

# BIOLOGY

RUTH BERNSTEIN

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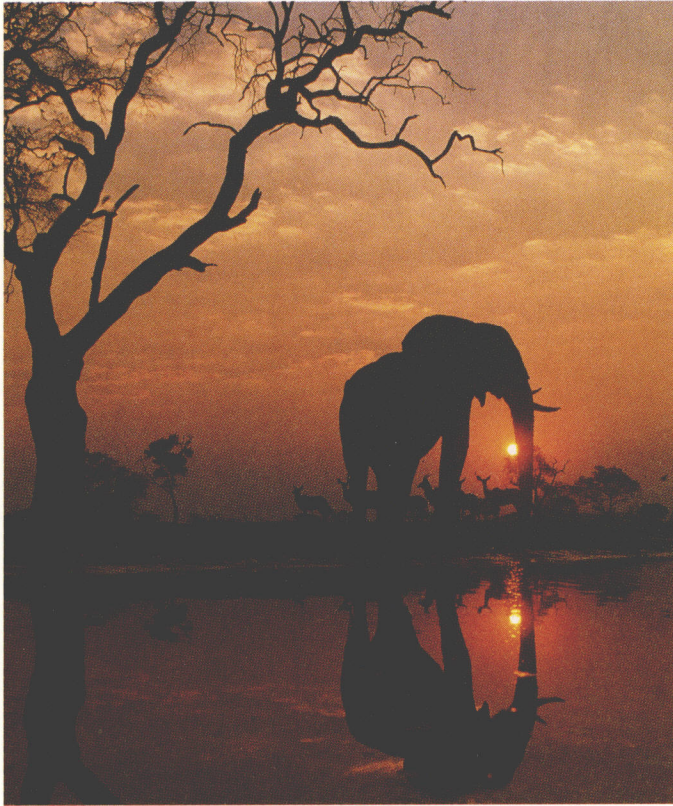
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## Publisher's Note to the Instructor

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### Full-Color Customization

*Your options are unlimited!* You can now create the ideal text for your course. Take a look at the contents of *Biology*. Are there some chapters you don't address in your course? If so, select just those chapters that you do cover. Then let Wm. C. Brown Publishers professionally print and bind the *full-color* general biology text that is right for your classroom.

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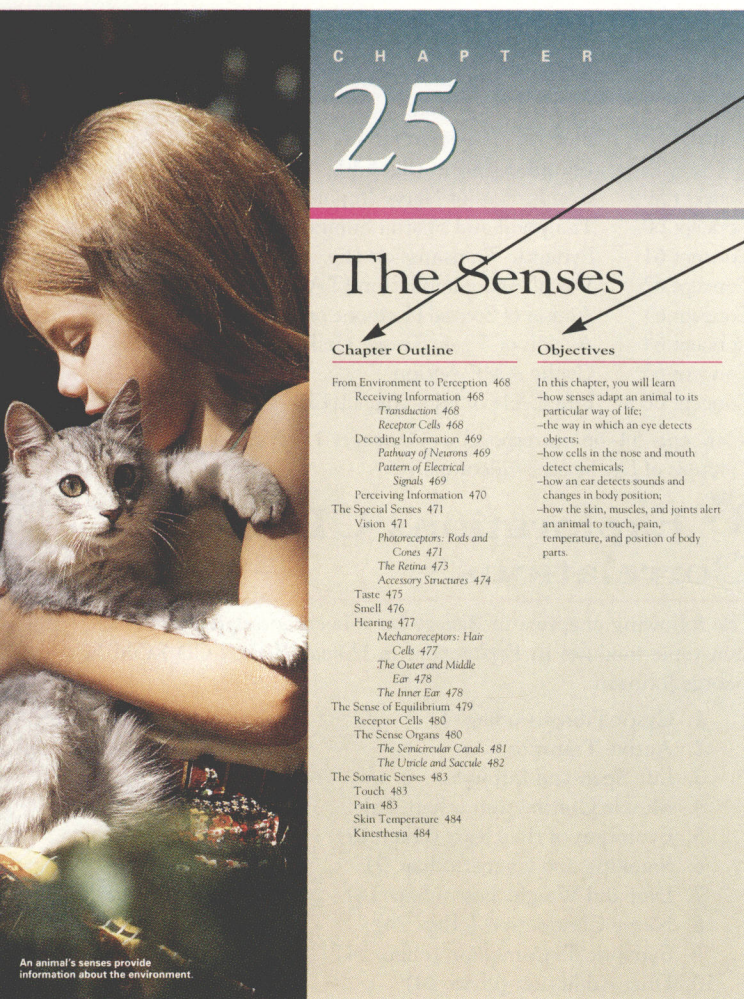
### Recycled Paper

*Biology* is printed on recycled paper stock. All of its ancillaries, as well as all advertising pieces, will also be printed on recycled paper. In addition, when possible, the inks used in printing are soy based.

Our goal in using these materials for *Biology* and its ancillary package is to minimize the environmental impact of our products.



# The *Biology* Learning System



## Chapter Outline and Objectives

Each chapter opens with a page-referenced Chapter Outline and a list of Objectives that introduce the student to important topics within the chapter and provide quick access to the material. These introductory features are followed by a prologue, which links the chapter material to everyday life.

## Chapter-by-Chapter Customization

A separate set of chapter page numbers appears at the top of the page for the benefit of adopters who wish to customize *Biology*.

## Cross References

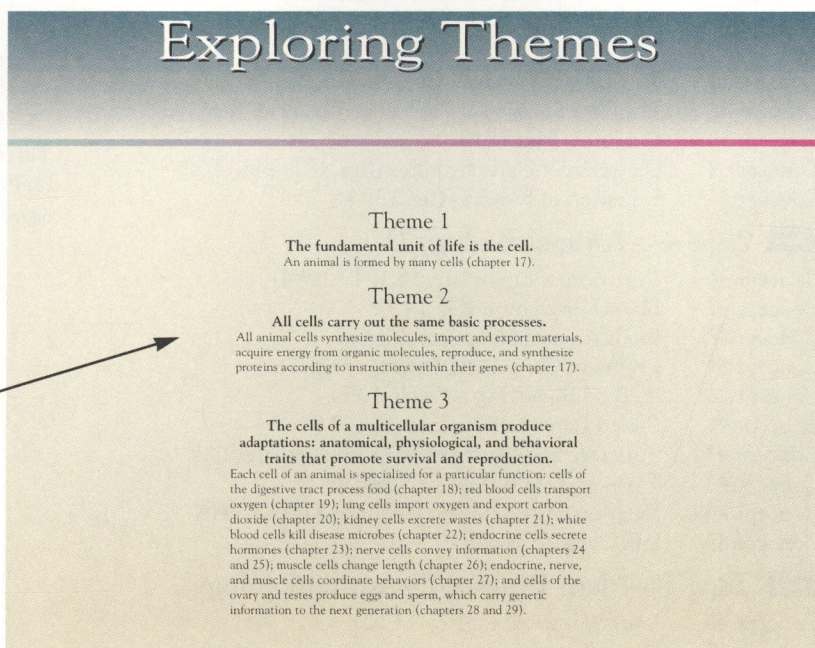
Within the narrative, cross references to foundational material presented in earlier chapters are identified with an icon (📖 see page 62) followed by a page number.

A eukaryotic cell has a variety of organelles—specialized compartments that contain the biochemical pathways (📖 see page 51) (enzymes, substrates, and other materials) for performing a particular task. In this way, the cell's biochemical pathways are organized according to function and kept separate from one another. The breakdown of glucose (to provide energy), for example, is isolated from the synthesis of polysaccharides.

## Thematic Presentation


Throughout the text, four biological themes are emphasized, and each of the five parts opens with “Exploring Themes,” an overview presenting one or more of these concepts that relate to the chapters within that part.

xviii





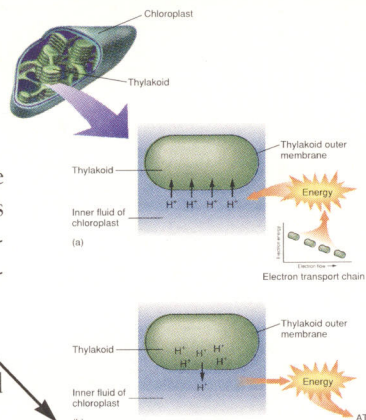
## Dramatic Visuals Program Tied to Animations

Colorful, informative photographs and illustrations enhance the learning program of this text. This icon (  ) identifies figures that are depicted in the Life Science Animations videotape series, which is made up of 53 animations. The tapes include:

- Tape 1 Chemistry, the Cell, and Energetics
- Tape 2 Cell Division/Hereditry/Genetics/Reproduction and Development
- Tape 3 Animal Biology I
- Tape 4 Animal Biology II
- Tape 5 Plant Biology/Evolution/Ecology

## In-Text Line Art

Simple line art placed within the narrative keeps the reader focused and typifies the drawings created by instructors as they lecture.

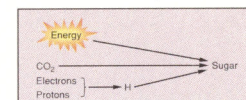


**Figure 6.9 The proton gradient.** (a) Energy released from the electron transport chain is used by transport proteins to pump protons ( $H^+$ ) across a membrane, from the outside to the inside of a thylakoid. (b) As the protons diffuse through a channel protein in the membrane, they release energy that is transferred to ATP.

formation of NADPH, which provides chemical energy, an electron, and a hydrogen atom for building sugar. Moreover, some of the oxygen gas that forms is used by the cell in cellular respiration. The rest diffuses out of the cell and into the surrounding environment, where it is available for use by animals and other organisms. The materials that enter and leave the light-dependent reactions are summarized in table 6.2.

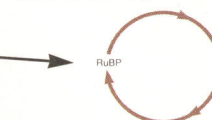
Table 6.2		
The Light-Dependent Reactions: Inputs and Outputs		
Inputs	Outputs	Fate of Outputs
Sunlight	Energy in ATP and NADPH	Energy in glucose
Electrons from water	Electrons in NADPH	Part of hydrogen atoms in glucose
Protons from water	Protons in NADPH and lone protons ( $H^+$ )	Part of hydrogen atoms in glucose
Oxygen from water	Oxygen gas	Released from cell or used in cellular respiration

drogen atoms) within molecules of NADPH become incorporated into the structure of a sugar molecule:



Sugar is built by a biochemical pathway called the Calvin-Benson cycle, which is located within the inner fluid (cytosol) of a photosynthetic bacterium or within the inner fluid (stroma) of a chloroplast (see fig. 6.2).

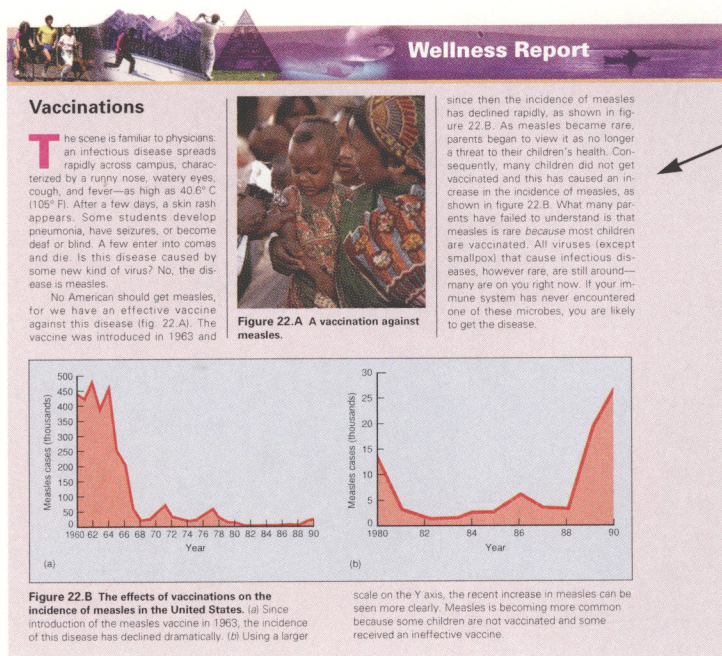
The Calvin-Benson cycle is a biochemical pathway that builds a three-carbon sugar from carbon dioxide, hydrogen atoms, and chemical energy. The pathway is a cycle in which the molecule that begins the pathway—ribulose biphosphate (RuBP)—becomes an end product that begins the same pathway again:



The cycle, shown in figure 6.10, begins when carbon dioxide joins with RuBP, which is a five-carbon molecule. (The enzyme that catalyzes this reaction, called RuBP carboxylase, is the most plentiful protein on earth.) The

## The Light-Independent Reactions

The light-independent reactions do not require light; they build sugar from carbon dioxide, using the ATP and NADPH formed during the light-dependent reactions. Energy within molecules of ATP and NADPH is used to build covalent bonds within a sugar molecule. Hydrogen atoms and electrons (which join with protons to form more hy-

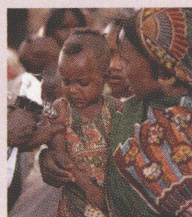


## Wellness Report

### Vaccinations

The scene is familiar to physicians: an infectious disease spreads rapidly across campus, characterized by a runny nose, watery eyes, cough, and fever—as high as  $40.6^{\circ}C$  ( $105^{\circ}F$ ). After a few days, a skin rash appears. Some students develop pneumonia, have seizures, or become deaf or blind. A few enter into comas and die. Is this disease caused by some new kind of virus? No, the disease is measles.

No American should get measles, for we have an effective vaccine against this disease (fig. 22.A). The vaccine was introduced in 1963 and



**Figure 22.A A vaccination against measles.**

since then the incidence of measles has declined rapidly, as shown in figure 22.B. As measles became rare, parents began to view it as no longer a threat to their children's health. Consequently, many children did not get vaccinated and this has caused an increase in the incidence of measles, as shown in figure 22.B. What many parents have failed to understand is that measles is rare because most children are vaccinated. All viruses (except smallpox) that cause infectious diseases, however rare, are still around—many are on you right now. If your immune system has never encountered one of these microbes, you are likely to get the disease.

## Boxed Readings

Three types of boxed readings occur within the narrative: Research Reports, Wellness Reports, and Environment Reports. Research Reports present the logic of research projects; Wellness Reports deal with the biological basis of fitness and wellness; and Environment Reports motivate student interest in biodiversity and ecology.

## Student Study Aids

Each chapter ends with a Summary, page-referenced Key Terms, Study Questions, Critical Thinking Problems, and an annotated list of Suggested Readings organized for both introductory-level and advanced-level students.

## New Technology CD-ROM

References to two new WCB Explorations CD-ROMS are found at the ends of many of the chapters. When chapter material relates to the topic of a CD-ROM module on *Explorations in Human Biology* or *Explorations in Cell Biology, Metabolism, and Genetics*, the student is presented with a brief topic overview and directed to the interactive CD-ROM module.

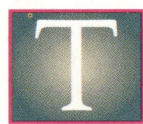
## EXPLORATION

### Interactive Software: Diet and Weight Loss

This interactive exercise explores how diet and exercise interact to determine whether we gain or lose weight. The program provides a pathway for energy, from food to either the synthesis of ATP or the storage of fat. The student alters the kinds and amounts of foods eaten as well as the amount of energy used in exercise. The effects of these three variables are then determined by measuring changes in the amount of stored fat.



# Preface



his book is an introduction to general biology and to how scientific thinking is done. Our main focus is to present biological information in an understandable way that captures student interest. Our particular approach emerged from our shared background as both research scientists and teachers of college freshmen.

## Our Experience

As research scientists, we view biology as a series of exciting questions that challenge us to pursue answers. We want to share this excitement with students and point out the many interesting questions yet to be answered. We also view biological phenomena as solutions to problems that organisms have encountered and then solved by means of evolved adaptations. All forms of life, for example, have the problem of moving certain materials into and out of their cells. The solutions to this problem are found in different parts of the organism—in lungs, digestive tracts, kidneys, roots, and leaves.

As teachers, we have more than twenty-five years of experience teaching introductory biology, usually a two-semester course covering most of the standard topics of biology, from cells to ecosystems. The experience taught us how to integrate different aspects of biology in ways that help students learn. Our students were a special group, identified by the university as high-risk students because they were not well prepared for this level of work. Our task was to bring these students up to university level in terms of their biological knowledge. Consequently, our classes involved more pedagogy and more one-on-one interactions than other university courses. Through this experience, we have come to understand the types of problems encountered by these students as well as by their teachers. Over the years, we have developed ways to motivate our students to think as scientists do and to understand sophisticated biological concepts.

## Unifying Concepts and Themes

We have found that it is essential to present the vast quantity of biological information in a conceptual framework. This framework allows each new topic to build on previous ones. New information can then enlighten rather than

confuse the student. For example, once the idea of adaptations to particular environments is developed, the details of plant and animal biology become variations on a familiar concept.

Throughout *Biology*, our explanations are written as clearly and precisely as possible, with the intention that students truly understand the material rather than simply memorize it. We've used standard biological terms, but only those essential for communication of the ideas.

Four biological themes are emphasized:

1. The fundamental unit of life is the cell.
2. All cells carry out the same basic processes.
3. The cells of a multicellular organism produce adaptations: anatomical, physiological, and behavioral traits that promote survival and reproduction.
4. Adaptations evolve in response to interactions with other organisms and with the physical environment.

The four themes are introduced, one after another, as we build a framework of biological knowledge. Each theme, once introduced, continues to function in the chapters that follow.

## The Learning System

Each chapter begins with a brief outline and a list of objectives, written in everyday language (e.g., "In this chapter you will learn how a cell uses its genes to build proteins"). This introductory material is followed by a prologue, which is designed to link the chapter material with everyday life. Within the chapter, we use three levels of headings to organize and subdivide the material and to focus the topic information. Each chapter ends with a summary, list of key terms, and two sets of questions: a set of study questions, designed to reveal whether the important concepts have been learned, and a set of critical thinking problems, designed to encourage students to use the concepts in new ways. We've also added a list of suggested readings arranged according to introductory level (for the beginning student) and advanced level (for the advanced student or instructor).

We make extensive use of in-text sketches, similar to the ones we draw on the blackboard while lecturing. They

are particularly useful in explaining the actions of invisible topics, such as chemical reactions, protein receptors, and chromosomes. As biologists, we all have many such mental images to help us remember and understand. We find it very helpful to students when we communicate these learning aids.

## The Boxed Essays

Throughout *Biology*, boxed essays are used to show how science is done and to relate chapter material to everyday life. We have included three kinds of boxed essays: Research Reports, Wellness Reports, and Environment Reports.

The Research Reports deal with the logic of classical and ongoing research projects. They are based on hypothesis formation and testing. These real examples of scientific thought portray the uncertain but exciting feel of research—the frustrations and joys that accompany the search for truth. In addition, logic trees, introduced in the first chapter, are used to show where each research project is positioned within the flow of scientific thought. The reports are designed to stimulate curiosity and critical thinking—to encourage the reader to consider alternative hypotheses and ways of testing them.

The Wellness Reports deal with the biological basis of fitness and wellness. Their purpose is to motivate students to learn about their own bodies through their study of biology. We link, for example, the warm-up phase of exercise with cellular respiration, antibiotics with protein synthesis, jet lag with hormone secretion, and drug addiction with neurotransmitters. Wherever possible, these reports involve the cellular basis of bodily function, a depth of knowledge students would probably not otherwise acquire.


The Environment Reports are inserted into the chapters on biodiversity and ecology. To our delight, we find that today's generation of students is sincerely concerned about the environment and seeks sophisticated knowledge about environmental problems. The Environment Reports are used to meet this need as well as to motivate interest in the fundamental basis of populations and ecosystems.

## Chapter Organization

The introductory chapter sets the stage for the study of biology as a science. It describes the scientific method and shows that science, like life itself, is a dynamic process. This first chapter also introduces fundamental concepts used in later chapters: the hierarchical organization of life, the basics of Darwin's theory of evolution, the nature of adaptations, and the kingdoms of life.

The chapters then follow a conventional sequence that begins with cells and ends with ecosystems. Parts I

and II develop our first two themes: the basic similarity of all cells with regard to structure, chemical processes, reproduction, and gene expression. Parts III and IV deal with our third theme: the ways in which the cells of a plant or animal are organized to form adaptations that promote survival and reproduction. Part V then develops our fourth theme: the origin of adaptations and their roles in biodiversity and ecology.

While we find this sequence works best for us, we are aware that not all biology courses are arranged in this way and, furthermore, that few courses include all the chapter topics. Hence, we have attempted to make each unit versatile in terms of sequence. Where material in previous chapters is essential background, we have used an icon  that directs the reader to specific pages where this information has been presented.

## The Biology Ancillary Package

Whether used by instructor or student, *Biology* comes equipped with unique and useful tools to enhance teaching and learning. You will find many of them correlated directly to corresponding material throughout the text.

## Useful Learning Aids for Students

1. **Student Study Guide.** This illustrated study guide, by Mary Vick of Hampton College, focuses students on important chapter material that is often difficult to learn without further reinforcement. Each chapter in the study guide contains a variety of features designed to help students study wisely, including: chapter outline, review questions, key terms, objective self-test (includes true-false, multiple-choice, matching, and completion), and critical thinking questions (with answers provided).
2. **Laboratory Manual.** Written by the faculty, Department of Biology, Wm. Paterson College, and coeditors Marty Hahn, Stephen Vail, and Jane Voos, this manual contains 30 student-tested laboratory exercises.
3. **Biology Study Cards.** A set of 200 two-sided study cards containing definitions of key terms, clearly labeled illustrations, and pronunciation guides is handy for student study anytime, anyplace.

## Useful Teaching Tools for Instructors

1. **Instructor's Manual/Test Item File.** Prepared by Linda K. Butler and Stephen W. Taber of the University of Texas, Austin, the IM/TIF features a test item file as well as the following elements for each chapter: objectives, key concepts, key terms



with definitions, chapter outline, answers to study questions, answers to critical thinking problems, and a list of audio-visual resources.


2. Microtest III. A computerized test bank containing the questions found in the test item file.
3. Extended Lecture Outline Software. An expanded outline for each chapter is available on Macintosh and Windows platforms. Instructors can add or delete material and print out for lecture use or student handouts.
4. Transparency Acetates. A set of 150 full-color transparencies of images found in the text is available to adopters.
5. Transparency Masters. A set of 100 one-color, labeled line drawings of images in the text is available to adopters.

## New Technology

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### Explorations CD-ROMs

Learn biological processes—using movement, color, sound, and interaction. Two new interactive CD-ROMs, *Explorations in Human Biology* and *Explorations in Cell Biology, Metabolism, and Genetics* by George Johnson, include 16 modules each that are either of high student interest, such as the unit on drug addiction, or are difficult concepts to understand, such as the unit on active transport.

When an Exploration correlates to topic material in a chapter in *Biology*, you'll find the CD-ROM icon () followed by a description of the module at the end of that particular chapter. A correlation chart that lists the Exploration topics and corresponding chapters in *Biology* can be found on page (xvii).


### Life Science Lexicon CD-ROM

This new interactive CD-ROM, by Will Marchuk of Red Deer College, offers students a glossary of over 1,200 key science terms and definitions; word construction through the use of prefixes, root words, and suffixes; descriptions of eponyms; more than 1,000 full-color images for selected terms; and over 200 questions for student quizzing.

### Life Science Animation Videotapes

Tied directly to text figures, these videotapes bring movement and multi-dimension to over 60 images of often difficult-to-understand physiological processes that can only be shown in a limited, step-by-step way in the textbook. However, with

the use of the animation tapes, these visual moving representations of key processes assist the instructor and enhance student learning.

Figures within the text that are correlated to animations are easily identified by the videotape icon ().

### BioSource Videodisc

Our new BioSource videodisc features nearly 10,000 full-color illustrations and photos, many from Wm. C. Brown Publishers' general biology textbooks. Approximately twenty minutes of life science animations are also included on the videodisc.

### Biology StartUp Software

This set of interactive Macintosh tutorials for students portrays difficult, biological concepts in a new way, using definitions, color illustrations and animations, and pronunciations spoken by a human voice. Quizzes are located at the ends of major sections.

## Acknowledgments

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We dedicate this book to our students and colleagues, who have made our study of biology such a pleasure.

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# Brief Contents

*Preface* xxi

**INTRODUCTION** Biology as a  
Science 1

## PART I

### Biology of Cells 21

- 1 Atoms and Molecules 23
- 2 The Chemistry of Life 39
- 3 Cells: An Overview 57
- 4 Cellular Membranes 71
- 5 Cellular Respiration 85
- 6 Photosynthesis 105

## PART II

### Cellular Reproduction and Inheritance 121

- 7 Mitosis and the Cell Cycle 123
- 8 Meiosis and the Life Cycle 141
- 9 Physical Basis of Inheritance 155

- 10 Patterns of Inheritance 175
- 11 From Genes to Proteins 191
- 12 Genetic Engineering 210

## PART III

### Biology of Plants 229

- 13 Plant Organization 231
- 14 Transport and Nutrition 255
- 15 Reproduction in Flowering  
Plants 271
- 16 Hormonal Control 291

## PART IV

### Biology of Animals 309

- 17 Animal Organization 311
- 18 Nutrition and Digestion 331
- 19 Circulation 353
- 20 Respiration 373

- 21 Body Fluids and  
Temperature 389
- 22 Defenses Against Diseases 405
- 23 Hormonal Control 427
- 24 Neural Control 445
- 25 The Senses 467
- 26 Locomotion 487
- 27 Behavior 507
- 28 Reproduction 525
- 29 Development 545

## PART V

### Evolution and Ecology 567

- 30 The Process of Evolution 569
- 31 Biodiversity 591
- 32 Population Ecology 617
- 33 Ecosystems 635
- 34 Human Ecology 663

*Glossary* 679

*Credit* 689

*Index* 693

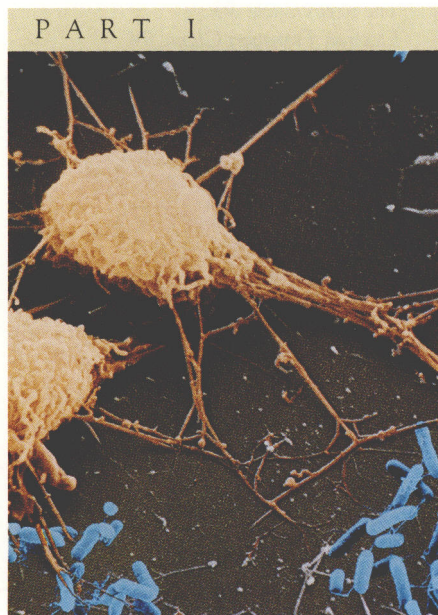
# Contents

List of Animations xvii  
List of Explorations xvii  
The Biology Learning System xviii  
Preface xxi

## INTRODUCTION Biology as a Science 1

The Realm of Biology 2  
    History of Science 2  
    Biology and Society 2  
The Scientific Process 3  
    Outline of the Scientific Process 3  
    Observations 4  
    Hypotheses 4  
    Predictions 4  
    Tests of the Predictions 4  
    Example: Hasler's Study of Homing by Salmon 4  
    Continuation of the Scientific Process 5  
Organization of Life 7  
    Hierarchy of Biological Organization 7  
    The Cell 7  
    The Individual and Higher Levels 9  
    Hierarchy of Classification 11  
    Species and Genus 11  
    Higher Levels 11  
    Kingdoms 12  
Evolution: Theoretical Foundation of Biology 13  
    Darwin's Theory of Evolution by Natural Selection 15  
    Reproductive Potential 15  
    Constancy of Numbers 15  
    Struggle for Existence 16  
    Individual Differences 16  
    Inheritance of Traits 16  
    Natural Selection 17  
    Products of Evolution 17  
    Adaptations 17  
    Species Diversity 17  
Summary 19  
Key Terms 19

Study Questions 19  
Critical Thinking Problems 20  
Suggested Readings 20



## Biology of Cells 21

### 1 Atoms and Molecules 23

Atoms 24  
    Physical Structure 24  
    The Nucleus 24  
    The Electrons 25  
    Kinds of Atoms 25  
    Chemical Properties 25  
    Arrangement of Electrons 25  
    Chemical Activities 26  
Ions 27  
Molecules 28  
    Ionic Bonds 30  
    Covalent Bonds 30  
    Hydrogen Bonds 30  
    Molecules as Ions 32

Watery Solutions 32  
    Water as a Solvent 32  
    Acidity of Watery Solutions 33  
    Acids and Bases 34  
    Buffers 34  
Chemical Reactions 34  
    Electrons and Energy 34  
    Energy Changes During Reactions 35  
    Rates of Reactions 36  
Summary 37  
Key Terms 37  
Study Questions 37  
Critical Thinking Problems 38  
Suggested Readings 38

## 2 The Chemistry of Life 39

The Atoms of Life 40  
The Macromolecules of Life 40  
    Polysaccharides 42  
    Lipids 42  
    Fats 43  
    Phospholipids 45  
    Steroids 45  
    Proteins 45  
    Protein Diversity 46  
    Protein Shapes 46  
    Nucleic Acids 48  
    Deoxyribonucleic Acid 48  
    Ribonucleic Acid 49  
Enzymes and Biochemistry 50  
    Enzyme Structure and Function 50  
    Biochemical Pathways 51  
    Control of Biochemical Pathways 52  
    Control of Enzyme Synthesis 52  
    Control of Enzyme Activity 52  
Summary 54  
Key Terms 54  
Study Questions 54  
Critical Thinking Problems 55  
Suggested Readings 55



### 3 Cells: An Overview 57

- Kinds of Cells 58
- The Prokaryotic Cell 59
  - Cell Wall and Plasma Membrane 60
  - DNA 60
  - Cytosol 61
- The Eukaryotic Cell 62
  - Membranes 62
  - The Nucleus 62
  - Chromosomes 63
  - Nucleoli 63
  - The Cytoplasm 63
  - Ribosomes 63
  - Endoplasmic Reticulum 63
  - Vesicles 64
  - The Golgi Apparatus 64
  - Mitochondria 64
  - Plastids 64
  - Vacuoles 65
  - The Cytoskeleton 65
  - The Cell Surface 65
  - The Cell Wall 65
  - Cilia and Flagella 66
  - The Glycocalyx 67
  - Cell-to-Cell Junctions 67
- Summary 69
- Key Terms 69
- Study Questions 70
- Critical Thinking Problems 70
- Suggested Readings 70

### 4 Cellular Membranes 71

- Structure of the Membrane 72
  - The Phospholipid Bilayer 72
  - Cholesterol 73
  - Proteins 73
- Transport Across Membranes 74
  - Simple Diffusion 75
  - Osmosis 76
  - Turgor Pressure 77
  - Facilitated Diffusion 77
  - Active Transport 78
  - Coupled Systems 78
  - Membrane Potentials 80
  - Bulk Transport 81
  - Endocytosis 81
  - Exocytosis 82
  - The Membrane Cycle 82
- Summary 82
- Key Terms 83
- Study Questions 83
- Critical Thinking Problems 83
- Suggested Readings 84

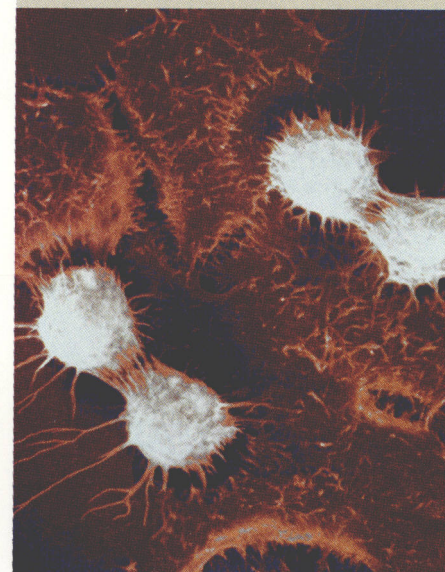
### 5 Cellular Respiration 85

- Energy and Life 86
  - Chemical Energy 86
  - Changes in Chemical Bonds 86
  - Transfers of Electrons 86
  - Adenosine Triphosphate 87
- Cellular Respiration 88
  - Glycolysis 88
  - Fermentation 90
  - From Glucose to Alcohol 90
  - From Glucose to Lactic Acid 91
  - Aerobic Respiration 92
  - From Pyruvic Acid to Acetyl Coenzyme A 92
  - The Krebs Cycle 93
  - Electron Transport Chain 94
  - Proton Gradient 94
- Fuels for Cellular Respiration 98
  - Monosaccharides 98
  - Fatty Acids 99
  - Amino Acids 102
- Summary 102
- Key Terms 103
- Study Questions 103
- Critical Thinking Problems 103
- Suggested Readings 103

### 6 Photosynthesis 105

- Overview of Photosynthesis 106
  - Photosynthesis and Aerobic Respiration 106
  - Evolution of Photosynthesis 106
  - Locations of Photosynthesis 106
- The Light-Dependent Reactions 108
  - The Capture of Light Energy 109
  - Pigments 109
  - Primary Electron Acceptors 110
  - Formation of ATP and NADPH 110
  - The Pathway of Electrons 110
  - Photosystems I and II 111
  - Linked Photosystems 111
- The Light-Independent Reactions 113
- Fates of the Products 115
  - The Monomers 118
  - Glyceraldehyde Phosphate 118
  - Glucose 118
  - The Polymers 118
- Summary 118
- Key Terms 119
- Study Questions 119
- Critical Thinking Problems 119
- Suggested Readings 119

## PART II



### Cellular Reproduction and Inheritance 121

#### 7 Mitosis and the Cell Cycle 123

- Limits to Cell Size 124
- Cell Division in Eukaryotic Cells 124
  - The Karyotype 125
  - The Cell Cycle 126
  - Interphase 127
  - Mitosis 128
  - Cytokinesis 133
  - Control of the Cell Cycle 134
  - Functions of Cell Division 136
  - Asexual Reproduction 136
  - Growth and Development 136
  - Replacement of Damaged Cells 136
- Cell Division in Prokaryotic Cells 136
- Summary 137
- Key Terms 138
- Study Questions 138
- Critical Thinking Problems 138
- Suggested Readings 138

#### 8 Meiosis and the Life Cycle 141

- Sexual Reproduction 142
- Diploidy and Haploidy 143
  - Roles of Fertilization and Meiosis 144
  - Characteristics of Diploid Cells 144
  - Advantages of Diploid Cells 145



- Meiosis 145
  - Meiosis I 146
  - Meiosis II 148
  - Meiosis Versus Mitosis 149
- The Life Cycle 149
  - Life Cycles with Diploid Adults 151
  - Life Cycles with Haploid Adults 151
  - Life Cycles with Both Diploid and Haploid Adults 151
- Summary 153
- Key Terms 153
- Study Questions 153
- Critical Thinking Problems 153
- Suggested Readings 153

## 9 The Physical Basis of Inheritance 155

- Phenotype and Genotype 156
- Chromosomes and Alleles 157
- Meiosis and the Inheritance of Genes 158
  - Separation of Alleles 159
  - Combining Alleles at Fertilization 160
  - Independent Assortment of Alleles 161
  - Linked Genes 162
  - Crossing-Over 163
- Genetic Variability 164
  - Mutations 164
  - Recombination 165
  - Amount of Genetic Variability 165
- Chromosomal Inheritance 166
  - Sex Determination 167
  - The Sex Chromosomes 167
  - Separation of Sex Chromosomes 167
  - Combining Sex Chromosomes at Fertilization 168
  - Too Many or Too Few Chromosomes 170
  - Sex Chromosomes 170
  - Autosomes 171
- Summary 172
- Key Terms 173
- Study Questions 174
- Critical Thinking Problems 174
- Suggested Readings 174

## 10 Patterns of Inheritance 175

- Alleles and Phenotypes 176
  - Dominant-Recessive Alleles 176
  - Incompletely Dominant Alleles 177
  - Codominant Alleles 177

- Inheritance Patterns 178
  - Mendelian Inheritance 179
    - Traits That Characterize Families 179
    - Recessive Alleles 179
  - Inheritance of X-Linked Traits 182
    - Recessive Alleles 182
    - Inheritance Pattern 183
  - Polygenic Inheritance 184
  - Epistasis 186
  - Pleiotropic Inheritance 186
  - Genomic Imprinting 188
- Summary 189
- Key Terms 189
- Study Questions 189
- Critical Thinking Problems 189
- Suggested Readings 189

## 11 From Genes to Proteins 191

- The Genetic Language 192
  - Genetic Codes for Amino Acids 192
  - Genetic Instructions for Proteins 193
- Gene Expression 193
  - Transcription: Building an RNA Copy of the Gene 193
  - Processing the Precursor mRNA 196
  - Translation: Building the Protein 197
  - The Ribosome 197
  - Transfer RNA 198
  - Assembling the Polypeptide 198
  - Control of Gene Expression 200
  - Response to Conditions Inside the Cell 200
  - Response to Conditions Outside the Cell 200
- The Gene 200
  - Definition of a Gene 202
  - The First Genes: DNA or RNA? 202
  - Mutations 202
    - Point Mutations 203
    - Dynamic Mutations 204
  - DNA Inserts 204
  - Chromosomal Mutations 204
- Viruses 204
  - The Structure of a Virus 204
  - How a Virus Reproduces 205
  - Invasion of a Cell 205
  - Synthesis of Viral Proteins 208
  - Retroviruses 208

- Summary 209
- Key Terms 210
- Study Questions 210
- Critical Thinking Problems 210
- Suggested Readings 210

## 12 Genetic Engineering 211

- Mass-Producing Proteins and Genes 212
  - Recombinant DNA Technology 212
  - Isolating the Gene 213
  - Preparing a Vector 216
  - Mass-Producing the Protein 216
  - The Polymerase Chain Reaction 217
  - The Procedure 217
  - Uses of the Procedure 218
- Describing Genes 219
  - Mapping Genes 219
  - DNA Probes 219
  - Restriction Fragment-Length Polymorphisms 219
  - Describing the Base Sequences of Genes 221
  - The Human Genome Project 223
- Transplanting Genes 223
  - Gene Therapy 223
  - Transgenic Organisms 225
- Summary 226
- Key Terms 227
- Study Questions 227
- Critical Thinking Problems 227
- Suggested Readings 227

## PART III



## Biology of Plants 229

## 13 Plant Organization 231

- Origin of Plants 232
  - From Unicellular Algae to Seaweeds 232
  - Colonization of Land 232



Cells and Tissues 233

- Basic Cell Types 234
- Parenchyma Cells 235
- Collenchyma Cells 235
- Sclerenchyma Cells 236
- Tube-Forming Cells 238
- Plant Tissues 238
- Vascular Tissues 238
- Dermal Tissue 240
- Ground Tissue 241
- Meristem 241

The Plant Body 242

- Leaves 246
- Internal Structure 246
- External Structure 247
- Attachment of the Leaf 247
- Stems 248
- Internal Structure 249
- External Structure 250
- Roots 250
- Internal Structure 250
- External Structure 250

Coordination of Cellular Activities 252

- Summary 253
- Key Terms 253
- Study Questions 253
- Critical Thinking Problems 253
- Suggested Readings 254

## 14 Transport and Nutrition 255

Transport of Fluids 256

- Ascent of Water 256
- Transpirational Pull 256
- Cohesion and Adhesion 257
- Pathway of Water Molecules 257
- Transport of Cell Products 259
- The Pathway from Source to Sink 259
- The Pressure-Flow Theory 259

Uptake of Water and Soil Nutrients 261

- From Epidermis to Xylem 261
- Soil Water 261
- Selective Uptake of Certain Nutrients 261
- Entry into the Xylem 263
- Mycorrhizae 264

Plant Nutrition 264

- Soil 265
- Soil Nutrients 267
- Nutrient Deficiencies 267
- Nutritional Adaptations 267
- Fertilizers 267

Summary 269

- Key Terms 269
- Study Questions 269
- Critical Thinking Problems 270
- Suggested Readings 270

## 15 Reproduction in Flowering Plants 271

Reproductive Patterns 272

- Inheritance: One Parent Versus Two 272

Asexual Reproduction 272

Sexual Reproduction 272

Life History 273

Annuals 273

Biennials 274

Perennials 274

The Flowers 274

Flower Structure 274

Perfect Versus Imperfect Flowers 276

Variations in Color, Shape, Scent, and Nectar 276

Formation of Gametophytes 278

Pollen Grains 278

Ovules 279

Union of the Gametes 279

Pollination 279

Fertilization 279

Development of the Embryo 279

The Seed 280

The Fruit 281

The Seedling 282

Growth 283

Primary Growth 283

The Shoot Apical Meristem 283

The Root Apical Meristem 283

Secondary Growth 284

Vascular Cambium 286

Cork Cambium 286

Summary 288

Key Terms 288

Study Questions 288

Critical Thinking Problems 288

Suggested Readings 289

## 16 Hormonal Control 291

Plant Hormones 292

Hormones That Promote Growth 292

Auxin 292

Gibberellin 294

Cytokinin 294

Other Hormones 294

Abscisic Acid 295

Ethylene 298

Salicylic Acid 299

Interactions Among Hormones 299

Synchrony with the Environment 299

Sensing the Environment 299

Phytochrome 300

Photoperiod 300

Seasonal Periods of Dormancy 300

Leaf Death 300

Physiological Changes 301

Bud Formation 302

Emergence from Dormancy 302

Seasonal Periods of Reproduction 302

Control of Flowering 302

Categories of Plants 302

Plant Movements 303

Tropisms 303

Nastic Responses 304

Control by Circadian Rhythms 306

Summary 306

Key Terms 306

Study Questions 306

Critical Thinking Problems 307

Suggested Readings 307

## PART IV



## Biology of Animals 309

## 17 Animal Organization 311

Origin of Animals 312

Selection for Multicellularity 312

Advantages of a Larger Body 312

Advantages of a Division of Labor 312

The First Animals 312

Animal Characteristics 312

Heterotrophy 313

Locomotion 313

Homeostasis 313

Body Temperature 314

Body Chemistry 315

Disturbances of Homeostasis 315

Organizations of Cells 316

Animal Tissues 316

Epithelial Tissue 316

Connective Tissue 316



*Muscle Tissue* 316  
*Nervous Tissue* 317  
 Organs and Organ Systems 321  
*Organs* 321  
*Organ Systems* 322  
 Coordination of Cellular Activities 326  
     Hormonal Control 326  
     Neural Control 327  
 Summary 328  
 Key Terms 328  
 Study Questions 329  
 Critical Thinking Problems 329  
 Suggested Readings 329

## 18 Nutrition and Digestion 331

Nutrition 332  
     Dietary Requirements 333  
     Nutritional Needs 333  
     Digestive Capabilities 333  
     Food for Energy 333  
     Energy Sources 333  
     Energy Stores 334  
     Food for Building Materials 334  
     Amino Acids 334  
     Fatty Acids 338  
     Vitamins 338  
     Minerals 338  
     Fiber 339  
 The Digestive System 339  
     Mouth and Esophagus 344  
     Stomach 344  
     Small Intestine 345  
     Digestion 345  
     Absorption 346  
     Pancreas and Liver 347  
     Large Intestine 349  
 Summary 350  
 Key Terms 350  
 Study Questions 351  
 Critical Thinking Problems 351  
 Suggested Readings 351

## 19 Circulation 353

Internal Transport Systems 354  
 The Human Circulatory System 354  
     Blood 355  
     What the Blood Transports 355  
     Red Blood Cells 356  
     Anemia 356  
     Network of Vessels 356  
     Arteries, Capillaries, and Veins 357  
     Shunting the Blood 358

    The Heart 359  
     Anatomy 359  
     Blood Flow 360  
     Heart Sounds 361  
     The Coronary Arteries 362  
 Cardiac Output 362  
     Heart Rate 362  
     Control by the Pacemaker 362  
     Control by the Brain and Adrenal Glands 364  
     Stroke Volume 365  
 Blood Pressure 365  
     Pressure Within the Vessels 366  
     The Arteries 366  
     The Veins 366  
     Low Blood Pressure 367  
     Hypotension 367  
     Cardiovascular Shock 368  
     High Blood Pressure 368  
     Physical Exercise and Emotion 368  
     Hypertension 368  
 Summary 369  
 Key Terms 370  
 Study Questions 370  
 Critical Thinking Problems 370  
 Suggested Readings 370

## 20 Respiration 373

Gas Exchange 374  
     Urgency of Gas Exchange 374  
     Surfaces for Gas Exchange 374  
     Large Surface 375  
     Wet Surface 375  
     Ventilated Surface 375  
     Linked with a Circulatory System 375  
 The Human Respiratory System 375  
     The Lungs 377  
     Breathing 377  
     Inhalation 379  
     Exhalation 379  
     Artificial Respiration 381  
     Regulation of Breathing 381  
     The Basic Rhythm of Breathing 381  
     Adjusting the Breathing Rate and Depth 381  
     The Upper Respiratory Tract 384  
     The Nose 384  
     The Pharynx 384  
     The Larynx 385  
     The Trachea 385  
     The Bronchi and Bronchioles 385  
 Summary 386  
 Key Terms 387  
 Study Questions 387  
 Critical Thinking Problems 387  
 Suggested Readings 387

## 21 Body Fluids and Temperature 389

Regulation of Body Fluids 390  
     The Urinary System of a Human 390  
     Organs That Form Urine 391  
     Organs That Transport Urine 391  
     The Formation of Urine 392  
     Filtration 393  
     Volume Reduction 394  
     Adjustments of Ions and Water 396  
     Regulation of Blood Pressure 397  
     Adjustment of pH 397  
 Regulation of Body Temperature 397  
     Anatomical and Behavioral Adaptations 398  
     How an Ectotherm Acquires Heat 398  
     How an Endotherm Retains Heat 398  
     How an Animal Eliminates Excess Heat 398  
     Physiological Adaptations 399  
     Lowering the Body Temperature 399  
     Raising the Body Temperature 400  
     Fever 400  
     When Temperature Control Fails 402  
 Summary 402  
 Key Terms 403  
 Study Questions 403  
 Critical Thinking Problems 403  
 Suggested Readings 404

## 22 Defenses Against Diseases 405

Disease Microbes 406  
     The Host-Parasite Relationship 406  
     Balance of Power 406  
     When Parasites Kill 406  
     Microbes That Cause Human Diseases 407  
     Protozoa 407  
     Fungi 408  
     Bacteria 408  
     Viruses 408  
 Natural Defenses of the Human Body 408  
     Preventing Invasions 409  
     The Local Response 409  
     The Release of Interferons 409  
     The Inflammatory Response 409  
     The General Response 414  
     Macrophages Within Vessels 414  
     The Inflammatory Response Within Lymph Nodes 414  
     Fever 416  
     Immunity 416  
     Naturally Acquired Immunity 416  
     Artificially Acquired Immunity 416

Undesirable Side Effects of the Immune System	417
Allergies	417
Autoimmune Disorders	419
Some Unconquered Diseases	420
Influenza	420
Acquired Immune Deficiency Syndrome	422
Summary	423
Key Terms	424
Study Questions	424
Critical Thinking Problems	424
Suggested Readings	424

## 23 Hormonal Control 427

Hormonal Control	428
Endocrine Glands	428
The Amount of Hormone Secreted	428
Stimulation of Secretory Cells	429
How Hormones Affect Their Target Cells	429
Lipid-Soluble Hormones	429
Water-Soluble Hormones	429
The Endocrine System	431
The Hypothalamus and the Pituitary	431
Posterior Pituitary	431
Anterior Pituitary	431
Thyroid Gland	434
Parathyroid Glands	435
Adrenal Glands	435
Adrenal Cortex	435
Adrenal Medulla	436
Pancreas	436
Thymus Gland	436
Pineal Gland	436
Ovaries and Testes	439
Links Between Hormonal and Neural Control	439
Summary	442
Key Terms	442
Study Questions	442
Critical Thinking Problems	442
Suggested Readings	443

## 24 Neural Control 445

Organization of the Nervous System	446
Pathways for the Flow of Information	446
Neural Tissue	446
Neurons	446
Glial Cells	446
Blood-Brain Barrier	448

The Neuron	448
Structure	448
Electrical Flow of Information	448
The Resting Neuron	449
Receiving Information	449
The Action Potential	450
Passing Information Along the Axon	450
Chemical Flow of Information	452
How the Message Is Relayed	452
The Role of Chemical Synapses	453
The Human Nervous System	453
The Peripheral Nervous System	454
Somatic Nervous System	455
Automatic Nervous System	457
The Spinal Cord	457
The Brain	457
The Limbic System	458
The Cerebral Cortex	459
Summary	463
Key Terms	463
Study Questions	463
Critical Thinking Problems	464
Suggested Readings	464

## 25 The Senses 467

From Environment to Perception	468
Receiving Information	468
Transduction	468
Receptor Cells	468
Decoding Information	469
Pathway of Neurons	469
Pattern of Electrical Signals	469
Perceiving Information	470
The Special Senses	471
Vision	471
Photoreceptors: Rods and Cones	471
The Retina	473
Accessory Structures	474
Taste	475
Smell	476
Hearing	477
Mechanoreceptors: Hair Cells	477
The Outer and Middle Ear	478
The Inner Ear	478
The Sense of Equilibrium	479
Receptor Cells	480
Sense Organs	480
The Semicircular Canals	481
The Utricle and Saccule	482
The Somatic Senses	483
Touch	483
Pain	483
Skin Temperature	484
Kinesthesia	484
Summary	484

Key Terms	484
Study Questions	485
Critical Thinking Problems	485
Suggested Readings	485

## 26 Locomotion 487

Animal Movement	488
The Skeleton	488
Bones	488
Bone Structure	490
Bone Functions	491
Joints	492
Ligaments	492
Cartilage	493
Synovial Fluid	496
Muscles	496
Attachments to Bones	496
Muscle Structure	496
Muscle Function	497
Contraction of a Muscle Cell	497
Energy of a Contraction	498
Stimulation of a Contraction	498
Types of Muscles	498
ATP Production by Muscle Cells	499
Specialized Muscle Fibers	501
Athletic Performance	503
Summary	503
Key Terms	504
Study Questions	504
Critical Thinking Problems	504
Suggested Readings	504

## 27 Behavior 507

Mechanisms of Behavior	508
Genetic Programming	508
Simple Innate Behaviors	509
Fixed-Action Patterns	510
Learning	510
Trial-and-Error Learning	510
Insight	510
Imprinting	511
Behavioral Ecology	512
Acquiring Resources	512
Habitat Selection	512
Foraging Behavior	512
Evading Predators	513
Migration	514
Seasonal Migrations	514
Reproductive Migrations	514
Social Behavior	514
Reproductive Behavior	515
Mating Behavior	515
Pair-Bonding	515
Parental Care	516