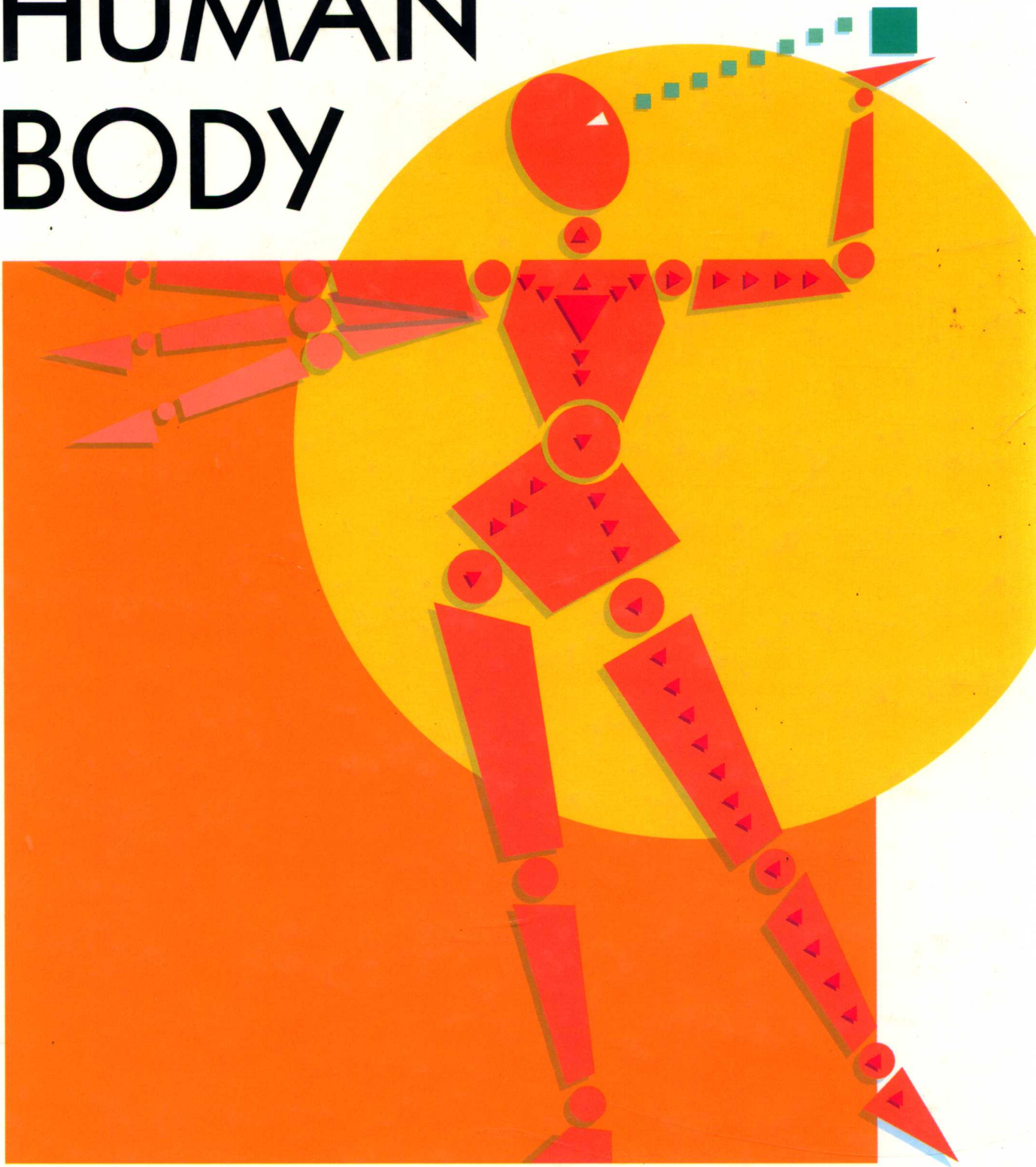
Understanding the

HUMAN BODY



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HUMAN BODY

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Preface

"YOU CAN'T SEE THE FOREST FOR THE TREES."

This saying has special relevance to the study of anatomy and physiology. There are so many trees in a forest, so much detailed information, that one can miss an appreciation of the forest itself, that is, the whole organism and the interactions of all its parts.

In anatomy and physiology courses, typically there are attempts to present as much material as possible. All the important information must be covered! Remember, however, that one definition of cover is to hide or conceal. So much detail can be presented that the main concepts are missed! There is a need for a book that presents the minimal amount of information. Such an approach, however, has its own dangers. The content can be so reduced that only individual pieces of information (trees) remain. There no longer is an entire, complex organism (forest) to be appreciated.

A balance between detail and the "big picture" can be achieved by considering how students learn. An approach commonly used by students is to list, define, and describe every detail of the information in an attempt to remember everything! Unfortunately, isolated facts are only remembered for a short time, usually until shortly after a test is taken. A better approach is to first *understand* the material by forming a conceptual framework that identifies and ties together the important points of a topic. In this text, explanations start with simple, easy-to-understand facts and are developed in a logical sequence. Students can see the "big picture" without being overwhelmed with details. Once the information is understood and the story makes sense, the details of the information naturally fall into place and are more easily remembered.

Remembering and understanding, however, are only the first steps in learning. They are important steps, and without them the next step is not possible. But there is a next step—developing the ability to use the understood material to solve problems. No book, no matter how much information it contains, can provide the answers to all possible questions. Students must develop the ability to apply what they know, analyze information, and synthesize solutions.

We believe problem-based learning can be developed through example and practice. By seeing how problems are solved, students gain insight into how to go about solving problems on their own. It gives them a "grab bag" of mental tricks to use for solving problems. By practicing, students develop and improve their mental skills. Eventually these skills become a natural and expected part of their approach to learning. Students develop a sense of confidence and accomplishment as they discover that they can indeed learn and solve problems.

The title of this text, *Understanding the Human Body*, was carefully chosen, because the term "understanding" has much to do with the philosophy of this book. Understanding is the bridge between remembering information and using information to solve problems. Information is not presented for its own sake, but for the understanding it provides. When a minimal number of the pieces of a puzzle are correctly arranged, the pattern of the puzzle can be seen. And with an understanding of the pattern, it is possible to fill in the blank spots, that is, use the information to solve problems.

Conceptual themes

The major conceptual themes emphasized throughout the text are the *relationship between structure and function* and the *regulation of homeostasis*. Just as the structure of a hammer makes it well-suited for the function of pounding nails, the forms of specific cells, tissues, and organs within the body allow them to perform specific functions effectively. For example, muscle cells contain proteins that make contraction possible, and bone cells surround themselves with a mineralized matrix that provides strength and support. Knowledge of structural and functional relationships makes it easier to understand anatomy and physiology and greatly enhances appreciation for the subject.

Homeostasis, the maintenance of an internal environment within an acceptably narrow range of values, is necessary for the survival of the human body. For instance, if the blood delivers inadequate amounts of oxygen to body cells, the heart and respiration rates increase until oxygen delivery to the body cells becomes adequate. The emphasis of this book is the regulatory mechanisms that normally maintain homeostasis. However, because failure of these mechanisms also illustrates how they work, pathologies resulting in dysfunction, disease, and possibly death also are presented.

A unique feature of this text is its consideration of microorganisms. Chapter 21 describes the basic biology of mi-

croorganisms with an emphasis on bacteria and viruses. Understanding how microorganisms grow and reproduce leads to an appreciation of disease symptoms, treatment strategies, and methods of preventing disease.

Relevant clinical examples

Clinical information should never be an end in itself. In some texts, mere clinical description or medical terminology represents a significant portion of the material. This text provides clinical examples to both promote interest and demonstrate relevance, but clinical information is used primarily to illustrate the application of basic knowledge. The ability to apply knowledge is a skill that goes beyond mere acquaintance with either clinical or basic anatomy and physiology content.

Analysis of practical problems

At best, some anatomy and physiology texts include a few "thought" questions that, for the most part, involve a restatement or a summary of content. Yet once students understand the material well enough to state it in their own words, it only seems logical for them to proceed to the next step—that is, to apply the knowledge to hypothetical situations. This text features two sets of problem-based learning questions in every chapter, *Predict Questions* and *Concept Review Questions* (to be highlighted in more detail later in this preface). Answers and explanations for the Predict Questions are provided at the back of the text. The explanations illustrate the methods used to solve problems and provide a model for the development of problem-based learning. The acquisition of such skills is necessary for a complete understanding of anatomy and physiology, it is fun, and it makes it possible for the student to deal with the many problems that occur as a part of professional and everyday life.

Illustration program

The statement, "A single picture is worth a thousand words," is especially true in anatomy and physiology. Structural and functional relationships become immediately apparent in the illustrations in this text. To maximize effectiveness, illustrations have been placed as close as possible to the narrative where they are cited, and special attention has been devoted to the figure legends, which summarize or emphasize the important features of each illustration. The illustrations also have been designed to be nonintimidating and aesthetically pleasing, features that encourage the student to spend time with the illustrations for maximum learning and pleasure. All the artwork in this textbook is in full color, making the illustrations attractive and emphasizing the important structures. In addition to the illustrations, photographs bring a dimension of realism to the text. In many cases, photographs are accompanied by line drawings that emphasize important features of the photograph.

Learning aids

The text must be an effective teaching tool. Because students learn best in different ways, a variety of teaching and learning aids are provided. This enables students to organize the material in their minds, determine the main points, and evaluate the progress of their learning.

Objectives. Each chapter begins with a series of *Objectives* that emphasize the important facts, topics, and concepts to be covered. The objectives are learning goals that focus attention on the material and tasks to be mastered by reading the chapter.

Vocabulary Aids. Learning anatomy and physiology is, in many ways, like learning a new language. To communicate effectively, a basic terminology, dealing with important or commonly used facts and concepts, must be mastered. At the beginning of each chapter are the *Key Terms*, a list of some of the more important new words to be learned along with their definitions. Throughout the text, these and additional important terms are presented in **boldface print.** When pronunciation of the word is complex, a *Pronunciation Key* is presented. Often simply being able to pronounce a word correctly is the key to remembering it. The *Glossary*, which collects the most important terms into one location for easy reference, also has a pronunciation key.

Understanding Essays. A unique feature of this text are the understanding essays. They are a more detailed examination of an important topic introduced in the main body of the text, providing a "taste" of what could be learned about a topic if it were examined in more detail. However, the intent is not to merely present more information. Instead, the understanding essay clarifies concepts by presenting an example of a concept in action. Furthermore, once the concept is better understood, the student is asked to solve a problem relating to the concept.

Some of the topics dealt with in the understanding essays include clinically important disorders such as diabetes mellitus, acidosis and alkalosis, cancer, and burns. Other topics emphasize fundamental processes such as osmosis, pH, action potentials, pain, antibody activity, and defecation. Structure and function are emphasized in the understanding essays that describe the vertebral column, muscle fibers, and the coronary circulation. The understanding essays also consider topical issues such as starvation and obesity, prevention of pregnancy, the human genome, and genetic recombination.

Boxed Essays. The boxed essays primarily emphasize pathologies of the human body. After an understanding of the normal operation of the body is presented in the text, the boxed essays survey representative diseases that disrupt homeostasis. In contrast to many anatomy and physiology texts, the boxed essays also describe diseases caused by microorganisms. By placing the essay material "aside," basic

understanding is not obscured by the details of pathologies, and a better contrast between normal and abnormal conditions is achieved. A consideration of pathology adds relevance and interest that makes the material more meaningful.

Predict Questions. The Predict questions require the application of concepts. When reading a text it is very easy to become a "passive" learner; everything seems very clear to passive learners until they attempt to use the information. The predict question converts the "passive" learner into an "active" learner who must use new information to solve a problem. The answer to this kind of question is not a mere restatement of fact, but rather a prediction, an analysis of the data, the synthesis of an experiment, or the evaluation and weighing of the important variables of the problem. For example, "Given a stimulus, predict how a system will respond." Or, "Given a clinical condition, explain why the observed symptoms occurred." Predict questions are practice problems that help to develop the skills necessary to answer the Concept Review questions at the end of the chapter. In this regard, not only are possible answers given for the predict questions, but explanations that demonstrate the process of problem-solving are provided in Appendix B.

Chapter Summary. The chapter Summary is an outline that briefly states the important facts and concepts presented in the chapter. It provides a perspective of the "big picture" and can be used as a preview or review of the chapter.

Content Review. The Content Review questions are another method used in this text to turn the "passive" learner into an "active" learner. The questions systematically cover the content and require students to summarize and restate the content in their own words.

Concept Review. Following the mastery of the content review and therefore the chapter content, the Concept Review questions require the application of that content to new situations. These are not essay questions that involve the restatement or summarization of chapter content. Instead, they provide additional practice in problem-based learning and promote the development and acquisition of problem-solving skills. In addition, problem-based learning activities improve long-term retention of information because once the information is understood and used, it "belongs" to the student.

Chapter Test. At the end of each chapter are the Chapter Test questions. They are matching and fill-in-the-blank questions that provide students with the opportunity to test their knowledge. Answers are provided for all the questions in Appendix C.

Appendices. Appendix A is a table of common disorders caused by pathogens. The diseases of each major organ system are listed with a brief description of the disease. Appendix B contains the answers to the Predict questions and Appendix C contains the answers to Chapter Test questions.

Supplements

Any textbook can be used alone, but thoughtfully developed supplements increase its effectiveness for both student and instructor because the supplements are designed to support the pedagogical model developed in the text.

Study Guide. The study guide by Philip Tate and James Kennedy of Phoenix College supports the problem-based learning approach of the text. It introduces the student to the content of anatomy and physiology using matching, labeling, and completion exercises. A Mastery Learning Activity consisting of multiple-choice questions emphasizes comprehension of the material, evaluates progress, and prepares the students for classroom testing. In addition, a Final Challenges section consisting of essay questions provides practice with questions similar to the Predict and Concept Review questions of the textbook. Answers are given for all exercises, and explanations are furnished for the Mastery Learning Activity and the Final Challenges. The study guide provides the reinforcement and practice so essential for the student's success in the course.

Instructor's Manual. For the instructor, this ancillary will be an invaluable teaching resource. Each chapter contains a brief synopsis, lecture outline, suggested topics for class discussion, and a list of selected audiovisual resources. A testbank of over 800 questions is also included in the manual. In addition, transparency masters of selected illustrations in *Understanding the Human Body* are included to enhance visual learning.

Computerized Test Bank. The test questions included in the instructor's manual are also available on a computerized test generation system compatible with IBM, Macintosh, and Apple computers. This system has many features that make it easy for the instructor to design tests and quizzes. All questions are categorized by subject matter and level of difficulty.

Transparency Acetates. A set of 60 full-color transparency acetates—with large, easy-to-read labels—is available to qualified adopters of the text for use as a teaching aid. These transparencies, which emphasize the major anatomical structures and physiological processes covered in the textbook, have been selected from illustrations in the text and provide a common vehicle for communication between the lecturer and the student.

Human Body Systems Software. Human body systems software helps beginning students further explore the human body. Individual modules introduce each of the eleven body systems. Each module contains an introduction, a tutorial

with practice review questions, practical applications, and a final quiz. The software runs on IBM-compatible computers.

Human Cadaver Dissection Video. This 60-minute video takes the student through a dissection of the musculature of the human body as well as the internal organs of the thorax and abdomen. The video provides a detailed explanation of the dissection procedure in vivid close-up with clear, precise commentary.

Acknowledgments

The efforts of many people are required to produce a modern textbook. It is difficult to adequately acknowledge the contributions of all the people who have played a role. The encouragement and emotional support of our families were essential for the completion of this project.

We wish to express our gratitude to the present and past staff of Mosby for their steadfast help and encouragement. It has clearly been more than a vocation to them. Laura Edwards, Amy Winston, and Robert Callanan have worked with us in an untiring fashion to bring this work to completion. Their effort and contributions, as well as the efforts of the many others who have influenced the design and production of this text, are greatly appreciated.

We also thank the team of artists who have contributed to the text. Their attention to detail and their artistic contributions have made the text an attractive as well as an effective teaching tool.

We sincerely thank the reviewers. This book was conscientiously reviewed by people who not only have experience in the health fields, but who are exceptional teachers, as well. Their constructive comments and suggestions have added substantially to the quality of the text.

Philip Tate
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Contents in Brief

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KEY TERMS

anatomical position
Position in which a person is standing erect with the feet forward, arms hanging to the sides, and the palms of the hands facing forward.

anatomy
Scientific discipline that investigates the structure of the body.

frontal plane
Plane running vertically through the body and separating it into anterior and posterior portions.

homeostasis
Existence and maintenance of a relatively constant environment within the body with respect to functions and the composition of fluids.

negative feedback
Mechanism by which any change from an ideal normal value is made smaller or is resisted.

physiology
Scientific discipline that deals with the processes or functions of living things.

positive feedback
Mechanism by which any change from an ideal normal value is made greater.

sagittal plane
Plane running vertically through the body and dividing it into right and left parts.

transverse plane
Plane running horizontally through the body and dividing it into superior and inferior parts; a horizontal cross section.

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CHAPTER 1

Introduction to the Human Body

OBJECTIVES

After reading this chapter you should be able to:

1. Explain the importance of understanding the relationship between structure and function.
2. Define anatomy and physiology.
3. Describe the seven structural levels of organization of the body and give the major characteristics of each level.
4. Define homeostasis and explain why it is important.
5. Define negative feedback and positive feedback and describe their relationship to homeostasis.
6. Define the directional terms for the human body and use them to locate specific body structures.
7. Describe the three major planes of the body.
8. Name the regions of the body and describe the subdivisions of each region.
9. Describe the major trunk cavities.

HUMAN ANATOMY AND PHYSIOLOGY is the study of the structure and function of the human body. Knowledge of its structure and function makes it possible to understand how the body responds to a stimulus. For example, eating a candy bar results in an increase in blood sugar (the stimulus). Knowledge of the pancreas allows one to predict that the pancreas will secrete insulin (the response), which increases the movement of sugar from the blood into cells. Consequently blood sugar levels decrease back toward a normal range of values. Knowledge of structure and function also provides the basis for understanding disease. In one type of diabetes mellitus, for example, the pancreas does not secrete adequate amounts of insulin. Even though blood sugar levels increase, without adequate insulin there is not enough movement of sugar into cells. Therefore cells are deprived of a needed source of energy and they malfunction.

The study of anatomy and physiology is essential for those who plan a career in the health sciences, because a sound knowledge of structure and function is necessary for health professionals to perform their duties adequately. Knowledge of anatomy and physiology is also beneficial to the nonprofessional. This background improves your ability to evaluate physiological activities, understand recommended treatments, critically evaluate advertisements and reports in the popular literature, and interact with health professionals.

ANATOMY AND PHYSIOLOGY

Anatomy (ă-nat´o-me) is the scientific study of the body's structure. For example, the shape and size of the body's bones can be described. Anatomy includes a wide range of studies, such as the form of structures, their microscopic organization, and the relationship between the structure of a body part and its function. Just as a hammer's structure makes it well-suited for pounding nails, the structure of a body part allows it to perform its functions effectively. For example, bones provide strength and support because bone cells surround themselves with a hard, mineralized substance. Understanding the relationship between structure and function makes it easier to understand and appreciate anatomy.

Physiology (fiz´e-ol´o-je) is the scientific study of the processes or functions of living things. It is important in physiology to recognize structures as changing rather than unchanging. The major goals of physiology are understanding and predicting the body's responses to stimuli and understanding how the body maintains conditions within a narrow range of values in the presence of a continually changing environment. For example, in a hot environment the body responds by producing sweat, which helps cool the body and maintains normal body temperature.

STRUCTURAL AND FUNCTIONAL ORGANIZATION

The body can be studied at seven structural levels: chemical, organelle, cellular, tissue, organ, organ system, and organism (Figure 1-1).

The structural and functional characteristics of all organisms are determined by their chemical makeup. The **chemical** level of organization involves interactions between atoms and their combinations into molecules. The function of a molecule is related intimately to its structure. For example, collagen molecules are strong, ropelike fibers that give skin structural strength and flexibility. With old age, the structure of collagen changes and the skin becomes fragile and is torn more easily. A brief overview of chemistry is presented in Chapter 2.

An **organelle** is a structure contained within a cell that performs one or more specific functions. For example, the nucleus is an organelle containing the cell's hereditary information. Organelles are discussed in Chapter 3.

Cells are the basic living units of all plants and animals. Although cell types differ in their structure and function, they have many characteristics in common. Knowledge of these characteristics and their variations is essential to a basic understanding of anatomy and physiology. The cell is discussed in Chapter 3.

A group of cells with similar structure and function plus

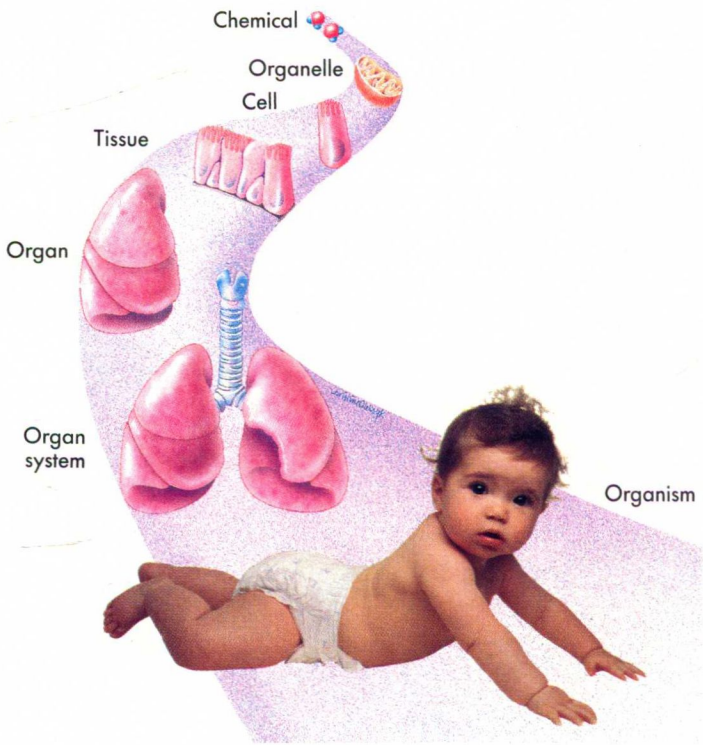

Figure 1-1 ● Levels of organization.
The seven levels of organization are the chemical, organelle, cellular, tissue, organ, organ system, and organism.

the extracellular substances located between them is a **tissue.** The many tissues that make up the body are classified into four primary tissue types: epithelial, connective, muscle, and nervous. Tissues are discussed in Chapter 4.

Organs are composed of two or more tissue types that together perform one or more common functions. The skin, stomach, eye, and heart are examples of organs.

An **organ system** is a group of organs classified as a unit because of a common function or set of functions. In this text the body is considered to have 11 major organ systems: the integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems (Table 1-1).

An **organism** is any living thing considered as a whole, whether composed of one cell or many. The human organism is a complex of mutually dependent organ systems.

Table 1-1 ● Organ systems of the body

System	Major components	Functions
Integumentary	Skin, hair, nails, and sweat glands	Protects, regulates temperature, prevents water loss, and produces vitamin D precursors
Skeletal	Bones, associated cartilage, and joints	Protects, supports, and allows body movement, produces blood cells and stores minerals
Muscular	Muscles attached to the skeleton	Produces body movement, maintains posture, and produces body heat