



ESSENTIALS OF
Anatomy &
Physiology

SEELEY
STEPHENS
TATE

SECOND EDITION

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Anatomy & Physiology

SECOND EDITION

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This book is dedicated to our families for their support and encouragement.

Rod R. Seeley, Professor of Physiology, Idaho State University

With a bachelor's degree in zoology from Idaho State University and a master's degree and doctorate in zoology from Utah State University, Rod Seeley has built a solid reputation as a widely published author of journal and feature articles, a popular public lecturer, and an award-winning instructor. Very much involved in the methods and mechanisms that help students learn, he contributes to this text his teaching expertise and proven ability to communicate effectively in any medium.

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PREFACE

Human anatomy and physiology courses present exciting challenges to both students and faculty. Acquisition of basic anatomical and physiological facts is essential to the study of these subjects, but the task doesn't end there. The human body is dynamic, and to understand its structure and function, it is necessary to accurately predict how it responds to stimuli. In addition, given responses, it is important to be able to analyze them and determine the possible stimuli that produce them. Knowledge and practice in solving problems that require predictions and analyses are necessary for the development of a strong background in anatomy and physiology. Students who develop problem-solving skills are better able to respond reasonably and effectively to new situations. They are better prepared to be effective health care professionals and citizens than people who have simply memorized information that is soon forgotten.

Like the first edition, the second edition of *Essentials of Anatomy and Physiology* is designed to help students learn the basic facts of human anatomy and physiology. Information is presented in a readable form that describes structures of the body, their functions, and how they are controlled. In addition, concepts are explained so that they can be understood rather than simply memorized. Emphasis is placed on developing the “big picture” rather than on simply presenting a large amount of detail. Only enough detail is included to allow students to understand the function of each system and how it is regulated.

Essentials of Anatomy and Physiology is unique in its approach to the development of problem-solving skills. It provides a gentle introduction to problem-solving techniques that can be emphasized to a greater extent as students progress through the course. The problem-solving exercises often use clinical examples that are relevant to students who take this course as part of their education for their careers or to students who are simply interested in the structural and functional characteristics of the human body.

Essentials of Anatomy and Physiology also compares favorably with other texts at this level with respect to the presentation of content, and the structure of the text is flexible in that it can be used successfully in the numerous courses that focus primarily on basic content and the learning of new vocabulary.

THEMES

The relationships between **structure and function** and **homeostasis** are major themes in this text, and there is an increased emphasis on these relationships in the second edition. Relationships between structures and their functions are apparent for many parts of the body. For example, bones are well suited to support the body, skin is well suited to provide a barrier between the inside and outside of the body, teeth are well suited for cutting and grinding food, and the urinary bladder is well suited for storing urine. However, relationships between structures and their functions must be described from other angles. For example, a more thorough explanation of bone structure and function allows students to understand how mineral deposits in the extracellular material of bone provide strength and how bone grows, protects internal organs, and stores essential minerals. A more thorough explanation of skeletal muscle structure and function allows students to understand how skeletal muscle cells are able to shorten with a force, how they are able to relax, and how they are controlled by the nervous system to result in coordinated movements.

Homeostasis, the maintenance of an internal environment within an acceptably narrow range of values, is necessary for the survival of the human body. For instance, if the blood delivers inadequate amounts of oxygen to body cells, heart and respiration rates increase until oxygen delivery becomes adequate. There is a continued emphasis in the second edition on the mechanisms that maintain homeostasis and on the presentation of these mechanisms in a clear and understandable fashion. Because failure of homeostatic mechanisms also illustrates how they work, pathological conditions that result in dysfunction, disease, and possibly death are also presented. A consideration of pathology adds relevance and interest that makes the material more meaningful. Many of the problem-solving exercises presented in this edition use examples that help students to understand common pathologies.

Teaching human anatomy and physiology in the 1990s is a greater challenge than before. There is an ever-increasing need for students to learn relevant, up-to-date information, but there is also an increasing recognition that knowledge of content alone is only a beginning. It is essential that anatomy and physiology students develop their ability to solve

practical, real-life anatomy and physiology problems. Though today's knowledge will change and expand, problem-solving skills will always be an asset for students.

The themes—the relationship between structure and function and homeostasis—combined with a problem-based learning approach, make this text quite unique among anatomy and physiology texts.

A SYSTEMATIC PRESENTATION OF CONTENT

This text provides a solid, although basic, foundation in anatomy and a basic coverage of physiology. Content is explained with an emphasis on a conceptual framework that ties individual bits of information together. Explanations start with simple, easy-to-understand facts and are developed in a logical sequence. Students will be able to see the “big picture” without being overwhelmed with details. In this edition, each chapter has been reviewed and updated. New discoveries that have been responsible for increasing the understanding of structures and functions have been incorporated while maintaining an emphasis on basic functions.

Understanding the material has a number of benefits. It makes the information meaningful and thus reduces the amount of memorization necessary to master the material, and it also makes it possible to use basic knowledge to solve problems. Reinforcing content through application improves long-term retention, because, once the information is understood and used, it “belongs” to the student.

There is greater emphasis on tables that present an overview of the regulation of systems. Examples include tables that provide an overview of the regulation of the heart, blood pressure, and respiration. The tables are designed to provide a concise and easily understood overview of all of the regulatory mechanisms that control a system. Students can then use this concise presentation of information to make predictions and solve problems. A better understanding of how homeostasis is maintained can be achieved with less effort than would be required if students had to create their own summaries of the regulatory systems.

RELEVANT CLINICAL EXAMPLES

Clinical information should not be an end in itself. In some texts, mere clinical descriptions or medical terminology represents a significant part of the material. This text provides clinical examples to promote interest, demonstrate relevance, and to illustrate the application of basic knowledge. As a result, students using this text are encouraged in

their professional and private lives to effectively use the knowledge they have gained through comprehending and solving basic clinical problems. New clinically related information and problems have been included in the text and, when appropriate, old problems have been updated to be consistent with the most current methodologies and information.

ANALYSIS OF PRACTICAL PROBLEMS

At best, some anatomy and physiology texts include a few “thought” questions that, for the most part, involve a restatement or a summary of content. Yet once students understand the material well enough to state it in their own words, it only seems logical for them to proceed to the next step—that is, to apply the knowledge to hypothetical situations. This text features two sets of problem-solving questions in every chapter, *Predict Questions* and *Concept Questions* (to be highlighted in more detail later in this preface). Answers and explanations for these questions are provided. The explanations illustrate the methods used to solve problems and provide a model for the development of problem-solving skills. The acquisition of such skills is necessary for a complete understanding of anatomy and physiology, it is fun, and it makes it possible for the student to deal with the many problems that occur as a part of professional and everyday life.

ILLUSTRATION PROGRAM

The statement, “A single picture is worth 10,000 words,” is especially true in anatomy and physiology. Structure/function relationships become immediately apparent in the well-designed, accurate illustrations in this text. To maximize the effectiveness of the illustrations, they have been placed as close as possible to the narrative where they are cited, and special attention has been devoted to the figure legends, which summarize or emphasize the important features of each illustration. Where appropriate, explanatory information is included in the illustration to make the concepts clearer to students. Although the anatomical drawings are accurate and the physiological flow diagrams and graphs are conceptually clear, the illustrations do more than just present important information. They are nonintimidating and aesthetically pleasing, and thus they encourage the student to spend time with them for maximum learning and pleasure. Most of the art in this textbook is in full color, making the illustrations attractive and emphasizing the important structures. In this edition, many illustrations have been altered, modified, or replaced to increase the ease of under-

standing, reflect the discovery of new information, or enhance the attractiveness of the presentation.

In addition to the illustrations, numerous photographs bring a dimension of realism to the text. In most cases, photographs are accompanied by line drawings that emphasize important features of the photograph.

HISTORY OF DEVELOPMENT

No matter how innovative our original vision for *Essentials of Anatomy and Physiology* may have been, there is no doubt that, without the help of numerous instructors who were willing to help us implement our ideas, we would have not been able to produce the first edition. It was our goal to produce a text embodying our unique ideas, which would also be judged suitable for widespread classroom use. Fortunately, many of our reviewers were in agreement with our goals, for they too had often experienced frustrations with their existing texts.

After *Anatomy and Physiology* was published, it became apparent that instructors like the problem-based learning approach, the example-rich narrative, and the well-planned illustrations. It also became apparent that many courses need a less comprehensive text—either due to time restrictions or a less clinically oriented student population. With this in mind, we began writing *Essentials of Anatomy and Physiology*, a book that combines the “essence” of the problem-solving approach and the outstanding illustrations of *Anatomy and Physiology* with the essential concepts necessary to understand this subject. Further, reviewers have provided extremely valuable comments about the problem-based learning approach used in this text. As a result, modified problems and additional problems have been included in the second edition, which are designed to encourage students to become “active” learners. In addition, emphasis has been placed on a gentle introduction to problem solving. The intent is to provide encouragement to students as they learn to solve problems.

The first edition of *Essentials of Anatomy and Physiology* was reviewed by a panel of 17 reviewers, and a list of suggested alterations reported by users was meticulously maintained. All of these comments were carefully evaluated before writing the first draft of the second edition. Subsequently, our first-draft manuscript was carefully reviewed by a panel of eight instructors, individuals who thoughtfully helped us focus on the “truly essential concepts” of anatomy and physiology. Special efforts were made to ensure that concepts are presented at an appropriate level of understanding for their students without

becoming erroneous or ambiguous. Reviewers for both the first and second editions were indispensable in our effort to produce a useful, accurate anatomy and physiology text.

The illustration program for the second edition enjoyed a similar developmental process. All illustrations have been carefully reviewed to ensure that the labeling and legends are at a similar level to the text. In as much as the illustrations can be as important as the narrative in an anatomy and physiology text, it was essential that they be accorded such treatment. Many illustrations have been replaced with new illustrations that have more color, updated information, or a clearer presentation. In addition, text material has been included in several illustrations to make the concept of the illustration clearer to students. The second edition of *Essentials of Anatomy and Physiology* builds on the first edition’s illustration program and is designed to make structures and physiological concepts clear and easily understood.

LEARNING AIDS

The text must be an effective teaching tool. Because each student may learn best in a different way, a variety of teaching and learning aids are provided. This enables students to organize the material in their minds, determine the main points, and evaluate the progress of their learning. All of these teaching aids were reviewed and changes eliminating ambiguities and emphasizing important concepts more clearly have been made.

Objectives

Each chapter begins with a series of learning objectives. The objectives are not a detailed cataloging of everything to be learned in the chapters. Rather, they emphasize the important facts, topics, and concepts to be covered. The chapter objectives are a conceptual framework to which additional material will be added as the chapter is read in detail.

Vocabulary aids

Learning anatomy and physiology is, in many ways, like learning a new language. To communicate effectively, a basic terminology, dealing with important or commonly used facts and concepts, must be mastered. At the beginning of each chapter are the *Key Terms*, a list of some of the more important new words to be learned along with their definitions. Throughout the text, these and additional terms are presented in **bold print**. When it is instructionally valuable, the *derivation* or *origin* of the word is given. In their original language, words are often

descriptive, and knowing the original meaning can enhance understanding and make it easier to remember the definition of the word. Common prefixes, suffixes, and combining forms of many biological terms appear on the inside front and back covers of the text and provide additional information on the derivation of words. When pronunciation of the word is complex, the *pronunciation* is given. Often simply being able to pronounce a word correctly is the key to remembering it. The most important terms and their pronunciations, when applicable, together with a pronunciation guide, are contained in the *Glossary* for easy reference. In the second edition pronunciation guides are provided more frequently with bold terms.

Did You Know?

Brief statements entitled *Did You Know?* often follow the discussion of an important concept. They illustrate important anatomical or physiological concepts and clarify them by presenting examples of the concepts in action. For example, a *Did You Know?* statement may illustrate the normal response of a system to exercise, or it might describe a pathological condition that shows how a system responds to an abnormal situation. The advantage of these brief statements is that they appear right after the presentation of concepts. In this way the relevance of the concept is immediately apparent, helping the student to better appreciate and understand it. The amount of current, relevant, and interesting information presented in *Did You Know?* statements has increased in the second edition.

Boxed Essays

These essays are expanded versions of the brief *Did You Know?* statements that permit a more detailed or complete coverage of a topic. Subjects covered include pathologies, current research, sports medicine, exercise physiology, pharmacology, and clinical applications. They are designed not only to illustrate the chapter content but to stimulate interest as well. There are more *Boxed Essays* in the second edition, allowing the presentation of topics that are highly interesting to students without substantially increasing the length of the book.

Predict Questions

Predict questions require the application of concepts. When reading a text, it is easy to become a “passive” learner; everything seems very clear to passive learners until they attempt to use the information. Predict questions convert the “passive” learner into an “active” learner who must use new information to solve problems. The answers to predict ques-

tion are not mere restatements of fact, but rather predictions, analyses of data, the synthesis of experiments, or the evaluation and weighing of the important variables of the problems. For example, “Given a stimulus, predict how a system will respond.” Or, “Given a clinical condition, explain why the observed symptoms occurred.” Predict questions are practice problems that help to develop the skills necessary to answer the concept questions at the end of the chapter. In this regard, not only are possible answers given for the predict questions, but explanations that demonstrate the process of problem-solving are also provided. In response to reviewers, the second edition includes more predict questions designed to provide a gentle introduction to problem solving. There is a transition from easier to harder questions from earlier to later chapters.

Tables

The tables in the book have several useful functions. They provide more specific information than that included in the text discussion, allowing the text to concentrate on the general or main points of a topic. They also summarize a particular aspect of the chapter content, providing a convenient way to find information quickly. Often a table is designed to accompany an illustration so that a written description and a visual presentation are combined to communicate information effectively. Several tables have been designed to summarize the mechanisms by which homeostasis is maintained and offer students an overview. On a single page, students can see all of the mechanisms that play a role in the regulation of some function. In conjunction with the text, these summary tables help students develop a working understanding of regulation of the heart, blood pressure, and others.

Chapter Summary

As the student reads the chapters, details can often obscure the overall picture. The chapter summary is an outline that briefly states the important facts and concepts and provides a perspective of the “big picture.”

Content Review

The content questions are another method used in this text to turn the passive learner into an active learner. The questions systematically cover the content and require students to summarize and restate the content in their own words.

Concept Review

Following the mastery of the content review, the concept review requires the application of that con-

tent to new situations. These are not essay questions that involve the restatement or summarization of chapter content. Instead, they provide additional practice in problem solving and promote the development and acquisition of problem-solving skills. The concept questions have been reviewed and altered much like the predict questions were reviewed and altered. The package of predict and concept questions in the second edition of *Essentials of Anatomy and Physiology* are unique because they encourage students to understand anatomy and physiology in a predictive and analytical fashion.

Appendixes

Appendix A is a table of measurements. Reference to this table will help the student relate the metric system to the more familiar English system when determining the size or weight of a structure.

Appendix B is a table of routine clinical tests along with their normal values and clinical significance. Reference to this table will provide students with the homeostatic values of many common substances in the blood and urine. Also, the importance of laboratory testing in the diagnosis and/or treatment of illnesses becomes apparent to the students.

Appendixes C, D, and E have been added to the second edition of *Essentials of Anatomy and Physiology*. Appendix C will help the student understand the shorthand of scientific notation. Appendix D explains the rationale behind how various solutions may be described. Appendix E explains the concept of pH and how it is measured.

SUPPLEMENTS

Any textbook can be used alone, but thoughtfully developed supplements increase its effectiveness for both student and instructor, because the supplements are designed to support the pedagogical model developed in the text. This text is accompanied by a wide range of supplements designed to complement the text.

Study Guide

The study guide by James Kennedy and Philip Tate of Phoenix College supports the problem-based learning approach of the text. It introduces the student to the content of anatomy and physiology using, matching, labeling, and completion exercises. A Mastery Learning Activity consisting of multiple-choice questions emphasizes comprehension of the material, evaluates progress, and prepares the student for classroom testing. In addition, a Final Challenges section consisting of essay questions provides practice with questions similar to the predict

and concept questions of the textbook. Answers are given for all exercises, and explanations are furnished for the Mastery Learning Activity and the Final Challenges. The study guide has been carefully reviewed by experienced instructors who currently teach anatomy and physiology, and it provides the reinforcement and practice so essential for the student's success in the course.

Laboratory Manual

The laboratory manual, developed by Kevin Patton of St. Charles County Community College, divides the material typically covered in anatomy and physiology labs into 42 subunits. Selection of the subunits and the sequence of their use permit the design of a laboratory course that is integrated with the emphasis and sequence of the lecture material. As with the textbook and the study guide, basic content is introduced first, and gradually more complex activities are developed. This laboratory manual also contains boxed hints, safety boxes, separate lab reports, and coloring exercises. An instructor's manual to accompany the laboratory manual is available. Once again, the suggestions and corrections of reviewers with wide experience in teaching anatomy and physiology have been incorporated in this supplement.

Instructor's Manual/Test Bank

The instructor's manual, written by James Kennedy of Phoenix College, has many features to assist in the development of a well-integrated course. It suggests ways to organize the material and is keyed to relevant transparencies, boxed essays, illustrations, and laboratory exercises. Major points that deserve emphasis are included, hints on how to reinforce concepts are given, typical problem areas are noted along with ways to deal with the problems, and possible topics for discussion are considered. Answers for the concept questions at the end of each chapter in the text are included, as are 150 transparency masters, including key diagrams from the text, as well as additional useful material for handouts. For the novice instructor or teaching assistant, there is a "Teaching Survival Guide." Each chapter includes a list of relevant audiovisual resources. The manual also contains an extensive listing of laboratory supply houses. Perhaps the most unique feature of this manual is the conversion notes that detail the differences in terms of organization and coverage between our text and several of the other leading texts now on the market. This is an ideal tool to assist you in converting your lecture notes from your current text to the Seeley/Stephens/Tate text. The Test Bank, also written by James Kennedy, has been carefully designed to complement the textbook and the study guide. The test

bank contains over 1000 test items, including multiple choice, completion, matching, and essay questions. Each question is classified according to level of difficulty, and answers are provided. All the questions have been carefully reviewed and painstakingly polished to offer an excellent evaluative tool.

Transparencies

A set of 150 full-color transparencies, which emphasize the major anatomical structures and physiological processes covered in the textbook, are available to qualified adopters. These transparencies have been selected from illustrations in the text and provide a common vehicle for communication between the lecturer and the student. Larger, bolder labels have been added to enhance classroom efficacy.

Test-generating system

The test bank questions are also available on Computest, a computerized test generation system for IBM users. It has many features that make it easy for the instructor to design tests and quizzes. The instructor can browse and select questions for inclusion on an examination using several different criteria, including question type and level of difficulty. A similar test-generating system is available for Macintosh and Apple users.

Human Body Systems Software

Developed by Kevin Patton and Katharine Baalman of St. Charles County Community College, this interactive software program allows the student to experience applications relevant to anatomy and physiology. The software is divided into 11 body system modules. Each module contains an introduction, a tutorial with practice review questions, a practical application section, and a final quiz. It is available on IBM to qualified adopters.

BodyCheck. The Anatomy and Physiology CD-ROM Tutorial

This interactive tutorial in CD-ROM format leads the student through a review of systemic anatomy and physiology. Gross human dissection photos, diagrams, x-rays, CT scans, and animations are used to provide visual support. A self-testing mode will help students make the most of their study time.

ACKNOWLEDGMENTS

The efforts of many people are required to produce a modern textbook. It is difficult to adequately acknowledge the contributions of all the people who have played a role. The encouragement and emotional support of our families were essential for the com-

pletion of this project. Their tolerance of the many evenings and weekends dedicated to this project and the many hours they enthusiastically endured discussions of the text were essential for its completion.

We wish to express our gratitude to the staff of Mosby for their steadfast help and encouragement. It has clearly been more than a vocation to them. Robert Callanan and Kristin Shahane have worked with us in an untiring fashion to bring this work to completion. We also thank our production editor, Mary Drone, who spent many hours turning our manuscript into a book. Their effort and contributions, as well as the many others who have influenced the design and production of this text, are greatly appreciated.

We thank the team of artists who have contributed to the text. Their attention to detail and their artistic contribution have made the text attractive as well as an effective teaching tool.

We sincerely thank the reviewers. This book was conscientiously reviewed by people who are exceptional teachers and who are dedicated to excellence. Their constructive comments and suggestions have added substantially to the quality of the text.

**Rod Seeley
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