

While the fourth edition of *Concepts of Human Anatomy and Physiology* has taken on a fresh, new look and has changed in other significant ways, we have made every effort to retain those features of previous editions that have contributed to the great popularity of this text over the years. Of major importance, the fourth edition is consistent with previous editions in its focus on unifying concepts as a means of integrating factual information. Just as important, a clear and interesting narrative, carefully rendered and attractive illustrations, and numerous pedagogical devices continue to be central in enabling students to assimilate a large body of information and to place what they have learned in a meaningful context.

As in previous editions, the material is organized so that instructors may tailor required text readings to their individual course needs. Because the text is designed for students who do not have extensive science backgrounds but who plan to enter health or other careers that require considerable knowledge of anatomy and physiology, the chapters in the opening unit present basic chemical, cellular, biological, and anatomical concepts. The chapters in the remaining four units then take a detailed approach to the anatomy and physiology of organs and systems. Throughout the text, we continue to promote the view of anatomy and physiology as dynamic sciences that serve as foundations for the health professions.

Having said this, we have no doubt that the fourth edition is the strongest by far. We are confident that it can be of immense value in helping students achieve learning objectives, in fostering in them a love of and respect for the science of human anatomy and physiology, and in persuading them to continue in the field.

What's New, Revised, or Improved

Followers of previous editions will quickly note the major physical improvements in the fourth edition. These include larger headings and text type, exciting new design elements, and other new features. We have revised the narrative, and in some cases reorganized chapters, in accordance with the helpful suggestions of reviewers and users. We have also added new material in light of recent scientific findings, taking care to connect new developments to basic principles. Listed below are some of the major fourth-edition changes.

1. **New and Revised Illustrations** An already outstanding illustration program has been greatly improved in this edition, which features many new full-color illustrations. In addition, a large number of the illustrations used in previous editions have been substantially revised.

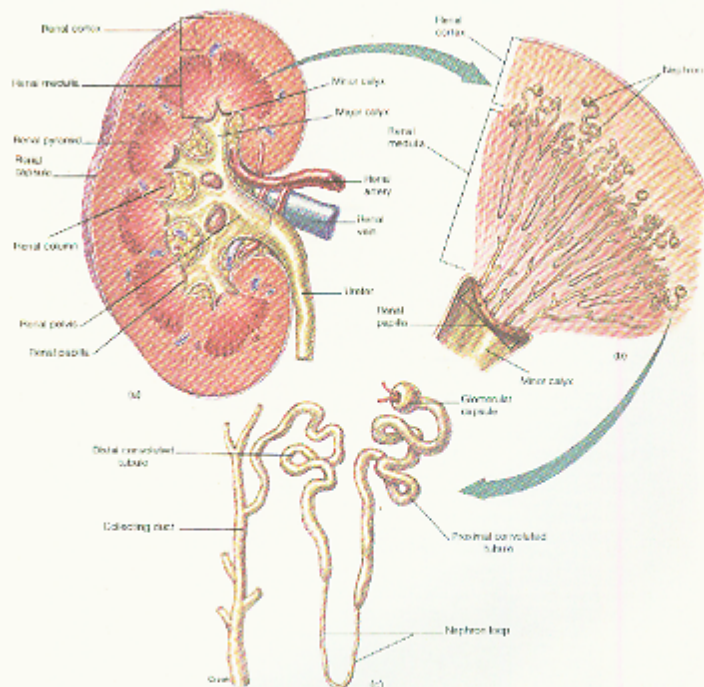


FIGURE 25.3

The internal structure of a kidney. (a) A coronal section showing the structure of the renal cortex, renal medulla, and renal pelvis. (b) A diagrammatic representation of a renal pyramid and renal

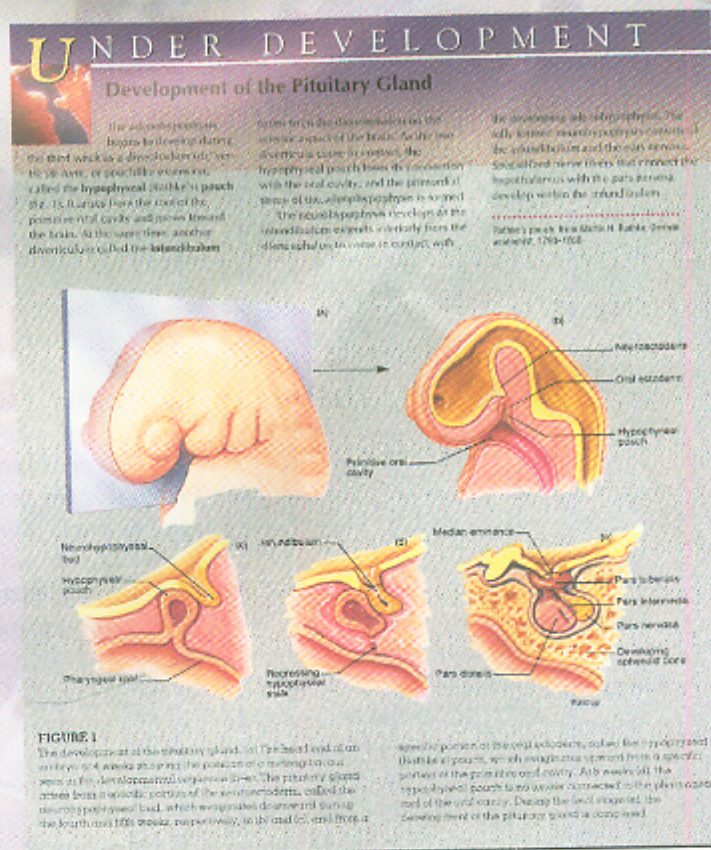
cortex to depict the tubules. (c) A diagrammatic view of a single nephron and a collecting duct.

In certain places, color coding has been introduced as a technique to aid learning. For example, the bones of the skull in chapter 9 are color coded so that each bone can be readily identified in the many renderings included in this chapter.

2. **Developmental Expositions** These features, entitled “Under Development” appear at the end of most systems chapters. Each discussion includes exhibits and explanations of the morphogenic events involved in the development of a body system. Placement at the end of a chapter ensures that the terminology needed to understand the embryonic structures has been introduced.

In a few chapters, an Under Development feature follows the relevant discussion of a specific body part or region; this occurs, for example, in sections on the skull, brain and spinal cord, ear and eye, and pituitary gland.

3. **Interrelationship Charts** New to this edition is a feature entitled **Nexus**. The Nexus page, which appears toward the end in each of the systems chapters, ties the functional aspects of one body system to each of the other systems, underscoring the concept of homeostasis. The gear-mechanism background art is symbolic of the body as a machine, in which all parts are interdependent in maintaining normal functioning.



NEXUS

Interactions of the Skeletal System with Other Body Systems

Integumentary System • Supplies vitamin D for absorption of calcium and synthesis of vitamin D • Provides skin with physical support	• Lymphocytes protect bone tissue following trauma • Bone marrow produces and stores lymphocytes and other cells of immune system
Muscular System • Causes bones to move joints • Partially responsible for bone shape and size • Provides attachment sites for muscles • Source of calcium for muscle contraction	Respiratory System • Provides O₂ and eliminates CO₂ • Forms respiratory passageway through nasal cavity • Protects lungs and aids in ventilation
Nervous System • Sensory receptors provide sensations of pain from bones and joints • Protects central nervous system with bony encasement • Source of calcium for neural function	Urinary System • Eliminates metabolic wastes from bone tissue • Activates vitamin D • Provides organs of urinary system with physical support and protection
Endocrine System • Hormonally controls bone growth and maintenance • Protects endocrine glands in head and pelvis • Source of calcium for cardiac muscle contraction	Digestive System • Provides nutrients for growth, maintenance, and repair of bone tissue • Provides organs of GI tract with physical support and protection • Stores minerals
Circulatory System • Transports O₂ and CO₂, nutrients, hormones, and fluids to and from the bones • Bone marrow produces blood cells • Source of calcium for cardiac muscle contraction	Reproductive System • Provides and/or secretes hormones that promote growth and development and maintain bone tissue • Provides organs of reproductive system with physical support and protection
Lymphatic System • Maintains balanced amount of interstitial fluid within bone tissue	

4. **Topic Icons** Throughout the text, short commentaries on clinical applications, development, and exercise physiology are set off in a distinct typeface and highlighted by the icons at right.

5. **New Content** A great deal of new information has been incorporated into this edition. The roles of nitric oxide as a regulatory molecule, the significance of NMDA receptors, and the requirements for T cell interactions are just a few examples of the new topics covered.

6. **Improved Flow of Information** Learning Objectives now appear at the beginning of each chapter so as not to interrupt the narrative. For the same reason, we have chosen to delete the Review Activities after each major section and to include the Clinical Investigations in the Instructor's Manual, where they can be easily duplicated and distributed to the class.

7. **Expanded Summaries** All of the end-of-chapter summaries have been reworked to reflect the text changes. These summaries are also more comprehensive, and they now include page references to the major sections.

8. A More Personal Approach It has been our experience that beginning students in anatomy and physiology are often intimidated by a very formal, academic writing style. In this edition, the language has been relaxed to engage the reader and make learning more enjoyable. Simple analogies are frequently used to promote understanding of concepts. The level of difficulty has been carefully controlled, recognizing the wide variation in motivation and background that typifies a broad spectrum of students.

Learning Aids: A Guide to the Student

The pedagogical devices in this text are designed to help you learn anatomy and physiology. Don't just read this text as you would a novel. Interact with it, using the pedagogical devices as tools. The more you use these tools, the more effective and enjoyable your study will become.

Chapter Introductions

The opening page of each chapter contains an overview of the contents of the chapter in outline form. Page numbers are indicated to guide you to the major sections. Learning objectives are also included, and should be checked both before and after studying each section of a chapter.

Concept Statements

One of the unique attributes of this text is the way in which major sections are introduced. Each of these sections is prefaced by a concept statement—a succinct expression of the main idea, or organizing theme, of the information presented in the section. These concept statements will help you gain an overview before encountering the details.

Terminology Aids

Where each technical term first appears in the narrative, it is set off by boldface or italic type and is often followed by a phonetic pronunciation in parentheses. Pause in your readings to learn the correct pronunciation of a term so that you will be better able to remember it. The phonetic spellings in this edition have been revised, making them easier than ever to interpret.

Word Derivations

The derivations of some of the terms in the text are provided in footnotes at the bottom of the page on which the term is introduced. Don't skip over these footnotes; they are often interesting in themselves. Furthermore, if you know how a word was derived, it becomes more meaningful and is easier to remember. You can identify the roots of each term by referring to the glossary of prefixes and suffixes on the inside front cover of the text.

Topical Commentaries

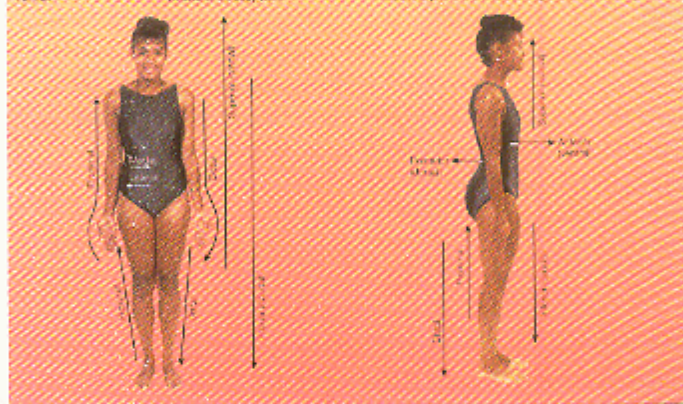
Set off from the text narrative are short paragraphs highlighted by icons that discuss topics of practical value. You will find it enjoyable, as well as instructive, to see how your newly acquired basic science knowledge is applied in real-world situations.

Illustrations and Tables

This text contains abundant tables and illustrations to support the concepts presented. Carefully studying the tables will enhance your understanding of the text. The summary tables will help you review for examinations. Although many of the figures can be admired for their beauty alone, it should be remembered that they were created for one primary purpose—to illustrate concepts presented in the text. Therefore, refer to the figures and analyze them as you read. Each one has been placed as close as possible to its text reference to spare you from flipping through pages.

Table 1.2 Directional terms for the human body

Term	Definition	Example
Superior (cranial, cephalic, anterior, dorsal)	Toward the head, toward the front (toward the feet)	The brain is superior to the stomach. The legs are inferior to the torso. The skull is on the anterior side of the body. The kidneys are posterior to the stomach. The heart is superior to the lungs. The vertebrae on the lateral side of the neck.
Inferior (caudal)	Toward the feet	
Medial	Toward the midline of the body	
Lateral	Toward the side of the body	
Proximal (deep)	Nearer to the center of the body	The elbow is proximal to the wrist.
Distal (superficial)	Farther from the center of the body	The wrist is distal to the elbow.
Proximal	Nearer to the center of the body	
Distal	Farther from the center of the body	
Anterior	Relative to ventral aspect	
Posterior	Relative to the body axis	



Following chapter 13 is a set of reference plates, including photographs of human cadaver dissections and several full-page newly rendered illustrations of the male and female trunk.

Chapter Summaries

At the end of each chapter the material is summarized for you in outline form, following the sequence of the text narrative. Review each summary after studying the chapter to be sure that you have not missed any points. In addition, use the chapter summaries in preparing for examinations.

Review Activities

A series of objective and essay questions follows each chapter summary. Answering these questions will provide you with feedback as to the depth of your learning and understanding. The answers to the objective questions are provided in Appendix A.

Glossary

The glossary of terms at the end of the text is particularly noteworthy for its comprehensiveness. The definitions for almost all of the terms are accompanied by pronunciation keys, and

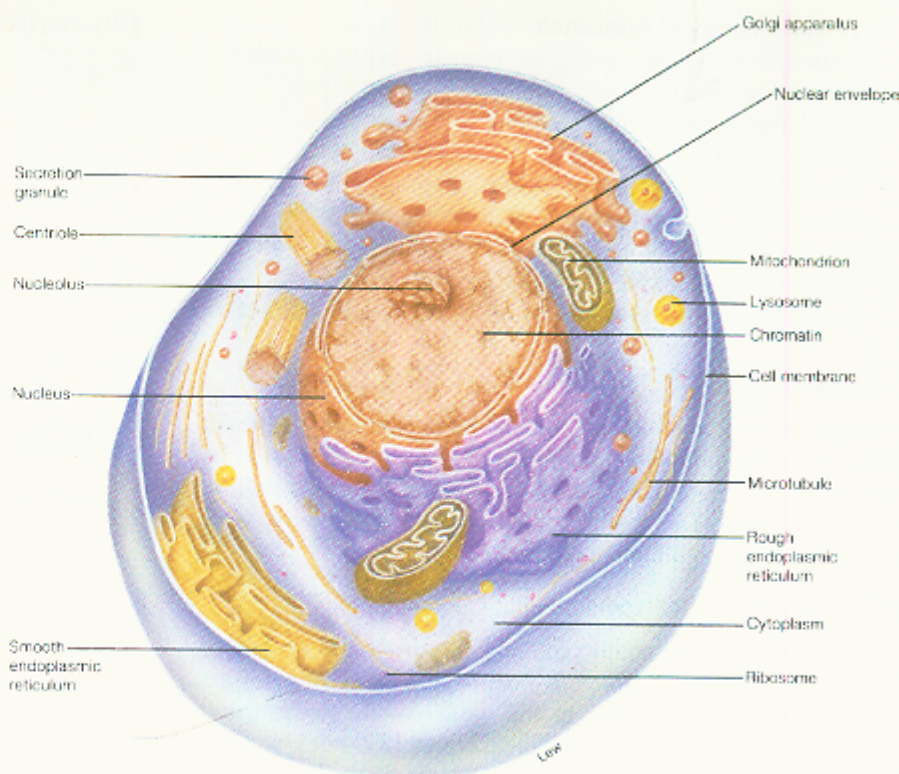
synonyms are indicated as appropriate. The majority of the terms in the glossary are accompanied by a page number indicating where the term is discussed in the text narrative. (Adjectival terms and general terms are not page referenced.) This useful feature is new to this edition. Look to the glossary as you review to check your understanding of the technical terminology.

Software Icon

This fourth edition introduces two new and exciting learning tools for the student.

 At the end of most chapters, a CD-ROM icon and a statement will appear that lists a module of the *Explorations* software that is appropriate for the chapter. The *Explorations* CD-ROM is available from Wm. C. Brown Publishers.

 A set of five videotapes, entitled *WCB Life Science Animations (LSA)*, contains over 50 animations of physiological processes integral to the study of anatomy and physiology. A videotape icon appears in appropriate figure legends to alert the reader of these animations, as shown in figure 3.1.



 **FIGURE 3.1**

A generalized cell and the principal organelles.

Life Science Animations (LSA)

Figure 2.5 Dissociation of sodium and chlorine
LSA 1

Figure 3.1 Generalized cell
LSA 2

Figure 3.4 Stages of endocytosis
LSA 3

Figure 3.19 RNA synthesis
LSA 16

Figure 3.21 Genetic code
LSA 17

Figure 3.23 Translation of mRNA
LSA 17

Figure 3.25 Golgi apparatus
LSA 4

Figure 3.26 Replication of DNA
LSA 15

Figure 3.30 Stages of mitosis
LSA 12

Figure 3.32 Meiosis
LSA 13

Figure 3.33 Genetic variation
LSA 14

Figure 4.13 Exergonic and endergonic reactions
LSA 11

Figure 4.15 ATP
LSA 11

Figure 4.18 Glycolysis
LSA 5

Figure 4.23 Krebs cycle
LSA 6

Figure 4.24 Electron transport and oxidative phosphorylation
LSA 7

Supplementary Materials

The supplementary materials that accompany the text are designed to help students in their learning activities and to guide instructors in planning course work and presentations. Following are brief descriptions of these supplements.

1. A *Laboratory Manual* written by Stuart I. Fox and Kent M. Van De Graaff to accompany the fourth edition of *Concepts of Human Anatomy and Physiology* requires that students read the text for relevant background information before attempting the laboratory exercises. It helps students gain the laboratory experience required to support the lecture portion of the course and includes exercises that have been repeatedly classroom tested.
2. The *Instructor's Manual for the Laboratory Manual* provides the answers to the questions that appear in the laboratory reports in the *Laboratory Manual*.
3. A *Student Study Guide* written by Kent M. Van De Graaff to accompany the fourth edition of *Concepts of Human Anatomy and Physiology* features the concept statements from the text, focus questions, mastery quizzes, study activities, and answer keys with explanations.
4. An *Instructor's Manual and Test Item File* prepared by Jeffrey and Karianne Prince provides instructional support in the use of the textbook. It also contains a test item file with approximately 70 items for each chapter to aid instructors in constructing examinations.

5. The following slide sets accompany the textbook and are free to adopters:
 - a. one hundred histology slides showing basic tissue types representative of all of the human body systems;
 - b. seventy clinical application slides, depicting important pathological conditions; and
 - c. twenty-five radiographic slides.Descriptions of these slides are included in the *Instructor's Manual*.
6. A set of 200 acetate transparencies is available to instructors who adopt this text. The transparencies were made from text illustrations chosen for their value in reinforcing lecture presentations.
7. All of the illustrations from the transparency set are collected in a *Student Study Art Notebook* available to students. With this notebook at their desk, students no longer have to worry about whether they will be able to see leader lines and labels in a large lecture hall. They can make notes right on the illustrations. Also available is the *Pictorial Review Notebook*, which contains the same illustrations without the labels.
8. *Knowledge Map of the Human Anatomy Systems* prepared by Craig Gundy is a computer tutorial developed for the Macintosh. The computer disk set (13 diskettes) provides an anatomical review of all of the body systems. A disk icon appears at the end of many chapters that contain material applicable to this software.

Figure 20.5 Agglutination of red blood cells
LSA 40

Figure 21.4 Coronary circulation
LSA 37

Figure 21.13 Conduction of electrical impulses in the
LSA 38 heart

Figure 21.40 Tetralogy of Fallot
LSA 39

Figure 23.12 Antibodies
LSA 42

Figure 23.18 Antibody production in primary and
LSA 41 secondary responses

Figure 23.21 B and T lymphocytes
LSA 43, 44

Figure 26.42 Pancreatic lipase
LSA 36

Figure 26.43 Digestion of fat
LSA 36

Figure 26.44 Fatty acids and monoglycerides
LSA 36

Figure 28.14 Spermatids and spermatozoa
LSA 19

Figure 28.15 Endocrine control of spermatogenesis
LSA 19

Figure 29.9 Primary oocyte at metaphase I and meiosis
LSA 20

Figure 30.18 Primitive line and primitive node
LSA 21

Figure 30.19 Four-week-old embryos
LSA 21

Figure 30.20 Five-week-old embryos
LSA 21

Figure 30.21 Six-week-old embryos
LSA 21

9. *Study Cards for Anatomy and Physiology* prepared by Kent M. Van De Graaff, R. Ward Rhees, and Christopher H. Creek is a boxed set of 300 3-by-5-inch cards. It serves as a well-organized and illustrated synopsis of the structure and function of the human body. Clinical information is presented as it applies to specific body organs and systems or physiological processes. The Study Cards offer a quick and effective way for students to review human anatomy and physiology.
10. Microtest—a new computerized testing service for generating examinations and quizzes—is available to instructors who adopt the text.
11. The WCB Anatomy & Physiology Video Series consists of
 - a. Human Skeletal Musculature System (90 min., color; ISBN 15210)
 - b. Introduction to the Human Cadaver and Prosection (30 min., color; ISBN 11177)
 - c. Introduction to Cat Dissection: Musculature (55 min., color; ISBN 11630)
 - d. Blood Cell Counting, Identification, & Grouping (30 min., color; ISBN 11629)
 - e. Internal Organs and the Circulatory System of the Cat (58 min., color; ISBN 13922)
 - f. Review of the Human Skeletal System (51 min., color; ISBN 13243)
 These exceptional videotapes are available free to adopters.
12. *Coloring Review Guide for Anatomy and Physiology* prepared by Robert J. Stone and Judith A. Stone is a plastic comb-bound book emphasizing learning through the process of color association. The Coloring Guide provides a thorough review of anatomical and physiological concepts. (ISBN 17109)
13. *Atlas of the Skeletal Muscles* prepared by Robert J. Stone and Judith A. Stone is a guide to the structure and function of human skeletal muscles. The illustrations help students locate muscles and understand their actions. (ISBN 10618)
14. *Case Histories in Human Physiology* compiled by Donna Van Wynsberge and Gregory M. Colley, M.D., affords students opportunities for integrating their thinking and for problem solving. An answer key is available for instructors. (ISBN 11606)
15. *Laboratory Guide: Human Anatomy and Physiology with Clinical Applications—Cat Version* written by Stuart I. Fox, Kent M. Van De Graaff, and Lawrence G. Thouin, Jr., is designed for anatomy and physiology courses that use a body systems' approach to teach structure and function of the human body. (ISBN 05687)

Acknowledgments

This book could not have been written without the enduring patience and support of our wives, Karen Van De Graaff and Ellen Fox, to whom this book is gratefully dedicated.

Many of the improvements in the fourth edition of *Concepts of Human Anatomy and Physiology* came about through comments that we received from the many users of previous editions. Although it would be impossible in this space to acknowledge them individually, we are deeply grateful to each one. As in the past, our colleagues at our respective institutions were very supportive and helpful. In particular, we would like to thank professors Michael J. Shively, Lawrence H. Thouin, R. Ward Rhees, James Rikel, William M. Hess, and Ferron L. Andersen.

We also wish to thank physicians who assisted in specific ways. Drs. Eric J. Van De Graaff, J. Phillip Freestone, Douglas W. Hacking, and Charles H. Stewart provided professional advice. Dr. Brent C. Chandler provided many of the radiographs used in the text. Drs. James N. Jones and Paul Urie assisted in updating the clinical information.

Quality illustrations for this text were provided by a number of talented artists. We are especially grateful for their tremendous contributions. Many of the renderings new to this edition were contributed by Christopher H. Creek.

The editorial and production staffs at Wm. C. Brown Publishers inspired, guided, and shaped this enormous project, and they were superb to work with. We owe a large debt of gratitude to Acquisitions Editor Colin Wheatley, Developmental Editor Kristine Noel, Production Editor Jane Matthews, and many other talented professionals at Wm. C. Brown. We are also especially appreciative of Ann Mirels, who laboriously copyedited the manuscript and provided numerous helpful suggestions.

Reviewers

The forthright criticisms and helpful suggestions of a knowledgeable and hard-working panel of reviewers added immeasurably to the quality of the final draft. The review panel for the fourth edition included

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Elgin Community College

Idna M. Corbett
West Chester University

John G. Dziak
Community College of Allegheny County, Allegheny Campus

Kathryn L. Hedges
Indiana University Northwest

Stan Hillman
Portland State University

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Langara College

P. Stephen Taraskevich
Nova-Southeastern University

Charles H. Woodward
Shepherd College

It is our sincere hope that students and instructors will enjoy using this text and that it will serve them well. As always, we welcome suggestions and comments for future editions.