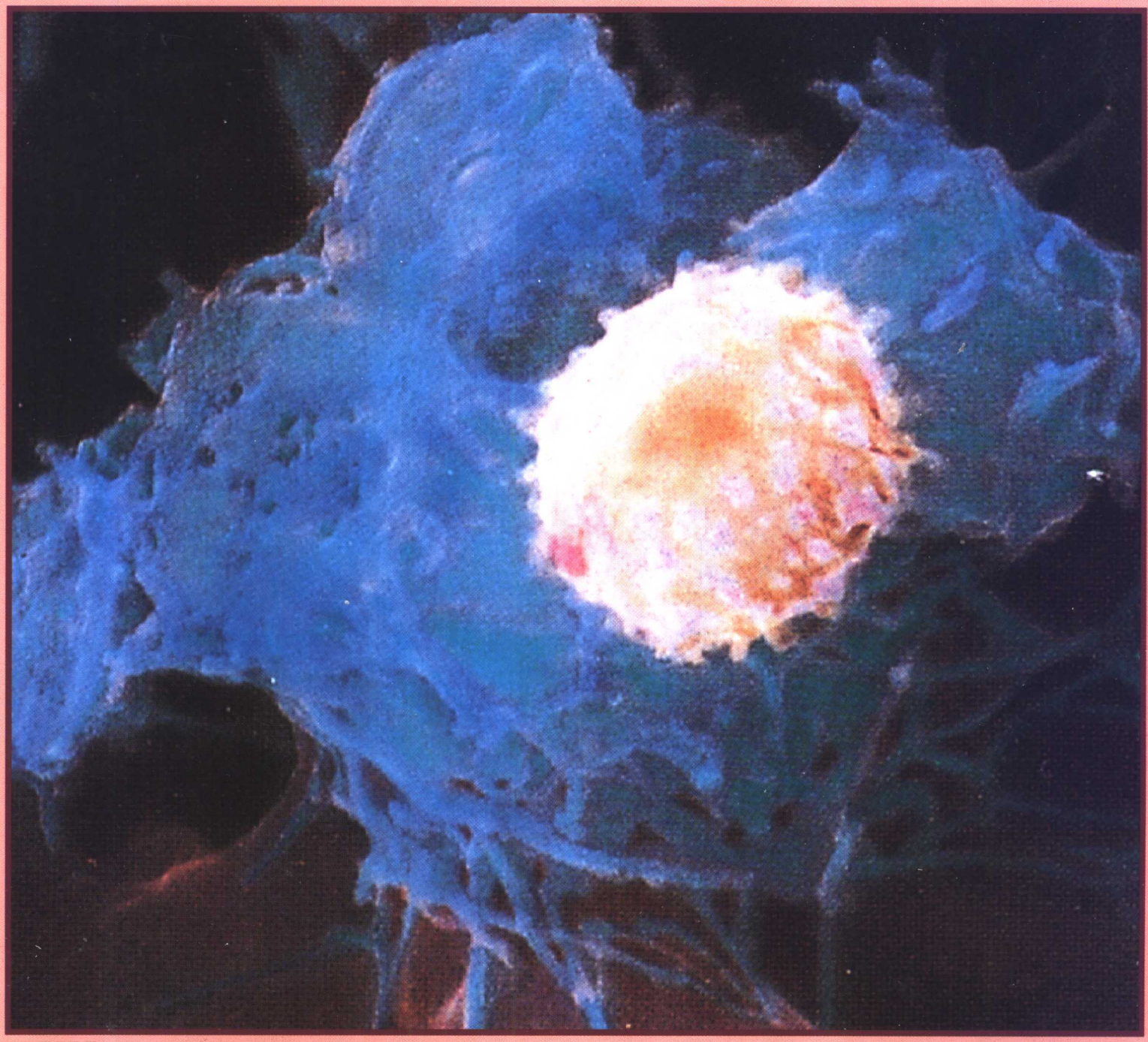
PHILLIP SHEELER



ESSENTIALS OF HUMAN PHYSIOLOGY

SECOND EDITION

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HUMAN PHYSIOLOGY

PHILLIP SHEELER
California State University, Northridge

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PREFACE

I have been teaching the Human Physiology course at California State University, Northridge for nearly 30 years. At this institution, the course is designed for students majoring in a broad spectrum of fields, including health science, nutrition science, physical education, physical therapy, pre-nursing studies, psychology, and a number of related disciplines. The varied and usually modest scientific backgrounds of the students and the diversity of their career goals have been important considerations in planning and writing this book, especially when deciding on the breadth and depth of the book's coverage and what preliminary foundations ought to be set.

For a majority of students, human physiology is the last undergraduate science course in their curriculum (perhaps in their college careers), and this too has guided me in selecting the topics to be presented and the extent of their detail. I've deliberately focused on topics whose understanding will help young, maturing adults be better informed about their body's functions and make prudent decisions where their personal health and well-being (and society's too) are concerned.

Over the years, I've used many textbooks for my course, most of them quite good. In recent years, however, there has been a trend in human physiology texts toward broader and broader coverage and greater and greater detail. The result is textbooks of human physiology that are needlessly elaborate and in which the coverage is so extensive and detailed that only a fraction of the book's content is covered in a one-semester course. Human physiology texts approaching 1000 pages in length are not uncommon. Probably the most alarming aspect of this trend is that many students are overwhelmed or intimidated by the text's size and do not do the necessary reading. Moreover, some students share the purchase of a single book and some buy no textbook at all. The need for an inexpensive book that can and will be read by students has been the primary motivation in writing this book and reigning in its scope and depth by limiting its size to a little over 400 pages. I'm hopeful the result is a text that realistically interfaces with the lecture coverage of a one-semester human physiology course.

In writing the book, I've tried to simplify concepts as well as present them in a concise manner. By preparing all of the illustrations myself, I've ensured that the figures and the text complement one another.

As a brief look at the table of contents reveals, *Essentials of Human Physiology* takes a "systems" approach to the subject. That is to say, the human body is viewed as an

integrated assemblage of different organ systems (such as the digestive system, the circulatory system, the excretory system, and so on). This is a classical approach and one that in my experience presents the subject in units that are easier to relate to, easier to conceptualize, and, most importantly, easier to understand. Throughout the text, however, I've tried to emphasize the interactions of the body's organ systems and their interdependence.

Essentials of Human Physiology has two particularly unusual features: (1) the book was prepared by the author using "desktop publishing" methods and (2) with each copy of the book, the student receives computer diskettes containing HyperCard[1] and Windows[2] software that augments the concepts presented in the text using *interactive* demonstrations and simple animations. Although the book is independent of the software, using the software materially assists the understanding of particular concepts, while at the same time giving the reader the opportunity to test his or her understanding.

To ensure that the software can be used effectively with minimum effort or computer expertise on the part of the student, clicking the computer's mouse at the appropriate time and with the cursor positioned at the appropriate location on the computer screen is the only requirement for using the interactive software. Students are not asked to enter text or data via the keyboard. There is no way to harm the software, even if the computer crashes or suffers a power loss during use. Once the computer is re-started, the software will function normally. The software also includes traditional multiple choice and true-false tests that challenge the student's understanding of the text. Guides to the installation and use of the software are presented in Appendix I (for HyperCard) and Appendix II (for Windows), at the back of the book.

I should like to express my appreciation to a number of people at Wm. C. Brown Publishers for their help with this project. Thanks are extended to my editor Colin Wheatley for his support and enthusiasm for the project, and to developmental editor Kris Noel, production editor Kay Driscoll, and copyeditors Kennie Harris and Kay J. Brimeyer. My thanks are also due to Hal Peters of Educational Software Products (Iowa City, Iowa) for preparing the Windows version of the interactive software.

My appreciation is also extended to a number of my colleagues at CSUN who reviewed and critiqued selected chapters of the book; my thanks go to Professor Joseph Moore, Professor Mary Lee Sparling, Professor Linda Caren, Professor Anthony Gaudin, and Professor Randy Cohen. My thanks are due also to Professor John McGill (Alpena Community College), Professor C. Thomas Wiltshire (Culver-Stockton College), and Professor John P. Harley (Eastern Kentucky University) for their reviews. My thanks also to Professor George Bloom (University of Minnesota) for comments on the illustrations. I should like also to thank CSUN graduate student Cynthia Lee Hockman who patiently copyedited the manuscript and rigorously tested the HyperCard software. Finally, I extend my thanks in advance to readers who may bring errors to my attention.

Phillip Sheeler
Northridge, California
May, 1995

[1] HyperCard is a trademark of Apple Computer, Inc.

[2] Windows is a trademark of Microsoft Corporation.

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CHAPTER 1

INTRODUCTION

ORGANIZATION OF THE BODY

Chapter Outline

Physiology is the branch of biological science that attempts to explain in chemical, physical, and molecular terms the multitude of phenomena that are displayed by living things. Physiology has several branches of its own, including *animal physiology, plant physiology*, and *microbial physiology*. This book is concerned with a specific aspect of animal physiology, namely *human physiology*–the study of how the human body works.

LEVELS OF ORGANIZATION OF THE BODY

Organ Systems

The human body is an extremely complex structure. To simplify the study of the body's physiology, it is helpful to subdivide the body into a number of different functional parts, each of which can then be considered separately. The major functional subdivisions of the human body are the body's so-called **organ systems**, each organ system having a rather specialized function. The body's major organ systems are listed in table 1.1.

Each organ system also has a hierarchy of structural and functional parts. Organ systems are comprised of a number of **organs**. For example, the eyes and ears are organs of the receptor system; the heart, arteries, and veins are organs of the circulatory system; the stomach and small intestine are organs of the digestive system; and the kidneys and urinary bladder are organs of the excretory system.

TABLE 1.1 THE BODY'S MAJOR ORGAN SYSTEMS*
Muscle system
Nervous system
Receptor system
Circulatory system
Immune system
Respiratory system
Digestive system
Excretory system
Endocrine system
Reproductive system

* Some physiologists consider the skin (or integument) a separate organ system. However, we will consider the functions of the skin in connection with other organ systems.

Tissues and Cells

Each of the organs of an organ system is formed by an assemblage of **tissues**, each tissue contributing in a particular way to the organ's overall function. For example, the stomach contains *muscle tissue* (which is responsible for contractions and other movements), *epithelial tissue* (which produces and releases the stomach's digestive enzymes and other secretions), *connective tissue* (which provides the organ's structural integrity), and *nerve tissue* (which carries information between the stomach and the brain in the form of nerve impulses). The various kinds of tissues that comprise the body's organs are listed in table 1.2.

Each tissue is made up of large numbers of individual **cells**. The cells of each tissue share properties that are common to the cells of other tissues, but they also possess tissue-specific properties (e.g., muscle cells *contract*; nerve cells *conduct* impulses; endocrine cells *secrete* hormones; and so on). Even cells can be subdivided into distinct structural and functional components called the subcellular **organelles** (e.g., nucleus, mitochondria, and ribosomes). The organization and functions of the cellular organelles are reviewed in chapter 3. Finally, each organelle is comprised of a specific array of **molecular** (and **atomic**) constituents.

Thus, in order of decreasing scope and increasing organizational and functional specificity, the levels of organization of the human body may be described as follows:

Whole Body
Organ Systems
Organs
Tissues
Cells
Organelles
Molecules

Most of the remaining chapters in this book deal with the organization and functions of the tissues and organs that make up the body's organ systems.

BODY REGIONS AND SPATIAL PLANES

Major Body Regions

The subdivision of the body into a number of organ systems is based on physiological (i.e., functional) distinctions. However, the body can also be subdivided into regions based on position or anatomical location. Even though we will not be concentrating on anatomy, it is helpful (and important) to be familiar with the body's general anatomical plan and how one region of the body is described in relation to other regions.

TABLE 1.2 THE BODY'S TISSUES

TISSUE	SUBTYPES	FUNCTIONS
Muscle	Striated	Contraction
	Smooth	Contraction
	Cardiac	Contraction
Nervous	Neuronal	Conduction and transmission
	Neuroglial	Support
Epithelial	Mucous membrane	Absorption and/or secretion
	Serous membrane	Secretion; lining of organs
	Endothelium	Lining of vessels
	Glandular epithelium	Secretion
Connective	Adipose	Fat storage
	Cartilage	Support
	Bone	Support
	Blood	Gas transport and immunity

The major body regions are (1) the **head** (**cranial** and **facial** subdivisions), (2) the **neck** (or **cervical** region), (3) the **trunk** (**thoracic**, **abdominal,** and **pelvic** subdivisions), (4) the right and left **upper limbs**, and (5) the right and left **lower limbs**. These regions are depicted in figure 1.1 and are listed in table 1.3.

In addition to the major body regions, one may distinguish the **dorsal** surface of the body (i.e., the rear or **posterior** surface) and the body's **ventral** surface (i.e., front or **anterior**).

1-1

Spatial Planes and Relative Movements of the Body

Just as there are three planes in space (i.e., three *dimensions)*, the body has three spatial planes; these are (1) the **frontal** (or **coronal**) plane; (2) the **median sagittal** (or **midsagittal)** plane; and (3) the **transverse** (or **horizontal)** plane (fig. 1.2). The frontal plane passes vertically through the body, dividing the body into front (anterior or ventral) and rear (posterior or dorsal) halves. The median sagittal plane also passes vertically through the body, but this plane divides the body into right and left halves. The transverse plane passes horizontally through the body from front to rear and divides the body into upper and lower halves.

1-2

Specific terms are used when describing spatial relationships among different parts of the body or when describing movement or progression through the body. For example, **anterior** movement implies forward movement through the body (e.g., from the dorsal

TABLE 1.3 THE BODY'S MAJOR REGIONS

MAJOR REGION(S)	SUBDIVISIONS
Head	Cranial region Facial region
Neck (cervical region)	
Trunk	Thoracic region Abdominal region Pelvic region
Upper Limbs	
Lower Limbs	

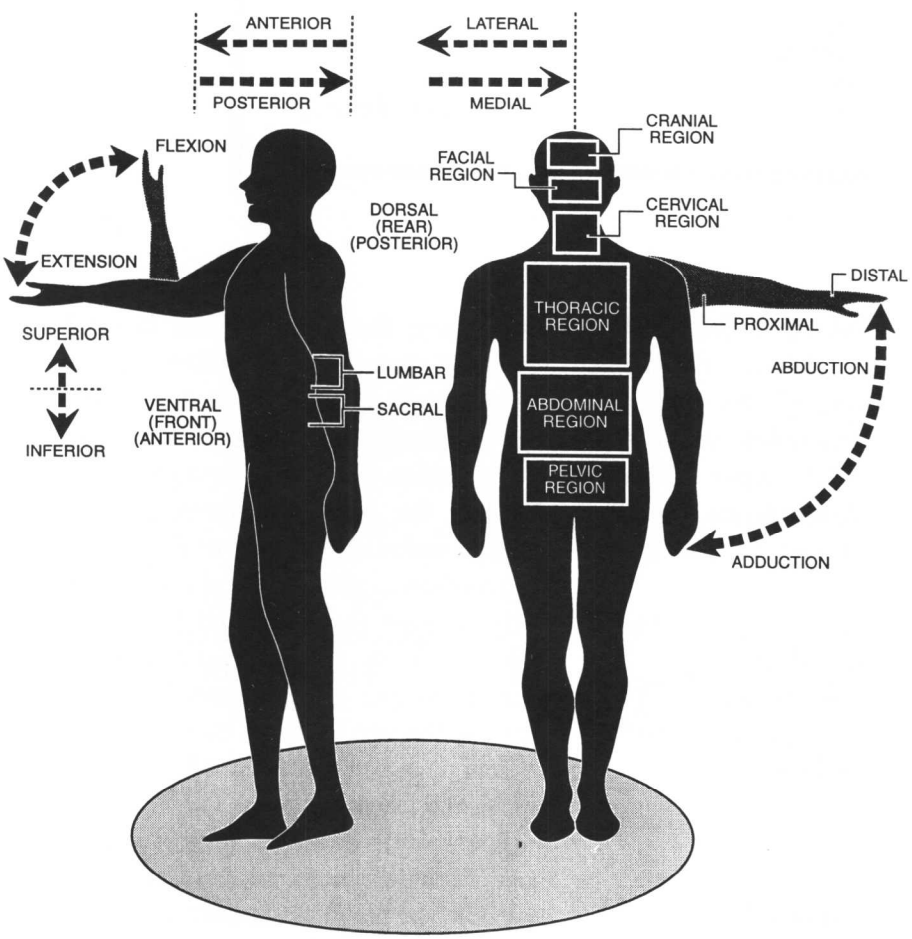

Figure 1.1
The body's major regions and spatial relationships.