain ______________________.
4. During ventricular relaxation, the A-V valves remain ______________________.
5. The pulmonary and aortic valves open when the pressure in the ______________________ exceeds the pressure in the pulmonary trunk and aorta.
6. The first sound of a cardiac cycle occurs when the ______________________ are closing.
7. The second sound of a cardiac cycle occurs when the ______________________ are closing.
8. The sound created when blood leaks back through an incompletely closed valve is called a ______________________.

Part B

Complete the following:

1. What changes did you note in the heart sounds when you inhaled deeply?

____

____

2. What changes did you note in the heart sounds following the exercise period?

____

____

Part C

Complete the following statements:

1. Normally, the ______________________ node serves as the pacemaker of the heart.
2. The ______________________ node is located in the inferior portion of the interatrial septum.
3. The large fibers on the distal side of the A-V node make up the ______________________.

4. The fibers that carry cardiac impulses from the interventricular septum into the myocardium are called ________________________.
5. An ________________________ is a recording of electrical changes occurring in the myocardium during a cardiac cycle.
6. The P wave corresponds to depolarization of the muscle fibers of the ________________________.
7. The QRS complex corresponds to depolarization of the muscle fibers of the ________________________.
8. The T wave corresponds to repolarization of the muscle fibers of the ________________________.
9. Why is atrial repolarization not observed in the ECG? ____

____

Part D

1. Attach a short segment of the ECG recording from each of the three leads you used and label the waves of each.

   Lead I

   Lead II

Lead III

2. What differences do you find in the ECG patterns of these leads? ______

3. How much time passed from the beginning of the P wave to the beginning of the QRS complex (P-Q interval, or P-R interval) in the ECG from Lead I? ______

4. What is the significance of this P-Q (P-R) interval? ______

5. How can you determine the heart rate from an electrocardiogram? ______

6. What was your heart rate as determined from the ECG? ______

Critical Thinking Application

If a person's heart rate is 72 beats per minute, determine the number of QRS complexes that would have appeared on an ECG during the first 30 seconds.

Laboratory Exercise 43

Factors Affecting the Cardiac Cycle

MATERIALS NEEDED

textbook
physiological recording apparatus such as a kymograph or Physiograph
live frog
dissecting tray
dissecting instruments
dissecting pins
frog Ringer's solution in plastic squeeze bottle
thread
small hook
medicine dropper
thermometer
ice
hot plate
calcium chloride, 2% solution
potassium chloride, 5% solution

For Optional Activity:

epinephrine, 1:10,000 solution
acetylcholine, 1:10,000 solution
caffeine, 0.2% solution
Virtual Physiology Lab: 4, Effects of Drugs on the Frog Heart

SAFETY

- Wear disposable gloves when handling the frogs.
- Dispose of the frogs according to your laboratory instructor.
- Wash your hands before leaving the laboratory.

Although the cardiac cycle is controlled by the S-A node serving as the pacemaker, the rate of heart action can be altered by various other factors. These factors include parasympathetic and sympathetic nerve impulses that originate in the cardiac center of the medulla oblongata, changes in body temperature, and concentrations of certain ions.

PURPOSE OF THE EXERCISE

To review the mechanism by which the heartbeat is regulated, to observe the action of a frog heart, and to investigate the effects of various factors on the frog heartbeat.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the mechanism by which the human cardiac cycle is controlled;
2. list several factors that affect the rate of the heartbeat;
3. identify the atrial and ventricular contractions, and determine the heart rate from a recording of a frog heartbeat;
4. test the effects of various factors on the action of a frog heart.

PROCEDURE

1. Review a textbook section on *regulation of the cardiac cycle.*
2. Complete Part A of Laboratory Report 43.

GENERAL SUGGESTION

Try to become familiar with the content and organization of this lab before you pith a frog. If you work quickly, one pithed frog should last for all of the experimental steps.

3. Observe the normal action of a frog heart. To do this, follow these steps:
   a. Obtain a live frog, and pith it according to the directions in Procedure C of Laboratory Exercise 19.

ALTERNATIVE PROCEDURE

An anesthetizing agent, tricaine methane sulfonate, can be used to prepare frogs for this lab. This procedure eliminates the need to pith frogs.

   b. Place the frog in a dissecting tray with its ventral side up, and pin its jaw and legs to the tray with dissecting pins.

Figure 43.1 Pin the frog to the dissecting tray and make incisions through the skin as indicated.

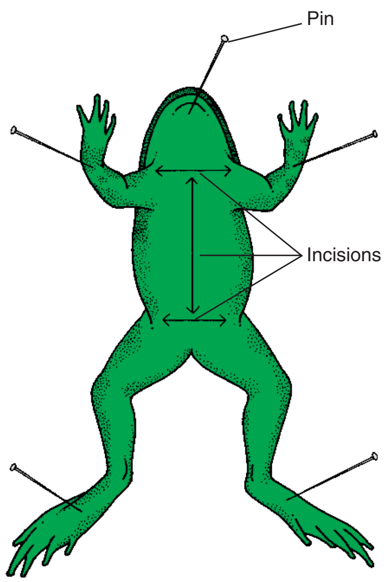
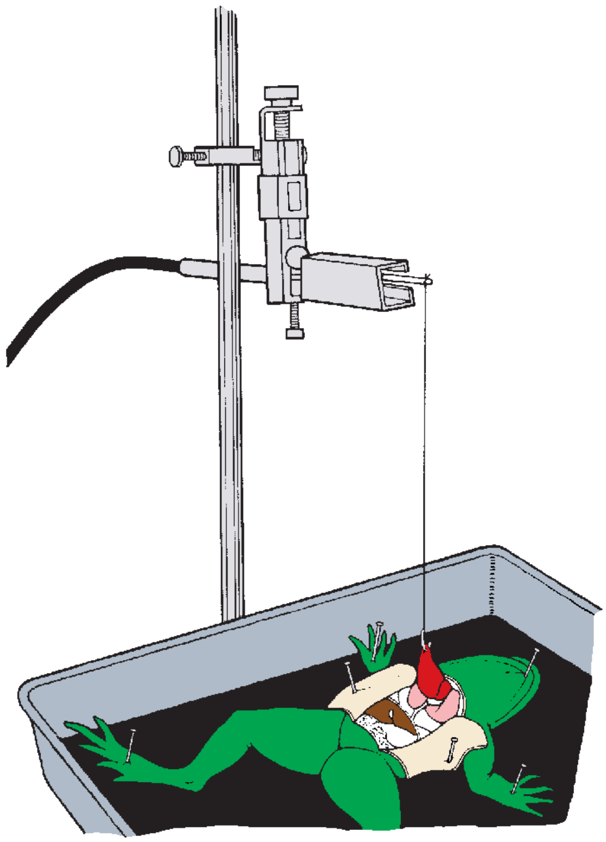


Figure 43.2 Attach a hook and thread to the tip of the ventricle.

c. Use scissors to make a midline incision through the skin from the pelvis to the jaw.
d. Cut the skin laterally on each side in the pelvic and pectoral regions, and pin the resulting flaps of skin to the tray (fig. 43.1).
e. Remove the exposed pectoral muscles and the sternum, being careful not to injure the underlying organs.
f. Note the beating heart surrounded by the thin-walled pericardium. Use forceps to lift the pericardium upward, and carefully slit it open with scissors, thus exposing the heart.
g. Flood the heart with frog Ringer's solution, and keep it moist throughout this exercise.
h. Note that the frog heart has only three chambers—two atria and a ventricle. Watch the heart carefully as it beats, and note the sequence of chamber movements during a cardiac cycle.

4. Tie a piece of thread about 45 cm long to a small metal hook, and insert the hook into the tip (apex) of the ventricle without penetrating the chamber (fig. 43.2). The laboratory instructor will demonstrate how to connect the thread to a physiological recording apparatus so that you can record the frog heart movements. The thread should be adjusted so that there is no slack in it, but at the same time it should not be so taut that it pulls the heart out of its normal position (fig. 43.3).

Figure 43.3 Attach the thread from the heart to the recording apparatus so that there is no slack in the thread.



5. Record the movements of the frog heart for 2–3 minutes. Identify on the recording the smaller atrial contraction waves and the larger ventricular contraction waves. Also, determine the heart rate (beats per minute) for each minute of recording, and calculate the average rate. Enter the results in Part B of the laboratory report.
6. Test the effect of temperature change on the frog's heart rate. To do this, follow these steps:
   a. Remove as much as possible of the Ringer's solution from around the heart, using a medicine dropper.
   b. Flood the heart with fresh Ringer's solution that has been cooled in an ice water bath to about 10°C (50°F).
   c. Record the heart movements, and determine the heart rate as before.
   d. Remove the cool liquid from around the heart, and replace it with room temperature Ringer's solution.
   e. After the heart is beating at its normal rate again, flood it with Ringer's solution that has been heated on a hot plate to about 35°C (95°F).
   f. Record the heart movements, and determine the heart rate as before.
   g. Enter the results in Part B of the laboratory report.
7. Complete Part B of the laboratory report.
8. Test the effect of an increased concentration of calcium ions on the frog heart. If the frog heart from the previous experiment is still beating, replace the fluid around it with room temperature Ringer's solution, and wait until its rate is normal. Otherwise, prepare a fresh specimen, and determine its normal rate as before. To perform the test, follow these steps:
   a. Flood the frog heart with 2% calcium chloride. (This solution of calcium chloride will allow ionization to occur providing Ca^{++}.)
   b. Record the heartbeat for about 5 minutes and note any change in rate.
   c. Flood the heart with fresh Ringer's solution until heart rate returns to normal.
9. Test the effect of an increased concentration of potassium ions on the frog heart. To do this, follow these steps:

   a. Flood the heart with 5% potassium chloride. (This solution of potassium chloride will allow ionization to occur providing K^+.)
   b. Record the heartbeat for about 5 minutes, and note any change in rate.
10. Complete Part C of the laboratory report.

OPTIONAL ACTIVITY

Plan an experiment to test the effect of some additional factor on the action of a frog heart. For example, you might test the effect of epinephrine, acetylcholine, caffeine, or some other available substance. If the laboratory instructor approves your plan, perform the experiment and record the heart movements. What do you conclude from the results of your experiment?

____

____

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Laboratory Report **43**

Name ______________________________

Date ______________________________

Section ______________________________

Factors Affecting the Cardiac Cycle

Part A

Complete the following statements:

1. The primary function of the heart is to ______________________________.
2. The ______________________ normally controls the heart rate.
3. Parasympathetic nerve fibers that supply the heart make up part of the ______________________ nerve.
4. Endings of parasympathetic nerve fibers secrete ______________________, which causes the heart rate to decrease.
5. Endings of sympathetic nerve fibers secrete ______________________, which causes the heart rate to increase.
6. The cardiac control center is located in the ______________________ of the brain stem.
7. Baroreceptors (pressoreceptors) located in the walls of the aorta and carotid arteries are sensitive to changes in ______________________.
8. If baroreceptors (pressoreceptors) in the walls of the venae cavae are stimulated by stretching, the cardioaccelerator center sends ______________________ impulses to the heart.
9. Rising body temperature usually causes the heart rate to ______________________.
10. Of the ions that affect heart action, the most important are ions of calcium and ______________________.

Part B

1. Describe the actions of the frog heart chambers during a cardiac cycle.

____

____

____

____

____

2. Attach a short segment of the normal frog heart recording in the following space. Label the atrial and ventricular waves of one cardiac cycle.

3. Temperature effect results:

Temperature	Heart Rate
10°C (50°F)	
Room temperature	
35°C (95°F)	

4. Summarize the effect of temperature on the frog's heart action that was demonstrated by this experiment. ______

Part C

Complete the following:

1. Describe the effect of an increased calcium ion (Ca^{++}) concentration on the frog's heart rate. ______

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2. Describe the effect of an increased potassium ion (K^+) concentration on the frog's heart rate. ______

Critical Thinking Application

In testing the effects of different ions on heart action, why were chlorides used in each case?

Laboratory Exercise 44

Blood Vessels

MATERIALS NEEDED

textbook
compound microscope
prepared microscope slides:
  artery cross section
  vein cross section
live frog
frog Ringer's solution
paper towel
rubber bands
frog board or heavy cardboard (with a 1-inch hole cut in one corner)
dissecting pins
thread
masking tape

For Optional Activity:

ice
hot plate
thermometer

SAFETY

- Wear disposable gloves when handling the live frogs.
- Return the frogs to the location indicated after the experiment.
- Wash your hands before leaving the laboratory.

The blood vessels form a closed system of tubes that carry blood to and from the heart, lungs, and body cells. These tubes include arteries and arterioles that conduct blood away from the heart; capillaries in which exchanges of substances occur between the blood and surrounding tissues; and venules and veins that return blood to the heart.

PURPOSE OF THE EXERCISE

To review the structure and functions of blood vessels and to observe examples of blood vessels microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the structure and functions of arteries, capillaries, and veins;
2. distinguish cross sections of arteries and veins microscopically;
3. identify the three major layers in the wall of an artery or vein;
4. identify the types of blood vessels in the web of a frog's foot.

PROCEDURE

1. Review a textbook section on *blood vessels.*
2. As a review activity, label figures 44.1 and 44.2.
3. Complete Part A of Laboratory Report 44.
4. Obtain a microscope slide of an artery cross section and examine it using low-power and high-power magnification. Identify the three distinct layers (tunics) of the arterial wall. The inner layer *(tunica interna),* is composed of an endothelium (simple squamous epithelium) and appears as a wavy line due to an abundance of elastic fibers that have recoiled just beneath it. The middle layer *(tunica media)* consists of numerous concentrically arranged smooth muscle cells with elastic fibers scattered among them. The outer layer *(tunica externa)* contains connective tissue that is rich in collagenous fibers (fig. 44.3).
5. Prepare a labeled sketch of the arterial wall in Part B of the laboratory report.
6. Obtain a slide of a vein cross section and examine it as you did the artery cross section. Note the thinner wall and larger lumen relative to an artery of comparable size. Identify the three layers of the wall and prepare a labeled sketch in Part B of the laboratory report.
7. Complete Part B of the laboratory report.
8. Observe the blood vessels in the webbing of a frog's foot. To do this, follow these steps:
   a. Obtain a live frog. Wrap its body in a moist paper towel, leaving one foot extending outward. Secure the towel with rubber bands, but be careful not to wrap the animal so tightly that it could be injured. Try to keep the nostrils exposed.

Figure 44.1 Label the tunics of the wall of this artery.

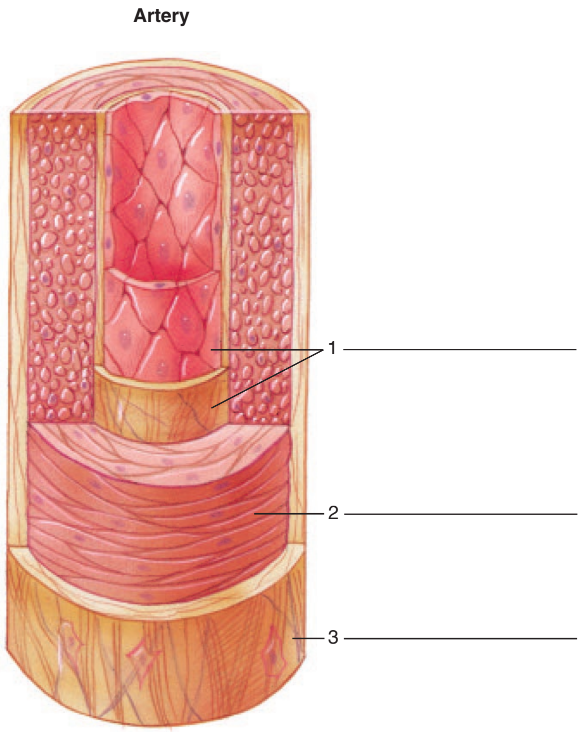
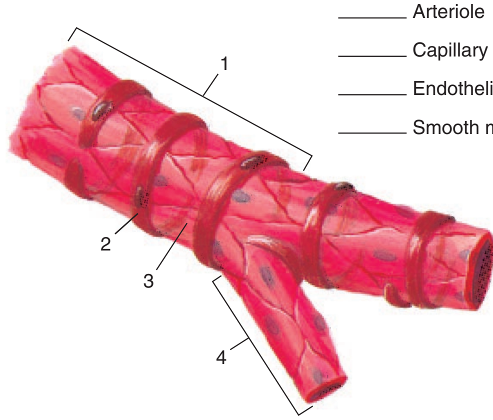


Figure 44.2 Label this arteriole by placing the correct numbers in the spaces provided.



_______ Arteriole

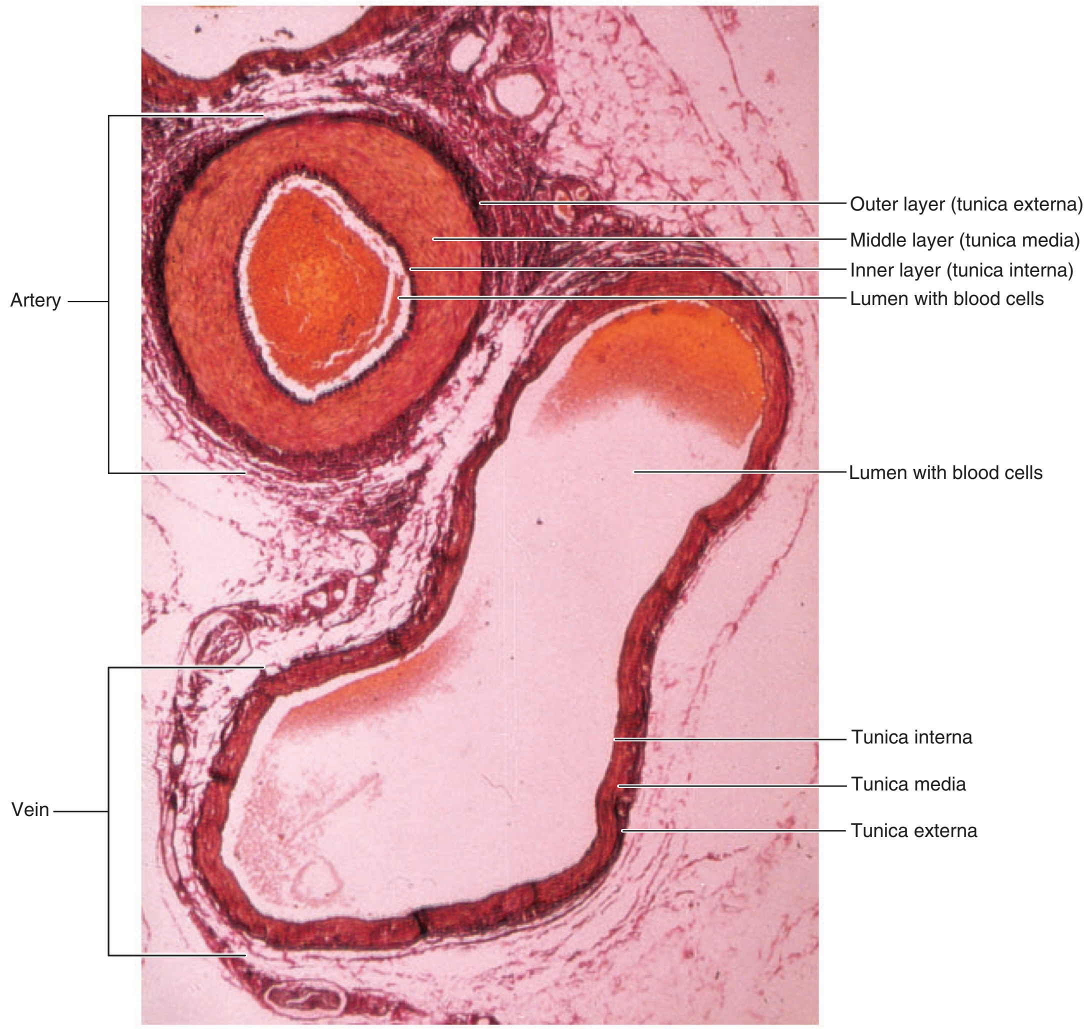
_______ Capillary

_______ Endothelium

_______ Smooth muscle cell

b. Place the frog on a frog board or on a piece of heavy cardboard with the foot near the hole in one corner.
c. Fasten the wrapped body to the board with masking tape.
d. Carefully spread the web of the foot over the hole and secure it to the board with dissecting pins and thread (fig. 44.4). Keep the web moist with frog Ringer's solution.
e. Secure the board on the stage of a microscope with heavy rubber bands and position it so that the web is beneath the objective lens.
f. Focus on the web using low-power magnification and locate some blood vessels. Note the movement of the blood cells and the direction of the blood flow. You might notice that red blood cells of frogs are nucleated. Identify an arteriole, a capillary, and a venule.

Figure 44.3 Cross section of an artery and a vein (5×).



g. Examine each of these vessels with high-power magnification.

OPTIONAL ACTIVITY

Investigate the effect of temperature change on the blood vessels of the frog's foot by flooding the web with a small quantity of ice water. Observe the blood vessels with low-power magnification and note any changes in their diameters or the rate of blood flow. Remove the ice water and replace it with water heated to about 35°C (95°F). Repeat your observations. What do you conclude from this experiment?

____

____

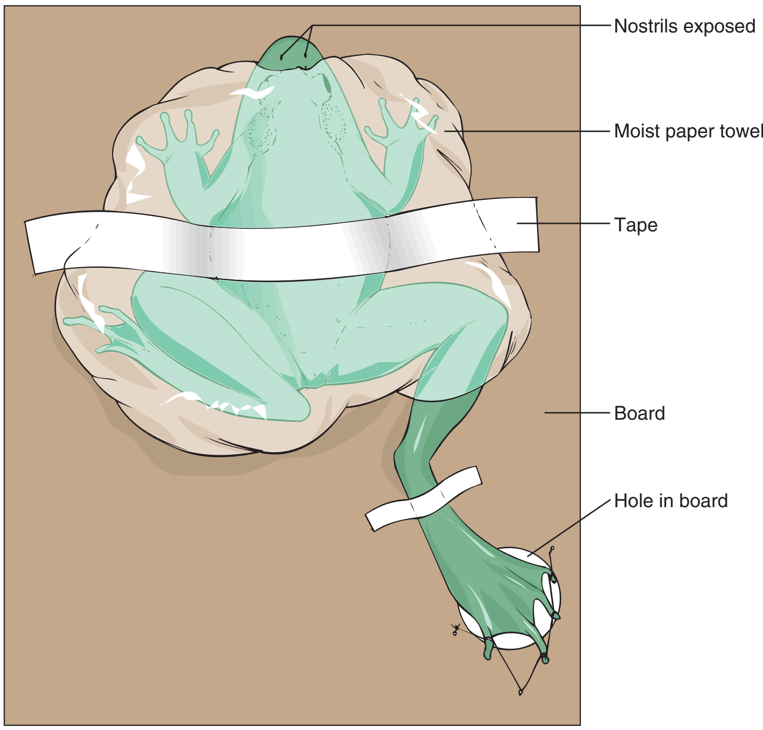
____

____

h. When finished, return the frog to the location indicated by your instructor. The microscope lenses and stage will likely need cleaning after the experiment.

9. Complete Part C of the laboratory report.

Figure 44.4 Spread the web of the foot over the hole and secure it to the board with pins and thread.



Laboratory Report **44**

Name ______________________________

Date ______________________________

Section ______________________________

Blood Vessels

Part A

Complete the following statements:

1. Simple squamous epithelial tissue called ________________________ forms the inner linings of the tunica interna of blood vessels.
2. The ________________________ of an artery wall contains many smooth muscle cells.
3. The ________________________ of an artery wall is largely composed of connective tissue.
4. Relaxation of the ________________________ in a blood vessel wall results in the vessel being in a condition of vasodilation.
5. The smallest blood vessels are called ________________________.
6. The protective tight arrangement between the capillaries and tissues of the brain is called the blood-brain ________________________.
7. Precapillary ________________________ are composed of smooth muscles that encircle the entrances to capillaries and thus can control the distribution of blood within tissues.
8. The process called ________________________ provides the most important means of transfer of biochemicals through capillary walls.
9. Filtration results when substances are forced through capillary walls by ________________________ pressure.
10. The presence of plasma proteins in blood increases its ________________________ pressure as compared to tissue fluids.
11. Excess tissue fluid is returned to the venous circulation by means of ________________________ vessels.
12. ________________________ in certain veins close if blood begins to back up in the vein.

Part B

1. Sketch and label a section of an arterial wall.

2. Sketch and label a section of a venous wall.

3. Describe the differences you noted in the structures of the arterial and venous walls. Mention each of the three layers of the wall. ____

____

____

____

____

Critical Thinking Application

Explain the functional significance of the differences you noted in the structures of the arterial and venous walls.

Part C

Complete the following:

1. How did you distinguish between arterioles and venules when you observed the vessels in the web of the frog's foot?

2. How did you recognize capillaries in the web?

3. What differences did you note in the rate of blood flow through the arterioles, capillaries, and venules?

4. Did you observe any evidence of precapillary sphincter activity? Explain your answer.

Laboratory Exercise 45

Pulse Rate and Blood Pressure

MATERIALS NEEDED

textbook
clock with second hand
sphygmomanometer
stethoscope
70% alcohol
absorbent cotton

For Demonstration:

pulse pickup transducer or plethysmogram
physiological recording apparatus

The surge of blood that enters the arteries each time the ventricles of the heart contract causes the elastic walls of these vessels to swell. Then, as the ventricles relax, the walls recoil. This alternate expanding and recoiling of an arterial wall can be felt as a pulse in vessels that run close to the surface of the body.

The force exerted by the blood pressing against the inner walls of arteries also creates blood pressure. This pressure reaches a maximum during ventricular contraction and then drops to its lowest level while the ventricles are relaxed.

PURPOSE OF THE EXERCISE

To examine the pulse, determine the pulse rate, measure blood pressure, and investigate the effects of body position and exercise on pulse rate and blood pressure.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. determine pulse rate;
2. test the effects of various factors on pulse rate;
3. measure blood pressure using a sphygmomanometer;
4. test the effects of various factors on blood pressure;
5. calculate pulse pressure and mean arterial pressure from blood pressure readings.

PROCEDURE

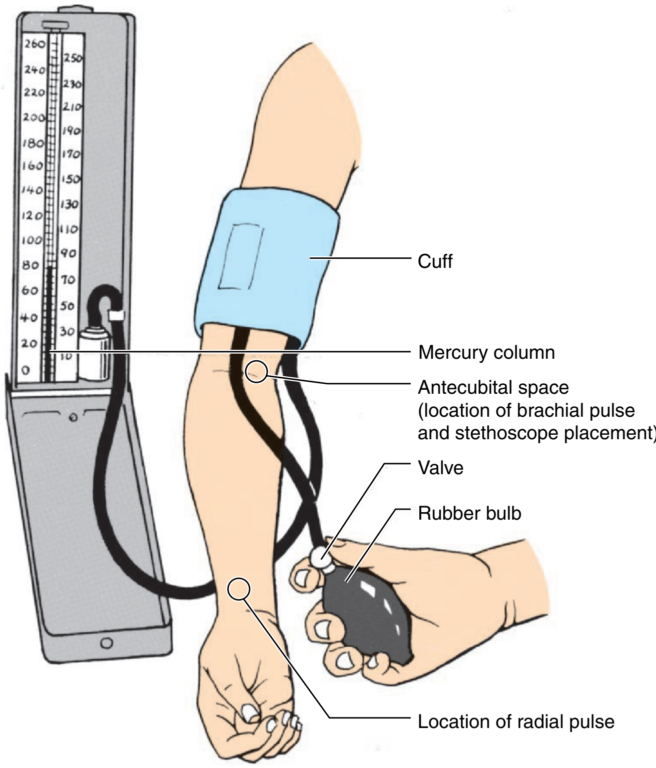
1. Review a textbook section on *blood pressure.*
2. Complete Part A of Laboratory Report 45.
3. Examine your laboratory partner's radial pulse. To do this, follow these steps:
   a. Have your partner sit quietly, remaining as relaxed as possible.
   b. Locate the pulse by placing your index and middle fingers over the radial artery on the anterior surface of the wrist. Do not use your thumb for sensing the pulse, because you may feel a pulse coming from an artery in the thumb itself.
   c. Note the characteristics of the pulse. That is, could it be described as regular or irregular, strong or weak, hard or soft?
   d. To determine the pulse rate, count the number of pulses that occur in 1 minute. This can be accomplished by counting pulses in 30 seconds and multiplying that number by 2.
4. Repeat the procedure and determine the pulse rate in each of the following conditions:
   a. immediately after lying down;
   b. 5 minutes after lying down;
   c. immediately after standing;
   d. 5 minutes after standing quietly;
   e. immediately after 3 minutes of strenuous exercise (omit if the person has health problems);
   f. 5 minutes after exercise has ended.
5. Complete Part B of the laboratory report.

DEMONSTRATION

If the equipment is available, the laboratory instructor will demonstrate how a photoelectric pulse pickup transducer or plethysmogram can be used together with a physiological recording apparatus to record the pulse. Such a recording allows an investigator to analyze certain characteristics of the pulse more precisely than is possible using a finger to examine the pulse. For example, the pulse rate can be determined very accurately from a recording, and the heights of the pulse waves provide information concerning the blood pressure.

6. Measure your laboratory partner's arterial blood pressure. To do this, follow these steps:
   a. Obtain a sphygmomanometer and a stethoscope.
   b. Clean the earpieces and the diaphragm of the stethoscope with cotton moistened with 70% alcohol.

Figure 45.1 Blood pressure is commonly measured by using a sphygmomanometer (blood pressure cuff).



c. Have your partner sit quietly with bare upper limb resting on a table at heart level. Have the person remain as relaxed as possible.
d. Locate the brachial artery at the antecubital space. Wrap the cuff of the sphygmomanometer around the arm so that its lower border is about 2.5 cm above the bend of the elbow. Center the bladder of the cuff in line with the *brachial pulse* (fig. 45.1).
e. Palpate the *radial pulse.* Close the valve on the neck of the rubber bulb connected to the cuff, and pump air from the bulb into the cuff. Inflate the cuff while watching the sphygmomanometer and note the pressure when the pulse disappears. (This is a rough estimate of the systolic pressure.) Immediately deflate the cuff.
f. Position the stethoscope over the brachial artery. Reinflate the cuff to a level 30 mm Hg higher than the point where the pulse disappeared during palpation.
g. Slowly open the valve of the bulb until the pressure in the cuff drops at a rate of about 2 or 3 mm Hg per second.
h. Listen for sounds (Korotkoff sounds) from the brachial artery. When the first loud tapping sound is heard, record the reading as the systolic pressure. This indicates the pressure exerted against the arterial wall during systole.
i. Continue to listen to the sounds as the pressure drops, and note the level when the last sound is heard. Record this reading as the diastolic pressure, which measures the constant arterial resistance.
j. Release all of the pressure from the cuff.
k. Repeat the procedure until you have two blood pressure measurements from each arm, allowing 2–3 minutes of rest between readings.
l. Average your readings and enter them in the table in Part C of the laboratory report.

7. Measure your partner's blood pressure in each of the following conditions:
   a. immediately after lying down;
   b. 5 minutes after lying down;
   c. immediately after standing;
   d. 5 minutes after standing quietly;
   e. immediately after 3 minutes of strenuous exercise (omit if the person has health problems);
   f. 5 minutes after exercise has ended.
8. Complete Part C of the laboratory report.

Laboratory Report **45**

Name ______________________________

Date ______________________________

Section ______________________________

Pulse Rate and Blood Pressure

Part A

Complete the following statements:

1. The maximum pressure achieved during ventricular contraction is called ________________________ pressure.
2. The lowest pressure that remains in the arterial system during ventricular relaxation is called ________________________ pressure.
3. The pulse rate is equal to the ________________________ rate.
4. A pulse that feels full and is not easily compressed is produced by an elevated ________________________.
5. The instrument commonly used to measure systemic arterial blood pressure is called a ________________________.
6. Blood pressure is expressed in units of ________________________.
7. The upper number of the fraction used to record blood pressure indicates the ________________________ pressure.
8. The ________________________ artery in the arm is the standard systemic artery in which blood pressure is measured.

Part B

1. Enter your observations of pulse characteristics and pulse rates in the table.

Test Subject	Pulse Characteristics	Pulse Rate
Sitting		
Lying down		
5 minutes later		
Standing		
5 minutes later		
After exercise		
5 minutes later		

2. Summarize the effects of body position and exercise on the characteristics and rates of the pulse. ______________

____

____

____

Part C

1. Enter the initial measurements of blood pressure in the table.

Reading	Blood Pressure in Right Arm	Blood Pressure in Left Arm
First		
Second		
Average		

2. Enter your test results in the table.

Test Subject	Blood Pressure
Lying down	
5 minutes later	
Standing	
5 minutes later	
After exercise	
5 minutes later	

3. Summarize the effects of body position and exercise on blood pressure. ______________________

____

____

____

4. Summarize any correlations between pulse rate and blood pressure from any of the experimental conditions.

____

____

____

Critical Thinking Application

When a pulse is palpated and counted, which blood pressure (systolic or diastolic) would be characteristic at that moment? Explain your answer.

____

____

____

____

Laboratory Exercise 46

Major Arteries and Veins

MATERIALS NEEDED

textbook
human torso
anatomical charts of the cardiovascular system

The blood vessels of the cardiovascular system can be divided into two major pathways—the pulmonary circuit and the systemic circuit. Within each circuit, arteries transport blood away from the heart. After exchanges of gases, nutrients, and wastes have occurred between the blood and the surrounding tissues, veins return the blood to the heart.

PURPOSE OF THE EXERCISE

To review the major circulatory pathways and to locate the major arteries and veins on anatomical charts and in the torso.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. distinguish and trace the pulmonary and systemic circuits;
2. locate the major arteries in these circuits on a chart or model;
3. locate the major veins in these circuits on a chart or model.

PROCEDURE A—PATHS OF CIRCULATION

1. Review textbook sections on the *pulmonary circuit* and *systemic circuit.*
2. As a review activity, label figure 46.1.
3. Locate the following blood vessels on the available anatomic charts and the human torso:

   pulmonary trunk

   pulmonary arteries

   pulmonary veins

   aorta

   superior vena cava

   inferior vena cava

Critical Thinking Application

Why is the left ventricle wall thicker than the right ventricle wall?

____

____

____

____

PROCEDURE B—THE ARTERIAL SYSTEM

1. Review a textbook section on the *arterial system.*
2. As a review activity, label figures 46.2, 46.3, 46.4, and 46.5.
3. Locate the following arteries of the systemic circuit on the charts and torso:

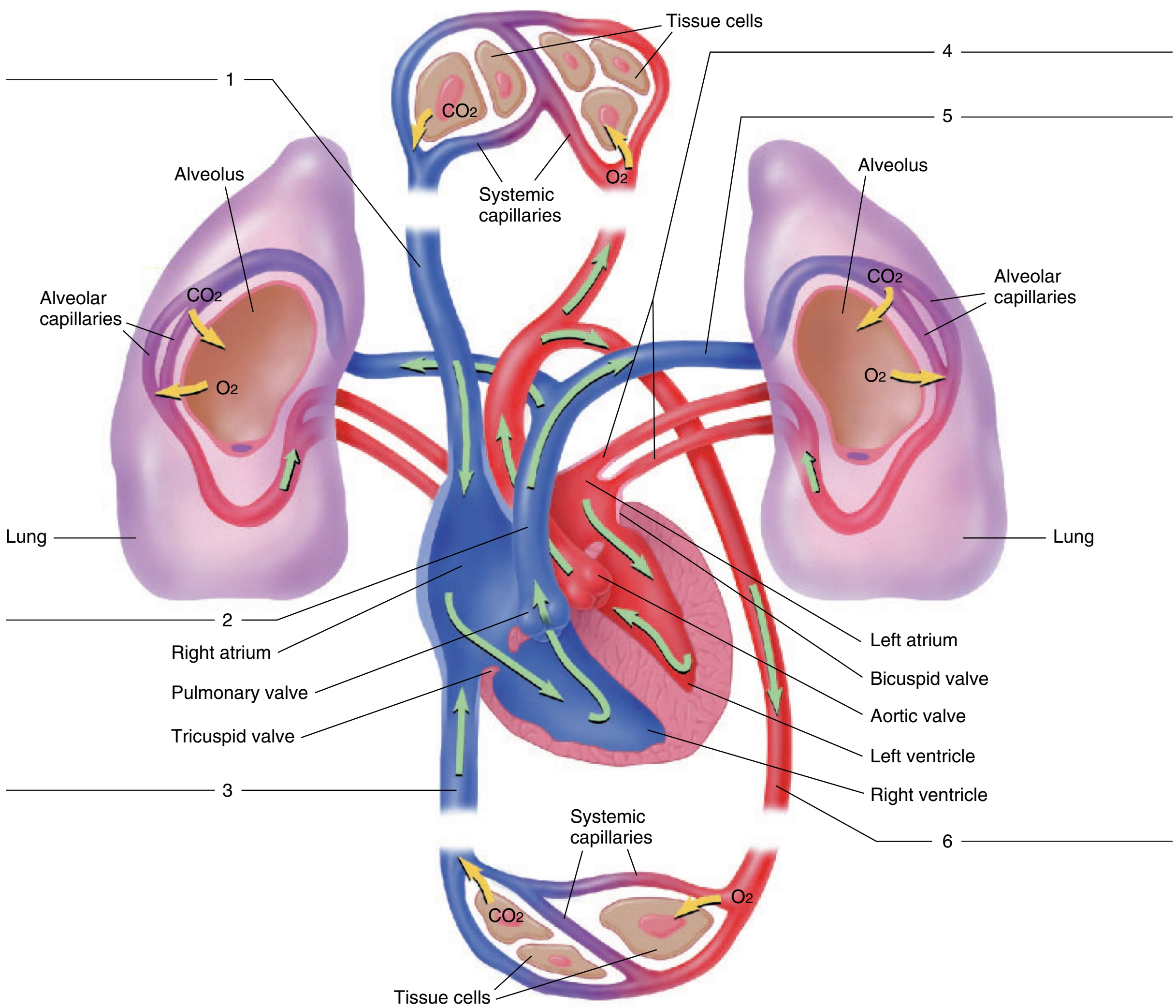
   aorta

   - ascending aorta
   - aortic sinus
   - aortic arch (arch of the aorta)
   - thoracic aorta
   - abdominal aorta

   branches of the aorta

   - coronary arteries
   - brachiocephalic artery
   - left common carotid artery
   - left subclavian artery
   - celiac artery
     - gastric artery

Figure 46.1 Label the major blood vessels associated with the pulmonary and systemic circuits.



splenic artery

hepatic artery

superior mesenteric artery

suprarenal arteries

renal arteries

gonadal arteries

ovarian arteries

testicular arteries

inferior mesenteric artery

middle sacral artery

common iliac arteries

arteries to neck, head, and brain

vertebral arteries

thyrocervical arteries

common carotid arteries

external carotid arteries

superior thyroid artery

superficial temporal artery

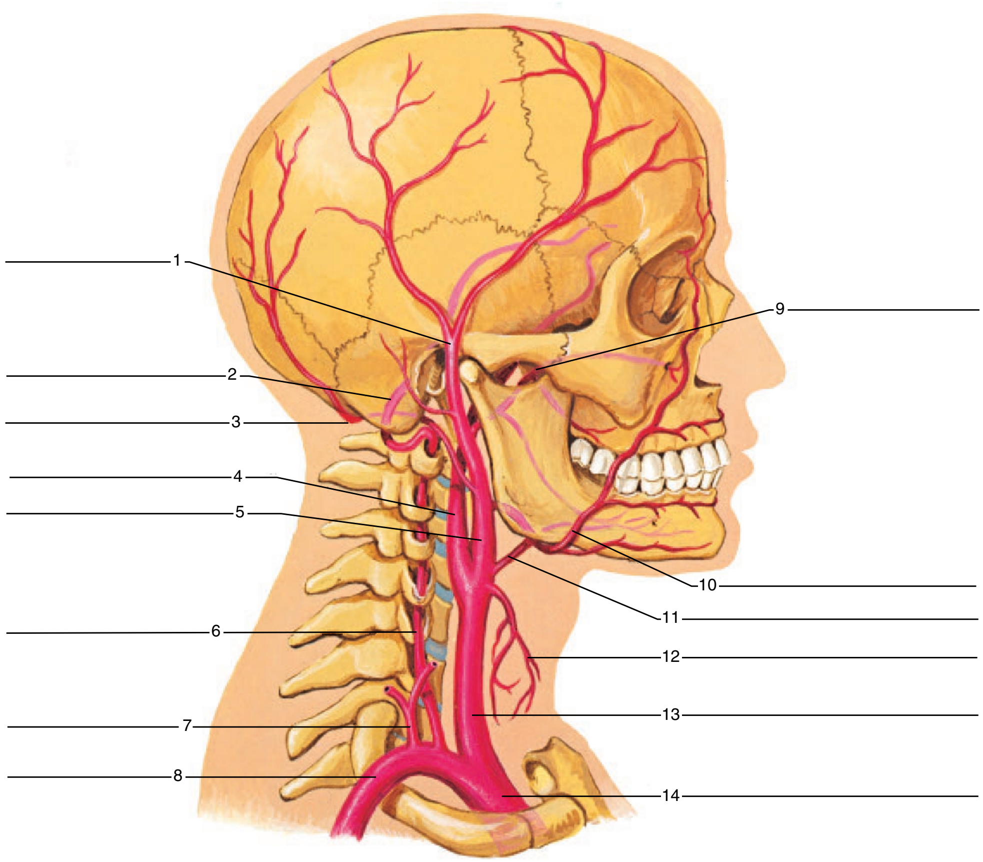
facial artery

internal carotid arteries

arteries to shoulder and upper limb

axillary artery

Figure 46.2 Label the arteries supplying the right side of the neck and head. (Note that the clavicle has been removed.)



brachial artery

deep brachial artery

ulnar artery

radial artery

arteries to the thoracic and abdominal walls

internal thoracic artery

anterior intercostal artery

posterior intercostal artery

arteries to pelvis and lower limb

common iliac artery

internal iliac artery

external iliac artery

femoral artery

deep femoral artery

popliteal artery

anterior tibial artery

dorsalis pedis artery (dorsal pedis artery)

posterior tibial artery

4. Complete Parts A and B of Laboratory Report 46.

PROCEDURE C— THE VENOUS SYSTEM

1. Review a textbook section on the *venous system.*
2. As a review activity, label figures 46.6, 46.7, 46.8, 46.9, and 46.10.
3. Locate the following veins of the systemic circuit on the charts and the torso:

veins from head, neck, and brain

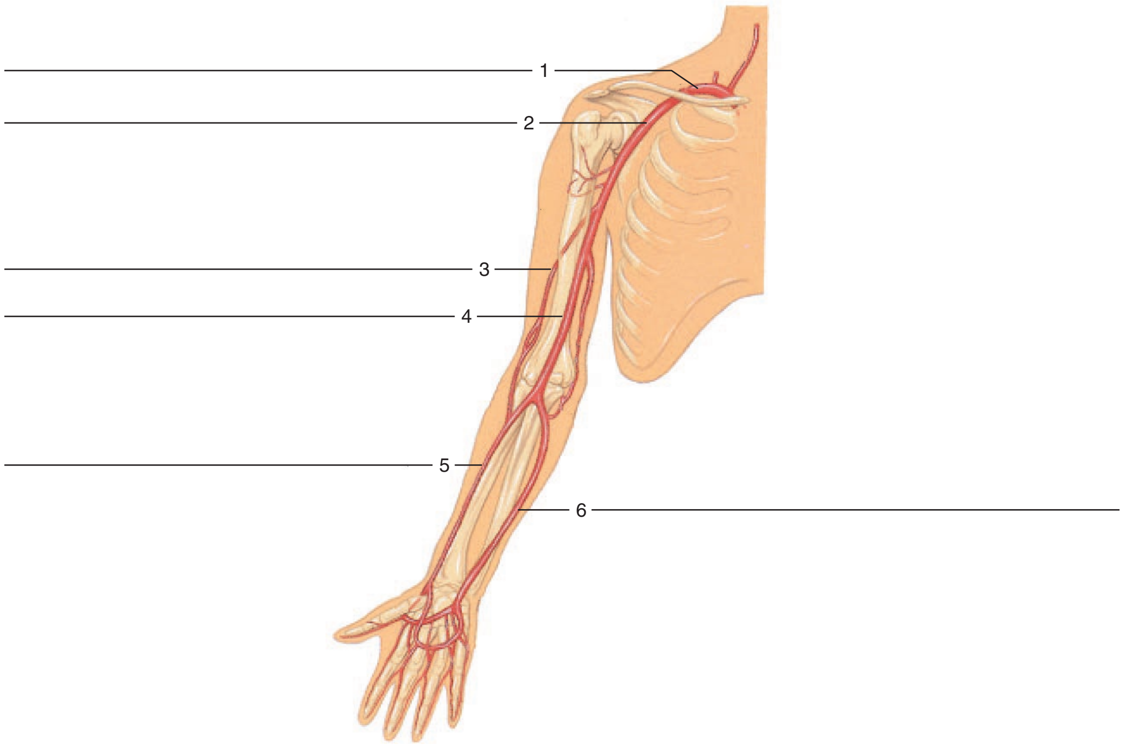
external jugular veins

internal jugular veins

subclavian veins

brachiocephalic veins

Figure 46.3 Label the major arteries of the shoulder and upper limb.



superior vena cava

veins from upper limb and shoulder

radial vein

ulnar vein

brachial vein

basilic vein

axillary vein

cephalic vein

median cubital vein

subclavian vein

veins of the abdominal and thoracic walls

internal thoracic veins

intercostal veins

azygos vein

posterior intercostal veins

superior hemiazygos vein

inferior hemiazygos vein

veins of the abdominal viscera

hepatic portal vein

gastric vein

superior mesenteric vein

splenic vein

inferior mesenteric vein

hepatic vein

gonadal vein

renal vein

suprarenal vein

veins from lower limb and pelvis

anterior tibial vein

posterior tibial vein

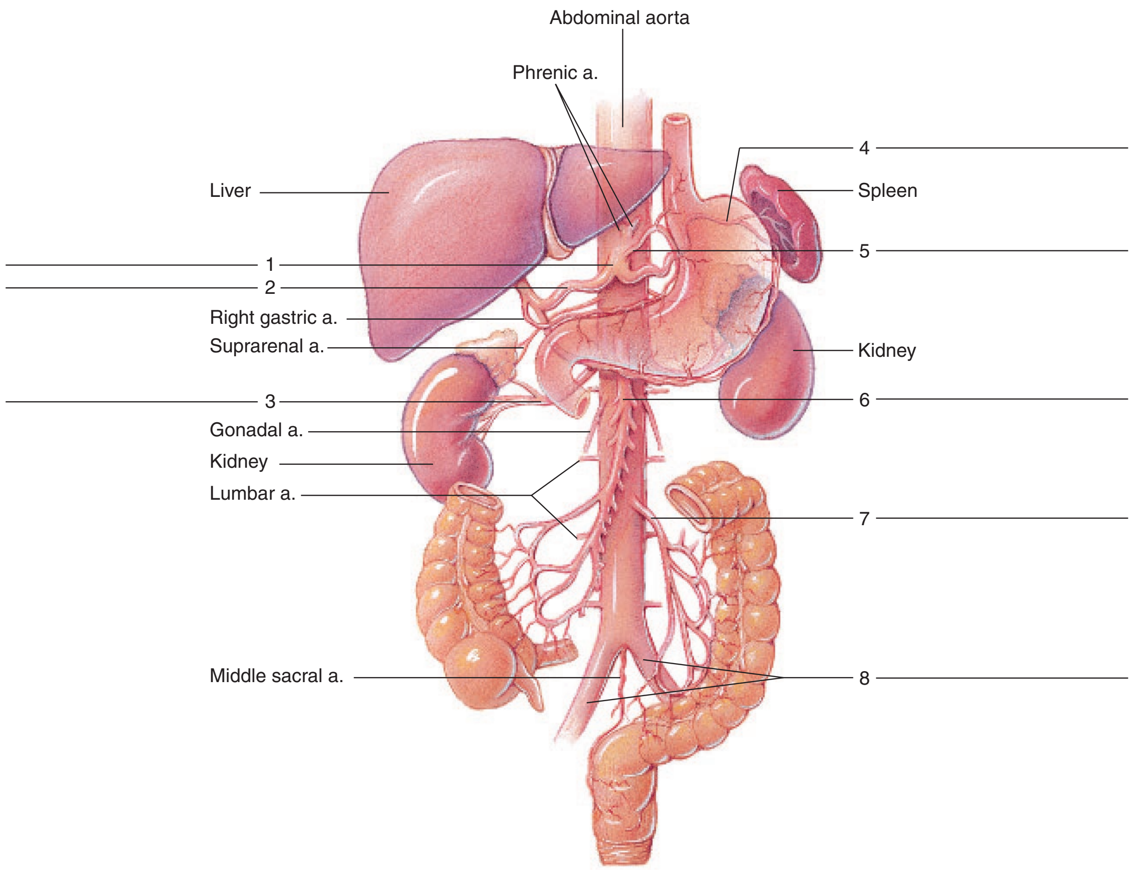
popliteal vein

femoral vein

great saphenous vein

small saphenous vein

Figure 46.4 Label the arteries associated with the abdominal aorta.



external iliac vein

internal iliac vein

common iliac vein

inferior vena cava

4. Complete Parts C, D, and E of the laboratory report.

Web Quest

Identify the major arteries and veins and describe their functions. Observe an animation of the exchanges in a capillary. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 46.5 Label the major arteries supplying the pelvis and lower limb.

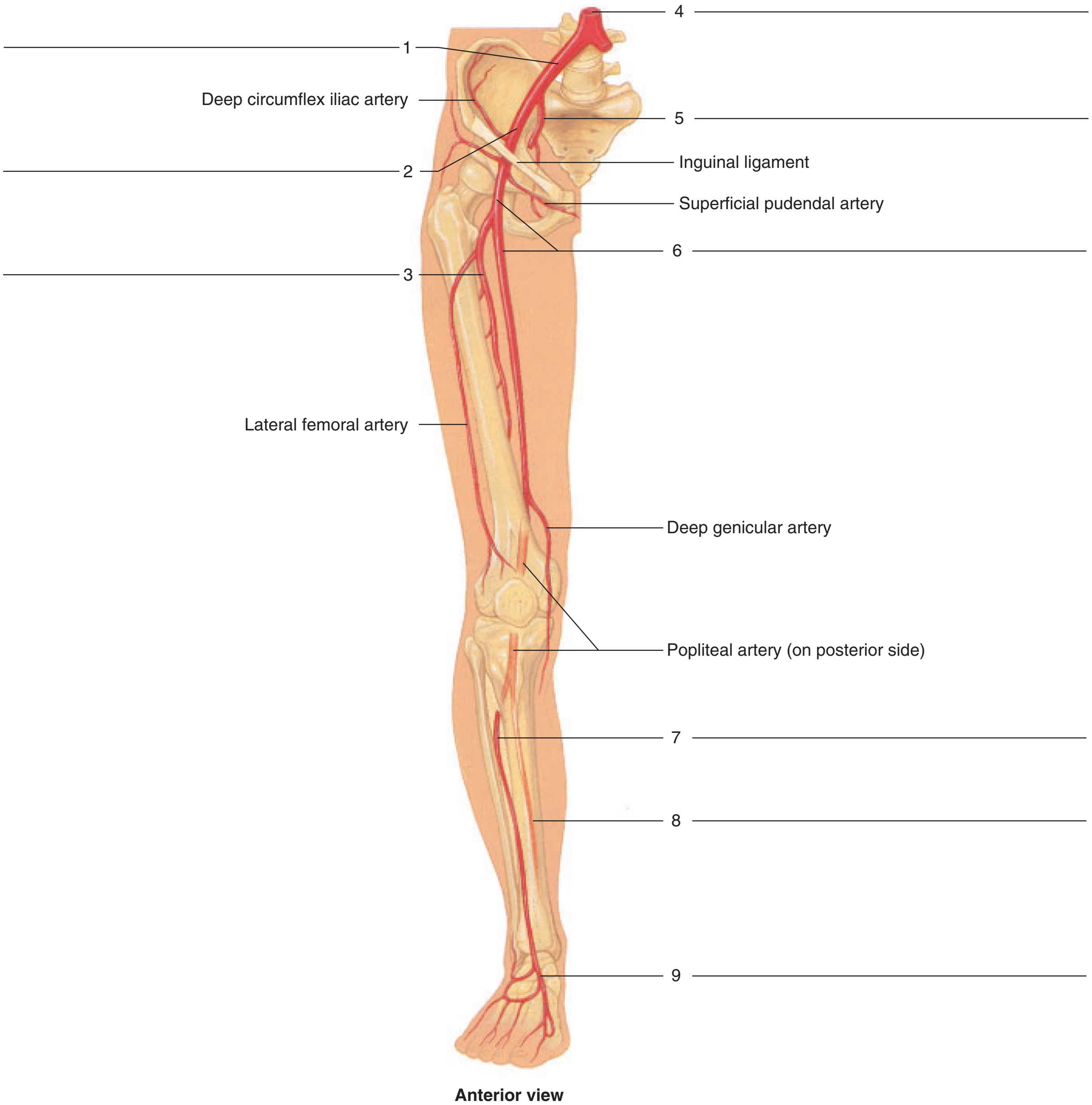


Figure 46.6 Label the major veins associated with the head and neck. (Note that the clavicle has been removed.)

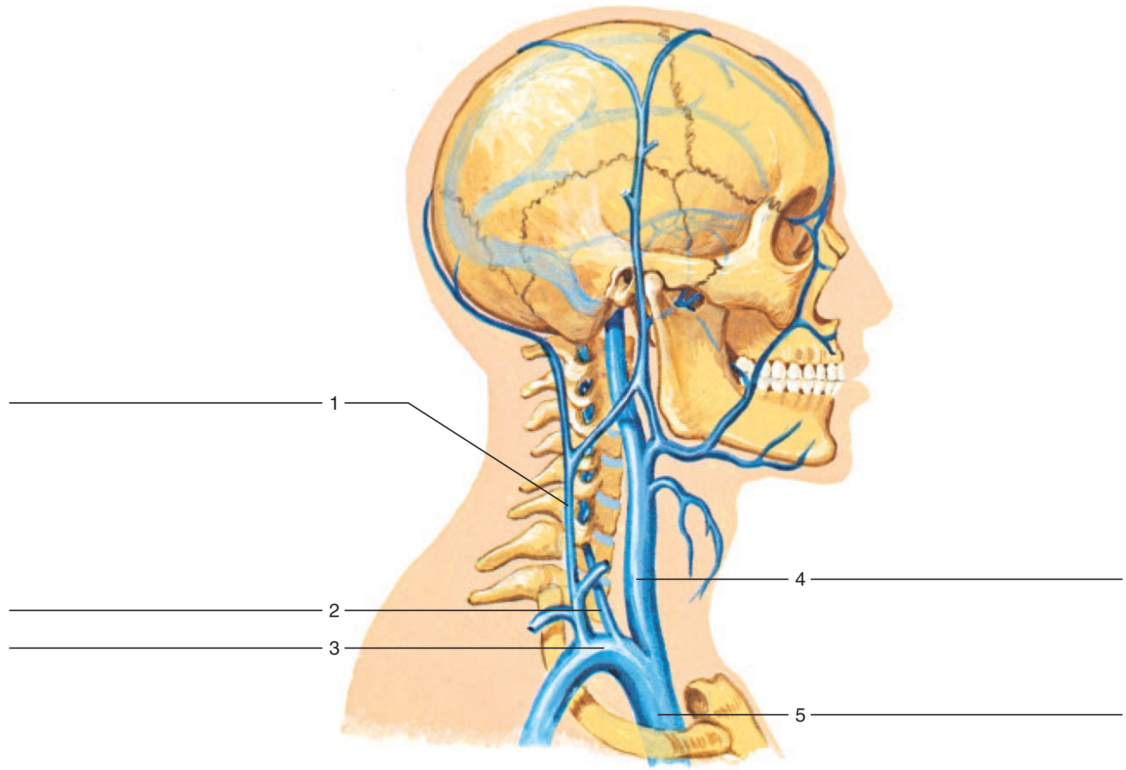


Figure 46.7 Label the veins associated with the thoracic wall.

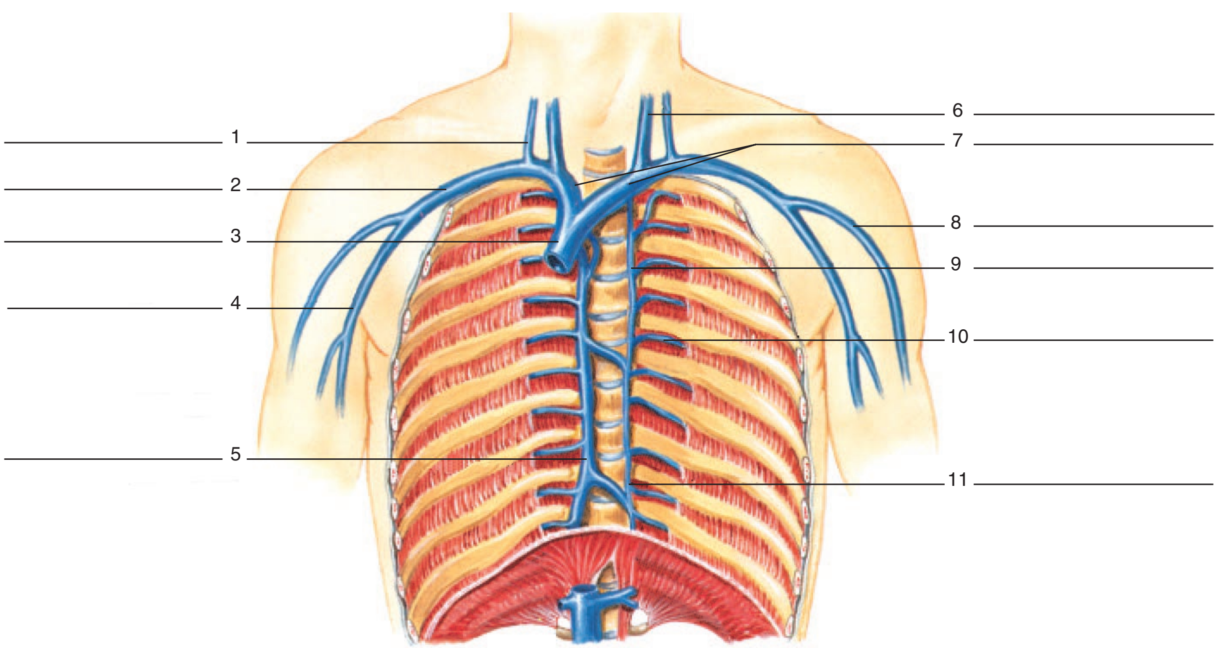


Figure 46.8 Label the veins of the upper limb and shoulder.

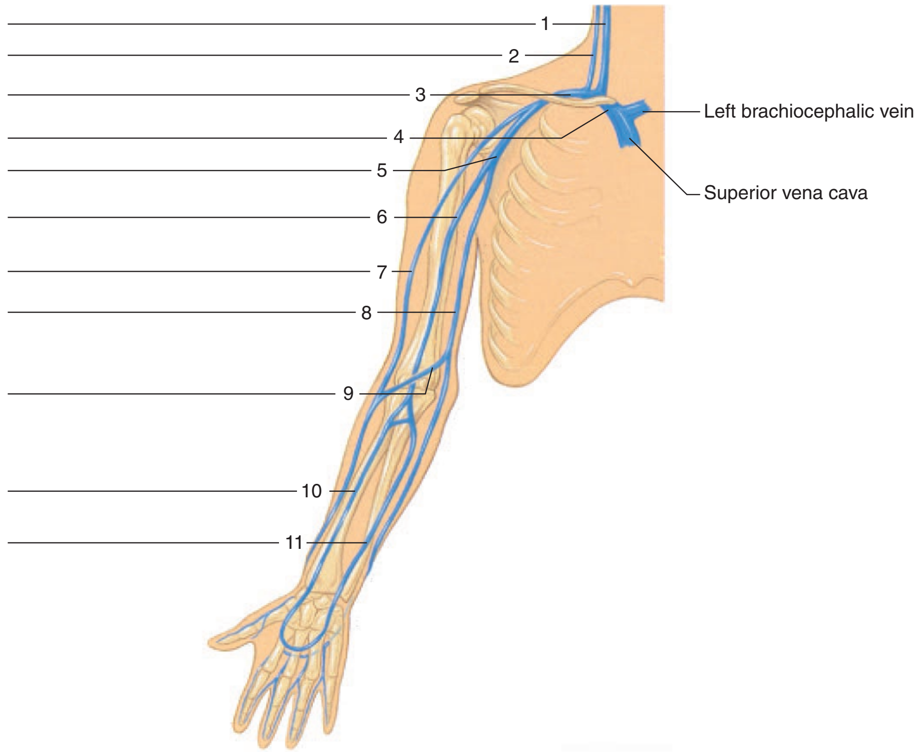
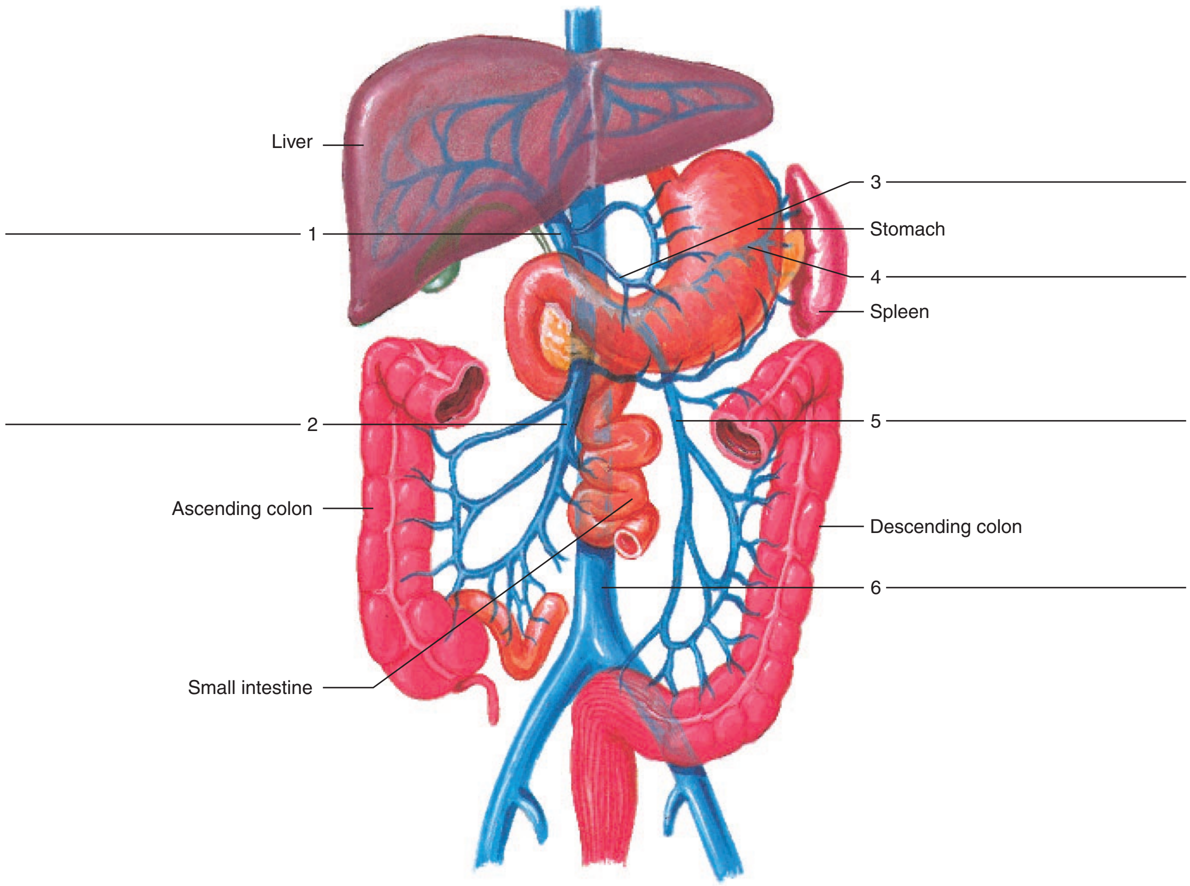


Figure 46.9 Label the veins that drain the abdominal viscera.



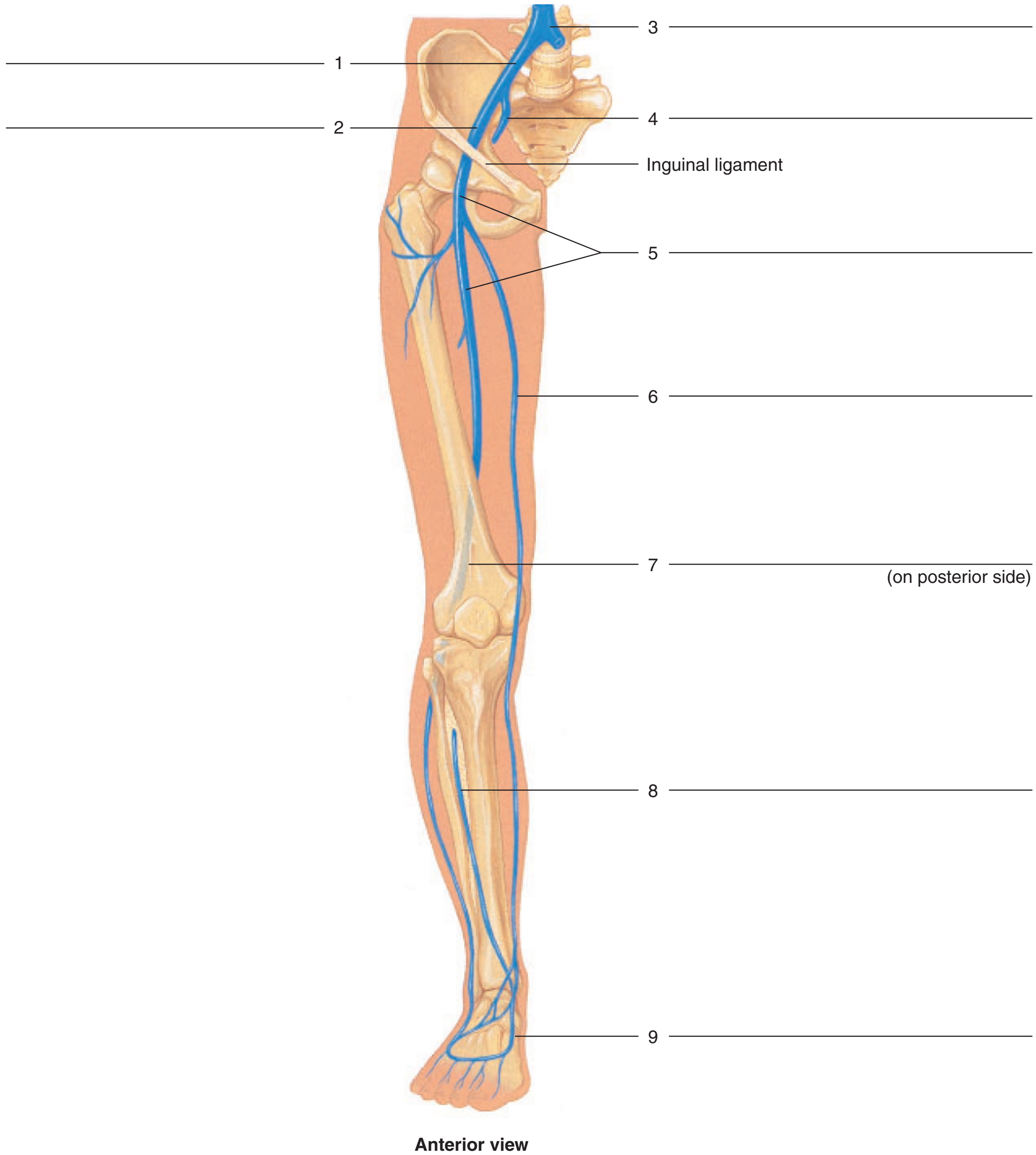


Figure 46.10 Label the veins of the pelvis and lower limb.

Laboratory Report **46**

Name ______________________________

Date ______________________________

Section ______________________________

Major Arteries and Veins

Part A

Match the arteries in column A with the regions supplied in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. anterior tibial	____	1. jaw, teeth, and face
b. celiac	____	2. larynx, trachea, thyroid gland
c. costocervical	____	3. kidney
d. deep brachial	____	4. upper digestive tract, spleen, and liver
e. external carotid	____	5. foot and toes
f. inferior mesenteric	____	6. gluteal muscles
g. internal carotid	____	7. triceps muscle
h. internal iliac	____	8. thoracic wall
i. lumbar	____	9. posterior abdominal wall
j. phrenic	____	10. adrenal gland
k. popliteal	____	11. diaphragm
l. renal	____	12. lower colon
m. suprarenal	____	13. brain
n. thyrocervical	____	14. forearm muscles
o. ulnar	____	15. knee joint

Part B

Provide the name of the missing artery in each of the following sequences:

1. brachiocephalic artery, ________________________, right axillary artery
2. ascending aorta, ________________________, thoracic aorta
3. abdominal aorta, ________________________, ascending colon
4. brachiocephalic artery, ________________________, right external carotid artery
5. axillary artery, ________________________, radial artery
6. common iliac artery, ________________________, femoral artery
7. pulmonary trunk, ________________________, lungs

Part C

Match each vein in column A with the vein it drains into from column B. Place the letter of your choice in the space provided.

Column A		Column B
a. anterior tibial	____	1. popliteal
b. basilic	____	2. axillary
c. brachiocephalic	____	3. inferior vena cava
d. common iliac	____	4. subclavian
e. external jugular	____	5. brachial
f. femoral	____	6. superior vena cava
g. popliteal	____	7. femoral
h. radial	____	8. external iliac

Part D

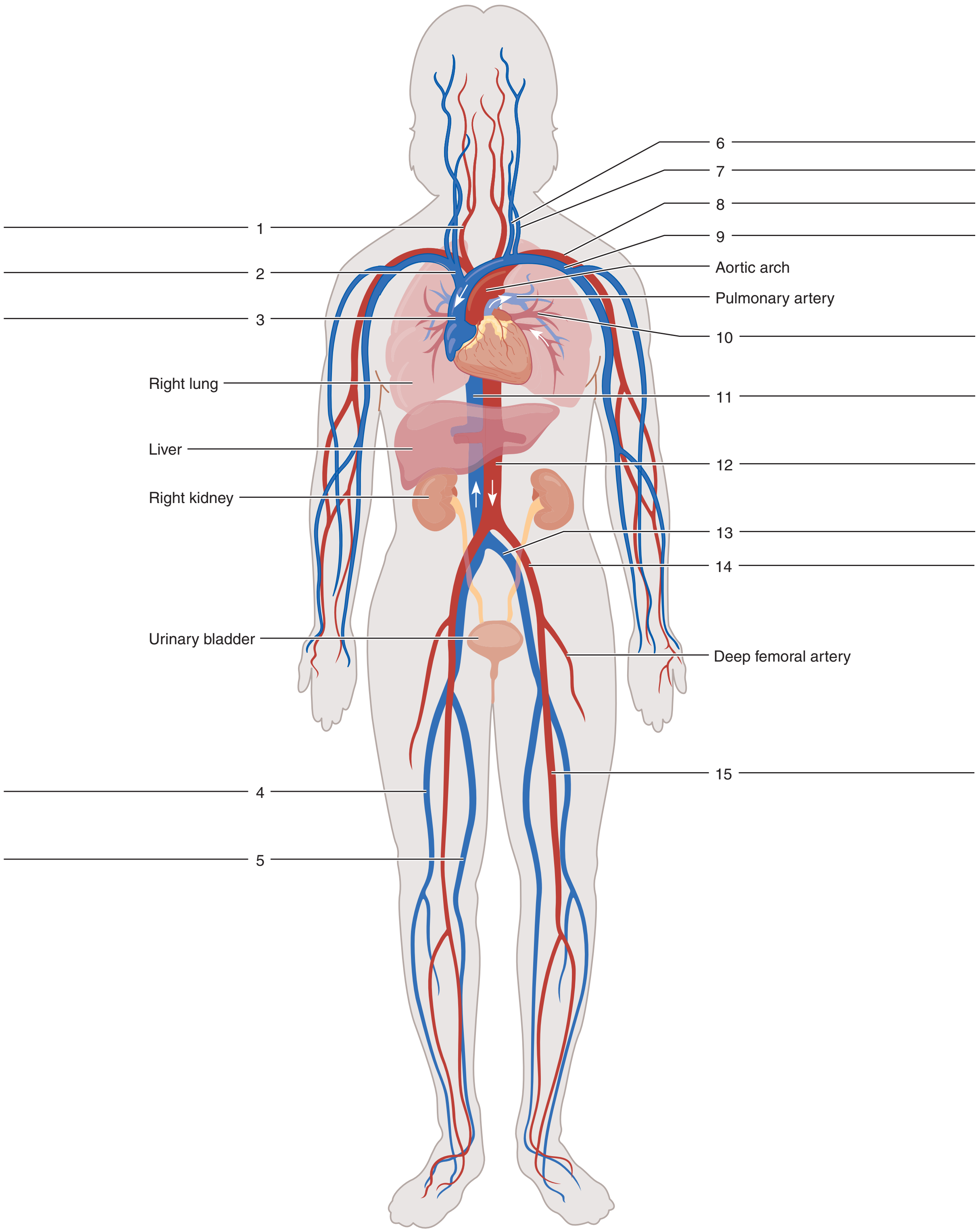
Provide the name of the missing vein or veins in each of the following sequences:

1. right subclavian vein, ________________________, superior vena cava
2. posterior tibial vein, ________________________, femoral vein
3. internal iliac vein, ________________________, inferior vena cava
4. medial cubital vein, ________________________, axillary vein
5. great saphenous vein, ________________________, external iliac vein
6. liver, ________________________, inferior vena cava
7. lungs, ________________________, left atrium
8. kidney, ________________________, inferior vena cava

Part E

Label the major arteries and veins indicated in figure 46.11.

Figure 46.11 Label the major arteries and veins of the systemic and pulmonary circuits.



Laboratory Exercise 47

Fetal Pig Dissection: Cardiovascular System

MATERIALS NEEDED

preserved fetal pig
dissecting tray
dissecting instruments
twine
disposable gloves
human torso

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

In this laboratory exercise, you will dissect the major organs of the cardiovascular system of the fetal pig. As before, while you are examining the organs of the fetal pig, compare them with the corresponding organs of the human torso.

If the cardiovascular system of the fetal pig has been injected, the arteries will be filled with red latex (large arteries may not be real red because of the thick wall) and the veins will be filled with blue latex. This will make it easier for you to trace the vessels as you dissect them.

PURPOSE OF THE EXERCISE

To examine the major organs of the cardiovascular system of the fetal pig, and to compare them with the corresponding organs of the human torso.

LEARNING OBJECTIVES

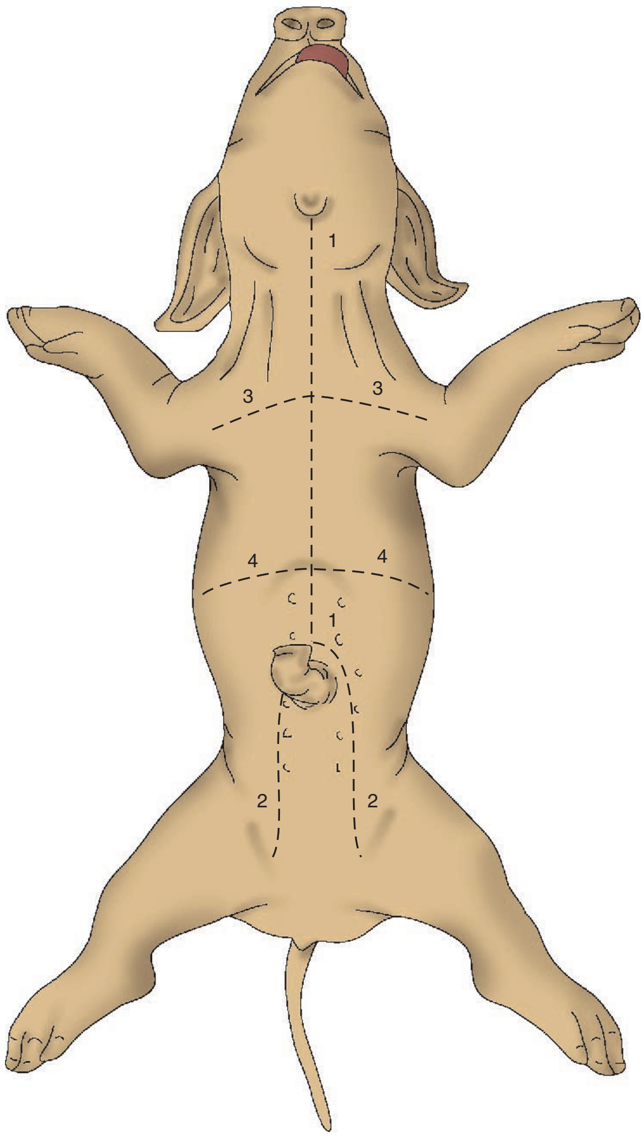
After completing this exercise, you should be able to

1. locate and identify the major organs of the cardiovascular system of the fetal pig;
2. locate and identify fetal circulatory features of the fetal pig and contrast fetal and adult circulation;
3. identify the corresponding organs in the human torso;
4. compare the features of the cardiovascular system of the fetal pig with those of the human.

PROCEDURE A— THE ARTERIAL SYSTEM

1. Place the fetal pig in the dissecting tray with its ventral side up. Spread and secure all four limbs with twine.
2. Open the thoracic cavity, and expose its contents. To do this, follow these steps:
   a. Make a longitudinal incision passing anteriorly from the diaphragm along one side of the sternum. Continue the incision through the neck muscles to the mandible. Try to avoid damaging the internal organs as you cut. Make a lateral cut on each side of the sternum into each arm (fig. 47.1).
   b. Make a lateral cut on each side along the anterior surface of the diaphragm, and cut the diaphragm loose from the thoracic wall.
   c. Spread the sides of the thoracic wall outward, and use a scalpel to make a longitudinal cut along each side of the inner wall of the rib cage to weaken the ribs. Continue to spread the thoracic wall laterally to break the ribs so that the flaps of the wall will remain open. It is often necessary to rinse the body cavities to remove any coagulated blood or excess latex that has leaked out during injection.
3. Note the location of the heart and the large blood vessels associated with it. Slit the thick *parietal pericardium* that surrounds the heart by cutting with scissors along the midventral line. Note how this membrane is connected to the *visceral pericardium* that is attached to the surface of the heart. Locate the *pericardial cavity,* the space between the two layers of the pericardium.
4. Remove the thymus gland to expose blood vessels anterior to the heart. Examine the heart (see figs. 41.1, 41.2, 41.3, and 47.2). It should be noted that

Figure 47.1 Incision lines indicate the locations for opening the ventral body cavity.



the arrangement of blood vessels coming off the aortic arch is different in the pig than in a human body. Locate the following:

right atrium

left atrium

right ventricle

left ventricle

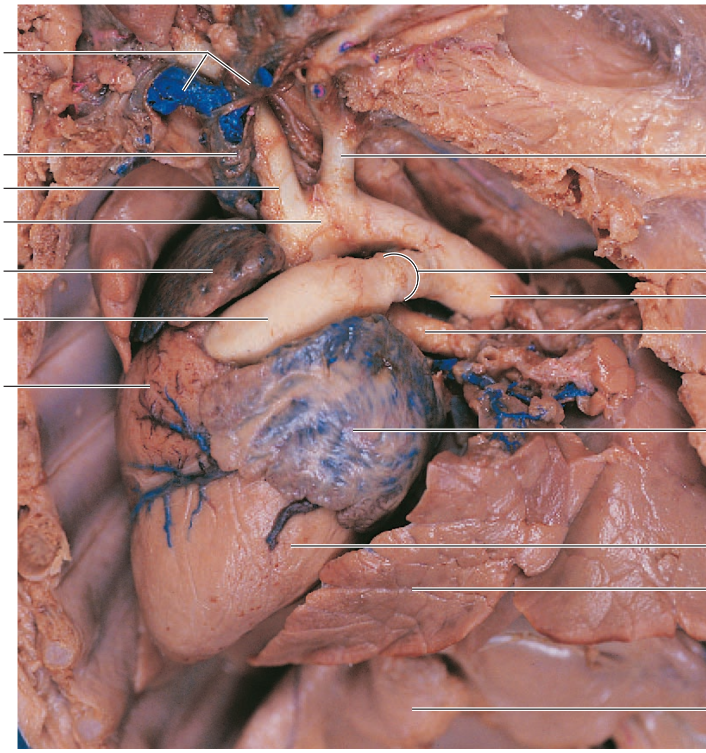
pulmonary trunk

aorta

coronary arteries

5. Trace the pulmonary trunk and locate the short vessel, the *ductus arteriosus,* that is connected to the aorta (fig. 47.2). This connection, found in fetal circulation, shunts blood from the pulmonary artery to the aorta as a partial bypass of nonfunctional, developing fetal lungs. This shunt becomes occluded after birth (forming the *ligamentum arteriosum*), allowing a fully functional pulmonary circuit.
6. Use a scalpel to open the heart chambers by making a cut along the frontal plane from its apex to its base. Remove any remaining latex from the chambers. Examine the valves between the chambers, and note the relative thicknesses of the chamber walls. Do not

Figure 47.2 Heart and associated arteries and veins of fetal circulation, ventral view. The anterior portion of the left lung has been removed.



remove the heart as it is needed for future relationship of major blood vessels.

7. Using figure 47.3 as a guide, locate and dissect the following arteries of the thorax and neck.

   aortic arch

   brachiocephalic trunk (artery)

   right subclavian artery

   left subclavian artery

   right common carotid artery

   left common carotid artery

8. Trace the right subclavian artery into the forelimb, and locate the following arteries:

   axillary artery

   brachial artery

   radial artery

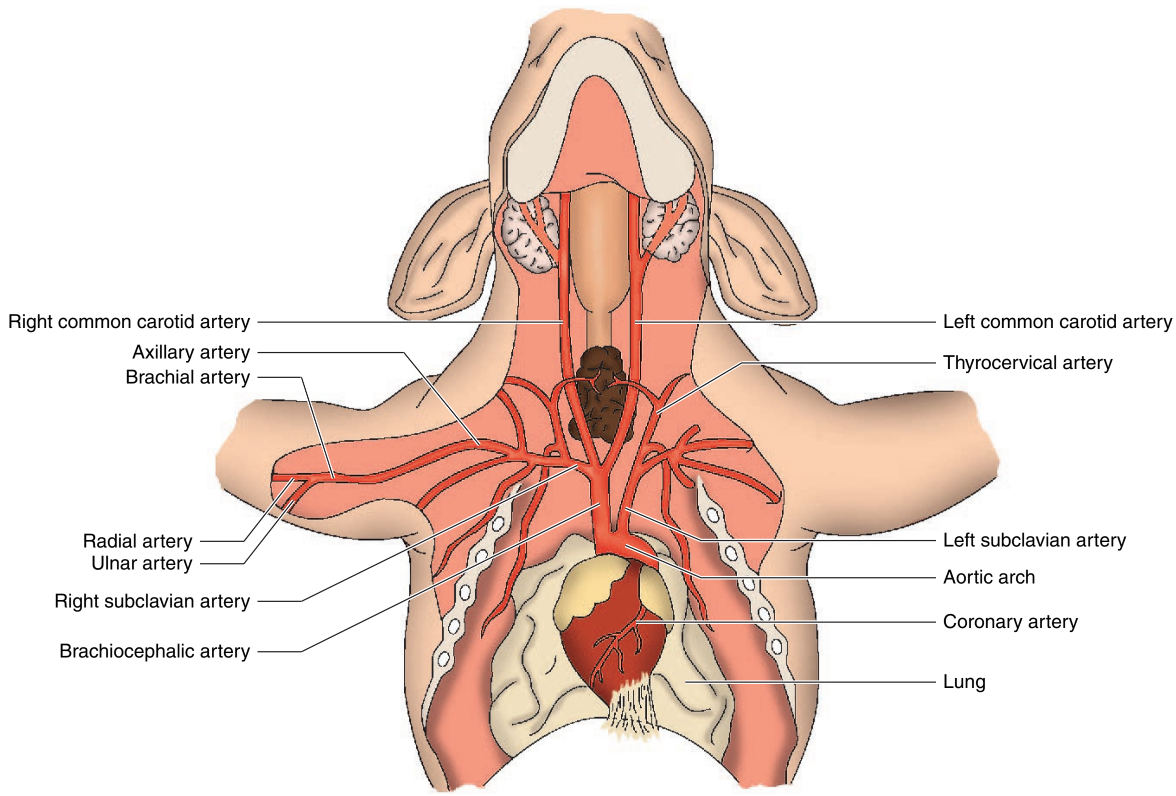
   ulnar artery

9. Open the abdominal cavity. To do this, follow these steps:
   a. Use scissors to make two longitudinal incisions from the pubic bones and continuing around the umbilical cord to meet at the midline. Extend the incision anteriorly to the diaphragm.
   b. Make a lateral incision through the body wall along either side of the inferior border of the diaphragm and along the bases of the thighs.
   c. Reflect the flaps created in the body wall as you would open a book, and expose the contents of the abdominal cavity. Sever the *umbilical vein* that extends from the umbilical cord to the liver. Reflect the umbilical cord along with the midventral strip of tissues to expose the two *umbilical arteries* parallel to a central urinary bladder. Flush the abdominal cavity of any coagulated blood or latex that leaked out during injection.
   d. Note the *parietal peritoneum* that forms the inner lining of the abdominal wall. Also note the *visceral peritoneum* that adheres to the surface of organs within the abdominal cavity.

10. As you expose and dissect blood vessels, try not to destroy other visceral organs needed for future studies. At times it will be necessary to displace some abdominal organs to locate some deep blood vessels.

    Using figure 47.4 as a guide, locate and dissect the following arteries of the abdomen:

Figure 47.3 Arteries of the trunk, neck, and forelimb of a fetal pig, ventral view. (*Note:* The pulmonary arteries are not included in this illustration.)



abdominal aorta (unpaired)

celiac trunk (unpaired)

anterior mesenteric artery (corresponds to superior mesenteric artery) (unpaired)

renal arteries (paired)

posterior mesenteric artery (corresponds to inferior mesenteric artery) (unpaired)

external iliac arteries (paired)

internal iliac arteries (paired)

umbilical arteries (paired)

11. Trace the external iliac artery into the left hindlimb, and locate the following:

    femoral artery

    deep femoral artery

12. Complete Part A of Laboratory Report 47.

PROCEDURE B—THE VENOUS SYSTEM

1. Examine the heart again, and locate the following veins:

    anterior vena cava (corresponds to superior vena cava)

    posterior vena cava (corresponds to inferior vena cava)

2. Using figure 47.5 as a guide, locate and dissect the following veins in the thorax and neck:

    right brachiocephalic vein

    left brachiocephalic vein

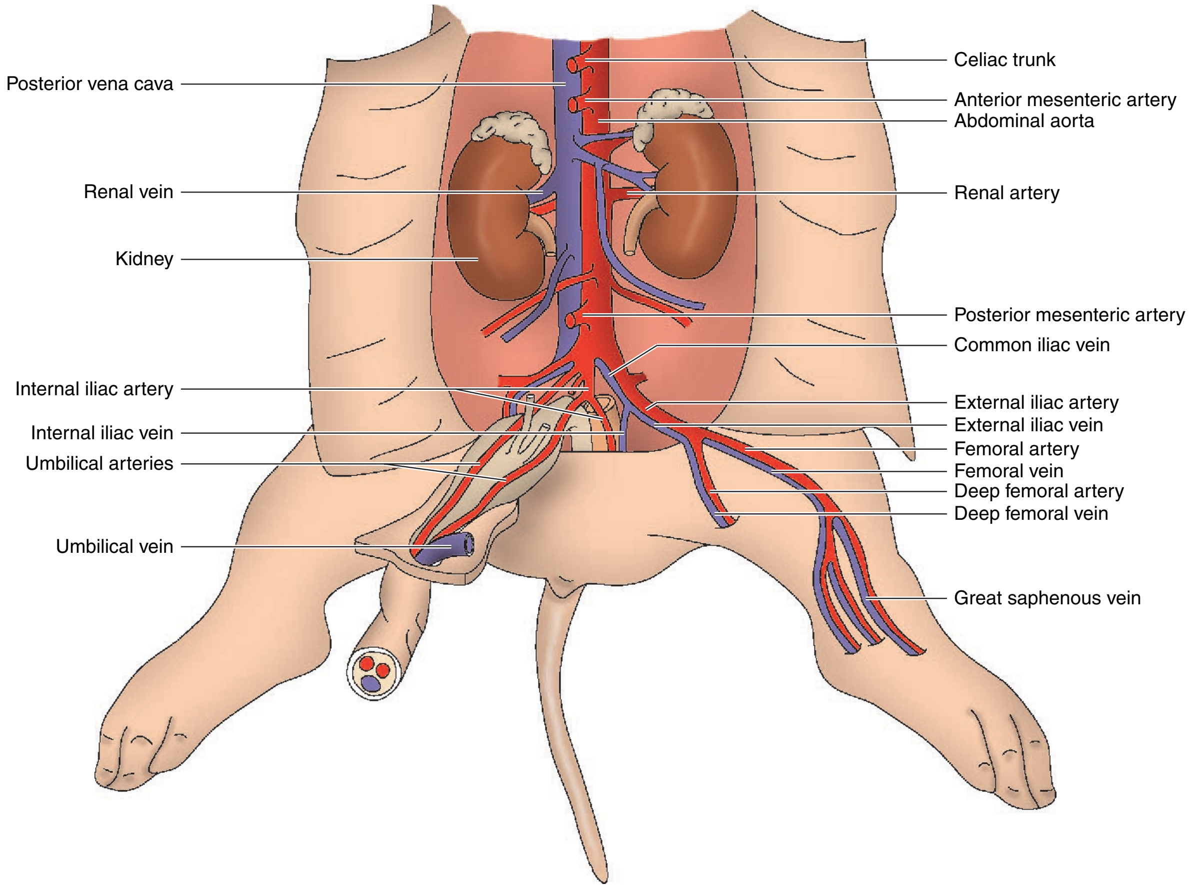
    right subclavian vein

    left subclavian vein

    internal jugular vein

    external jugular vein

Figure 47.4 Arteries (*red*) and veins (*blue*) of the abdominal cavity of a fetal pig, ventral view.



3. Trace the right subclavian vein into the forelimb, and locate the following veins:

   axillary vein

   brachial vein

4. Using figure 47.4 as a guide, locate and dissect the following veins in the abdomen:

   posterior vena cava

   renal veins

   common iliac vein

   internal iliac vein

   external iliac vein

5. Using figure 47.6 as a guide, locate and dissect the following veins (branches of the hepatic portal system):

   hepatic portal vein

   gastrosplenic vein

   mesenteric vein

   anterior mesenteric vein (corresponds to superior mesenteric vein)

   posterior mesenteric vein (corresponds to inferior mesenteric vein)

6. Locate and trace the umbilical vein (that was cut) from the umbilical cord into the liver. Inside the liver it becomes the *ductus venosus,* which drains oxygenated fetal blood into the posterior vena cava. The umbilical vein and the ductus venosus degenerate after birth.
7. Trace the external iliac vein into the left hindlimb (see figure 47.4), and locate the following veins:

   femoral vein

   deep femoral vein

   great saphenous vein

8. Complete Part B of the laboratory report.

Figure 47.5 Veins of the trunk, neck, and forelimb of a fetal pig, ventral view.

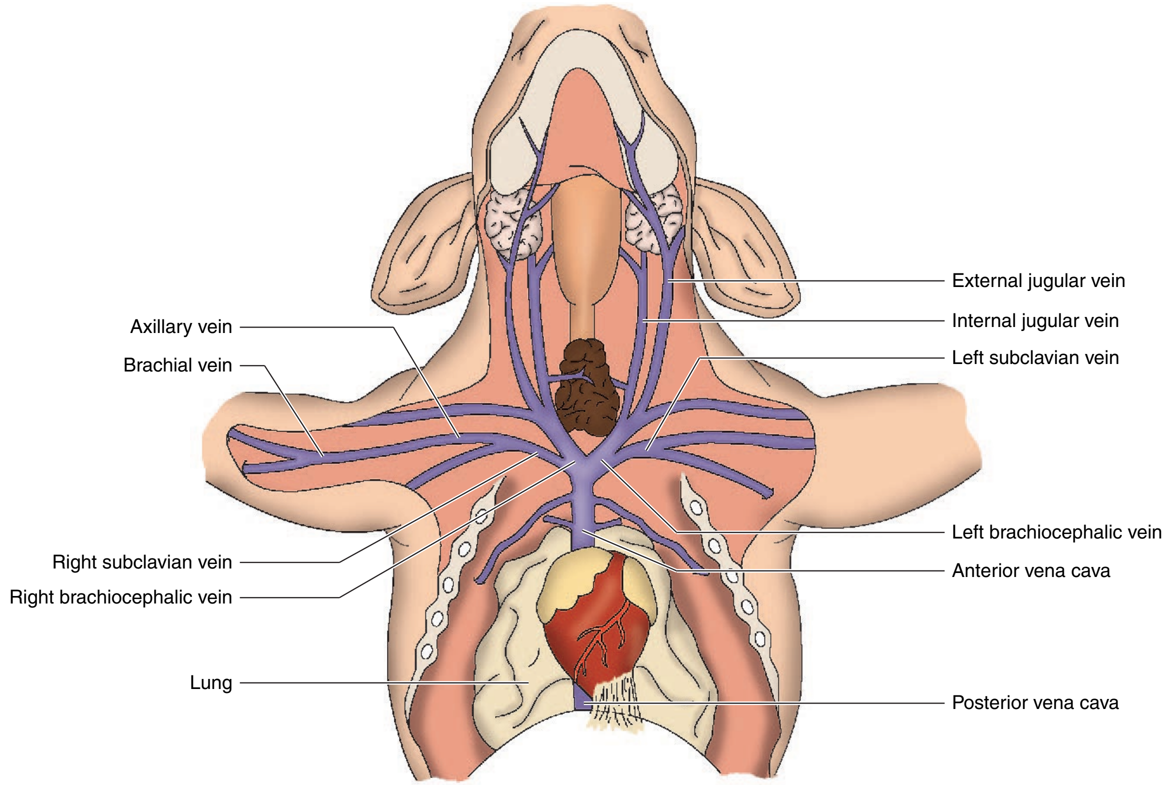
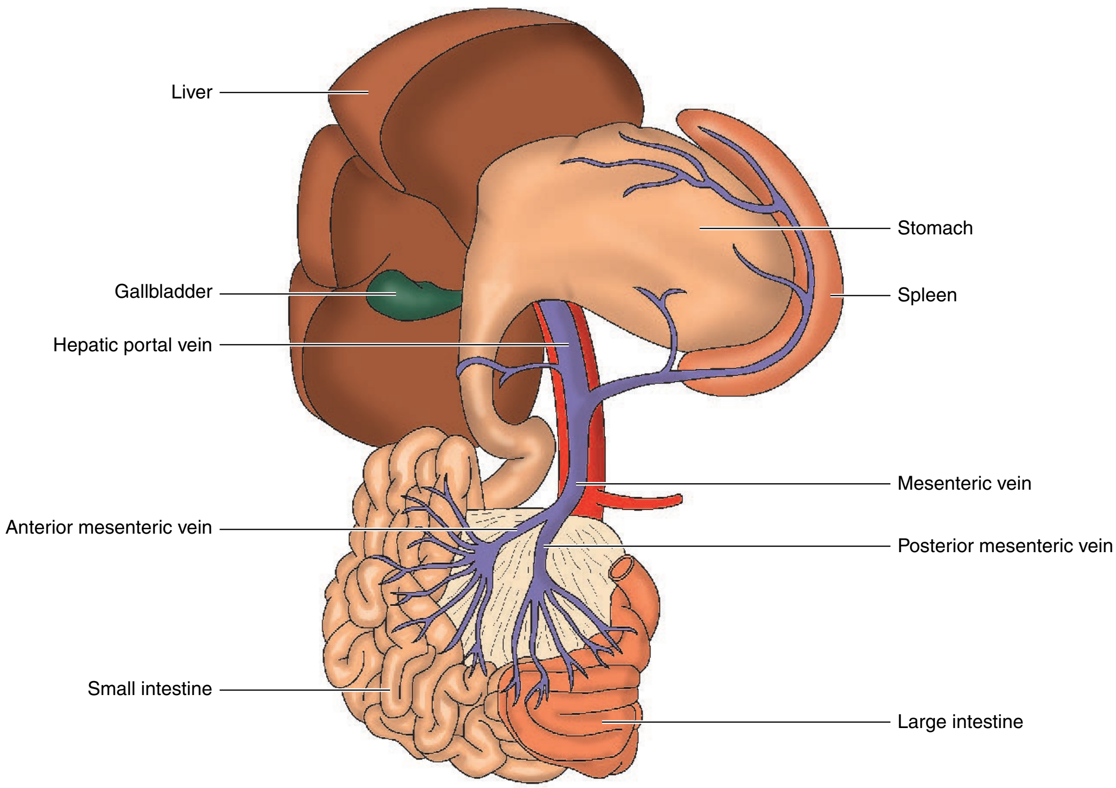


Figure 47.6 Hepatic portal vein and its tributaries of a fetal pig, ventral view. The liver and stomach are retracted to obtain a clear view.



Laboratory Report **47**

Name ______________________

Date ______________________

Section ______________________

Fetal Pig Dissection: Cardiovascular System

Part A

Complete the following:

1. Describe the position and attachments of the parietal pericardium of the heart of the fetal pig. ______________________

2. Describe the relative thicknesses of the walls of the heart chambers of the fetal pig. ______________________

3. Explain how the wall thicknesses are related to the functions of the chambers. ______________________

4. Compare the origins of the common carotid arteries of the fetal pig with those of the human. ______________________

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5. Compare the origins of the external and internal iliac arteries of the fetal pig with those of the human. ______

Part B

Complete the following:

1. Compare the relative sizes of the external and internal jugular veins of the fetal pig with those of the human.

2. List twelve veins that pigs and humans have in common.

Critical Thinking Application

Explain the high oxygen content in the umbilical veins of both a human and a pig fetus.

Laboratory Exercise 48

Lymphatic System

MATERIALS NEEDED

textbook
human torso
anatomical chart of the lymphatic system
compound microscope
prepared microscope slides:
  lymph node section
  human thymus section
  human spleen section

The lymphatic system is closely associated with the cardiovascular system and includes a network of capillaries and vessels that assist in the circulation of body fluids. These lymphatic capillaries and vessels provide pathways through which excess fluid can be transported away from intercellular spaces within tissues and returned to the bloodstream.

The organs of the lymphatic system also help to protect the tissues against infections by filtering particles from lymph and by supporting the activities of lymphocytes that furnish immunity against specific disease-causing agents.

PURPOSE OF THE EXERCISE

To review the structure of the lymphatic system and to observe the microscopic structure of a lymph node, thymus, and spleen.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the major lymphatic pathways in an anatomical chart or model;
2. locate and identify the major chains of lymph nodes in an anatomical chart or model;
3. describe the structure of a lymph node;
4. identify the major microscopic structures of a lymph node, thymus, and spleen.

PROCEDURE A—LYMPHATIC PATHWAYS

1. Review a textbook section on *lymphatic pathways.*
2. As a review activity, label figure 48.1.
3. Complete Part A of Laboratory Report 48.
4. Observe the human torso and the anatomical chart of the lymphatic system and locate the following features:

lymphatic vessels

lymph nodes

lymphatic trunks

  lumbar trunk

  intestinal trunk

  intercostal trunk

  bronchomediastinal trunk

  subclavian trunk

  jugular trunk

collecting ducts

  thoracic (left lymphatic) duct

  right lymphatic duct

internal jugular veins

subclavian veins

PROCEDURE B—LYMPH NODES

1. Review a textbook section on *lymph nodes.*
2. As a review activity, label figure 48.2.
3. Complete Part B of the laboratory report.
4. Observe the anatomical chart of the lymphatic system and the human torso, and locate the clusters of lymph nodes in the following regions:

cervical region

axillary region

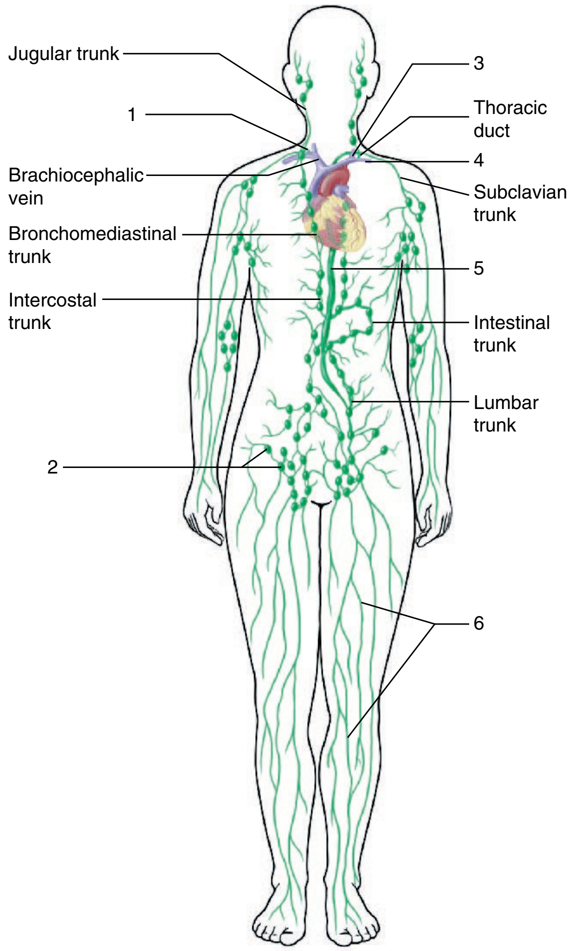
inguinal region

pelvic cavity

abdominal cavity

thoracic cavity

Figure 48.1 Label the diagram by placing the correct numbers in the spaces provided.



____ Jugular vein

____ Lymph nodes

____ Lymphatic vessels

____ Right lymphatic duct

____ Subclavian vein

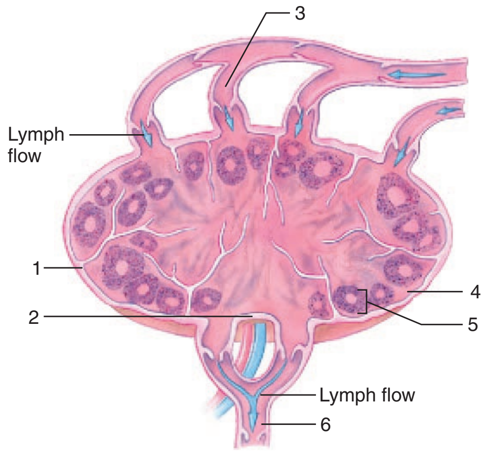
____ Thoracic duct

5. Palpate the lymph nodes in your cervical region. They are located along the lower border of the mandible and between the ramus of the mandible and the sternocleidomastoid muscle. They feel like small, firm lumps.
6. Obtain a prepared microscope slide of a lymph node and observe it using low-power magnification. Identify the *capsule* that surrounds the node and is mainly composed of collagenous fibers, the *lymph nodules* that appear as dense masses near the surface of the node, and the *lymph sinus* that appears as narrow space between the nodules and the capsule.
7. Examine a nodule within the lymph node using high-power magnification. Note that the nodule contains densely packed *lymphocytes.*
8. Prepare a labeled sketch of a representative section of a lymph node in Part D of the laboratory report.

PROCEDURE C—THYMUS AND SPLEEN

1. Review a textbook section on the *thymus* and *spleen.*
2. Locate the thymus and spleen in the anatomical chart of the lymphatic system and on the human torso.
3. Complete Part C of the laboratory report.
4. Obtain a prepared microscope slide of human thymus and observe it using low-power magnification (fig. 48.3). Note how the thymus is subdivided into *lobules* by *septa* of connective tissue that contain blood vessels. Identify the *capsule* of loose connective tissue that surrounds the thymus, the outer *cortex* of a lobule that is composed of densely packed cells and is deeply stained, and the inner *medulla* of a lobule that is

Figure 48.2 Label this diagram of a lymph node by placing the correct numbers in the spaces provided.



_____ Afferent lymphatic vessel

_____ Capsule

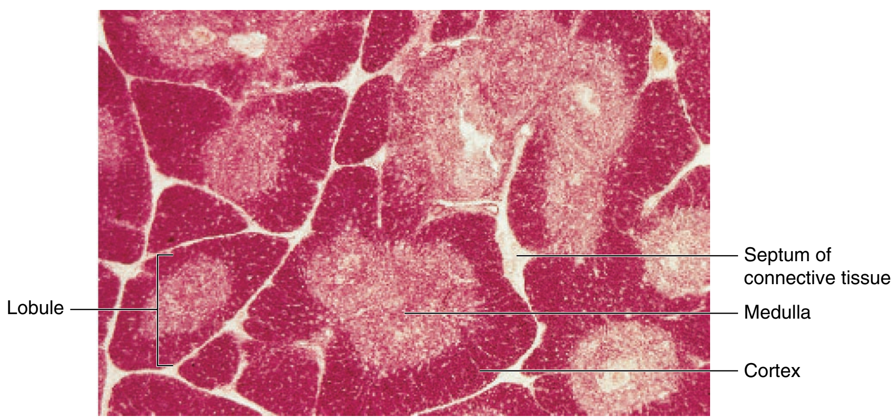
_____ Efferent lymphatic vessel

_____ Hilum

_____ Nodule

_____ Sinus

Figure 48.3 A section of the thymus gland (10× micrograph enlarged to 20×).



composed of loosely packed lymphocytes and epithelial cells and is lightly stained.

5. Examine the cortex tissue of a lobule using high-power magnification. The cells of the cortex are composed of densely packed *lymphocytes* among some epithelial cells and macrophages. Some of these cortical cells may be undergoing mitosis, so that their chromosomes may be visible.
6. Prepare a labeled sketch of a representative section of the thymus in Part D of the laboratory report.
7. Obtain a prepared slide of the human spleen and observe it using low-power magnification (fig. 48.4). Identify the *capsule* of dense connective tissue that surrounds the spleen. Note that the tissues of the spleen include circular *nodules of white* (in unstained tissue) *pulp* that are enclosed in a matrix of *red pulp.*
8. Examine a nodule of white pulp and red pulp using high-power magnification. The cells of the white pulp are mainly *lymphocytes.* Also, there may be an arteriole centrally located in the nodule. The cells of the red pulp are mostly red blood cells with many lymphocytes and macrophages.
9. Prepare a labeled sketch of a representative section of the spleen in Part D of the laboratory report.

Web Quest

Locate the six major areas of lymph nodes and identify the components of the lymphatic system. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

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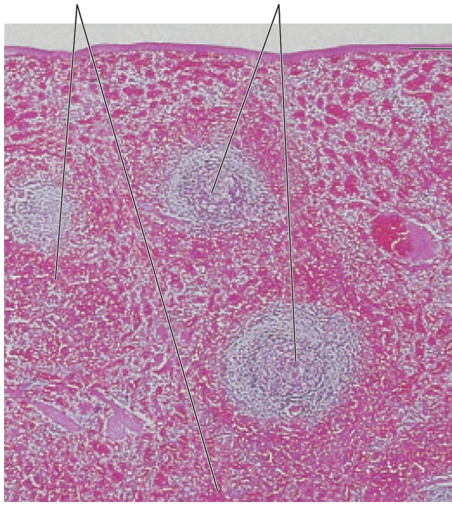
Figure 48.4 Micrograph of a section of the spleen (15×).



Laboratory Report **48**

Name ______________________________

Date ______________________________

Section ______________________________

Lymphatic System

Part A

Complete the following statements:

1. Lymphatic pathways begin as lymphatic ______________________ that merge to form lymphatic vessels.
2. The wall of a lymphatic capillary consists of a single layer of ______________________ epithelial cells.
3. Once tissue (interstitial) fluid is inside a lymph capillary, the fluid is called ______________________.
4. Lymphatic vessels contain ______________________ that help prevent the backflow of lymph.
5. Lymphatic vessels usually lead to ______________________ that filter the fluid being transported.
6. The ______________________ is the larger and longer of the two lymphatic collecting ducts.

Part B

Complete the following statements:

1. Lymph nodes contain large numbers of white blood cells called ______________________ and macrophages that fight invading microorganisms.
2. The indented region of a bean-shaped lymph node is called the ______________________.
3. ______________________ that contain germinal centers are the structural units of a lymph node.
4. The spaces within a lymph node are called lymph ______________________ through which lymph circulates.
5. Lymph enters a node through a(an) ______________________ lymphatic vessel.
6. The partially encapsulated lymph nodes in the pharynx are called ______________________.
7. The aggregations of lymph nodules found within the mucosal lining of the small intestine are called ______________________.
8. The lymph nodes in the cervical region are associated with the lymphatic vessels that drain the ______________________.
9. The lymph nodes associated with the lymphatic vessels that drain the lower limbs are located in the ______________________ region.

Part C

Complete the following statements:

1. The thymus is located in the ______________________, anterior to the aortic arch.
2. The hormone secreted by the thymus is called ______________________.

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3. The _______________________ is the largest of the lymphatic organs.
4. Blood vessels enter the spleen through the region called the _______________________.
5. The sinuses within the spleen contain _______________________.
6. The tiny islands of tissue within the spleen that contain many lymphocytes comprise the _______________________.
7. The _______________________ of the spleen contains large numbers of red blood cells, lymphocytes, and macrophages.
8. _______________________ within the spleen function to engulf and destroy foreign particles and cellular debris.

Part D

Lymph node sketch (____×)	Thymus sketch (____×)
Spleen sketch (____×)	

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Laboratory Exercise 49

Organs of the Digestive System

MATERIALS NEEDED

textbook
human torso
sagittal head section model
skull with teeth
teeth, sectioned
tooth model, sectioned
paper cup
compound microscope
prepared microscope slides of the following:
  parotid gland (salivary gland)
  esophagus
  stomach (fundus)
  pancreas (exocrine portion)
  small intestine (jejunum)
  large intestine
Virtual Physiology Lab: 8, Digestion of Fat

The digestive system includes the organs associated with the alimentary canal and several accessory structures. The alimentary canal, which is a muscular tube, passes through the body from the opening of the mouth to the anus. It includes the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. The canal is adapted to move substances throughout its length. It is specialized in various regions to store, digest, and absorb food materials and to eliminate the residues. The accessory organs, which include the salivary glands, liver, gallbladder, and pancreas, secrete products into the alimentary canal that aid digestive functions.

PURPOSE OF THE EXERCISE

To review the structure and function of the digestive organs and to examine the tissues of these organs microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate the major digestive organs;
2. describe the functions of these organs;
3. recognize tissue sections of these organs;
4. identify the major features of each tissue section.

PROCEDURE A—MOUTH AND SALIVARY GLANDS

1. Review textbook sections on the *mouth* and *salivary glands.*
2. As a review activity, label figures 49.1, 49.2, and 49.3.
3. Examine the mouth of the torso, the sagittal head section model, and a skull. Locate the following structures:

   oral cavity

   vestibule

   tongue

   frenulum (lingual)

   papillae

   lingual tonsils

   palate

   hard palate

   soft palate

   uvula

   palatine tonsils

   pharyngeal tonsils (adenoids)

   gums (gingivae)

   teeth

   incisors

   cuspids

   bicuspids

   molars

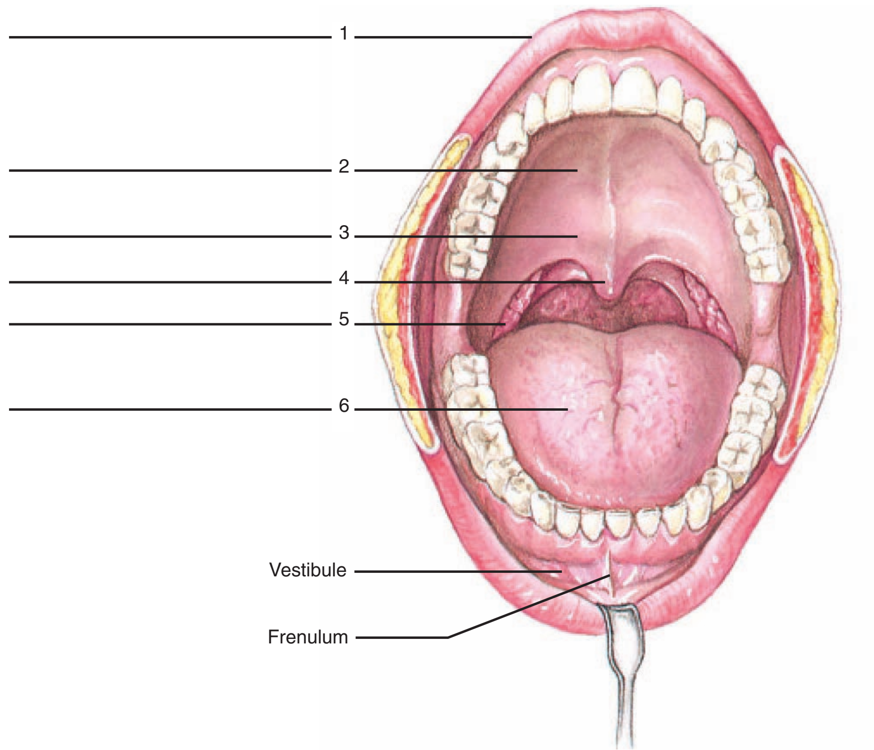
4. Examine a sectioned tooth and a tooth model. Locate the following features:

   crown

   enamel

   dentin

Figure 49.1 Label the major features of the mouth.



neck

root

pulp cavity

cementum

root canal

5. Observe the head of the torso, and locate the following:

parotid salivary gland

parotid duct (Stensen's duct)

submandibular salivary gland

submandibular duct (Wharton's duct)

sublingual salivary gland

6. Examine a microscopic section of a parotid gland, using low-and high-power magnification. Note the numerous glandular cells arranged in clusters around small ducts. Also note a larger secretory duct surrounded by lightly stained cuboidal epithelial cells (fig. 49.4).
7. Complete Part A of Laboratory Report 49.

PROCEDURE B—PHARYNX AND ESOPHAGUS

1. Review textbook sections on the *pharynx* and *esophagus.*
2. As a review activity, label figure 49.5.
3. Observe the torso, and locate the following features:

pharynx

nasopharynx

opening to auditory tube (Eustachian tube)

oropharynx

laryngopharynx

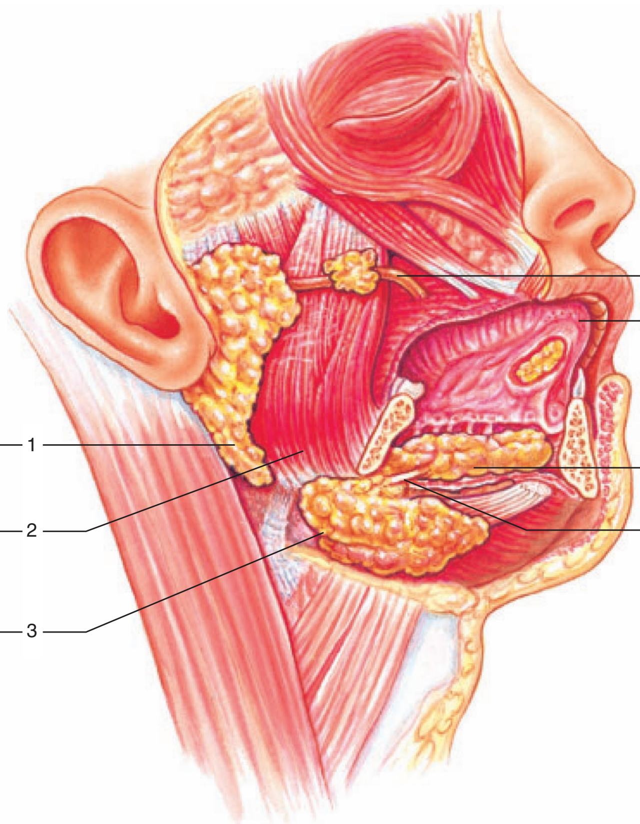
epiglottis

esophagus

lower esophageal sphincter (cardiac sphincter)

4. Have your partner take a swallow from a cup of water. Carefully watch the movements in the

Figure 49.2 Label the features associated with the major salivary glands.



anterior region of the neck. What steps in the swallowing process did you observe? ____________

____

____

____

____

5. Examine a microscopic section of esophagus wall, using low-power magnification. Note that the inner lining is composed of stratified squamous epithelium and that there are layers of muscle tissue in the wall. Locate some mucous glands in the submucosa. They appear as clusters of lightly stained cells.
6. Complete Part B of the laboratory report.

PROCEDURE C—THE STOMACH

1. Review a textbook section on the *stomach.*
2. As a review activity, label figures 49.6 and 49.7.
3. Observe the torso, and locate the following features of the stomach:

   rugae

   cardiac region

   fundic region

   body region

   pyloric region

   pyloric canal

   pyloric sphincter (valve)

   lesser curvature

   greater curvature
4. Examine a microscopic section of stomach wall, using low-power magnification. Note how the inner lining of simple columnar epithelium dips inward to form gastric pits. The gastric glands are tubular structures that open into the gastric pits. Near the deep ends of these glands, you should be able to locate some intensely stained (bluish) chief cells

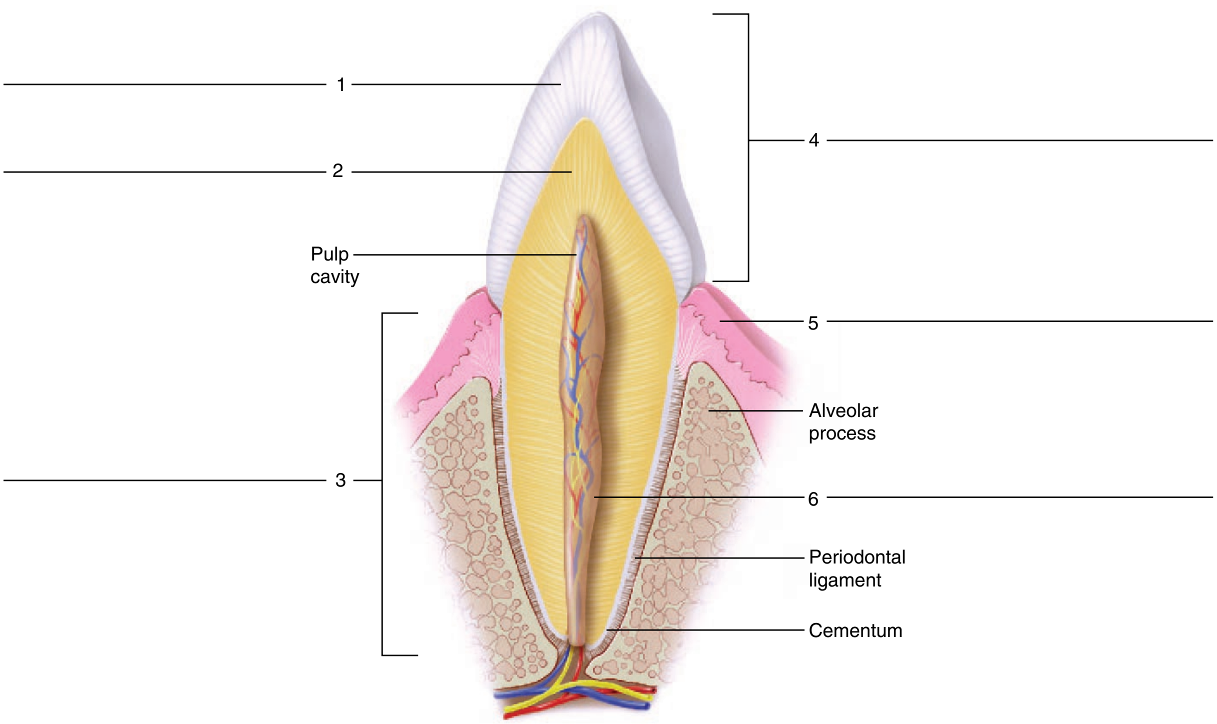


Figure 49.3 Label the features of this cuspid tooth.

and some lightly stained (pinkish) parietal cells (fig. 49.8). What are the functions of these cells?

____

____

____

____

____

5. Complete Part C of the laboratory report.

PROCEDURE D—PANCREAS AND LIVER

1. Review textbook sections on the *pancreas, liver,* and *small intestine.*
2. As a review activity, label figure 49.9.
3. Observe the torso and locate the following structures:

pancreas

pancreatic duct

liver

right lobe

quadrate lobe

caudate lobe

left lobe

gallbladder

hepatic ducts

common hepatic duct

cystic duct

common bile duct

hepatopancreatic sphincter (sphincter of Oddi)

4. Examine the pancreas slide using low-power magnification. Observe the exocrine (acinar) cells that secrete pancreatic juice. See figure 37.11 in Laboratory Exercise 37 for a micrograph of the pancreas.
5. Complete Part D of the laboratory report.

PROCEDURE E—SMALL AND LARGE INTESTINES

1. Review textbook sections on the *small intestine* and *large intestine*.
2. As a review activity, label figure 49.10.
3. Observe the torso, and locate each of the following features:

Figure 49.4 Micrograph of the parotid salivary gland (300×).

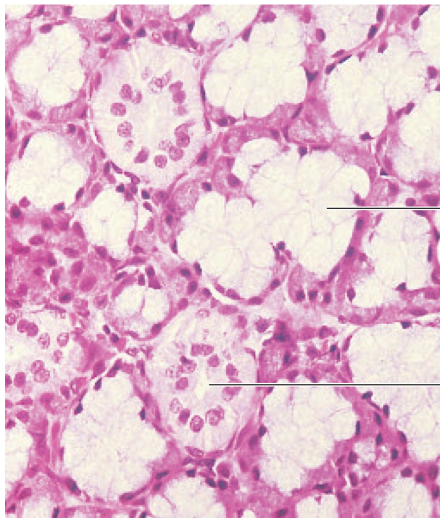


Figure 49.5 Label the features associated with the pharynx.

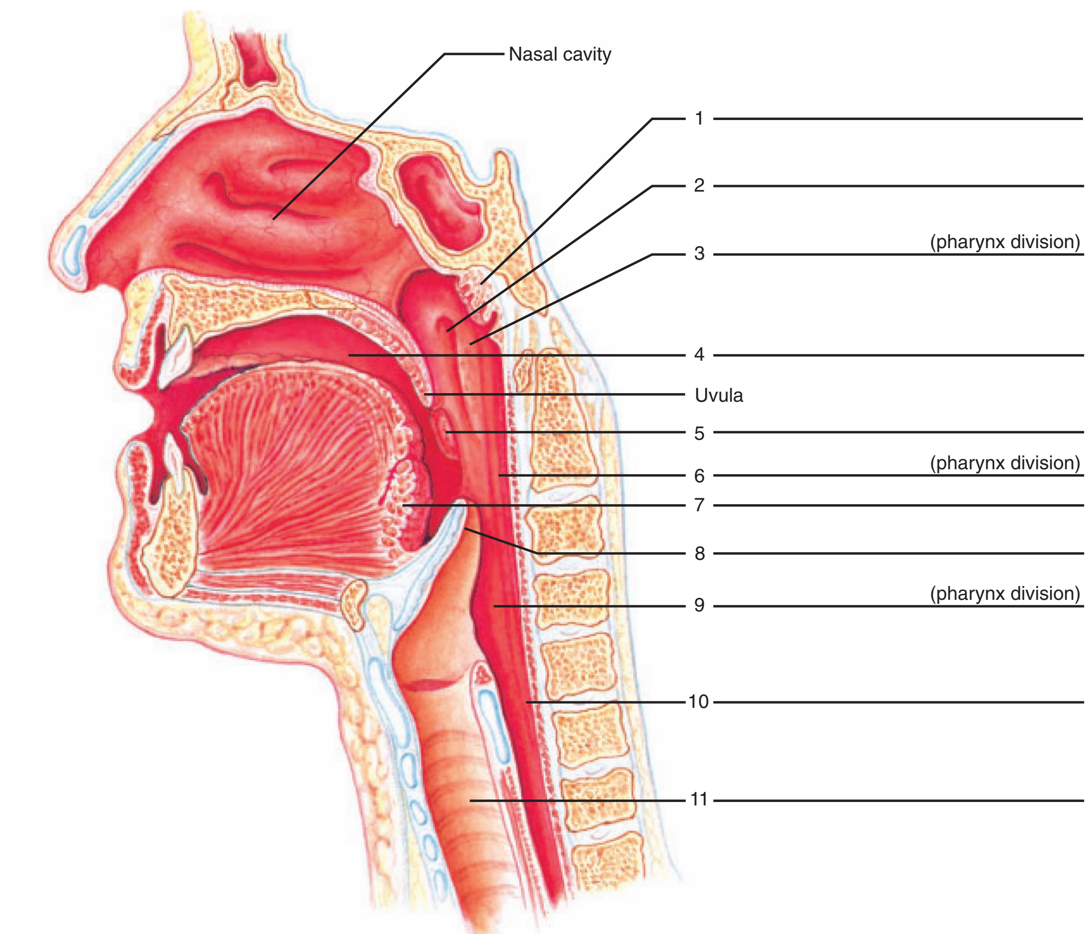


Figure 49.6 Label the major regions of the stomach and associated structures.

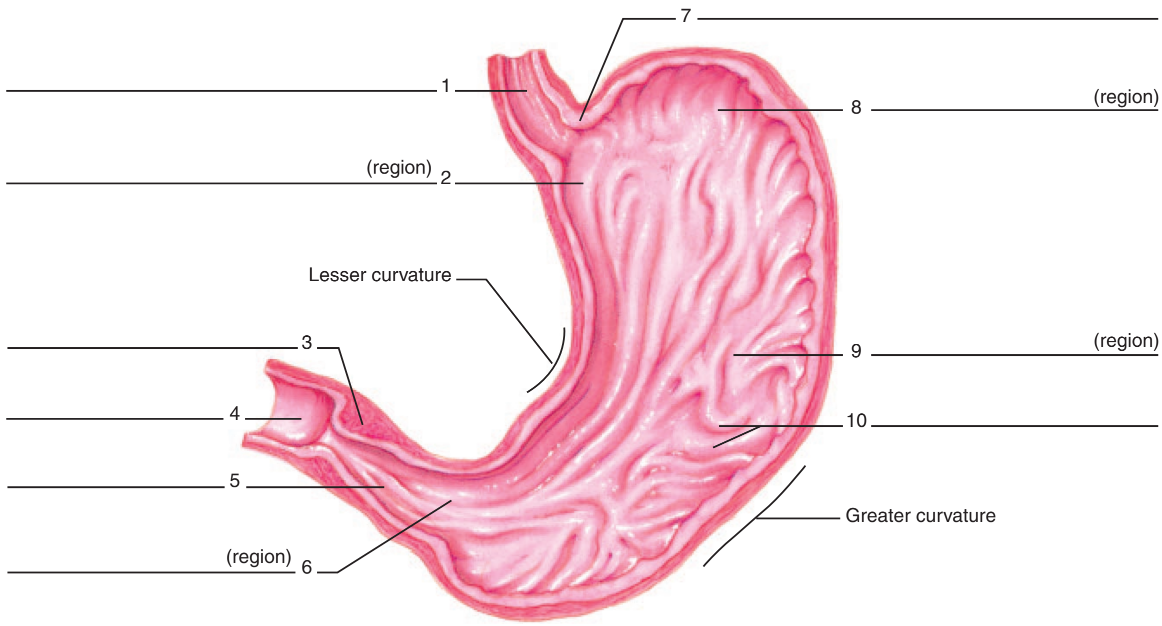
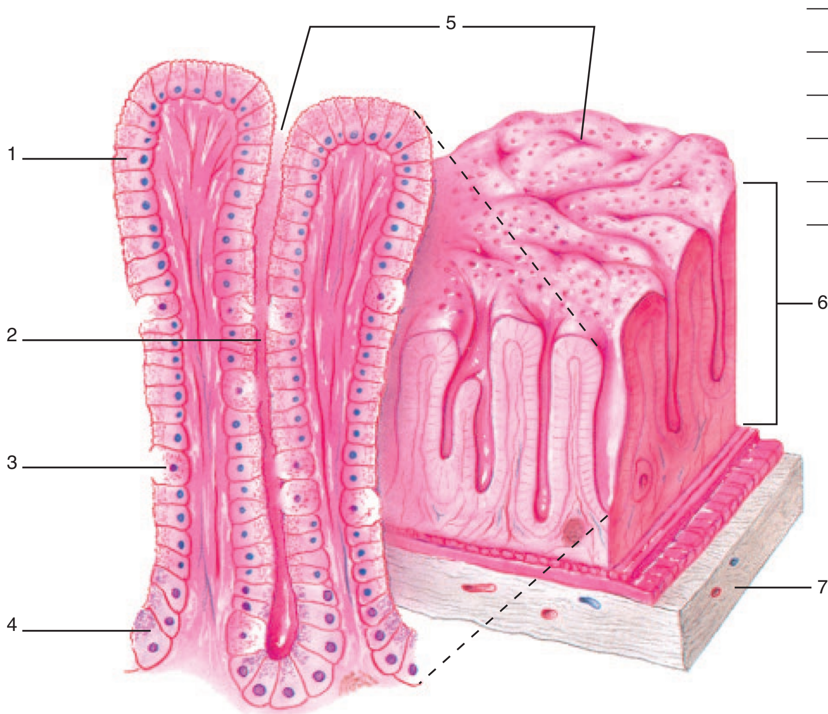


Figure 49.7 Label the lining of the stomach by placing the correct numbers in the spaces provided.



____ Chief cell

____ Gastric gland

____ Gastric pits

____ Mucosa

____ Mucous cell

____ Parietal cell

____ Submucosa

Figure 49.8 Micrograph of the mucosa of the stomach wall (50× micrograph enlarged to 100×).

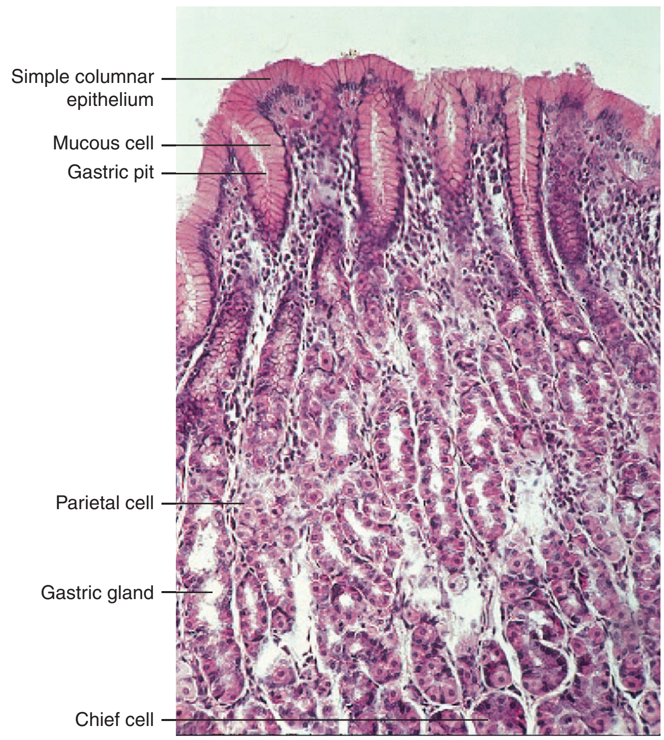


Figure 49.9 Label the features associated with the liver and pancreas.

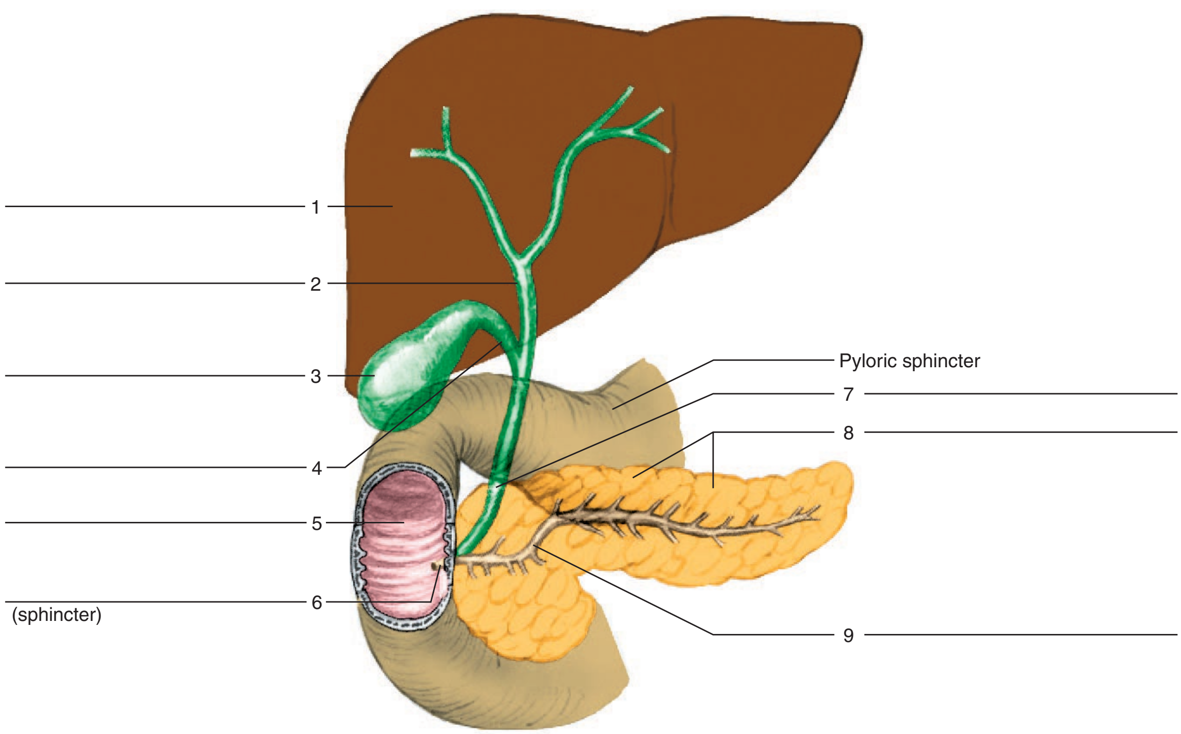
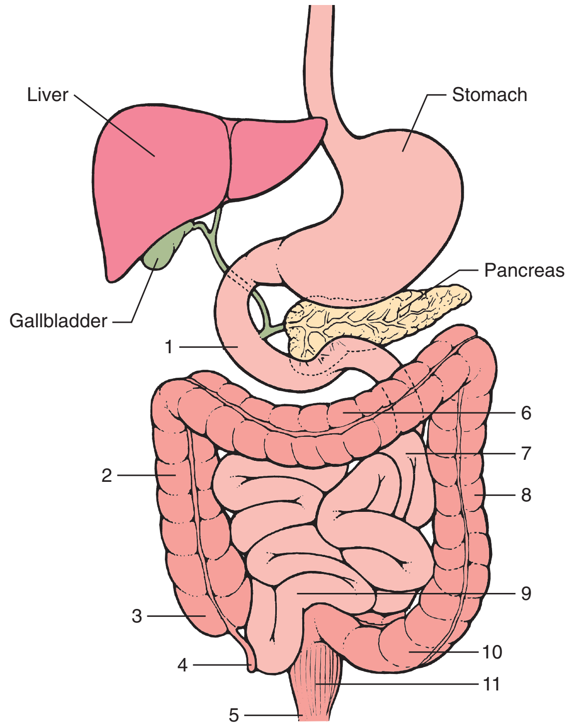


Figure 49.10 Label this diagram of the small and large intestine by placing the correct numbers in the spaces provided.



_____ Anal canal

_____ Ascending colon

_____ Cecum

_____ Descending colon

_____ Duodenum

_____ Ileum

_____ Jejunum

_____ Rectum

_____ Sigmoid colon

_____ Transverse colon

_____ Vermiform appendix

small intestine
- duodenum
- jejunum
- ileum

mesentery

ileocecal sphincter (valve)

large intestine
- large intestinal wall
  - haustra
  - teniae coli
  - epiploic appendages
- cecum
- vermiform appendix
- ascending colon
- right colic (hepatic) flexure
- transverse colon
- left colic (splenic) flexure
- descending colon
- sigmoid colon
- rectum
- anal canal
- anal columns

anal sphincter muscles
- internal anal sphincter
- external anal sphincter

anus

4. Examine a microscopic section of small intestine wall using low-power magnification. Identify the mucosa, submucosa, muscular layer, and serosa. Note the villi that extend into the lumen of the tube. Study a single villus using high-power magnification. Note the core of connective tissue and the covering of simple columnar epithelium that contains some lightly stained goblet cells (fig. 49.11). What is the function of these villi?_____________________________

____

____

____

____

5. Examine a microscopic section of large intestine wall. Note the lack of villi. Also note the tubular mucous glands that open on the surface of the

Figure 49.11 Micrograph of the inner duodenal wall (100×).

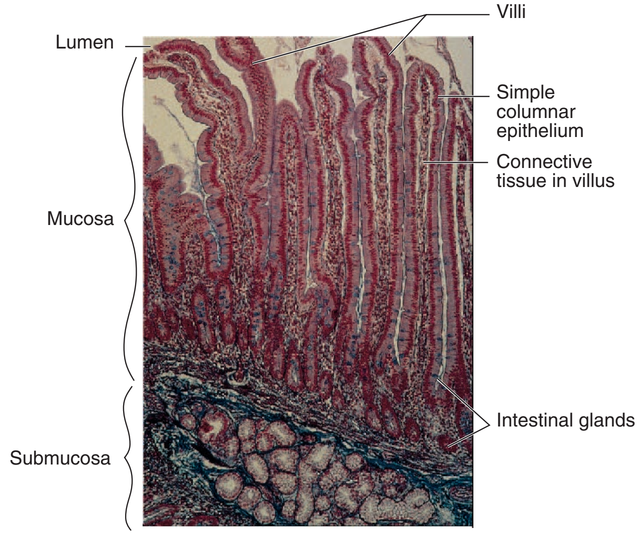
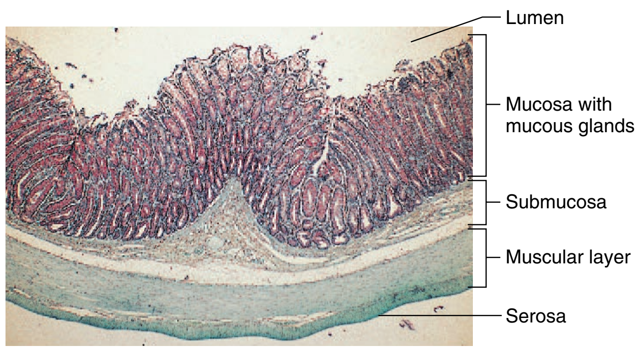


Figure 49.12 Micrograph of the large intestine wall (64×).



inner lining and the numerous lightly stained goblet cells. Locate the four layers of the wall (fig. 49.12). What is the function of the mucus secreted by these glands? ________________________________

____

____

____

6. Complete Part E of the laboratory report.

Critical Thinking Application

How is the structure of the small intestine better adapted for absorption than the large intestine?

____

____

____

____

Web Quest

Summarize the functions of the organs of the digestive system. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 49

Name ______________________________

Date ______________________________

Section ______________________________

Organs of the Digestive System

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. adenoids (pharyngeal tonsils)	____	1. bonelike substance beneath tooth enamel
b. amylase	____	2. smallest of major salivary glands
c. crown	____	3. tooth specialized for grinding
d. dentin	____	4. chamber between tongue and palate
e. frenulum	____	5. projections on tongue surface
f. incisor	____	6. cone-shaped projection of soft palate
g. molar	____	7. secretes the digestive enzymes in saliva
h. oral cavity	____	8. attaches tooth to jaw
i. palate	____	9. chisel-shaped tooth
j. papillae	____	10. roof of oral cavity
k. periodontal ligament	____	11. space between the teeth, cheeks, and lips
l. serous cell	____	12. anchors tongue to floor of mouth
m. sublingual gland	____	13. lymphatic tissue in posterior wall of pharynx near auditory tubes
n. uvula	____	14. portion of tooth projecting beyond gum
o. vestibule	____	15. splits starch into disaccharides

Part B

Complete the following:

1. The part of the pharynx superior to the soft palate is called the ______________________________.
2. The middle part of the pharynx is called the ______________________________.
3. The inferior portion of the pharynx is called the ______________________________.
4. The auditory tube opens through the wall of the ______________________________.

5. List six major actions in the swallowing reflex. ______________________________

____

____

____

____

____

6. The esophagus passes through the mediastinum posterior to the ______________ as it descends into the thorax.

7. ______________ is the main secretion of the esophagus.

Part C

Complete the following:

1. Name the four regions of the stomach. ______________________________

____

2. Name the valve that prevents regurgitation of food from the small intestine back into the stomach. ______________

____

3. Name the gastric cells that secrete digestive enzymes. ______________________________
4. Name the gastric cells that secrete hydrochloric acid. ______________________________
5. Name the most important digestive enzyme secreted in the stomach. ______________________________
6. Name a hormone secreted by the stomach that stimulates gastric glands to secrete. ______________
7. Name the semifluid paste of food particles and gastric juice. ______________________________
8. Summarize the functions of the stomach. ______________________________

____

____

____

Part D

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. amylase	____	1. activates protein-digesting enzyme trypsin
b. bile salts	____	2. causes emulsification of fats
c. cholecystokinin	____	3. carries on phagocytosis in liver
d. enterokinase	____	4. carbohydrate-digesting enzyme
e. Kupffer cells	____	5. fat-digesting enzyme
f. lipase	____	6. protein-digesting enzyme
g. nuclease	____	7. stimulates gallbladder to release bile
h. secretin	____	8. stimulates pancreas to secrete fluids high in bicarbonate ions
i. trypsin	____	9. nucleic acid-digesting enzyme

Part E

Complete the following:

1. Name the three portions of the small intestine. ______________________________
2. Describe the function of the mesentery. ______________________________
   ____
3. Name the lymphatic capillary found in an intestinal villus. ______________________________
4. Name five digestive enzymes secreted by the small intestinal mucosa. ______________________________
   ____
5. Name the four portions of the colon. ______________________________
   ____
6. Name the valve that controls movement of material between the small and large intestines. ______________________________
   ____
7. Name the small projection that contains lymphatic tissue attached to the cecum. ______________________________
8. Summarize the functions of the small intestine. ______________________________
   ____
   ____
   ____
9. Summarize the functions of the large intestine. ______________________________
   ____
   ____
   ____

Laboratory Exercise 50

Fetal Pig Dissection: Digestive System

MATERIALS NEEDED

preserved fetal pig
dissecting tray
dissecting instruments
bone cutter
disposable gloves
human torso
hand lens

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

In this laboratory exercise, you will dissect the major digestive organs of a fetal pig. As you observe these organs, compare them with those of the human by observing the parts of the human torso.

PURPOSE OF THE EXERCISE

To examine the major digestive organs of the fetal pig, and to compare these organs with those of the human.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the major digestive organs of the fetal pig;
2. identify the corresponding organs in the human torso;
3. compare the digestive system of the fetal pig with that of the human.

PROCEDURE

1. Place the fetal pig in the dissecting tray on its left side.
2. Locate the major salivary glands on one side of the head. To do this, follow these steps:
   a. Clear away any remaining fascia and other connective tissue from the region below the ear and near the joint of the mandible.
   b. Identify the *parotid gland,* a relatively large triangular mass of glandular tissue just below the ear. Although this gland covers a large area, it is poorly developed in the fetal stage of development.
   c. Look for the compact *submandibular gland* just below the parotid gland, near the angle of the jaw.
   d. Locate the small *sublingual gland* that is adjacent, anterior and medial to the submandibular gland (fig. 50.1).
3. Open the oral cavity. To do this, follow these steps:
   a. Use scissors to cut through the soft tissues at the angle of the mouth.
   b. When you reach the bone of the jaw, use a bone cutter to cut through the bone, thus freeing the mandible (fig. 50.2).
   c. Open the mouth wide, and locate the following features:

      cheek

      lip

      palate

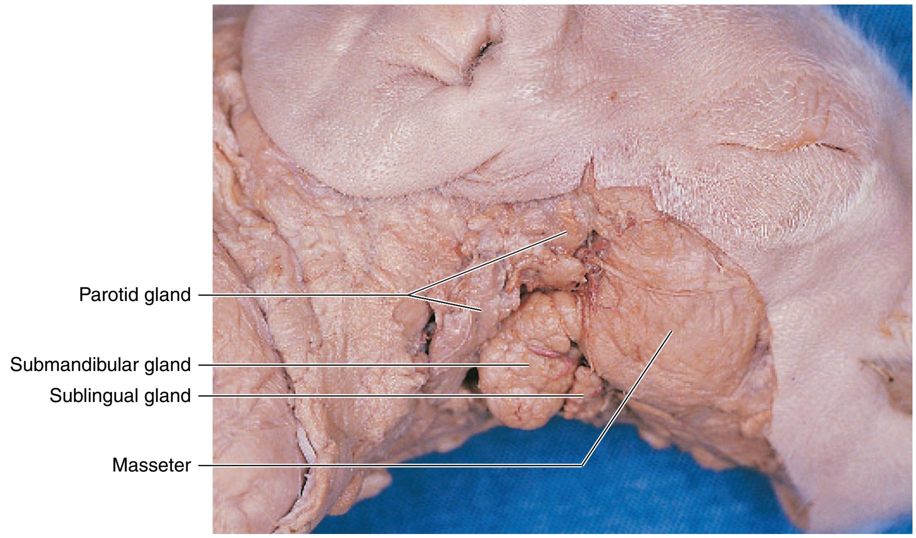
      - hard palate with transverse ridges
      - soft palate

      tongue

      - papillae (examine with a hand lens)

4. Examine any erupted teeth of the maxilla. The primary (deciduous) teeth of a young pig would include six incisors, two cuspids (canines), eight bicuspids (premolars), and zero molars on each jaw. Cut into some of the gum tissue to locate any developing teeth that have not erupted.
5. Complete Part A of Laboratory Report 50.
6. Examine organs in the abdominal cavity with the fetal pig positioned with its ventral side up. You might wish to remove some of the side walls of the body cavity to make observations easier.

Figure 50.1 Salivary glands of a fetal pig, lateral view.



7. Examine the large *liver,* which is located just beneath the diaphragm and is attached to the central portion of the diaphragm and the ventral body wall by the *falciform ligament.* Also, locate the elongated *spleen,* which is lateral and ventral to the stomach on the left side (fig. 50.3). Locate the five lobes of the liver. A *greater omentum* extends from the spleen to the stomach, and the *lesser omentum* connects the liver to the stomach. Lift the liver to find the greenish to nearly colorless *gallbladder* embedded in the underside of the liver on the right side. Also note the *cystic duct* by which the gallbladder is attached to the *common bile duct* and the *hepatic duct,* which originates in the liver and attaches to the cystic duct. Trace the common bile duct to its connection with the duodenum (fig. 50.4).
8. Locate the *stomach* in the upper left side of the abdominal cavity. At its anterior end, note the union of the *esophagus,* which passes through the diaphragm. Identify the *cardiac, fundic, body,* and *pyloric regions* of the stomach. Use scissors to make an incision along the convex border of the stomach from the cardiac region to the pylorus. The greenish substance found in the stomach and the rest of the digestive tract is called *meconium.* Meconium found in a fetal digestive tract is a combination of sloughed-off epithelial cells, amniotic fluid residues that were swallowed, and bile-stained mucus. It will be the first substance of bowel movements after birth. Note that the lining of the stomach has numerous folds (*rugae*). Examine the *pyloric sphincter,* which creates a constriction between the stomach and small intestine.
9. Locate the *pancreas* by lifting the stomach and separating some thin peritoneal membrane over the surface of the pancreas. The pancreas extends from the left stomach region into the loop of the duodenum of the small intestine.
10. Trace the *small intestine,* beginning at the pyloric sphincter. The first portion, the *duodenum,* is a short loop that has the common bile duct and the pancreatic duct leading into it. The proximal half of the remaining portion of the small intestine is the *jejunum,* and the distal half is the *ileum.* Open the small intestine and note the velvety appearance of the villi. Note how the mesentery supports the small intestine from the dorsal body wall. The small intestine terminates on the left side, where it joins the large intestine.
11. Locate the *large intestine,* and identify the short blind sac called the *cecum.* Make an incision at the junction between the ileum and cecum, and look for the *ileocecal sphincter.* A characteristic of the large intestine of the pig is the *spiral colon.* This is a tightly coiled mass on the left ventral region of the abdominal cavity. Also locate the *rectum,* which extends through the pelvic cavity to the *anus.*
12. Complete Part B of the laboratory report.

Figure 50.2 Oral cavity of the fetal pig with the lower jaw and tongue retracted.

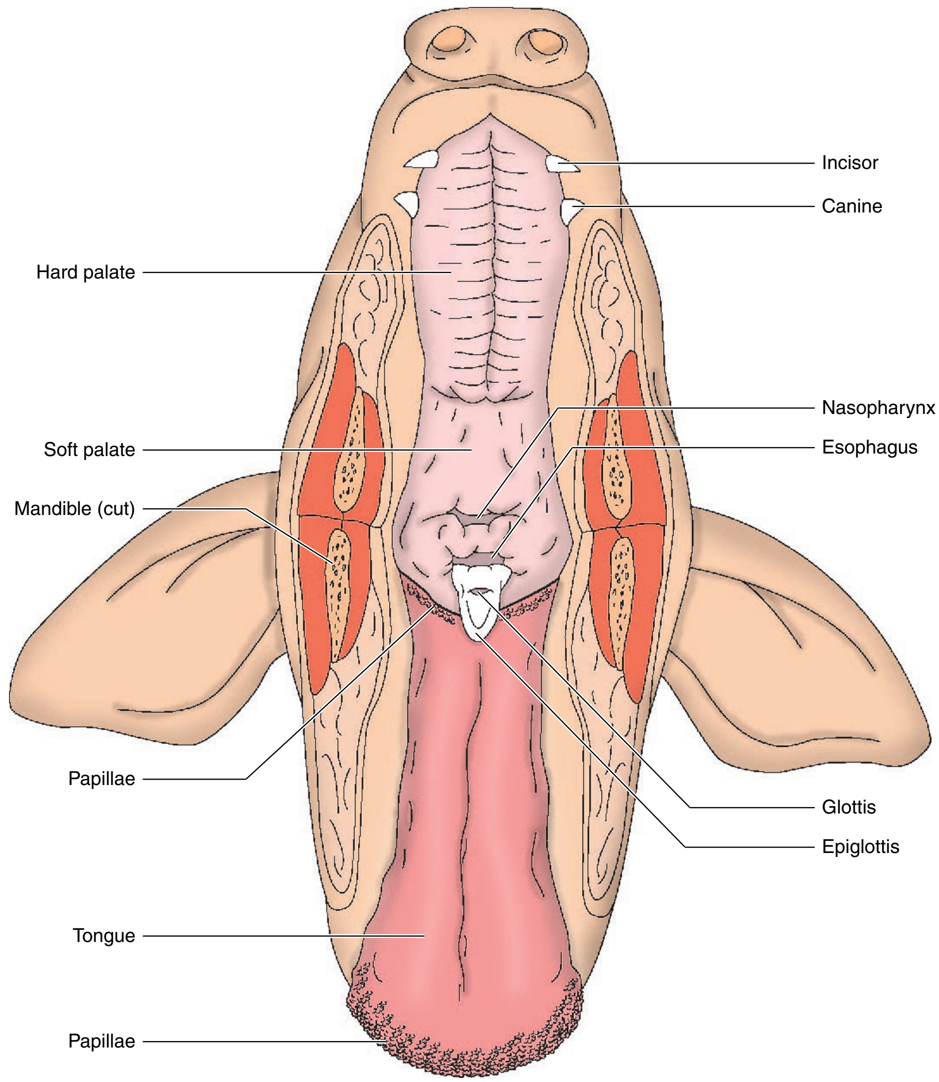


Figure 50.3 Abdominal digestive organs of the fetal pig, ventral view.

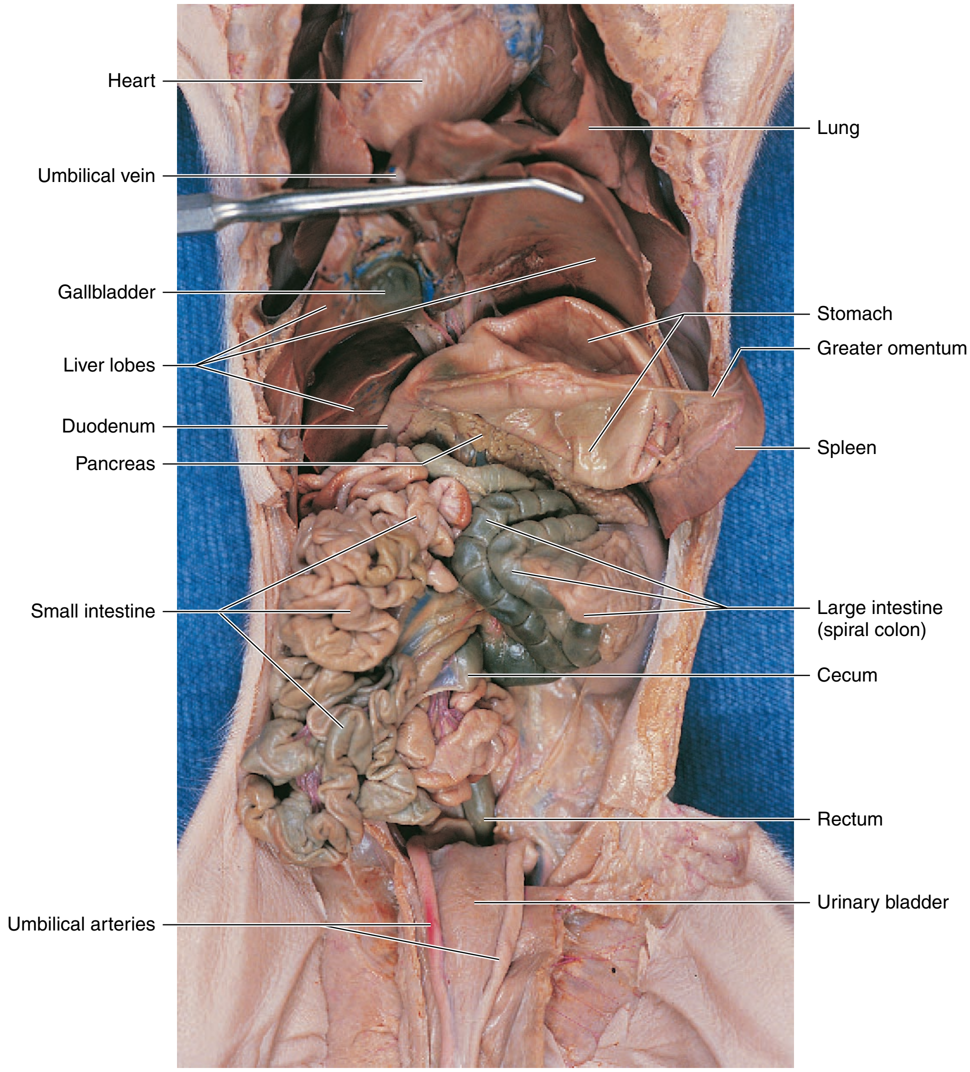
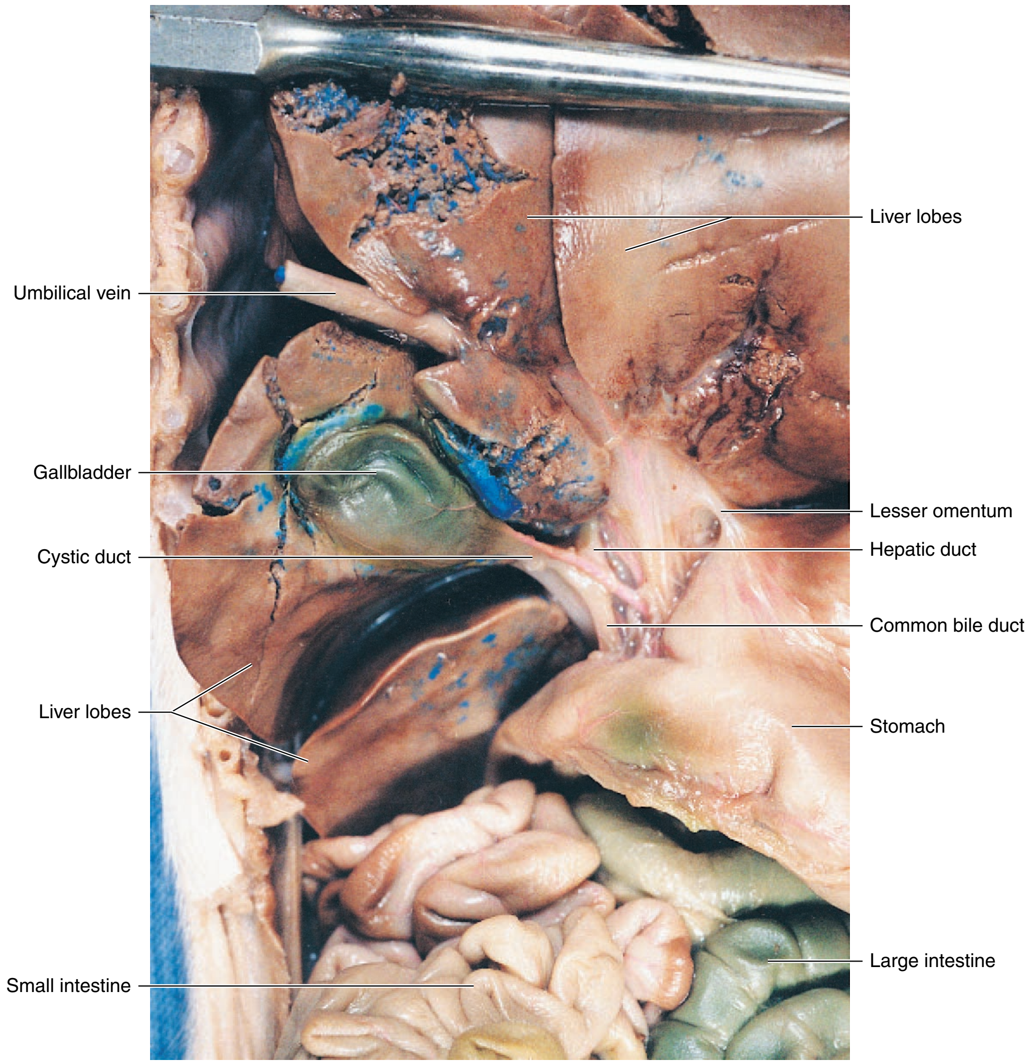


Figure 50.4 Digestive organs associated with the gallbladder of a fetal pig, ventral view. The liver is retracted for this view.



Laboratory Report **50**

Name ______________________________

Date ______________________________

Section ______________________________

Fetal Pig Dissection: Digestive System

Part A

Complete the following:

1. Compare the locations of the major salivary glands of the human with those of the fetal pig. ______________________________

2. Compare the types and numbers of primary (deciduous) teeth present in the pig's maxilla with those of the human. ______________________________

3. In what ways do the pig's teeth seem to be adapted to its diet? ______________________________

4. What part of the human soft palate is lacking in the pig? ______________________________

5. What do you think is the function of the transverse ridges (rugae) in the hard palate of the pig? ______________________________

6. Describe the papillae on the surface of the tongue of the pig. ______________________________

Part B

Complete the following:

1. Describe how the peritoneum and mesenteries are associated with the organs in the abdominal cavity. ______________________________

2. Describe the inner lining of the stomach. ______________________________

3. Compare the structure of the human liver with that of the fetal pig. ______________________________

4. Compare the structure and location of the human large intestine with those of the fetal pig. ______________________________

5. What feature of the human cecum is lacking in the fetal pig? ______________________________

Laboratory Exercise 51

Action of a Digestive Enzyme

MATERIALS NEEDED

0.5% amylase solution*
beakers (50 and 500 mL)
distilled water
funnel
pipets (1 and 10 mL)
pipet rubber bulbs
0.5% starch solution
graduated cylinder (10 mL)
test tubes
test-tube clamps
wax marker
iodine-potassium-iodide solution
medicine dropper
ice
water bath (37°C/98.6°F)
porcelain test plate
Benedict's solution
hot plates
test-tube rack
thermometer

*The amylase must be free of sugar. See Appendix 1.


Virtual Physiology Lab: 10, Enzyme Characteristics

SAFETY

- Use only a mechanical pipetting device (never your mouth). Use pipets with rubber bulbs or dropping pipets.
- Wear safety glasses when working with acids and when heating test tubes.
- Use test-tube clamps when handling hot test tubes.
- If an open flame is used for heating the test solutions, keep clothes and hair away from the flame.

The digestive enzyme in salivary secretions is called *amylase.* This enzyme splits starch molecules into sugar (disaccharide) molecules, which is the first step in the digestion of complex carbohydrates.

As in the case of other enzymes, amylase is a protein whose activity is affected by exposure to certain environmental factors including excessive heat, radiation, electricity, and certain chemicals.

PURPOSE OF THE EXERCISE

To investigate the action of amylase and the effect of heat on its enzymatic activity.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the action of amylase;
2. test a solution for the presence of starch or the presence of sugar;
3. test the effects of varying temperatures on the activity of amylase.

PROCEDURE A—AMYLASE ACTIVITY

1. Mark three clean test tubes as *tubes 1, 2, 3,* and prepare the tubes as follows:

   Tube 1: Add 6 mL of amylase solution.

   Tube 2: Add 6 mL of starch solution.

   Tube 3: Add 5 mL of starch solution and 1 mL of amylase solution.

2. Shake the tubes well to mix the contents and place them in a warm water bath (37°C/98.6°F) for 10 minutes.
3. At the end of the 10 minutes, test the contents of each tube for the presence of starch. To do this, follow these steps:
   a. Place 1 mL of the solution to be tested in a depression of a porcelain test plate.
   b. Next add two drops of iodine-potassium-iodide solution and note the color of the mixture. If the solution becomes blue-black, starch is present.
   c. Record the results in Part A of Laboratory Report 51.
4. Test the contents of each tube for the presence of sugar (disaccharides in this instance). To do this, follow these steps:
   a. Place 1 mL of the solution to be tested in a clean test tube.
   b. Add 1 mL of Benedict's solution.

c. Place the test tube with a test-tube clamp in a beaker of boiling water for 2 minutes.
d. Note the color of the liquid. If the solution becomes green, yellow, orange, or red, sugar is present. Blue indicates a negative test, whereas green indicates a positive test with the least amount of sugar, and red indicates the greatest amount of sugar present.
e. Record the results in Part A of the laboratory report.

5. Complete Part A of the laboratory report.

PROCEDURE B—EFFECT OF HEAT

1. Mark three clean test tubes as *tubes 4, 5,* and *6.*
2. Add 1 mL of amylase solution to each of the tubes and expose each solution to a different test temperature for 3 minutes as follows:

   Tube 4: Place in beaker of ice water (about 0°C/32°F).

   Tube 5: Place in warm water bath (about 37°C/98.6°F).

   Tube 6: Place in beaker of boiling water (about 100°C/212°F). Use a test-tube clamp.

3. Add 5 mL of starch solution to each tube, shake to mix the contents, and return the tubes to their respective test temperatures for 10 minutes. It is important that the 5 mL of starch solution added to tube 4 be at ice-water temperature before it is added to the 1 mL of amylase solution.
4. At the end of the 10 minutes, test the contents of each tube for the presence of starch and the presence of sugar by following the directions in Procedure A.
5. Complete Part B of the laboratory report.

OPTIONAL ACTIVITY

Devise an experiment to test the effect of some other environmental factor on amylase activity. For example, you might test the effect of a strong acid by adding a few drops of concentrated hydrochloric acid to a mixture of starch and amylase solutions. Be sure to include a control in your experimental plan. That is, include a tube containing everything except the factor you are testing. Then you will have something with which to compare your results. *Carry out your experiment only if it has been approved by the laboratory instructor.*

Laboratory Report **51**

Name ______________________________

Date ______________________________

Section ______________________________

Action of a Digestive Enzyme

Part A—Amylase Activity

1. Test results:

Tube	Starch	Sugar
1 Amylase solution		
2 Starch solution		
3 Starch-amylase solution		

2. Complete the following:

a. Explain the reason for including tube 1 in this experiment. ______________________________

b. What is the importance of tube 2? ______________________________

c. What do you conclude from the results of this experiment? ______________________________

Part B—Effect of Heat

1. Test results:

Tube	Starch	Sugar
4 0°C (32°F)		
5 37°C (98.6°F)		
6 100°C (212°F)		

2. Complete the following:

   a. What do you conclude from the results of this experiment? ______________________________

   ____

   ____

   ____

   ____

   ____

   b. If digestion failed to occur in one of the tubes in this experiment, how can you tell if the amylase was destroyed by the factor being tested or if the amylase activity was simply inhibited by the test treatment?

   ____

   ____

   ____

   ____

   ____

Critical Thinking Application

What test result would occur if the amylase used contained sugar? ______________________ Will your results be valid? Explain your answer.

____

____

____

____

Laboratory Exercise 52

Organs of the Respiratory System

MATERIALS NEEDED

textbook
human skull (sagittal section)
human torso
larynx model
thoracic organs model
compound microscope
prepared microscope slides of the following:
trachea (cross section)
lung, human (normal)

For Demonstrations:

animal lung with trachea (fresh or preserved)
prepared microscope slides of the following:
lung tissue (smoker)
lung tissue (emphysema)

SAFETY

- Wear disposable gloves when working on the fresh or preserved animal lung demonstration.
- Wash your hands before leaving the laboratory.

The organs of the respiratory system include the nose, nasal cavity, sinuses, pharynx, larynx, trachea, bronchial tree, and lungs. They mainly function to process incoming air and to transport it to and from the atmosphere outside the body and the air sacs of the lungs.

In the air sacs, gas exchanges take place between the air and the blood of nearby capillaries. The blood, in turn, transports gases to and from the air sacs and the body cells. This entire process of transporting and exchanging gases between the atmosphere and the body cells is called *respiration.*

PURPOSE OF THE EXERCISE

To review the structure and function of the respiratory organs and to examine the tissues of some of these organs microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate the major organs of the respiratory system;
2. describe the functions of these organs;
3. recognize tissue sections of the trachea and lung;
4. identify the major features of these tissue sections.

PROCEDURE A—RESPIRATORY ORGANS

1. Review a textbook section on *organs of the respiratory system.*
2. As a review activity, label figures 52.1, 52.2, 52.3, and 52.4.
3. Examine the sagittal section of the human skull, and locate the following features:

   nose

   nostrils (external nares)

   nasal cavity

   nasal septum

   nasal conchae

   superior meatus

   middle meatus

   inferior meatus

   sinuses

   maxillary sinus

   frontal sinus

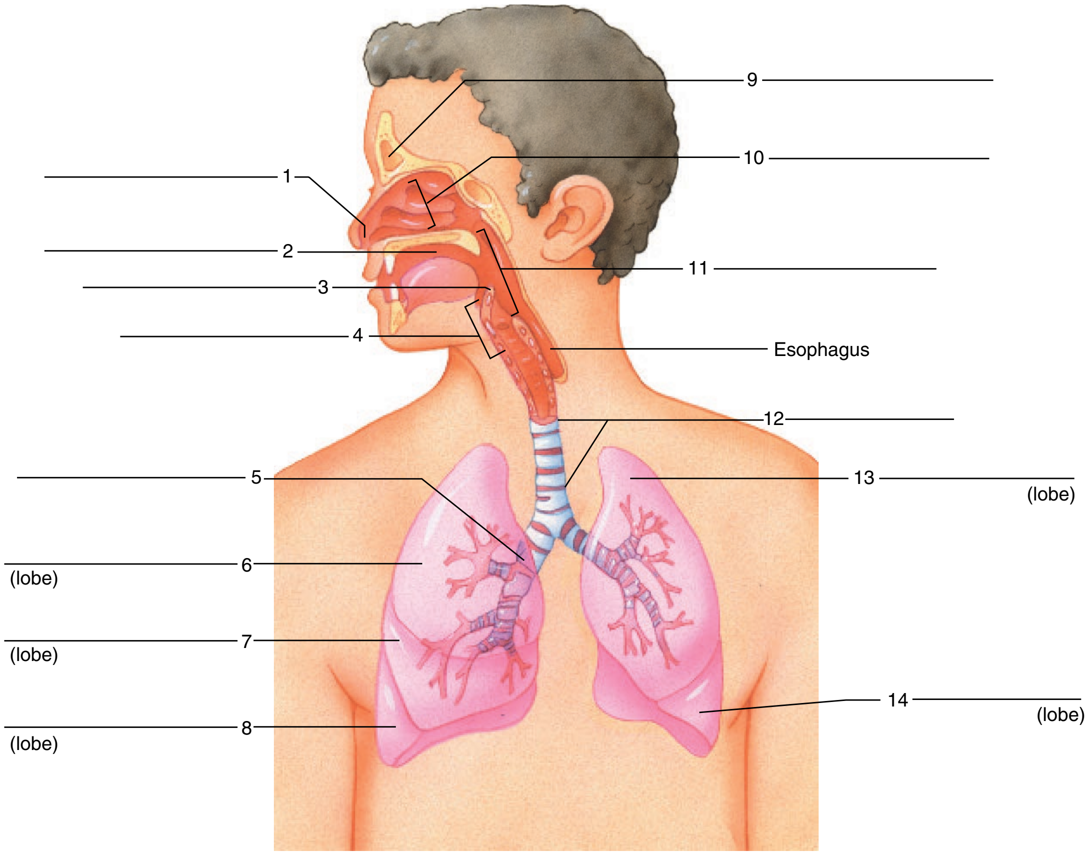
   ethmoidal sinus

   sphenoidal sinus

4. Observe the larynx model, the thoracic organs model, and the human torso. Locate the features listed in step 3. Also locate the following:

   pharynx

Figure 52.1 Label the major features of the respiratory system, including the lobes of the lungs.



larynx (palpate your own larynx)
- vocal cords
  - false vocal cords
  - true vocal cords
- thyroid cartilage ("Adam's apple")
- cricoid cartilage
- epiglottis
- epiglottic cartilage
- arytenoid cartilages
- corniculate cartilages
- cuneiform cartilages
- glottis

trachea (palpate your own trachea)

bronchi
- primary bronchi
- secondary bronchi

lung
- hilus
- lobes
  - superior lobe
  - middle lobe (right only)
  - inferior lobe
- lobules

visceral pleura

parietal pleura

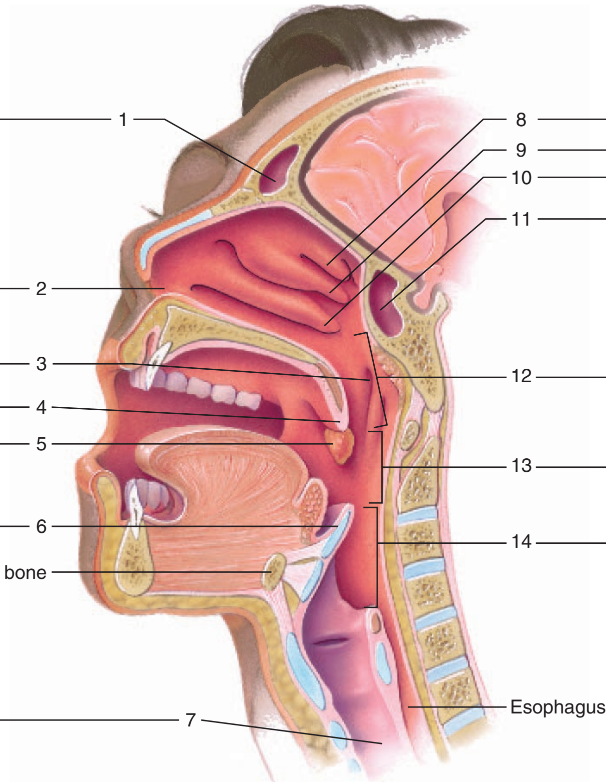
pleural cavity

5. Complete Part A of Laboratory Report 52.

PROCEDURE B—RESPIRATORY TISSUES

1. Obtain a prepared microscope slide of a trachea and use low-power magnification to examine it. Notice the inner lining of ciliated pseudostratified

Figure 52.2 Label the features of this sagittal section of the upper respiratory tract.



DEMONSTRATION

Observe the animal lung and the attached trachea. Identify the larynx, major laryngeal cartilages, trachea, and the incomplete cartilaginous rings of the trachea. Open the larynx and locate the vocal folds. Examine the visceral pleura on the surface of a lung, and squeeze a portion of a lung between your fingers. How do you describe the texture of the lung?

columnar epithelium and the deep layer of hyaline cartilage, which represents a portion of an incomplete (C-shaped) tracheal ring (fig. 52.5).

2. Use high-power magnification to observe the cilia on the free surface of the epithelial lining. Locate mucus-secreting goblet cells in the epithelium.
3. Prepare a labeled sketch of a representative portion of the tracheal wall in Part B of the laboratory report.
4. Obtain a prepared microscope slide of a human lung. Examine it using low-power magnification and note the numerous open spaces of the air sacs (alveoli). Look for a bronchiole—a tube with a relatively thick wall and a wavy inner lining. Locate the smooth muscle tissue in the wall of this tube (fig. 52.6). You also may see a section of cartilage as part of the bronchiole wall.
5. Use high-power magnification to examine the alveoli. Note that their walls are composed of simple squamous epithelium. You also may see sections of blood vessels filled with blood cells.
6. Prepare a labeled sketch of a representative portion of the lung in Part B of the laboratory report.
7. Complete Part C of the laboratory report.

DEMONSTRATION

Examine the prepared microscope slides of the lung tissue of a smoker and a person with emphysema using low-power magnification. How does the smoker's lung tissue compare with that of the normal lung tissue that you examined previously? ______________________

____

____

How does the emphysema patient's lung tissue compare with the normal lung tissue? __________________

____

____

Figure 52.3 Label the major features of the larynx: (*a*) anterior view; (*b*) posterior view.

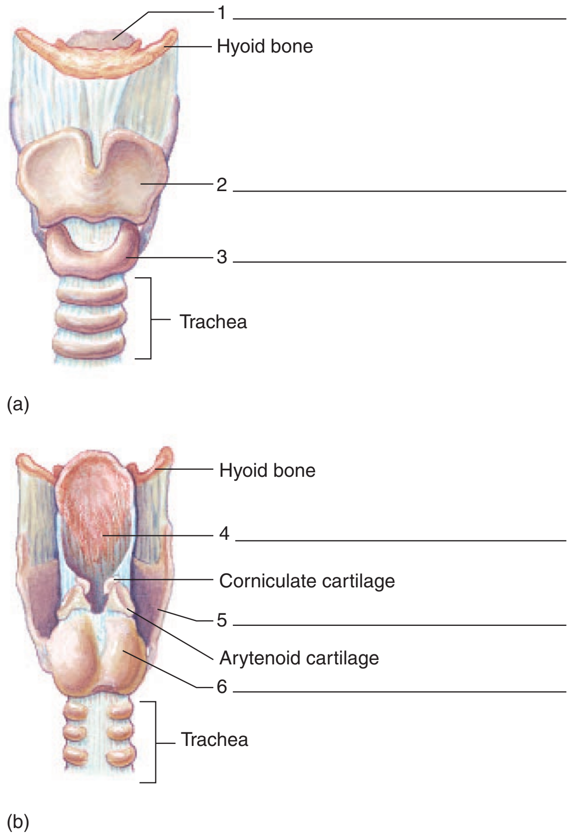


Figure 52.4 Label the features of the superior aspect of the larynx with the glottis closed.

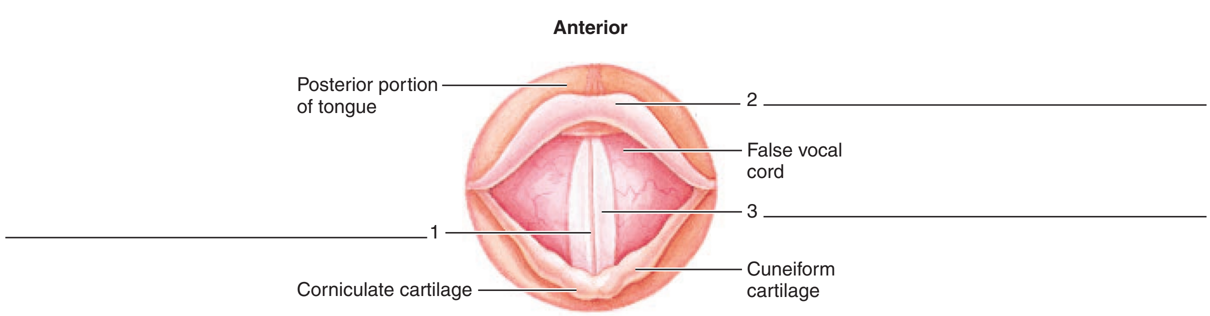


Figure 52.5 Micrograph of a section of the tracheal wall (63×).

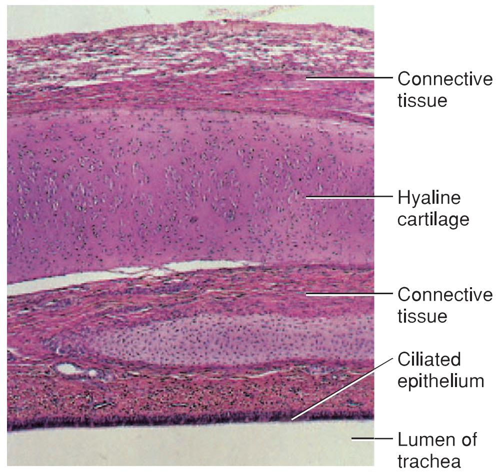
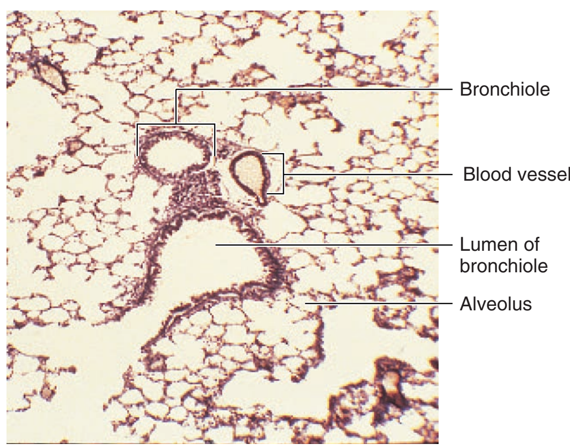


Figure 52.6 Micrograph of human lung tissue (35×).



Laboratory Report **52**

Name ______________________________

Date ______________________________

Section ______________________________

Organs of the Respiratory System

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. alveolus	____	1. potential space between visceral and parietal pleurae
b. cricoid cartilage	____	2. most inferior portion of larynx
c. epiglottis	____	3. serves as resonant chamber and reduces weight of skull
d. glottis	____	4. microscopic air sacs for gas exchange
e. lung	____	5. consists of large lobes
f. nasal concha	____	6. opening between vocal cords
g. pharynx	____	7. fold of mucous membrane containing elastic fibers responsible for sounds
h. pleural cavity	____	8. increases surface area of nasal mucous membrane
i. sinus (paranasal sinus)	____	9. passageway for air and food
j. vocal cord (true)	____	10. partially covers opening of larynx during swallowing

Part B

1. Prepare a labeled sketch of a portion of the tracheal wall.

2. Prepare a labeled sketch of a portion of lung tissue.

Part C

Complete the following:

1. What is the function of the mucus secreted by the goblet cells? ______________________________

2. Describe the function of the cilia in the respiratory tubes. ______________________________

3. How is breathing improved if the smooth muscle of the bronchial tree relaxes? ______________________________

Critical Thinking Application

Why are the alveolar walls so thin?

____

Laboratory Exercise 53

Fetal Pig Dissection: Respiratory System

MATERIALS NEEDED

preserved fetal pig
dissecting tray
dissecting instruments
beaker of water
disposable gloves
human torso

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

In this laboratory exercise, you will dissect the major respiratory organs of a preserved fetal pig. As you observe these structures in the fetal pig, compare them with those of the human torso.

PURPOSE OF THE EXERCISE

To examine the major respiratory organs of the fetal pig, and to compare these organs with those of the human.

LEARNING OBJECTIVES

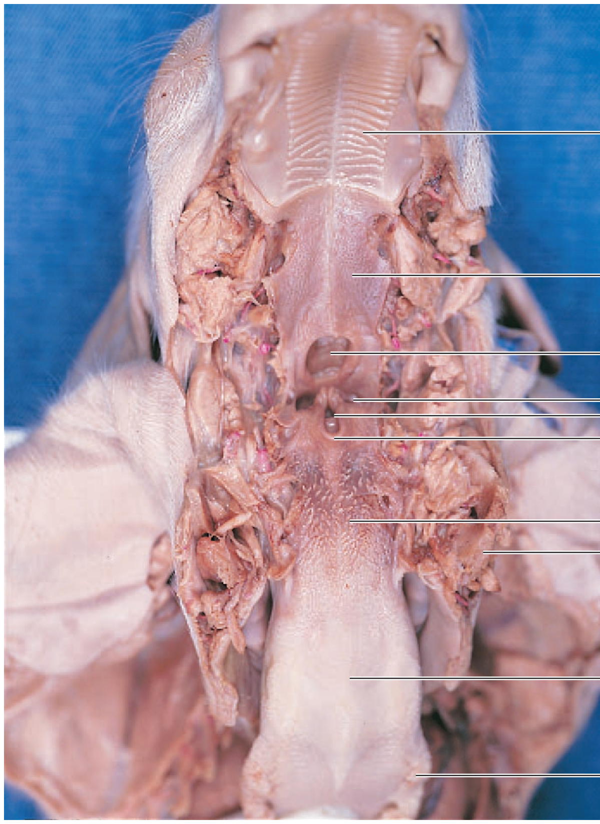
After completing this exercise, you should be able to

1. locate and identify the major respiratory organs of the fetal pig;
2. identify the corresponding organs in the human torso;
3. compare the respiratory system of the human with that of the fetal pig.

PROCEDURE

1. Place the fetal pig in a dissecting tray with its ventral side up.
2. Examine the *nostrils (external nares)* located on the the flat *rostrum (snout).*
3. Open the mouth wide to expose the *hard palate* and the *soft palate* (see figs. 50.2 and 53.1). Cut through the tissues of the soft palate, and observe the *nasopharynx* above it. Locate the small openings of the *auditory tubes* in the lateral walls of the nasopharynx. Insert a probe into an opening of an auditory tube. Examine the *oropharynx* located near the base of the tongue.
4. Pull the tongue posteriorly and locate the *epiglottis* at its base. Also identify the *glottis,* which is the opening into the larynx. (In the human the term *glottis* refers to the opening between the vocal folds within the larynx.) Locate the *esophagus,* which is dorsal to the larynx.
5. Open the thoracic cavity, and expose its contents. Examine the organs located in the *mediastinum.* Note that the mediastinum separates the right and left lungs and pleural cavities within the thorax.
6. Dissect the *trachea* in the neck, and expose the *larynx* at the anterior end near the base of the tongue. Note the *tracheal rings,* and locate the *thyroid gland* on the trachea, just posterior to the larynx. Locate a small *parathyroid gland* attached to the dorsal surface of the thyroid gland. Also note the *thymus gland,* extending along each side of the trachea into the thorax (fig. 53.2).
7. Examine the larynx by removing any attached muscles, and identify the *thyroid cartilage* and *cricoid cartilage* in its wall. Make a longitudinal incision through the ventral wall of the larynx, and locate the *vocal cords* that appear as whitish folds inside.
8. Remove the heart and trace the trachea posteriorly to where it divides into *bronchi,* which pass into the lungs (fig. 53.3).
9. Examine the *lungs,* each of which is subdivided into lobes—a *cranial,* a *middle,* and a *caudal lobe.* The right lung has an additional deep *acccessory lobe.* Notice the thin membrane, the *visceral pleura,* on the surface of each lung. Also notice the *parietal pleura,* which forms the inner lining of the thoracic wall, and locate the spaces of the *pleural cavities.*

Figure 53.1 Oral cavity of the fetal pig with tongue pulled posteriorly, ventral view.



10. Make an incision through a lobe of a lung, and examine its interior. Note the branches of the smaller air passages. You can see the branches of the bronchial tree if you follow a primary bronchus into the lung and gently scrape away lung tissue with a scalpel.
11. Examine the *diaphragm* and locate the *phrenic nerve.* This nerve appears as a white thread passing along the side of the heart to the diaphragm (fig. 53.2).
12. Remove a small piece of the lung and notice the solid texture of the tissue. Place the piece of lung into a beaker of water. Does the fetal lung tissue float or sink? ______________________
13. Complete Laboratory Report 53.

Critical Thinking Application

Under what conditions would a piece of lung tissue sink?

____

____

____

Under what conditions would it float?

____

____

____

Figure 53.2 Respiratory organs and glands of the fetal pig, ventral view.

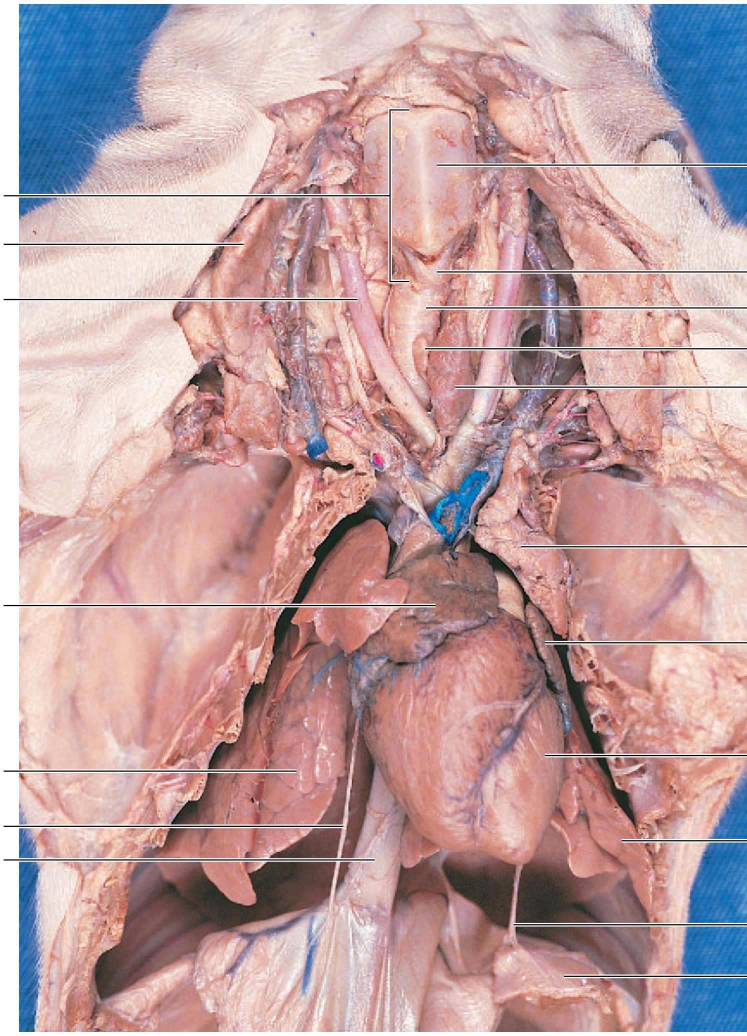
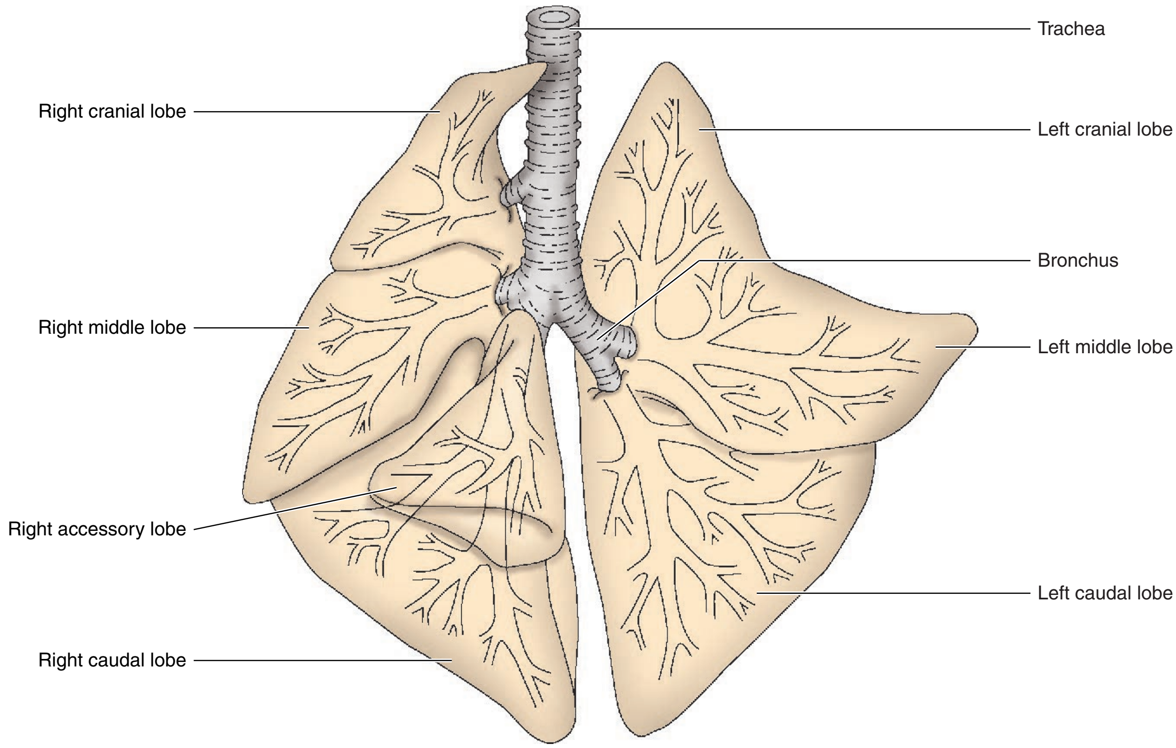


Figure 53.3 Lungs and respiratory tubes of the fetal pig, ventral view.



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Laboratory Report **53**

Name ______________________

Date ______________________

Section ______________________

Fetal Pig Dissection: Respiratory System

Complete the following:

1. What is the purpose of the auditory tubes opening into the nasopharynx? ______________________

2. Distinguish between the glottis and the epiglottis. ______________________

3. Are the tracheal rings of the fetal pig complete or incomplete circles? ____________ How does this feature compare with that of the human? ______________________

4. Compare the number of lobes in the human lungs with the number of lobes in the fetal pig. ______________________

5. Describe the attachments of the diaphragm. ____

____

____

____

____

6. What major structures are located within the mediastinum?_________________________________
________________________________ How does this compare to the human mediastinum? __________
____

Laboratory Exercise 54

Breathing and Respiratory Volumes and Capacities

MATERIALS NEEDED

textbook
spirometer, handheld (dry portable)
70% alcohol
cotton
disposable mouthpieces
meter stick

For Demonstration:

lung function model
Virtual Physiology Lab: 6, Pulmonary Function
Virtual Physiology Lab: 7, Respiration and Exercise

SAFETY

- Clean the spirometer with cotton moistened with 70% alcohol before each use.
- Place a new disposable mouthpiece on the stem of the spirometer before each use.
- Dispose of the cotton and mouthpieces according to your laboratory instructor.

Breathing involves the movement of air from outside the body through the bronchial tree and into the alveoli and the reversal of this air movement. These movements are caused by changes in the size of the thoracic cavity that result from skeletal muscle contractions and from the elastic recoil of stretched tissues.

The volumes of air that move in and out of the lungs during various phases of breathing are called *respiratory air volumes* and *capacities.* These volumes can be measured by using an instrument called a spirometer. However, the values obtained vary with a person's age, sex, height, and weight. Various respiratory capacities can be calculated by combining two or more of the respiratory volumes.

PURPOSE OF THE EXERCISE

To review the mechanisms of breathing and to measure or calculate certain respiratory air volumes and respiratory capacities.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the mechanisms responsible for inspiration and expiration;
2. define the respiratory air volumes and respiratory capacities;
3. measure or calculate the respiratory air volumes and capacities.

PROCEDURE A—BREATHING MECHANISMS

1. Review textbook sections on *inspiration* and *expiration.*
2. Complete Part A of Laboratory Report 54.

DEMONSTRATION

Observe the mechanical lung function model. Note that it consists of a heavy glass bell jar with a rubber sheeting tied over its wide open end. Its narrow upper opening is plugged with a rubber stopper through which a glass Y tube is passed. Small rubber balloons are fastened to the arms of the Y (fig. 54.1). What happens to the balloons when the rubber sheeting is pulled downward?

____

____

What happens when the sheeting is pushed upward?

____

____

____

How do you explain these changes? ________________

____

____

____

What part of the respiratory system is represented by

the rubber sheeting? ______________________________

the bell jar? ____________________________________

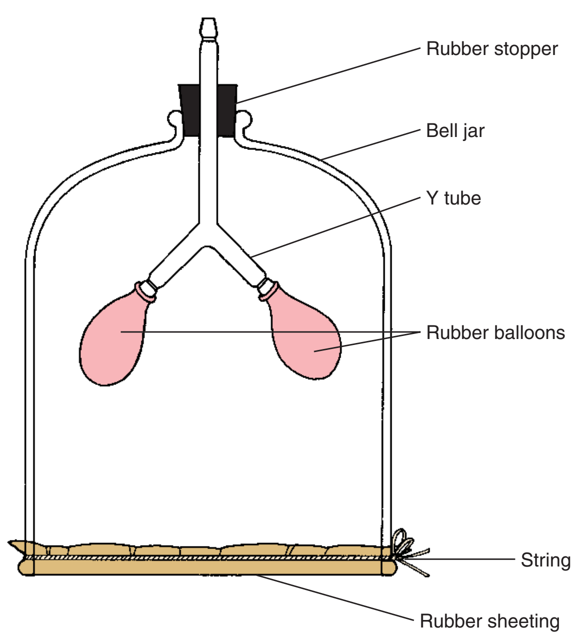
the Y tube? _____________________________________

the balloons? ___________________________________

PROCEDURE B—RESPIRATORY AIR VOLUMES AND CAPACITIES

1. Review a textbook section on *respiratory volumes and capacities.*
2. Complete Part B of the laboratory report.
3. Obtain a handheld spirometer. Note that the needle can be set at zero by rotating the adjustable dial. Before using the instrument, clean it with cotton moistened with 70% alcohol and place a new disposable mouthpiece over its stem. The instrument should be held with the dial upward and air should be blown into the disposable mouthpiece. Movement of the needle indicates the air volume that leaves the lungs (fig. 54.2).
4. *Tidal volume* is the volume of air that enters (or leaves) the lungs during a *respiratory cycle* (one inspiration plus the following expiration). *Resting tidal volume* is the volume of air that enters (or leaves) the lungs during normal, quiet breathing (fig. 54.3). To measure this volume, follow these steps:
   a. Sit quietly for a few moments.
   b. Position the spirometer dial so that the needle points to zero.
   c. Place the mouthpiece between your lips and exhale three ordinary expirations into it after inhaling through the nose each time. *Do not force air out of your lungs; exhale normally.*
   d. Divide the total value indicated by the needle by 3 and record this amount as your resting tidal volume on the table in Part C of the laboratory report.
5. *Expiratory reserve volume* is the volume of air in addition to the tidal volume that leaves the lungs during forced expiration. To measure this volume, follow these steps:
   a. Breathe normally for a few moments. Set the needle to zero.
   b. At the end of an ordinary expiration, place the mouthpiece between your lips and exhale all of the air you can force from your lungs through the spirometer.
   c. Record the results as your expiratory reserve volume in Part C.

Figure 54.1 A lung function model.



6. *Vital capacity* is the maximum volume of air that can be exhaled after taking the deepest breath possible. To measure this volume, follow these steps:
   a. Breathe normally for a few moments. Set the needle at zero.
   b. Breathe in and out deeply a couple of times, then take the deepest breath possible.
   c. Place the mouthpiece between your lips and exhale all the air out of your lungs, slowly and forcefully.
   d. Record the value as your vital capacity in Part C. Compare your result with that expected for a person of your sex, age, and height listed in tables 54.1 and 54.2. Use the meter stick to determine your height in centimeters if necessary or multiply your height in inches times 2.54 to calculate your height in centimeters. Considerable individual variations from the expected will be noted due to parameters other than sex, age, and height, which could include physical shape, health, medications, and others.

Critical Thinking Application

It can be noted from the data in tables 54.1 and 54.2 that vital capacities gradually decrease with age. Propose an explanation for this normal correlation.

____

____

____

____

7. *Inspiratory reserve volume* (IRV) is the volume of air in addition to the tidal volume that enters the lungs during forced inspiration. Calculate your inspiratory reserve volume by subtracting your tidal volume (TV) and your expiratory reserve volume (ERV) from your vital capacity (VC):

$$IRV = VC - (TV + ERV).$$

8. *Inspiratory capacity* (IC) is the maximum volume of air a person can inhale following exhalation of

Figure 54.2 A handheld spirometer can be used to measure respiratory air volumes.

Figure 54.3 Graphic representation of respiratory volumes and capacities.

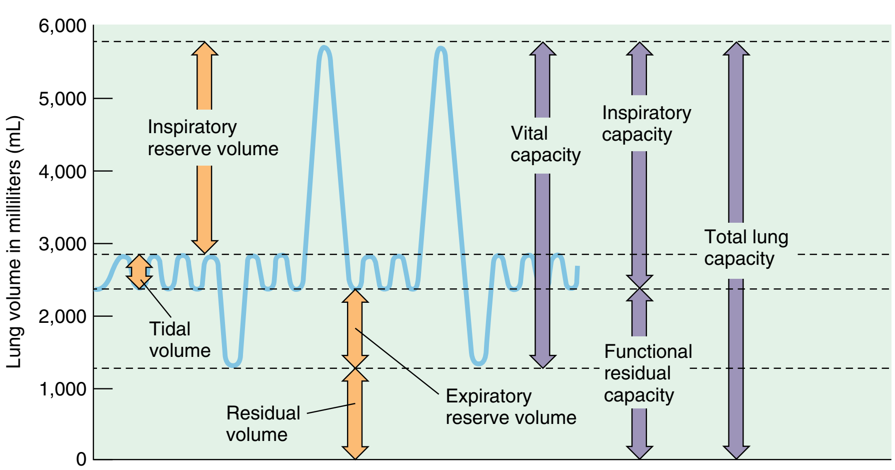


Table 54.1 Predicted Vital Capacities (in Milliliters) for Females

	Height in Centimeters																								
Age	**146**	**148**	**150**	**152**	**154**	**156**	**158**	**160**	**162**	**164**	**166**	**168**	**170**	**172**	**174**	**176**	**178**	**180**	**182**	**184**	**186**	**188**	**190**	**192**	**194**
16	2950	2990	3030	3070	3110	3150	3190	3230	3270	3310	3350	3390	3430	3470	3510	3550	3590	3630	3670	3715	3755	3800	3840	3880	3920
17	2935	2975	3015	3055	3095	3135	3175	3215	3255	3295	3335	3375	3415	3455	3495	3535	3575	3615	3655	3695	3740	3780	3820	3860	3900
18	2920	2960	3000	3040	3080	3120	3160	3200	3240	3280	3320	3360	3400	3440	3480	3520	3560	3600	3640	3680	3720	3760	3800	3840	3880
20	2890	2930	2970	3010	3050	3090	3130	3170	3210	3250	3290	3330	3370	3410	3450	3490	3525	3565	3605	3645	3695	3720	3760	3800	3840
22	2860	2900	2940	2980	3020	3060	3095	3135	3175	3215	3255	3290	3330	3370	3410	3450	3490	3530	3570	3610	3650	3685	3725	3765	3800
24	2830	2870	2910	2950	2985	3025	3065	3100	3140	3180	3220	3260	3300	3335	3375	3415	3455	3490	3530	3570	3610	3650	3685	3725	3765
26	2800	2840	2880	2920	2960	3000	3035	3070	3110	3150	3190	3230	3265	3300	3340	3380	3420	3455	3495	3530	3570	3610	3650	3685	3725
28	2775	2810	2850	2890	2930	2965	3000	3040	3070	3115	3155	3190	3230	3270	3305	3345	3380	3420	3460	3495	3535	3570	3610	3650	3685
30	2745	2780	2820	2860	2895	2935	2970	3010	3045	3085	3120	3160	3195	3235	3270	3310	3345	3385	3420	3460	3495	3535	3570	3610	3645
32	2715	2750	2790	2825	2865	2900	2940	2975	3015	3050	3090	3125	3160	3200	3235	3275	3310	3350	3385	3425	3460	3495	3535	3570	3610
34	2685	2725	2760	2795	2835	2870	2910	2945	2980	3020	3055	3090	3130	3165	3200	3240	3275	3310	3350	3385	3425	3460	3495	3535	3570
36	2655	2695	2730	2765	2805	2840	2875	2910	2950	2985	3020	3060	3095	3130	3165	3205	3240	3275	3310	3350	3385	3420	3460	3495	3530
38	2630	2665	2700	2735	2770	2810	2845	2880	2915	2950	2990	3025	3060	3095	3130	3170	3205	3240	3275	3310	3350	3385	3420	3455	3490
40	2600	2635	2670	2705	2740	2775	2810	2850	2885	2920	2955	2990	3025	3060	3095	3135	3170	3205	3240	3275	3310	3345	3380	3420	3455
42	2570	2605	2640	2675	2710	2745	2780	2815	2850	2885	2920	2955	2990	3025	3060	3100	3135	3170	3205	3240	3275	3310	3345	3380	3415
44	2540	2575	2610	2645	2680	2715	2750	2785	2820	2855	2890	2925	2960	2995	3030	3060	3095	3130	3165	3200	3235	3270	3305	3340	3375
46	2510	2545	2580	2615	2650	2685	2715	2750	2785	2820	2855	2890	2925	2960	2995	3030	3060	3095	3130	3165	3200	3235	3270	3305	3340
48	2480	2515	2550	2585	2620	2650	2685	2715	2750	2785	2820	2855	2890	2925	2960	2995	3030	3060	3095	3130	3160	3195	3230	3265	3300
50	2455	2485	2520	2555	2590	2625	2655	2690	2720	2755	2785	2820	2855	2890	2925	2955	2990	3025	3060	3090	3125	3155	3190	3225	3260
52	2425	2455	2490	2525	2555	2590	2625	2655	2690	2720	2755	2790	2820	2855	2890	2925	2955	2990	3020	3055	3090	3125	3155	3190	3220
54	2395	2425	2460	2495	2530	2560	2590	2625	2655	2690	2720	2755	2790	2820	2855	2885	2920	2950	2985	3020	3050	3085	3115	3150	3180
56	2365	2400	2430	2460	2495	2525	2560	2590	2625	2655	2690	2720	2755	2790	2820	2855	2885	2920	2950	2980	3015	3045	3080	3110	3145
58	2335	2370	2400	2430	2460	2495	2525	2560	2590	2625	2655	2690	2720	2750	2785	2815	2850	2880	2920	2945	2975	3010	3040	3075	3105
60	2305	2340	2370	2400	2430	2460	2495	2525	2560	2590	2625	2655	2685	2720	2750	2780	2810	2845	2875	2915	2940	2970	3000	3035	3065
62	2280	2310	2340	2370	2405	2435	2465	2495	2525	2560	2590	2620	2655	2685	2715	2745	2775	2810	2840	2870	2900	2935	2965	2995	3025
64	2250	2280	2310	2340	2370	2400	2430	2465	2495	2525	2555	2585	2620	2650	2680	2710	2740	2770	2805	2835	2865	2895	2920	2955	2990
66	2220	2250	2280	2310	2340	2370	2400	2430	2460	2495	2525	2555	2585	2615	2645	2675	2705	2735	2765	2800	2825	2860	2890	2920	2950
68	2190	2220	2250	2280	2310	2340	2370	2400	2430	2460	2490	2520	2550	2580	2610	2640	2670	2700	2730	2760	2795	2820	2850	2880	2910
70	2160	2190	2220	2250	2280	2310	2340	2370	2400	2425	2455	2485	2515	2545	2575	2605	2635	2665	2695	2725	2755	2780	2810	2840	2870
72	2130	2160	2190	2220	2250	2280	2310	2335	2365	2395	2425	2455	2480	2510	2540	2570	2600	2630	2660	2685	2715	2745	2775	2805	2830
74	2100	2130	2160	2190	2220	2245	2275	2305	2335	2360	2390	2420	2450	2475	2505	2535	2565	2590	2620	2650	2680	2710	2740	2765	2795

From E. DeF. Baldwin and E. W. Richards, Jr., "Pulmonary Insufficiency 1, Physiologic Classification, Clinical Methods of Analysis, Standard Values in Normal Subjects" in *Medicine* 27:243, © by William & Wilkins. Used by permission.

Table 54.2 Predicted Vital Capacities (in Milliliters) for Males

	Height in Centimeters																							
Age	**146**	**148**	**150**	**152**	**154**	**156**	**158**	**160**	**162**	**164**	**166**	**168**	**170**	**172**	**174**	**176**	**178**	**180**	**182**	**184**	**186**	**188**	**190**	**192**	**194**
16	3765	3820	3870	3920	3975	4025	4075	4130	4180	4230	4285	4335	4385	4440	4490	4540	4590	4645	4695	4745	4800	4850	4900	4955	5005
18	3740	3790	3840	3890	3940	3995	4045	4095	4145	4200	4250	4300	4350	4405	4455	4505	4555	4610	4660	4710	4760	4815	4865	4915	4965
20	3710	3760	3810	3860	3910	3960	4015	4065	4115	4165	4215	4265	4320	4370	4420	4470	4520	4570	4625	4675	4725	4775	4825	4875	4930
22	3680	3730	3780	3830	3880	3930	3980	4030	4080	4135	4185	4235	4285	4335	4385	4435	4485	4535	4585	4635	4685	4735	4790	4840	4890
24	3635	3685	3735	3785	3835	3885	3935	3985	4035	4085	4135	4185	4235	4285	4330	4380	4430	4480	4530	4580	4630	4680	4730	4780	4830
26	3605	3655	3705	3755	3805	3855	3905	3955	4000	4050	4100	4150	4200	4250	4300	4350	4395	4445	4495	4545	4595	4645	4695	4740	4790
28	3575	3625	3675	3725	3775	3820	3870	3920	3970	4020	4070	4115	4165	4215	4265	4310	4360	4410	4460	4510	4555	4605	4655	4705	4755
30	3550	3595	3645	3695	3740	3790	3840	3890	3935	3985	4035	4080	4130	4180	4230	4275	4325	4375	4425	4470	4520	4570	4615	4665	4715
32	3520	3565	3615	3665	3710	3760	3810	3855	3905	3950	4000	4050	4095	4145	4195	4240	4290	4340	4385	4435	4485	4530	4580	4625	4675
34	3475	3525	3570	3620	3665	3715	3760	3810	3855	3905	3950	4000	4045	4095	4140	4190	4225	4285	4330	4380	4425	4475	4520	4570	4615
36	3445	3495	3540	3585	3635	3680	3730	3775	3825	3870	3920	3965	4010	4060	4105	4155	4200	4250	4295	4340	4390	4435	4485	4530	4580
38	3415	3465	3510	3555	3605	3650	3695	3745	3790	3840	3885	3930	3980	4025	4070	4120	4165	4210	4260	4305	4350	4400	4445	4495	4540
40	3385	3435	3480	3525	3575	3620	3665	3710	3760	3805	3850	3900	3945	3990	4035	4085	4130	4175	4220	4270	4315	4360	4410	4455	4500
42	3360	3405	3450	3495	3540	3590	3635	3680	3725	3770	3820	3865	3910	3955	4000	4050	4095	4140	4185	4230	4280	4325	4370	4415	4460
44	3315	3360	3405	3450	3495	3540	3585	3630	3675	3725	3770	3815	3860	3905	3950	3995	4040	4085	4130	4175	4220	4270	4315	4360	4405
46	3285	3330	3375	3420	3465	3510	3555	3600	3645	3690	3735	3780	3825	3870	3915	3960	4005	4050	4095	4140	4185	4230	4275	4320	4365
48	3255	3300	3345	3390	3435	3480	3525	3570	3615	3655	3700	3745	3790	3835	3880	3925	3970	4015	4060	4105	4150	4190	4235	4280	4325
50	3210	3255	3300	3345	3390	3430	3475	3520	3565	3610	3650	3695	3740	3785	3830	3870	3915	3960	4005	4050	4090	4135	4180	4225	4270
52	3185	3225	3270	3315	3355	3400	3445	3490	3530	3575	3620	3660	3705	3750	3795	3835	3880	3925	3970	4010	4055	4100	4140	4185	4230
54	3155	3195	3240	3285	3325	3370	3415	3455	3500	3540	3585	3630	3670	3715	3760	3800	3845	3890	3930	3975	4020	4060	4105	4145	4190
56	3125	3165	3210	3255	3295	3340	3380	3425	3465	3510	3550	3595	3640	3680	3725	3765	3810	3850	3895	3940	3980	4025	4065	4110	4150
58	3080	3125	3165	3210	3250	3290	3335	3375	3420	3460	3500	3545	3585	3630	3670	3715	3755	3800	3840	3880	3925	3965	4010	4050	4095
60	3050	3095	3135	3175	3220	3260	3300	3345	3385	3430	3470	3500	3555	3595	3635	3680	3720	3760	3805	3845	3885	3930	3970	4015	4055
62	3020	3060	3110	3150	3190	3230	3270	3310	3350	3390	3440	3480	3520	3560	3600	3640	3680	3730	3770	3810	3850	3890	3930	3970	4020
64	2990	3030	3080	3120	3160	3200	3240	3280	3320	3360	3400	3440	3490	3530	3570	3610	3650	3690	3730	3770	3810	3850	3900	3940	3980
66	2950	2990	3030	3070	3110	3150	3190	3230	3270	3310	3350	3390	3430	3470	3510	3550	3600	3640	3680	3720	3760	3800	3840	3880	3920
68	2920	2960	3000	3040	3080	3120	3160	3200	3240	3280	3320	3360	3400	3440	3480	3520	3560	3600	3640	3680	3720	3760	3800	3840	3880
70	2890	2930	2970	3010	3050	3090	3130	3170	3210	3250	3290	3330	3370	3410	3450	3480	3520	3560	3600	3640	3680	3720	3760	3800	3840
72	2860	2900	2940	2980	3020	3060	3100	3140	3180	3210	3250	3290	3330	3370	3410	3450	3490	3530	3570	3610	3650	3680	3720	3760	3800
74	2820	2860	2900	2930	2970	3010	3050	3090	3130	3170	3200	3240	3280	3320	3360	3400	3440	3470	3510	3550	3590	3630	3670	3710	3740

From E. DeF. Baldwin and E. W. Richards, Jr., "Pulmonary Insufficiency 1, Physiologic Classification, Clinical Methods of Analysis, Standard Values in Normal Subjects" in *Medicine* 27:243, © by William & Wilkins. Used by permission.

the tidal volume. Calculate your inspiratory capacity by adding your tidal volume (TV) and your inspiratory reserve volume (IRV):

IC = TV + IRV.

9. *Functional residual capacity* (FRC) is the volume of air that remains in the lungs following exhalation of the tidal volume. Calculate your functional residual capacity (FRC) by adding your expiratory reserve volume (ERV) and your residual volume (RV), which you can assume is 1,200 mL:

FRC = ERV + 1,200.

10. Complete Part C of the laboratory report.

OPTIONAL ACTIVITY

Determine your *minute respiratory volume.* To do this, follow these steps:

1. Sit quietly for a while, and then to establish your breathing rate, count the number of times you breathe in 1 minute. This might be inaccurate because conscious awareness of breathing rate can alter the results. You might ask a laboratory partner to record your breathing rate at some time when you are not expecting it to be recorded.
2. Calculate your minute respiratory volume by multiplying your breathing rate by your tidal volume.

   __________ × __________ = ________________
   (breathing rate) (tidal volume) (minute respiratory volume)
3. This value indicates the total volume of air that moves into your respiratory passages during each minute of ordinary breathing.

Laboratory Report **54**

Name ______________________________

Date ______________________________

Section ______________________________

Breathing and Respiratory Volumes and Capacities

Part A

Complete the following statements:

1. Nerve impulses are carried to the diaphragm by the ______________________ nerves.
2. When the diaphragm contracts, the size of the thoracic cavity ______________________.
3. The ribs are raised by contraction of the ______________________ muscles, which increases the size of the thoracic cavity.
4. Only a thin film of lubricating serous fluid separates the parietal pleura from the ______________________ of a lung.
5. A mixture of lipoproteins, called __________________, acts to reduce the tendency of alveoli to collapse.
6. Muscles that help to force out more than the normal volume of air by pulling the ribs downward and inward include the ______________________.
7. We inhale when the diaphragm ______________________.

Part B

Match the air volumes in column A with the definitions in column B. Place the letter of your choice in the space provided.

Column A

a. expiratory reserve volume
b. functional residual capacity
c. inspiratory capacity
d. inspiratory reserve volume
e. residual volume
f. tidal volume
g. total lung capacity
h. vital capacity

Column B

____ 1. volume in addition to tidal volume that leaves the lungs during forced expiration

____ 2. vital capacity plus residual volume

____ 3. volume that remains in lungs after the most forceful expiration

____ 4. volume that enters or leaves lungs during a respiratory cycle

____ 5. volume in addition to tidal volume that enters lungs during forced inspiration

____ 6. maximum volume a person can exhale after taking the deepest possible breath

____ 7. maximum volume a person can inhale following exhalation of the tidal volume

____ 8. volume of air remaining in the lungs following exhalation of the tidal volume

Part C

1. Test results for respiratory air volumes and capacities:

Respiratory Volume or Capacity	Expected Value* (approximate)	Test Result	Percent of Expected Value (test result/expected value × 100)
Tidal volume (resting) (TV)	500 mL		
Expiratory reserve volume (ERV)	1,100 mL		
Vital capacity (VC)	4,600 mL (or enter yours from the table)		
Inspiratory reserve volume (IRV)	3,000 mL		
Inspiratory capacity (IC)	3,500 mL		
Functional residual capacity (FRC)	2,300 mL		

**The values listed are most characteristic for a tall, young adult.*

2. Complete the following:

   a. How do your test results compare with the expected values? ______________________

   ____

   ____

   ____

   ____

   b. How does your vital capacity compare with the average value for a person of your sex, age, and height?

   ____

   ____

   c. What measurement in addition to vital capacity is needed before you can calculate your total lung capacity?

   ____

3. If your experimental results are considerably different than the predicted vital capacities, propose reasons for the differences. As you write this paragraph, consider factors like smoking, exercise, respiratory disorders, and medications. (Your instructor might have you make some class correlations from class data.) ______________________

   ____

   ____

   ____

   ____

   ____

Laboratory Exercise 55

Control of Breathing

MATERIALS NEEDED

textbook
clock with second hand
paper bags, small

For Demonstration:

flasks
glass tubing
rubber stoppers, two-hole
calcium hydroxide solution (limewater)

For Optional Activity:

pneumograph
physiological recording apparatus
Virtual Physiology Lab: 7, Respiration and Exercise

Normal breathing is controlled from a poorly defined region of the brain stem called the respiratory center. This center initiates nerve impulses that travel to various muscles, causing rhythmic breathing movements.

Various factors can influence the respiratory center and thus affect the rate and depth of breathing. These factors include stretch of the lung tissues, emotional state, and the presence in the blood of certain chemicals, such as carbon dioxide, hydrogen ions, and oxygen. For example, the breathing rate increases as the blood concentration of carbon dioxide or hydrogen ions increases or as the concentration of oxygen decreases.

PURPOSE OF THE EXERCISE

To review the mechanisms that control breathing, and to investigate some of the factors that affect the rate and depth of breathing.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate the breathing center in the brain;
2. describe the mechanisms that control normal breathing;
3. list several factors that influence the breathing center;
4. test the effect of various factors on the rate and depth of breathing.

PROCEDURE A—CONTROL OF BREATHING

1. Review a textbook section on *control of breathing.*
2. Complete Part A of Laboratory Report 55.

DEMONSTRATION

When a solution of calcium hydroxide is exposed to carbon dioxide, a chemical reaction occurs and a white precipitate of calcium carbonate is formed as indicated by the following reaction:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_2 + H_2O$$

Thus, a clear water solution of calcium hydroxide (limewater) can be used to detect the presence of carbon dioxide because the solution becomes cloudy if this gas is bubbled through it.

The laboratory instructor will demonstrate this test for carbon dioxide by drawing some air through limewater in an apparatus such as that shown in figure 55.1. Then the instructor will blow an equal volume of expired air through a similar apparatus. (*Note:* A new sterile mouthpiece should be used each time the apparatus is demonstrated.) Watch for the appearance of a precipitate that causes the limewater to become cloudy. Was there any carbon dioxide in the atmospheric air drawn through the limewater?________________________

____

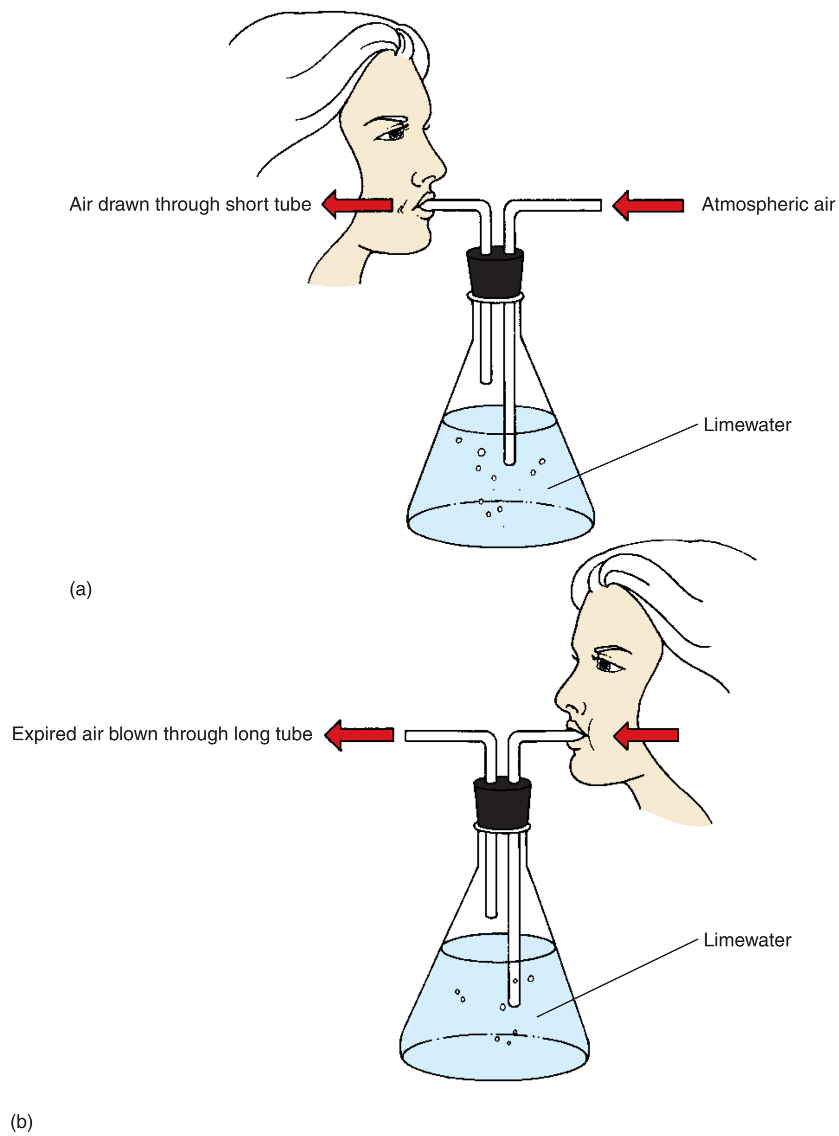
If so, how did the amount of carbon dioxide in the atmospheric air compare with the amount in the expired air? ____________________________________

____

____

____

Figure 55.1 Apparatus used to demonstrate the presence of carbon dioxide in air: (*a*) atmospheric air is drawn through limewater; (*b*) expired air is blown through limewater.



PROCEDURE B—FACTORS AFFECTING BREATHING

Perform each of the following tests, using your laboratory partner as a test subject.

1. *Normal breathing.* To determine the subject's normal breathing rate and depth, follow these steps:
   a. Have the subject sit quietly for a few minutes.
   b. After the rest period, ask the subject to count backwards mentally, beginning with five hundred.
   c. While the subject is distracted by counting, watch the subject's chest movements, and count the breaths taken in a minute. Use this value as the normal breathing rate (breaths per minute).
   d. Note the relative depth of the breathing movements.
   e. Record your observations in the table in Part B of the laboratory report.
2. *Effect of hyperventilation.* To test the effect of hyperventilation on breathing, follow these steps:
   a. Seat the subject and *guard to prevent the possibility of the subject falling over.*
   b. Have the subject breathe rapidly and deeply for a maximum of 1 minute. *If the subject begins to*

feel dizzy, the hyperventilation should be halted immediately to prevent the subject from fainting from complications of alkalosis. The increased blood pH causes vasoconstriction of cerebral arterioles, which decreases circulation and oxygen to the brain.
   c. After the period of hyperventilation, determine the subject's breathing rate and judge the breathing depth as before.
   d. Record the results in Part B.
3. *Effect of rebreathing air.* To test the effect of rebreathing air on breathing, follow these steps:
   a. Have the subject sit quietly (approximately 5 minutes) until the breathing rate returns to normal.
   b. Have the subject breathe deeply into a small paper bag that is held tightly over the nose and mouth. *If the subject begins to feel light headed or like fainting, the rebreathing air should be halted immediately to prevent further acidosis and fainting.*
   c. After 2 minutes of rebreathing air, determine the subject's breathing rate and judge the depth of breathing.
   d. Record the results in Part B.
4. *Effect of breath holding.* To test the effect of breath holding on breathing, follow these steps:
   a. Have the subject sit quietly (approximately 5 minutes) until the breathing rate returns to normal.
   b. Have the subject hold his or her breath as long as possible. *If the subject begins to feel light headed or like fainting, breath holding should be halted immediately to prevent further acidosis and fainting.*
   c. As the subject begins to breathe again, determine the rate of breathing, and judge the depth of breathing.
   d. Record the results in Part B.
5. *Effect of exercise.* To test the effect of exercise on breathing, follow these steps:
   a. Have the subject sit quietly (approximately 5 minutes) until breathing rate returns to normal.
   b. Have the subject exercise by rapidly running in place for 3–5 minutes.
   c. After the exercise, determine the breathing rate, and judge the depth of breathing.
   d. Record the results in Part B.
6. Complete Part B of the laboratory report.

OPTIONAL ACTIVITY

A *pneumograph* is a device that can be used together with some type of recording apparatus to record breathing movements. The laboratory instructor will demonstrate the use of this equipment to record various movements, such as those that accompany coughing, laughing, yawning, and speaking.

Devise an experiment to test the effect of some factor, such as hyperventilation, rebreathing air, or exercise, on the length of time a person can hold the breath. *After the laboratory instructor has approved your plan,* carry out the experiment, using the pneumograph and recording equipment. What conclusion can you draw from the results of your experiment? ___________

____

____

____

____

Laboratory Report 55

Name ______________________________

Date ______________________________

Section ______________________________

Control of Breathing

Part A

Complete the following statements:

1. The respiratory center is widely scattered throughout the ________________________ and medulla oblongata of the brain stem.
2. The two major components of the respiratory center are the rhythmicity area of the ________________________ and the pneumotaxic area of the pons.
3. The ________________________ group within the medulla oblongata establishes the basic rhythm of breathing.
4. The ________________________ group within the medulla oblongata functions during forceful breathing.
5. The ________________________ regulates the duration of inspiratory bursts and controls the breathing rate.
6. Chemosensitive areas of the respiratory center are located in the ventral portion of the ________________________.
7. These chemosensitive areas are stimulated by changes in the blood concentrations of hydrogen ions and ________________________.
8. As the blood concentration of carbon dioxide increases, the breathing rate ________________________.
9. ________________________ combines with water to form carbonic acid.
10. When carbonic acid dissociates, ________________________ and hydrogen ions are released.
11. As a result of increased breathing, the blood concentration of carbon dioxide is ________________________.
12. As a result of hyperventilation, breath-holding time is ________________________.

Part B

1. Record the results of your breathing tests in the table.

Factor Tested	Breathing Rate (breaths/min)	Breathing Depth (+, ++, +++)
Normal		
Hyperventilation		
Rebreathing air		
Breath holding		
Exercise		

2. Briefly explain the reason for the changes in breathing that occurred in each of the following cases:

   a. Hyperventilation

   ____

   ____

   ____

   ____

   b. Rebreathing air

   ____

   ____

   ____

   ____

   c. Breath holding

   ____

   ____

   ____

   ____

   d. Exercise

   ____

   ____

   ____

   ____

3. Complete the following:

   a. Why is it important to distract a person when you are determining the normal rate of breathing?

   ____

   ____

   b. How can the depth of breathing be measured accurately?

   ____

   ____

Critical Thinking Application

Why is it dangerous for a swimmer to hyperventilate in order to hold the breath for a longer period of time?

____

____

____

____

Laboratory Exercise 56

Structure of the Kidney

MATERIALS NEEDED

textbook
human torso
kidney model
preserved pig (or sheep) kidney
dissecting tray
dissecting instruments
long knife
compound microscope
prepared microscope slide of a kidney section

SAFETY

- Wear disposable gloves when working on the kidney dissection.
- Dispose of the kidney and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

The two kidneys are the primary organs of the urinary system. They are located in the upper quadrants of the abdominal cavity, against the posterior wall and behind the parietal peritoneum. They perform a variety of complex activities that lead to the production of urine.

The other organs of the urinary system include the ureters, which transport urine away from the kidneys; the urinary bladder, which stores urine; and the urethra, which conveys urine to the outside of the body.

PURPOSE OF THE EXERCISE

To review the structure of the kidney, to dissect a kidney, and to observe the major structures of a nephron microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. describe the location of the kidneys;
2. locate and identify the major structures of a kidney;
3. identify the major structures of a nephron;
4. trace the path of filtrate through a renal tubule;
5. trace the path of blood through the renal blood vessels.

PROCEDURE A—KIDNEY STRUCTURE

1. Review a textbook section on *kidney structure.*
2. As a review activity, label figures 56.1 and 56.2.
3. Complete Part A of Laboratory Report 56.
4. Observe the human torso and the kidney model. Locate the following:

   kidneys

   ureters

   urinary bladder

   urethra

   renal sinus

   renal pelvis

      major calyces

      minor calyces

   renal papillae

   renal medulla

      renal pyramids

   renal cortex

      renal columns

   nephrons

5. To observe the structure of a kidney, follow these steps:
   a. Obtain a pig or sheep kidney and rinse it with water to remove as much of the preserving fluid as possible.
   b. Carefully remove any adipose tissue from the surface of the specimen.
   c. Locate the following features:

Figure 56.1 Label the major structures of the urinary system.

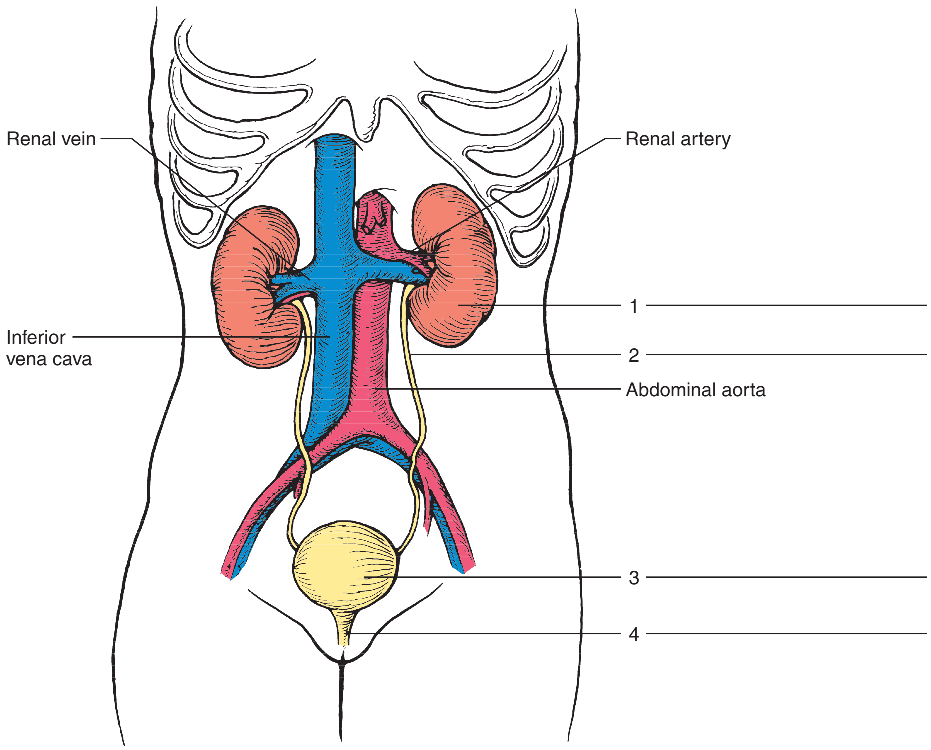


Figure 56.2 Label the major structures in the longitudinal section of a kidney.

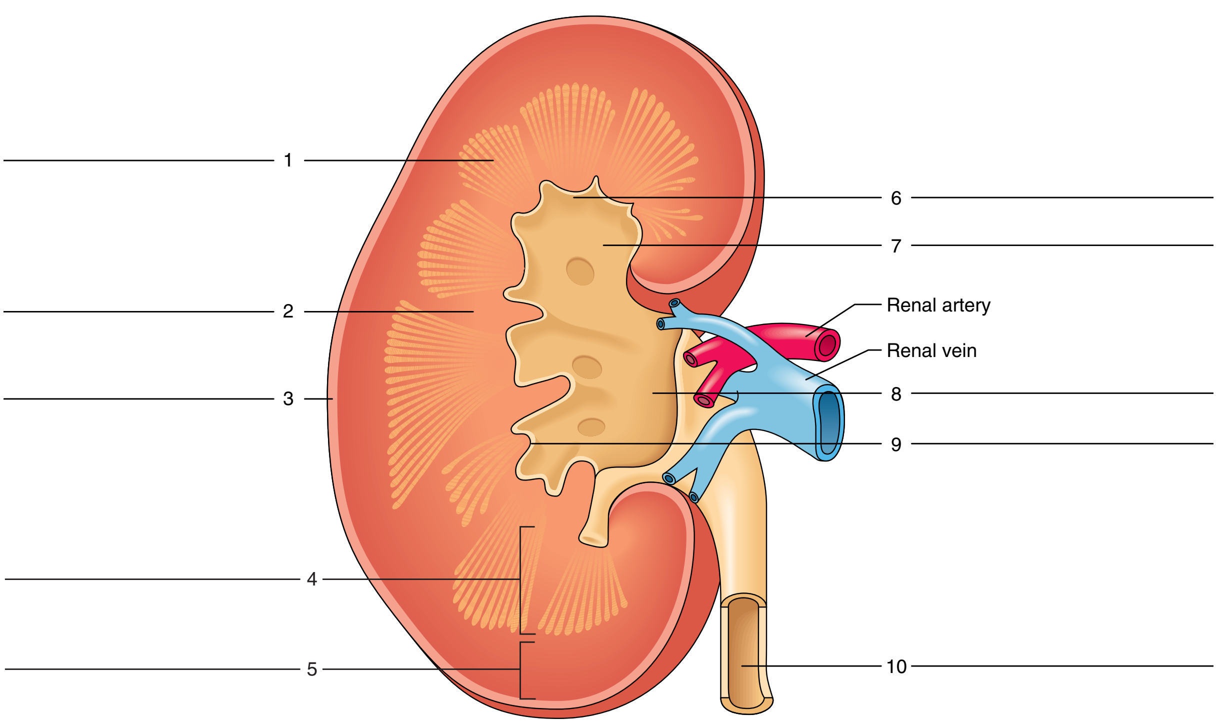
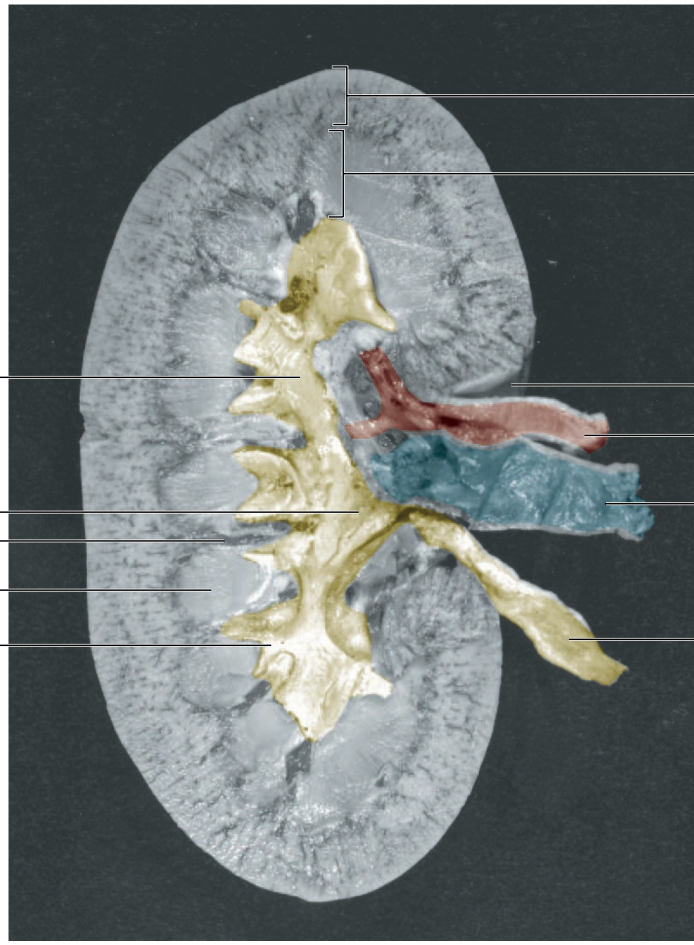


Figure 56.3 Longitudinal section of a pig kidney that has a triple injection of latex (*red* in the renal artery, *blue* in the renal vein, and *yellow* in the ureter and renal pelvis).



renal capsule

hilum

renal artery

renal vein

ureter

d. Use a long knife to cut the kidney in half longitudinally along the frontal plane, beginning on the convex border.

e. Rinse the interior of the kidney with water, and using figure 56.3 as a reference, locate the following:

renal pelvis

major calyces

minor calyces

renal cortex

renal columns (extensions of cortex between renal pyramids)

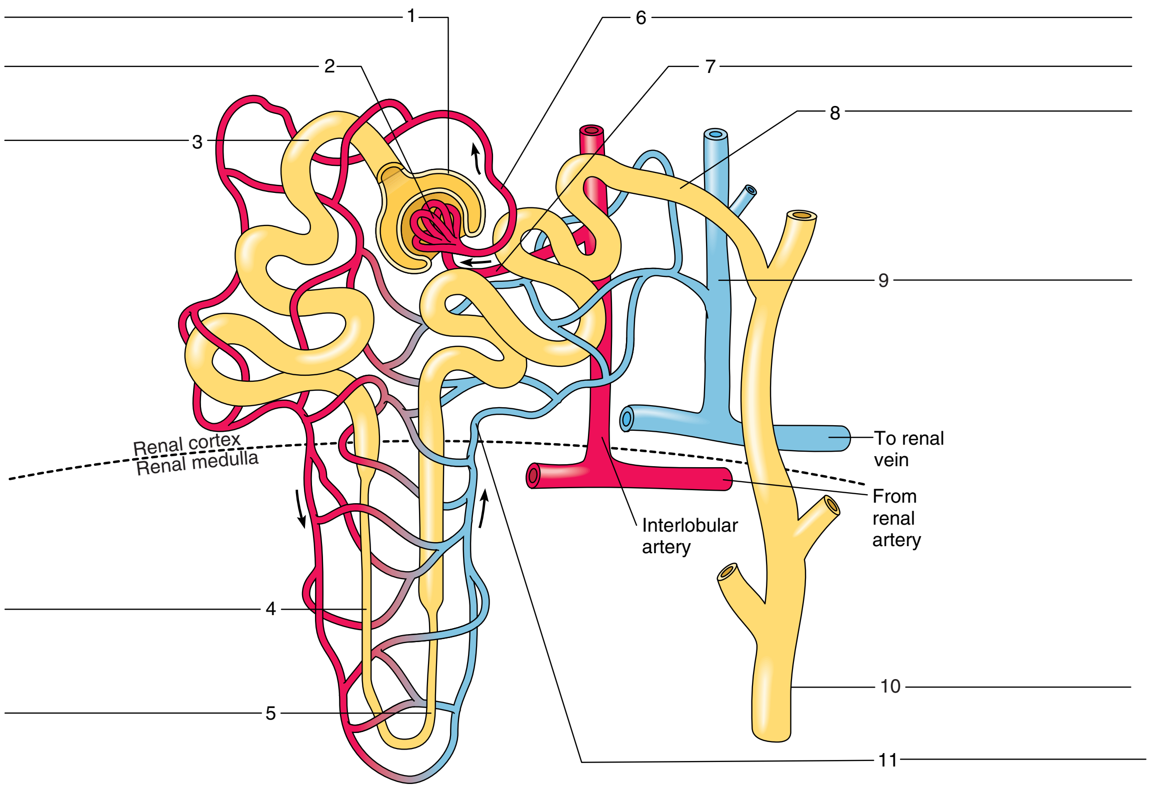
renal medulla

renal pyramids

PROCEDURE B—THE RENAL BLOOD VESSELS AND NEPHRONS

1. Review a textbook section on *nephrons.*
2. As a review activity, label figure 56.4.
3. Complete Part B of the laboratory report.
4. Obtain a microscope slide of a kidney section and examine it using low-power magnification. Locate the *renal capsule,* the *renal cortex* (which appears somewhat granular and may be more darkly stained

Figure 56.4 Label the major structures of the nephron and the blood vessels associated with it.



than the other renal tissues), and the *renal medulla.*

5. Examine the renal cortex using high-power magnification. Locate a *renal corpuscle.* These structures appear as isolated circular areas. Identify the *glomerulus,* which is the capillary cluster inside the corpuscle, and the *glomerular capsule,* which appears as a clear area surrounding the glomerulus. Also note the numerous sections of renal tubules that occupy the spaces between renal corpuscles.
6. Prepare a labeled sketch of a representative section of renal cortex in Part C of the laboratory report.
7. Examine the renal medulla using high-power magnification. Identify longitudinal and cross sections of various collecting ducts. Note that these ducts are lined with simple epithelial cells, which vary in shape from squamous to cuboidal.
8. Prepare a labeled sketch of a representative section of renal medulla in Part D of the laboratory report.
9. Complete Part E of the laboratory report.

Web Quest

What are two major functions of kidneys? Compare mammal kidneys and review the urinary system at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report **56**

Name ______________________

Date ______________________

Section ______________________

Structure of the Kidney

Part A

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A		Column B
a. calyces	____	1. shell around the renal medulla
b. hilum	____	2. branches of renal pelvis to renal papillae
c. nephron	____	3. conical mass of tissue within renal medulla
d. renal column	____	4. projection with tiny openings into a minor calyx
e. renal cortex	____	5. hollow chamber within kidney
f. renal papilla	____	6. microscopic functional unit of kidney
g. renal pelvis	____	7. cortical tissue between renal pyramids
h. renal pyramid	____	8. superior funnel-shaped end of ureter inside the renal sinus
i. renal sinus	____	9. medial depression for blood vessels and ureter to enter kidney chamber

Part B

Complete the following:

1. Distinguish between a renal corpuscle and a renal tubule. ______________________

____

____

____

____

2. Number the following structures to indicate their respective positions in relation to the nephron. Assign the number 1 to the structure attached to the glomerular capsule.

____ ascending limb of nephron loop

____ collecting duct

____ descending limb of nephron loop

____ distal convoluted tubule

____ proximal convoluted tubule

____ renal papilla

3. Number the following structures to indicate their respective positions in the blood pathway within the kidney. Assign the number 1 to the vessel nearest the renal artery.

____ afferent arteriole

____ efferent arteriole

____ glomerulus

____ peritubular capillary

____ renal vein

4. Explain how the blood vessels associated with the renal corpuscle help to maintain relatively high blood pressure within the glomerulus. ______________________________

5. Define and explain *juxtaglomerular apparatus.* ______________________________

Part C

Prepare a sketch of a representative section of renal cortex. Label the glomerulus, glomerular capsule, and sections of renal tubules.

Part D

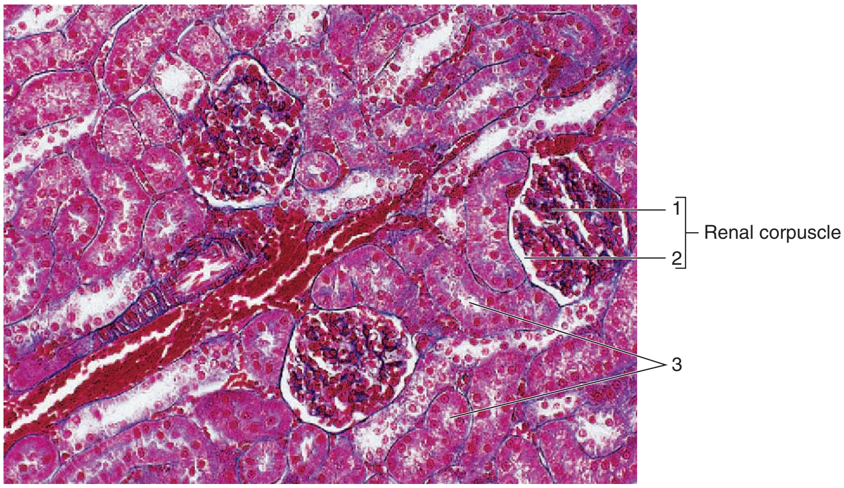
Prepare a sketch of a representative section of renal medulla. Label a longitudinal section and a cross section of a collecting duct.

Part E

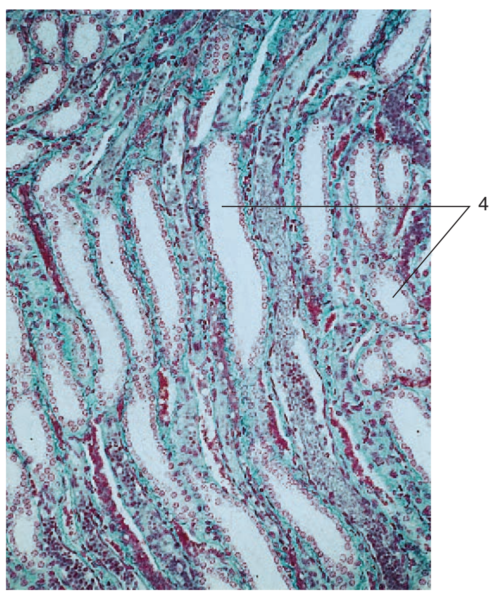
Identify the structures indicated in figure 56.5.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Figure 56.5 (*a*) Micrograph of a section of the renal cortex (220×). (*b*) Micrograph of a section of the renal medulla (80× micrograph enlarged to 200×).



(a)



(b)

Laboratory Exercise 57

Urinalysis

MATERIALS NEEDED

disposable urine-collecting container
paper towel
urinometer cylinder
urinometer hydrometer
laboratory thermometer
pH test paper
reagent strips (individual or combination strips such as Chemstrip or Multistix) to test for the presence of the following:
- glucose
- protein
- ketones
- bilirubin
- hemoglobin/occult blood

compound microscope
microscope slide
coverslip
centrifuge
centrifuge tube
graduated cylinder, 10 mL
medicine dropper
Sedi-stain
normal and abnormal simulated urine specimens (optional)

SAFETY

- Wear disposable gloves when working with body fluids.
- Work only with your own urine sample.
- Use an appropriate disinfectant to wash the laboratory table before and after the procedures.
- Place glassware in a disinfectant when finished.
- Dispose of contaminated items as instructed.
- Wash your hands before leaving the laboratory.

Urine is the product of kidney functions, which include the removal of various waste substances from the blood and the maintenance of body fluid and electrolyte balances. Consequently, the composition of urine varies from time to time because of differences in dietary intake and physical activity. Also, the volume of urine produced by the kidneys varies with such factors as fluid intake, environmental temperature, relative humidity, respiratory rate, and body temperature.

An analysis of urine composition and volume often is used to evaluate the functions of the kidneys and other organs. This procedure, called *urinalysis,* involves observing the physical characteristics of a urine sample, testing for the presence of certain organic and inorganic substances, and examining the microscopic solids present in the sample.

PURPOSE OF THE EXERCISE

To perform the observations and tests commonly used to analyze the characteristics and composition of urine.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. evaluate the color, transparency, and specific gravity of a urine sample;
2. determine the pH of a urine sample;
3. test a urine sample for the presence of glucose, protein, ketones, bilirubin, and hemoglobin;
4. perform a microscopic study of urine sediment;
5. evaluate the results of these observations and tests.

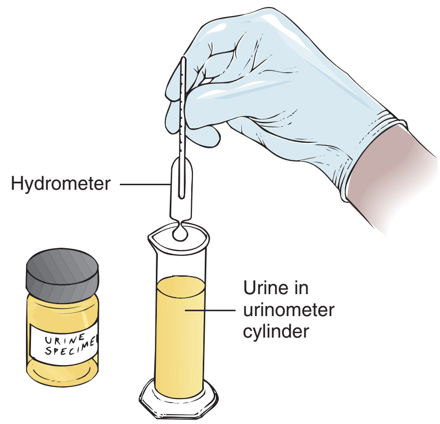
WARNING

While performing the following tests you should wear disposable latex gloves so that skin contact with urine is avoided. Observe all safety procedures listed for this lab. (Normal and abnormal simulated urine specimens could be used instead of real urine for this lab.)

PROCEDURE

1. Proceed to the restroom with a clean, disposable container. The first small volume of urine should not be collected because it contains abnormally high levels of microorganisms from the urethra. Collect a midstream sample of about 50 mL of urine. The best collections are the first specimen in the morning or

Figure 57.1 Float the hydrometer in the urine, making sure that it does not touch the sides of the cylinder.



one taken 3 hours after a meal. Refrigerate samples if they are not used immediately.

2. Place a sample of urine in a clean, transparent container. Describe the *color* of the urine. Normal urine varies from light yellow to amber, depending on the presence of urochromes, which are end-product pigments produced during the decomposition of hemoglobin. Dark urine indicates a high concentration of pigments.

   Abnormal urine colors include yellow-brown or green, due to elevated concentrations of bile pigments, and red to dark brown, due to the presence of blood. Certain foods, such as beets or carrots, and various drug substances also may cause color changes in urine, but in such cases the colors have no clinical significance. Enter the results of this and the following tests in Part A of Laboratory Report 57.
3. Evaluate the *transparency* of the urine sample (that is, judge whether the urine is clear, slightly cloudy, or very cloudy). Normal urine is clear enough to see through. You can read newsprint through slightly cloudy urine; you can no longer read newsprint through cloudy urine. Cloudy urine indicates the presence of various substances that may include mucus, bacteria, epithelial cells, fat droplets, or inorganic salts.
4. Determine the *specific gravity* of the urine sample. Specific gravity is the ratio of the weight of something to the weight of an equal volume of pure water. For example, mercury (at 15°C) weighs 13.6 times as much as an equal volume of water; thus, it has a specific gravity of 13.6. Although urine is mostly water, it has substances dissolved in it and is slightly heavier than an equal volume of water. Thus, urine has a specific gravity of more than 1.000. Actually, the specific gravity of normal urine varies from 1.003 to 1.035.

   To determine the specific gravity of a urine sample, follow these steps:
   a. Pour enough urine into a clean urinometer cylinder to fill it about three-fourths full. Any foam that appears should be removed with a paper towel.
   b. Use a laboratory thermometer to measure the temperature of the urine.
   c. Gently place the urinometer hydrometer into the urine, and *make sure that the float is not touching the sides of the cylinder* (fig. 57.1).
   d. Position your eye at the level of the urine surface. Determine which line on the stem of the hydrometer intersects the lowest level of the concave surface (meniscus) of the urine.
   e. Because liquids tend to contract and become denser as they are cooled, or to expand and become less dense as they are heated, it may be necessary to make a temperature correction to obtain an accurate specific gravity measurement. To do this, add 0.001 to the hydrometer reading for each 3 degrees of urine temperature above 25°C or subtract 0.001 for each 3 degrees below 25°C. Enter this calculated value in the table of the laboratory report as the test result.
5. Reagent strips can be used to perform a variety of urine tests. In each case, directions for using the strips are found on the strip container. *Be sure to read them.*

   To perform each test, follow these steps:
   a. Obtain a urine sample and the proper reagent strip.
   b. Read the directions on the strip container.
   c. Dip the strip in the urine sample.
   d. Remove the strip at an angle and let it touch the inside rim of the urine container to remove any excess liquid.

e. Wait for the length of time indicated by the directions on the container before you compare the color of the test strip with the standard color scale on the side of the container. The value or amount represented by the matching color should be used as the test result and recorded in Part A of the laboratory report.

ALTERNATIVE PROCEDURE

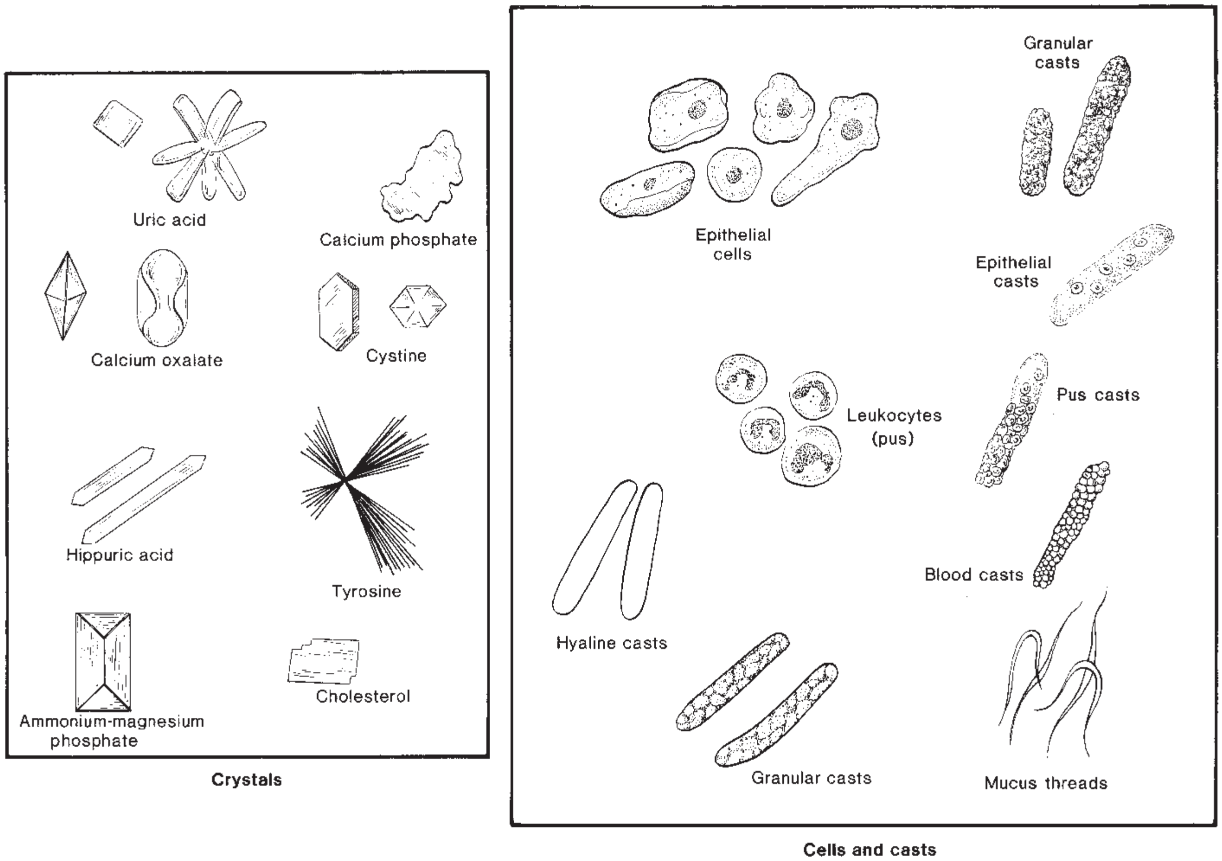
If combination reagent strips (Chemstrip or Multistix) are being utilized, locate the appropriate color chart for each test being evaluated. Wait the designated time for each color reaction before the comparison is made to the standard color scale.

6. Perform the *pH test.* The pH of normal urine varies from 4.6 to 8.0, but most commonly it is near 6.0 (slightly acidic). The pH of urine may decrease as a result of a diet high in protein, or it may increase with a vegetarian diet. Significant daily variations within the broad normal range are results of concentrations of excesses from variable diets.
7. Perform the *glucose test.* Normally, there is no glucose in urine. However, glucose may appear in the urine temporarily following a meal high in carbohydrates. Glucose also may appear in the urine as a result of uncontrolled diabetes mellitus.
8. Perform the *protein test.* Normally, proteins of large molecular size are not present in urine. However, those of small molecular sizes, such as albumins, may appear in trace amounts, particularly following strenuous exercise. Increased amounts of proteins also may appear as a result of kidney diseases in which the glomeruli are damaged or as a result of high blood pressure.
9. Perform the *ketone test.* Ketones are products of fat metabolism. Usually they are not present in urine. However, they may appear in the urine if the diet fails to provide adequate carbohydrate, as in the case of prolonged fasting or starvation, or as a result of insulin deficiency (diabetes mellitus).
10. Perform the *bilirubin test.* Bilirubin, which results from hemoglobin decomposition in the liver, normally is absent in urine. It may appear, however, as a result of liver disorders that cause obstructions of the biliary tract. Urochrome, a normal yellow component of urine, is a result of additional breakdown of bilirubin.
11. Perform the *hemoglobin/occult blood test.* Hemoglobin occurs in the red blood cells, and because such cells normally do not pass into the renal tubules, hemoglobin is not found in normal urine. Its presence in urine usually indicates a disease process, a transfusion reaction, or an injury to the urinary organs.
12. Complete Part A of the laboratory report.
13. A urinalysis usually includes a study of urine sediment—the microscopic solids present in a urine sample. This sediment normally includes mucus, certain crystals, and a variety of cells, such as the epithelial cells that line the urinary tubes and an occasional white blood cell. Other types of solids, such as casts or red blood cells, may indicate a disease or injury if they are present in excess. (Casts are cylindrical masses of cells or other substances that form in the renal tubules and are flushed out by the flow of urine.)

    To observe urine sediment, follow these steps:

    a. Thoroughly stir or shake a urine sample to suspend the sediment, which tends to settle to the bottom of the container.
    b. Pour 10 mL of urine into a clean centrifuge tube and centrifuge it for 5 minutes at slow speed (1,500 rpm). Be sure to balance the centrifuge with an even number of tubes filled to the same levels.
    c. Carefully decant 9 mL (leave 1 mL) of the liquid from the sediment in the bottom of the centrifuge tube, as directed by your laboratory instructor. Resuspend the 1 mL of sediment.
    d. Use a medicine dropper to remove some of the sediment and place it on a clean microscope slide.
    e. Add a drop of Sedi-stain to the sample and add a coverslip.
    f. Examine the sediment with low-power (reduce the light when using low power) and high-power magnifications.
    g. Identify the kinds of solids present with the aid of figure 57.2.
    h. In Part B of the laboratory report, make a sketch of each type of sediment that you observed.
14. Complete Part B of the laboratory report.

Figure 57.2 Types of urine sediment. Healthy individuals lack many of these sediments and possess only occasional to trace amounts of others.



Laboratory Report 57

Name ____________________

Date ____________________

Section ____________________

Urinalysis

Part A

1. Enter your observations, test results, and evaluations in the following table:

Urine Characteristics	Observations and Test Results	Normal Values	Evaluations
Color		Light yellow to amber	
Transparency		Clear	
Specific gravity (corrected for temperature)		1.003–1.035	
pH		4.6–8.0	
Glucose		0 (negative)	
Protein		0 to trace	
Ketones		0	
Bilirubin		0	
Hemoglobin/occult blood		0	
(Other)			
(Other)			

2. Summarize the results of the urinalysis. ______

Critical Thinking Application

Why do you think it is important to refrigerate a urine sample if an analysis cannot be performed immediately after collecting it?

______

Part B

1. Make a sketch for each type of sediment you observed. Label any from those shown in figure 57.2.

2. Summarize the results of the urine sediment study. ______

Laboratory Exercise 58

Fetal Pig Dissection: Urinary System

MATERIALS NEEDED

human torso
preserved fetal pig
dissecting tray
dissecting instruments
disposable gloves

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

In this laboratory exercise, you will dissect the urinary organs of the fetal pig. As you observe these structures, compare them with the corresponding human organs by observing the parts of the human torso.

PURPOSE OF THE EXERCISE

To examine the urinary organs of the fetal pig, and to compare them with those of the human.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the urinary organs of the fetal pig;
2. identify the corresponding organs in the human torso;
3. compare the urinary organs of the fetal pig with those of the human.

PROCEDURE

1. Place the fetal pig in a dissecting tray with its ventral side up.
2. Open the abdominal cavity, and remove the liver, stomach, spleen, pancreas, small intestine, and large intestine.
3. Locate the *kidneys* in the dorsal abdominal wall on either side of the vertebral column. Note that the kidneys are located dorsal to the *parietal peritoneum* (retroperitoneal).
4. Carefully remove the parietal peritoneum surrounding the kidneys. Locate the following, using figure 58.1 as a guide:

   ureters

   renal arteries

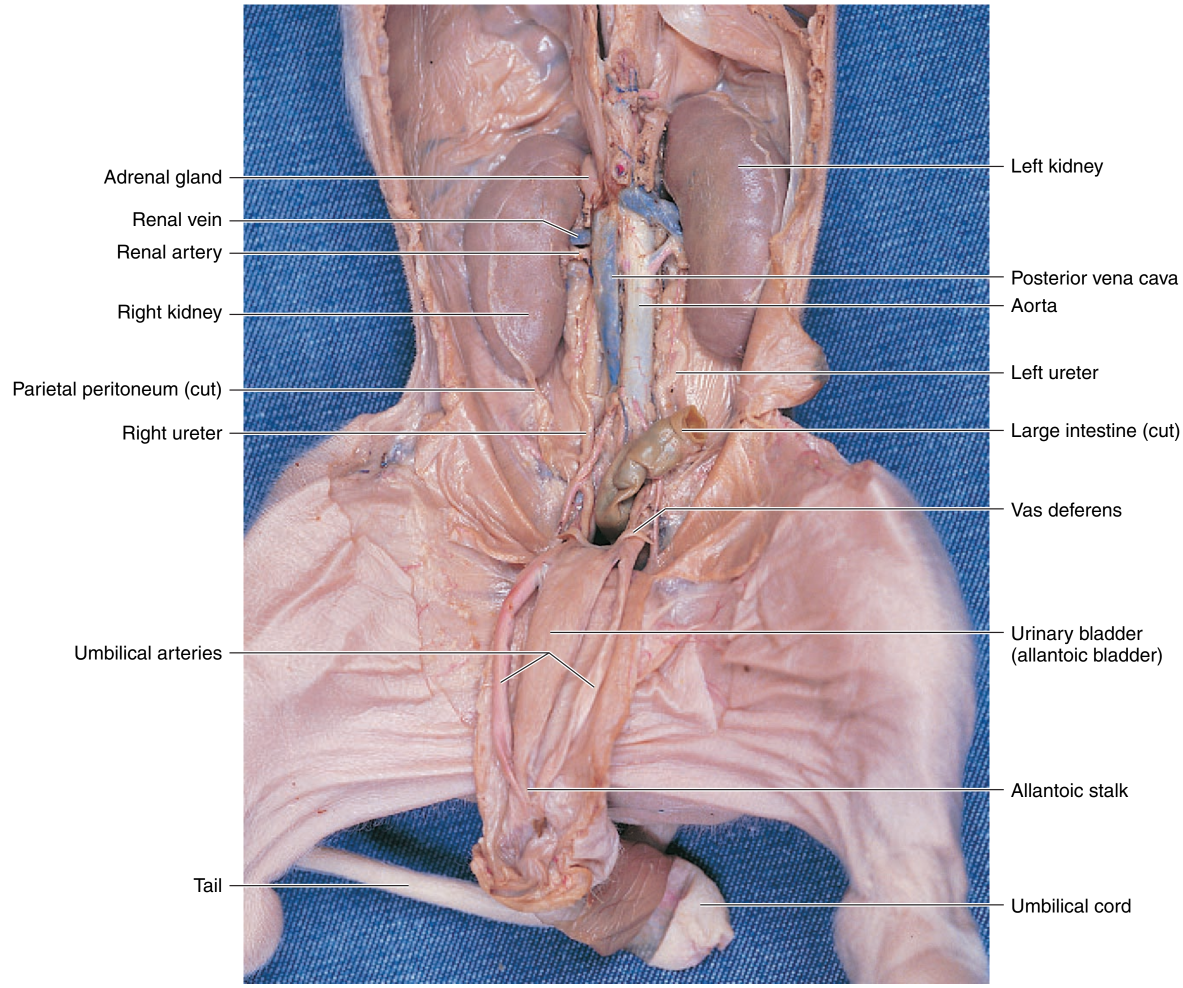
   renal veins
5. Locate the bandlike *adrenal glands,* which lie medially and anteriorly to the kidneys. Note that the adrenal glands are pale orange.
6. Expose the ureters by cleaning away the connective tissues along their lengths. Note that they enter the *fetal urinary bladder (allantoic bladder)* on the dorsal surface.
7. Examine the fetal urinary bladder, and note that it is an elongated, muscular, collapsed sac between two umbilical arteries. Trace the allantoic bladder into the umbilical cord where it becomes the *allantoic stalk.* The fetal urinary bladder becomes a urinary bladder after birth when the umbilical cord deteriorates and wastes no longer eliminate through the allantoic stalk.
8. Use a sharp scalpel to open the bladder, and examine its interior. Locate the openings of the ureters and the urethra on the inside.
9. Expose the *urethra* at the posterior of the urinary bladder. The urethra extends through the *penis* in the male. In the female, the urethra enters the *urogenital sinus* a short distance from the urogenital orifice.
10. Remove one kidney, and section it longitudinally along the frontal plane. Use figure 56.3 as a reference for a kidney of a pig. Identify the following features:

    renal capsule

    renal cortex

    renal medulla

Figure 58.1 Urinary system of the male fetal pig, ventral view.



renal pyramid

renal pelvis

hilum

11. Discard the organs and tissues that were removed from the fetal pig, as directed by the laboratory instructor.
12. Complete Laboratory Report 58.

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Laboratory Report 58

Name ______________________

Date ______________________

Section ______________________

Fetal Pig Dissection: Urinary System

Complete the following:

1. Compare the positions of the kidneys in the fetal pig with those in the human. ______________________

2. Compare the locations of the adrenal glands in the fetal pig with those in the human. ______________________

3. Trace the elimination of any urinary wastes from the allantoic bladder in a fetus. ______________________

4. Describe the wall of the urinary bladder of the fetal pig. Include the thickness, texture, and inner surface in your answer. ______________________

5. Compare the termination of the urethra of the female pig with a human female. ______________________

Laboratory Exercise 59

Male Reproductive System

MATERIALS NEEDED

textbook
human torso
model of the male reproductive system
anatomical chart of the male reproductive system
compound microscope
prepared microscope slides of the following:
  testis section
  epididymis, cross section
  penis, cross section

The organs of the male reproductive system are specialized to produce and maintain the male sex cells, to transport these cells together with supporting fluids to the female reproductive tract, and to produce and secrete male sex hormones.

These organs include the testes, in which sperm cells and male sex hormones are produced, and sets of internal and external accessory organs. The internal organs include various tubes and glands, whereas the external structures are the scrotum and the penis.

PURPOSE OF THE EXERCISE

To review the structure and functions of the male reproductive organs and to examine some of these organs microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the organs of the male reproductive system;
2. describe the functions of these organs;
3. recognize sections of the testis, epididymis, and penis microscopically;
4. identify the major features of these microscopic sections.

PROCEDURE A—MALE REPRODUCTIVE ORGANS

1. Review textbook sections on *male reproductive organs.*
2. As a review activity, label figures 59.1 and 59.2.
3. Observe the human torso, the model, and anatomical chart of the male reproductive system. Locate the following features:

   testes
   inguinal canal
   spermatic cord
   epididymis
   vas deferens
   ejaculatory duct
   seminal vesicles
   prostate gland
   bulbourethral glands
   scrotum
   penis
     corpora cavernosa
     corpus spongiosum
     tunica albuginea
     glans penis
     external urethral orifice
     prepuce
     crura
     bulb
4. Complete Part A of Laboratory Report 59.

PROCEDURE B—MICROSCOPIC ANATOMY

1. Obtain a microscope slide of a human testis section and examine it, using low-power magnification (fig. 59.3). Locate the thick *fibrous capsule* (tunica albuginea) on the surface and the numerous sections of *seminiferous tubules* inside.
2. Focus on some of the seminiferous tubules using high-power magnification (fig. 59.4). Locate the *epithelium,* which forms the inner lining of each

Figure 59.1 Label the structures of the male reproductive system in this sagittal view.

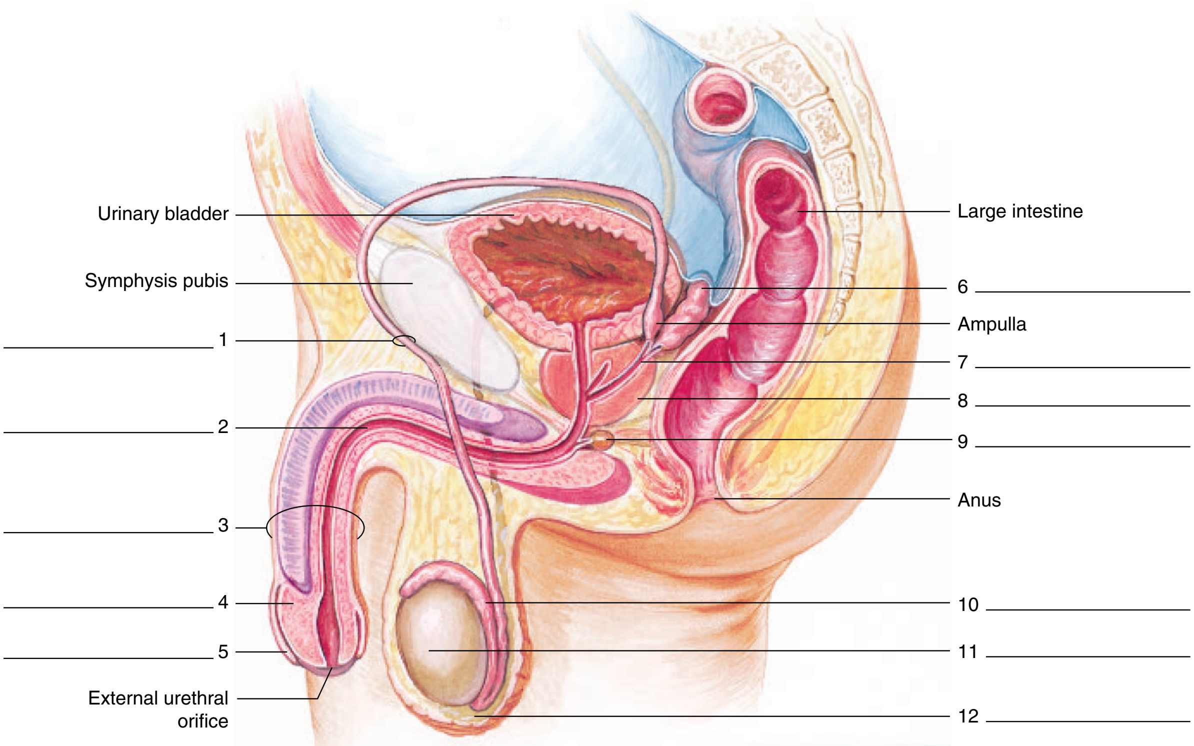


Figure 59.2 Label the diagram of (*a*) the sagittal section of a testis and (*b*) a cross section of a seminiferous tubule by placing the correct numbers in the spaces provided.

____ Epididymis

____ Germinal epithelial cell

____ Interstitial cells

____ Seminiferous tubules

____ Spermatozoa

____ Testis

____ Vas deferens

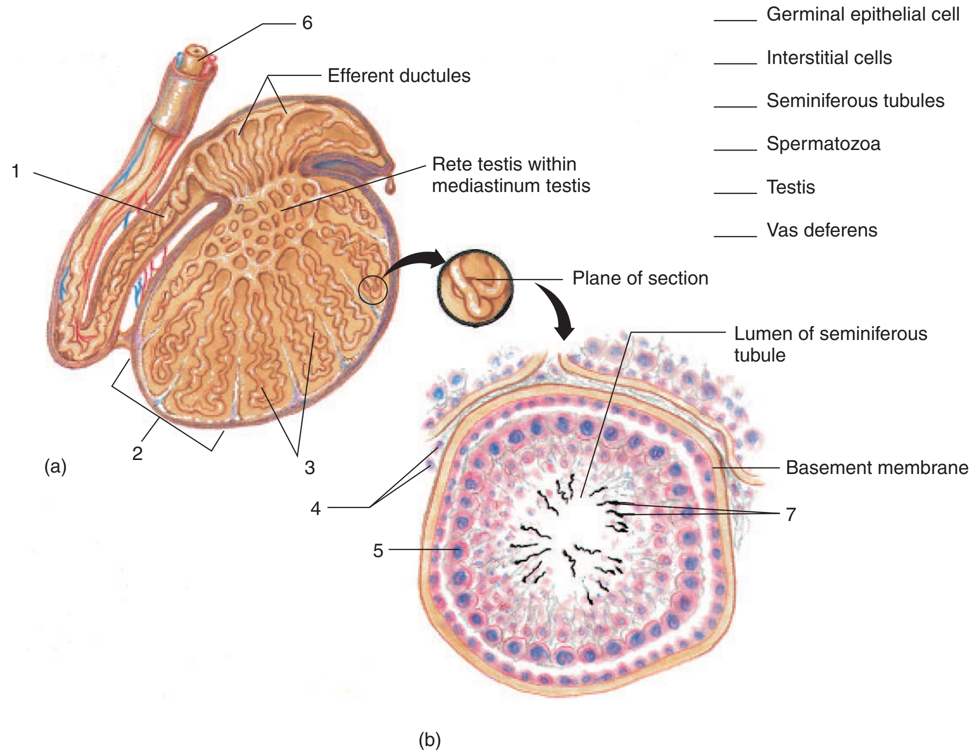


Figure 59.3 Micrograph of a human testis (1.7×).

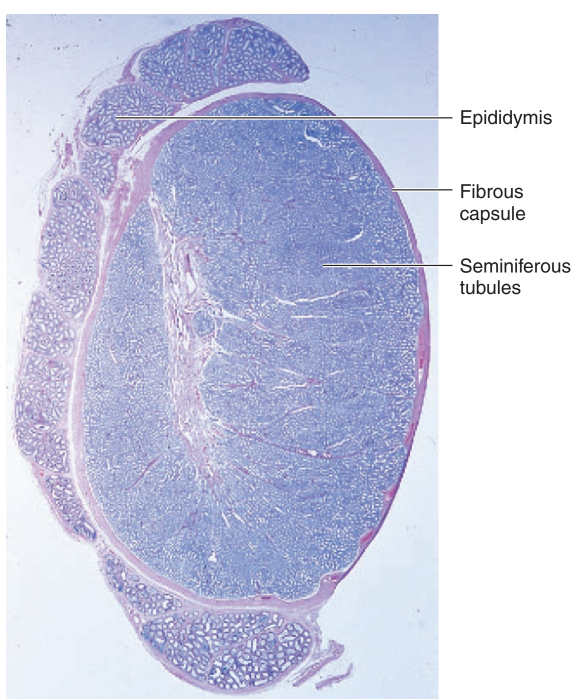
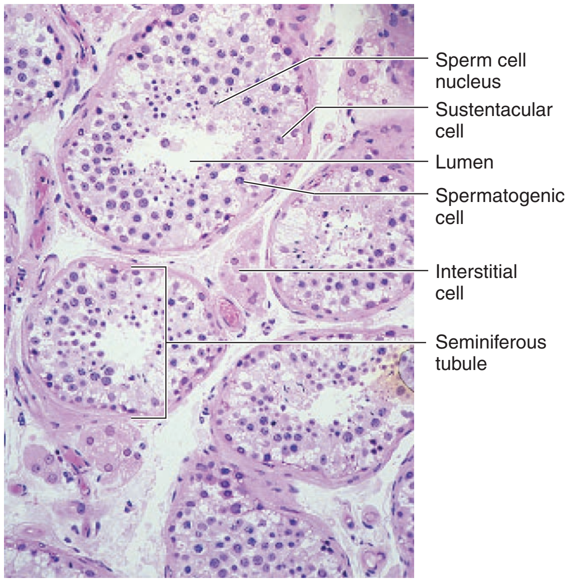


Figure 59.4 Micrograph of seminiferous tubules (50× micrograph enlarged to 135×).



tube. Within this epithelium, identify some *sustentacular cells* or supporting cells (Sertoli's cells), which have pale, oval-shaped nuclei, and some *spermatogenic cells,* which have smaller, round nuclei. Near the lumen of the tube, find some darkly stained, elongated heads of developing sperm cells. In the spaces between adjacent seminiferous tubules, locate some isolated *interstitial cells* (cells of Leydig).

3. Prepare a labeled sketch of a representative section of the testis in Part B of the laboratory report.
4. Obtain a microscope slide of a cross section of *epididymis* (fig. 59.5). Examine its wall using high-power magnification. Note the elongated, *pseudostratified columnar epithelial cells* that comprise most of the inner lining. These cells have nonmotile stereocilia (microvilli) on their free surfaces. Also note the thin layer of smooth muscle and connective tissue surrounding the tube.
5. Prepare a labeled sketch of the epididymis wall in Part B of the laboratory report.
6. Obtain a microscope slide of a *penis* cross section, and examine it with low-power magnification (fig. 59.6). Identify the following features:

   corpora cavernosa

   corpus spongiosum

   tunica albuginea

   urethra

   skin

7. Prepare a labeled sketch of a penis cross section in Part B of the laboratory report.
8. Complete Part B of the laboratory report.

Web Quest

Review the structures and functions of the male reproductive system at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 59.5 Micrograph of a cross section of a human epididymis (50× micrograph enlarged to 145×).

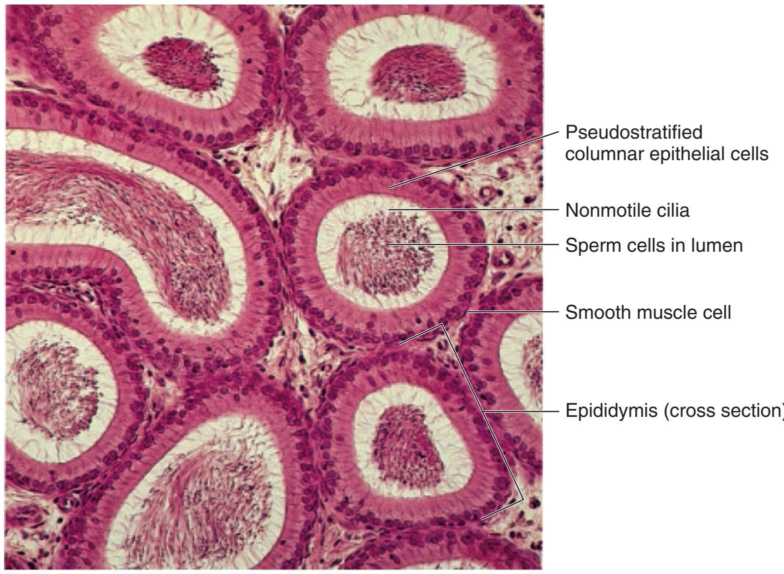
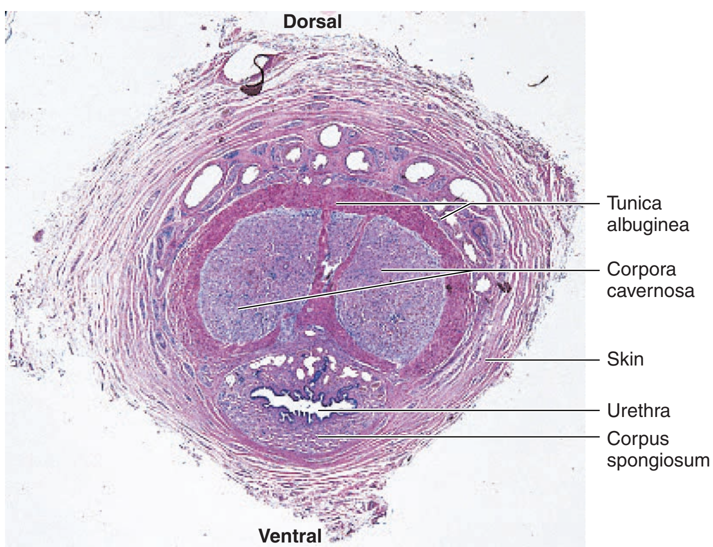


Figure 59.6 Micrograph of a cross section of the body of the penis (5×).



Laboratory Report **59**

Name ______________________________

Date ______________________________

Section ______________________________

Male Reproductive System

Part A

Complete the following statements:

1. Each testis is suspended by a ______________________ cord within the scrotum.
2. The descent of the testes from near the developing kidneys is stimulated by the male sex hormone ______________________.
3. The descent of the testes is aided by a fibromuscular cord called the ______________________.
4. As the testes descend, they pass through the ______________________ of the abdominal wall into the scrotum.
5. The ______________________ is a highly coiled tube on the surface of the testis.
6. ______________________ is the process by which sperm cells are formed.
7. The number of chromosomes normally present in a human sperm cell is ______________________.
8. The anterior end of a sperm head, called the ______________________, contains enzymes that aid the penetration of an egg cell at the time of fertilization.
9. Sperm cells undergo maturation while they are stored in the ______________________.
10. The pH of seminal fluid is slightly ______________________.
11. The sensitive, cone-shaped end of the penis is called the ______________________.
12. ______________________ is the process by which semen is forced out through the urethra.

Part B

1. Prepare a labeled sketch of a representative section of the testis.

2. Prepare a labeled sketch of a region of the epididymis.

3. Prepare a labeled sketch of a penis cross section.

4. Briefly describe the function of each of the following:

   a. sustentacular cell (supporting cell)

   ____

   ____

   ____

   b. spermatogenic cell

   ____

   ____

   ____

c. interstitial cell

d. epididymis

e. corpora cavernosa and corpus spongiosum

Laboratory Exercise 60

Female Reproductive System

MATERIALS NEEDED

textbook
human torso
model of the female reproductive system
anatomical chart of the female reproductive system
compound microscope
prepared microscope slides of the following:
  ovary section with maturing follicles
  uterine tube, cross section
  uterine wall section

For Demonstration:

prepared microscope slides of the following:
  uterine wall, early proliferative phase
  uterine wall, secretory phase
  uterine wall, early menstrual phase

The organs of the female reproductive system are specialized to produce and maintain the female sex cells, to transport these cells to the site of fertilization, to provide a favorable environment for a developing offspring, to move the offspring to the outside, and to produce female sex hormones.

These organs include the ovaries, which produce the egg cells and female sex hormones, and sets of internal and external accessory organs. The internal accessory organs include the uterine tubes, uterus, and vagina. The external organs are the labia majora, labia minora, clitoris, and vestibular glands.

PURPOSE OF THE EXERCISE

To review the structure and functions of the female reproductive organs and to examine some of their features microscopically.

LEARNING OBJECTIVES

After completing this exercise, you should be able to

1. locate and identify the organs of the female reproductive system;
2. describe the functions of these organs;
3. recognize sections of the ovary, uterine tube, and uterus wall microscopically;
4. identify the major features of these microscopic sections.

PROCEDURE A— FEMALE REPRODUCTIVE ORGANS

1. Review a textbook section on *female reproductive organs.*
2. As a review activity, label figures 60.1, 60.2, and 60.3.
3. Observe the human torso, the model, and anatomical chart of the female reproductive system. Locate the following features:

ovaries
- medulla
- cortex

ligaments
- broad ligament
- suspensory ligament
- ovarian ligament
- round ligament

uterine tubes (oviducts; fallopian tubes)
- infundibulum
- fimbriae

uterus
- fundus
- body
- cervix
- cervical orifice
- endometrium
- myometrium
- perimetrium (serous membrane)

rectouterine pouch

vagina
- fornices
- vaginal orifice
- hymen
- mucosal layer
- muscular layer
- fibrous layer

Figure 60.1 Label the structures of the female reproductive system in this sagittal view.

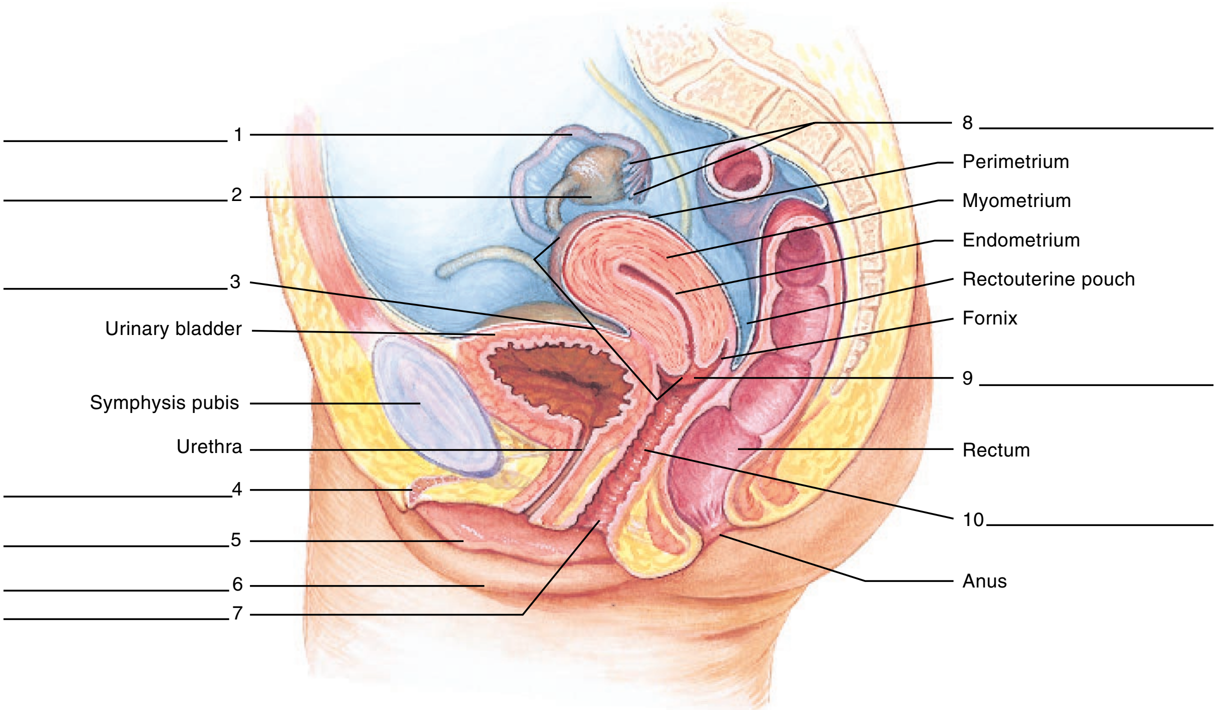


Figure 60.2 Label the female external reproductive organs and associated structures.

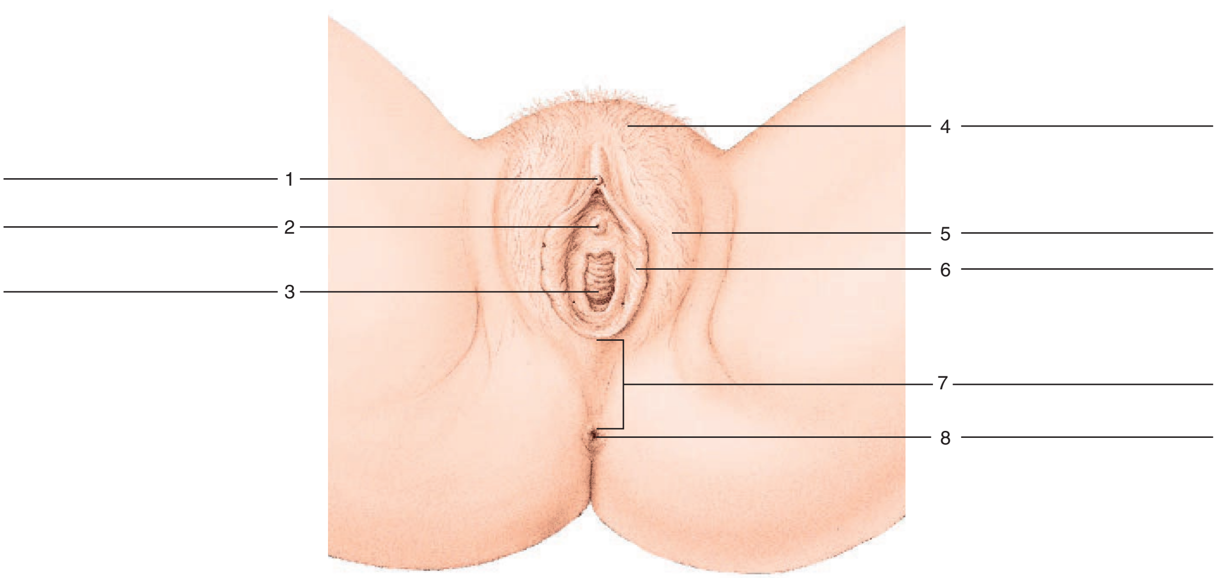
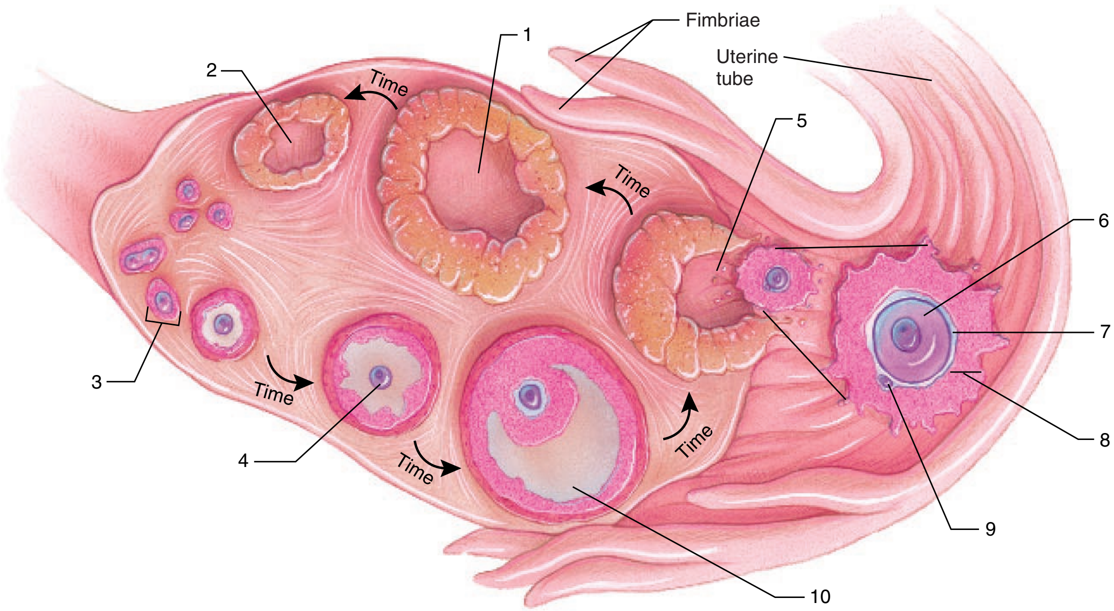


Figure 60.3 Label this ovary by placing the correct numbers in the spaces provided.



____ Corona radiata
____ Corpus albicans
____ Corpus luteum
____ First polar body
____ Follicular fluid
____ Ovulation site
____ Primary follicle
____ Primary oocyte
____ Secondary oocyte
____ Zona pellucida

mons pubis

vulva (external accessory organs)

- labia majora
- labia minora
- vestibular glands
- clitoris
  - corpora cavernosa
  - glans

vestibule

vestibular bulbs

4. Complete Part A of Laboratory Report 60.

PROCEDURE B—MICROSCOPIC ANATOMY

1. Obtain a microscope slide of an ovary section with maturing follicles, and examine it with low-power magnification (fig. 60.4). Locate the outer layer, or *cortex,* which is composed of densely packed cells, and the inner layer, or *medulla,* which largely consists of loose connective tissue.
2. Focus on the cortex of the ovary using high-power magnification (fig. 60.5). Note the thin layer of small cuboidal cells on the free surface. These cells comprise the *germinal epithelium.* Also locate some *primordial follicles* just beneath the germinal epithelium. Note that each follicle consists of a single, relatively large *primary oocyte* with a prominent nucleus and a covering of *follicular cells.*
3. Prepare a labeled sketch of the ovarian cortex in Part B of the laboratory report.
4. Use low-power magnification to search the ovarian cortex for maturing follicles in various stages of development. Prepare three labeled sketches in Part B of the laboratory report to illustrate the changes that occur in a follicle as it matures.
5. Obtain a microscope slide of a cross section of a uterine tube. Examine it using low-power magnification (fig. 60.6). Note that the shape of the lumen is very irregular.
6. Focus on the inner lining of the uterine tube with high power. Note that the lining is composed of *simple columnar epithelium* and that some of the epithelial cells are ciliated on their free surfaces.
7. Prepare a labeled sketch of a representative region of the wall of the uterine tube in Part B of the laboratory report.

Figure 60.4 Micrograph of the ovary (30× micrograph enlarged to 80×).

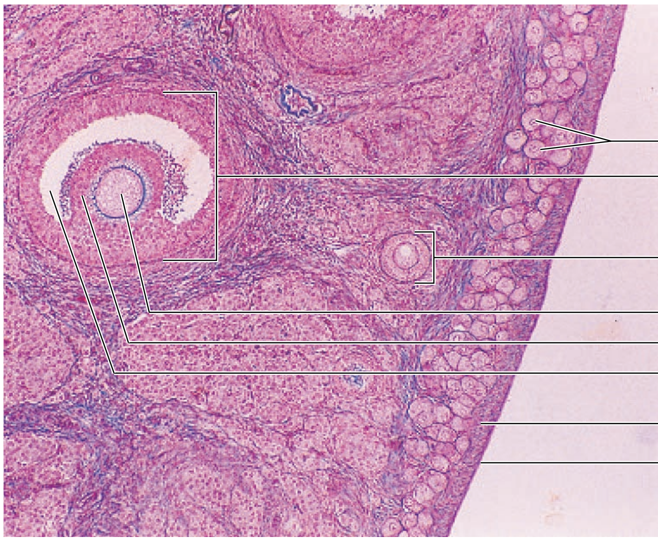
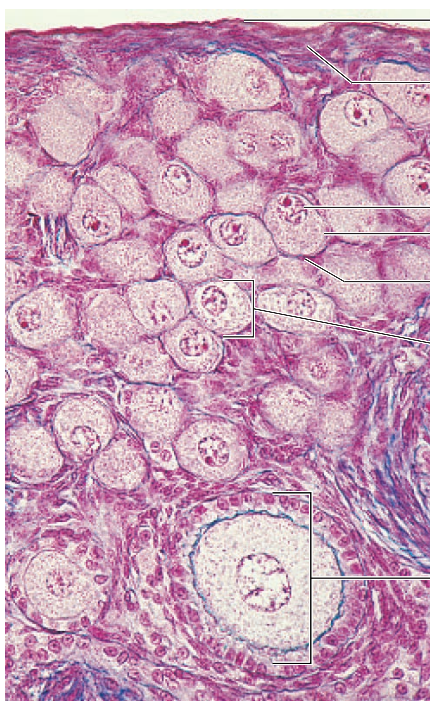


Figure 60.5 Micrograph of the ovarian cortex (100× micrograph enlarged to 200×).



8. Obtain a microscope slide of the uterine wall section. Examine it using low-power magnification (fig. 60.7) and locate the following:

   endometrium

   myometrium

   perimetrium

9. Prepare a labeled sketch of a representative section of the uterine wall in Part B of the laboratory report.

10. Complete Part B of the laboratory report.

DEMONSTRATION

Observe the slides in the demonstration microscopes. Each slide contains a section of uterine mucosa taken during a different phase in the menstrual cycle. In the *early proliferative phase,* note the simple columnar epithelium on the free surface of the mucosa and the numerous sections of tubular uterine glands in the tissues

Figure 60.6 Micrograph of a cross section of the uterine tube (8×).

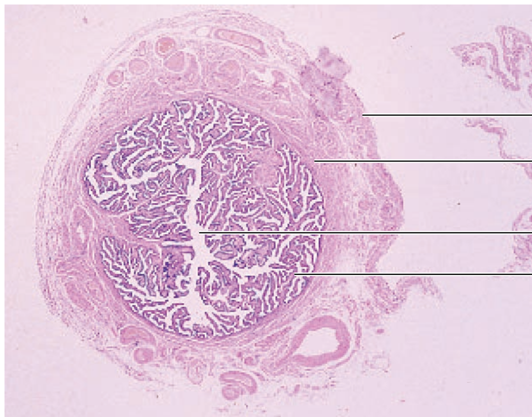
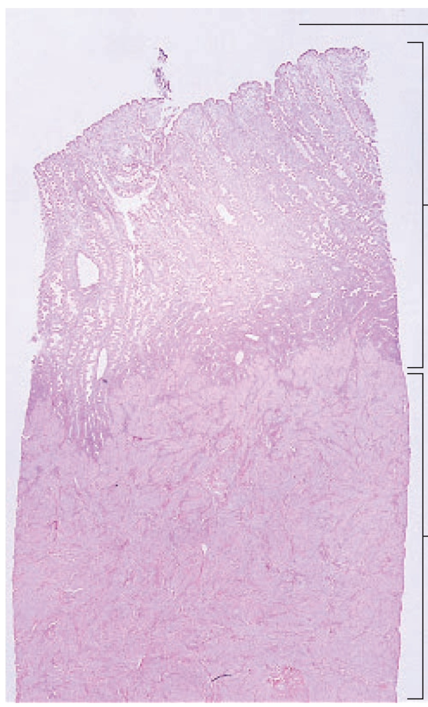


Figure 60.7 Micrograph of a section of the uterine wall (10× micrograph enlarged to 35×).



beneath the epithelium. In the *secretory phase,* note that the endometrium is thicker and that the uterine glands appear more extensive and that they are coiled. In the *early menstrual phase,* note that the endometrium is thinner because its surface layer has been lost. Also note that the uterine glands are less apparent and that the spaces between the glands contain many leukocytes. What is the significance of these changes?

____

____

____

Web Quest

Review the structures and functions of the female reproductive system at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Laboratory Report 60

Name ______________________________

Date ______________________________

Section ______________________________

FEMALE REPRODUCTIVE SYSTEM

Part A

Complete the following statements:

1. The ovaries are located in the lateral wall of the ______________________ cavity.
2. The largest of the ovarian attachments is called the ______________________ ligament.
3. The meiosis of egg formation is called ______________________.
4. A primary oocyte is closely surrounded by flattened epithelial cells called ______________________ cells.
5. When a primary oocyte divides, a secondary oocyte and a(an) ______________________ are produced.
6. ______________________ is the process by which a secondary oocyte is released from the ovary.
7. The ______________________ is the funnel-shaped expansion at the end of a uterine tube.
8. A portion of the uterus called the ______________________ extends downward into the upper portion of the vagina.
9. The inner mucosal lining of the uterus is called the ______________________.
10. The myometrium is largely composed of ______________________ tissue.
11. The vaginal orifice is partially closed by a thin membrane called the ______________________.
12. The rounded mass of fatty tissue overlying the symphysis pubis of the female is called the ____________________ ______________________.

Part B

1. Prepare a labeled sketch of a representative region of the ovarian cortex.

2. Prepare a series of three labeled sketches to illustrate follicular maturation.

3. Prepare a labeled sketch of a representative section of the wall of a uterine tube.

4. Prepare a labeled sketch of a representative section of uterine wall.

5. Complete the following:

   a. Describe the fate of a mature follicle. ______________________________

   b. Describe the function of the cilia in the lining of the uterine tube. ______________________________

   c. Briefly describe the changes that occur in the uterine lining during a menstrual cycle. ______________________________

Laboratory Exercise 61

Fetal Pig Dissection: Reproductive Systems

MATERIALS NEEDED

preserved fetal pig
dissecting tray
dissecting instruments
magnifying lens
disposable gloves
models of human reproductive systems

SAFETY

- Wear disposable gloves when working on the fetal pig dissection.
- Dispose of tissue remnants and gloves as instructed.
- Wash the dissecting tray and instruments as instructed.
- Wash your laboratory table.
- Wash your hands before leaving the laboratory.

In this laboratory exercise, you will dissect the reproductive system of the fetal pig. If you have a female fetal pig, begin with Procedure A. If you have a male fetal pig, begin with Procedure B. After completing the dissection, exchange fetal pigs with someone who has dissected one of the opposite gender and examine its reproductive organs.

As you observe the fetal pig reproductive organs, compare them with the corresponding human organs by examining the models of the human reproductive systems.

PURPOSE OF THE EXERCISE

To examine the reproductive organs of the fetal pig, and to compare them with the corresponding organs of the human.

LEARNING OBJECTIVES

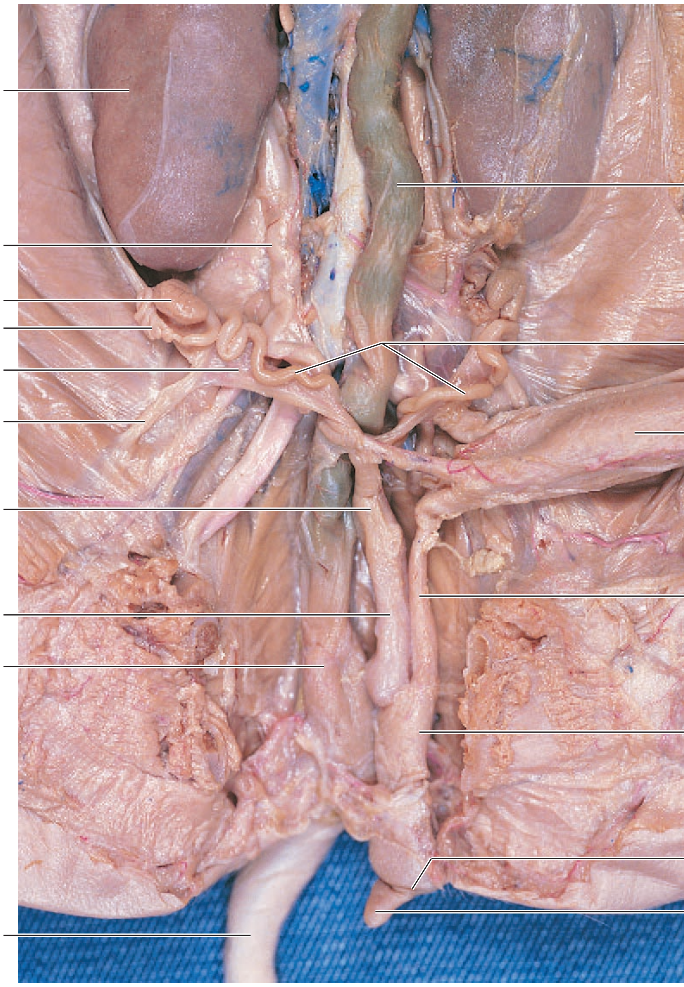
After completing this exercise, you should be able to

1. locate and identify the reproductive organs of a fetal pig;
2. identify the corresponding organs in models of the human reproductive systems;
3. compare the reproductive organs of the fetal pig with those of the human.

PROCEDURE A—FEMALE REPRODUCTIVE SYSTEM

1. Place the female fetal pig in a dissecting tray with its ventral side up, and open its abdominal cavity.
2. Locate the small oval *ovaries* just posterior to the kidneys (fig. 61.1).
3. Near the anterior end of the ovary, locate the funnel-shaped *infundibulum,* which is at the end of the coiled *uterine tube* or *oviduct.* Note the tiny projections, or *fimbriae,* that create a fringe around the edge of the infundibulum. Trace the uterine tube around the ovary to its connection with the *uterine horn.* These structures can best be located with a magnifying lens in fetal pigs.
4. Examine the uterine horn. Note that it is suspended from the body wall by a mesentery, the *broad ligament.* Also note the fibrous *round ligament,* which extends from the uterine horn laterally and posteriorly to the body wall.
5. Use scissors and cut carefully through the midline of the pelvis to observe the remaining organs of the reproductive system.
6. Trace the uterine horns posteriorly, and note that they unite to form the *uterine body,* which is located between the urethra and rectum. The Y-shaped uterus in a pig will allow the large uterus to contain a litter of pigs. The uterine body is continuous with the *vagina,* which leads to the outside.
7. Trace the *urethra* from the urinary bladder posteriorly, and note that it and the vagina open into a common chamber, called the *urogenital sinus.* The opening of this chamber, which is ventral to the anus, is called the *urogenital orifice.* Locate the *genital papilla,* which is like a small hood over the urogenital orifice.
8. Use scissors to open the vagina along its lateral wall, beginning at the urogenital orifice and continuing to the body of the uterus. Note the *urethral orifice* in the ventral wall of the urogenital sinus, and locate the small, rounded *cervix* of the

Figure 61.1 Reproductive system of the female fetal pig, ventral view.



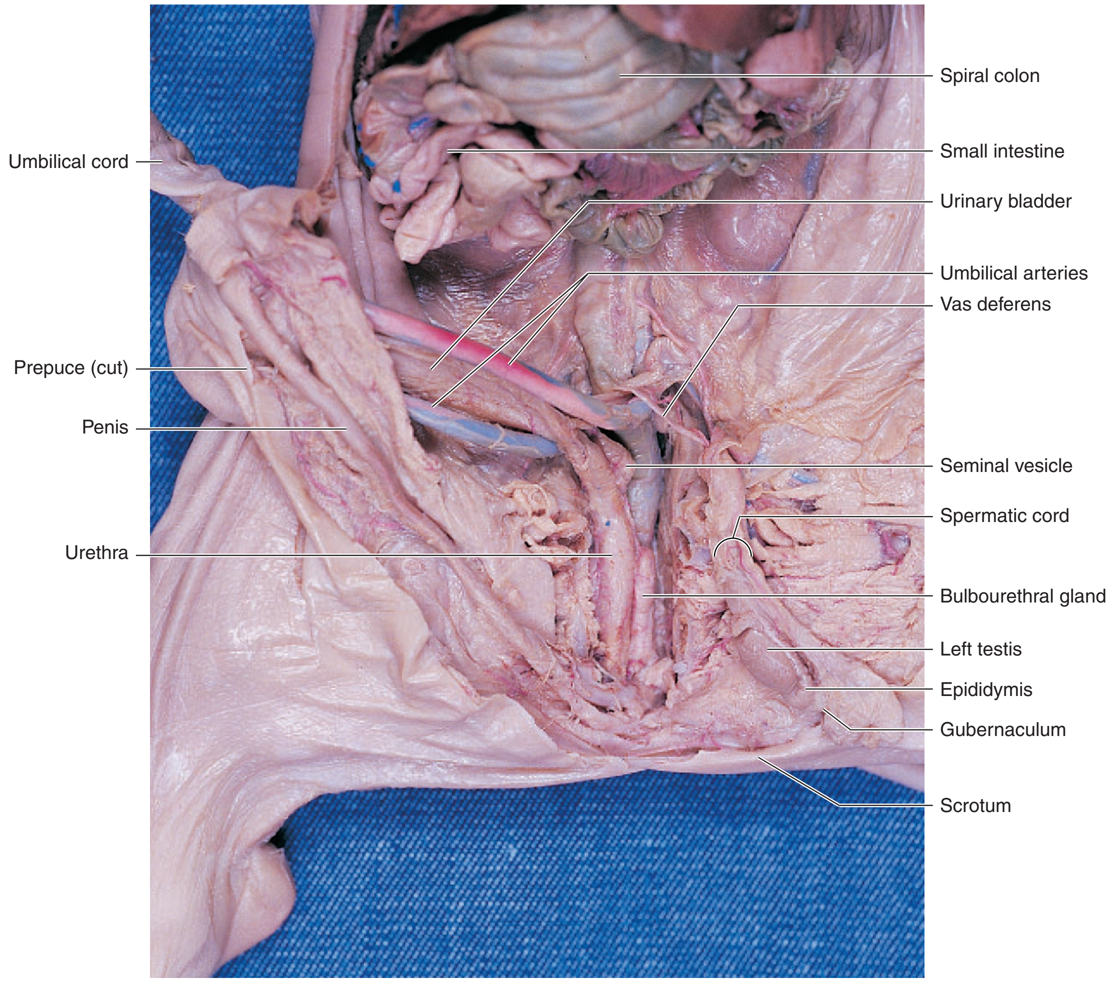
uterus, which projects into the vagina at its deep end. The *clitoris* is located in the ventral wall of the urogenital sinus near its opening to the outside.

9. Complete Part A of Laboratory Report 61.

PROCEDURE B— MALE REPRODUCTIVE SYSTEM

1. Place the male fetal pig in a dissecting tray with its ventral side up.
2. Locate the *scrotum,* which appears as an external pouch just ventral to the anus. During fetal development, the *testes* migrate from posterior to the kidneys through the *inguinal canals* into the scrotum by means of a *gubernaculum.* The gubernaculum, a cord of tissue that extends from the *epididymis* to the scrotum, grows slower than other tissues and "pulls" each testis into the scrotum. Make an incision on the left side of the scrotum and continue the incision anteriorly to open one of the inguinal canals to locate the *spermatic cord* (fig. 61.2).
3. Locate a testis within the inguinal sac. The exact location will vary depending on the degree of development of the fetal pig. Remove the sheath surrounding the testis, and locate the convoluted epididymis cupped around the lateral surface of each testis.
4. Locate the spermatic cord on the left side, leading away from the testis. This cord contains the *vas deferens,* which is continuous with the epididymis as well as with the nerves and blood vessels that supply the testis on that side. Trace the spermatic cord to the body wall, where its contents pass through the inguinal canal and enter the pelvic cavity (fig. 61.2).
5. Locate the *penis* and identify the *prepuce,* which forms a sheath around the penis. Make an incision

Figure 61.2 Reproductive system of the male fetal pig, ventral view.



through the skin of the prepuce, and expose the shaft of the penis.

6. Use scissors and cut carefully through the midline of the pelvis to observe the remaining organs of the reproductive system. Trace the vas deferens from the inguinal canal to the penis. Note that the vas deferens loops over the ureter within the pelvic cavity and passes downward behind the urinary bladder to join the urethra. Locate the small, paired *seminal vesicles,* which appear as enlargements near the junction of the vas deferens and urethra. A careful dissection between the seminal vesicles might expose the *prostate gland* near the junction of the urinary bladder and the urethra. (It is difficult to locate in the fetal pig.)
7. Trace the urethra to the penis. Locate the *bulbourethral glands,* which form elongated swellings along the urethra, on either side at the proximal end of the penis.
8. Use a sharp scalpel to cut a transverse section of the penis. Identify the urethra that serves as a common pathway for urine and semen in male pigs and humans. Locate the *urogenital orifice* at the distal end of the penis.
9. Complete Part B of the laboratory report.

Laboratory Report 61

Name ______________________

Date ______________________

Section ______________________

Fetal Pig Dissection: Reproductive Systems

Part A

Complete the following:

1. Compare the relative lengths and paths of the uterine tubes (oviducts) of the fetal pig and the human. ______________________

2. How do the shape and structure of the uterus of the fetal pig compare with that of the human? ______________________

3. Assess the function of the uterine horns of the pig. ______________________

4. Compare the relationship of the urethra and the vagina in the fetal pig and in the human. ______________________

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Part B

Complete the following:

1. Explain the location of the testes in the fetal pig.

2. How do the location and the relative size of the bulbourethral glands of the fetal pig compare with that of the human?

3. Compare the location and size of the prepuce in the fetal pig and in the human.

Laboratory Exercise 62

Fertilization and Early Development

MATERIALS NEEDED

textbook
sea urchin egg suspension*
sea urchin sperm suspension*
compound microscope
depression microscope slide
coverslip
medicine droppers
prepared microscope slide of the following:
  sea urchin embryos (early and late cleavage)
models of human embryos

For Optional Activity:

Vaseline
toothpick

For Demonstration:

preserved mammalian embryos

*See the Instructor's Manual for a source of materials.

Fertilization is the process by which the nuclei of an egg and a sperm cell come together and combine their chromosomes, forming a single cell called a zygote.

Ordinarily, before fertilization can occur in a human female, an egg cell must be released from the ovary and must be carried into a uterine tube. Also, semen containing sperm cells must be deposited in the vagina; some of these sperm cells must travel through the uterus and into the uterine tubes. Although many sperm cells may reach an egg cell, only one will participate in the fertilization of the egg.

Shortly after fertilization, the zygote undergoes division (mitosis) to form two cells. These two cells become four, they in turn divide into eight, and so forth. The resulting mass of cells continues to grow and undergoes developmental changes and growth that give rise to an offspring.

PURPOSE OF THE EXERCISE

To review the process of fertilization, to observe sea urchin eggs being fertilized, and to examine embryos in early stages of development.

LEARNING OBJECTIVES

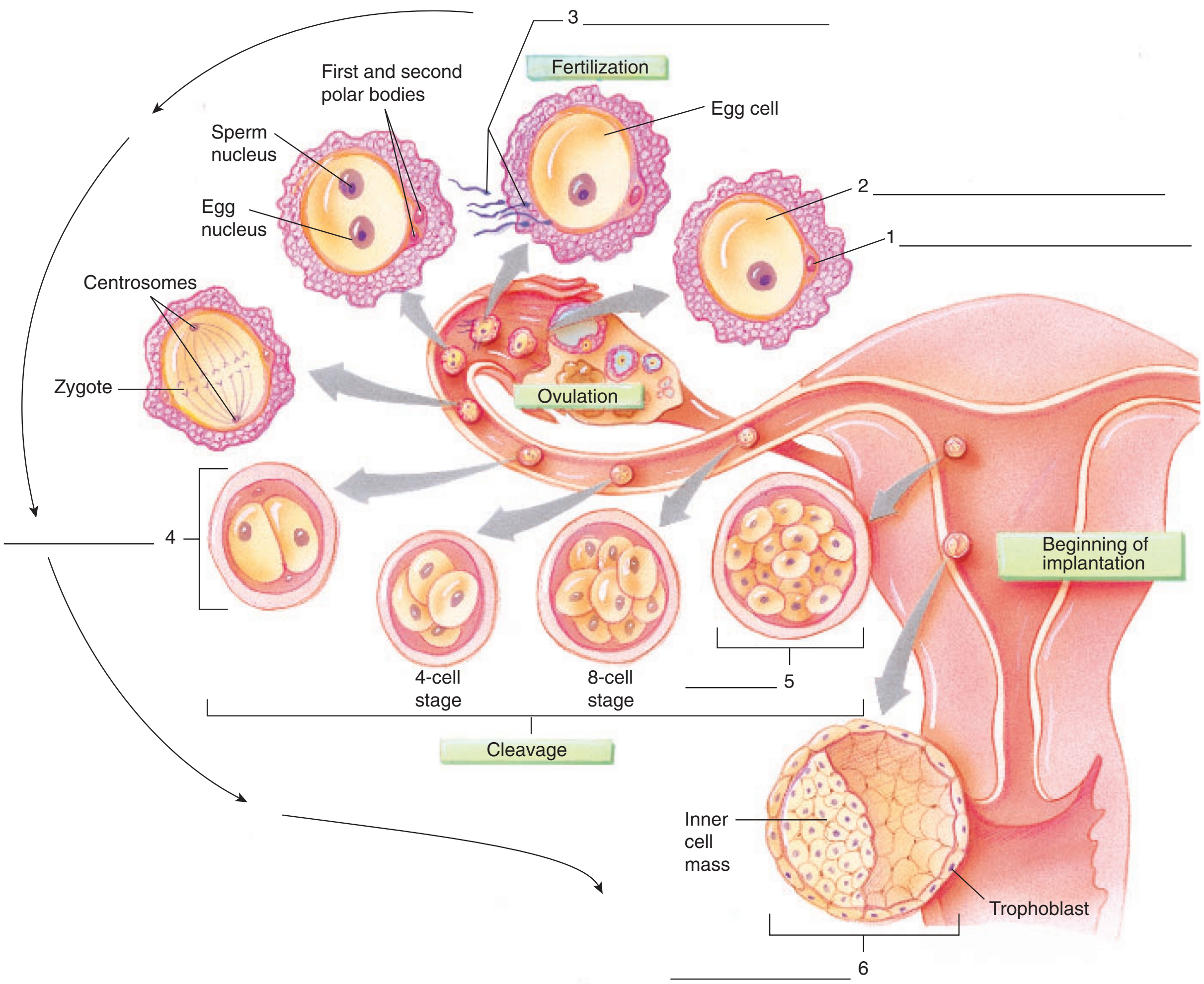
After completing this exercise, you should be able to

1. describe the process of fertilization;
2. describe the early developmental stages of a sea urchin;
3. describe the early developmental stages of a human;
4. identify the major features of human embryo models.

PROCEDURE A—FERTILIZATION

1. Review textbook sections on *fertilization* and *embryonic development.*
2. As a review activity, label figure 62.1.
3. Complete Part A of Laboratory Report 62.
4. Although it is difficult to observe fertilization in animals in which the process occurs internally, it is possible to view forms of external fertilization. For example, egg and sperm cells can be collected from sea urchins, and the process of fertilization can be observed microscopically. To make this observation, follow these steps:
   a. Place a drop of sea urchin egg-cell suspension in the chamber of a depression slide, and add a coverslip.
   b. Examine the egg cells using low-power magnification.
   c. Focus on a single egg cell with high-power magnification, and sketch the cell in Part B of the laboratory report.
   d. Remove the coverslip and add a drop of sea urchin sperm-cell suspension to the depression slide. Replace the coverslip, and observe the sperm cells with high-power magnification as they cluster around the egg cells. This attraction is stimulated by gamete secretions.
   e. Observe the egg cells with low-power magnification once again, and watch for the appearance of *fertilization membranes.* Such a membrane forms as soon as an egg cell is

Figure 62.1 Label the diagram of the stages of early human development.



penetrated by a sperm cell; it looks like a clear halo surrounding the egg cell.

f. Focus on a single fertilized egg cell, and sketch it in Part B of the laboratory report.

OPTIONAL ACTIVITY

Use a toothpick to draw a thin line of Vaseline around the chamber of the depression slide containing the fertilized sea urchin egg cells. Place a coverslip over the chamber, and gently press it into the Vaseline to seal the chamber and prevent the liquid inside from evaporating. Keep the slide in a cool place so that the temperature never exceeds 22°C (72°F). Using low-power magnification, examine the slide every 30 minutes, and look for the appearance of two-, four-, and eight-cell stages of developing sea urchin embryos.

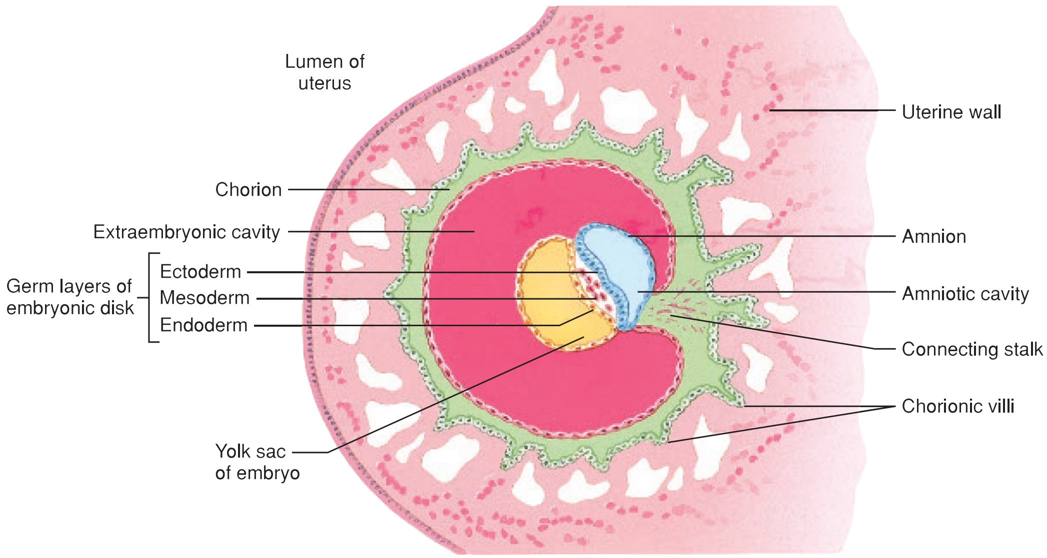
PROCEDURE B—SEA URCHIN EARLY DEVELOPMENT

1. Obtain a prepared microscope slide of developing sea urchin embryos. This slide contains embryos in various stages of cleavage. Search the slide using low-power magnification, and locate embryos in two-, four-, eight-, and sixteen-cell stages. Observe that cleavage results in an increase of cell numbers; however, the cells get progressively smaller.
2. Prepare a sketch of each stage in Part C of the laboratory report.

PROCEDURE C—HUMAN EARLY DEVELOPMENT

1. Review textbook sections on *cleavage* and *embryonic stages.*

Figure 62.2 Major features of the early embryo and the structures associated with it.



2. As a review activity, study figures 62.2 and 62.3.
3. Complete Parts D and E of the laboratory report.
4. Observe the models of human embryos, and identify the following features:

blastomeres

morula

blastocyst

inner cell mass

trophoblast

embryonic disk

primary germ layers

ectoderm

endoderm

mesoderm

connecting stalk

chorion

chorionic villi (from trophoblast)

lacunae

amnion

amniotic fluid

umbilical cord

umbilical arteries

umbilical vein

yolk sac

allantois

placenta

DEMONSTRATION

Observe the preserved mammalian embryos that are on display. In addition to observing the developing external body structures, identify such features as the chorion, chorionic villi, amnion, yolk sac, umbilical cord, and placenta. What special features provide clues as to the type of mammal these embryos represent?

____

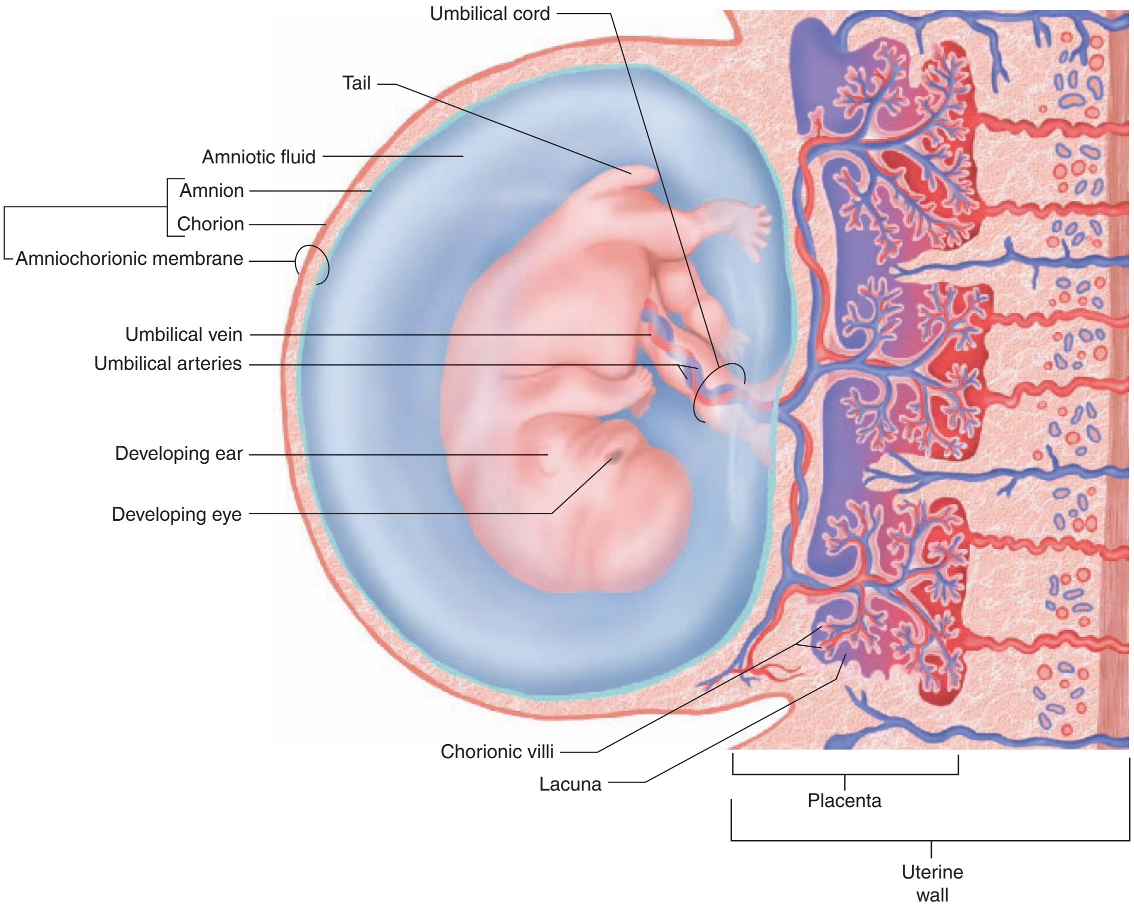
____

____

Web Quest

Examine topics of infertility, fetal development, pregnancy, birth and many more. Search these at http://www.mhhe.com/biosci/abio/martinlmwq.mhtml

Figure 62.3 Structures associated with this 7-week-old embryo.



Laboratory Report **62**

Name ______________________________

Date ______________________________

Section ______________________________

Fertilization and Early Development

Part A

Complete the following statements:

1. The zona pellucida surrounds the cell membrane of a(an) ____________________.
2. Enzymes secreted by the ____________________ of a sperm cell help it to penetrate the zona pellucida.
3. The cell resulting from fertilization is called a(an) ____________________.
4. The cell resulting from fertilization divides by the process of ____________________.
5. ____________________ is the phase of development during which cellular divisions result in smaller and smaller cells.
6. ____________________ on the inner lining of the uterine tube aid in moving a developing embryo.
7. The hollow ball of cells formed early in development is called a(an) ____________________.
8. A human offspring is called a(an) ____________________ until the end of the eighth week of development.
9. After the eighth week, a developing human is called a(an) ____________________ until the time of birth.

Part B

Prepare sketches of the following:

Single sea urchin egg (____×)	Fertilized sea urchin egg (____×)

Part C

Prepare sketches of the following:

Two-cell sea urchin embryo (____×)	Four-cell sea urchin embryo (____×)
Eight-cell sea urchin embryo (____×)	Sixteen-cell sea urchin embryo (____×)

Part D

Match the terms in column A with the descriptions in column B. Place the letter of your choice in the space provided.

Column A

a. blastocyst
b. chorionic villi
c. ectoderm
d. endoderm
e. mesoderm
f. morula
g. trophoblast

Column B

____ 1. germ layer that gives rise to muscle and bone tissues
____ 2. hollow ball of cells
____ 3. cells forming wall of blastocyst
____ 4. solid ball of about sixteen cells
____ 5. inner germ layer of embryonic disk
____ 6. slender extensions that grow out from the trophoblast
____ 7. outer germ layer of embryonic disk

Part E

Complete the following statements:

1. The embryonic membrane that is attached to the edge of the embryonic disk and surrounds the developing body is called the ____________________.
2. The umbilical cord contains three blood vessels, two of which are ____________________.
3. Eventually the amniotic cavity is surrounded by a double-layered membrane called the ________________________ ________________________.
4. The ____________________ and allantois function to form blood cells during the early stages of development.
5. The ____________________ gives rise to the umbilical blood vessels.
6. The embryonic stage is completed by the end of the ____________________ week of development.
7. All essential external and internal body parts are formed during the ____________________ stage of development.
8. ____________________ fluid protects the embryo from jarred movements and provides a watery environment for development.

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Appendix 1

Preparation of Solutions

Amylase solution, 0.5%
Place 0.5 g of bacterial amylase in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved. See the Instructor's Manual for a supplier of amylase that is free of sugar. (Store amylase powder in a freezer until mixing this solution.)

Benedict's solution
Prepared solution is available from various suppliers.

Caffeine, 0.2%
Place 0.2 g of caffeine in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Calcium chloride, 2.0%
Place 2.0 g of calcium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Calcium hydroxide solution (limewater)
Add an excess of calcium hydroxide to 1 L of distilled water. Stopper the bottle and shake thoroughly. Allow the solution to stand for 24 hours. Pour the supernatant fluid through a filter. Store the clear filtrate in a stoppered container.

Epsom salt solution, 0.1%
Place 0.5 g of Epsom salt in a graduated cylinder or volumetric flask. Add distilled water to the 500 mL level. Stir until dissolved.

Glucose, 1%
Place 1 g of glucose in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Iodine-potassium-iodide (IKI solution)
Add 20 g of potassium iodide to 1 L of distilled water and stir until dissolved. Then add 4.0 g of iodine and stir again until dissolved. Solution should be stored in a dark stoppered bottle.

Methylene blue
Dissolve 0.3 g of methylene blue powder in 30 mL of 95% ethyl alcohol. In a separate container, dissolve 0.01 g of potassium hydroxide in 100 mL of distilled water. Mix the two solutions. (Prepared solution is available from various suppliers.)

Physiological saline solution
Place 0.9 g of sodium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Potassium chloride, 5%
Place 5.0 g of potassium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Quinine sulfate, 0.5%
Place 0.5 g of quinine sulfate in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Ringer's solution (frog)
Dissolve the following salts in 1 L of distilled water:

6.50 g sodium chloride

0.20 g sodium bicarbonate

0.14 g potassium chloride

0.12 g calcium chloride

Sodium chloride solutions
1. *0.9% solution.* Place 0.9 g of sodium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.
2. *1.0% solution.* Place 1.0 g of sodium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.
3. *3.0% solution.* Place 3.0 g of sodium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

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4. *5.0% solution.* Place 5.0 g of sodium chloride in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Starch solutions

1. *0.5% solution.* Add 5 g of cornstarch to 1 L of distilled water. Heat until the mixture boils. Cool the liquid and pour it through a filter. Store the filtrate in a refrigerator.
2. *1.0% solution.* Add 10 g of cornstarch to 1 L of distilled water. Heat until the mixture boils. Cool the liquid and pour it through a filter. Store the filtrate in a refrigerator.

Sucrose, 5% solution

Place 5.0 g of sucrose in a graduated cylinder or volumetric flask. Add distilled water to the 100 mL level. Stir until dissolved.

Wright's stain

Prepared solution is available from various suppliers.

Appendix 2

Assessments of Laboratory Reports

Numerous assessment models can be utilized for laboratory reports. A rubric, which can be used for performance assessments, contains a description of the elements (requirements or criteria) of success to various degrees. The term *rubric* originated from *rubrica terra,* which is Latin for the application of red earth to indicate anything of importance. A rubric used for assessment contains elements for judging student performance, with points awarded for varying degrees of success in meeting the objectives. The content and the quality level necessary to attain certain points are indicated in the rubric. It is effective if the assessment tool is shared with the students before the laboratory exercise is performed.

Following are two sample rubrics that could easily be modified to meet the needs of a specific course. Some of the elements for these sample rubrics may not be necessary for every laboratory exercise. The generalized rubric needs to contain the possible assessment points that correspond to objectives for a specific course. The point value for each element may vary. The specific rubric example contains performance levels for laboratory reports. The elements and the point values could easily be altered to meet the value placed on laboratory reports for a specific course.

ASSESSMENT: GENERALIZED LABORATORY REPORT RUBRIC

Element	Assessment Points Possible	Assessment Points Earned
1. Figures are completely and accurately labeled.	____________	____________
2. Sketches are accurate, contain proper labels, and are of sufficient detail.	____________	____________
3. Colored pencils were used extensively to differentiate structures on illustrations.	____________	____________
4. Matching and fill-in-the-blank answers are completed and accurate.	____________	____________
5. Short-answer/discussion questions contain complete, thorough, and accurate answers. Some elaboration is evident for some answers.	____________	____________
6. Data collected are complete, accurately displayed, and contain a valid explanation.	____________	____________
Total Points	____________	____________

ASSESSMENT: SPECIFIC LABORATORY REPORT RUBRIC

Element	Excellent Performance (4 points)	Proficient Performance (3 points)	Marginal Performance (2 points)	Novice Performance (1 point)	Points Earned
Figure labels	Labels completed with ≥ 90% accuracy.	Labels completed with 80%–89% accuracy.	Labels completed with 70%–79% accuracy.	Labels <70% accurate.	
Sketches	Accurate use of scale, details illustrated, and all structures labeled accurately.	Minor errors in sketches. Missing or inaccurate labels on one or more structures.	Sketch is not realistic. Missing or inaccurate labels on two or more structures.	Several missing or inaccurate labels.	
Matching and fill-in-the-blanks	All completed and accurate.	One to two errors or omissions.	Three to four errors or omissions.	Five or more errors or omissions.	
Short-answer and discussion questions	Answers are complete, valid, and contain some elaboration. No misinterpretations are noted.	Answers are generally complete and valid. Only minor inaccuracies were noted. Minimal elaboration exists.	Marginal answers to the questions and contains inaccurate information.	Many answers are incorrect or fail to address the topic. There may be misinterpretations.	
Data collection and analysis	Data collection is complete and displayed with a valid interpretation.	Only minor data missing or a slight misinterpretation exists.	Some omissions. Not displayed or interpreted accurately.	Data collection is incomplete or shows serious misinterpretations.	

TOTAL POINTS EARNED ____________

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