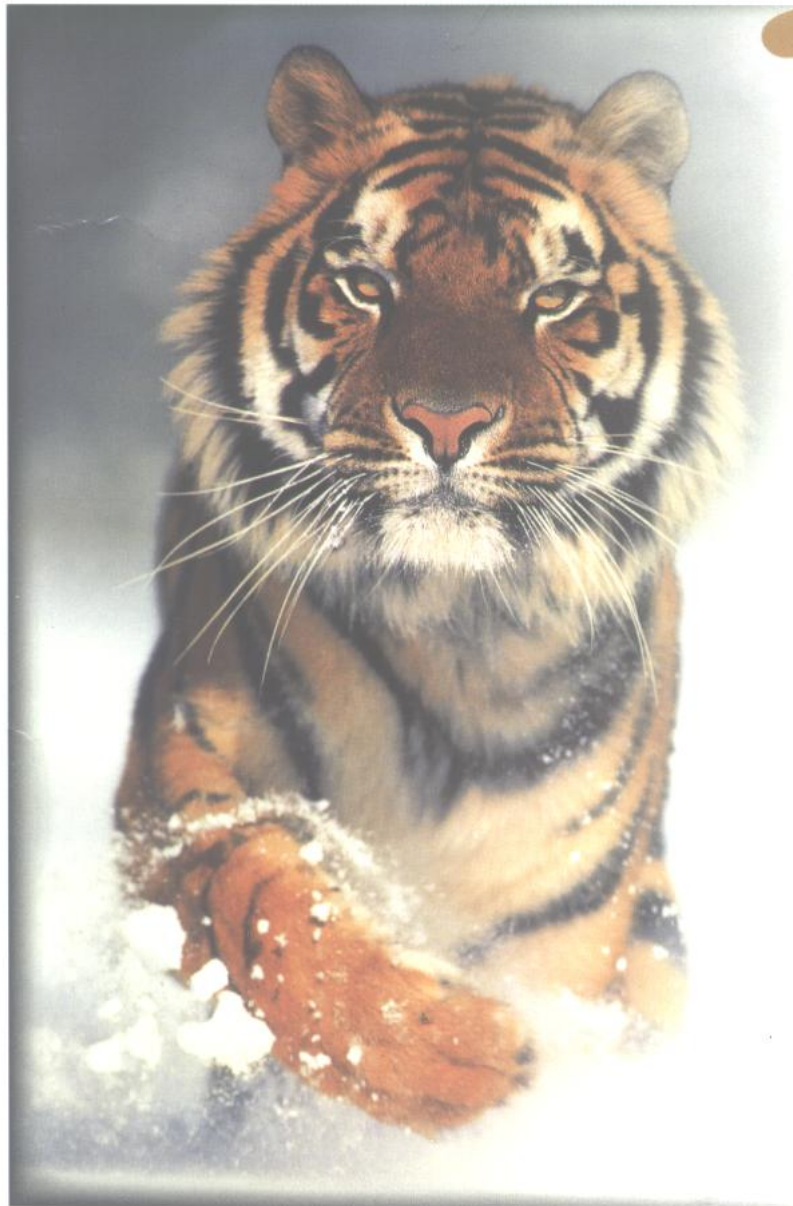


# Biology

sixth edition



sylvia s. mader

# Biology

seventh edition

sylvia s. mader



Boston, Massachusetts Burr Ridge, Illinois Dubuque, Iowa  
Madison, Wisconsin New York, New York San Francisco, California St. Louis, Missouri

## WCB/McGraw-Hill

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### INTERNATIONAL EDITION

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# Preface

**B**iology is an introductory text that covers the concepts and principles of biology from the structure and function of the cell to the organization of the biosphere. It draws upon the entire world of living things to bring out an evolutionary theme that is introduced from the start.

## Scientific Process

*Biology* emphasizes the scientific process. Notable contributions to biology, including significant experiments, are discussed throughout the text. Chapter 1 explains the scientific method and also illustrates this method by walking students through experiments in the current literature. The text has numerous *Doing Science* readings, many written by contemporary biologists who tell how they go about doing their research and how their findings can be applied to human beings.

Every chapter of *Biology* has been revised and thoroughly updated; however, this edition has not grown significantly in page length. Every chapter has been skillfully revised and rewritten. All illustrations have been carefully correlated to the textual material to ensure that each illustration is on the same or facing page as its textual reference. This direct correlation aids in learning and studying.

## Concepts

In this edition the major topics are numbered, and the concepts, which have replaced learning objectives, are grouped according to these topics. This numbering system is used in the textual material, and in the summary, which reviews the concepts according to each major topic. This system allows instructors to assign just certain portions of the chapter and it also allows students to study the chapter in terms of the concepts presented.

## New Chapters

Chapter six, "Metabolism: Energy and Enzymes," is new to this edition. This chapter, which explains the laws of thermodynamics, how the cell makes use of ATP, and how enzymes function, lays a foundation for the revised photosynthesis and cellular respiration chapters that follow.

The science of ecology is undergoing fundamental changes, and the ecology chapters have been rewritten to have a modern approach. Four chapters (23–26) are devoted to reviewing the ecological principles that explain how the

natural world works. These chapters make frequent reference to how humans impact the environment, and chapter 27 is concerned with this topic alone. Ecological problems of our day are considered.

Ecology is further emphasized in this edition because *Ecology Focus* readings appear in each part, and the part entitled "Behavior and Ecology" has been moved to follow Part III, "Evolution." This sequence is logical because evolution and ecology are intertwined.

Like ecology, systematics is now undergoing changes that promise to revolutionize the science. Cladistics is now challenging the traditional school and has been well received by many. Therefore, students need to be exposed to how cladists go about determining evolutionary relationships. More and more reliance is being placed on molecular data, which suggests there are three domains of life: bacteria, archaea, and eukarya. All of these topics are considered in Part V, including a thorough examination of each kingdom.

## New Pedagogy

Consistent with accepted educational methodology, this edition of *Biology* features an introduction and a closing that emphasize the concepts of the chapter. The introduction, which appears on the chapter opening page, sparks student interest and highlights the overall themes for the chapter. *Connecting Concepts*, which closes the text portion of the chapter, stimulates critical thinking and shows how the concepts in the chapter are related to the concepts in other chapters.

## Readings

The readings have now been organized into four types. The *Doing Science* readings are often written by contemporary scientists who tell us about their particular type of research and how they became interested in this field of biology. Some of the *Doing Science* readings feature the work of minority researchers such as Barbara McClintock's work regarding "jumping genes" and Susumu Tonegawa's work in antibody diversity. The *Health Focus* readings give practical information concerning some particular topic of interest, such as proper nutrition and how to prevent cancer. The *Ecology Focus* readings draw attention to some particular environmental problem such as the need to preserve



tropical rain forests and the relationship between ozone holes and skin cancer. *A Closer Look* readings are designed to expand, in an interesting way, on the core information presented in each chapter.

### New Appearance

There are many new illustrations in *Biology*, but special attention was given to Part I in which all art pieces are color consistent with new animal and plant cells in chapter four, "Cell Structure and Function." Location icons are now a part of all organelle illustrations.

The appearance of this edition is completely new and improved. Color has been used more effectively, and all text art is now screened in one or two colors. And, the summary statements no longer have a color screen. The end result is a book whose appearance will be pleasing to all.

### Technology

Many technology aids are available for use with *Biology*, and each chapter now has its own listing of these. For the student, the Mader Home Page offers exercises to aid learning and resources that expand on the text's content and applica-

tions. *Explorations in Human Biology* and *Explorations in Cell Biology and Genetics* are interactive CD-ROMs that bring biology to life. *The Life Science Animations* videotapes include fifty-three additional topics that can be studied in a visually appealing way. *The Dynamic Human* CD-ROM offers three-dimensional visuals that facilitate an understanding of human anatomy and physiology. Other aids are also available, and all of these are listed on the technology page (see page xviii of the preface).

For the Instructor, the *Extended Lecture Outline* makes the contents of the book available in a way that facilitates lecture preparation. The outline is available on the Mader Home Page and on disk by request. *The Visual Resource Library* on CD-ROM makes the text illustrations available for classroom use. The images and their labels can even be manipulated. To help with the mechanics of teaching there is a computerized version of the *Test Item File* available in Windows and Macintosh formats.

### Aids to the Reader

*Biology* includes a number of aids that have helped students study biology successfully and enjoyably.

#### ► NEW TO THIS EDITION

► Part IV: Ecology was thoroughly updated for this edition and all chapters have been completely rewritten. *Ecology Focus* readings occur throughout the text.

A new chapter (6) entitled "Metabolism: Energy and Enzymes," the first of three energetics chapters, was rewritten, and the other two chapters (7 and 8) have been revised.

Systematics received special attention and the three domains of life are discussed. Cladistics has been revised and made clearer for the student.

► New art appears throughout the text, and in Part I the colors used are consistent with new plant and animal cells. Color is more effectively used

throughout the text, giving the book a completely new appearance.

► Four types of readings are featured:

*Doing Science*  
*Ecology Focus*  
*Health Focus*  
*A Closer Look*

► The chapter opening page has an integrated outline of the major topics and chapter concepts. The major topics are numbered in the chapter outlines, in the text, and in the Summary. The introduction, which sparks student interest and highlights certain themes, is on the chapter opening page. Each chapter ends with *Con-*

*necting Concepts*, which emphasizes how the concepts of the chapter are related to concepts in other chapters.

► Technology Aids are correlated to the text. *Explorations in Human Biology* and *Explorations in Cell Biology and Genetics* CD-ROMs offer exciting new ways to understand biological concepts. *The Dynamic Human* on CD-ROM is an interactive three-dimensional visual guide to human anatomy and physiology.

► Explore the Mader Home Page for even more information:

<http://www.mhhe.com/sciencemath/biology/mader/>



The inside cover lists major contributions to the field of biology in a concise, chronological manner. Students may refer to these whenever it is appropriate.

An introduction for each part highlights the central ideas of that part and specifically tells the student how the topics within each part contribute to biological knowledge.

The chapter begins with an integrated outline that numbers the major topics of the chapter and lists the concepts for each topic.

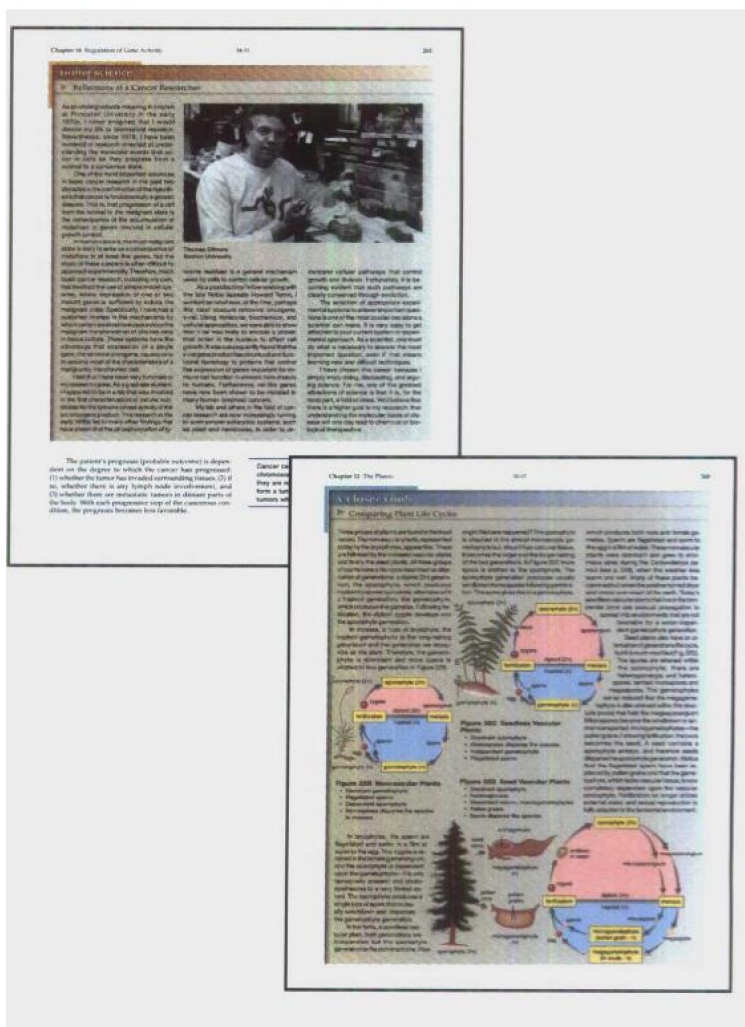
Each chapter has an introduction on the chapter opening page that sparks student interest in the themes for the chapter.

Internal summaries stress the chapter's key concepts. These appear at the ends of major sections and help students focus their study efforts on the basics.

The illustrations and tables in *Biology* are consistent with multicultural educational goals. Often it is easier to understand a given process by studying a drawing, especially when it is carefully coordinated with the text. Every illustration appears on the same or facing page to its reference.

Four types of readings are included in the text. *Doing Science* readings invite the reader to share in the excitement of past and current research projects. *Ecology Focus* readings draw attention to some environmental problem. *Health Focus* readings review measures to keep healthy. *A Closer Look* reading is designed to expand in an interesting way on the core information presented in the chapter.

These appear at the close of the text portion of the chapter, and they stimulate critical thinking by showing how the concepts of the chapter are related to others in the text.





## End of Chapter Pedagogy

The numbered major topics are repeated in the *Summary*, which reviews the concepts for each topic. *Reviewing the Chapter* are a series of study questions that follow the sequence of the chapter. *Testing Yourself* consists of objective questions that allow students to test their ability to answer recall-based questions. Answers to *Testing Yourself* questions are given in Appendix A. *Applying the Concepts* are critical thinking questions based on biological concepts. *Using Technology* lists the available technology, including the Mader Home Page address, for the chapter. *Understanding the Terms* provides a page reference for boldfaced terms in the chapter. A matching exercise allows students to test their knowledge of the terms.

## Further Readings

The list of readings at the end of each part suggests references that can be used for further study of the topics covered in the chapters of that part. The references listed in this section were carefully chosen for readability and ac-

cessibility. References are followed by a short description and an indication of their level of rigor.

## Appendices and Glossary

The appendices contain optional information. *Appendix A* is the answer key to the objective questions found at the end of each chapter; *Appendix B* is an expanded table of chemical elements; *Appendix C* explains the metric system; *Appendix D* is a classification of organisms; and *Appendix E* is a listing of acronyms used in the text along with the complete term. The glossary defines the boldface terms in the text. These terms are the ones most necessary for the successful study of biology. Terms that are difficult to pronounce have a phonetic spelling, and the Greek and Latin derivation is given for selected terms.

402 23-20 Part IV: Behavior and Ecology

### Connecting Concepts

Modern ecology began with descriptive studies by nineteenth-century naturalists. In fact, an early definition of the field was "scientific natural history." However, modern ecology has grown to be much more than a simple descriptive field. Ecology is now very much an experimental, predictive science.

Much of the success in the development of ecology as a predictive science has come from studies of populations and the development of models that examine how populations change over time. The simplest models are based on population growth when there are unlimited resources. This results in exponential growth, a type of population growth that is only rarely seen in nature. Pest species may exhibit exponential growth until they run out of resources. Because so few natural populations exhibit exponential growth, population ecologists realized they must incorporate resource limitation in their models. The simplest models that account for limited resources result in sigmoidal or logistic growth. Populations which exhibit logistic growth will cease growth when they reach the environmental carrying capacity.

Many modern ecological studies are concerned with identifying the factors that place limits on population growth and that set the environmental carrying capacity. A combination of careful descriptive studies, experiments done in nature, and sophisticated models has allowed ecologists to make good predictions about which factors have the greatest influence on population growth. The example of the winter moth is a good case in point.

The next step in the development of modern ecology has been to try to understand how populations of different species affect each other. This is known as community ecology. Because each population in a community responds to environmental changes in slightly different ways, developing predictive models that explain how communities change has been challenging. However, ecologists are beginning to be able to predict how communities will change through time and to understand what factors influence community properties such as species number, abundance of individuals, and species interactions.

### Summary

#### 23.1 Scope of Ecology

Ecology is the study of the interactions of organisms with other organisms and with the physical environment. Ecology encompasses several levels of study: organism, population, community, ecosystem, and finally the biosphere. Ecologists are particularly interested in how interactions affect the distribution and abundance of organisms.

Population density is simply the number of individuals per unit area or volume. Distribution of these individuals can be uniform, random, or clumped. A population's distribution is often determined by limiting factors; that is, abiotic factors like water, temperature, and availability of nutrients.

#### 23.2 Characteristics of Populations

Population size is dependent upon natality (number of births), mortality (number of deaths), immigration, and emigration. The number of births minus the number of deaths results in the net reproductive rate (symbolized as  $r$ ) per capita per unit time.

One model for population growth assumes that the environment offers unlimited resources. In the example given, the members of the population have discrete reproductive events, and therefore the size of next year's population is given by the equation:  $N_{t+1} = rN_t$ . Under these conditions, exponential growth results in a J-shaped curve.

Most environments restrict growth, and exponential growth cannot continue indefinitely. Under these circumstances an S-shaped or logistic growth curve results. The growth of the population is given by the equation  $dN/dt = rN(K-N)/K$  for populations in which individuals have repeated reproductive events. The term  $(K-N)/K$  represents the unused portion of the carrying capacity ( $K$ ). When the population reaches carrying capacity, the population stops growing because environmental resistance opposes biotic potential; the maximum net reproductive rate for a population.

Individuals are at different stages of their life span in a population. Mortality (deaths per capita) within a population can be recorded in a life table and illustrated by a survivorship curve. The pattern of population growth is reflected in the age distribution of a population, which consists of prereproductive, reproductive, and postreproductive segments. Populations that are growing exponentially have a pyramid-shaped age distribution pattern.

#### 23.3 Regulation of Population Size

Population growth is limited by density-independent (e.g., weather) and density-dependent factors (predation, competition, and resource availability). Do some populations have an intrinsic means of regulating population growth as opposed to density-independent and density-dependent factors, which are extrinsic means? Territoriality is given as an example of a possible intrinsic means of regulation.

#### 23.4 Life History Patterns

The logistic growth model has been used to suggest that the environment promotes either  $r$ -selection or  $K$ -selection. So-called  $r$ -selection occurs in unpredictable environments where density-independent factors affect population size. Energy is allocated to producing as many small offspring as possible. Adults remain small and do not invest in parental care of offspring.  $K$ -selection occurs in environments that remain relatively stable, where density-dependent factors affect population size. Energy is allocated to survival and repeated reproductive events. The adults are large and invest in parental care of offspring. Actual life histories contain trade-offs between these two patterns.

#### 23.5 Human Population Growth

The human population is expanding exponentially, and it is unknown when the population size will level off. Most of the expected increase will occur in certain LDCs (less-developed countries) of Africa, Asia, and Latin America. Support for family planning, human development, and delayed child bearing could help prevent an expected increase.

892 49-20 Part VII: Animal Structure and Function

### Applying the Concepts

- Hormone levels are maintained by feedback control. Contrast control of neurotransmitter levels in the nervous system with control of hormone levels in the endocrine system.
- The nervous system is fast acting, and the endocrine system is fairly slow moving. Contrast message delivery in the nervous system with that in the endocrine system.
- Hormone levels greatly affect the phenotype. Use the effect of sex hormones to substantiate this concept.

### Using Technology

Your study of hormones and endocrine systems is supported by these available technologies:

- Exploring the Internet: The Mader Home Page provides resources for and help with studying this chapter.  
<http://www.mhhe.com/sciencemath/biology/mader/> (Click on Biology)
- This Dynamic Human CD-ROM: Endocrine System
- Explorations in Cell Biology & Genetics CD-ROM: Cell-Cell Interactions (K4)
- Explorations in Human Biology CD-ROM: Hormone Action (B1)
- Life Science Animations Video: Video K3: Animal Biology I: Peptide Hormone Action (EAMP) (B2)

### Understanding the Terms

Addison disease 883	hypothalamus 878
adrenal cortex 882	insulin 885
adrenal gland 882	melanocyte-stimulating hormone (MSH) 880
adrenal medulla 882	nonsteroid hormone 875
adrenocorticotrophic hormone (ACTH) 880	norepinephrine 882
aldosterone 882	oxytocin 878
anabolic steroid 887	pancreas 885
androgen 887	pancreatic islet 885
antidiuretic hormone (ADH) 878	parathyroid gland 881
circadian rhythm 888	parathyroid hormone (PTH) 881
cortisol 882	pineal gland 888
Cushing syndrome 883	pituitary gland 878
cyclic AMP 875	progesterone 887
diabetes mellitus 885	prolactin (PRL) 880
endocrine system 873	prostaglandin 888
epinephrine 882	renin 882
estrogen 887	second messenger 875
glucagon 885	steroid hormone 874
golter 880	thymus 888
gonad 877	thyroid gland 880
gonadotrophic hormone 880	thyroid-stimulating hormone (TSH) 880
growth hormone (GH) 879	thyroxine 880
hormone 874	

Match the terms to these definitions:

- \_\_\_\_\_ Hormone secreted by the adrenal cortex that regulates the sodium and potassium ion balance of the blood.
- \_\_\_\_\_ Chemical messengers produced in one part of the body that control the activity of other parts.
- \_\_\_\_\_ Hormone secreted by the posterior pituitary that increases the permeability of the collecting ducts in a kidney.
- \_\_\_\_\_ Gland—either at the skin surface (fish, amphibians) or in the third ventricle of the brain. (mammals)—that produces melatonin.
- \_\_\_\_\_ Hormone secreted by the anterior lobe of the pituitary gland that stimulates activity in the adrenal cortex.
- \_\_\_\_\_ Large gland in the neck that produces several important hormones, including thyroxine and calcitonin.
- \_\_\_\_\_ Hormone, secreted by the pancreas, which causes the liver to break down glycogen and raises the blood glucose level.
- \_\_\_\_\_ Substance secreted by the anterior pituitary; it promotes cell division, protein synthesis, and bone growth.



## ► technology

Several state-of-the-art technology products are available that are correlated to this textbook. These useful and enticing supplements can assist you in teaching and can improve student learning.

### Exploring the Internet

<http://www.mhhe.com/sciencemath/biology/mader/>

The Mader Home Page allows students and teachers from all over the world to communicate. *Biology* has a complete text-specific site developed exclusively for users of the sixth edition. By visiting this site, students can access additional study aids, explore links to other relevant biology sites, catch up on current information, and pursue other activities.

### The Internet Primer

by Fritz J. Erickson &  
John A. Vonk

This short, concise primer shows students and instructors how to access and use the Internet. The guide provides enough information to get started by describing the most critical elements of using the Internet.

### The Dynamic Human CD-ROM

This guide to anatomy and physiology interactively illustrates the complex relationships between anatomical structures and their functions in the human body. Realistic, three-dimensional visuals are the premier feature of this exciting learning tool. The program covers each body system, demonstrating to the viewer the anatomy, physiology, histology, and clinical applications of each system. *The Dynamic Human* is listed in the Using Technology section at the end of each systems chapter.

### Explorations in Human Biology CD-ROM; Explorations in Cell Biology and Genetics CD-ROM

These interactive CDs, by Dr. George B. Johnson, feature fascinating topics in biology. *Explorations in Human Biology* and *Explorations in Cell Biology and Genetics* have 33 different modules that allow stu-

dents to study a high-interest biological topic in an interactive way. In this edition of *Biology*, the Explorations that correlate to the chapter are listed in the Using Technology section, which appears at the end of each chapter. The modules are briefly described in the Instructor's Manual.

### Life Science Animations Videotapes

Fifty-three animations of key physiological processes are available on videotapes. The animations bring visual movement to biological processes that are difficult to understand on the text page. In this edition of *Biology*, the Explorations that correlate to the chapter are listed in the Using Technology section, which appears at the end of each chapter.

### BioSource Videodisc

*BioSource Videodisc*, by WCB/McGraw-Hill and Sandpiper Multimedia, Inc., features 20 minutes of animations and nearly 10,000 full-color illustrations and photos, many from leading WCB/McGraw-Hill biology textbooks.

### Bioethics Forums Videodisc

*Bioethics Forums* is an interactive program that explores societal dilemmas arising from recent breakthroughs in biology, genetics, and biomedical technology. The scenarios are fictional, but the underlying science and social issues are real. *Bioethics Forums* encourages students to explore the science behind decisions as well as the processes of ethical reasoning and decision-making.

### Visual Resource Library

Our electronic art image bank is a CD-ROM that contains hundreds of biological images from *Biology*, Sixth Edition. The CD-ROM contains an easy-to-use program that enables you quickly to view images, and you may easily import the images into PowerPoint to create your own multimedia presentations or use the already prepared PowerPoint presentations. The CD-ROM also includes several video clips featuring key animated biological processes.

### Virtual Biology Laboratory CD-ROM

by John T. Beneski and Jack Waber, West Chester University

This CD-ROM is designed primarily for nonscience major students. The exercises are designed to expose students to the types of tools used by biologists, allow students to perform experiments without the use of wet lab setups, and support and illustrate topics and concepts from a traditional biology course.

### Virtual Physiology Laboratory CD-ROM

This CD-ROM features ten simulations of the most common and important animal-based experiments ordinarily performed in the physiology component of your laboratory. This revolutionary program allows students to repeat laboratory experiments until they adeptly master the principles involved. The program contains video, audio, and text to clarify complex physiological functions.

### The Secret of Life Video Modules

WGBH, Boston and BBC-TV

WGBH has produced eight 15-minute video modules that illuminate the biological universe with unique stories and animation. Each module concludes with a series of stimulating questions for class discussion.

### The Secret of Life Videodisc

WGBH, Boston

A two-sided videodisc is available as a companion to *Biology*, Sixth Edition. Topic coverage includes biotechnology, human reproduction, portraits of modern science and research, and human genetics.

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Our CD-ROM products may be packaged with the text at a cost savings. Contact your WCB/McGraw-Hill sales representative for details.

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## Technology Correlations

The Sixth Edition of *Biology* has three technology learning tools that are correlated to the chapters. The Using Technology section at the end of the chapter lists those that are appropriate to that chapter.<sup>1</sup>



*The Dynamic Human* is an interactive CD-ROM with three-dimensional visuals demonstrating the anatomy, physiology, and histology, along with clinical applications, of each body system.



*Explorations in Human Biology* and *Explorations in Cell Biology and Genetics* are interactive CD-ROMs consisting of 33 different modules that cover key topics in biology.



*Life Science Animations* is a set of five video-tapes containing 53 animations of processes integral to the study of biology.



### Chapter 1 A View of Life

Life Science Animations 52 (Tape 5)

### Chapter 2 Basic Chemistry

Life Science Animations 1 (Tape 1)

### Chapter 4 Cell Structure and Function

Life Science Animations 2, 3, 4 (Tape 1)

### Chapter 5 Membrane Structure and Function

Explorations in Cell Biology 2, 3  
Life Science Animations 2, 3 (Tape 1)

### Chapter 6 Metabolism: Energy and Enzymes

Explorations in Cell Biology 6, 8  
Life Science Animations 7, 11 (Tape 2)

### Chapter 7 Photosynthesis

Explorations in Cell Biology 9  
Life Science Animations 8, 9, 10 (Tape 1)

### Chapter 8 Cellular Respiration

Explorations in Cell Biology 8  
Life Science Animations 5, 6, 7, 11 (Tape 1)

### Chapter 9 Cell Division

Explorations in Cell Biology 5  
Life Science Animations 12, 50 (Tapes 1 and 5)

### Chapter 10 Meiosis and Sexual Reproduction

Explorations in Cell Biology 10  
Life Science Animations 13, 14, 19, 20 (Tape 2)

### Chapter 12 Chromosomes and Genes

Explorations in Cell Biology 11

### Chapter 13 Human Genetics

Explorations in Cell Biology 1, 12, 13  
Explorations in Human Biology 1

### Chapter 14 DNA: The Genetic Material

Life Science Animations 15 (Tape 2)

### Chapter 15 Gene Activity

Explorations in Cell Biology 1, 15  
Life Science Animations 16, 17 (Tape 2)

### Chapter 16 Regulation of Gene Activity

Explorations in Cell Biology 15, 16  
Life Science Animations 18 (Tape 2)

### Chapter 17 Recombinant DNA and Biotechnology

Explorations in Cell Biology 14, 17

### Chapter 20 Origin and History of Life

Life Science Animations 53 (Tape 5)

### Chapter 25 Ecosystems

Life Science Animations 51, 52 (Tape 5)

### Chapter 27 Human Impact on the Global Environment

Explorations in Human Biology 16

### Chapter 30 The Protists

Life Science Animations 45 (Tape 4)

### Chapter 32 The Plants

Life Science Animations 46, 47

### Chapter 36 Plant Structure

Life Science Animations 46 (Tape 5)

### Chapter 37 Nutrition and Transport in Plants

Life Science Animations 47, 48 (Tape 5)

### Chapter 38 Growth and Development in Plants

Life Science Animations 49 (Tape 5)

### Chapter 40 Animal Organization and Homeostasis

Dynamic Human, Anatomical Orientation

### Chapter 41 Circulation

Explorations in Human Biology 5  
Life Science Animations 37, 38, 39, 40 (Tape 4)  
Dynamic Human, Cardiovascular System

### Chapter 42 Lymph Transport and Immunity

Explorations in Human Biology 12, 13  
Life Science Animations 41, 42, 43, 44 (Tape 4)  
Dynamic Human, Lymphatic System

### Chapter 43 Digestion and Nutrition

Explorations in Human Biology 7  
Life Science Animations 33 (Tape 4)  
Dynamic Human, Digestive System

### Chapter 44 Respiration

Explorations in Human Biology 3, 6  
Dynamic Human, Respiratory System

### Chapter 45 Osmotic Regulation and Excretion

Dynamic Human, Urinary System

### Chapter 46 Neurons and Nervous Systems

Explorations in Cell Biology 8, 9  
Explorations in Human Biology 10  
Life Science Animations 22, 23, 24, 25 (Tape 3)  
Dynamic Human, Nervous System

### Chapter 47 Sense Organs

Life Science Animations 26, 27 (Tape 3)

### Chapter 48 Support Systems and Locomotion

Explorations in Human Biology 4, 9  
Life Science Animations 30, 31 (Tape 3)

Dynamic Human, Muscular System, Skeletal System

### Chapter 49 Hormones and Endocrine Systems

Explorations in Cell Biology 4  
Explorations in Human Biology 11  
Life Science Animations 28 (Tape 3)  
Dynamic Human, Endocrine System

### Chapter 50 Reproduction

Explorations in Human Biology 13  
Dynamic Human, Reproductive System

### Chapter 51 Development

Life Science Animations 21, (Tape 2)

<sup>1</sup>Technology aids are described per chapter in the *Instructor's Manual*.



## More Teaching and Learning Aids

### Instructor's Manual/Test Item File

The Instructor's Manual/Test Item File, prepared by Dr. John Richard Schrock, Emporia State University, is designed to assist instructors as they plan and prepare for classes using *Biology*. The first part of the Instructor's Manual pertains to the text chapters and the second part is the Test Item File.

The Instructor's Manual contains both an extended lecture outline and lecture enrichment ideas, which together review in detail the contents of the text chapter. The technology section lists videos and computer software items that are available from outside sources and also those that are available from WCB/McGraw-Hill. Answers to the Applying the Concepts questions appear in the Instructor's Manual.

The Test Item File for each chapter contains approximately 60 objective test questions and several essay questions. These same questions are found in the computerized version of the test item file.

### Study Guide

To ensure close coordination with the text, Sylvia Mader has written the *Student Study Guide* that accompanies the text. Each text chapter has a corresponding study guide chapter that includes a listing of objectives, study questions, and a chapter test. Answers to the study questions and the chapter tests are provided to give students immediate feedback.

The concepts in the study guide are the same as those in the text, and the study questions in the study guide are sequenced according to these concepts. Instructors who make their choice of concepts known to the students can thereby direct student learning in an efficient manner. Instructors and students who make use of the *Student Study Guide* should find that student performance increases dramatically.

### Laboratory Manual

Sylvia Mader has also written the *Laboratory Manual* to accompany *Biology*. With few exceptions, each chapter in the text has an accompanying laboratory exercise in the manual (some chapters have more than one accompanying exercise). In this way, instructors are better able to emphasize particular portions of the curriculum, if they wish. The 35 laboratory sessions in the manual are designed to further help students appreciate the scientific method and to learn the fundamental concepts of biology and the specific content of each chapter. All exercises have been tested for student interest, preparation time, and feasibility.

### Laboratory Resource Guide

More extensive information regarding preparation is found in the *Laboratory Resource Guide*. The guide includes suggested sources for materials and supplies, directions for making up solutions and setting up the laboratory, expected

results for the exercises, and suggested answers to questions in the laboratory manual. It is free to all adopters of the laboratory manual.

### Transparencies

A set of 300 full color transparency acetates accompany the text. These acetates contain key illustrations from the text. This set of transparencies is also available as slides.

### Visuals Testbank

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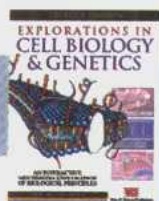
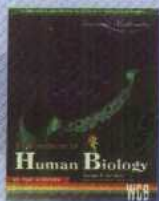


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# A

**abscisic acid (ABA) (ab-SIZ-ik)** Plant hormone that causes stomates to close and that initiates and maintains dormancy. 687

**abscission (ab-SIZH-un)** Dropping of leaves, fruits, or flowers from a plant. [L. *abscissus*, cut off] 687

**acetylcholine (ACh) (uh-set-ul-KOH-leen)** Neurotransmitter active in both the peripheral and central nervous systems. 822

**acetylcholinesterase (AChE) (uh-set-ul-koh-luh-NES-tuh-rays)** Enzyme that breaks down acetylcholine within a synapse. 822

**acetyl-CoA** Molecule made up of a two-carbon acetyl group attached to coenzyme A. During aerobic cellular respiration, the acetyl group enters the Krebs cycle for further breakdown. 134

**acid** Molecules tending to raise the hydrogen ion concentration in a solution and to lower its pH numerically. 30

**acid deposition** Return to earth as rain or snow of the sulfate or nitrate salts of acids produced by commercial and industrial activities. 476

**actin** Muscle protein making up the thin filaments in a sarcomere; its movement shortens the sarcomere, yielding muscle contraction. 867

**action potential** Nerve impulse; membrane potential changes in an active axon. 820

**active site** Region on the surface of an enzyme where the substrate binds and where the reaction occurs. 104

**active transport** Use of a plasma membrane carrier protein to move particles from a region of lower to higher concentration; it opposes equilibrium and requires energy. 90

**adaptation** Organism's modification in structure, function, or behavior suitable to the environment. [L. *ad*, toward, and *aptus*, fit, suitable] 4, 295

**adaptive radiation** Evolution of a large number of species from a common ancestor. 317

**adenine (A) (AD-un-een)** One of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA. 225

**adipose tissue** Connective tissue in which fat is stored. [L. *adipalis*, fatty] 720

**ADP (adenosine diphosphate) (ah-den-ah-SEEN dy-FAHS-fayt)** Nucleotide with two phosphate groups that can accept another phosphate group and become ATP. 51, 102

**adrenal cortex** Outer portion of the adrenal gland; secretes hormones such as mineralocorticoid aldosterone and glucocorticoid cortisol. 882

**adrenal gland (uh-DREEN-ul)** Gland that lies atop a kidney; the adrenal medulla produces the hormones epinephrine and norepinephrine and the adrenal cortex produces the corticoid hormones. [L. *ad*, toward, and *renis*, kidney] 882

**adrenal medulla** Inner portion of the adrenal gland; secretes the hormones epinephrine and norepinephrine. 882

**adrenocorticotrophic hormone (ACTH) (uh-DREE-noh-kawrt-ih-koh-TROH-pik)** Hormone secreted by the anterior lobe of the pituitary gland that stimulates activity in the adrenal cortex. 880

**aerobic respiration** Aerobic breakdown of glucose including glycolysis in cytosol and the Krebs cycle, and electron transport in mitochondria. Results in carbon dioxide and water, and typically 36 ATP. [Gk. *aeros*, air] 130

**age structure diagram** Representation of the number of individuals in each age group in a population. 391

**agglutination (uh-gloot-un-AY-shun)** Clumping of red blood cells due to a reaction between antigens on red blood cell plasma membranes and antibodies in the plasma. [L. *ad*, to, and *glutinis*, be sticky] 750

**aldosterone (al-DAHS-tuh-rohn)** Hormone secreted by the adrenal cortex that regulates the sodium and potassium ion balance of the blood. 813, 882

**alga (pl., algae)** Aquatic, plantlike organism carrying out photosynthesis and belonging to the kingdom Protista. [L. *alga*, seaweed] 524

**allantois (uh-LANT-uh-wus)** Extraembryonic membrane that accumulates nitrogenous wastes in birds and reptiles and contributes to the formation of umbilical blood vessels in mammals. [Gk. *allantos*, sausage] 922

**allele (uh-LEEL)** Alternative form of a gene—alleles occur at the same locus on homologous chromosomes. [Gk. *allelon*, reciprocal, parallel] 177

**allopatric speciation (al-uh-PA-trik)** Origin of new species in populations that are separated geographically. [Gk. *allo*, different, and *patri*, fatherland] 316

**altruism** Social interaction that has the potential to decrease the fitness of the member exhibiting the behavior. [L. *alter*, the other] 378

**alveolus (pl., alveoli) (al-VEE-uh-lus)** Terminal, microscopic, grapelike air sac found in vertebrate lungs. [L. *alveolus*, dim. of *alveus*, cavity] 795

**amino acid** Organic molecule having an amino group and an acid group, that covalently bonds to produce protein molecules. 46

**amnion (AM-nee-ahn)** Extraembryonic membrane of birds, reptiles, and mammals that forms an enclosing, fluid-filled sac. [Gk. *amnion*, membrane around fetus] 922

**amniote egg** Egg that has an amnion, as seen during the development of reptiles, birds, and mammals. 624

**amoeboid** Protist that moves and engulfs prey with pseudopods; amoebalike in movement. 530

**amphibian** Member of a class of terrestrial vertebrates that includes frogs, toads, and salamanders; they are still tied to a watery environment for reproduction. [Gk. *amphibios*, living on both land and in water] 622

**analogous structure** Structures that have a similar function in separate lineages and differ in structure and origin. 497

**androgen** Male sex hormones; testosterone is an androgen. [Gk. *andros*, male, and L. *genitus*, producing] 887

**angiosperm** Flowering plant; the seeds are borne within a fruit. [Gk. *angion*, dim. of *angos*, vessel, and *sperma*, seed] 567, 637

**Animalia** Animal kingdom of organisms that includes eukaryotic heterotrophs that typically ingest food, are multicellular with specialized tissues, and are motile. 502

- annelid** Invertebrate of the phylum Annelida, which includes clam worms, tube worms, earthworms, and leeches; characterized by a segmented body. [L. *annelus*, dim. of *annulus*, ring] 600
- anther** In flowering plants, pollen-bearing portion of stamen. 568, 695
- antheridium** Reproductive organ found in nonvascular and some vascular plants which produces flagellated sperm. [Gk. *anthos*, flower, and *-idion*, small] 556
- anthropoid (AN-thruh-poyd)** Group of primates that includes only monkeys, apes, and humans. [Gk. *anthropos*, man, and *-eides*, like] 351
- antibiotic** Substance produced by a microorganism or semisynthetically that has the capacity to kill or inhibit growth of infectious microorganisms. 517
- antibody** Protein produced in response to the presence of an antigen; each antibody combines with a specific antigen [Gk. *anti*, against] 747, 760
- anticodon** Three nucleotides on a tRNA molecule attracted to a complementary codon on mRNA. 242
- antidiuretic hormone (ant-ih-DY-yuu-RET-ik) (ADH)** Hormone secreted by the posterior pituitary that increases the permeability of the collecting ducts in a kidney. [Gk. *anti*, against, and L. *ouresis*, urination] 812, 878
- antigen** Foreign substance, usually a protein or a polysaccharide, that stimulates the immune system to react, such as to produce antibodies. [Gk. *anti*, against, and L. *genitus*, forming, causing] 747, 760
- aorta** In humans, the major systemic artery that takes blood from the heart to the tissues. [L. *aorte*, great artery] 742
- appendicular skeleton (ap-un-DIK-yuh-ler)** Part of the skeleton that consists of the pectoral and pelvic girdles and the bones of the arms and legs. [L. *appendicula*, dim. of *appendix*, appendage, and Gk. *skeleton*, dried body] 862
- aquifer (AHK-wuh-fur)** Rock layers that contain water and will release it in appreciable quantities to wells or springs [L. *aqua*, water, and *fero*, to bear, carry] 435, 479
- Archaea** One of the three domains of life often found living in extreme habitats; prokaryotic cells that have unique genetic, biochemical, and physiological characteristics. 502, 519
- arteriole** Vessel that takes blood from an artery to capillaries. 736
- artery** Blood vessel that transports blood away from the heart. 736
- arthropod (AR-throh-pahd)** Invertebrate of the phylum Arthropoda, which includes lobsters, insects, and spiders; characterized by jointed appendages. [Gk. *arthron*, joint, and *podos*, foot] 603
- ascus (pl., asci)** Fingerlike sac in which nuclear fusion, meiosis, and ascospore formation occur during sexual reproduction of the sac fungi. [Gk. *askos*, bag, sac] 545
- asexual reproduction** Reproduction that requires only one parent and does not involve gametes. 148, 894
- aster** Short, radiating fibers produced by the centrosomes in animal cells. [Gk. *aster*, star] 153
- asymmetry** Body plan having no particular symmetry. 576
- atom** Smallest particle of an element that displays the properties of the element. [Gk. *atomos*, uncut, indivisible] 20
- ATP (adenosine triphosphate) (ah-DEN-ah-seen try-FAHS-fayt)** Nucleotide with three phosphate groups. The breakdown of ATP into ADP + P makes energy available for energy-requiring processes in cells. 51, 102
- atrial natriuretic hormone (ANH)** Hormone secreted by the heart that increases sodium excretion. 813
- atrial ventricular valve** Heart valve located between an atrium and a ventricle. 738
- atrium (pl., atria)** Chamber; particularly an upper chamber of the heart lying above a ventricle. 738
- australopithecine (aw-stray-loh-PITH-uh-syn)** One of several species of *Australopithecus*, a genus that contains the first generally recognized hominids. [L. *australis*, southern, *pithecus*, ape, and *ramus*, branch] 354
- autonomic system (awt-uh-NAHM-ik)** Division of the peripheral nervous system that regulates internal organs. [Gk. *autos*, self, and *nomas*, roving] 829
- autotroph** Organism that can make organic molecules from inorganic nutrients. [Gk. *autos*, alone, and *trophe*, food] 327
- auxin (AHK-sun)** Plant hormone regulating growth, particularly cell elongation; also called indoleacetic acid (IAA). [Gk. *auximos*, promoting growth] 572
- axial skeleton (AK-see-ul)** Part of the skeleton forming the vertical support or axis, including the skull, the rib cage, and the vertebral column. [L. *axi*, axis, hinge, and Gk. *skeleton*, dried body] 860
- axon** Elongated portion of a neuron that conducts nerve impulses typically from the cell body to the synapse. [Gk. *axon*, axis] 818
- ## B
- Bacteria** One of the three domains of life; prokaryotic cells other than archaea with unique genetic, biochemical, and physiological characteristics. 502
- bacteriophage** Virus that infects bacteria. [Gk. *bacterion*, rod, and *phagein*, to eat] 223, 510
- Barr body** Dark-staining body (discovered by M. Barr) in the nuclei of female mammals that contains a condensed, inactive X chromosome. 256
- base** Molecules tending to lower the hydrogen ion concentration in a solution and raise its pH numerically. 30
- basidium (pl., basidia) (buh-SID-ee-um)** Clublike structure in which nuclear fusion, meiosis, and basidiospore production occur during sexual reproduction of club fungi. [Gk. *basis*, pedestal] 547
- behavior** Observable, coordinated responses to environmental stimuli. 368
- benthic division (BEN-thik)** Ocean floor, which supports a unique set of organisms in contrast to the pelagic division. [Gk. *benthos*, depths] 465
- bicarbonate ion (HCO<sub>3</sub><sup>-</sup>)** Ion that participates in buffering the blood, and the form in which carbon dioxide is transported in the bloodstream. 797
- bilateral symmetry** Body plan having two corresponding or complementary halves. 576
- bile** Secretion of the liver that is temporarily stored and concentrated in the gallbladder before being released into the small intestine, where it emulsifies fat. 780
- binary fission** Splitting of a parent cell into two daughter cells; serves as an asexual form of reproduction in bacteria. [L. *binarius*, of two, and *fissura*, cleft, break] 148, 515
- binomial system** Assignment of two names to each organism, the first of which designates the genus and second of which is the specific epithet. 492
- biogeochemical cycle (by-oh-jee-oh-KEM-i-kal)** Circulating pathway of elements such as carbon and nitrogen from the environment, through biotic communities and also back to the environment. 434
- biogeography** Study of the geographical distribution of organisms. [Gk. *bios*, life, *geo*, earth, and *grapho*, writing] 290
- biological clock** Internal mechanism that maintains a biological rhythm in the absence of environmental stimuli. 679
- biological magnification** Process by which substances become more concentrated in organisms in the higher trophic levels of a food web. 480
- biome (BY-ohm)** Major terrestrial community characterized by certain climatic conditions and dominated by particular types of plants. 449
- biosphere** Zone of air, land, and water at the surface of the earth in which living organisms are found. [Gk. *bios*, life, and L. *sphaera*, ball] 6, 384, 428, 444
- biotic potential** Maximum population growth rate under ideal conditions. 387



- bivalent (by-VAY-lent)** Homologous chromosomes, each having sister chromatids that are joined by a nucleoprotein lattice during meiosis; also called tetrad. [L. *bis*, two, and *valens*, strength] 162
- blastocoel** Fluid-filled cavity of a blastula [Gk. *blastos*, bud, and *koiloma*, cavity] 915
- blastocyst** Early stage of human embryonic development that consists of a hollow fluid-filled ball of cells. 923
- blastula (BLAST-chuh-luh)** Hollow, fluid-filled ball of cells occurring during animal development prior to gastrula formation. [Gk. dim. of *blastos*, bud, and L. *ula*, little] 915
- blood** Type of connective tissue in which cells are separated by a liquid called plasma. 721
- blood pressure** Force of blood pushing against the inside wall of blood vessels. 743
- B lymphocyte (LIM-fuh-syt)** Lymphocyte that matures in the bone marrow and, when stimulated by the presence of a specific antigen, gives rise to antibody-producing plasma cells. [L. *lymph*a, clear water, and Gk. *kytos*, cell] 760
- bone** Connective tissue in which the cells lie within lacunae embedded in a hard matrix of mineral salts deposited around protein fibers. 721
- bronchiole (BRAHNG-kee-ohl)** Small tube that conducts air from a bronchus to the alveoli. [Gk. dim. of *bronchos*, windpipe] 795
- bronchus (pl., bronchi) (BRAHNG-kus)** Branch of the trachea in vertebrates that leads to lungs. [Gk. *bronchos*, windpipe] 795
- bud** In plants, undeveloped shoot, largely meristematic tissue covered by immature leaves and protected by bud scales; in animals, a protuberance from the body that develops into a new individual. 648
- buffer** Substance or group of substances that tend to resist pH changes in a solution, thus stabilizing its relative acidity and basidity. 31
- C**
- C<sub>3</sub> photosynthesis** Direct use of the Calvin cycle, in which CO<sub>2</sub> binds to ribulose biphosphate (RuBP) to form two three-carbon phosphoglycerate (PGA) molecules; because CO<sub>2</sub> fixation produces a three-carbon product, this is called C<sub>3</sub> photosynthesis. 124
- C<sub>4</sub> photosynthesis** Involves CO<sub>2</sub> fixation resulting in the four-carbon oxaloacetate molecule; requires almost twice as much energy as C<sub>3</sub> photosynthesis, but it inhibits photorespiration and thus is advantageous in hot, dry climates. Used in numerous grasses and some other plant groups. 124
- Calvin cycle** Light-independent reactions of photosynthesis, carbon dioxide is fixed and reduced to yield a sugar-phosphate molecule that can be used to form glucose or regenerate RuBP, the first molecule of the cycle. The cycle uses ATP and NADPH from light-dependent reactions. 121
- camouflage** Method of hiding from predators in which the organism's behavior, form, and pattern of coloration allow it to blend into the background and prevent detection. 414
- CAM plant** Plant that fixes carbon dioxide at night to produce a C<sub>4</sub> molecule that releases carbon dioxide to the Calvin cycle during the day; CAM stands for crassulacean-acid metabolism. 124
- cancer** Malignant tumor whose nondifferentiated cells exhibit loss of contact inhibition, uncontrolled growth, and the ability to invade tissue and metastasize. 260
- capillary** Microscopic blood vessel; gas and other substances are exchanged across the walls of a capillary between blood and tissue fluid. [L. *capillus*, hair] 736
- carbohydrate** Class of organic compounds consisting of a carbon chain with hydrogen and oxygen atoms attached; includes monosaccharides, disaccharides, and polysaccharides. [L. *carbo*, charcoal, and Gk. *hydatos*, water] 39
- carbon cycle** Biogeochemical cycle in which carbon moves from the atmosphere through biotic communities and back to the atmosphere. 436
- carbon dioxide (CO<sub>2</sub>) fixation** Binding of carbon dioxide to an organic molecule such as RuBP of the Calvin cycle. 122
- carbonic anhydrase** Enzyme in red blood cells that speeds the formation of carbonic acid from water and carbon dioxide. [Gk. *an*, without, and *hydrias*, water] 797
- carcinogen (kar-SIN-uh-jen)** Environmental agent that causes mutations leading to the development of cancer. [Gk. *carcino*, ulcer, and *gene*, origin] 264
- cardiac muscle** Striated, involuntary muscle tissue found only in the heart. [Gk. *kardia*, heart] 722
- cardiovascular (or circulatory) system** Organ system consisting of the blood, heart, and a series of blood vessels that distribute blood under the pumping action of the heart. [Gk. *kardia*, heart, and L. *vascular*, vessel] 734
- carnivore** Consumer in a food chain that eats other animals. 429
- carpel (KAHR-pul)** In flowering plants, a reproductive unit of a pistil; consisting of three parts—the stigma, the style, and the ovary. [Gk. *karpos*, fruit] 695
- carrier** Heterozygous individual who has no apparent abnormality but can pass on an allele for a recessively inherited genetic disorder. 215
- carrier protein** Protein that combines with and transports a molecule across the plasma membrane. 90
- carrying capacity** Largest number of organisms of a particular species that can be maintained indefinitely by a given environment. 389
- cartilage** Connective tissue in which the cells lie within lacunae embedded in a flexible proteinaceous matrix. [L. *cartilago*, gristle] 720
- Casparian strip (kas-PAIR-ee-un)** Layer of impermeable lignin and suberin bordering four sides of root endodermal cells; prevents water and solute transport between adjacent cells. 645, 662
- catastrophism (ka-TAS-truh-fism)** Belief espoused by Georges Cuvier that periods of catastrophic extinctions occurred, after which repopulation of surviving species took place, giving the appearance of change through time. [Gk. *katastrophe*, calamity, misfortune] 288
- cell** Smallest unit that displays the properties of life; composed of cytoplasm surrounded by a plasma membrane. 58
- cell cycle** Repeating sequence of cell growth and mitosis. 150
- cell plate** Structure across a dividing plant cell that signals the location of new plasma membranes and cell walls. 154
- cell theory** One of the major theories of biology which states that all organisms are made up of cells; cells are capable of self-reproduction and cells came only from pre-existing cells. 58
- cellular respiration** Metabolic reactions that use the energy from carbohydrate or fatty acid or amino acid breakdown to produce ATP molecules; includes fermentation, and aerobic respiration. 130
- cellulose** Polysaccharide that is the major complex carbohydrate in plant cell walls. 40
- cell wall** Structure that surrounds a plant, protistan, fungal or bacterial cell and maintains cell shape and rigidity. 63, 94
- central nervous system (CNS)** Brain and spinal cord of vertebrates. 824
- centriole** Cell organelle, existing in pairs, that occurs in the centrosome and may help organize a mitotic spindle for chromosome movement during animal cell division. [Gk. *centrum*, center] 74, 152
- centromere (SEN-truh-mir)** Constriction where sister chromatids of a chromosome are held together. [Gk. *centrum*, center, and *meros*, part] 149
- centrosome (SEN-truh-sohm)** Central microtubule organizing center of cells. In animal cells, it contains two centrioles. [Gk. *centrum*, center, and *soma*, body] 73, 152