

Solomon & Davis

**Human Anatomy
&
Physiology**

human & anatomy & physiology

Eldra Pearl Solomon
P. William Davis

HILLSBOROUGH COMMUNITY COLLEGE



SAUNDERS COLLEGE PUBLISHING

Philadelphia New York Chicago
San Francisco Montreal Toronto
London Sydney Tokyo Mexico City
Rio de Janeiro Madrid

Address orders to:
383 Madison Avenue
New York, NY 10017

Address editorial correspondence to:
West Washington Square
Philadelphia, PA 19105

Text Typeface: 10/12 Meridien
Compositor and Color Separator: York Graphic Services
Acquisitions Editor: Mike Brown
Developmental Editor: Amy Satran
Project Editor: Carol Field
Copy Editor: Ruth Low
Managing Editor & Art Director: Richard L. Moore
Design Assistant: Virginia A. Bollard
Text Design: Adrienne Onderdonk Dudden
Cover Design: Richard L. Moore
Art Color Concepting and Page Layout: Emily Harste
Four-Color Medical Art: Iris J. Nichols
Two-Color Medical Art: Virginia L. Schoonover
All Other Text Art: J&R Technical Services, Inc.
Production Managers: Tim Frelick and Tom O'Connor
Assistant Production Manager: Maureen Read

Cover Credit: Artwork © 1982 by Virginia L. Schoonover

**Library of Congress Cataloging in
Publication Data**

Solomon, Eldra Pearl.
Human anatomy & physiology.

Includes index.

1. Human physiology. 2. Anatomy, Human.
I. Davis, P. William. II. Title. [DNLM: 1. Anatomy.
2. Physiology. QS S689h]
QP34.5.S68 1983 612 82-60530

ISBN 0-03-059992-X

HUMAN ANATOMY & PHYSIOLOGY

ISBN 0-03-059992-X

© 1983 by CBS College Publishing. Copyright 1978 by McGraw-Hill, Inc. All rights reserved. Printed in the United States of America.

**Library of Congress catalog card
number 82-60530.**

2345 071 987654321

CBS COLLEGE PUBLISHING
Saunders College Publishing
Holt, Rinehart and Winston
The Dryden Press

To our parents

Rabbi Theodore and Freda Brod

and

Percival and Ruth Davis

whose example, help, and encouragement
have contributed more to our lives
than we can express.

preface

The human body is a marvel of biological engineering. The study of its design and function should be an exciting experience, and our principal goal in preparing this book has been to make it so.

AUDIENCE

HUMAN ANATOMY & PHYSIOLOGY is designed as a textbook for the introductory course in human anatomy and physiology. The book is tailored to meet the needs of students in allied health, medical, and biology programs who have only a minimal foundation in the physical and biological sciences. The student population served by this textbook is broader than in former years and now includes those studying for careers as nurses, radiology technologists, nuclear medicine technologists, radiation therapy technologists, medical assistants, sonography technologists, medical laboratory technologists, emergency medical technologists, physical therapists, physical education instructors, and mental health paraprofessionals. The book can also be used successfully for premedical and pre dental students, and others in the biological sciences, as well as many liberal arts students who elect to take anatomy and physiology because of personal interest.

PHILOSOPHY AND APPROACH

Because the structures of the body are exquisitely designed to carry out specific functions, one can best appreciate and understand anatomy and physiology when structure and function are studied together. Accordingly, we have integrated the discussion of anatomy and physiology as much as possible throughout the textbook. We have used a systems rather than a regional approach, and although anatomy has not been slighted, an emphasis has been placed on physiology.

From our own teaching experience we have

found that students learn most effectively and most enjoyably when they can immediately apply what they are learning to familiar issues, problems, and experiences. Thus we frequently relate material in the text to examples within the student's frame of reference. When we describe pigment cells and melanin, for example, we refer to their role in suntan and sunburn. When we discuss immunology, we apply the concepts to viral infections, immunization, and allergy.

Yet it is also true that in order to achieve an understanding of the body as a whole, it is necessary to learn about its parts, and there are a great many parts. To minimize the tendency that many students have to learn anatomy in fragmented fashion, we have tried to relate each part as it is discussed in its role in the organism and its relationships to all the other parts.

Emphasis has been placed throughout on presenting the human body as a living, functioning, homeostatic organism. An example of this philosophy may be found in the chapters devoted to the muscular and skeletal systems, where muscles and bones are presented as a functioning unit. Instead of simply listing bones to memorize, followed by a still longer list of muscles with their origins, insertions, and actions, we ask and answer such questions as: how do these structures work together to permit us to take a step or to shake our heads?

Clinical material has been introduced where appropriate throughout the text. Most students enrolled in anatomy and physiology courses are very curious about disease processes and other aspects of clinical physiology, and this type of application is of tremendous interest to them. Even more important, normal function is illuminated by contrasting dysfunction. For example, the normal role of ADH becomes more clear when diabetes insipidus is explained, and the actions of insulin are better understood and remembered when the homeostatic imbalances that occur in diabetes mellitus are discussed.

READABILITY

Special care has been taken to make the reading level appropriate for today's college student. New technical terms are set in boldface and defined, and new concepts are thoroughly explained. Students will find the writing style easy to read and enjoyable.

ILLUSTRATIONS

Anatomy is probably the most visually oriented of all the sciences, so high-quality illustrations are vital to the learning process. A great deal of time, creative effort, and expense have gone into the illustration program for this book. Medical illustrators Iris Nichols and Virginia Schoonover rendered most of the medical art, with most of the remainder provided by John Cordes' J&R Technical Services. The use of full color has been carefully utilized to increase the instructional effectiveness of the art.

Illustrations have been carefully planned not merely to create interest but to reinforce concepts presented in the text. Many illustrations are presented in a sequential manner, such as the development of a bone cell in Chapter 6 and the formation of urine in Chapter 23. Many physicians and research scientists have been generous in sharing striking photomicrographs, scanning and transmission electron micrographs, CT scans, and roentgenograms.

ORGANIZATION

HUMAN ANATOMY & PHYSIOLOGY is organized into seven parts, each containing several chapters.

Part I. Organization of the Body

Chapter 1 introduces the student to the basic organization and structure of the body. Full-color medical illustrations show the relationship among organs in a series of progressive dissections, and a series of CT scans illustrate cross sections through the body at various levels. The central physiological concept of homeostasis is discussed and supported with diagrams and examples. Clinical techniques for visualizing body parts are presented in a box. In Chapter 2 chemical concepts that will be used throughout the book are introduced in biological context. The structure and basic physiology of the cell are explored in Chapter 3. Chapter 4 describes the tissues of the body, and includes a section on neoplasms with emphasis on defects of cancer cells. The importance of the skin to the integrity of the body is discussed in

Chapter 5, which also includes sections on inflammation and repair of wounds and on burns.

Part II. Support and Movement

Skeletal tissue is described in Chapter 6. Skeletal remodeling, fractures and healing, bone disease, and hormones and the skeleton are among the topics discussed. The skeletal system is the focus of Chapter 7, which includes a series of full-color illustrations of the skull. In Chapter 8 muscle tissue is described and in Chapter 9 all of the parts of the musculoskeletal system are put together as the muscular system and its actions are discussed.

Part III. Regulation of Body Activities

Neurons and their interaction with emphasis on transmission of impulses and integration are the main focus of Chapter 10. Chapter 11 addresses the central nervous system with full-color illustrations of brain and spinal cord. Information is synthesized to show how the various parts of the nervous system work together to control specific activities such as movement and posture. In Chapter 12 the peripheral nervous system is examined, and in Chapter 13 the sense organs are discussed. Chapter 14 emphasizes the role of the endocrine system in maintaining homeostasis. Discussion of the consequences of endocrine malfunction reinforces the concepts of normal endocrine physiology.

Part IV. The Circulatory System: Internal Transport and Defense

Chapter 15 is devoted to the blood. Chapter 16 focuses on the heart with emphasis on cardiac physiology. In Chapter 17 the blood vessels, the pattern of circulation, the physiology of circulation, and cardiovascular disease are discussed. The structure and physiology of the lymphatic system are presented in Chapter 18. Immunity is discussed in Chapter 19. Among the topics covered are antibody diversity, classes of antibodies, passive immunity, immunosurveillance, transplantation, allergic response, and autoimmune disease.

Part V. Obtaining Oxygen, Nutrients, and Energy

Chapter 20 focuses upon the respiratory system with discussion of high flying, low diving, smoking, and air pollution. In Chapter 21 the journey of a meal

through the digestive system is traced. Chapter 22 focuses upon the required nutrients and how they are utilized by the cells of the body. Emphasis is placed on the integration of carbohydrate, lipid, and protein metabolism, and concepts of nitrogen balance, energy balance, basal metabolic rate, and nutritional imbalance are introduced.

Part VI. Regulation of Fluids and Electrolytes

Chapter 23 focuses on the urinary system with emphasis on the homeostatic function of the kidneys. Chapter 24 is devoted to fluid and electrolyte balance. It is here that information dispersed throughout many other chapters is brought together and synthesized.

Part VII. Perpetuating the Human Species

The male and female reproductive systems are discussed in Chapter 25 with emphasis on reproductive physiology and endocrinology. Chapter 26 is devoted to human development and includes discussion of the birth process, circulatory changes that take place at birth, environmental effects on the embryo, the human life cycle, and the aging process. Human genetics is discussed in Chapter 27 with emphasis on chromosomal abnormalities and gene defects.

LEARNING AIDS

To help the student succeed in mastering the principles of anatomy and physiology, a variety of pedagogical devices have been employed.

Part introductions give an overview of the general content of the component chapters.

A chapter outline at the beginning of each chapter shows the student how the material is organized and divides the material into workable units.

Learning objectives at the beginning of each chapter indicate exactly what the student must be able to do to demonstrate mastery of the material in the chapter.

Key terms at the beginning of each chapter include definitions, phonetic pronunciations, and, where appropriate, information about word roots that are apt to recur.

Clinical material in the running text that is not essential for understanding the concept being discussed is set off by a color screen. In many cases such clinical information helps to reinforce descriptions of normal processes by describing pathologic conditions that occur when a system fails to function homeo-

statically. Should the instructor choose to eliminate such clinical highlights, however, the color screen permits easy identification.

Numerous tables (many of them illustrated) are used throughout the text to organize and summarize material presented in the text. In some cases, for example in the muscle chapter and circulation chapter, tables are utilized to present anatomic material in concise and manageable form.

Boxes are used both to present enrichment material, e.g., extensive treatments of clinical applications of physiological concepts, and to present topics such as glycolysis in greater depth.

Numerous diagrams present conceptual material presented in the text.

Medical illustrations have been carefully designed to help the student accurately visualize descriptions of structures described in the text. Many are in full color.

Photomicrographs, scanning and transmission electron micrographs, roentgenograms, CT scans, and photographs of clinical interest are included to illustrate topics discussed in the text.

A **summary** in outline form at the end of each chapter helps the student to review the main ideas presented in the chapter.

An objective post test is included at the end of each chapter so that the student can evaluate his or her mastery of concepts presented in the chapter and set forth in the objectives. **Answers** are provided at the back of the book.

Review questions at the end of each chapter give the student the opportunity to check understanding of concepts, and to synthesize some of the material presented.

A **glossary of terms** is included in the combined Glossary–Index.

An **appendix on exercise physiology** is included.

An **appendix on common prefixes**, suffixes, and word roots is included.

Additional pedagogical aids may be found in specific chapters. For example, an **index of muscles** in Chapter 9 keys muscles to tables and illustrations within that chapter, enabling students to easily locate a specific muscle in the functionally arranged descriptions.

SUPPLEMENTARY MATERIALS

The Study Guide that accompanies the text has been designed around the learning objectives. Each chapter includes a list of key concepts, a scientific vocabulary matching test, questions testing mastery of each learning objective, a test evaluating overall mastery of the chapter, and a set of comprehension questions.

Answers are provided to all questions and tests. Included are diagrams for the student to label and crossword puzzles at the end of each unit.

The Instructor's Manual includes suggestions for course organization and lists of reference works and audiovisual sources. For each chapter, there is an overview, as well as suggestions for enrichment including readings and film, clinical applications, topics for class discussion, and essay questions.

The Test Bank includes both chapter and unit tests. Answers are provided for all questions. Tests are presented in such a way that the instructor can duplicate them directly from the printed page.

A set of overhead transparencies includes two- and four-color illustrations chosen and designed for optimum utility in the classroom and laboratory.

ACKNOWLEDGMENTS

Many people who generously shared their time, talents, and experience have helped us develop this book. Mrs. Karen Davis provided substantial help in editing and improving the manuscript, in typing much of the manuscript, and in preparing the ancillary materials. Dr. E. Marshall Johnson, Chairman of the Department of Anatomy at the Jefferson Medical College of Thomas Jefferson University, has been most generous with his time in reviewing the entire manuscript. Dr. Richard Schmidt of Jefferson Medical College has reviewed all of the medical illustrations. We appreciate their many valuable suggestions. We are indebted to Dr. Susan Pross for her help with the immunology chapter, Dr. Jack Gratch for his assistance with the urinary system chapter, and Dr. Claude Villee for extensive help on the physiology of the adjustment of the respiratory system to high and low atmospheric pressures. We thank Dr. Dennis Pupello, Dr. Robert Bramson, and Professor Jon N. Ehringer for their help in obtaining roentgenograms, CT scans, and other clinical illustrations and for their guidance in interpreting them. In this area we also acknowledge the assistance of Mr. Barry Lowans of the Eastman Kodak Corporation. For their clinical advice and help in obtaining illustrations we want to thank Dr. Al Brod, Dr. Jerome Koser, Dr. Lewis Lang, Dr. Wilfred D. Little, Mrs. Phala Pesano, Dr. Dee Mitchell, Dr. George Morris, Ms. Lucille Lane, and Dr. Gerald Turner. Dr. Pietro Bramante supplied many carefully prepared slides of human tissue from which photomicrographs were prepared.

For their help in reviewing the manuscript and valuable suggestions for improving it we thank Professors Charles Brown of Hillsborough Community College, Richard J. Connnett of the University of Rochester Medical Center, Ken Davis of Memphis

State University, Russell P. Davis of University of Arizona, Edward S. Fox of Ohio State University, David Goldblatt of University of Rochester Medical Center, Rebecca A. Halyard of Clayton Junior College, Elvis J. Holt of Indiana University-Purdue University at Fort Wayne, Christopher Kennett of Montclair State College, Sylvia Lianides of West Valley College, Ruth McFarland of Mount Hood Community College, James A. Metcalf of George Mason University, Ted Namm of University of Lowell, Massachusetts, Normand Sasseville of Southeastern Massachusetts University, Christopher Schatte of Colorado State University, Rod Seeley of Idaho State University, Richard S. Sinclair of Texas College of Osteopathic Medicine, Tom Sourisseau of Cabrillo College, Kent Van De Graaff of Brigham Young University, and Linda Lochner Williams of Mercyhurst College.

In addition to the combined help of all of these experts, we were fortunate to have the support and guidance of many competent and dedicated people at Saunders College Publishing. We want to thank our Publisher Don Jackson who gave us the opportunity to write for Saunders and who encouraged us with his support and confidence. Our Editor, Michael Brown, has steered this project from the very beginning and has helped us navigate through oceans of details. We greatly appreciate his guidance and friendship. We want to thank our Developmental Editor Amy Satran for her valuable assistance in reorganizing and improving the manuscript. Art Director Richard Moore coordinated the illustration program and shepherded hundreds of pieces of art from medical illustrators and studio to their final form. Our Project Editor Carol Field took all of the hundreds of parts and expertly guided their synthesis into a finished textbook. Project Editor Don Reisman and Developmental Assistant Leesa Massey Collins helped with many details. Thanks also to Production Manager Tim Frelick and Assistant Production Manager Maureen Read. Marketing Manager John Tugman has given us valuable suggestions and has been responsible for letting everyone know that the project was finally ready for students to enjoy. To all of these very talented people we are grateful.

Finally we want to thank our families, especially our spouses Ed and Karen, for their superpatience and help. We appreciate Mical Solomon's help in preparing the Index-Glossary on his Apple computer and Amy Solomon's proofreading.

We invite the input of our readers and welcome any suggestions for further improving this textbook. Our address is Hillsborough Community College, P.O. Box 22127, Tampa, Florida 33622.

Eldra Pearl Solomon
P. William Davis

contents overview

PART 1

ORGANIZATION OF THE BODY 1

- Chapter 1 The Human Body: An Introduction 2
- Chapter 2 The Chemistry of Life 36
- Chapter 3 The Cell: Basic Unit of Life 62
- Chapter 4 Tissues: The Fabric of the Body 86
- Chapter 5 The Integumentary System 106



PART 2

SUPPORT AND MOVEMENT 119

- Chapter 6 Skeletal Tissues 120
- Chapter 7 The Skeletal System 144
- Chapter 8 Muscle Tissue 190
- Chapter 9 The Muscular System 210

PART 3

REGULATION OF BODY ACTIVITIES 249

- Chapter 10 The Nervous System: Basic Organization and Function 250
- Chapter 11 The Central Nervous System 276
- Chapter 12 The Peripheral Nervous System 320
- Chapter 13 Sense Organs 348
- Chapter 14 Endocrine Regulation 382

PART 4

THE CIRCULATORY SYSTEM: INTERNAL TRANSPORT AND DEFENSE 413

- Chapter 15 The Blood 414
- Chapter 16 The Heart 434
- Chapter 17 The Circulation 454
- Chapter 18 The Lymphatic System 502
- Chapter 19 The Body's Defense Mechanisms: Immunity 520

PART 5

OBTAINING OXYGEN, NUTRIENTS, AND ENERGY 539

- Chapter 20 Respiration 540
- Chapter 21 The Digestive System 570
- Chapter 22 Nutrition and Metabolism 610

PART 6

REGULATION OF FLUIDS AND ELECTROLYTES 637

- Chapter 23 The Urinary System 638
- Chapter 24 Body Fluid, Electrolyte, and pH Balance 656

PART 7

PERPETUATING THE HUMAN SPECIES 675

- Chapter 25 Reproduction 676
- Chapter 26 Development 710
- Chapter 27 Inheritance 728

- Appendices 747
- Answers to Post-Test Questions 753
- Glossary/Index 761

contents

PART 1 **ORGANIZATION OF THE BODY**

1

Chapter 1 The Human Body: An Introduction 2

What Are Anatomy and Physiology? 4
The Requirements of Life 4
The Characteristics of Life 6
The Organization of Life 7
The Body Systems 9
Homeostasis 15
Plan of the Body 19
Summary 32
Post-Test 33
Review Questions 34

Chapter 2 The Chemistry of Life 36

Elements and Atoms 38
Molecules and Their Bonds 40
Inorganic Compounds 44
Organic Compounds 47
Enzymes: Chemical Regulators 56
Summary 59
Post-Test 60
Review Questions 60

Chapter 3 The Cell: Basic Unit of Life 62

Inside the Cell 66
Movement of Materials Through Cell Membranes 74
How Cells Divide 79
Summary 84
Post-Test 84
Review Questions 85

Chapter 4 Tissues: The Fabric of the Body 86

Epithelial Tissue 88
Connective Tissue 93
Muscle Tissue 101
Nervous Tissue 102
Neoplasms—Unwelcome Tissues 103
Summary 104
Post-Test 105
Review Questions 105

Chapter 5 The Integumentary System 106

Functions of the Skin 108
Layers of the Skin 108
Specialized Structures of the Skin 110
Pigmentation 113
The Skin in Stress 114
Summary 117
Post-Test 118
Review Questions 118

PART 2 **SUPPORT AND MOVEMENT**

119

Chapter 6 Skeletal Tissues 120

Functions of the Skeletal System 122
Typical Bones 122
The Development of Bones 127
Bone Growth and Bone Cells 130
Bone Modeling and Remodeling 132
Cartilage 138
Tendons and Ligaments 141
Hormones and the Skeleton 141
Summary 142
Post-Test 143
Review Questions 143

Chapter 7 The Skeletal System 144

Joints 146
The Skeleton 155
Summary 187
Post-Test 188
Review Questions 189

Chapter 8 Muscle Tissue 190

A Typical Muscle 192
The Muscle Cell 193
Exercise and Muscles 204
Smooth Muscle 205
Other Contractile Cells 206
Summary 208
Post-Test 208
Review Questions 209

Chapter 9 The Muscular System 210

- Musculoskeletal Dynamics 214
- Muscle Shapes and Functions 216
- How to Use the Muscle Tables 219
- Index to Muscles Tabulated 222
- Summary 245
- Post-Test 248
- Review Questions 248

PART 3
REGULATION OF BODY ACTIVITIES 249

Chapter 10 The Nervous System: Basic Organization and Function 250

- General Structure 252
- Cells of the Nervous System 253
- Nerves and Ganglia 259
- How the Nervous System Works 260
- New Frontiers 273
- Summary 273
- Post-Test 274
- Review Questions 275

Chapter 11 The Central Nervous System 276

- Protective Coverings 278
- The Cerebrospinal Fluid 278
- The Spinal Cord 281
- The Brain 286
- Effects of Drugs on the Nervous System 315
- Summary 316
- Post-Test 318
- Review Questions 319

Chapter 12 The Peripheral Nervous System 320

- The Somatic System 322
- The Autonomic System 335
- Summary 345
- Post-Test 346
- Review Questions 346

Chapter 13 Sense Organs 348

- Kinds of Sense Organs 350
- A Typical Sense Organ 350
- The Diffuse Sense Organs 351
- The Chemical Senses 355
- The Eye 356
- Sound and the Ear 370
- Summary 378
- Post-Test 379
- Review Questions 380

Chapter 14 Endocrine Regulation 382

- How Hormones Work 384
- Hypothalamus and Pituitary Gland 388
- Thyroid Gland 394
- Parathyroid Glands 398
- Islets of Langerhans 400
- Adrenal Glands 404
- The Physiology of Stress 408
- The Pineal Gland 409
- Other Hormones 410
- Summary 410
- Post-Test 411
- Review Questions 411

PART 4
THE CIRCULATORY SYSTEM: INTERNAL TRANSPORT AND DEFENSE 413

Chapter 15 The Blood 414

- Characteristics of Blood 416
- Plasma 416
- Red Blood Cells 417
- White Blood Cells 423
- Platelets 426
- Blood Transfusion and Blood Groups 429
- Summary 432
- Post-Test 432
- Review Questions 433

Chapter 16 The Heart 434

- Anatomy of the Heart 436
- Cardiac Physiology 444
- Summary 451
- Post-Test 452
- Review Questions 452

Chapter 17 The Circulation 454

- The Blood Vessels 456
- The Pattern of Circulation 460
- Physiology of Circulation 467
- Cardiovascular Disease 493
- Summary 498
- Post-Test 500
- Review Questions 501

Chapter 18 The Lymphatic System 502

- Lymphatic Vessels 504
- Lymphatic Circulation 504
- Lymph Nodules 504
- Lymph Nodes 508
- Some Major Groups of Lymph Nodes 509
- The Spleen 512

The Thymus Gland 515
 Role of the Lymphatic System in Fluid Homeostasis 516
 Summary 518
 Post-Test 518
 Review Questions 519

Chapter 19 The Body's Defense Mechanisms: Immunity 520

Nonspecific Defense Mechanisms 522
 Specific Defense Mechanisms 525
 Summary 537
 Post-Test 538
 Review Questions 538

PART 5
OBTAINING OXYGEN, NUTRIENTS, AND ENERGY **539**

Chapter 20 Respiration 540

A Breath of Air 542
 Why We Have a Respiratory System 542
 The Respiratory System 542
 Gas Transport 550
 Breathing Mechanics 556
 The Control of Respiration 558
 The Defense of the Lung 561
 Summary 567
 Post-Test 568
 Review Questions 569

Chapter 21 The Digestive System 570

General Organization and Function 572
 Ingestion: Beginning the Journey 576
 Inside the Stomach 585
 In the Small Intestine 589
 The Pancreas 593
 The Liver 594
 Chemical Digestion 597
 Absorption 600
 Through the Large Intestine 602
 Summary 606
 Post-Test 607
 Review Questions 608

Chapter 22 Nutrition and Metabolism 610

Metabolism 612
 Water and Why We Need It 612
 Minerals 612
 Vitamins 613
 Carbohydrates 614
 Lipids 625

Proteins 628
 Balanced Nutrition 631
 Nutritional Imbalance 632
 Summary 634
 Post-Test 635
 Review Questions 636

PART 6
REGULATION OF FLUIDS AND ELECTROLYTES **637**

Chapter 23 The Urinary System 638

Fluid Balance and Homeostasis 640
 The Kidneys 640
 The Ureters 652
 The Bladder 652
 The Urethra 653
 Micturition (Urination) 653
 The Kidney and Homeostasis 653
 Summary 654
 Post-Test 654
 Review Questions 655

Chapter 24 Body Fluid, Electrolyte, and pH Balance 656

Water 658
 Salt and Water Homeostasis in Body Fluids 662
 Potassium Homeostasis 665
 pH Homeostasis 665
 Other Ions 670
 Summary 673
 Post-Test 673
 Review Questions 674

PART 7
PERPETUATING THE HUMAN SPECIES **675**

Chapter 25 Reproduction 676

The Male 678
 The Female 687
 Physiology of Sexual Response: Cycle of Sexual Response 699
 Fertilization 700
 Birth Control 701
 Sexually Transmitted Disease (STD) 705
 Summary 708
 Post-Test 709
 Review Questions 709

Chapter 26 Development 710

In the Beginning: Early Development 712
Implantation 713
Fetal Membranes and Placenta 713
Development of the Embryo and Fetus 715
Parturition (Birth) 719
Adjusting to Extrauterine Life 722
Environmental Influences on the Embryo 722
The Human Life Cycle 724
The Physiology of Aging 724
Summary 726
Post-Test 727
Review Questions 727

Chapter 27 Inheritance 728

The Genetic Code 730
The Role of Genes 731
How Genes Behave 734
Genes and Disease 739
Chromosomes and Disease 742
Summary 742
Post-Test 744
Review Questions 745

Appendix on Exercise Physiology 747
Answers to Post-Test Questions 753
Appendix on Common Prefixes, Suffixes, and Word
Roots 757
Glossary/Index 761

CHAPTER OUTLINE

- I. What are anatomy and physiology?
- II. The requirements of life
- III. The characteristics of life
- IV. The organization of life
- V. The body systems
 - A. Protective covering
 - B. Support and movement
 - C. Integration and regulation
 - D. Running the machinery of the body
 - E. Reproduction
- VI. Homeostasis
 - A. Feedback systems
 - B. An example of homeostasis: Regulation of body temperature
 - C. An example of homeostasis: Regulation of blood-sugar level
- VII. Plan of the body
 - A. The general directions
 - B. Body planes and sections
 - C. Body regions
 - D. Body cavities
 - E. Integrating body structure

LEARNING OBJECTIVES

After you have studied this chapter you should be able to:

1. Define anatomy and physiology and identify their subdisciplines, as given in this chapter.
2. Describe six requirements of life.
3. Describe six characteristics shared by living organisms.
4. List in sequence the levels of biological organization in the human body, starting with the simplest (the atom) and ending with the most complex (the organism).
5. List the functions and homeostatic capabilities of the ten principal organ systems.
6. Define homeostasis and tell why it is a basic functional mechanism of human physiology, giving examples.
7. Describe the anatomical position.
8. Define and use properly the principal orientational terms employed in human anatomy.
9. Draw or identify on diagrams sagittal, transverse, and frontal sections of body structures such as blood vessels or the brain.
10. Define and locate the principal regions and cavities of the human body.

SOME KEY TERMS

ANATOMY (uh-nat-uh-me) The science that deals with the structure of living things and the relation of their parts; the study of anatomy often involves dissecting body parts. (*ana-*, apart + *tom*, cut)

CEPHALIC (se-fal-ik) Pertaining to the head. (*cephal*, head + *-ic*, pertaining to)

HOMEOSTASIS (*home-ee-oh-stay-sis*) The balanced internal environment of the body; the automatic tendency of an organism to maintain such a steady state. (*homeo-*, same + *stas*, stand + *-is*, indicates a noun)

INFERIOR (in-feer-ee-ur) Lower; applied to structures nearer the feet than the head. (*inferior*, lower)

LATERAL (*lat-ur-ul*) Pertaining to the side; situated away from the midline of the body. (*lateral*, side)

MEDIAL (*med-dee-ul*) Toward the midline of the body as opposed to lateral. (*medi*, middle)

METABOLISM (*meh-tab-oh-lizm*) The sum of all chemical reactions that take place within an organism. (*metabol*, change + *-ism*, indicates a process)

ORGAN (*or-gun*) A differentiated part of an organism consisting of tissues organized to perform a specific function, e.g., the heart or stomach. (*organ*, instrument)

PHYSIOLOGY (*fiz-ee-ol-uh-jee*) The science that deals with the functions of living organisms or their parts. (*physiologia*, the study of nature)

SAGITTAL (*sadj-i-tul*) Refers to a section or plane through the body that divides the body into right and left parts. The term may also be applied to an organ or other body part. (*sagitta*, arrow)

SUPERIOR (*sue-peer-ee-ur*) Higher; applied to structures nearer the head than the feet. (*super*, above)

VISCERA (*vis-ur-uh*) The organs located within the body cavities. (singular, *viscus*, body organ)

CHAPTER 1

the human body: an introduction



Rodin's "The Thinker." (Courtesy of William T. Moore, Jr.)

4 organization of the body

Imagine that you have purchased a new car. You have taken all of your family and friends for rides, you have lifted the hood and made knowing comments about the engine for the benefit of your neighbors, you have filed the official papers in a safe place, and still, you just cannot get that beautiful new chariot out of your head. You settle down in an easy chair, turn on the light, and begin to read the owner's manual.

You may or may not own a car, but one thing is certain: you do have a body. This book can be considered an owner's manual for the human body. Although this machine may have a remarkably good performance record, it is irreplaceable at any price and has no manufacturer's warranty. It seems only sensible to study the body and learn how it works.

WHAT ARE ANATOMY AND PHYSIOLOGY?

The study of body structure is the science of **anatomy**; the study of its function, or how it works, is **physiology**. Both are broad fields with many subdivisions. **Gross anatomy**, for example, deals with organs and structures of the body that can be studied by dissection, whereas microscopic anatomy, the study of tissues, is known as **histology**. The study of the structure of individual cells is called **cytology**. **Embryology** is the study of the development of the organism before birth, and **pathology** is the study of disease processes. In our study of the human body we shall deal with all these subdisciplines.

Medical science is an applied form of anatomy and physiology that uses the findings of anatomists and physiologists to maintain health and treat disease (Fig. 1-1). Some of the branches of medical science are defined in Box 1-1.

The anatomy and physiology of the body are intricately interrelated. Each structure is perfectly adapted for carrying out its specific function. For example, the muscular walls of the heart are especially constructed for pumping blood from its hollow chambers. The blood is forced into large blood vessels with elastic walls that permit the vessels to expand as they fill with blood and then snap back to normal size. Between the chambers of the heart, flaplike valves prevent the blood from flowing backward. Look for the relationships between the structure and function of the body parts you are studying. Try to understand how the size, shape, and structure of each part is related to the job it must perform.

THE REQUIREMENTS OF LIFE

An appropriate environment is necessary for life to exist and thrive. From their surroundings humans must be able to obtain the following:

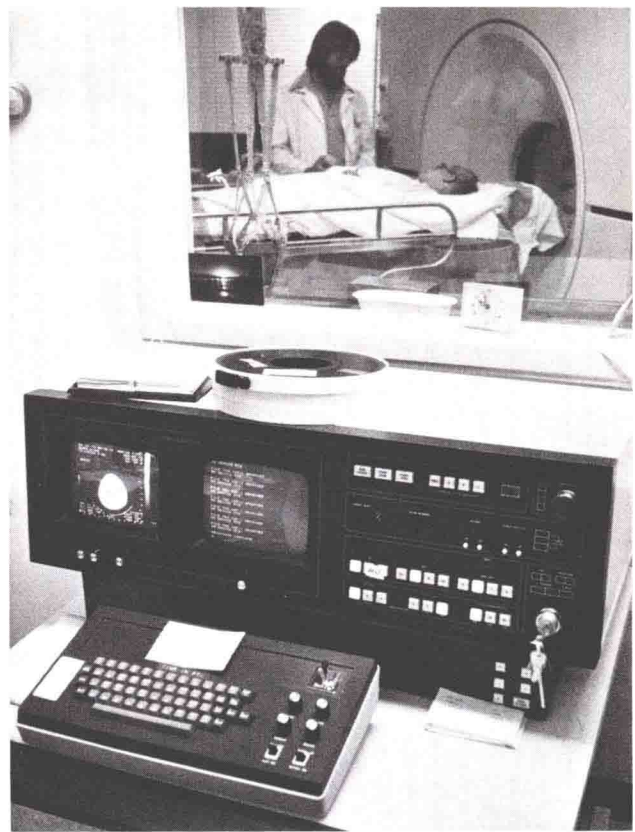


FIGURE 1-1 Medical science is an applied form of anatomy and physiology. During the past few decades knowledge of anatomy and physiology gained through research has contributed to the development of improved and more sophisticated methods of diagnosing and treating disease. Here a patient is being prepared for CT scanning. This is a process in which x-ray equipment is combined with a computer and cathode-ray tube to produce images of cross sections through the body. The image may be viewed on a television screen called the physician's console as shown in the illustration. For further information on CT scanning read Box 1-2. (Courtesy of Morton B. Plant Hospital, Clearwater, Florida)

1. **Water.** Water is not only essential to life, it is part of life. The human body consists of more than 60% water by weight. Most of the chemical activities essential to human life take place in a watery medium. Each day we lose water in urine, sweat, and exhaled air. This fluid loss must be replaced by drinking liquids and eating foods containing water.

2. **Food.** Our food consists mainly of plants or animals that have eaten plants. (Even if we eat rattlesnake meat, the snake fed on mice that lived mainly on plant products such as seeds.) The food we consume is broken down into chemical substances needed by each of the body cells (microscopic building blocks of the body). These substances are used either as raw materials to make new chemical substances and body parts or as fuel molecules that cells break down in order to obtain energy.

3. **Oxygen.** Oxygen is a gas that makes up about 20% of our atmosphere. Like most living cells, those