To my parents M.A. Thibodeau and Florence Thibodeau, who had a deep respect for education at all levels and who truly believed that you never give up being a student.

To my wife Emogene, an ever-generous and uncommonly discerning critic, for her love, support, and encouragement over the years.

To my children Douglas and Beth for making it all worthwhile.

Gary A Thibodeau

To my family and friends who never let me forget the joys of discovery, adventure, and good humor.

To the many teachers who taught me more by who they were than by what they said.

To my students who help me keep the joy of learning fresh and exciting.

Kevin T. Patton
Gary Thibodeau has been teaching anatomy and physiology for more than three decades. Since 1975, Anatomy & Physiology has been a logical extension of his interest and commitment to education. Gary’s teaching style encourages active interaction with students, and he uses a wide variety of teaching methodologies—a style that has been incorporated into every aspect of this edition. He is considered a pioneer in the introduction of collaborative learning strategies to the teaching of anatomy and physiology. Recent conferral of Emeritus status in the University of Wisconsin System has provided him with additional time to interact with students and teachers across the country and around the world. His focus continues to be successful student-centered learning—leveraged by text, Web-based, and ancillary teaching materials. Over the years, his success as a teacher has resulted in numerous awards from both students and professional colleagues. His biography is included in numerous publications, including Who’s Who is America; Who’s Who in American Education; Outstanding Educators in America; American Men and Women of Science; and Who’s Who in Medicine and Healthcare. While earning master’s degrees in both zoology and pharmacology, as well as a PhD in physiology, Gary says that he became “fascinated by the connectedness of the life sciences.” That fascination has led to this edition’s unifying themes that focus on how each concept fits into the “Big Picture” of the human body.

Kevin Patton has taught anatomy and physiology to community college and university students from various backgrounds for two decades. This experience has helped him produce a text that will be easier to understand for all students. He has earned several citations for teaching anatomy and physiology and in 1993 was awarded the Missouri Governor’s Award for Excellence in Teaching. “One thing I’ve learned,” says Kevin, “is that most of us learn scientific concepts more easily when we can see what’s going on.” His talent for using imagery to teach is evident throughout this edition. Kevin’s interest in promoting excellence in teaching anatomy and physiology has led him to take an active role in the Human Anatomy and Physiology Society (HAPS), currently serving as President Emeritus. Like Gary, Kevin found that the work that led him to a PhD in vertebrate anatomy and physiology instilled in him an appreciation for the “Big Picture” of human structure and function.
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SUCCESS IN BOTH TEACHING AND LEARNING IS, IN MANY WAYS, DETERMINED BY HOW EFFECTIVE WE ARE IN TRANSFORMING INFORMATION INTO KNOWLEDGE. THIS IS ESPECIALLY TRUE IN SCIENTIFIC DISCIPLINES, SUCH AS ANATOMY AND PHYSIOLOGY, WHERE BOTH STUDENT AND TEACHER ARE NOW BEING CONFRONTED WITH AN ENORMOUS ACCUMULATION OF FACTUAL INFORMATION. ANATOMY & PHYSIOLOGY IS INTENDED TO HELP TRANSFORM THAT INFORMATION INTO A COHERENT KNOWLEDGE BASE BY EFFECTIVE USE OF UNIFYING THEMES AND BY FOCUSING ON THE SIGNIFICANT AND ON WHAT IS GERMANE IN BOTH DISCIPLINES. THIS IS A TEXTBOOK INTENDED FOR USE AS BOTH A TEACHING AND A LEARNING TOOL. IT WAS WRITTEN TO HELP STUDENTS UNIFY INFORMATION, STIMULATE CRITICAL THINKING, AND HOPEFULLY, ACQUIRE A TASTE FOR KNOWLEDGE ABOUT THE WONDERS OF THE HUMAN BODY. THIS IS A TEXTBOOK THAT WILL HELP STUDENTS AVOID BECOMING LOST IN A MAZE OF FACTS IN A COMPLEX LEARNING ENVIRONMENT. IT WILL ENCOURAGE THEM TO EXPLORE, TO QUESTION, AND TO LOOK FOR RELATIONSHIPS NOT ONLY BETWEEN RELATED FACTS IN A SINGLE DISCIPLINE BUT ALSO BETWEEN FIELDS OF ACADEMIC INQUIRY AND PERSONAL EXPERIENCE. IT IS OUR HOPE THAT ANATOMY & PHYSIOLOGY WILL HELP BOTH STUDENTS AND TEACHERS TRANSFORM INFORMATION INTO KNOWLEDGE.

This fifth edition of the text has been extensively revised. New and improved pedagogical features, additional full-color illustrations, and the addition of carefully selected new information in both anatomy and physiology provide an accurate and up-to-date presentation. We have retained the basic philosophy of personal and interactive teaching that characterized previous editions. In addition, essential, accurate, and current information continues to be presented in a comfortable writing style; emphasis is placed on concepts rather than descriptions, and the “connectedness” of human structure and function is repeatedly reinforced by unifying themes.

UNIFYING THEMES

Anatomy and physiology encompass a body of knowledge that is large and complex. Students are faced with the need to know and understand a multitude of individual structures and functions that constitute a bewildering array of seemingly disjointed information. Ultimately, the student of anatomy and physiology must be able to “pull together” this information to view the body as a whole—to see the “Big Picture.” If a textbook is to be successful as a teaching tool in such a complex learning environment, it must help unify information, stimulate critical thinking, and motivate students to master a new vocabulary.

To accomplish this synthesis of information, unifying themes are required. In addition, a mechanism to position and implement these themes must be an integral part of each chapter. Unit One begins with “Seeing the Big Picture,” an overview that encourages students to place individual structures or functions into an integrated and multifunctional framework. Then, throughout the book, the specific information presented is highlighted in a special “Big Picture” section so that it can be viewed as an integral component of a single multifaceted organism. This section, first introduced in the second edition, became so popular with students that we now include a “Big Picture” section in every chapter.

Anatomy & Physiology is dominated by two major unifying themes: (1) the complementarity of normal structure and function and (2) homeostasis. The student is shown, in every chapter of the book, how organized anatomical structures of a particular size, shape, form, or placement serve unique and specialized functions. The integrating principle of homeostasis is used to show how the “normal” interaction of structure and function is achieved and maintained by dynamic counterbalancing forces within the body. Repeated emphasis of these principles encourages students to integrate otherwise isolated factual information into a cohesive and understandable whole. The Big Picture summarizes the larger interaction between structures and functions of the different body systems. As a result, anatomy and physiology emerge as living and dynamic topics of personal interest and importance to students.

AIMS OF THE REVISION

As in past editions, our revision efforts focused on identifying the need for new or revised information and for additional visual presentations that would better serve to clarify important, yet sometimes difficult, content areas. For example, we incorporated new information about the genetic basis of body structure and function gleaned from the ongoing human genome studies throughout this edition and introduced for the first time the fields of genomics and proteomics. In addition, we reorganized and rewrote much of Chapter 1 to reflect increased emphasis on the process of science, the relationship of science and society, and the unifying theme of homeostasis.

Recent editions of this textbook have been noted for their incorporation of the latest news in science as a way of engaging students in this dynamic field. This edition has maintained that tradition by introducing information about using anthrax and other diseases as a weapon, the new success of artificial hearts and other medical breakthroughs, and new information about the genetic basis of health and disease. Over the life of this textbook, each change in the selection, sequencing, or method of presentation of material has been evaluated by the authors and also by many other anatomy and physiology teachers working at every level of instruction. The feedback received from these colleagues, and from students using the text, was of inestimable value. Their input, coupled with the guidance of Mosby professionals, has helped us evaluate this entire integrated teaching and
learning package and make it the best edition yet. The package includes the textbook and an array of supplements.

We put great effort into ensuring the technical accuracy of our book. To this end we consulted with noted experts currently active in various specialties of human biological research to ensure the information presented is as up-to-date as possible. Working health care professionals were consulted to ensure that clinically oriented examples and case studies reflect current practice. As a result of this joint effort, we were able to meet our specific goal of making this text and its accompanying supplements extremely effective teaching and learning tools.

As teachers of anatomy and physiology, we know that to be effective a text must be readable, and it must challenge and excite the student. This text remains one that students will read—one designed to help the teacher teach and the student learn. To accomplish this end, we facilitated the comprehension of difficult material for students with thorough, consistent, and nonintimidating explanations that are free of unnecessary terminology and extraneous information. We have also added many examples of highly effective illustrated tables and skillfully and accurately created full-color artwork to provide a multisensory learning tool.

ILLUSTRATIONS AND DESIGN

A major strength of this text has always been the exceptional quality, accuracy, and beauty of the illustration program. This edition features many new illustrations by Barbara Cousins. We worked very closely with Barbara to provide attractive and colorful illustrations that clearly and accurately portray the major concepts of anatomy and physiology.

The truest test of any illustration is how effectively it can complement and strengthen the written information in the text and how successfully it can be used by the student as a learning tool. Each illustration is explicitly referred to in the text and is designed to support the text discussion. Careful attention has been paid to placement and sizing of the illustrations to maximize usefulness and clarity. Each figure and all labels are relevant to and consistent with the text discussion. Each illustration has a boldface title for easy identification.

The beauty of artistically drawn full-color artwork is both aesthetically pleasing and functional. Color is used to highlight specific structures in drawings to help organize or highlight complex material in illustrated tables or conceptual flow charts. The text is also filled with dissection photographs, exceptional light micrographs, and scanning (SEM) and transmission (TEM) electron micrographs, some of which are new to this edition. In addition, examples of medical imagery, including CT scans, PET scans, MRIs, and x-rays, are used throughout the textbook to show structural detail, explain medical procedures, or enhance the understanding of differences that distinguish pathological conditions from normal structure and function. All illustrations used in the text are an integral part of the learning process and should be carefully studied by the student.

LEARNING AIDS

Anatomy & Physiology is a student-oriented text. Written in a readable style, the text was designed with numerous pedagogical aids to motivate and maintain interest. The special features and learning aids listed below are intended to facilitate learning and retention of information in the most effective and efficient manner. No textbook can replace the direction and stimulation provided by an enthusiastic teacher to a curious and involved student. However, a full complement of innovative pedagogical aids that are carefully planned and implemented can contribute a great deal to the success of a text as a learning tool. An excellent textbook can and should be enjoyable to read and should be helpful to both student and teacher. We hope you agree that the learning aids in Anatomy & Physiology successfully meet the high expectations we have set.

UNIT INTRODUCTIONS

Each of the six major units of the text begins with a brief overview statement. The general content of the unit is discussed, and the chapters and their topics are listed. Before beginning the study of material in a new unit, students are encouraged to scan the introduction and each of the chapter outlines in the unit to understand the relationship and “connectedness” of the material to be studied. Each unit has a color-coded tab at the outside edge of every page to help you quickly find the information you need.

CHAPTER LEARNING AIDS

- **Chapter Outline**—summarizes the contents of a chapter at a glance.

  An overview outline introduces each chapter and enables the student to preview the content and direction of the chapter at the major concept level before beginning the detailed reading. Page references enable students to quickly locate topics in the chapter.

- **Key Terms**—introduce you to the language of anatomy and physiology.

  The most important key terms are presented at the beginning of the chapter. These terms are identified in **boldface italic** type in the text to highlight their importance. They are defined in the text body and may also be found in the glossary at the back of the book. The **boldface** type feature enables students to scan the text for new words before beginning their first detailed reading of the material so they may read without having to disrupt the flow to grapple with new, multisyllabic words or phrases.

- **Color-Coded Illustrations**—help beginning students appreciate the “Big Picture” of human structure and function.

  A special feature of the illustrations in this text is the careful and consistent use of color to identify important structures and substances that recur throughout the book. Consistent use of a color key helps beginning students appreciate the “Big Picture” of human structure and function each time they see a familiar structure in a new illustration. For an explanation of the color scheme, see the color key on page xxix, preceding the Unit One introductory text.
• **Directional Rosettes**—help students learn the orientation of anatomical structures.

Where appropriate, small orientation diagrams and directional rosettes are included as part of an illustration to help students locate a structure with reference to the body as a whole or orient a small structure in a larger view.

• **Quick Check questions**—test your knowledge of material just read.

Short objective-type questions are located immediately following major topic discussions throughout the body of the text. These questions cover important information presented in the preceding section. Students unable to answer the questions should reread that section before proceeding.

• **Cycle of Life**—describes major changes that occur over a person’s lifetime.

In many body systems, changes in structure and function are frequently related to a person’s age or state of development. In appropriate chapters of the text, these changes are highlighted in this special section.

• **The Big Picture**—explains the interactions of the system discussed in a particular chapter with the body as a whole.

This special “whole body” section helps students relate information about body structures or functions that are discussed in the chapter to the body as a whole.

• **Mechanisms of Disease**—helps you understand the basic principles of human function by showing you what happens when things “go wrong.”

Examples of pathology, or disease, are included in many chapters of the book to stimulate student interest and to help students understand that the disease process is a disruption in homeostasis, a breakdown of normal integration of form and function. The intent of the “Mechanisms of Disease” section is to reinforce the normal mechanisms of the body while highlighting the general causes of disorders for a particular body system.

• **Chapter Summary**—outlines essential information in a way that helps you organize your study.

Detailed end-of-chapter summaries provide excellent guides for students as they review the text materials before examinations. Many students also find the summaries to be useful as a chapter preview in conjunction with the chapter outline.

• **Case Study**—challenges you with “real-life” clinical situations so you can creatively apply what you have learned.
Preface

Many chapters contain boxed essays, often clinical in nature, that expand on or relate to material covered in the text. Examples of subjects include inflammation, diabetes mellitus, and skin cancer.

- **Health Matters**—present current information on diseases, disorders, treatments, and other health issues related to normal structure and function.

- **Diagnostic Study**—keep you abreast of developments in diagnosing diseases and disorders.

- **FYI**—give you more in-depth information on interesting topics mentioned in the text.

- **Sports and Fitness**—highlight sports-related topics.

- **Career Choices**—highlight individuals in health-related careers.

These boxes contain information related to health issues or clinical applications. In some instances, examples of structural anomaly or pathophysiology are presented. Information of this type is often useful in helping students understand the mechanisms involved in maintaining the “normal” interaction of structure and function.

- **Career Choices**—highlight individuals in health-related careers.

Exercise physiology, sports injury, and physical education applications are highlighted in these boxes.

- **Sports and Fitness**—highlight sports-related topics.

- **Career Choices**—highlight individuals in health-related careers.

A Career Choices box, each newly created for this edition, appears at the end of each unit. These boxes describe some of the diverse opportunities currently available in health-related occupations and also demonstrate the importance of how an understanding of anatomy and physiology will be useful to students in their futures.
MINI-ATLAS OF HUMAN ANATOMY
A full-color Mini-Atlas of Human Anatomy containing cadaver dissections, osteology, organ casts, and surface anatomy photographs follows the last chapter.

GLOSSARY
A comprehensive glossary of terms is located at the end of the text. Accurate, concise definitions and phonetic pronunciation guides are provided.

LEARNING SUPPLEMENTS FOR STUDENTS
MERLIN
MERLIN is an interactive web site with content updates, student resources, and WebLinks. WebLinks provide students with access to hundreds of important sites simply by clicking on a subject in the book’s table of contents. Now enhanced with activities and quizzes, MERLIN is a virtual library of information at your fingertips.

CD-ROM: PANORAMA OF ANATOMY AND PHYSIOLOGY
Free with every copy of Anatomy & Physiology is an interactive CD-ROM, developed by Cecil Hampton and Melissa Cufman-Falvey, that builds on the textbook content. The opening menu of choices offers students dozens of exercises and learning opportunities that will enhance and reinforce their learning of anatomy and physiology. Examples of content include study questions on topics such as cytology, endocrinology, and histology; quizzes; body schematics; cadaver photos and images for labeling; movie clips, humor, and fun facts.

STUDY AND REVIEW GUIDE
The Study and Review Guide, written by Linda Swisher, is a valuable workbook for students that provides the reinforcement and practice necessary for students to succeed in their study of anatomy and physiology. Important concepts from the text are reinforced through Concept Reviews, organized by objectives and referenced to the text. Clinical Challenges apply the material to “real-life” situations. Matching, completion, and illustration labeling exercises are provided for every chapter.

ANATOMY & PHYSIOLOGY LABORATORY MANUAL
The A&P Laboratory Manual, newly revised by Kevin Patton, continues to be an invaluable resource for students. This extensively illustrated manual contains 55 well-integrated exercises providing hands-on learning experience to help students acquire a thorough understanding of the human body.

A full-color reference section on histology specimens and cat and fetal pig anatomy is included. Other features are boxed hints on handling specimens and managing laboratory activities, boxed safety tips, coloring exercises, and coverage of cat, fetal pig, and laboratory rat dissection. Each exercise concludes with a lab report that may also serve as a self-test.

TEACHING SUPPLEMENTS FOR INSTRUCTORS
INSTRUCTOR’S RESOURCE CD-ROM
The Instructor’s Resource CD-ROM was written and developed specifically for this new edition of Anatomy & Physiology. It includes an Instructor’s Resource Manual for the textbook with critical thinking questions, learning objectives and activities, teaching tips for the text and CD, synopses of difficult concepts, and clinical applications exercises. The new CD-ROM also includes a Computerized Test Bank with almost 6,000 multi-choice, true/false, short answer, and challenge questions, as well as the Electronic Image collection to accompany Anatomy & Physiology, featuring approximately 400 full-color illustrations and photographs.

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COLOR KEY

COLOR KEY

BIOCHEMISTRY

Carbon
Chloride
Energy (ATP)
Hydrogen
Nitrogen
Oxygen
Potassium
Sodium
Sulfur

OTHER STRUCTURES

Afferent (Sensory) Pathway
Artery
Bone
Efferent (Motor) Pathway
Hormone
Muscle
Nerve
Schwann Cell
Vein

CELLULAR STRUCTURES

Axon
Cytosol
Golgi Apparatus
Mitochondrion
Na⁺ Channel
Nucleus
Plasma Membrane