ELEVENTH EDITION

CAT VERSION

Elaine N. Marieb Susan J. Mitchell Lori A. Smith

Human Anatomy & Physiology Laboratory Manual

Anatomy and Physiology Laboratory Safety Guidelines*

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

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*Adapted from:

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

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

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Eleventh Edition

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Preface to the Instructor

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

This manual, intended for students in introductory human anatomy and physiology courses, presents a wide range of laboratory experiences for students concentrating in nursing, physical therapy, dental hygiene, pharmacology, respiratory therapy, and health and physical education, as well as biology and premedical programs. It differs from *Human Anatomy & Physiology Laboratory Manual, Main Version* in that it contains detailed guidelines for dissecting a laboratory animal. The manual's coverage is intentionally broad, allowing it to serve both one- and two-semester courses.

Basic Approach and Features

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

Each of the 46 exercises leads students toward a coherent understanding of the structure and function of the human body. The manual begins with anatomical terminology and an orientation to the body, which together provide the necessary tools for studying the various body systems. The exercises that follow reflect the dual focus of the manual—both anatomical and physiological aspects receive considerable attention. As the various organ systems of the body are introduced, the initial exercises focus on organization, from the cellular to the organ system level. As indicated by the table of contents, the anatomical exercises are usually followed by physiological experiments that familiarize students with various aspects of body functioning and promote the critical understanding that function follows structure. Homeostasis is continually emphasized as a requirement for optimal health. Pathological conditions are viewed as a loss of homeostasis; these discussions can be recognized by the homeostatic imbalance logo within the descriptive material of each exercise. This holistic approach encourages an integrated understanding of the human body.

Features

- The numerous physiological experiments for each organ system range from simple experiments that can be performed without specialized tools to more complex experiments using laboratory equipment, computers, and instrumentation techniques.
- The laboratory Review Sheets following each exercise provide space for recording and interpreting experimental results and require students to label diagrams and answer matching and short-answer questions.
- In addition to the figures, isolated animal organs such as the sheep heart and pig kidney are employed to study anatomy because of their exceptional similarity to human organs.
- All exercises involving body fluids (blood, urine, saliva) incorporate current Centers for Disease Control and Prevention (CDC) guidelines for handling human body fluids. Because it is important that nursing students, in particular, learn how to safely handle bloodstained articles, the human focus has been retained. However, the decision to allow testing of human (student) blood or to use animal blood in the laboratory is left to the discretion of the instructor in accordance with institutional guidelines. The CDC guidelines for handling body fluids are reinforced by the laboratory safety procedures described on the inside front cover of this text, in Exercise 29: Blood, and in the *Instructor's Guide*. You can photocopy the inside front cover and post it in the lab to help students become well versed in laboratory safety.
- Five icons alert students to special features or instructions. These include:

The dissection scissors icon appears at the beginning of activities that entail the dissection of isolated animal organs.

The homeostatic imbalance icon directs the student's attention to conditions representing a loss of homeostasis.

A safety icon notifies students that specific safety precautions must be observed when using certain equipment or conducting particular lab procedures. For example, when working with ether, a hood is to be used; and when handling body fluids such as blood, urine, or saliva, gloves are to be worn.

BIOPAC® The BIOPAC icon in the materials list for an exercise clearly identifies use of the BIOPAC Student Lab System and alerts you to the equipment needed. BIOPAC is used in Exercises 14, 18, 20, 21, 31, 33, 34, and 37. The instructions in the lab manual are for use with the BIOPAC MP36/35 and MP45 data acquisition unit. Note there are some exercises that are not compatible with the MP45 data acquisition unit. For those exercises, the MP45 will not be listed in the materials section. The instructions included in the lab manual are for use with BSL software 3.7.5 to 3.7.7 for Windows and BSL software 3.7.4 to 3.7.7 for Mac OS X with some exceptions. Refer to the Materials section in each exercise for the applicable software version. For instructors using the MP36 (or MP35/30) data acquisition unit using BSL software versions earlier than 3.7.5 (for Windows) and 3.7.4 (for Mac OS X), access BIOPAC instructions in MasteringA&P for Exercises 14, 18, 20, 21, 31, and 34.

PEx The PhysioEx icon at the end of the materials list for an exercise directs students to the corresponding PhysioEx computer simulation exercise found in the back of the lab manual.

- Other data acquisition instructions are available in MasteringA&P, including:

PowerLab® Instructions
For Exercises 14, 21, 31, 33, 34, and 37, instructors using PowerLab equipment may print these exercises for student handouts.

iWorx® Instructions
For Exercises 14, 18, 21, 31, 33, 34, and 37, instructors using iWorx equipment in their laboratory may print these exercises for student handouts.

Intelitool® Instructions
Four physiological experiments (Exercises 14i, 21i, 31i, and 37i) using Intelitool equipment are available. Instructors using Intelitool equipment in their laboratory may print these exercises for student handouts.

What's New

In this revision, we have continued to try to respond to reviewers' and users' feedback concerning trends that are having an impact on the anatomy and physiology laboratory experience, most importantly:

- The ongoing search for good pedagogy and effective use of laboratory time
- The need to develop critical thinking skills
- The desire for more frequent quizzing delivered in both print and media formats, and for more computer-based practice exercises
- The need for laboratory simulations

The specific changes implemented to address these trends are described next.

NEW! Extensive Instructor Support Materials

Instructor's Resource DVD (0321884981 / 9780321884985) New for this edition, the Instructor's Resource DVD (IRDVD) organizes all instructor media resources into one convenient location and allows for easy quizzing in the lab. The IRDVD provides both **JPEG and PowerPoint files of all figures and tables** from the manual, with enlarged labels and easy-to-read type for optimal presentation.

IRDVD resources include:

- **Labeled and unlabeled JPEG files of all numbered figures and tables.** An extra set of JPEG files provides unlabeled figures with leader lines for **quick and easy quizzing in the lab.**
- **Customizable PowerPoint files** of all figures, with editable leader lines and labels.
- **A&P Flix™ Animations**
- **New Bone and Dissection videos**
- **Updated Electronic Test Bank** of Pre-Lab and Post-Lab Quizzes
- **PAL 3.0 Instructor Resources:** All images from PAL 3.0 in JPEG and PowerPoint format, with editable labels and leader lines, and embedded links to relevant 3-D anatomy animations and bone rotations. Instructors can quickly and easily create assignments based on the structures they cover in their course. Also included is an index of anatomical structures covered in PAL 3.0.

NEW! MasteringA&P® with Pearson eText

MasteringA&P is an online learning and assessment system proven to help students learn. It helps instructors maximize lab time with customizable, easy-to-assign, automatically graded assessments that motivate students to learn outside of class and arrive prepared for lab. The powerful gradebook provides unique insight into student and class performance, even before the first lab exam. As a result, instructors can spend valuable time where students need it most.

MasteringA&P resources include:

- **NEW! Bone and Dissection Videos review key bones and organ dissections found in the lab manual.** Each video is supported with activities with hints and specific wrong answer feedback to help students preview or review for lab exercises involving dissection and bone identification.
- **NEW! Drag-and-Drop Art Labeling Questions** let students assess their knowledge of terms and structures.
- **Updated! Assignable pre-lab and post-lab quizzes for all 46 exercises** in the lab manual.
- **Assignable quizzes and lab practicals from the PAL™ 3.0 Test Bank.**
- **Assignable pre-lab and post-lab quizzes for PhysioEx™ 9.1.**
- **Access to PAL 3.0 and PhysioEx 9.1** in the Study Area.
- **Instructor Access to IRDVD content.** A 24-month subscription to MasteringA&P is included with each new copy of the lab manual, and provides access directions and an access code.

In addition, MasteringA&P New Design is now available and offers:

- **Seamless integration with Blackboard Learn.** Using a Blackboard Building Block, this integration delivers streamlined access to your customizable content and highly personalized study paths, responsive learning tools, and real-time evaluation and diagnostics within the context of Blackboard Learn.
- **Student registration offers temporary access,** allowing students to access their Mastering course materials from day one, but defer payment for up to 17 days while they are waiting for financial aid.
- **Improved registration experience** provides a single point of access for instructors and students who are teaching and learning with multiple Mastering courses.

- **Simple user interface allows for quick and easy access** to Assignments, eText (also available offline with an iPad® app), and Results, and more options for course customization.
- **Communication Tools, including Email, Chat, Discussion Boards, and ClassLive Whiteboard** can be used to foster collaboration, class participation, and group work.

NEW! Customization Options

An enhanced custom program allows instructors to pick and choose content to tailor the lab manual to their own course. Instructors can now customize the lab manual at the activity level, selecting only those activities they assign. Each activity includes relevant background information, full-color figures, tables, and charts.

For information on creating a custom version of this manual, visit www.pearsonlearningsolutions.com/, or contact your Pearson representative for details.

NEW! Group Challenge Activities

Designed to teach critical thinking skills, these new activities challenge students to find the relationships between anatomical structures and physiological concepts, and to use that information to understand anatomy and physiology at a deeper level.

New Group Challenge Activities include:

Ex. 1: The Language of Anatomy, p. 10

Ex. 2: Odd Organ Out, p. 24

Ex. 5: Compare and Contrast Membrane Transport Processes, p. 62

Ex. 6: 1 Identifying Epithelial Tissues, p. 74
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Ex. 9: Odd Bone Out, p. 128

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Ex. 39: Odd Enzyme Out, p. 601

Ex. 40: Urinary System Sequencing, p. 617

Ex. 42: Reproductive Homologues, p. 638

Ex. 45: Odd Phenotype Out, p. 674

NEW! Improved Organization and Streamlined Text

This edition features key improvements to the lab manual's organization. Select content has been moved and divided for better efficiency in the lab. Important information from two smaller exercises is now integrated into other appropriate exercises: *serous membranes* are now more elaborately discussed in Ex. 1 (Language of Anatomy), and the *fetal skull* is covered in Ex. 12 (Axial Skeleton). We have also divided two exercises that were previously very large: The Spinal Cord and Spinal Nerves (Ex. 19) is now covered separately from The Autonomic Nervous System (Ex. 20). In addition, coverage of *vision* has been divided into two exercises: Anatomy of the Visual System (Ex. 23) and Visual Tests and Experiments (Ex. 24). Please refer to the new detailed *Table of Contents* for changes to the numbering of Ex. 8–24 (the numbering of Ex. 1–7 and Ex. 25–46 remains the same as the previous edition).

Other improvements to the lab manual include carefully edited, more accessible language; a new, user-friendly design featuring checklists that help students track their progress; and updated terminology that reflects the most recent information in *Terminologia Anatomica* and *Terminologia Histologica*.

Student Supplements

PAL Practice Anatomy Lab™ 3.0

Practice Anatomy Lab (PAL) 3.0 is an indispensable virtual anatomy study and practice tool that gives students 24/7 access to the most widely used laboratory specimens including human cadaver, cat, and fetal pig as well as anatomical models and histological images that are used in the laboratory.

PAL 3.0 features:

- **An interactive cadaver** that allows students to peel back layers of the human cadaver and view hundreds of brand-new dissection photographs specifically commissioned for this version.
- **Interactive histology** that allows students to view the same tissue slide at varying magnifications.
- **Quizzes give students more opportunity for practice.** Each time the student takes a quiz or lab practical exam, a new set of questions is generated.
- **Integration of nerves, arteries, and veins** across body systems.
- **Integrated muscle animations** of the origin, insertion, action, and innervations of key muscles.
- **Rotatable bones** help students appreciate the three-dimensionality of bone structures.

PAL 3.0 is available in the Study Area of MasteringA&P. The PAL 3.0 DVD can also be packaged with this lab manual at no additional charge.

PEx NEW! PhysioEx™ 9.1

PhysioEx 9.1 provides easy-to-use laboratory simulations in 12 exercises, containing a total of 63 physiology laboratory activities. 9.1 features input data variability that allows you to change variables and test out various hypotheses for the experiments. It can be used to supplement or substitute for wet labs. PhysioEx allows students to repeat labs as often as they like, perform experiments without harming live animals, and conduct experiments that are difficult to perform because of time, cost, or safety concerns.

PhysioEx 9.1 software features:

- **Input data variability** that allows students to change variables and test various hypotheses for the experiments.

- **New online format with easy step-by-step instructions** puts everything students need to do to complete the lab in one convenient place. Students gather data, analyze results, and check their understanding, all on screen.
- **Stop & Think Questions** and **Predict Questions** help students think about the connection between the activities and the physiological concepts they demonstrate.
- **Greater data variability in the results** reflects more realistically the results that students would encounter in a wet lab experiment.
- **New Pre-lab and Post-lab Quizzes** and short-answer **Review Sheets** are offered to help students prepare for and review each activity.
- **Students can save their Lab Report as a PDF,** which they can print and/or email to their instructor.
- **A Test Bank of assignable pre-lab and post-lab quizzes** for use with TestGen® or its course management system is provided for instructors.
- **Seven videos of lab experiments** demonstrate the actual experiments simulated on-screen, making it easy for students to understand and visualize the context of the simulations. Videos demonstrate the following experiments: Skeletal Muscle, Blood Typing, Cardiovascular Physiology, Use of a Water-Filled Spirometer, Nerve Impulses, BMR Measurement, and Cell Transport.

PhysioEx 9.1 topics include:

- Exercise 1: *Cell Transport Mechanisms and Permeability.* Explores how substances cross the cell membrane. Topics include: simple and facilitated diffusion, osmosis, filtration, and active transport.
- Exercise 2: *Skeletal Muscle Physiology.* Provides insights into the complex physiology of skeletal muscle. Topics include: electrical stimulation, isometric contractions, and isotonic contractions.
- Exercise 3: *Neurophysiology of Nerve Impulses.* Investigates stimuli that elicit action potentials, stimuli that inhibit action potentials, and factors affecting the conduction velocity of an action potential.
- Exercise 4: *Endocrine System Physiology.* Investigates the relationship between hormones and metabolism; the effect of estrogen replacement therapy; the diagnosis of diabetes; and the relationship between the levels of cortisol and adrenocorticotropic hormone and a variety of endocrine disorders.
- Exercise 5: *Cardiovascular Dynamics.* Allows students to perform experiments that would be difficult if not impossible to do in a traditional laboratory. Topics include: vessel resistance and pump (heart) mechanics.
- Exercise 6: *Cardiovascular Physiology.* Examines variables influencing heart activity. Topics include: setting up and recording baseline heart activity, the refractory period of cardiac muscle, and an investigation of factors that affect heart rate and contractility.
- Exercise 7: *Respiratory System Mechanics.* Investigates physical and chemical aspects of pulmonary function. Students collect data simulating normal lung volumes. Other activities examine factors such as airway resistance and the effect of surfactant on lung function.
- Exercise 8: *Chemical and Physical Processes of Digestion.* Examines factors that affect enzyme activity by manipulating (in compressed time) enzymes, reagents, and incubation conditions.
- Exercise 9: *Renal System Physiology.* Simulates the function of a single nephron. Topics include: factors influencing glomerular filtration, the effect of hormones on urine function, and glucose transport maximum.
- Exercise 10: *Acid-Base Balance.* Topics include: respiratory and metabolic acidosis/alkalosis, and renal and respiratory compensation.
- Exercise 11: *Blood Analysis.* Topics include: hematocrit determination, erythrocyte sedimentation rate determination, hemoglobin determination, blood typing, and total cholesterol determination.
- Exercise 12: *Serological Testing.* Investigates antigen-antibody reactions and their role in clinical tests used to diagnose a disease or an infection.

The PhysioEx 9.1 CD-ROM is available in a value package of the lab manual for no additional charge and is available in the Study Area of MasteringA&P.

Also Available

Practice Anatomy Lab 3.0 Lab Guide

without PAL 3.0 DVD (0-321-84025-9)
with PAL 3.0 DVD (0-321-85767-4)
by Ruth Heisler, Nora Hebert, Jett Chinn, Karen Krabbenhoft, Olga Malakhova

Written to accompany PAL™ 3.0, the new *Practice Anatomy Lab 3.0 Lab Guide* contains exercises that direct the student to select images and features in PAL 3.0, and then assesses their understanding with labeling, matching, short answer, and fill-in-the-blank questions. Exercises cover three key lab specimens in PAL 3.0—human cadaver, anatomical models, and histology.

The Anatomy Coloring Book, Fourth Edition (0-321-83201-9)

by Kapit and Elson

For more than 35 years, **The Anatomy Coloring Book** has been the best-selling human anatomy coloring book! A useful tool for anyone with an interest in learning anatomical structures, this concisely written text features precise, extraordinary hand-drawn figures that were crafted especially for easy coloring and interactive study. The **Fourth Edition** features user-friendly two-page spreads with enlarged art, clearer, more concise text descriptions, and new boldface headings that make this classic coloring book accessible to a wider range of learners.

A Brief Atlas of the Human Body, 2nd Edition (0-321-66261-X)

by Hutchinson, Mallatt, Marieb, Wilhelm

This full-color atlas includes 107 bone and 47 soft-tissue photographs with easy-to-read labels, and a comprehensive histology photomicrograph section covering basic tissue and organ systems.

Instructor's Guide (0-321-86170-1)
by Marieb, Mitchell, Smith

This guide accompanies all versions of the *Human Anatomy & Physiology Laboratory Manual* and includes detailed directions for setting up the laboratory, time allotments for each exercise, common problems encountered in the lab, alternative activities, and answers to the pre-lab quizzes, activity questions, and review sheets that appear in the Lab Manual.

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Getting Started—What to Expect, The Scientific Method, and Metrics

Two hundred years ago science was largely a plaything of wealthy patrons, but today's world is dominated by science and its technology. Whether or not we believe that such domination is desirable, we all have a responsibility to try to understand the goals and methods of science that have seeded this knowledge and technological explosion.

The biosciences are very special and exciting because they open the doors to an understanding of all the wondrous workings of living things. A course in human anatomy and physiology (a minute subdivision of bioscience) provides such insights in relation to your own body. Although some experience in scientific studies is helpful when beginning a study of anatomy and physiology, perhaps the single most important prerequisite is curiosity.

Gaining an understanding of science is a little like becoming acquainted with another person. Even though a written description can provide a good deal of information about the person, you can never really know another unless there is personal contact. And so it is with science—if you are to know it well, you must deal with it intimately.

The laboratory is the setting for "intimate contact" with science. It is where scientists test their ideas (do research), the essential purpose of which is to provide a basis from which predictions about scientific phenomena can be made. Likewise, it will be the site of your "intimate contact" with the subject of human anatomy and physiology as you are introduced to the methods and instruments used in biological research.

For many students, human anatomy and physiology is taken as an introductory-level course; and their scientific background exists, at best, as a dim memory. If this is your predicament, this prologue may be just what you need to fill in a few gaps and to get you started on the right track before your actual laboratory experiences begin. So—let's get to it!

The Scientific Method

Science would quickly stagnate if new knowledge were not continually derived from and added to it. The approach commonly used by scientists when they investigate various aspects of their respective disciplines is called the **scientific method.** This method is *not* a single rigorous technique that must be followed in a lockstep manner. It is nothing more or less than a logical, practical, and reliable way of approaching and solving problems of every kind—scientific or otherwise—to gain knowledge. It includes five major steps.

Step 1: Observation of Phenomena

The crucial first step involves observation of some phenomenon of interest. In other words, before a scientist can investigate anything, he or she must decide on a *problem* or focus for the investigation. In most college laboratory experiments, the problem or focus has been decided for you. However, to illustrate this important step, we will assume that you want to investigate the true nature of apples, particularly green apples. In such a case you would begin your studies by making a number of different observations concerning apples.

Step 2: Statement of the Hypothesis

Once you have decided on a focus of concern, the next step is to design a significant question to be answered. Such a question is usually posed in the form of a **hypothesis,** an unproven conclusion that attempts to explain some phenomenon. (At its crudest level, a hypothesis can be considered to be a "guess" or an intuitive hunch that tentatively explains some observation.) Generally, scientists do not restrict themselves to a single hypothesis; instead, they usually pose several and then test each one systematically.

We will assume that, to accomplish step 1, you go to the supermarket and randomly select apples from several bins. When you later eat the apples, you find that the green apples are sour, but the red and yellow apples are sweet. From this observation, you might conclude *(hypothesize)* that "green apples are sour." This statement would represent your current understanding of green apples. You might also reasonably predict that if you were to buy more apples, any green ones you buy will be sour. Thus, you would have gone beyond your initial observation that "these" green apples are sour to the prediction that "all" green apples are sour.

Any good hypothesis must meet several criteria. First, *it must be testable.* This characteristic is far more important than its being correct. The test data may or may not support the hypothesis, or new information may require that the hypothesis be modified. Clearly the accuracy of a prediction in any scientific study depends on the accuracy of the initial information on which it is based.

In our example, no great harm will come from an inaccurate prediction—that is, were we to find that some green apples are sweet. However, in some cases human life may depend on the accuracy of the prediction. For that and other reasons: (1) Repeated testing of scientific ideas is important, particularly because scientists working on the same problem do not always agree in their conclusions. (2) Careful observation is essential, even at the very outset of a study, because conclusions drawn from scientific tests are only as accurate as the information on which they are based.

A second criterion is that, even though hypotheses are guesses of a sort, *they must be based on measurable, describable facts. No mysticism can be theorized.* We cannot conjure up, to support our hypothesis, forces that have not been shown to exist. For example, as scientists, we cannot say that the tooth fairy took Johnny's tooth unless we can prove that the tooth fairy exists!

Third, a hypothesis *must not be anthropomorphic.* Human beings tend to anthropomorphize—that is, to relate all experiences to human experience. Whereas we could state that bears instinctively protect their young, it would be anthropomorphic to say that bears love their young, because love is a human emotional response. Thus, the initial hypothesis must be stated without interpretation.

Step 3: Data Collection

Once the initial hypothesis has been stated, scientists plan experiments that will provide data (or evidence) to support or disprove their hypotheses—that is, they *test* their hypotheses. Data are accumulated by making qualitative or quantitative observations of some sort. The observations are often aided by the use of various types of equipment such as cameras, microscopes, stimulators, or various electronic devices that allow chemical and physiological measurements to be taken.

Observations referred to as **qualitative** are those we can make with our senses—that is, by using our vision, hearing, or sense of taste, smell, or touch. For some quick practice in qualitative observation, compare and contrast an orange and an apple. (*Compare* means to emphasize the similarities between two things, whereas *contrast* means that the differences are to be emphasized.)

Whereas the differences between an apple and an orange are obvious, this is not always the case in biological observations. Quite often a scientist tries to detect very subtle differences that cannot be determined by qualitative observations; data must be derived from measurements. Such observations based on precise measurements of one type or another are **quantitative observations**. Examples of quantitative observations include careful measurements of body or organ dimensions such as mass, size, and volume; measurement of volumes of oxygen consumed during metabolic studies; determination of the concentration of glucose in urine; and determination of the differences in blood pressure and pulse under conditions of rest and exercise. An apple and an orange could be compared quantitatively by analyzing the relative amounts of sugar and water in a given volume of fruit flesh, the pigments and vitamins present in the apple skin and orange peel, and so on.

A valuable part of data gathering is the use of experiments to support or disprove a hypothesis. An **experiment** is a procedure designed to describe the factors in a given situation that affect one another (that is, to discover cause and effect) under certain conditions.

Two general rules govern experimentation. The first of these rules is that the experiment(s) should be conducted in such a manner that every **variable** (any factor that might affect the outcome of the experiment) is under the control of the experimenter. The **independent variables** are manipulated by the experimenter. For example, if the goal is to determine the effect of body temperature on breathing rate, the independent variable is body temperature. The effect observed or value measured (in this case breathing rate) is called the **dependent** or **response variable**. Its value "depends" on the value chosen for the independent variable. The ideal way to perform such an experiment is to set up and run a series of tests that are all identical, except for one specific factor that is varied.

One specimen (or group of specimens) is used as the **control** against which all other experimental samples are compared. The importance of the control sample cannot be overemphasized. The control group provides the "normal standard" against which all other samples are compared relative to the dependent variable. Taking our example one step further, if we wanted to investigate the effects of body temperature (the independent variable) on breathing rate (the dependent variable), we could collect data on the breathing rate of individuals with "normal" body temperature (the implicit control group), and compare these data to breathing-rate measurements obtained from groups of individuals with higher and lower body temperatures.

The second rule governing experimentation is that valid results require that testing be done on large numbers of subjects. It is essential to understand that it is nearly impossible to control all possible variables in biological tests. Indeed, there is a bit of scientific wisdom that mirrors this truth—that is, that laboratory animals, even in the most rigidly controlled and carefully designed experiments, "will do as they damn well please." Thus, stating that the testing of a drug for its painkilling effects was successful after having tested it on only one postoperative patient would be scientific suicide. Large numbers of patients would have to receive the drug and be monitored for a decrease in postoperative pain before such a statement could have any scientific validity. Then, other researchers would have to be able to uphold those conclusions by running similar experiments. *Repeatability* is an important part of the scientific method and is the primary basis for support or rejection of many hypotheses.

During experimentation and observation, data must be carefully recorded. Usually, such initial, or raw, data are recorded in table form. The table should be labeled to show the variables investigated and the results for each sample. At this point, *accurate recording* of observations is the primary concern. Later, these raw data will be reorganized and manipulated to show more explicitly the outcome of the experimentation.

Some of the observations that you will be asked to make in the anatomy and physiology laboratory will require that a drawing be made. Don't panic! The purpose of making drawings (in addition to providing a record) is to force you to observe things very closely. You need not be an artist (most biological drawings are simple outline drawings), but you do need to be neat and as accurate as possible. It is advisable to use a 4H pencil to do your drawings because it is easily erased and doesn't smudge. Before beginning to draw, you should examine your specimen closely, studying it as though you were going to have to draw it from memory. For example, when looking at cells you should ask yourself questions such as "What is their shape—the relationship of length and width? How are they joined together?" Then decide precisely what you are going to show and how large the drawing must be to show the necessary detail. After making the drawing, add labels in the margins and connect them by straight lines (leader lines) to the structures being named.

Step 4: Manipulation and Analysis of Data

The form of the final data varies, depending on the nature of the data collected. Usually, the final data represent information converted from the original measured values (raw data) to some other form. This may mean that averaging or some other statistical treatment must be applied, or it may require conversions from one kind of units to another. In other cases, graphs may be needed to display the data.

Elementary Treatment of Data

Only very elementary statistical treatment of data is required in this manual. For example, you will be expected to understand and/or compute an average (mean), percentages, and a range.

Two of these statistics, the mean and the range, are useful in describing the *typical* case among a large number of samples evaluated. Let us use a simple example. We will assume that the following heart rates (in beats/min) were recorded during an experiment: 64, 70, 82, 94, 85, 75, 72, 78. If you put these numbers in numerical order, the **range** is easily computed, because the range is the difference between the highest and lowest numbers obtained (highest number minus lowest number). The **mean** is obtained by summing the items and dividing the sum by the number of items. What is the range and the mean for the set of numbers just provided?

1. ______________________________

The word *percent* comes from the Latin meaning "for 100"; thus *percent,* indicated by the percent sign, %, means parts per 100 parts. Thus, if we say that 45% of Americans have type O blood, what we are really saying is that among each group of 100 Americans, 45 (45/100) can be expected to have type O blood. Any ratio can be converted to a percent by multiplying by 100 and adding the percent sign.

$$.25 \times 100 = 25\% \qquad 5 \times 100 = 500\%$$

It is very easy to convert any number (including decimals) to a percent. The rule is to move the decimal point two places to the right and add the percent sign. If no decimal point appears, it is *assumed* to be at the end of the number; and zeros are added to fill any empty spaces. Two examples follow:

$$0.25 = 0.25 = 25\%$$
$$5 = 5 \quad = 500\%$$

Change the following to percents:

2. 38 = __________ **4.** 1.6 = __________

3. .75 = __________

Note that although you are being asked here to convert numbers to percents, percents by themselves are meaningless. We always speak in terms of a percentage *of* something.

To change a percent to decimal form, remove the percent sign, and divide by 100. Change the following percents to whole numbers or decimals:

5. 800% = __________ **6.** 0.05% = __________

Making and Reading Line Graphs

For some laboratory experiments you will be required to show your data (or part of them) graphically. Simple line graphs allow relationships within the data to be shown interestingly and allow trends (or patterns) in the data to be demonstrated. An advantage of properly drawn graphs is that they save the reader's time because the essential meaning of a large amount of statistical data can be seen at a glance.

To aid in making accurate graphs, graph paper (or a printed grid in the manual) is used. Line graphs have both horizontal (X) and vertical (Y) axes with scales. Each scale should have uniform intervals—that is, each unit measured on the scale should require the same distance along the scale as any other. Variations from this rule may be misleading and result in false interpretations of the data. By convention, the condition that is manipulated (the independent variable) in the experimental series is plotted on the X-axis (the horizontal axis); and the value that we then measure (the dependent variable) is plotted on the Y-axis (the vertical axis). To plot the data, a dot or a small x is placed at the precise point where the two variables (measured for each sample) meet; and then a line (this is called the **curve**) is drawn to connect the plotted points.

Sometimes, you will see the curve on a line graph extended beyond the last plotted point. This is (supposedly) done to predict "what comes next." When you see this done, be skeptical. The information provided by such a technique is only slightly more accurate than that provided by a crystal ball! When constructing a graph, be sure to label the X-axis and Y-axis and give the graph a legend **(Figure G.1)**.

To read a line graph, pick any point on the line, and match it with the information directly below on the X-axis and with that directly to the left of it on the Y-axis. The figure below (Figure G.1) is a graph that illustrates the relationship between breaths per minute (respiratory rate) and body temperature. Answer the following questions about this graph:

7. What was the respiratory rate at a body temperature of 96°F? ______________

8. Between which two body temperature readings was the increase in breaths per minute greatest? ______________

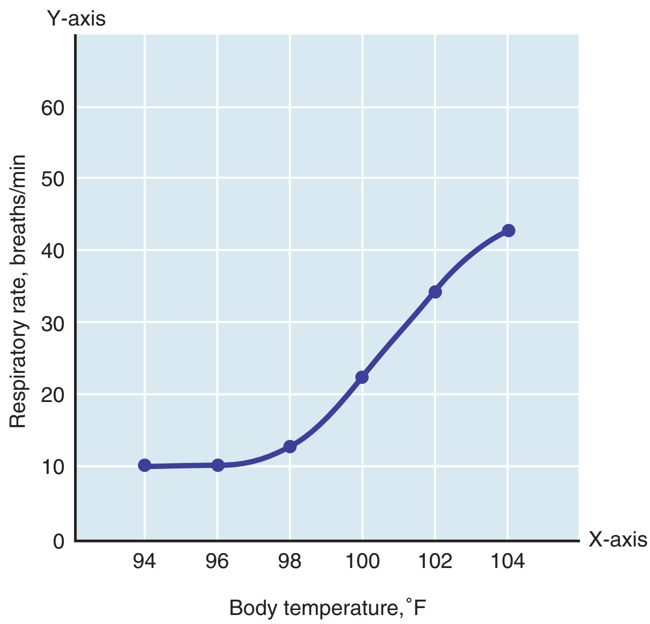

Figure G.1 Example of graphically presented data. Respiratory rate as a function of body temperature.

*Answers are given at the end of this section (page xx).

Step 5: Reporting Conclusions of the Study

Drawings, tables, and graphs alone do not suffice as the final presentation of scientific results. The final step requires that you provide a straightforward description of the conclusions drawn from your results. If possible, your findings should be compared to those of other investigators working on the same problem. For laboratory investigations conducted by students, these comparative figures are provided by classmates.

It is important to realize that scientific investigations do not always yield the anticipated results. If there are discrepancies between your results and those of others, or what you expected to find based on your class notes or textbook readings, this is the place to try to explain those discrepancies.

Lab Report

Cover Page
- Title of Experiment
- Author's Name
- Course
- Instructor
- Date

Introduction
- Provide background information.
- Describe any relevant observations.
- State hypotheses clearly.

Materials and Methods
- List equipment or supplies needed.
- Provide step-by-step directions for conducting the experiment.

Results
- Present data using a drawing (figure), table, or graph.
- Analyze data.
- Summarize findings briefly.

Discussion and Conclusions
- Conclude whether data gathered support or do not support hypotheses.
- Include relevant information from other sources.
- Explain any uncontrolled variables or unexpected difficulties.
- Make suggestions for further experimentation.

Reference List
- Cite the source of any material used to support this report.

Results are often only as good as the observation techniques used. Depending on the type of experiment conducted, you may need to answer several questions. Did you weigh the specimen carefully enough? Did you balance the scale first? Was the subject's blood pressure actually as high as you recorded it, or did you record it inaccurately? If you did record it accurately, is it possible that the subject was emotionally upset about something, which might have given falsely high data for the variable being investigated? Attempting to explain an unexpected result will often teach you more than you would have learned from anticipated results.

When the experiment produces results that are consistent with the hypothesis, then the hypothesis can be said to have reached a higher level of certainty. The probability that the hypothesis is correct is greater.

A hypothesis that has been validated by many different investigators is called a **theory.** Theories are useful in two important ways. First, they link sets of data; and second, they make predictions that may lead to additional avenues of investigation. (OK, we know this with a high degree of certainty; what's next?)

When a theory has been repeatedly verified and appears to have wide applicability in biology, it may assume the status of a **biological principle.** A principle is a statement that applies with a high degree of probability to a range of events. For example, "Living matter is made of cells or cell products" is a principle stated in many biology texts. It is a sound and useful principle, and will continue to be used as such—unless new findings prove it wrong.

We have been through quite a bit of background concerning the scientific method and what its use entails. Because it is important that you remember the phases of the scientific method, they are summarized here:

1. Observation of some phenomenon
2. Statement of a hypothesis (based on the observations)
3. Collection of data (testing the hypothesis with controlled experiments)
4. Manipulation and analysis of the data
5. Reporting of the conclusions of the study (routinely done by preparing a lab report—see page xvii)

Writing a Lab Report Based on The Scientific Method

A laboratory report is not the same as a scientific paper, but it has some of the same elements and is a formal way to report the results of a scientific experiment. The report should have a cover page that includes the title of the experiment, the author's name, the name of the course, the instructor, and the date. The report should include five separate, clearly marked sections: Introduction, Materials and Methods, Results, Discussion and Conclusions, and References. Use the previous template to guide you through writing a lab report.

Metrics

No matter how highly developed our ability to observe, observations have scientific value only if we can communicate them to others. Without measurement, we would be limited to qualitative description. For precise and repeatable communication of information, the agreed-upon system of measurement used by scientists is the **metric system.**

A major advantage of the metric system is that it is based on units of 10. This allows rapid conversion to workable numbers so that neither very large nor very small figures need be used in calculations. Fractions or multiples of the standard units of length, volume, mass, time, and temperature have been assigned specific names. The metric system **(Table G.1)** shows the commonly used units of the metric system, along with the prefixes used to designate fractions and multiples thereof.

To change from smaller units to larger units, you must *divide* by the appropriate factor of 10 (because there are fewer of the larger units). For example, a milliunit (*milli* = one-thousandth), such as a millimeter, is one step smaller than a centiunit (*centi* = one-hundredth), such as a centimeter. Thus to change milliunits to centiunits, you must divide by 10. On the other hand, when converting from larger units to smaller ones, you must *multiply* by the appropriate factor of 10. A partial scheme for conversions between the metric units is shown on the next page.

Table G.1 Metric System

A. Commonly used units		B. Fractions and their multiples		
Measurement	**Unit**	**Fraction or multiple**	**Prefix**	**Symbol**
Length	Meter (m)	10^6 one million	mega	M
Volume	Liter (L; l with prefix)	10^3 one thousand	kilo	k
Mass	Gram (g)	10^{-1} one-tenth	deci	d
Time*	Second (s)	10^{-2} one-hundredth	centi	c
Temperature	Degree Celsius (°C)	10^{-3} one-thousandth	milli	m
		10^{-6} one-millionth	micro	μ
		10^{-9} one-billionth	nano	n

* The accepted standard for time is the second; and thus hours and minutes are used in scientific, as well as everyday, measurement of time. The only prefixes generally used are those indicating *fractional portions* of seconds—for example, millisecond and microsecond.

$$\text{microunit} \underset{\times 1000}{\overset{\div 1000}{\rightleftharpoons}} \text{milliunit} \underset{\times 10}{\overset{\div 10}{\rightleftharpoons}} \text{centiunit} \underset{\times 100}{\overset{\div 100}{\rightleftharpoons}} \text{unit} \underset{\times 1000}{\overset{\div 1000}{\rightleftharpoons}} \text{kilounit}$$

$$\text{smallest} \rightleftharpoons \text{largest}$$

The objectives of the sections that follow are to provide a brief overview of the most-used measurements in science or health professions and to help you gain some measure of confidence in dealing with them. A listing of the most frequently used conversion factors, for conversions between British and metric system units, is provided in the appendix.

Length Measurements

The metric unit of length is the **meter (m).** Smaller objects are measured in centimeters or millimeters. Subcellular structures are measured in micrometers.

To help you picture these units of length, some equivalents follow:

One meter (m) is slightly longer than one yard (1 m = 39.37 in.).

One centimeter (cm) is approximately the width of a piece of chalk. (Note: There are 2.54 cm in 1 in.)

One millimeter (mm) is approximately the thickness of the wire of a paper clip or of a mark made by a No. 2 pencil lead.

One micrometer (µm) is extremely tiny and can be measured only microscopically.

Make the following conversions between metric units of length:

9. 12 cm = __________ mm

10. 2000 µm = __________ mm

Now, circle the answer that would make the most sense in each of the following statements:

11. A match (in a matchbook) is (0.3, 3, 30) cm long.

12. A standard-size American car is about 4 (mm, cm, m, km) long.

Volume Measurements

The metric unit of volume is the liter. A **liter** (l, or sometimes L, especially without a prefix) is slightly more than a quart (1 L = 1.057 quarts). Liquid volumes measured out for lab experiments are usually measured in milliliters (ml). (The terms *ml* and *cc,* cubic centimeter, are used interchangeably in laboratory and medical settings.)

To help you visualize metric volumes, the equivalents of some common substances follow:

A 12-oz can of soda is a little less than 360 ml.

A fluid ounce is about 30 (it's 29.57) ml (cc).

A teaspoon of vanilla is about 5 ml (cc).

Compute the following:

13. How many 5-ml injections can be prepared from 1 liter of a medicine? ______________

14. A 450-ml volume of alcohol is ______________ L.

Mass Measurements

Although many people use the terms *mass* and *weight* interchangeably, this usage is inaccurate. **Mass** is the amount of matter in an object; and an object has a constant mass, regardless of where it is—that is, on earth, or in outer space. However, weight varies with gravitational pull; the greater the gravitational pull, the greater the weight. Thus, our astronauts are said to be weightless when in outer space, but they still have the same mass as they do on earth. (Astronauts are not *really* weightless. It is just that they and their surroundings are being pulled toward the earth at the same speed; and so, in reference to their environment, they appear to float.)

The metric unit of mass is the **gram (g).** Medical dosages are usually prescribed in milligrams (mg) or micrograms (µg); and in the clinical agency, body weight (particularly of infants) is typically specified in kilograms (kg; 1 kg = 2.2 lb).

The following examples are provided to help you become familiar with the masses of some common objects:

Two aspirin tablets have a mass of approximately 1 g.

A nickel has a mass of 5 g.

The mass of an average woman (132 lb) is 60 kg.

Make the following conversions:

15. 300 g = __________ mg = __________ µg

16. 4000 µg = __________ mg = __________ g

17. A nurse must administer to her patient, Mrs. Smith, 5 mg of a drug per kg of body mass. Mrs. Smith weighs 140 lb. How many grams of the drug should the nurse administer to her patient?

__________ g

Temperature Measurements

In the laboratory and in the clinical agency, temperature is measured both in metric units (degrees Celsius, °C) and in British units (degrees Fahrenheit, °F). Thus it helps to be familiar with both temperature scales.

The temperatures of boiling and freezing water can be used to compare the two scales:

The freezing point of water is 0°C and 32°F.

The boiling point of water is 100°C and 212°F.

As you can see, the range from the freezing point to the boiling point of water on the Celsius scale is 100 degrees, whereas the comparable range on the Fahrenheit scale is 180 degrees. Hence, one degree on the Celsius scale represents a greater change in temperature. Normal body temperature is approximately 98.6°F or 37°C.

To convert from the Celsius scale to the Fahrenheit scale, the following equation is used:

$$°C = \frac{5(°F - 32)}{9}$$

To convert from the Fahrenheit scale to the Celsius scale, the following equation is used:

$$°F = (9/5\ °C) + 32$$

Perform the following temperature conversions:

18. Convert 38°C to °F: _______________

19. Convert 158°F to °C: _______________

Answers

1. range of 94–64 or 30 beats/min; mean 77.5

2. 3800%

3. 75%

4. 160%

5. 8

6. 0.0005

7. 10 breaths/min

8. interval between 100–102° (went from 22 to 36 breaths/min)

9. 12 cm = 120 mm

10. 2000 µm = 2 mm

11. 3 cm long

12. 4 m long

13. 200

14. 0.45 L

15. 300 g = $\underline{3 \times 10^5}$ mg = $\underline{3 \times 10^8}$ µg

16. 4000 µg = $\underline{4}$ mg = $\underline{4 \times 10^{-3}}$ g (0.004 g)

17. 0.32 g

18. 100.4°F

19. 70°C

1

EXERCISE

The Language of Anatomy

MATERIALS

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

OBJECTIVES

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

PRE-LAB QUIZ

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

Most of us are naturally curious about our bodies. This fact is demonstrated by infants, who are fascinated with their own waving hands or their mother's nose. Unlike the infant, however, the student of anatomy must learn to observe and identify the dissectible body structures formally.

A student new to any science is often overwhelmed at first by jargon used in that subject. The study of anatomy is no exception. But without this specialized terminology, confusion is inevitable. For example, what do *over, on top of, superficial to, above,* and *behind* mean in reference to the human body? Anatomists have an accepted set of reference terms that are universally understood. These allow body structures to be located and identified precisely with a minimum of words.

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

Anatomical Position

When anatomists or doctors refer to specific areas of the human body, the picture they keep in mind is a universally accepted standard position called the **anatomical position.** It is essential to understand this position because much of the body terminology used in this book refers to this body positioning, regardless of the position the body happens to be in. In the anatomical position the human body is erect, with the feet only slightly apart, head and toes pointed forward, and arms hanging at the sides with palms facing forward **(Figure 1.1a)**.

☐ Assume the anatomical position, and notice that it is not particularly comfortable. The hands are held unnaturally forward rather than hanging with palms toward the thighs.

Check the box when you have completed this task.

Surface Anatomy

Body surfaces provide a wealth of visible landmarks for study. There are two major divisions of the body:

Axial: Relating to head, neck, and trunk, the axis of the body

Appendicular: Relating to limbs and their attachments to the axis

Anterior Body Landmarks

Note the following regions (Figure 1.1a):

Abdominal: Anterior body trunk region inferior to the ribs

Acromial: Point of the shoulder

Antebrachial: Forearm

Antecubital: Anterior surface of the elbow

Axillary: Armpit

Brachial: Arm

Buccal: Cheek

Carpal: Wrist

Cephalic: Head

Cervical: Neck region

Coxal: Hip

Crural: Leg

Digital: Fingers or toes

Femoral: Thigh

Fibular (peroneal): Side of the leg

Frontal: Forehead

Hallux: Great toe

Inguinal: Groin area

Mammary: Breast region

Manus: Hand

Mental: Chin

Nasal: Nose

Oral: Mouth

Orbital: Bony eye socket (orbit)

Palmar: Palm of the hand

Patellar: Anterior knee (kneecap) region

Pedal: Foot

Pelvic: Pelvis region

Pollex: Thumb

Pubic: Genital region

Sternal: Region of the breastbone

Tarsal: Ankle

Thoracic: Chest

Umbilical: Navel

Posterior Body Landmarks

Note the following body surface regions (Figure 1.1b):

Acromial: Point of the shoulder

Brachial: Arm

Calcaneal: Heel of the foot

Cephalic: Head

Dorsum: Back

Femoral: Thigh

Gluteal: Buttocks or rump

Lumbar: Area of the back between the ribs and hips; the loin

Manus: Hand

Occipital: Posterior aspect of the head or base of the skull

Olecranal: Posterior aspect of the elbow

Otic: Ear

Pedal: Foot

Perineal: Region between the anus and external genitalia

Plantar: Sole of the foot

Popliteal: Back of the knee

Sacral: Region between the hips (overlying the sacrum)

Scapular: Scapula or shoulder blade area

Sural: Calf or posterior surface of the leg

Vertebral: Area of the spinal column

ACTIVITY 1

Locating Body Regions

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

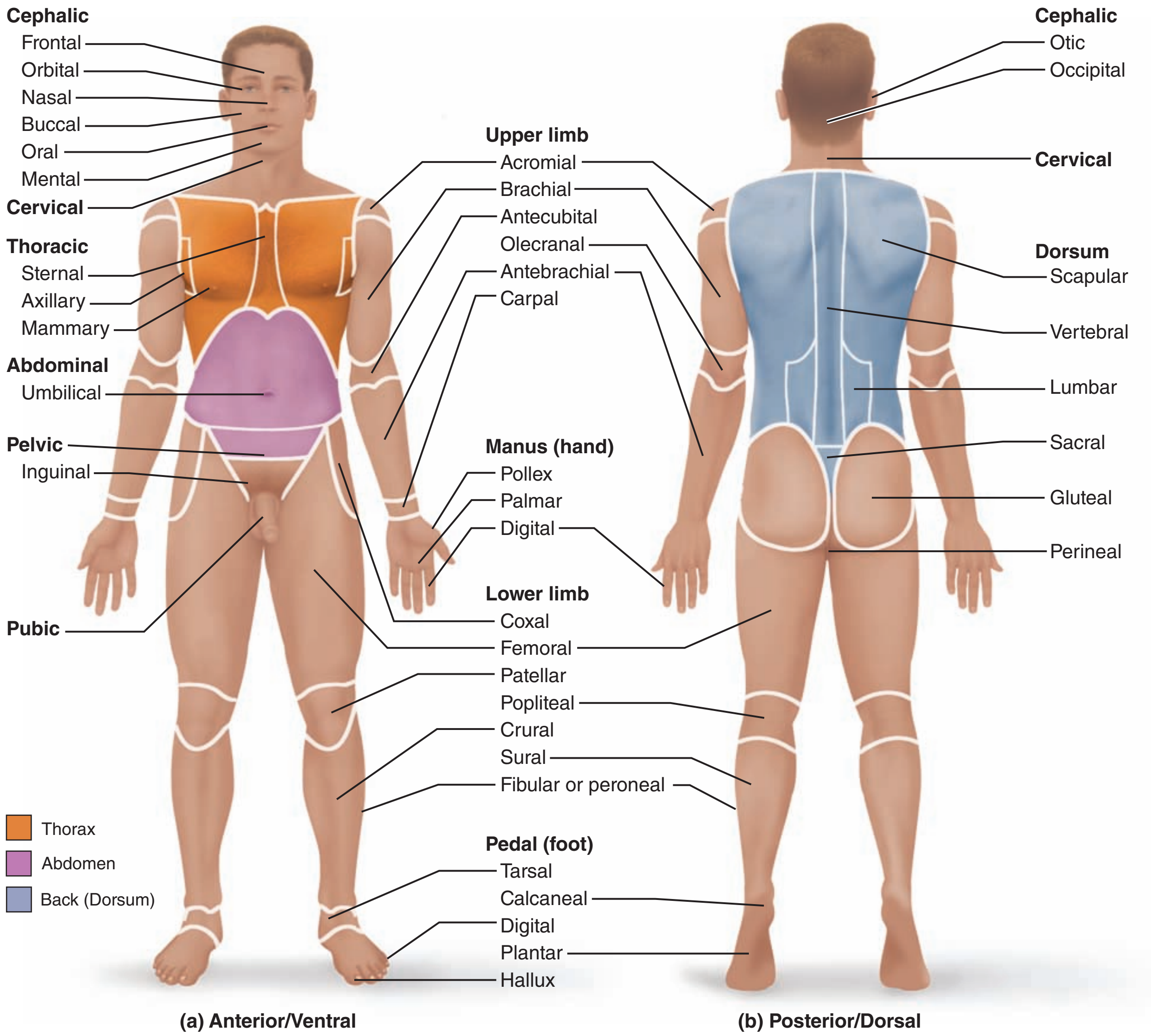

Figure 1.1 Surface anatomy. (a) Anatomical position. **(b)** Heels are raised to illustrate the plantar surface of the foot.

1

Body Orientation and Direction

Study the terms below (see **Figure 1.2** for a visual aid). Notice that certain terms have a different meaning for a four-legged animal (quadruped) than they do for a human (biped).

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

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

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

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

Cephalad (cranial)/caudal *(toward the head/toward the tail):* In humans these terms are used interchangeably with *superior* and *inferior,* but in four-legged animals they are synonymous with *anterior* and *posterior,* respectively.

Dorsal/ventral *(backside/belly side):* These terms are used chiefly in discussing the comparative anatomy of animals, assuming the animal is standing. *Dorsum* is a Latin word meaning "back." Thus, *dorsal* refers to the animal's back or the *back*side of any other structures; for example, the posterior surface of the human leg is its dorsal surface. The term *ventral* derives from the Latin term *venter,* meaning "belly," and always refers to the belly side of animals. In humans the terms *ventral* and *dorsal* are used interchangeably with the terms *anterior* and *posterior,* but in four-legged animals *ventral* and *dorsal* are synonymous with *inferior* and *superior,* respectively.

Proximal/distal *(nearer the trunk or attached end/farther from the trunk or point of attachment):* These terms are used primarily to locate various areas of the body limbs. For example, the fingers are distal to the elbow; the knee is proximal to the toes. However, these terms may also be used to indicate regions (closer to or farther from the head) of internal tubular organs.

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

ACTIVITY 2

Practicing Using Correct Anatomical Terminology

Before continuing, use a human torso model, a human skeleton, or your own body to specify the relationship between the following structures when the body is in the anatomical position.

1. The wrist is _______________ to the hand.
2. The trachea (windpipe) is _______________ to the spine.
3. The brain is _______________ to the spinal cord.
4. The kidneys are _______________ to the liver.
5. The nose is _______________ to the cheekbones.
6. The thumb is _______________ to the ring finger.
7. The thorax is _______________ to the abdomen.
8. The skin is _______________ to the skeleton.

Body Planes and Sections

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

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

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

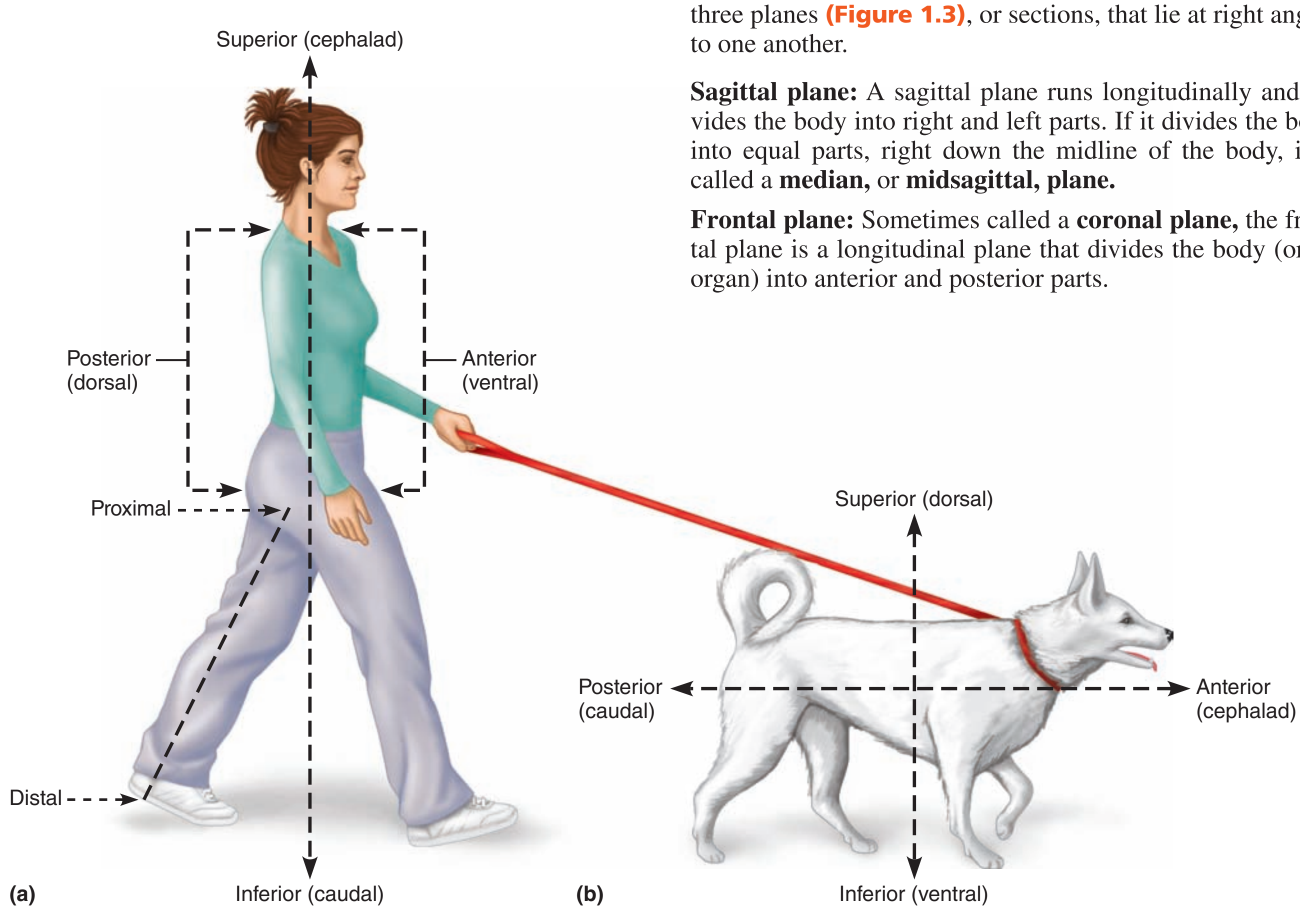

Figure 1.2 Anatomical terminology describing body orientation and direction. **(a)** With reference to a human. **(b)** With reference to a four-legged animal.

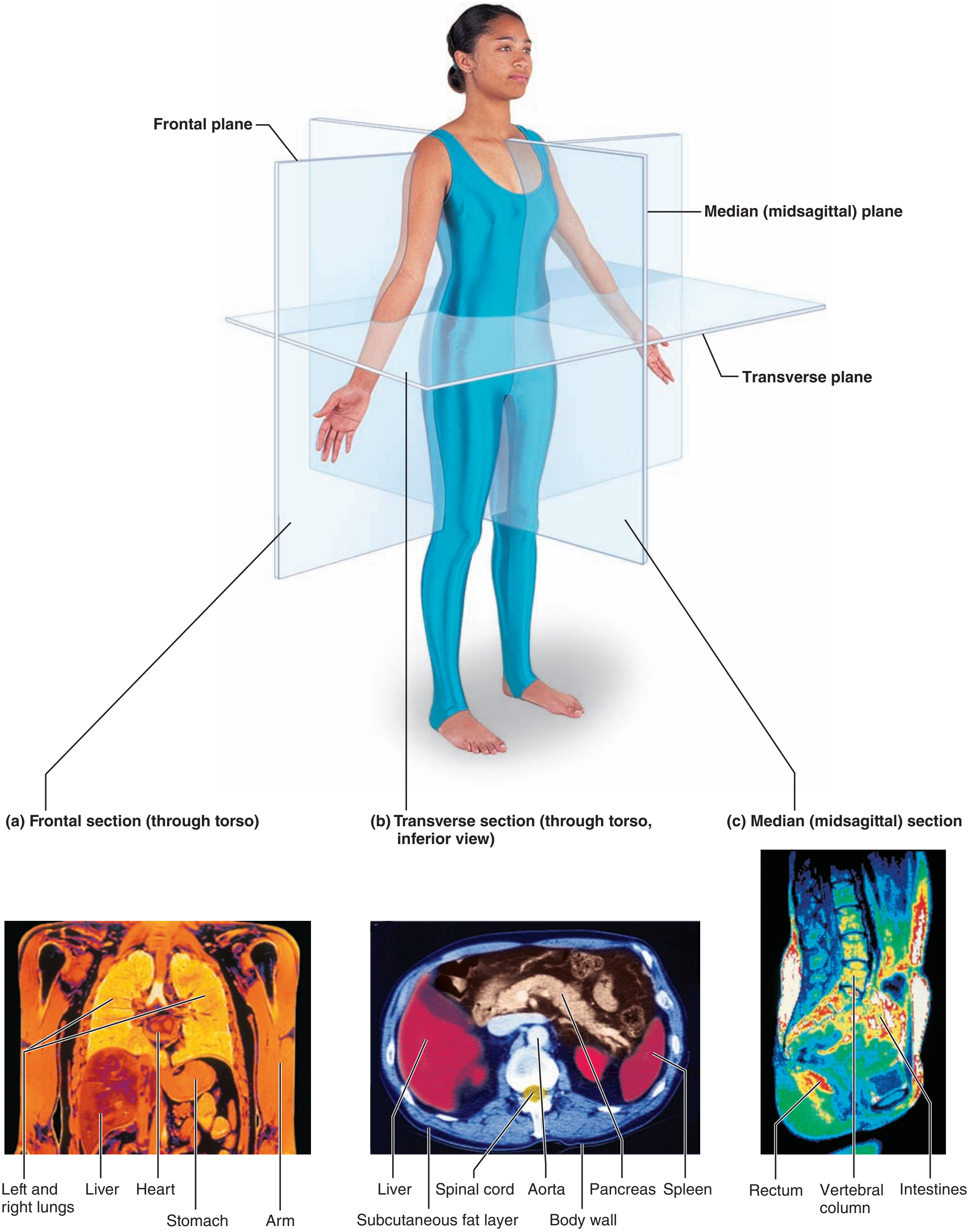

Figure 1.3 Planes of the body with corresponding magnetic resonance imaging (MRI) scans.

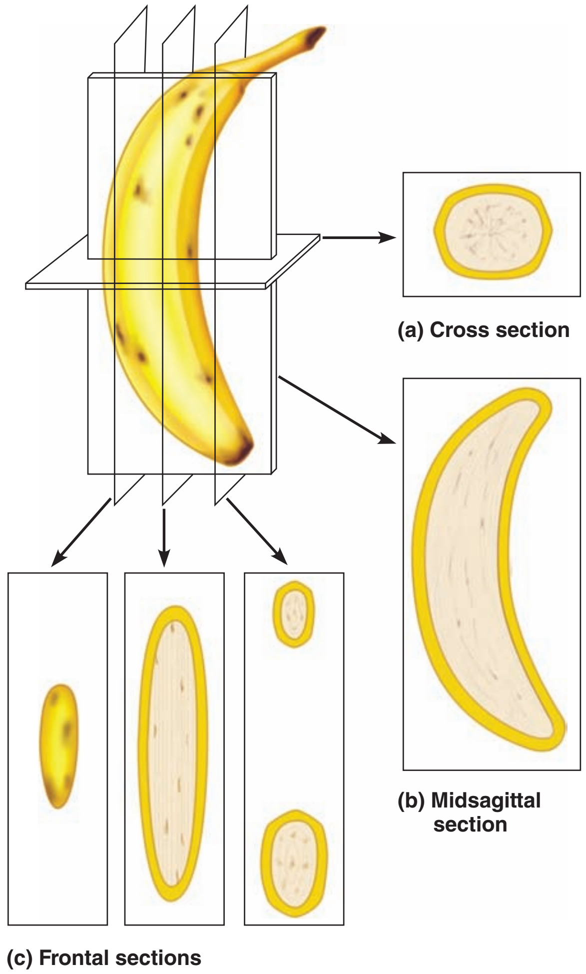

Figure 1.4 Objects can look odd when viewed in section. This banana has been sectioned in three different planes **(a–c)**, and only in one of these planes **(b)** is it easily recognized as a banana. If one cannot recognize a sectioned organ, it is possible to reconstruct its shape from a series of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

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

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

A sagittal or frontal plane section of any nonspherical object, be it a banana or a body organ, provides quite a different view than a transverse section **(Figure 1.4)**.

ACTIVITY 3

Observing Sectioned Specimens

1. Go to the demonstration area and observe the transversely and longitudinally cut organ specimens (kidneys). Pay close attention to the different structural details in the samples because you will need to draw these views in the Review Sheet at the end of this exercise.

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

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

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

Transverse cut Longitudinal cut Oblique cut

Body Cavities

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

Dorsal Body Cavity

The dorsal body cavity can be subdivided into the **cranial cavity,** which contains the brain within the rigid skull, and the **vertebral** (or **spinal**) **cavity,** within which the delicate spinal cord is protected by the bony vertebral column. Because the spinal cord is a continuation of the brain, these cavities are continuous with each other.

Ventral Body Cavity

Like the dorsal cavity, the ventral body cavity is subdivided. The superior **thoracic cavity** is separated from the rest of the ventral cavity by the dome-shaped diaphragm. The heart and lungs, located in the thoracic cavity, are protected by the bony rib cage. The cavity inferior to the diaphragm is often referred to as the **abdominopelvic cavity.** Although there is no further physical separation of the ventral cavity, some describe the abdominopelvic cavity as two areas: a superior **abdominal cavity,** the area that houses the stomach, intestines, liver, and other organs, and an inferior **pelvic cavity,** the region that is partially enclosed by the bony pelvis and contains the reproductive organs, bladder, and rectum. Notice in the lateral view (Figure 1.5a) that the abdominal and pelvic cavities are not continuous with each other in a straight plane but that the pelvic cavity is tipped forward.

Serous Membranes of the Ventral Body Cavity

The walls of the ventral body cavity and the outer surfaces of the organs it contains are covered with an exceedingly thin, double-layered membrane called the **serosa,** or **serous membrane.** The part of the membrane lining the cavity walls is referred to as the **parietal serosa,** and it is continuous with a similar membrane, the **visceral serosa,** covering the external

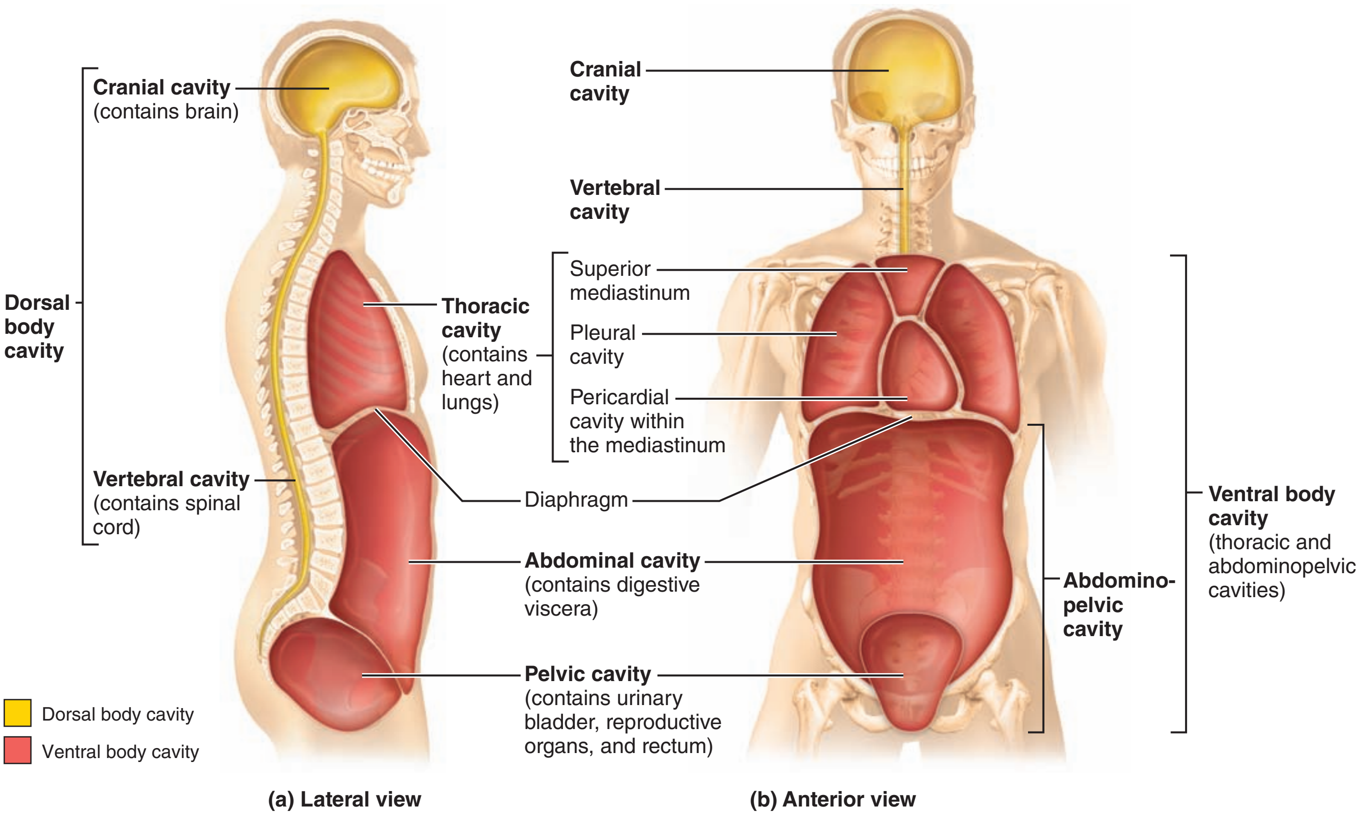

Figure 1.5 **Dorsal and ventral body cavities and their subdivisions.**

surface of the organs within the cavity. These membranes produce a thin lubricating fluid that allows the visceral organs to slide over one another or to rub against the body wall with minimal friction. Serous membranes also compartmentalize the various organs so that infection of one organ is prevented from spreading to others.

The specific names of the serous membranes depend on the structures they surround. The serosa lining the abdominal cavity and covering its organs is the **peritoneum,** that enclosing the lungs is the **pleura,** and that around the heart is the **pericardium** **(Figure 1.6)**.

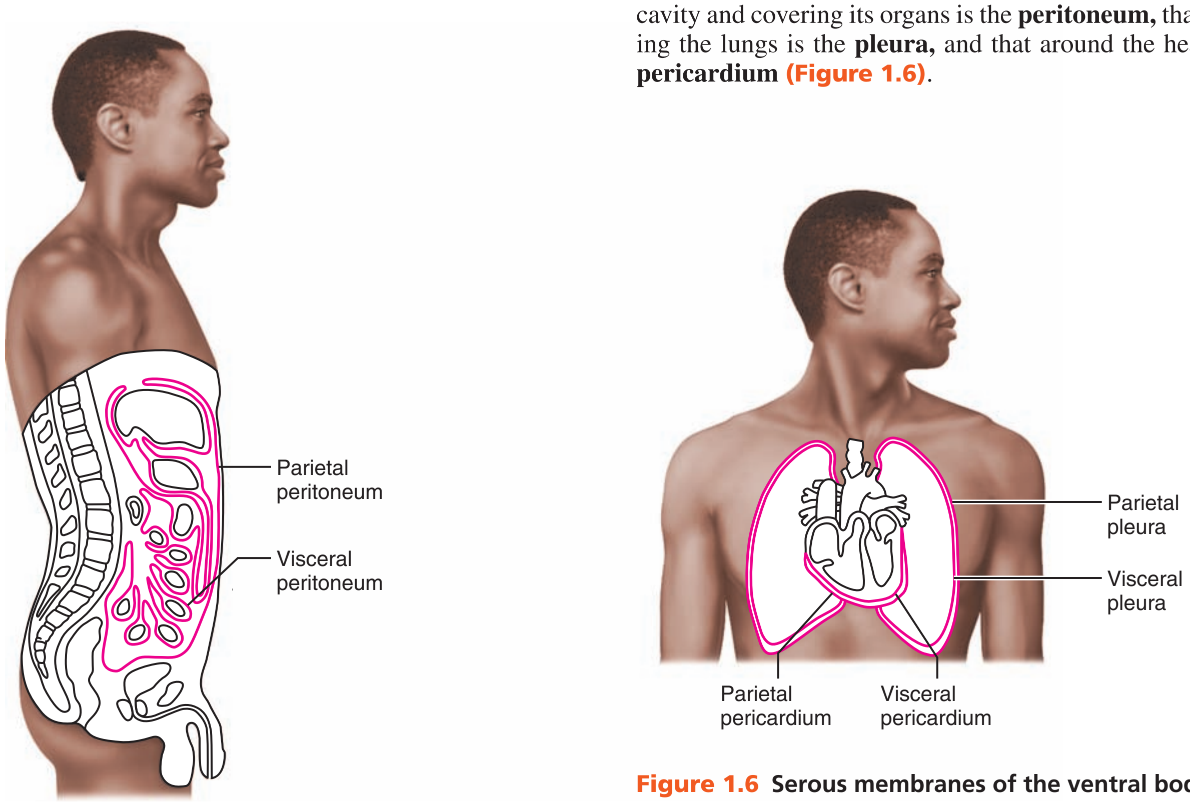

Figure 1.6 **Serous membranes of the ventral body cavities.**

1

Abdominopelvic Quadrants and Regions

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

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

ACTIVITY 4

Identifying Organs in the Abdominopelvic Cavity

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

Name two organs found in the left upper quadrant.

_______________ and _______________

Name two organs found in the right lower quadrant.

_______________ and _______________

What organ (Figure 1.7) is divided into identical halves by

the median plane? _______________ ■

A different scheme commonly used by anatomists divides the abdominal surface and abdominopelvic cavity into nine separate regions by four planes **(Figure 1.8)**. Although the names of these nine regions are unfamiliar to you now, with a little patience and study they will become easier to remember. As you read through the descriptions of these nine regions, locate them (Figure 1.8), and note the organs contained in each region.

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

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

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

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

Lumbar regions: Between the ribs and the flaring portions of the hip bones; lateral to the umbilical region

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

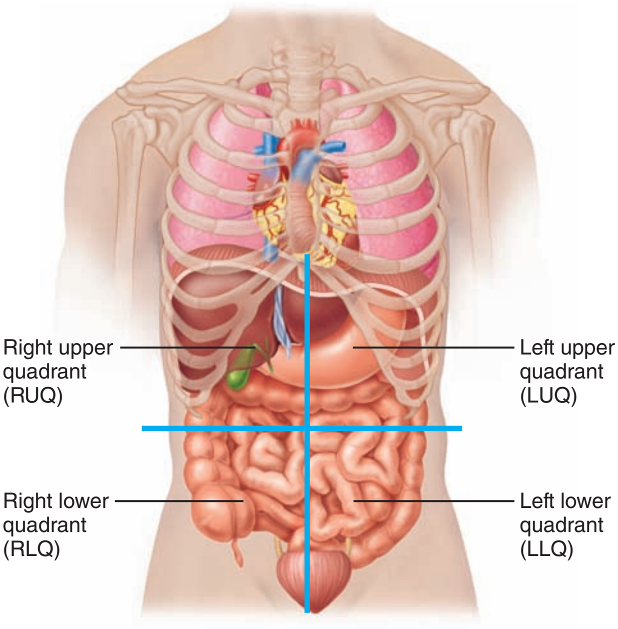

Figure 1.7 Abdominopelvic quadrants. Superficial organs all shown in each quadrant.

ACTIVITY 5

Locating Abdominal Surface Regions

Locate the regions of the abdominal surface on a human torso model and on yourself before continuing. ■

Other Body Cavities

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

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

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

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

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

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

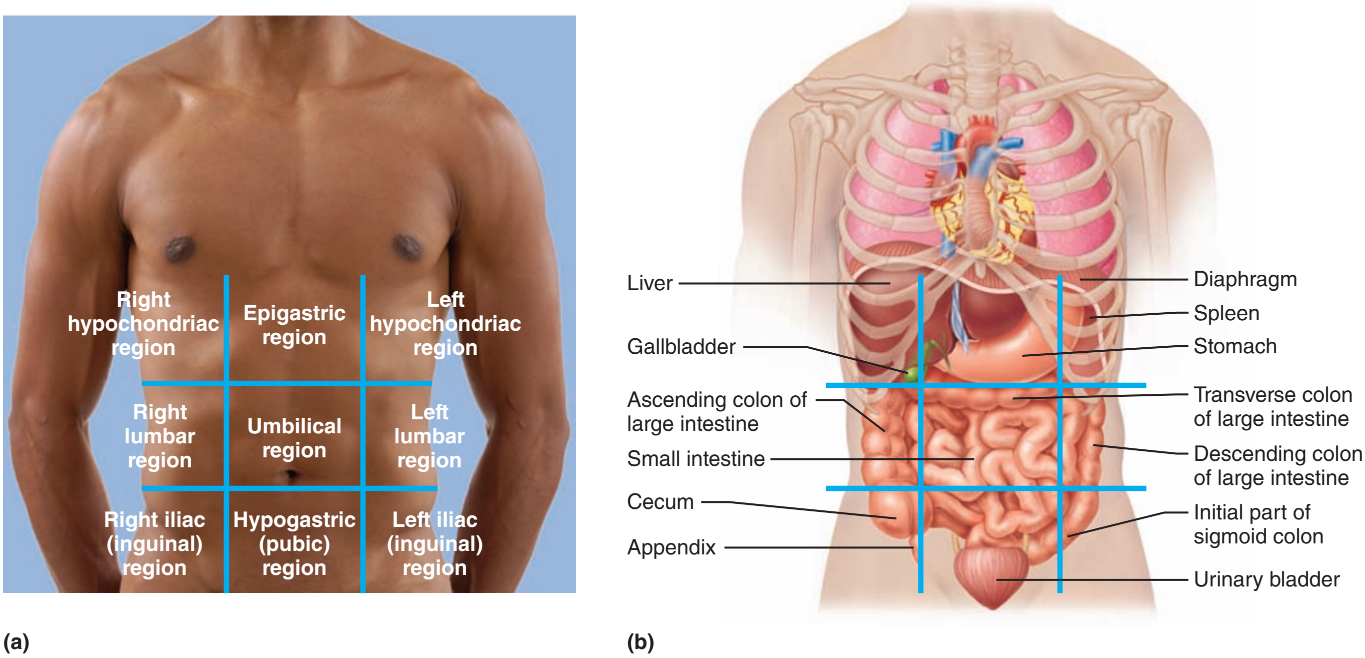

Figure 1.8 Abdominopelvic regions. Nine regions delineated by four planes. **(a)** The superior horizontal plane is just inferior to the ribs; the inferior horizontal plane is at the superior aspect of the hip bones. The vertical planes are just medial to the nipples. **(b)** Superficial organs are shown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

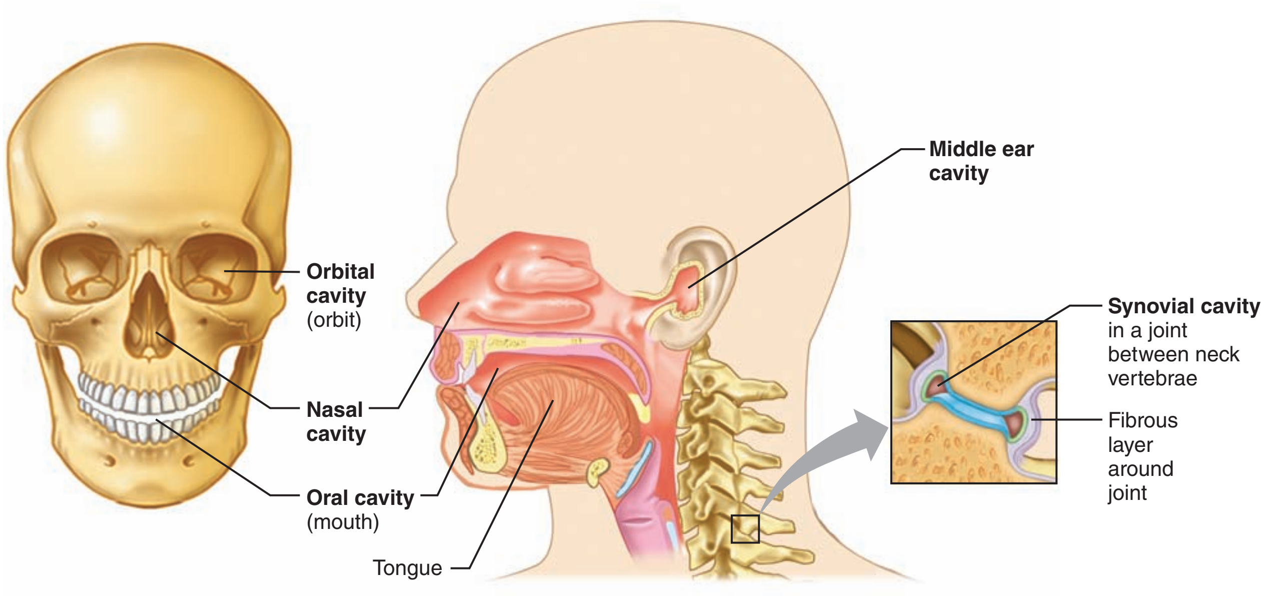

Figure 1.9 Other body cavities. The oral, nasal, orbital, and middle ear cavities are located in the head and open to the body exterior. Synovial cavities are found in joints between many bones such as the vertebrae of the spine, and at the knee, shoulder, and hip.