Laboratory Manual

Hole's Human Anatomy & Physiology

Tenth edition

10

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DAVID SHIER

JACKIE BUTLER

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Mc Graw Hill Higher Education

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TENTH EDITION

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Some of the laboratory experiments included in this text may be hazardous if materials are handled improperly or if procedures are conducted incorrectly. Safety precautions are necessary when you are working with chemicals, glass test tubes, hot water baths, sharp instruments, and the like, or for any procedures that generally require caution. Your school may have set regulations regarding safety procedures that your instructor will explain to you. Should you have any problems with materials or procedures, please ask your instructor for help.

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PREFACE

This laboratory manual was prepared to be used with the textbook *Hole's Human Anatomy and Physiology,* 10th edition, by David Shier, Jackie Butler, and Ricki Lewis. As with the textbook, the laboratory manual is designed for students with minimal backgrounds in the physical and biological sciences who are pursuing careers in allied health fields.

The laboratory manual contains sixty-two laboratory exercises and reports, which are closely integrated with the chapters of the textbook. The exercises are planned to illustrate and review anatomical and physiological facts and principles presented in the 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. Often 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 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 means to meet the objectives of the class do not require dissection, NABT accepts the use of alternatives to dissection, including models and the various forms of multimedia. The Association encourages teachers to be sensitive to substantive student objections to dissection and to consider providing appropriate lessons for those students where necessary.

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

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

ILLUSTRATIONS

Diagrams from the textbook and diagrams similar to those in the 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 the textbook.

It should be noted that frequent variations exist in anatomical structures among humans. The illustrations in the textbook and the laboratory manual represent normal (normal means the most common variation) anatomy.

FEATURES OF THIS EDITION

This new edition of the laboratory manual has been made more user-friendly. Many of the changes are a result of evaluations and suggestions from anatomy and physiology students. Many suggestions from users and reviewers of the ninth edition 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 for greater ease in laboratory preparations.
4. New art has been created for the textbook and the lab manual. Additional color has been included for many figures.
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. A list of terms is provided to assist the labeling of many figures. The first example is figure 11.3.
7. Computer literacy is integrated with relevant laboratory exercises. "Web Quest" activities are found at the end of most exercises. Discover the answers to many scientific questions at www.mhhe.com/shier10 Click on Student Edition and click on Martin Lab Manual, Web Quest. Here you'll find links to help you with your quest.

8. "Critical Thinking Applications" are incorporated within most of the laboratory exercises to enhance valuable critical thinking skills that students need throughout their lives.

9. Two assessment tools (rubrics) for laboratory reports are included in Appendix 2.
10. The *Instructor's Manual for the Laboratory Manual to Accompany Hole's Human Anatomy and Physiology* has been revised and updated. It is found in the Online Learning Center for Hole's Human Anatomy & Physiology, 10th edition, www.mhhe.com/shier10 and www.mhhe.com/biosci/ap/labcentral
11. 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).

REVIEWERS

I would like to express my sincere gratitude to all users of the laboratory manual who provided suggestions for its improvement. I am especially grateful for the contributions of the reviewers who kindly reviewed the manual and examined the manuscript of the new edition. Their thoughtful comments and valuable suggestions are greatly appreciated. They include the following:

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I am grateful for the professional talent of David Shier, Jackie Butler, and Ricki Lewis for all of their coordination efforts and guidance with the laboratory manual. The deepest gratitude is extended to John W. Hole, Jr. for his years of dedicated effort in previous editions of this classic work and for the opportunity to revise his established laboratory manual.

I am particularly thankful to Dr. Norman Jenkins, retired president of Kishwaukee College, and Dr. David Louis, president of Kishwaukee College, for their support and confidence in my endeavors. I am appreciative for the expertise of J. Womack Photography. The professional reviews of the nursing procedures were provided by Kathy Schnier. I am also grateful to Michele Dukes, Troy Hanke, Jenifer Holtzclaw, Angele Myska, Sparkle Neal, Robert Stockley, Shatina Thompson, Jana Voorhis, and DeKalb Clinic Chartered for their contributions. There have been valuable contributions from my students who have supplied thoughtful suggestions and assisted in clarification of details.

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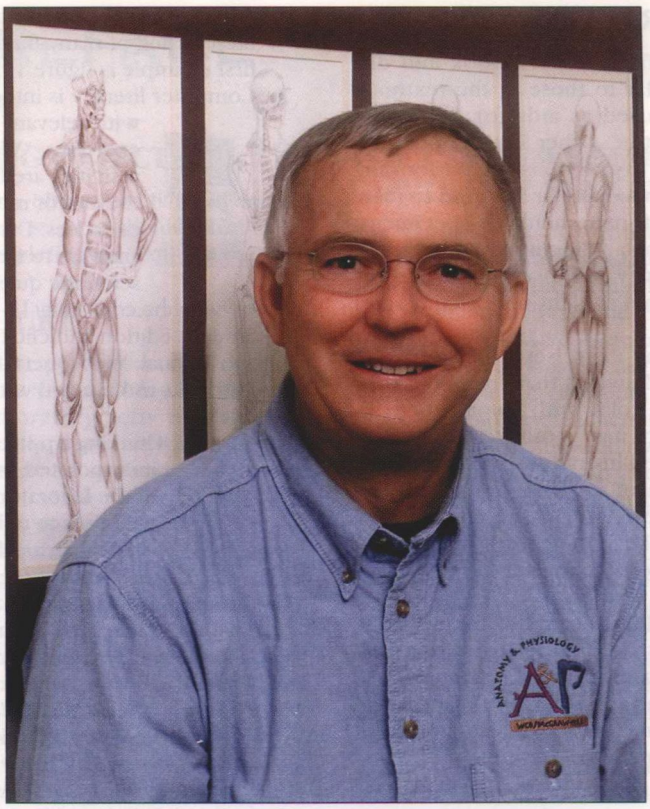


This tenth edition is the fourth revision by Terry R. Martin of Kishwaukee College. Terry's teaching experience of over thirty years, his interest in students and love for college instruction, and his innovative attitude and use of technology-based learning enhance the solid tradition of John Hole's laboratory manual. Among Terry's awards are the 1972 Kishwaukee College Outstanding Educator, 1977 Phi Theta Kappa Outstanding Instructor Award, 1989 Kishwaukee College ICCTA Outstanding Educator Award, 1996 Who's Who Among America's Teachers, 1996 Kishwaukee College Faculty Board of Trustees Award of Excellence, and 1998 Continued Excellence Award for Phi Theta Kappa Advisors. Terry's professional memberships include the National Association of Biology Teachers, Illinois Association of Community College Biologists, Human Anatomy and Physiology Society, Chicago Area Anatomy and Physiology Society (founding member), Phi Theta Kappa (honorary member), DeKalb County Prairie Stewards, and Nature Conservancy. In addition to writing many publications, he co-produced with Hassan Rastegar a videotape entitled *Introduction to the Human Cadaver and Prosection,* published by Wm. C. Brown Publishers in 1989. Terry revised the *Laboratory Manual to Accompany Hole's Essentials of Human Anatomy and Physiology,* 8th edition, and authored *Human Anatomy and Physiology Laboratory Manual, Fetal Pig Dissection,* 2nd edition. Terry serves as a Faculty Consultant for the Advanced Placement Biology examination readings. During 1994, Terry was a faculty exchange member in Ireland. He has also been involved in his community, most notably as a Commissioner for Boy Scouts of America. We are pleased to have Terry continue the tradition of John Hole's laboratory manual.

The Editor

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 about 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 everyone has their own learning style, there are techniques that work well for most students. Using 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 you remember the phases of the cell cycle in the correct sequence. Try creating 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 often 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.

Correlation of Textbook Chapters and Laboratory Exercises

Textbook Chapters		*Related Laboratory Exercises*	
Chapter 1	Introduction to Human Anatomy and Physiology	Exercise 1	Scientific Method and Measurements
		Exercise 2	Body Organization and Terminology
Chapter 2	Chemical Basis of Life		
Chapter 3	Cells	Exercise 3	Care and Use of the Microscope
		Exercise 4	Cell Structure and Function
		Exercise 5	Movements Through Cell Membranes
		Exercise 6	The Cell Cycle
Chapter 4	Cellular Metabolism		
Chapter 5	Tissues	Exercise 7	Epithelial Tissues
		Exercise 8	Connective Tissues
		Exercise 9	Muscle and Nervous Tissues
Chapter 6	Skin and the Integumentary System	Exercise 10	Integumentary System
Chapter 7	Skeletal System	Exercise 11	Structure and Classification of Bone
		Exercise 12	Organization of the Skeleton
		Exercise 13	The Skull
		Exercise 14	Vertebral Column and Thoracic Cage
		Exercise 15	Pectoral Girdle and Upper Limb
		Exercise 16	Pelvic Girdle and Lower Limb
Chapter 8	Joints of the Skeletal System	Exercise 17	The Joints
Chapter 9	Muscular System	Exercise 18	Skeletal Muscle Structure
		Exercise 19	Skeletal Muscle Contraction
		Exercise 20	Muscles of the Face, Head, and Neck
		Exercise 21	Muscles of the Chest, Shoulder, and Upper Limb
		Exercise 22	Muscles of the Deep Back, Abdominal Wall, and Pelvic Outlet
		Exercise 23	Muscles of the Hip and Lower Limb
		Exercise 24	Cat Dissection: Musculature
Chapter 10	Nervous System I: Basic Structure and Function	Exercise 25	Nervous Tissue and Nerves
		Exercise 26	Nerve Impulse Stimulation
Chapter 11	Nervous System II: Divisions of the Nervous System	Exercise 27	The Meninges and Spinal Cord
		Exercise 28	The Reflex Arc and Reflexes
		Exercise 29	The Brain and Cranial Nerves
		Exercise 30	Dissection of the Sheep Brain
Chapter 12	Somatic and Special Senses	Exercise 31	Receptors and Somatic Senses
		Exercise 32	Senses of Smell and Taste
		Exercise 33	The Ear and Hearing
		Exercise 34	Sense of Equilibrium
		Exercise 35	The Eye
		Exercise 36	Visual Tests and Demonstrations
Chapter 13	Endocrine System	Exercise 37	Endocrine System
Chapter 14	Blood	Exercise 38	Blood Cells
		Exercise 39	Blood Testing—A Demonstration
		Exercise 40	Blood Typing

Correlation of Textbook Chapters and Supplemental Laboratory Exercises

Chapter 9	Muscular System	Exercise 1	Physiograp: Computerized Muscle Physiology
Chapter 11	Nervous System II: Divisions of the Nervous System	Exercise 2	Flexicomp: Computerized Reflex Physiology
Chapter 15	Cardiovascular System	Exercise 3	Cardiocomp: Computerized Electrocardiography
Chapter 19	Respiratory System	Exercise 4	Spirocomp: Computerized Spirometry

CONTENTS

SCIENTIFIC METHOD AND MEASUREMENTS

MATERIALS NEEDED

Meterstick
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 a 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 may include organization and presentation of data as tables, graphs, and drawings. From the interpretation of the data analysis, *conclusions* are drawn. (If the data do not support the hypothesis, you must reexamine the experimental design and the data, and if needed, develop a new hypothesis.) The final presentation of the information is made from the conclusions. Results and conclusions are presented to the scientific community for evaluation through peer reviews, presentations at professional meetings, and published articles. If many investigators working independently can validate the hypothesis by arriving at the same conclusions, the explanation 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 new information. The five components of the scientific method are summarized as

Observations
↓
Hypothesis
↓
Experiment
↓
Analysis of data
↓
Conclusions

Metric measurements are characteristic tools of scientific investigations. 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 OF THE EXERCISE

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

LEARNING OBJECTIVES

After completing this exercise, you should be able to

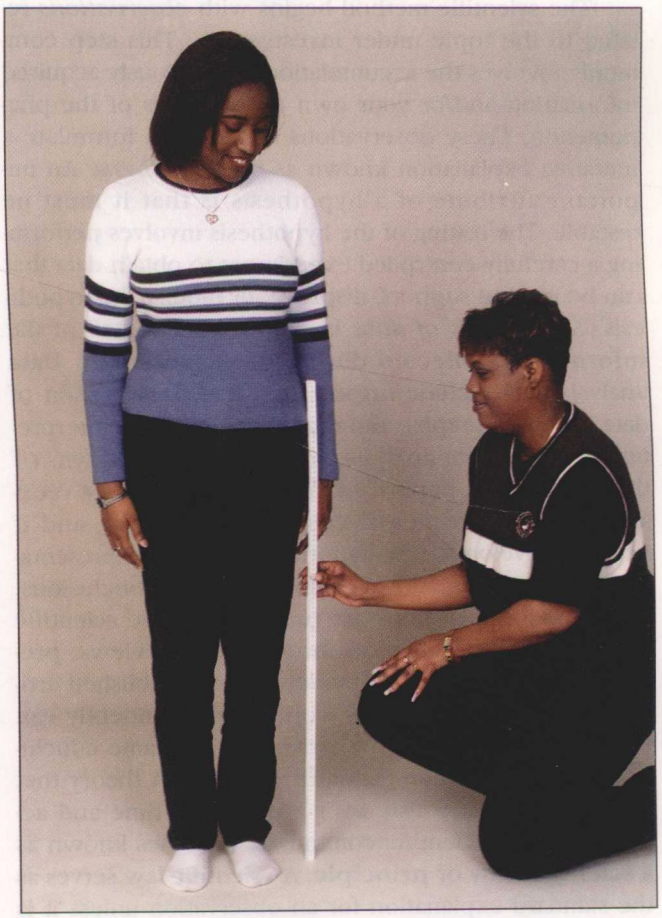
1. List in the correct order and describe all steps of the scientific method.
2. Use the scientific method to test the validity of a hypothesis concerning the direct, linear relationship between human height and upper limb length.
3. Make conversions from English measurements to the metric system, and vice versa.
4. Formulate a 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 meterstick to measure an upper limb length of ten subjects. For each measurement, place the meterstick in the axilla (armpit) and record the length in centimeters to the end of the longest finger (fig. 1.1). Obtain the height of each person in centimeters by measuring them without shoes against a wall (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.

Figure 1.2 Measurement of height.



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

   Height × 0.4 = expected upper limb length

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

   Length of upper limb/height = actual % of height

5. A graph is an excellent way to display a visual representation of the data. Plot the subjects' data in Part A of the laboratory 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 of the length of body parts to 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 estimate 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 the radius and height. Formulate a hypothesis that can be tested. Make measurements, analyze data, and develop a conclusion from your experiment. Complete Part B of the laboratory report.

Web Quest

Examine additional information about the scientific method at
www.mhhe.com/shier10
Click on Student Edition. Click on Martin Lab Manual, Web Quest.