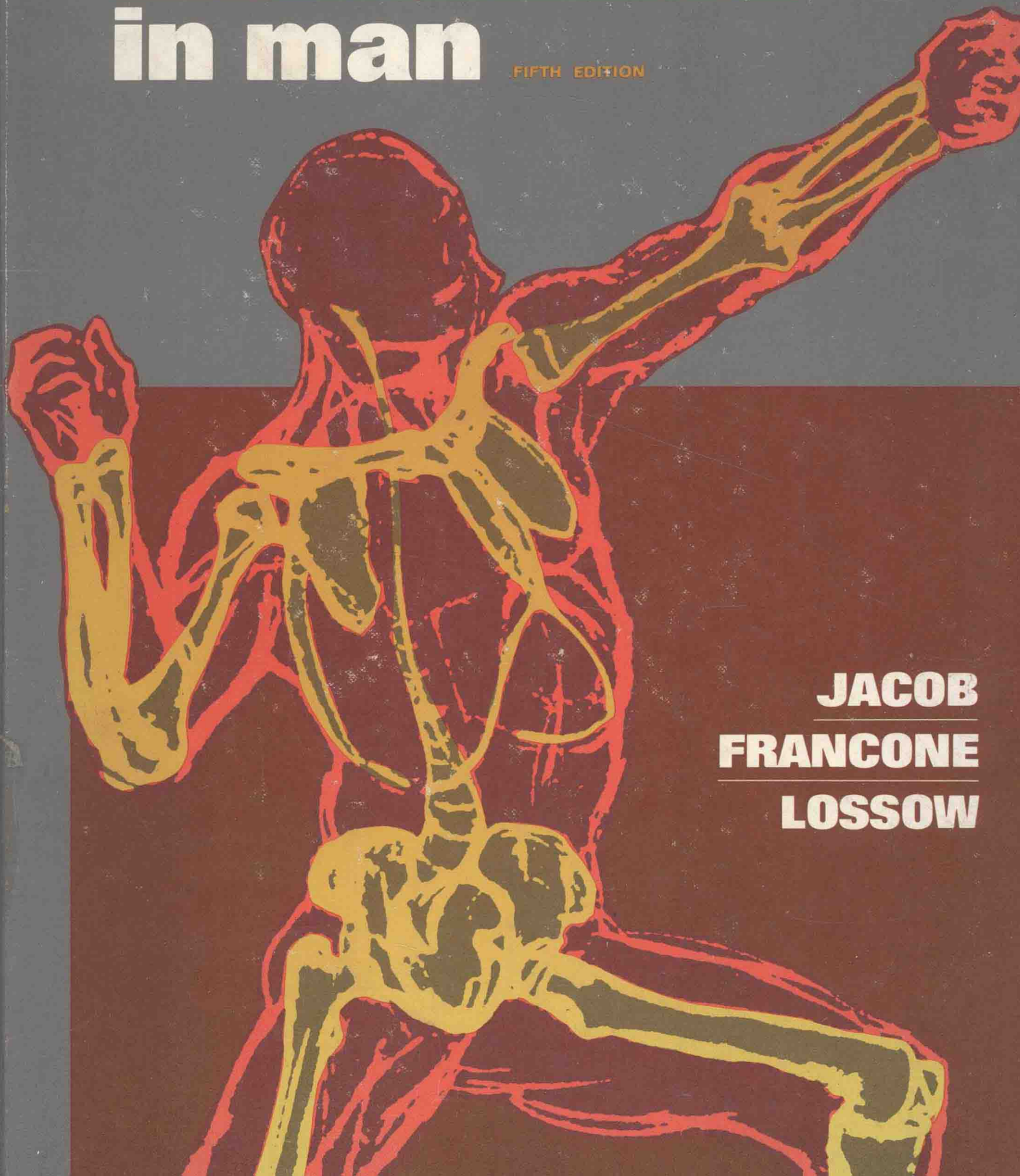
structure and function in man

FIFTH EDITION



JACOB
FRANCONE
LOSSOW

STRUCTURE AND FUNCTION IN MAN

FIFTH EDITION

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IN MEMORIAM

The fifth edition of *Structure and Function in Man* is published in memory of our co-author Clarice Ashworth Francone, who died late last year. We were fortunate that she was able to complete work on this edition and its artwork, which, as in previous editions, excels in accuracy, clarity, and beauty. She will be deeply missed by both of us.

STANLEY W. JACOB

WALTER J. LOSSOW

To my father, without whose encouragement this would not have been possible.

STANLEY W. JACOB

To my son Don.

CLARICE ASHWORTH FRANCONE

To my students.

WALTER J. LOSSOW

Preface to the Fifth Edition

The past few years have seen the emergence of several new career opportunities to join the already existing professions of nursing and other paramedical disciplines. *Structure and Function in Man* originally was written in 1965 to fulfill the need for a unified understanding of anatomy and physiology on the part of those students preparing for health-related careers. Today, it is in its fifth edition, indicating its continuing sound background in the basic foundations needed by these students. At the same time, it is enjoying increasing acceptance abroad, with foreign translations taking it to the students of other countries.

This edition features a larger, more open format and relabeling of all anatomic illustrations, using a modern, clear typeface. Four colors have been used in the printed illustrations, with more color added in some figures to aid student comprehension. A second color is being used within the text to simplify textual organization for the reader.

The fifth edition of *Structure and Function in Man* contains a totally new chapter, "Basic Chemistry and the Chemical Constituents of Living Matter." New material on basic physiology has been incorporated into almost all chapters. To reinforce the discussion of fundamental physiologic concepts, practical treatments of disorders are discussed to help the student, who today will be given a greater responsibility in patient care. In addition, with the help of a reader who has never taken a course in anatomy and physiology, revisions have been made throughout the text so that it can be easily read and understood by the beginning student. Multiple teaching aids include chapter objectives at the beginning of each chapter and an outlined summary at the end. Additionally, there are review questions at the end of each chapter; a full glossary; an appendix with prefixes, suffixes, and combining forms; and an updated list of Suggested Additional Reading. Visual aids featured in this fifth edition include

1. Twenty-six new illustrations, to bring the total to 525.
2. Thirty-five revised illustrations.
3. Thirty new or revised Tables.

In addition, some of the textual changes include the addition to the chapter on the muscular system of a narrative describing muscle actions; completely revised descriptions of neurons, the nerve impulse, the neuromuscular junction, and synapses; a more thorough discussion of the organization of the cerebral cortex; added material on electroencephalograms, sleep,

and seizure disorders; more detailed descriptions of sensory and motor pathways and the autonomic nervous system; amplification of the descriptions of the physiology of vision, equilibrium, and hearing; rewritten sections on the circulation that describe in greater detail the cardiac cycle, the regulation of blood pressure, and shock; extensive revision of the chapter on the lymphatic system, including an updating of the section on the B and T cell immune systems; completely revised sections on the transport of oxygen and carbon dioxide and the regulation of respiration; more detailed descriptions of the digestion of major foodstuffs and metabolism; a completely rewritten discussion of temperature regulation; considerable additional data on the endocrine glands and the mechanisms of hormone action; a new section on the development of the mammary glands and lactation, and added material on dysmenorrhea, menopause, the functions of androgens, and venereal disease.

STANLEY W. JACOB, M.D.
WALTER J. LOSSOW, PH.D.

Acknowledgments

If this text receives any measure of success many individuals will have made this possible.

We wish to express our appreciation to Barbara Weber, Terry Bristol, Beverly Methvin, Karen Clement, Anna Conley, Joel Cruz, Marilyn Jacob, Lois Locke, Blanche Palmer, Frances Kemper, Paula Burnett, Frank Weber, William Weaver, Ph.D., Helyn Galash, Robert Brooks, Ph.D., Marilyn Underdahl, Rebecca Meyer, and Bonnie Marble.

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Preface to the First Edition

Many centuries ago anatomy and physiology were taught in a single course—not so much for the benefit of the student, but because the two fields of knowledge were not really separate even in the minds of researchers and educators. At the time there was insufficient knowledge of either science to warrant separate treatment. As the years passed, intensive studies were completed by methodically curious scientists in both fields. These investigations were aided by the progressive development of the physical and chemical sciences and by advances in technology providing more refined methods for observation and experimentation.

Gradually, the accumulation of facts and the elucidation of general concepts made specialization necessary; so anatomy and physiology were taught as individual sciences. Recent years have witnessed a return to the older philosophy of treating them as one integrated subject in the hope that students would more readily understand life as the truly integrated process it is.

One cannot appreciate the subject matter of physiology without first learning the basic concepts of anatomy. One cannot realize the full significance of human structure without also understanding the complex functions associated with it. Thus, while specialization is still necessary for advanced students, beginning and reviewing students at every educational level benefit from an integrated presentation of anatomy and physiology.

Structure and Function in Man is designed for use by the beginning student. This book emphasizes physiology without neglecting anatomy, an accomplishment due to the incorporation of approximately 300 new half-tone drawings depicting the anatomy of the entire body. The text employs the Nomina Anatomica (N.A.) terminology, replacing such words as *Eustachian* with *auditory* and *pituitary* with *hypophysis*. A brief survey of each organ system is presented; chapters are comprehensively summarized and study questions included. Complete lists of references have not been added; to do so in a field as wide as anatomy and physiology would have created a book of inordinate length. Clues to further reading are provided in a special section at the end of the text. This book is only a beginning.

"The hardest conviction to get into the mind of the beginner is that the education he is receiving in college is not a medical course but a life course for which the work of a few years under teachers is but a preparation."—Sir William Osler.

Portland, Oregon

STANLEY W. JACOB
CLARICE A. FRANCONE

Visual Aids

To supplement the text and laboratory manual by Jacob, Francone, and Lossow, certain illustrations have been made into visual teaching aids that can be purchased directly from the W. B. Saunders Company, West Washington Square, Philadelphia, Pa., 19105. These aids consist of a set of acetate overlays in two colors for use with an overhead projector. The overlays are based on illustrations from the text and cover the structure and function of important body systems. More information can be obtained by contacting the W. B. Saunders Company or one of its local representatives.

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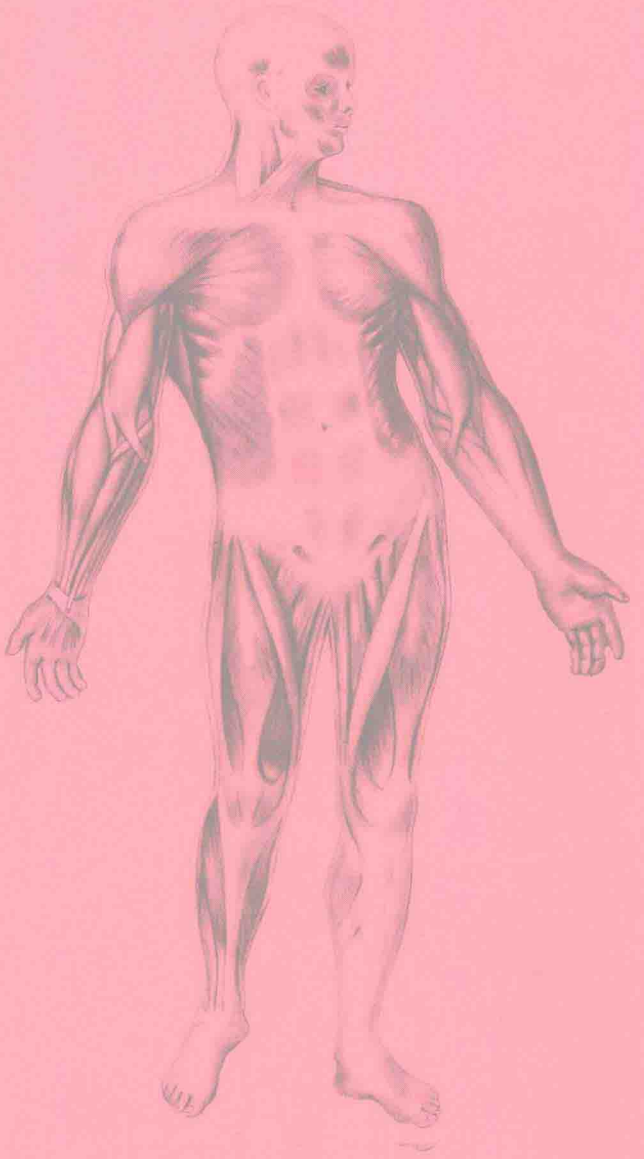
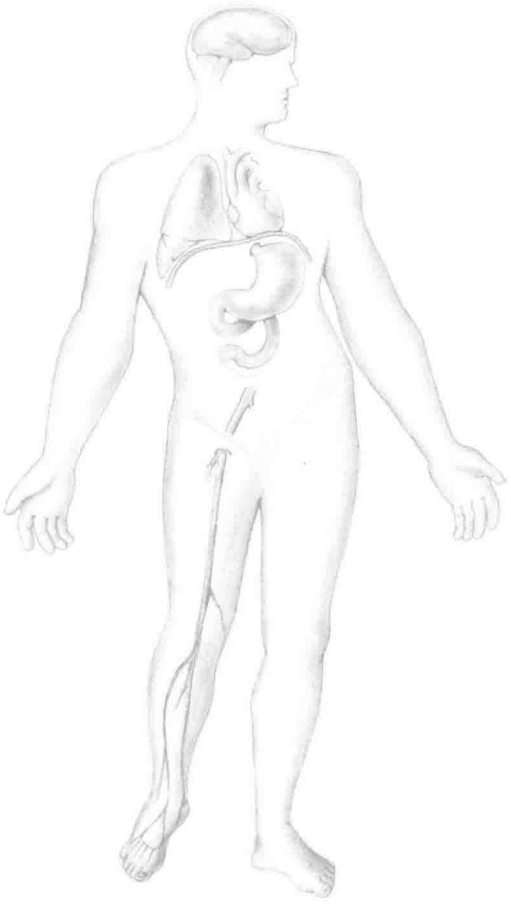
Unit 1 □ INTRODUCTION



1
The Body As A Whole



Objectives

The aim of this chapter is to enable the student to:

- Describe the distribution of body fluids.
- Describe the basic mechanism for maintaining homeostasis.
- Identify the major homeostatic organs and systems of the body.
- Identify the two major types of communication mechanisms involved in the coordination of the body.
- Construct a diagram of the body and label it with respect to anatomical directions, planes and cavities.
- Define and relate the cell, tissue, organ, and system as structural units.
- List the major systems of the human body.

THE HUMAN BODY

The order and plan of creation have challenged man throughout history. His world is organized into a solar system, the solar system into a galaxy, and the galaxy into a universe. In the opposite direction, his world is divided into civilizations, civilizations into societies, societies into human individuals, and these human individuals into chemical elements. Man finds himself, like Huxley, overcome at the "wonderful unity of plan in the thousands and thousands of living constructions, and the modifications of similar apparatuses to serve diverse ends." Such is the human body.

The Complex Organism

Man as a living organism may be viewed as an assemblage of minute units, called cells, which are marvelously integrated both structurally and functionally. Cells eventually specialize or differentiate to a greater or lesser extent. An aggregate of similarly differentiated cells composes a tissue, such as the fat cells of adipose tissue. Tissues, in turn, form organs; organs form systems. Ultimately, systems combine in an intricate manner to create a thinking, acting human being. When viewing the human body in this fashion, one stands in awe at the complexity of the organization of the body and the fine balance and interdependence of the various parts. Anatomy and physiology describe this interdependence of structure and function.

Scientific Study

Anatomy Defined. *Human anatomy* is the science of the shape and structure of the body and its parts. *Gross anatomy* deals with the macroscopic structures uncovered by dissection and visible to the unaided eye. *Microscopic anatomy* employs the use of the light microscope. The most detailed studies involve the methods of *electron microscopy*.

Physiology Defined. *Human physiology* is the study of the functions of the body and its parts. *Cellular physiology* is the most prominent specialized branch and is concerned with the study of the activities of individual cells and their parts.

The division between *anatomy* and *physiology* is not always clear, and the use of these terms is best considered an indication of emphasis rather than a sharp division of subject matter. In many areas, the interplay between these two approaches of inquiry has become so close that scientists have tended to specialize in the study of particular *organs* and *organ systems*, the definitions of which involve both structural and functional aspects. *Cardiology*, for example, is the study of the heart and related elements.

-ology: The Study of. On a more detailed level, the fields of *cytology*, study of the structure and function of the individual cells, and *histology*, study of tissue structure and function, have both become generally recognized disciplines.

Two other perspectives deserve special mention in a survey of the approaches to studying the structure and function of the human body. These are *pathology* and *embryology*. Pathology is the study of abnormal or disease states in the body, and is distinct from the more general inquiry into the normal structure and functioning of the organism. Embryology is the study of the development of the fertilized egg into the mature organism. The techniques of the anatomist, as well as those of the physiologist, are employed in both pathology and embryology.

Development of the Electron Microscope

Since the discovery and identification of atoms and molecules by 19th century physiologists, the single most impressive development in the study of biological structures has been the construction of the first electron microscope in the 1930's (Fig. 1–1). Electron microscopy is still a rapidly developing discipline, and it will perhaps be several decades before we have progressed sufficiently in our experimentation to reach the limits of its applicability. The impact of this instrument has been to multiply many times over our potential source of information about the fine details of cellular organization. In fact, it is the slowness of the development of physiological techniques of analysis on the molecular level that most severely retards our ability to interpret meaningfully what the electron microscope reveals.

The physiological side of analysis on the molecular level is termed *molecular biology*, and is based primarily on the use of sophisti-

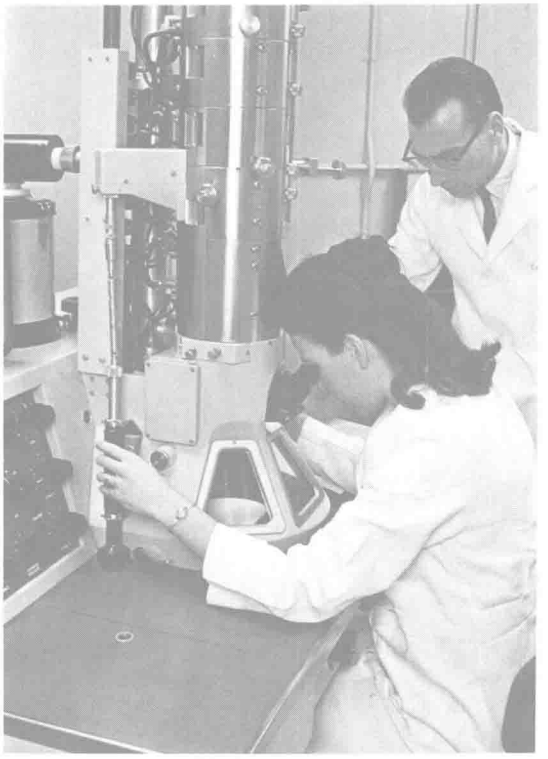


Figure 1–1. The electron microscope is now being employed to study structures at a magnification of 200,000×.

cated biochemical techniques to study the structure of the basic molecular units of the cell and the mechanisms by which they function. Further categorization or specialization on this level of detail does not occur, since there are common objectives in the study of molecules, molecular structures and mechanisms.

Body Fluids

Body fluids are found within the cells *(intracellular)*, or outside the cells in the *extracellular* space. The extracellular space is further divided into a *vascular*, or *plasma*, *compartment* and an *interstitial compartment* (between cells). In adults *plasma* accounts for about 5 per cent of the body weight; *interstitial fluid*, 15 per cent; and *intracellular fluid*, 45 per cent. Hence, approximately 65 per cent of the body weight consists of water, three-fourths of which is intracellular. Three-fourths of the water in the extracellular space is in the interstitial compartment. (See Chapter 17 for additional information.)

Homeostasis

To function properly, cells require a constant environment. The environment of the body cells, the interstitial fluid medium (derived from the blood stream) immediately surrounding each cell, is called the internal environment of the body. From the time the cell was identified as the basic structural and functional unit of life, physiologists have recognized the importance of maintaining a constant internal environment. Claude Bernard, the famous French physiologist who introduced the term "internal environment" *(milieu intérieur)*, is chiefly responsible for this basic concept. The American physiologist Walter Cannon developed a more general concept of constant internal body conditions and coined the term *homeostasis* (G. *homoios*, like; G. *stasis*, position) for the "steady state" conditions (holding within normal ranges despite continuous change) that are maintained by coordinated physiological processes. Among the homeostatic control mechanisms now understood are those maintaining normal concentrations of blood constituents, body temperature, volume and pH of body fluids, blood pressure, and heart rate.

All the homeostatic control mechanisms of the body operate by a process of **negative feedback.** The feedback is, in effect, an informational signal that tells the *driving mechanism* (or functional unit) how well it is doing at establishing or maintaining some variable at the desired level. The feedback is called negative because the change induced is negative to the initial change and counterbalances it. For example, if an individual's breathing becomes too shallow and slow, the removal of carbon dioxide from the body will be reduced and the concentration of carbon dioxide in the blood will rise. The rise in carbon dioxide concentration becomes an informational signal that is fed back to the center in the brain that controls breathing. Breathing will be stimulated and the elimination of carbon dioxide from the body will be increased, thereby reducing the concentration of carbon dioxide toward the normal value. If breathing becomes too deep and rapid, the concentration of carbon dioxide in the blood will fall and feedback responses