CONCEPTS IN BIOLOGY

ENGER • ROSS

EIGHTH EDITION

CONCEPTS IN BIOLOGY

eighth edition

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TECHNOLOGY SUPPLEMENTS

EXPLORATIONS

Explorations in Human Biology and *Explorations in Cell Biology and Genetics* are interactive CD-ROMs by George B. Johnson. *Explorations* are referenced at the ends of related chapters of *Concepts in Biology* by a CD icon ( ). The *Explorations* contain activities that can be used by an instructor in lecture and/or placed in a lab or resource center for student use. This interactive software consists of modules that cover key topics discussed in a biology course. The CD-ROMs are available for use with Macintosh and IBM Windows computers. *Explorations* are referenced in the following chapters:

Explorations in Human Biology

Chapter 4	Cystic Fibrosis, Module 1 Active Transport, Module 2
Chapter 7	Smoking and Cancer, Module 6
Chapter 10	Constructing a Genetic Map, Module 14 Heredity in Families, Module 15
Chapter 14	Pollution of a Freshwater Lake, Module 16
Chapter 18	Cystic Fibrosis, Module 1 Active Transport, Module 2 Evolution of the Heart, Module 5
Chapter 19	Life Span and Lifestyle, Module 3 Diet and Weight Loss, Module 7

Explorations in Cell Biology and Genetics

Chapter 4	Cell Size, Module 2 Active Transport, Module 3
Chapter 5	Enzymes in Action: Kinetics, Module 7
Chapter 6	Oxidative Respiration, Module 8 Photosynthesis, Module 9
Chapter 7	Reading DNA, Module 15 Gene Regulation, Module 16 Making a Restriction Map, Module 17
Chapter 10	Constructing a Genetic Map, Module 11 Heredity in Families, Module 12
Chapter 18	Active Transport, Module 3

LIFE SCIENCE ANIMATIONS

Life Science Animations by Wm. C. Brown Publishers is a set of six videotapes containing 66 animations of physiological processes integral to the study of biology. Topics covered include chemistry, genetics, and reproduction. The animations are keyed to the *Concepts in Biology* text by a videotape icon ( ) ahead of the legends for the following figures:

Figure 2.9 Tape 1 (1)	**Fluoride Ion** Formation of an Ionic Bond
Table 3.1	**A Summary of the Types of Organic Molecules Found in Living Things**
Tape 4 (42)	Structure and Function of Antibodies
Figure 4.1 Tape 1 (2)	**Cells—Basic Structure of Life** Journey into a Cell
Figure 4.6 *Tape 6 (2)	**Osmotic Influences on Cells** Osmosis
Figure 4.7 Tape 1 (4)	**Facilitated Diffusion** Cellular Secretion
Figure 4.8 *Tape 6 (3)	**Active Transport** Active Transport Across a Cell Membrane
Figure 4.9 Tape 1 (3)	**Phagocytosis** Endocytosis
Figure 5.2 *Tape 6 (1)	**Enzyme-Substrate Complex Formation** Lock-and-Key Model of Enzyme Action
Figure 6.2	**Biochemical Pathways That Involve Energy Transformation**
Tape 5 (46)	Journey into a Leaf
Figure 6.3 Tape 1 (11)	**Just the Right Amount of Power for the Job** ATP as an Energy Carrier
Figures 6.5, 6.8 Tape 1 (6)	**Oxidation-Reduction (Redox) Reactions** Oxidative Respiration (including Krebs Cycles)
Figures 6.7, 6.10 Tape 1 (5)	**Glycolysis** Glycolysis
Figures 6.9, 6.12, 6.19 Tape 1 (7)	**The Electron Transport Process** The Electron Transport Chain and the Production of ATP

Figure 6.19 Tape 1 (8)	**The Light-Energy Conversion Stage** The Photosynthetic Electron Transport Chain and Production of ATP
Figure 6.21 Tape 1 (9,10)	**The Carbon Dioxide Conversion Stage** C_3 Photosynthesis, C_4 Photosynthesis
Figures 7.6, 7.7 Tape 2 (15)	**The Process of DNA Replication** DNA Replication
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Figure 8.1 Tape 2 (12)	**The Cell Cycle** Mitosis
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Figure 10.2 Tape 4 (40)	**A Pair of Homologous Chromosomes** A, B, O Blood Types
Figure 14.5 Tape 5 (52)	**Energy Flow through an Ecosystem** Energy Flow through an Ecosystem
Figures 15.9, 15.11 Tape 5 (51)	**The Carbon Cycle, The Nitrogen Cycle** Carbon and Nitrogen Cycles

**Physiological Concepts of Life Science* videotape.

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PREFACE

PURPOSE

We are proud to present the eighth edition of *Concepts in Biology*. The origin of this book is deeply rooted in our concern for the education of college students in the field of biology. With each new edition, we've worked hard to maintain our original goal of writing a book that is useful, interesting, and user-friendly.

We continue to believe that large, thick books intimidate introductory-level students, who often are already anxious about taking science courses. Lengthy books also tend to put off those students who are simply uninterested in science. In addition, larger books are more expensive, and their production expends more natural resources. The printing of our text on recycled paper reflects this philosophy.

Organization

Concepts in Biology is arranged in a traditional manner, progressing from the basic to the complex. It begins with a discussion of the meaning, purpose, and future of biology as a scientific endeavor. It then covers biological concepts as an expanding spiral of knowledge. Thus, chemistry is followed by cell biology, cell division, genetics, ecology, evolution, anatomy and physiology, and the diversity and classification of living things.

The Eighth Edition

As always, we greatly appreciate the suggestions of users of the text and reviewers of the current edition. We have carefully considered their comments and responded by making appropriate changes.

The text material has been significantly rewritten to ensure a flow of ideas that will best enable students to link information in a logical way. "For Your Information," "Experience This," and feature boxes ("How Science Works" and "Outlooks") were revised to include topical information of interest to students.

The illustrations are a vital and integrated part of the text. They have been carefully chosen to clarify textual material and provide new insights. Fully one-quarter of all the illustrations have been revised. Captions have been critically examined for accuracy and appropriateness. Following is a list of the chapters in which significant changes and improvements have been made.

Chapter 1: What is Biology? Coverage of the scientific method was enhanced for better student understanding of the idea that the scientific method is not a lock-step approach to problem solving, but is more flexible.

Chapter 2: Simple Things of Life This chapter has been reworked to better focus student attention on the energy associated with chemical bonds and how that relates to the formation of molecules typically found in living things. This information is presented at the outset of the chapter and is dealt with throughout. The concepts of mixtures and suspensions are presented early in the chapter and are correlated with the information on chemical bonding. These points should better enable the student to understand the nature of matter and chemical reactions. The section dealing with chemical reactions has been improved to provide a better foundation for biochemical information presented in later chapters.

Chapter 4: Cell Structure and Function Because the concepts of diffusion, osmosis, dialysis, active transport, phagocytosis, and facilitated diffusion are so important, they have been given their own headings: "Getting Through Membranes" and "Controlled Methods of Transporting Molecules." Information formerly presented in other chapters has been gathered together at this point and again related to the basic chemical principles presented in chapters 1, 2, and 3. A more detailed introduction is provided for the concepts of iso-, hyper-, and hypotonic solutions.

Chapter 6: Biochemical Pathways This chapter has undergone major changes. The first portion of the chapter focuses on energy and cells, particularly cellular respiration and photosynthesis. However, the discussion of photosynthesis is short and is presented to underscore the concept of energy flow and utilization among living things. The remainder of the chapter concentrates on respiration, both aerobic and anaerobic. The basics of oxidation-reduction reactions are also featured early in this chapter and are continued throughout.

Because of the difficulty associated with the topics in chapter 6, three levels of presentation have been developed. Level 1 is the most basic, providing the student with only the most elementary understanding. Level 2 develops the concepts by exploring the topic in greater depth, while level 3 presents the greatest detail. Students are advised to ask

their instructor which level of understanding they should try to achieve. For allied health students, it is probably advisable to utilize all three levels. They can use level 1 material as an introduction to the topic, level 2 to more slowly increase their understanding, and level 3 to attain the degree of understanding required for further biological and clinical courses dealing with respiration and associated concepts.

Chapter 11: Diversity Within Species The chapter has been retitled, and a new "Outlooks" reading, "Biology, Race, and Racism," has been added. The term *allele frequency* has been used throughout when appropriate, rather than the less precise term *gene frequency*. A new section on the nature of species and the difficulty in defining a species has also been added.

Chapter 12: Natural Selection and Evolution This chapter also carries a new title, "Natural Selection and Evolution," making the point that these two concepts are not the same. A new section summarizing the causes of evolution has been added.

Chapter 13: Speciation and Evolutionary Change Two new sections have been added: "The Tentative Nature of Evolutionary Thought" and "Human Evolution."

Chapter 15: Community Interactions New information on integrated pest management has been added, and the material on succession has been moved to chapter 14.

Chapter 17: Behavioral Ecology A new section on human behavior has been added.

Chapter 19: Nutrition: Food and Diet A new section has been added on the technical definition of obesity and how to calculate it. Many sections have been modified to incorporate the most recent information about nutrition.

Chapter 21: Human Reproduction, Sex, and Sexuality A new "How Science Works" reading has been added on "Speculation on the Evolution of Human Sexual Behavior" In addition, recent material on the role of genes in homosexuality has been added. Several new illustrations about the following topics appear: Turner's syndrome, Klinefelter's syndrome, descent of the testes, Barr body, and sperm production.

Chapter 22: The Origin of Life and Evolution of Cells A new "How Science Works" reading on RNA as the first genetic material has been added to this chapter.

Chapter 25: Plantae A new "Outlooks" reading on the plant materials we use for spices has been added.

Chapter 26: Animalia A new "Outlooks" reading on parthenogenesis has been added.

Aids to the Reader

Concepts in Biology, eighth edition, contains a number of features intended to actively involve students in the learning process. Each chapter contains these elements:

Chapter Outline As part of the chapter opening, the outline lists the major headings in the chapter.

Purpose This statement explains the value of each chapter to the understanding of a complete biology course.

For Your Information This introductory section provides interesting and timely information related to the chapter content.

What's Ahead? At the beginning of each chapter, a list of questions focuses students' attention on the nature of the material and engages their interest.

Topical Headings Throughout the chapter, headings emphasize the essential concepts for understanding biology as a science.

Full-Color Graphics Numerous line drawings and photographs illustrate concepts or associate new concepts with previously mastered information. Every illustration emphasizes a point or helps teach a concept.

Chapter Summary At the end of each chapter, the summary clearly reviews the concepts presented.

Thinking Critically This feature focuses on issues that challenge the student to think logically through problems and arrive at conclusions based on the concepts of the chapter.

Experience This Using this feature, students can apply knowledge gained from the chapter.

Questions This review of the material helps students determine whether they have mastered the contents of the chapter. Page references are provided to send students back into the chapter to find the answers.

Chapter Glossaries The glossary at the end of each chapter immediately reinforces the terms necessary for student comprehension of concepts.

Comprehensive Glossary The glossary at the end of the text serves as a single resource for essential terminology used throughout.

Phonetic Pronunciations You will notice that phonetic spellings follow most glossary entries. The following pronunciation system is used:

An unmarked vowel (a,e,i,o,u) at the end of a syllable has the long sound, as in the word "prey" (pra). An unmarked vowel followed by a consonant has the short sound, as in the phonetic spelling of the word "cell" (sel).

A vowel in the middle of a syllable may have a mark over it to indicate a short or long sound. A straight bar (ā) indicates the long sound, and a small arc (ă), the short sound. The word "acetyl" (ă-sēt´ l) shows these two marks plus an accent (´) that indicates stress on the second syllable. Some phonetic spellings may also have a double accent (˝). The double-accented syllable is stressed, too, but not as much as the single-accented syllable; for example, res˝ pĭ rā´ shun.

Writing Style and Readability The Fry Readability Graph has been used to verify the appropriateness of the language level for an introductory biology course. The informal, easy-to-read style has been praised by reviewers and adopters.

Boldface type is used to focus student attention on a key term when it is first defined in the text. Italic type emphasizes important terms, phrases, names, and titles. Graphics—often in the form of logical flow diagrams, analogy diagrams, and charts—clarify the text narrative.

Support Materials

The following supplementary materials have been developed to accompany *Concepts in Biology,* eighth edition:

The **Instructor's Manual/Test-Item File** provides a rationale for the use of each chapter as well as explanations about *Experience This* and an answer key for text questions.

Classroom Testing Software, a computerized test bank of the test items in the instructor's manual, is available in DOS, Windows, and Macintosh formats.

The **Laboratory Manual** features 29 carefully designed, class-tested exploratory investigations that may be used in the laboratory.

The **Laboratory Resource Guide** provides information on acquiring, organizing, and preparing laboratory equipment and supplies. The guide follows the arrangement of exercises in the laboratory manual, enabling instructors to efficiently select learning experiences most appropriate for their students. Estimates of the time required for students to complete individual laboratory experiences are also provided, along with answers to questions in the laboratory manual.

A revised **Student Study Guide,** in a reformatted version, features an overview as well as multiple-choice, fill-in-the-blank, and label/diagram/explain questions. Answers to the objective questions are provided in an appendix to allow for immediate feedback. The study guide is available through your college bookstore.

Seventy-five full-color **transparencies** are available free to adopters of *Concepts in Biology.* The transparencies are taken from the text and represent the important figures that merit extra visual review and discussion.

Supplementary Materials

How to Study Science

The new second edition of this workbook, by Fred Drewes of Suffolk County Community College, offers students helpful suggestions for meeting the considerable challenges of a science course. It gives practical advice on such topics as how to take notes, how to get the most out of laboratories, and how to overcome science anxiety. Exercises at the end of each chapter are appropriate for either classroom assignments or independent study.

A Life Science Lexicon/A Life Science Living Lexicon CD-ROM

The printed reference book, *A Life Science Lexicon,* by William Marchuk of Red Deer College, is now also available on CD-ROM as *A Life Science Living Lexicon.* Both products help introductory-level students quickly master the vocabulary of the life sciences, carefully explaining the rules of word construction and derivation while giving definitions of important terms. The *Living Lexicon* also provides illustrations, audio pronunciations, and student-interactive quizzing and notetaking capabilities.

Life Science Animations Videotapes

Life Science Animations by Wm. C. Brown Publishers is a set of six videotapes containing 66 animations of physiological processes integral to the study of biology. Topics covered include chemistry, genetics, and reproduction. The animations are keyed to *Concepts in Biology* through the use of a small videotape icon(▪▪) alongside the figure legend. A list of the animated figures in this text appears on page xii.

Interactive Explorations CD-ROMs

Explorations in Human Biology and *Explorations in Cell Biology and Genetics* are interactive CD-ROMs by George B. Johnson, available for use with both Mac and Windows computers. The *Explorations* offer interactive modules related to key topics covered in biology courses. The CD-ROMs can be used by an instructor in lecture and/or placed in a lab or resource center for students. *Explorations* are referenced at the ends of appropriate chapters of *Concepts in Biology.* A list of the *Explorations* topics and their corresponding chapters is provided on page xii.

BioSource Videodisc

BioSource Videodisc, by Wm. C. Brown Publishers and Sandpiper Multimedia, Inc., features twenty minutes of animations and nearly 10,000 full-color illustrations and photos, many from leading WCB biology textbooks.

Biology Startup

Biology Startup is a five-disk set of Macintosh tutorials by Myles C. Robinson and Kathleen Pace of Grays Harbor College. This software is designed to help nonmajors students master fundamental biological concepts such as chemistry and cell biology. *Biology Startup* can be a valuable addition to a resource center and is especially helpful to students enrolled in developmental education courses or those who need additional assistance to succeed in an introductory biology course.

Acknowledgments

A large number of people have knowingly or unknowingly helped us write this text. Our families continued to give understanding and support as we worked on this revision. We acknowledge the thousands of students in our classes who have given us feedback over the years concerning the material and its relevancy. They were the best possible source of criticism.

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To The Student

This text is designed to make understanding biological principles easier. Each chapter is subdivided into topics separated by headings. These headings are listed in the outline at the beginning of each chapter. The subdivisions contain logical chunks of material; they should make learning more manageable for you.

Following the outline is a section entitled "Purpose." This section gives you some hints about how the chapter fits in with the other parts of the book. It directs you to where you are going and lets you know why you are going there. By paying careful attention to the purpose, you will be able to tell when you have attained your goal and why this goal was set.

As with most science classes, you are likely to find biological vocabulary a difficult hurdle. To help you approach this "foreign language," important terms are printed in **boldface** the first time they are used in the text. Each new term is defined at least three times: first, in the narrative when the term becomes a functional part of biological thought; second, in the chapter glossary at the end of the chapter in which it first appears; and third, in the comprehensive glossary at the end of the book. As you review a chapter, you should mentally define each of the new terms. If you are unsure of the meaning of a term, check yourself against the definition in the book. In this edition, we have also provided a phonetic pronunciation guide for each glossary term so that you will learn to pronounce each term correctly as you learn its meaning.

Numerous illustrations appear throughout the text. These illustrations should do more than just attract your attention. Each has been carefully chosen to help you understand a point or tie a concept to something you already know. Use these illustrations and their captions to learn and understand the ideas presented.

Each chapter ends with a summary. As you finish studying a chapter, read the summary, sentence by sentence. If you come across information that seems new, you may not have thoroughly studied part of the chapter.

Following the summary we have presented a thought-provoking situation entitled "Thinking Critically." It asks you to use your newfound knowledge and previous experience in considering the situation. Most often, there is no one right answer. You will be stimulated to think something through and to raise points for discussion.

The most valuable aspect of an introductory biology course is not the tidbits of factual information you gather, but the new ways in which you see yourself and your environment. The section entitled "Experience This" will help you apply basic biological concepts to real situations.

Immediately preceding the chapter glossary is a series of review questions. You can use them to channel your attention as you study a chapter or as a review to check that you are well prepared for a test on the chapter material. All of the questions are directly answered either in the chapter narrative or in the illustrations.

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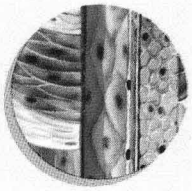

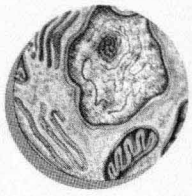

chapter 1

What Is Biology?

CHAPTER OUTLINE

PURPOSE

This chapter is a general introduction to the nature of science and the significance of biological science in your everyday life. It presents a scientist's view of the world and describes what living things are and how they differ from nonliving things. This chapter lays the groundwork for helping you understand and answer questions about living things you encounter. You will be better able to understand and answer biological questions after you have an understanding of how science works.

FOR YOUR INFORMATION

As a result of recent, rapid advances in science, most newspapers have added a science page as a weekly feature. Some articles deal with controversial issues such as DNA testing and criminal cases, or religion and science. Other publications and media cover factual material. These features are intended to keep the general public aware of the most significant advances in all areas of science. Subjects such as recombinant DNA theory, biological amplification, and punctuated evolution are no longer discussed exclusively in scientific journals that only the most well-informed, practicing scientist can understand.

WHAT'S AHEAD?

What does science have to do with me?
How do I know if the information I have is the result of scientific investigation?
What are the steps in the scientific method?
If somebody says it came from science, how do I know that's true?
How have biologists made my life better?
What makes something alive?
What kinds of problems do biologists have to deal with now and in the future?