PRINCIPLES OF ANATOMY AND PHYSIOLOGY

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PREFACE

AUDIENCE

Principles of Anatomy and Physiology is designed for use in introductory courses in human anatomy and physiology. It assumes no previous study of the body or of the physicochemical principles on which body structure and function are based. The text has been written especially for students in allied health-science programs, such as nursing education, medical assistant, physician's assistant, medical laboratory technology, radiologic technology, inhalation therapy, dental hygiene, physical therapy, mortuary science, medical records, and other paramedical-oriented programs. However, because of the scope of the text, we feel it may be used also by students in other programs, such as biological sciences, premedical, predental, science technology, liberal arts, and physical education.

OBJECTIVES

The subject matter of human anatomy and physiology is an exceedingly large and complex body of knowledge to present in an introductory course. Accordingly, we have emphasized unifying concepts and data considered critical to a basic understanding and working knowledge of the human body. We have selected data that support or explain these concepts or that are generally considered basic to an introduction to the subject matter, and we have rejected data unessential to this objective. Our second primary objective is to present the material at a reading level that can be handled by the average student enrolled in health-science programs leading to diploma as well as associate and baccalaureate degrees. Of course, we have not avoided technical vocabulary or vital, but difficult, concepts. Instead, we have attempted to develop step-by-step, easy-to-comprehend explanations of each concept and have avoided needlessly difficult nontechnical vocabulary and syntax. We feel that these goals are, in fact, essential to good textbook writing at any level.

THEMES

Two major themes dominate the text: homeostasis and pathology. Throughout the book, the student is shown how normal anatomy and physiology is maintained by dynamic counterbalancing forces. Pathology is viewed as a disruption in homeostasis. Accordingly, we have presented a large number of clinical topics and have contrasted them with specific normal processes.

ORGANIZATION

The book is organized into five principal areas of concentration: (1) Organization of the Human Body, (2) Principles of Support and Movement, (3) Control Systems, (4) Maintenance of the Human Body, and (5) Continuity.

Unit 1, Organization of the Human Body, is designed to provide an understanding of the structural and functional levels of the body from molecules to organ systems. The first chapter introduces the concept of homeostasis and defines negative and positive feedback systems. The second chapter in the unit contains all the physicochemical principles and data required for an understanding of the physiology presented in the rest of the text. The first half of the chapter (the atom, chemical reactions, and inorganic compounds) is intended for the student who has never taken a chemistry course. The second half (organic compounds) will probably be essential reading for all students.

Chapters 3 to 6 deal with cell, tissue, and organ system levels of organization. A generalized cell is used to demonstrate the cellular level, and a series of illustrations is provided for each cell part. Each illustration series includes an electron micrograph of the part, an adjacent labeled line drawing of the electron micrograph, and a small illustration of the whole cell, with the part under consideration in color. The discussion of the cell ends with a description and schematic drawing of protein synthesis. We have not listed specific codes for specific amino acids. But we have given

a general description of how base sequence in hereditary material determines amino acid sequence in proteins, which, in turn, determines structural and functional properties of the body. This principle is applied elsewhere in the book. For example, errors in metabolism and the special type of hemoglobin associated with sickle cell anemia are covered in a later unit. Tissue organization is presented through descriptions of the structure, functions, and locations of the principal kinds of epithelium and connective tissue, excluding bone and blood. The histology of bone, blood, muscle, and nerve tissue is dealt with later under the relevant organ systems. A discussion of inflammation and tissue repair is also included. The skin and its accessory organs is utilized to acquaint the student with the organization of organs and systems.

The final chapter in the unit prepares the student for the study of gross anatomy by introducing him to the overall structural plan of the body. Included are short sections on body cavities, regions and planes of the body, and directional terms.

Unit 2, Principles of Support and Movement, analyzes the anatomy and physiology of the skeletal system, articulations, and the skeletal muscle system. Histology and physiology of cardiac and smooth muscle are also included. The gross anatomy of bones and muscles has been organized into a series of exhibits. Most of these exhibits contain a drawing or drawings of the bone or muscles under consideration, and all contain written descriptions in either tabular or highly condensed narrative form. Roentgenograms of bones are included to provide students with an opportunity to transfer knowledge to clinical situations. Many students find muscle identification an onerous chore. To help the student, we have provided the following learning aids: The illustrations of muscles are shown with duplicates of the drawings that are used for bone identification. In this way, the student is given consistent points of reference. We have also presented a brief section on the criteria for naming skeletal muscles, and each muscle exhibit contains a listing of appropriate prefixes, roots, and suffixes and their definitions.

Unit 3, Control Systems, emphasizes the importance of the nerve impulse in the immediate maintenance of homeostasis, the role of receptors in providing information about the internal and external environment, and the importance of hormones in maintaining long-range homeostasis. The material on gross anatomy of the brain is geared toward explaining functional interrelationships between the major parts of the brain and between the brain and the rest of the body. Clinical topics relate structural and/or physiological disruptions in specific areas of the nervous system to symptoms. Factors that affect conduction across synapses are discussed, and Parkinsonism is used as an example of disruption in impulse conduction. In the chapter on the endocrine system, emphasis is placed on the regulation of hormone secretion through feedback systems, and a flowchart is presented for each system. Discussion of the effects and regulation of the sex hormones is omitted here because we feel that these topics can be dealt with more logically in the chapters on reproduction and development. The unit ends with a relatively thorough explanation of how the general stress syndrome operates, how it differs from homeostatic responses, and why it is protective. We feel that this topic provides background for some of the current concepts of disease and also presents a good review of some of the material in the unit.

Unit 4, Maintenance of the Human Body, is designed to show the student how the body maintains itself on a day-to-day basis through such activities as respiration, digestion, cellular metabolism, urine production, and buffer systems. Antigen-antibody response is a prevailing theme in the chapters on the circulatory system, and topics such as the role of the thymus in immunity and the problem of transplant rejection are included. The presentation of blood pressure and flow has been carefully constructed, and we hope this material is clearer in *Principles of Anatomy and Physiology* than it is in most competing texts.

Digestion is treated regionally so that the anatomy and physiology are integrated. For example, the student learns the anatomy and physiology of the mouth and its accessory organs and the digestive processes that occur within the mouth before he continues to the next segment of the gastrointestinal tract. A subsequent chapter deals with the fate of absorbed foods. Here, emphasis is placed on the relationships of protein and fat metabolism to the glucose pathway. A chart showing integrated metabolism summarizes much of this material. The role of vitamins and minerals in enzyme-coenzyme systems is mentioned. Specific vitamins and minerals, their sources, known and suspected functions, and deficiency symptoms are listed in exhibits.

Restoration and maintenance of fluid balance and blood pH is an important area of knowledge for students considering careers in health fields.

Consequently, the last two chapters in the unit pay particular attention to these topics.

Unit 5, Continuity, emphasizes the relationship of the endocrine system to sexual development, regulation of menstrual and ovarian cycles, and maintenance of pregnancy. The unit concludes with a few simple and basic concepts of classical genetics so that the health student will have some background for understanding the inheritance of genetic disorders.

SPECIAL FEATURES

The book contains a number of special learning aids for students, including the following:

1. Student Objectives appear at the beginning of each chapter. Each objective describes a knowledge or skill the student should acquire as he studies the chapter. (See Note to Student for an explanation of how the objectives can be utilized.) End-of-chapter Review Questions and Problems are designed specifically to help meet the stated objectives. In addition, each chapter Summary in Outline provides a checklist of major topics the student should learn.
2. The health-science student is generally expected to learn a great deal about the anatomy of certain organ systems—specifically, bones, skeletal muscles, blood vessels, and nerves. In these high anatomy areas, we have pulled the anatomical details out of the narrative and placed them in Exhibits, most of which contain illustrations. This method organizes the data and deemphasizes rote learning of concepts presented in the narrative.
3. An unusually large number of clinical applications are described. The topics provide review of normal body processes and allow the student to see why the study of anatomy and physiology is so fundamental to a career in any of the health fields. Topics include such interest sparkers as acupuncture and pain, smoking and cancer, and the birth process. In addition, glossaries of selected medical terminology appear at the ends of most chapters.
4. Many roentgenograms are used.
5. A two-part glossary appears at the end of the book. The first part contains prefixes, suffixes, and combining words; the second part contains important terms used in the text. A pronunciation key is included.

SUPPLEMENTARY MATERIALS

Ancillary materials are also available for use with *Principles of Anatomy and Physiology*. These include

1. A complimentary Teachers' Guide. For each chapter of the textbook, the Guide contains a résumé, a listing of key instructional concepts, problem-solving essay questions, and selected audiovisual materials. A directory of the distributors of the audiovisual materials is also provided.
2. A complimentary Question Card File. The File is a booklet containing objective test questions for each chapter in the textbook. The questions have been carefully designed to evaluate student understanding of data, concepts, clinical situations, and their applications.
3. A slide set consisting of fifty slides selected from illustrations in the textbook. It is available through Canfield Press.
4. Laboratory and Study Manual. The Manual is geared specifically to the textbook in terms of content and illustrations. It contains modules that guide the student in making microscopic examinations, recording data, and performing gross examinations, and physiological experiments. A unique feature of the Manual is the incorporation of selected modules that deal with clinical considerations and applications only. At the discretion of the instructor, some of the modules may be utilized as out-of-class assignments or as part of student evaluation. The Manual is available through Burgess Publishing Company.

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We are especially pleased with the outstanding quality of the line drawings. The bulk of the artwork was prepared by Russell Peterson, who provided us with numerous insights regarding the conceptualization of the art and the correlation of the art with the textual material. Nelva B. Richardson drew the anatomical and physiological illustrations in Chapters 20 to 25. Heather Kortebein and Barbara Hack prepared many biological and flowchart illustrations throughout the book. Selected pieces of art were also reviewed by Drs. Hollinshead and Elson.

Myra Schachne did the time-consuming photographic research. The many individuals, publishers, and companies who provided photographs, photomicrographs, and electron micrographs are acknowledged in appropriate captions.

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NOTE TO THE STUDENT

At the beginning of each chapter is a listing of Student Objectives. *Before* you read the chapter, please read the objectives carefully. Each objective is a statement of a skill or knowledge we would like you to acquire. To meet these objectives you will have to do several things. Obviously, you must read the chapter very carefully, and, if there are sections of the chapter you do not understand after one reading, reread the sections before continuing. In conjunction with your reading, pay particular attention to the figures and Exhibits; they have been carefully coordinated to what you are reading. At the end of each chapter are two other guides you may find useful. The first of these guides, Chapter Summary in Outline, is a summary of important topics discussed in the chapter. This section is designed to consolidate the essential points covered in the chapter so you may recall and relate them to each other. The second guide, Review Questions and Problems, is a series of questions designed specifically to help you to meet your objectives. After you have answered the questions, you should return to the beginning of the chapter and reread the objectives to see whether or not you have met your goal.

This textbook is dedicated to

Teachers who have inspired us,
Students we hope to motivate, and
Our families, who have encouraged us

CONTENTS

UNIT 1

ORGANIZATION OF THE HUMAN BODY

CHAPTER 1

AN INTRODUCTION TO THE HUMAN BODY

STUDENT OBJECTIVES

After you have read this chapter, you should be able to:

1. Define physiology and anatomy with its subdivisions
2. Determine the relationship between structure and function
3. Compare the levels of structural organization within the human body
4. Define a cell, tissue, organ, system, and organism
5. Explain why homeostasis is a state that results in normal body activities and why the inability to achieve homeostasis is a condition which leads to malfunction and related disorders
6. Identify the effects of stress on homeostasis
7. Describe the interrelationships of body systems in maintaining homeostasis
8. Compare the role of the endocrine and nervous systems in maintaining homeostasis
9. Define a feedback system and explain its role in homeostasis
10. Contrast the homeostasis of blood pressure through nervous control and blood sugar level through hormonal control

You are about to begin a study of the human body in order to learn how your body is organized and how it functions. The study of the human body involves many branches of science, each of which contributes to a more comprehensive understanding of the parts of your body and how they work. Once you learn how your body normally works, you can understand what happens to your body when it is injured, diseased, or placed under stress.

Two branches of science that will help you understand your body parts and functions are anatomy and physiology. **Anatomy** refers to the study of *structure* and the relationships among structures. Anatomy is a very broad science, and the study of structure becomes more meaningful when specific aspects of the science are considered. For example, *gross anatomy* deals with structures that can be studied without using a microscope. Another kind of anatomy, *systemic anatomy*, covers particular systems of the body, such as the system of nerves, spinal cord, and brain, or the system of heart, blood vessels, and blood. *Regional anatomy* is a division of anatomy dealing with a specific region of the body, such as the head, neck, chest, or abdomen. *Developmental anatomy* is the study of development from the fertilized egg to the adult form. This branch of anatomy, also called *embryology*, is generally restricted to the study of development from the fertilized egg to the period just before birth. Other branches of anatomy are *pathological anatomy*, the study of structural changes caused by disease, and *histology*, the microscopic study of the structure of tissues and cells.

Whereas anatomy and its branches deal with structures of the body, **physiology** deals with the *functions* of the body parts. In other words, physiology is concerned with how a part of the body actually works. As you will see in later chapters, physiology cannot be completely separated from anatomy. Each structure of the body is custom-modeled to carry out a particular set of functions. For instance, the interior of the nose is lined with hairs that allow the nose to perform the function of filtering dust from inhaled air. Bones are able to function as rigid supports for the body because they are constructed of hard minerals. In a sense, then, the structure of a part determines what functions it will perform. In turn, body functions often influence the size, shape, and health of the structures. For example, glands perform the function of manufacturing chemicals. Some of these chemicals stimulate bones to build up minerals so they become hard and strong. Other chemicals cause the bones to give up some of their minerals so they do not become too thick or too heavy. Anatomy cannot really be understood without a knowledge of physiology, and vice versa. For this reason, you will learn about the human body by studying its structures and functions together.

HOW ARE YOU PUT TOGETHER?

The human body is an organism consisting of levels of structural organization that are associated with each other in several ways. **An organism** is a total living form. Some organisms, like the amoeba, consist of only one cell. Most organisms, including humans, consist of millions of cells. The lowest level of structural organization, the *chemical level*, includes all chemical substances essential for maintaining life. All these chemicals are made up of atoms joined together in various ways (Figure 1–1). The chemicals, in turn, are put together to form the next higher level of organization, the *cellular level*. **Cells**, as you probably know, are the basic structural and functional units of the organism. Among the many kinds of cells found in your body are muscle cells, nerve cells, and blood cells. Figure 1–1 shows several isolated cells from the lining of the stomach. Each of these cells has a different structure, and each performs a different job.

From the cellular level, the next higher level of structural organization is the *tissue level*. **Tissues** are groups of cells that are joined together to perform specific functions. For example, when the isolated cells shown in Figure 1–1 are joined

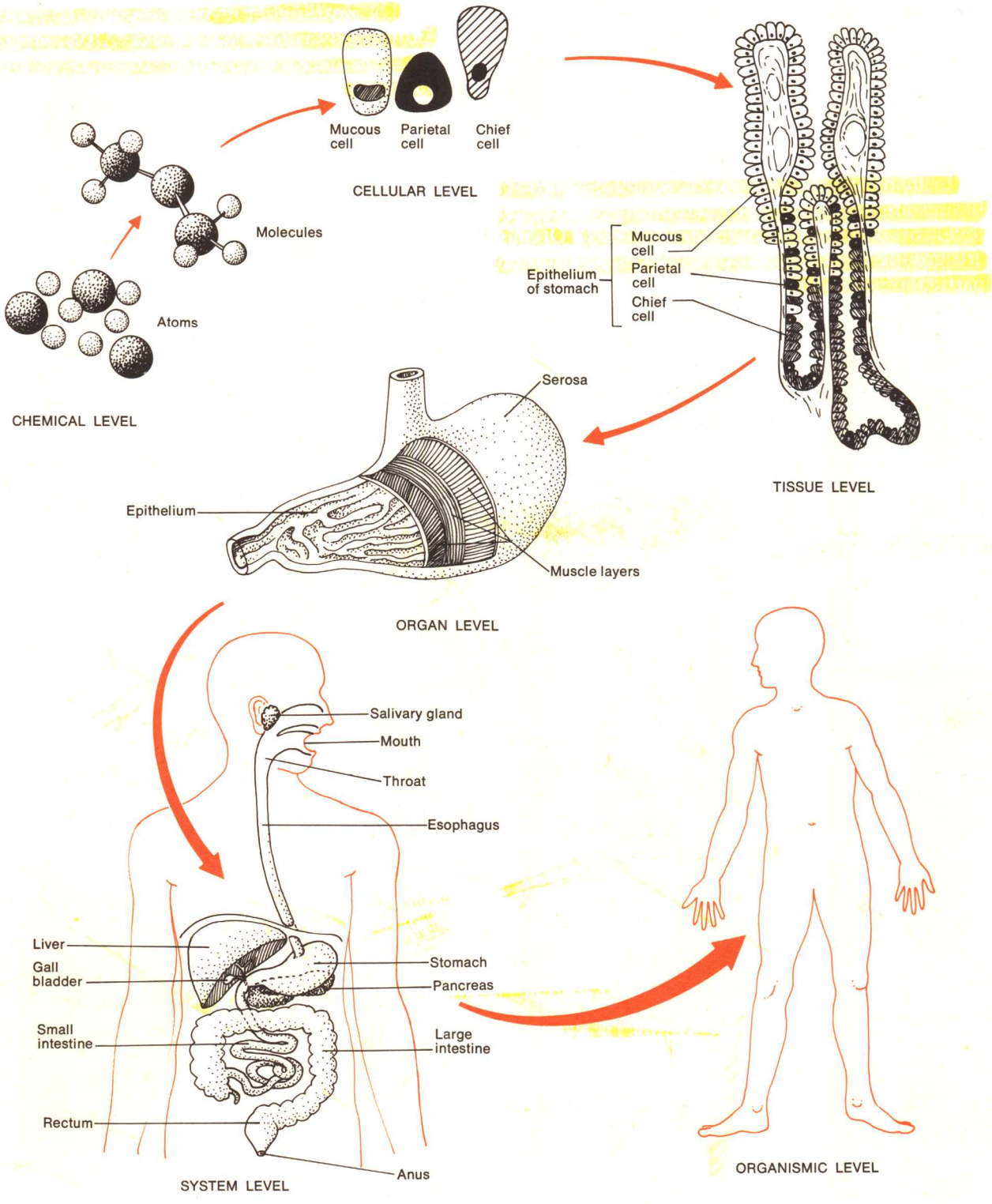


Figure 1–1. Levels of structural organization.

together, they form a tissue called *epithelium*, which lines the stomach. Each kind of cell in the tissue has a specific function. Mucous cells produce mucus, a slime that lubricates food as it passes through the stomach. Parietal cells produce acid in the stomach, and chief cells produce enzymes needed to digest proteins. Other examples of tissues in your body are muscle tissue, bone tissue, and nervous tissue.

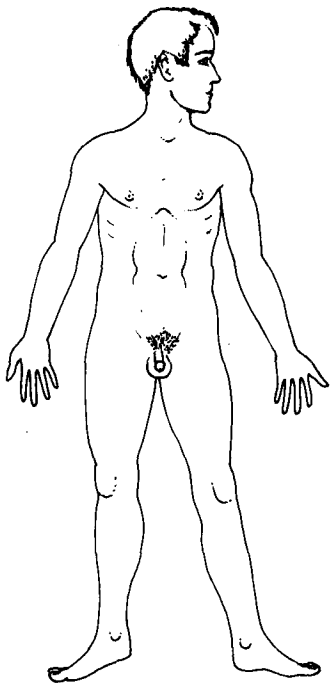
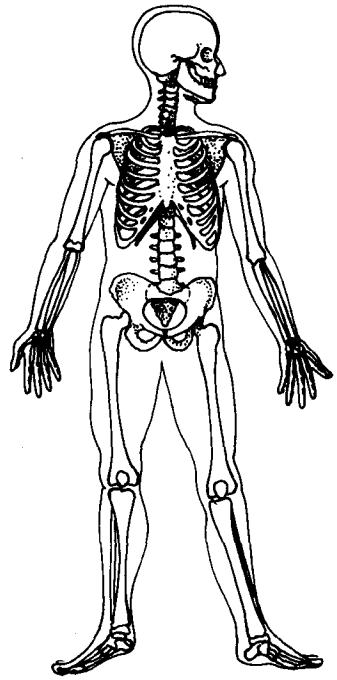
In many places in the body, different kinds of tissues are joined together to form an even higher level of organization, the *organ level*. **Organs** are groups of two or more tissues that perform a particular function. Examples of organs are the heart, liver, lungs, brain, and stomach. Referring to Figure 1–1, you will see that the stomach is an organ since it consists of two or more tissues. Three of the tissues that make up the stomach are shown here. The serous tissue layer (also called the serosa) protects the stomach and reduces friction when the stomach moves and rubs against other organs. The muscle tissue layers of the stomach contract to mix food and pass the food on to the next digestive organ. The epithelial tissue layer produces mucus, acid, and enzymes.

The next higher level of structural organization in the body is the *system level*. A **system** consists of an association of organs that have a common function. The digestive system, which functions in the breakdown of food, is comprised of the mouth, saliva-producing glands, throat, esophagus, stomach, small intestine, large intestine, rectum, liver, gallbladder, and pancreas. All the parts of the body functioning with each other constitute the total organism.

In the chapters that follow, you will examine the structure and function of the following body systems: integumentary (pertaining to the skin), skeletal, muscular, nervous, endocrine (pertaining to hormones), circulatory, respiratory, digestive, urinary, and reproductive. Exhibit 1–1 contains a listing of these systems, their representative organs, and their general functions.

The systems are presented in the Exhibit in the order in which they will be studied in later chapters.

Exhibit 1–1. PRINCIPAL SYSTEMS OF THE HUMAN BODY, REPRESENTATIVE ORGANS, AND FUNCTIONS

SYSTEM AND DIAGRAM OF REPRESENTATIVE ORGANS	SYSTEM AND DIAGRAM OF REPRESENTATIVE ORGANS
1. INTEGUMENTARY	2. SKELETAL
	
The skin and its associated structures such as hair, nails, and glands	All the bones of the body
FUNCTION: Protects the body, regulates body temperature, and eliminates wastes	FUNCTION: Supports and protects the body, gives leverage, produces blood cells, and stores minerals